VEGETATION MANAGEMENT'S ROLE IN CARBON STORAGE

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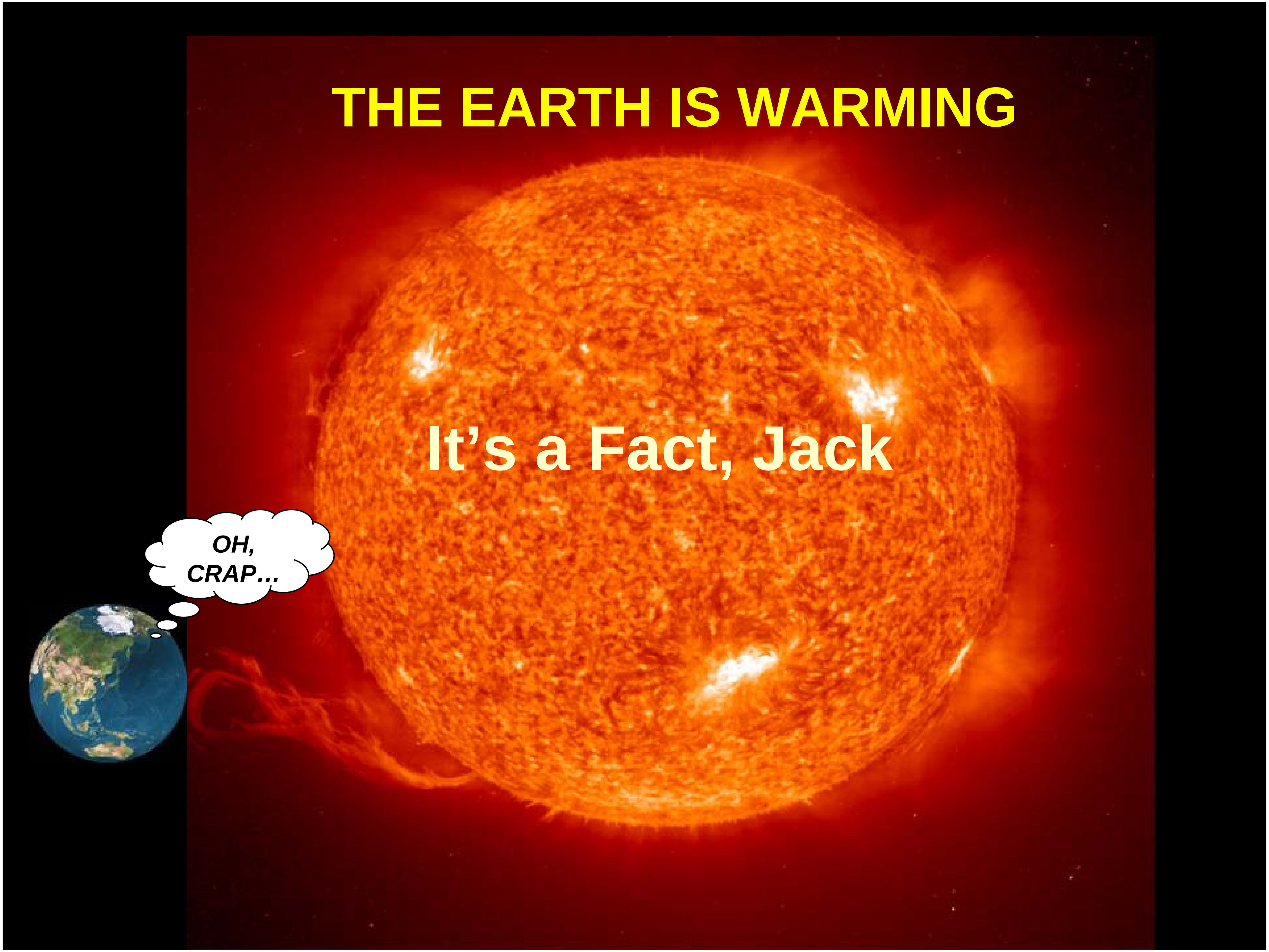
- **Carbon cycle and forestry** — ***Dale Johnson***
- **Biomass for power** — ***Greg Morris***
- **Accounting protocols** — ***Steve Mader***
- **Management contrasts** — ***Cajun James***
- **Modeling scenarios** — ***Jianwei Zhang***
- **Accounting assumptions** — ***John Nickerson***
- **Fire risk** — ***Carl Skinner***
- **Economics of carbon storage** — ***Jeff Kline***
- ***Salvage issues*** — ***Tom Bonnicksen***

"Connecting the Big Dots: Forest Carbon, Climate Change, and Renewable Energy"

Mark Nechodom

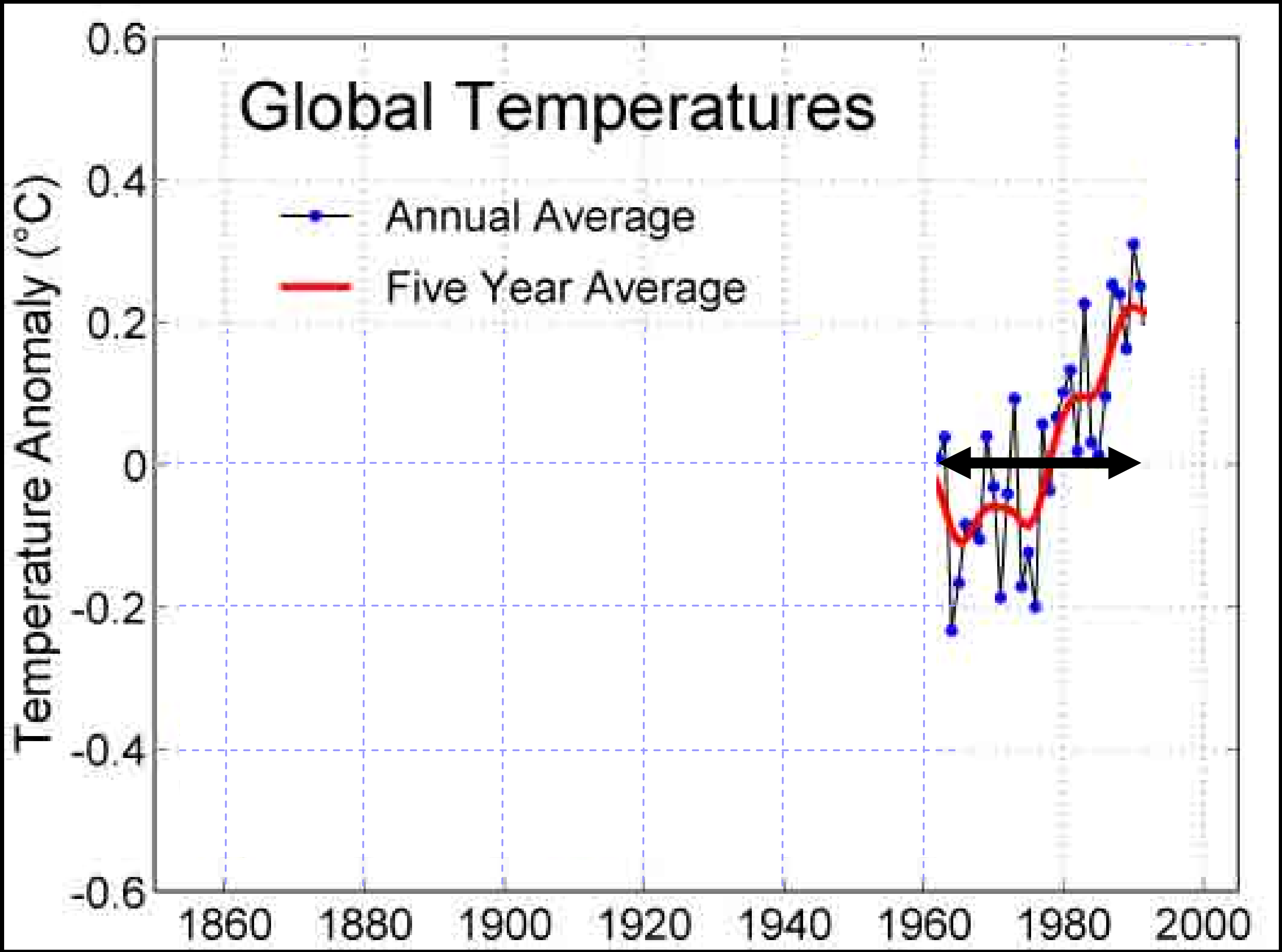
VEGETATION MANAGEMENT'S ROLE IN CARBON STORAGE

- **Who Cares?**
- **What's in it for Me?**
- **What are the Options?**
- **What are the Consequences?**

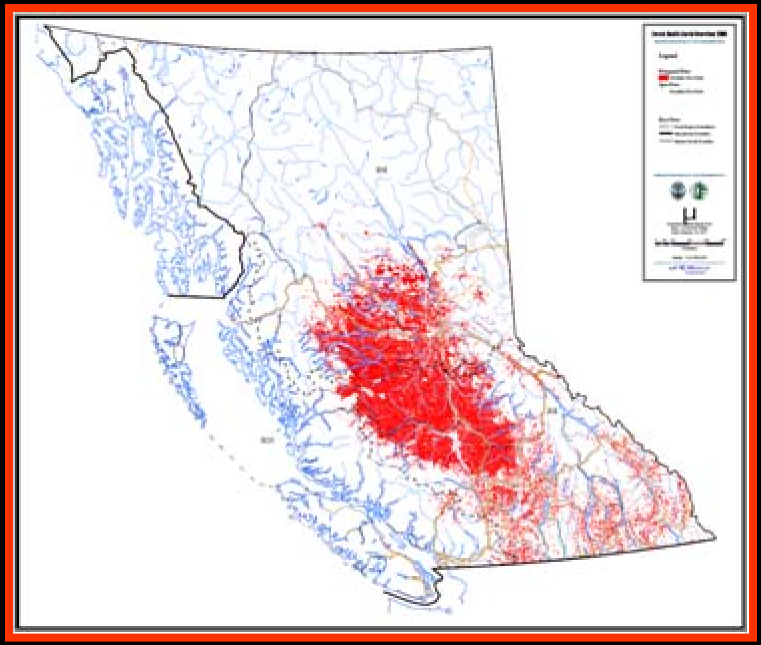

THE EARTH IS WARMING
It’s a Fact, Jack
OH, CRAP…

INSTUMENTAL TEMPERATURE RECORD

Global mean surface temperature anomaly 1850 to 2006 relative to 1961–1990



Brohan et al. 2006



BRITISH COLUMBIA

MOUNTAIN PINE BEETLE

9.2 million ha 2006

8.7 million ha 2005

7.0 million ha 2004

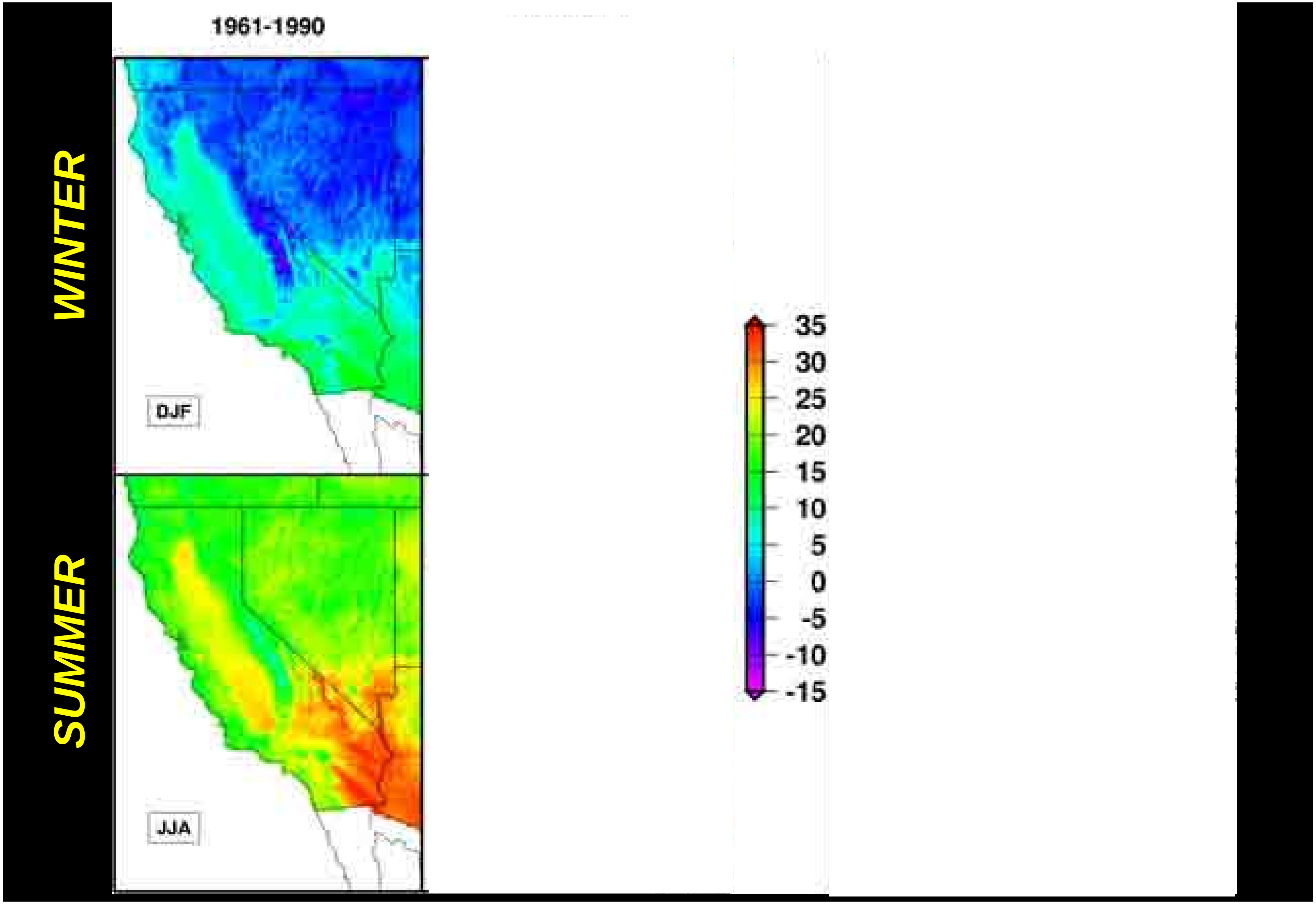
4.1 million ha 2003

1.9 million ha 2002

Evenaged and
over mature

Warm winters

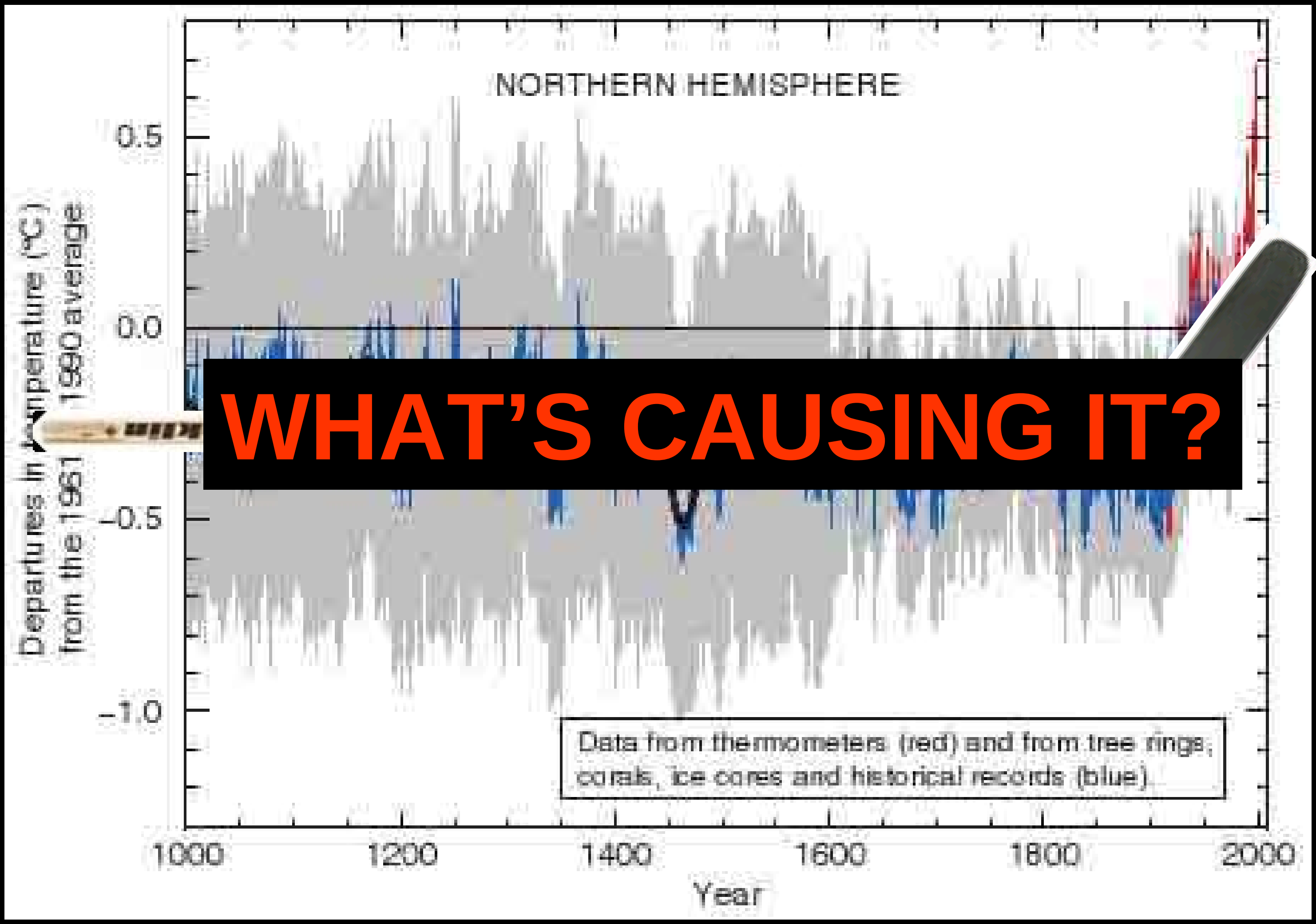
NOAA GEOPHYSICAL FLUIDS DYNAMICS LABORATORY TEMPERATURE PROJECTIONS (ºC)



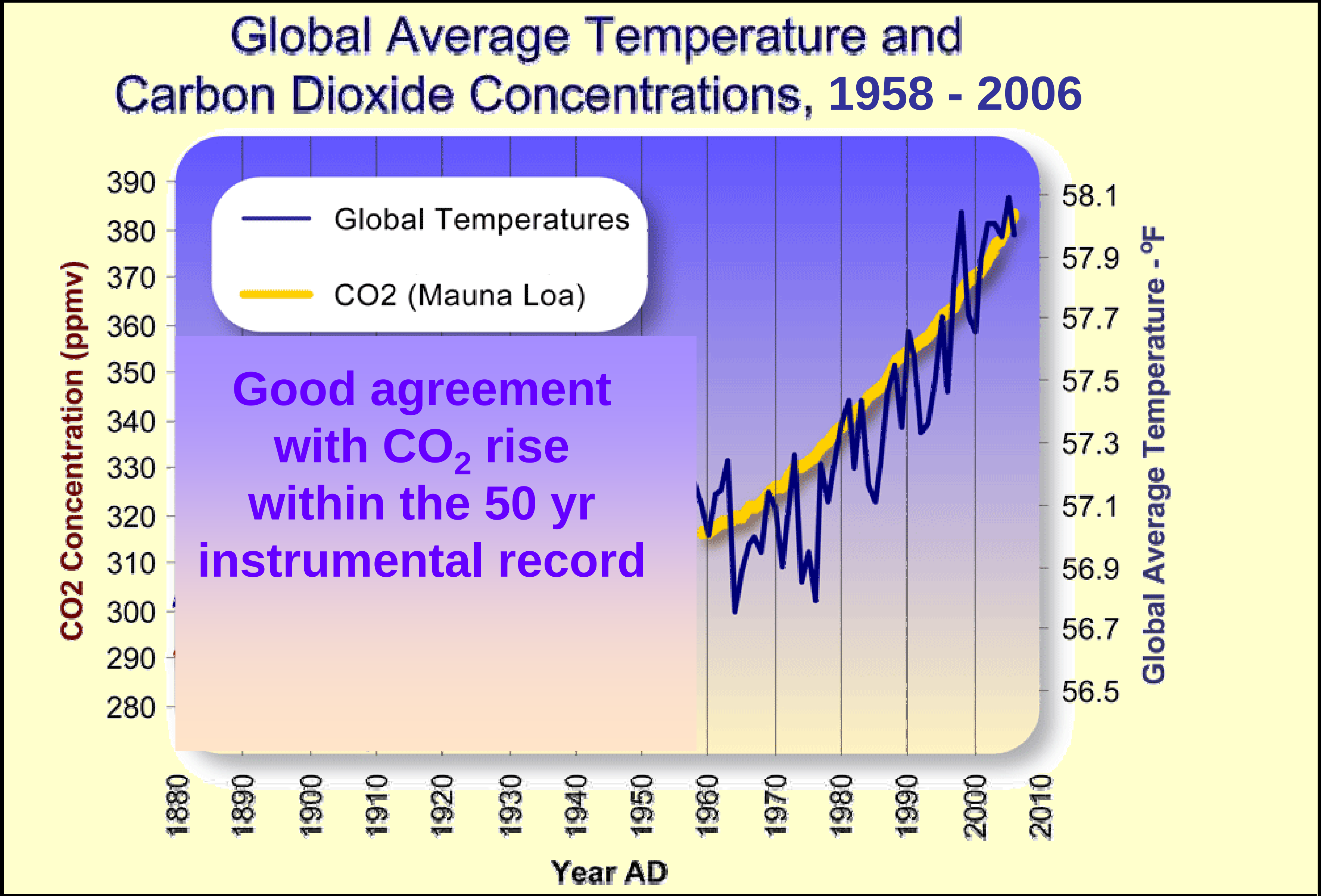
Michael E. Mann
Director, Earth System Science Center, The Pennsylvania State University

Mann, M.E., Bradley, R.S. and Hughes, M.K. Northern Hemisphere Temperatures During the Past Millennium: Inferences, Uncertainties, and Limitations, *Geophysical Research Letters*, 26, 759-762, 1999.

NORTHERN HEMISPHERE TEMPERATURE RISES GREATER THAN IN PAST 1 THOUSAND YEARS?



From Mann et al. 1999, IPCC 2001



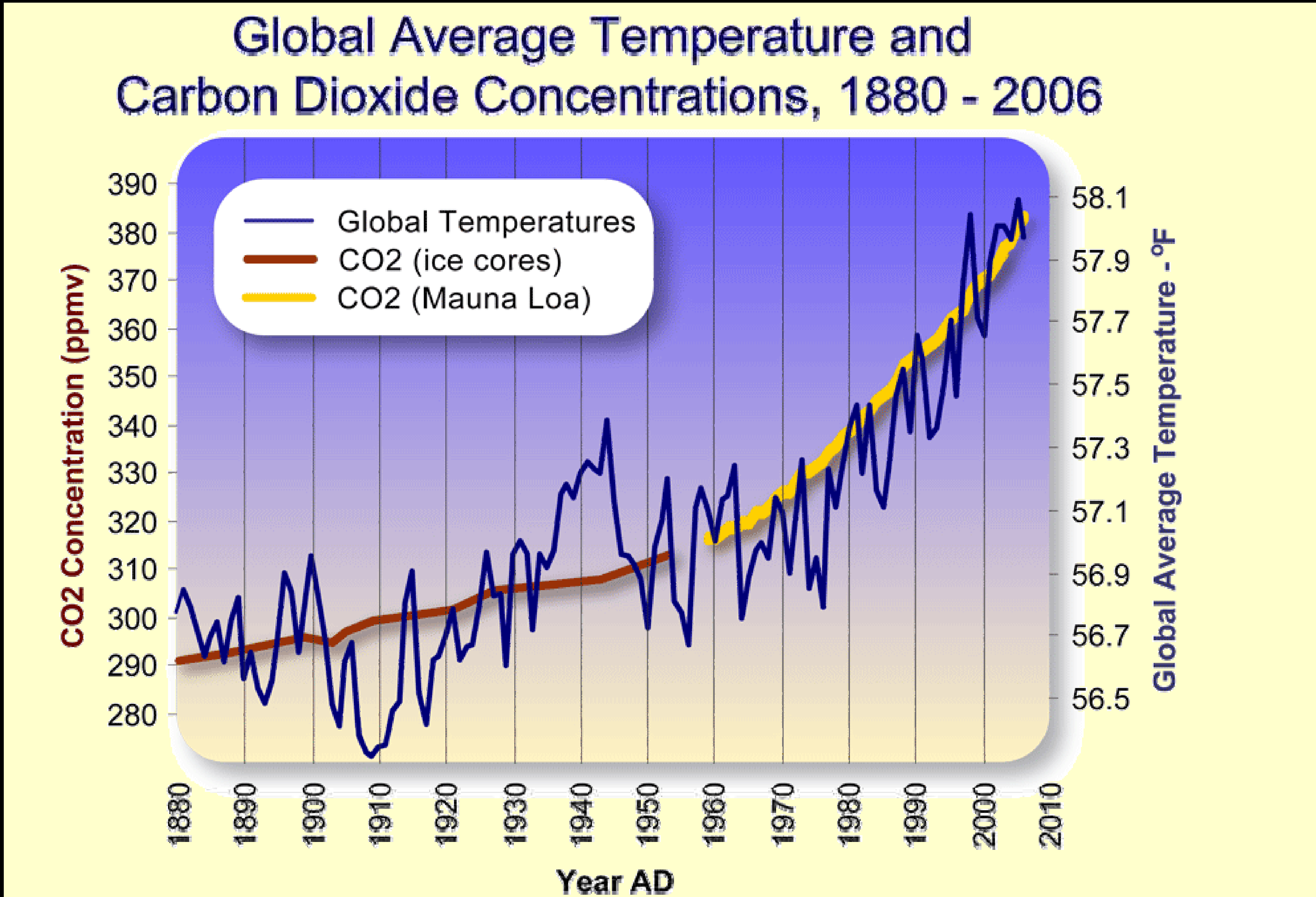
The Woods Hole Research Center 2007
(Based on data from NOAA and Oak Ridge National Laboratory

Argument:

It’s part of a natural cycle.

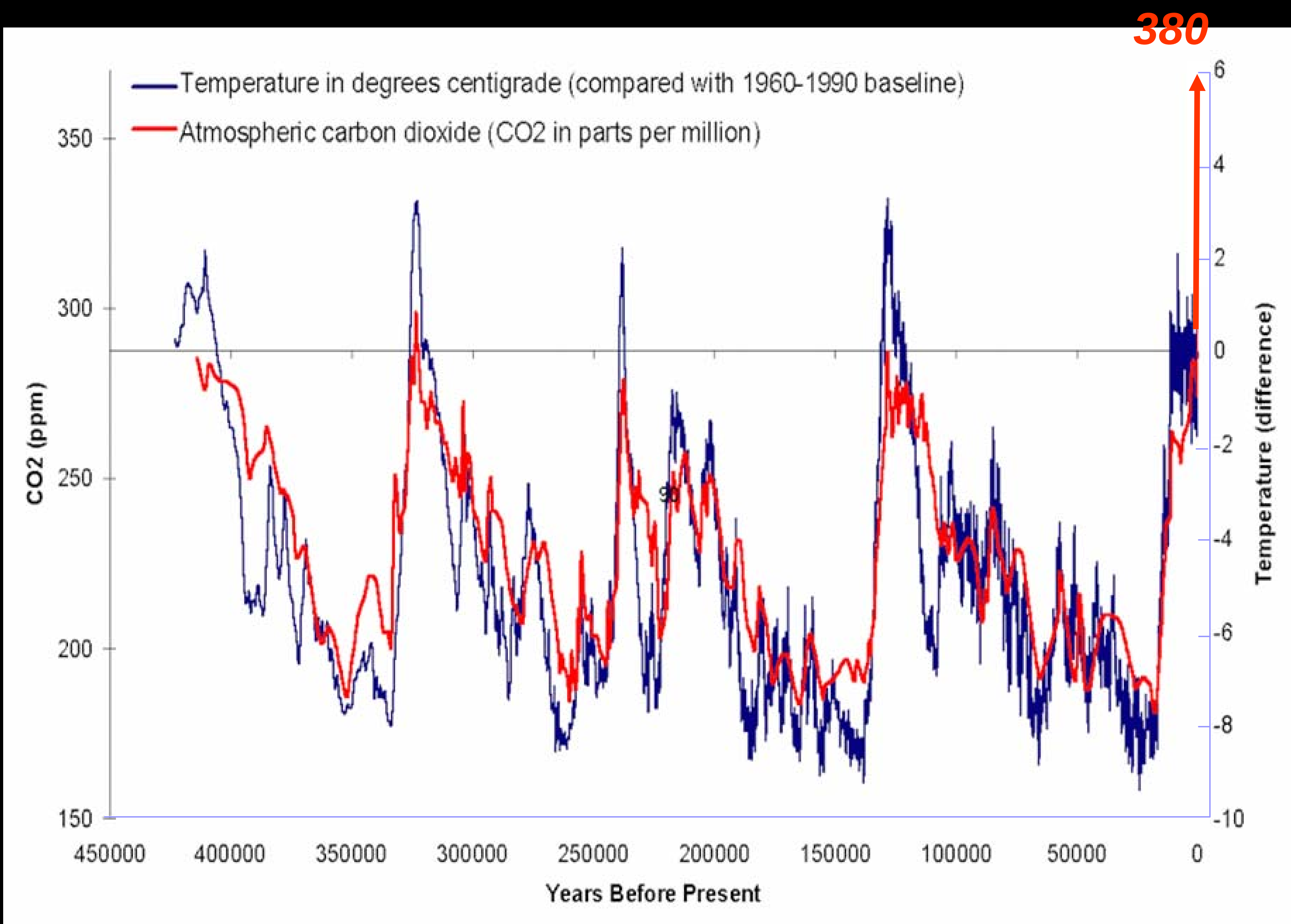
Fifty-year records are but a blink of an eye.

CO_2 has risen and fallen many times over the millennia, and this, too, shall pass.



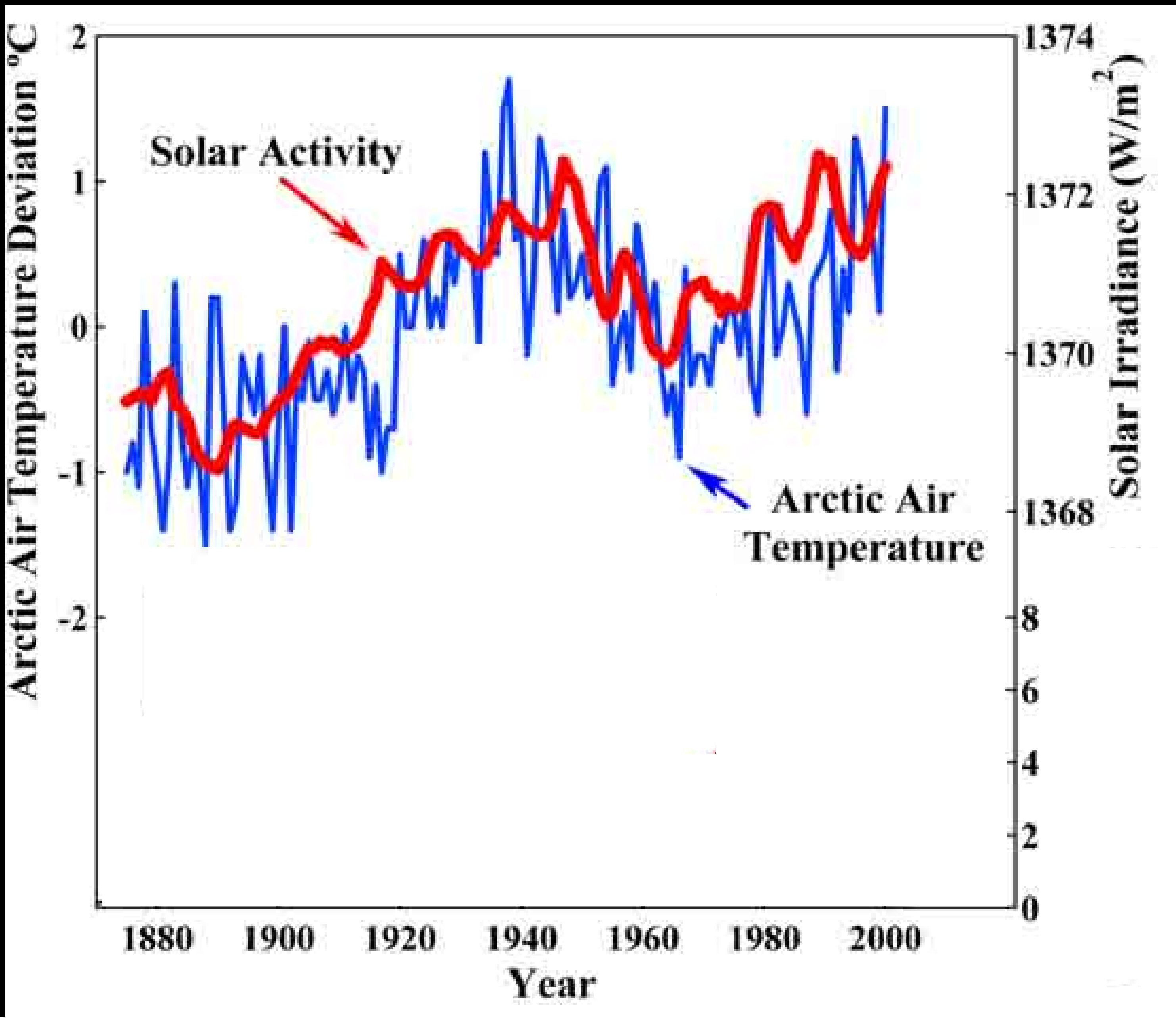
The Woods Hole Research Center 2007
(Based on data from NOAA and Oak Ridge National Laboratory

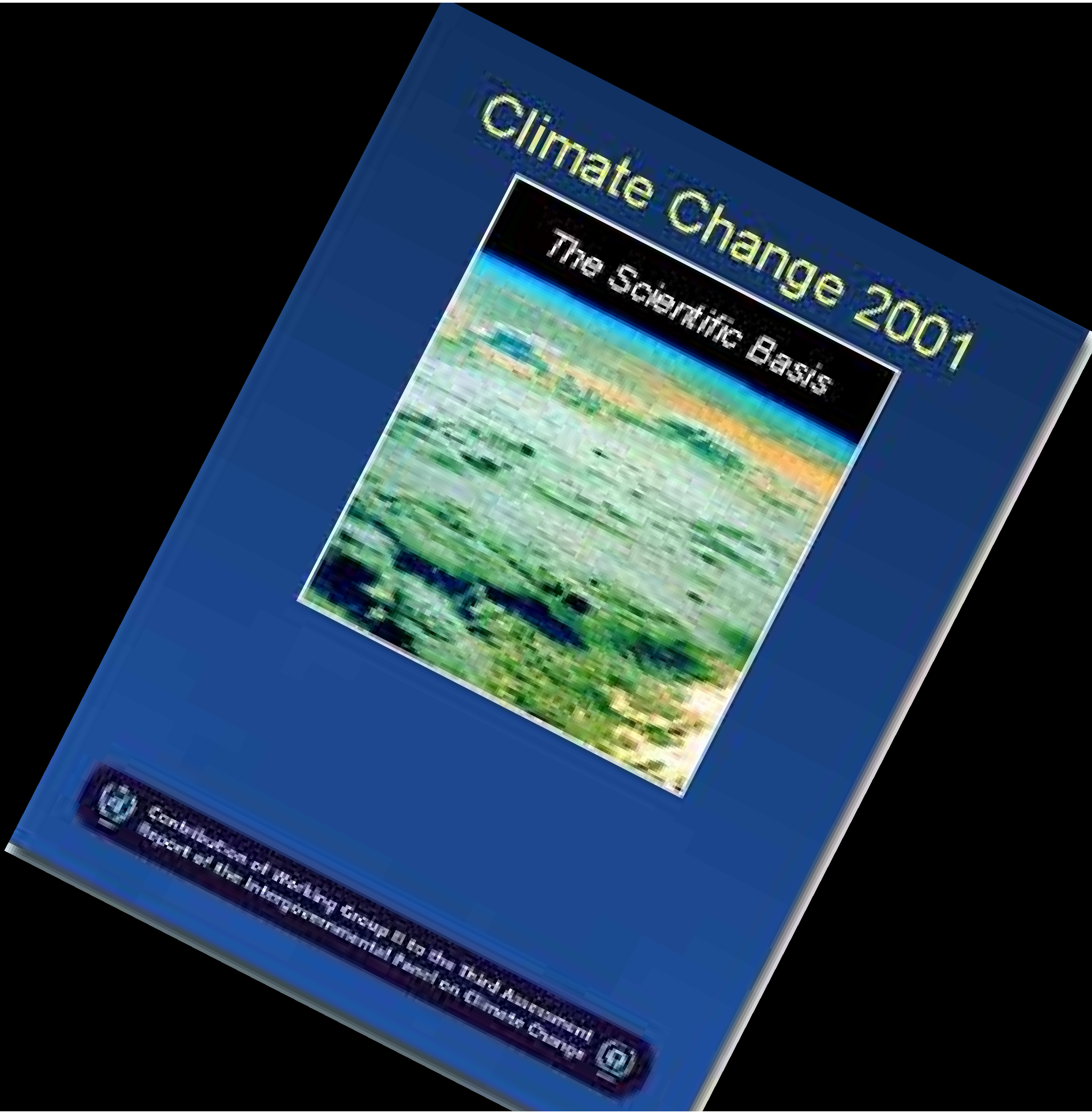
Greenland Ice Coring



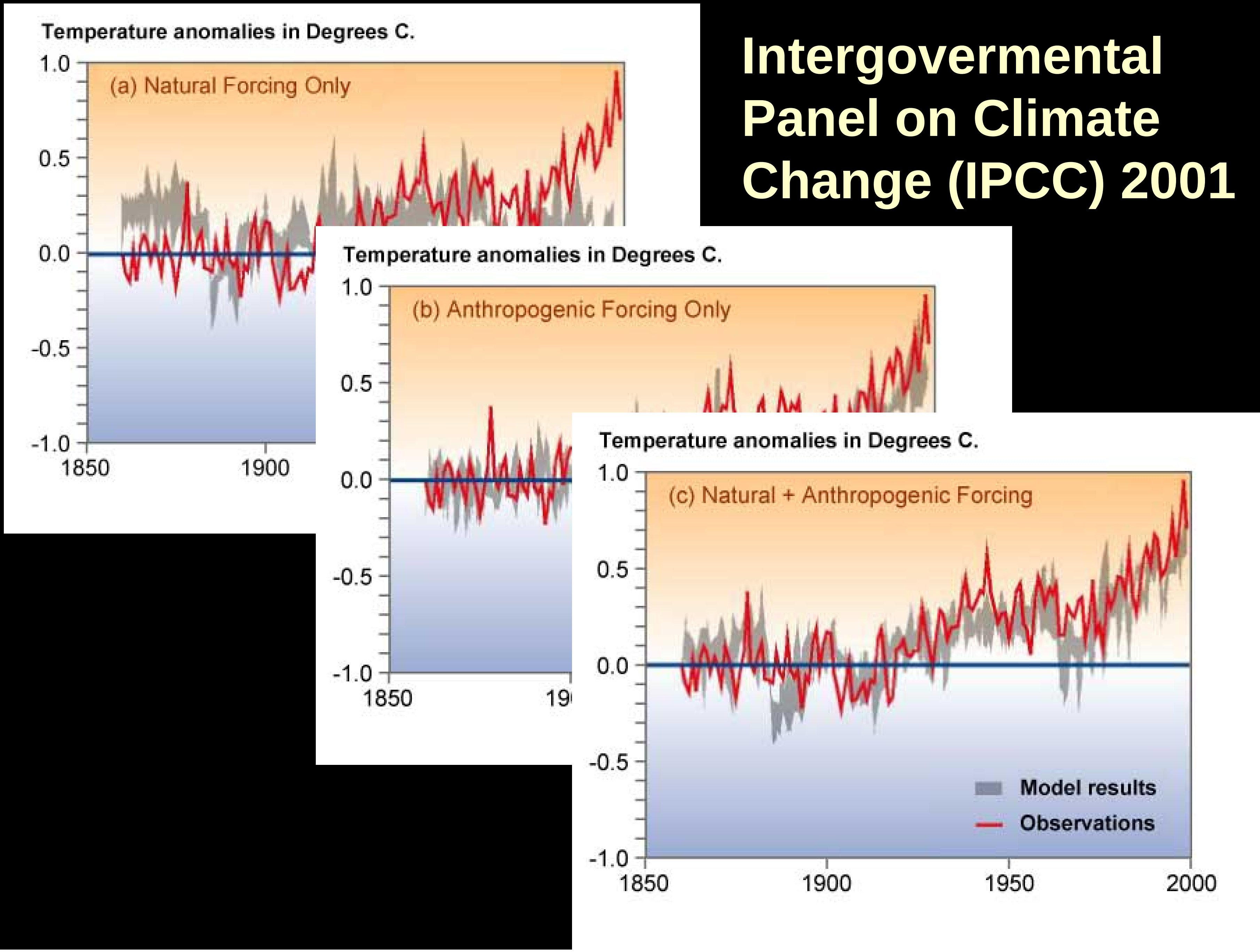
380
Temperature in degrees centigrade (compared with 1960-1990 baseline)
Atmospheric carbon dioxide (CO2 in parts per million)
CO2 (ppm)
350
300
250
200
150
Temperature (difference)
6
4
2
0
-2
-4
-6
-8
-10
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
Years Before Present

Robinson et al. 2007 *J Am Phys Surg*




Climate Change 2001
The Scientific Basis

Intergovermental Panel on Climate Change (IPCC) 2001

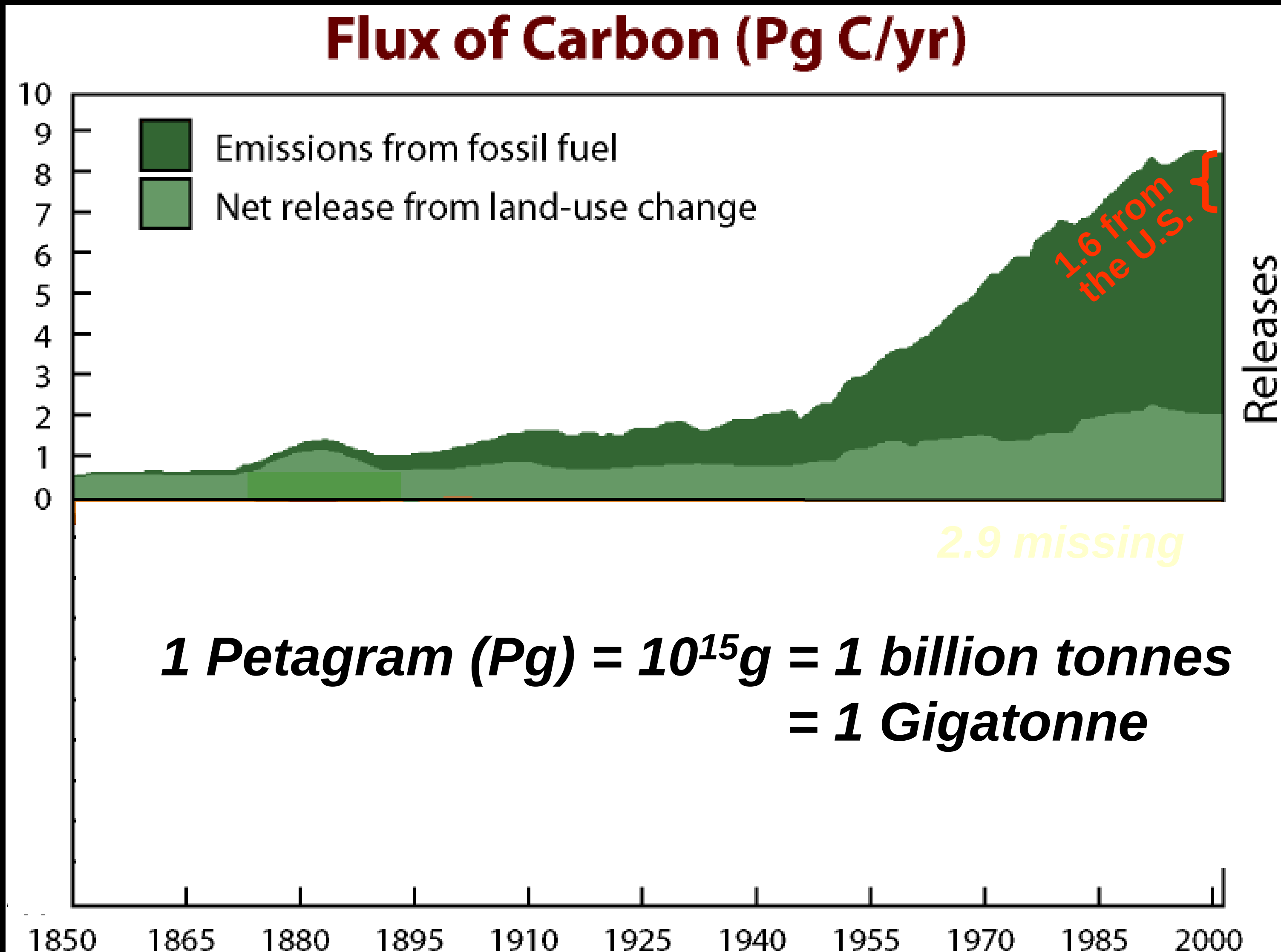


Ammann et al. 2007 *Proc. Nat. Acad. Sci.*

"…even large solar irradiance change combined with realistic volcanic forcing over past centuries could not explain the late 20th century warming without inclusion of greenhouse gas forcing."

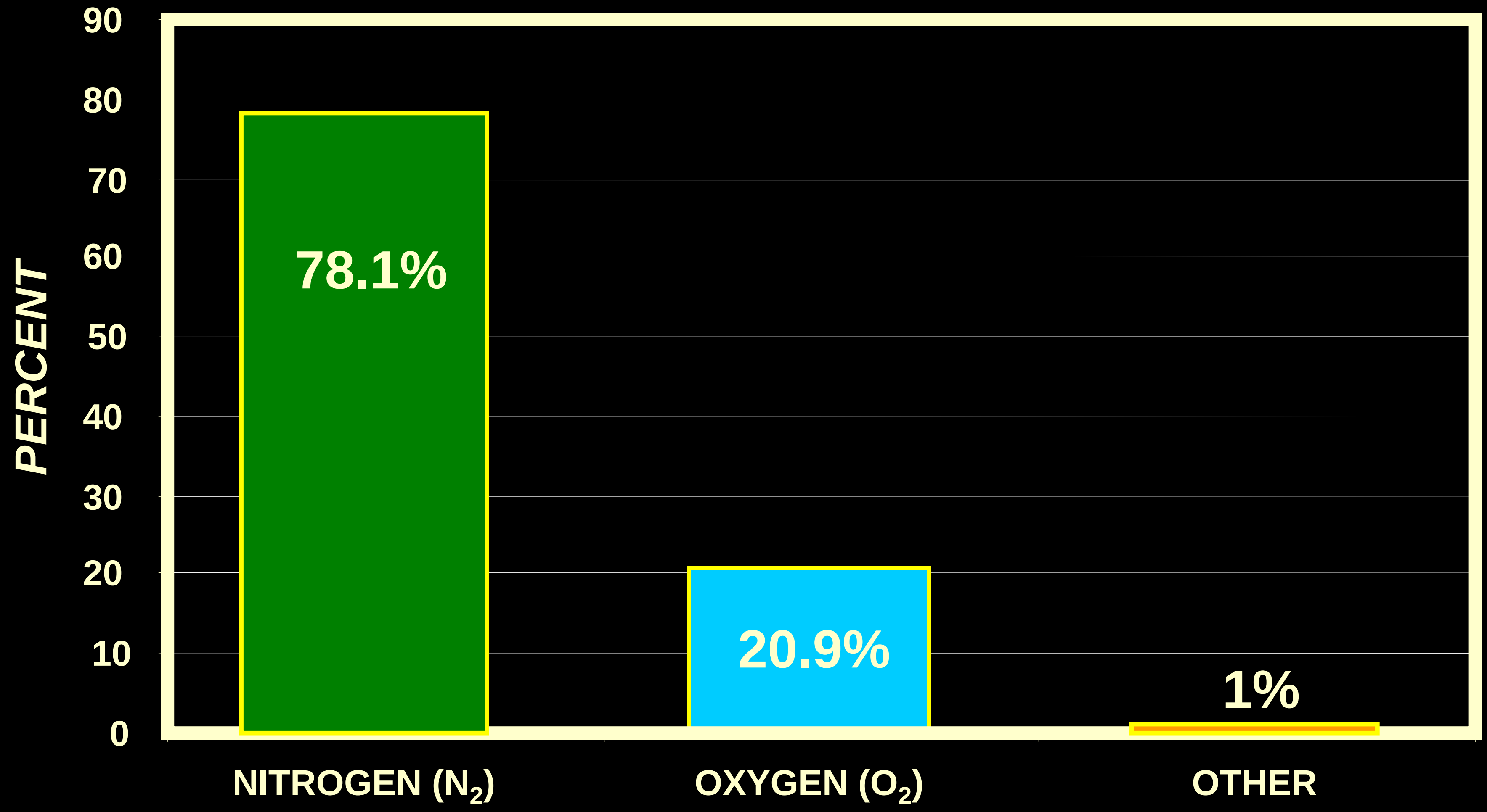
"Although solar and volcanic effects appear to dominate most of the slow climate variations within the past thousand years, the impacts of greenhouse gases have dominated since the second half of the last century."

Global Carbon Emissions



Woods Hole Research Inst. 2007

ATMOSPHERIC COMPOSITION



ATMOSPHERIC COMPOSITION

Major constituents *(%)*

N_2 (78.1)
O_2 (20.9)
} *99%*

***Not* Greenhouse Gases**

GREENHOUSE GASES

Absorb long wave radiation, some is emitted back to space, some downward to heat the atmosphere. They include:

Water Vapor
Carbon Dioxide
Methane
Ozone
Nitrous Oxide
Sulfur Hexafluoride
Hydrofluorocarbons
Chlorofluorcarbons

How plentiful are they?

Greenhouse Gases are Minor Constituents, But…

% composition

H_2O	***(0.48)***
CO_2	***(0.038)***
CH_4	***(0.00017)***
N_2O	***(0.00003)***
O_3	***(0.000007)***
CFC’s	***(0.00000014)***

U.S. EPA www.epa.gov/highgwp/scientific.html

Greenhouse Gases are Minor Constituents, But…

	% composition	*GWP*	*Atomospheric stability (yrs)*
H_2O	*(0.48)*	*0.5 to 3*	
CO_2	*(0.038)*	*1*	*50-200*
CH_4	*(0.00017)*	*21*	*9-15*
N_2O	*(0.00003)*	*310*	*120*
O_3	*(0.000007)*		
CFC's	*(0.00000014)*	*6,500-9.200*	*50,000*

GWP = Global Warming Potential

U.S. EPA www.epa.gov/highgwp/scientific.html

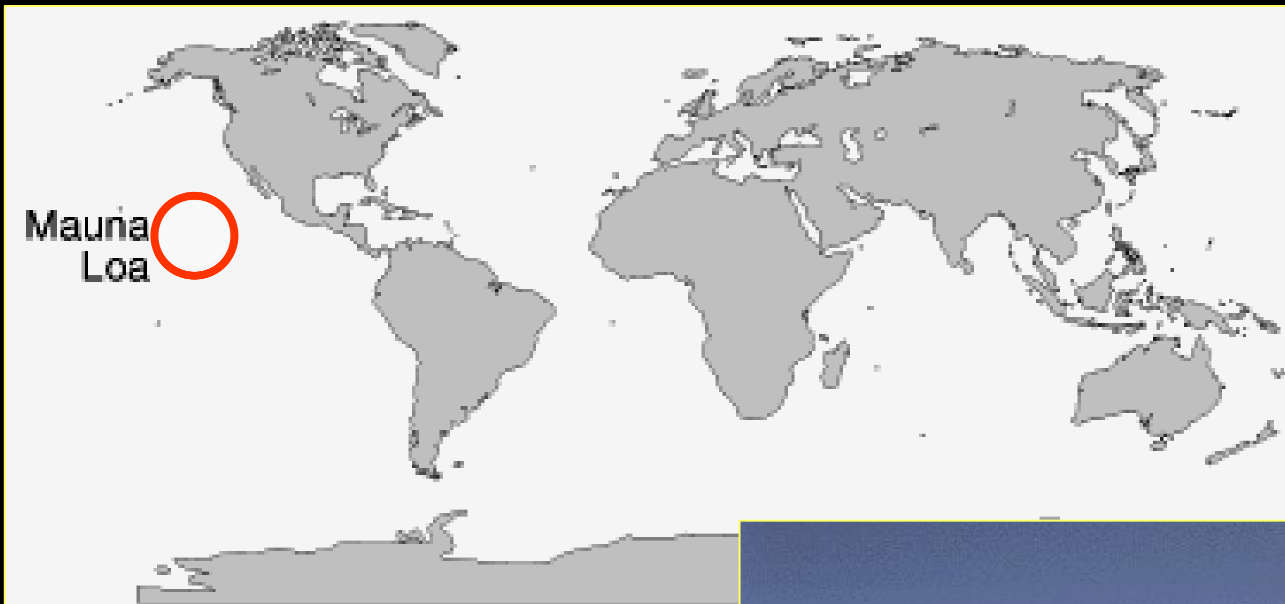
ANNUAL TRACE GAS EMISSIONS BY SOURCE

Langenfelds et al. 2002

	CO_2 *(Pg C)*	CH_4 *(Tg)*
Vegetation and Soils	60-120	25-70
Biomass Burning	1-3	20-40
Fossil Fuels	6-7	50-80
Rice Paddies		40-280
Natural Wetlands		40-150
Termites		20-150
Ruminant Animals		60-160
Oceans	60-100	4-65

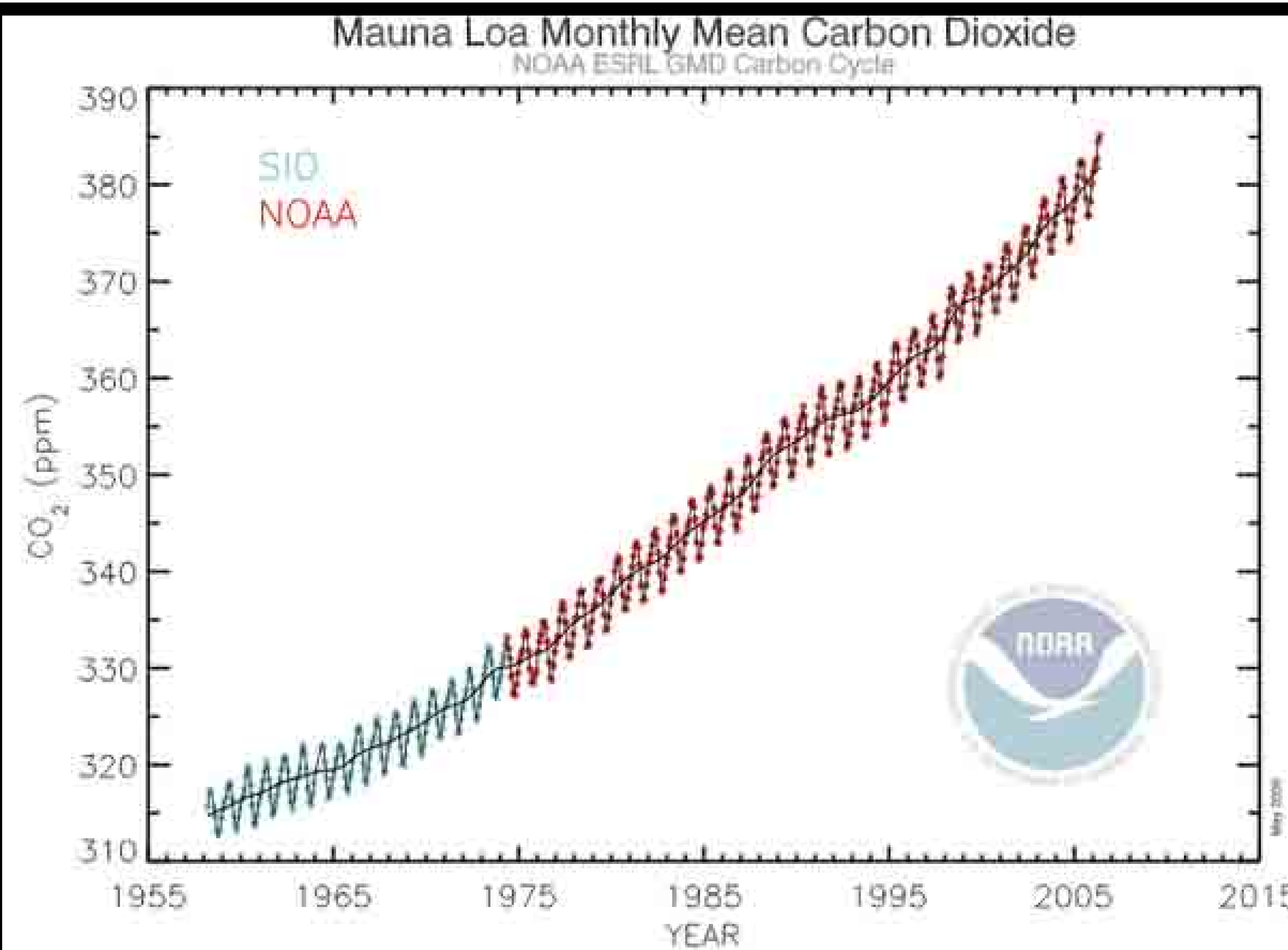
Petagram = 10^{15} = 1 billion tonnes

Teragram = 10^{12} = 1 million tonnes



Continuous records
1958 to present

3,397m above sea level
Latitude 19.5°N



Atmospheric carbon dioxide monthly mean mixing ratios. Data prior to May 1974 are from the Scripps Institution of Oceanography (SIO, blue), data since May 1974 are from the National Oceanic and Atmospheric Administration (NOAA, red). A long-term trend curve is fitted to the monthly mean values. Contact Dr. Pieter Tans, NOAA ESRL GMD Carbon Cycle, Boulder, Colorado, (303) 497-6678, pieter.tans@noaa.gov, and Dr. Ralph Keeling, SIO GRD, La Jolla, California, (858) 534-7582, rkeeling@ucsd.edu.

KYOTO PROTOCOL PARTICIPATION 2005

Signed and ratified

Signed, ratification pending

Signed, ratification declined

No position

The U.S. Lacks a Comprehensive National Policy on Greenhouse Gas Emissions

Instead, there are voluntary, state, and region-based programs to regulate greenhouse gas emissions

For example, replacing fossil fuels with biofuels

President Bush's State of the Union Address, January 2007

Proposed to cut U.S. gasoline consumption up to 20% by 2017 by increasing ethanol production to 35 billion gallons per year

Facts:

- **113 ethanol plants in U.S. 77 more under construction**
- **Most are in the farm belt**
- **One ton crop residues ~ 100 gallons of ethanol**
- **35 billion gallons requires 350 million tons residue**
- **Current U.S. crop residues ~ 500 million tons**

Problems

- Crop residue is not a waste
- Essential to preserving soil quality
- Soil carbon comes from plant residues
- Residues can restore soil quality and soil carbon, or produce energy. But not both.
- Crop residue harvesting is a reality in sub-Saharan Africa, South Asia, China, and other developing countries
- It is not a coincidence that these regions have been plagued by severe soil degradation.

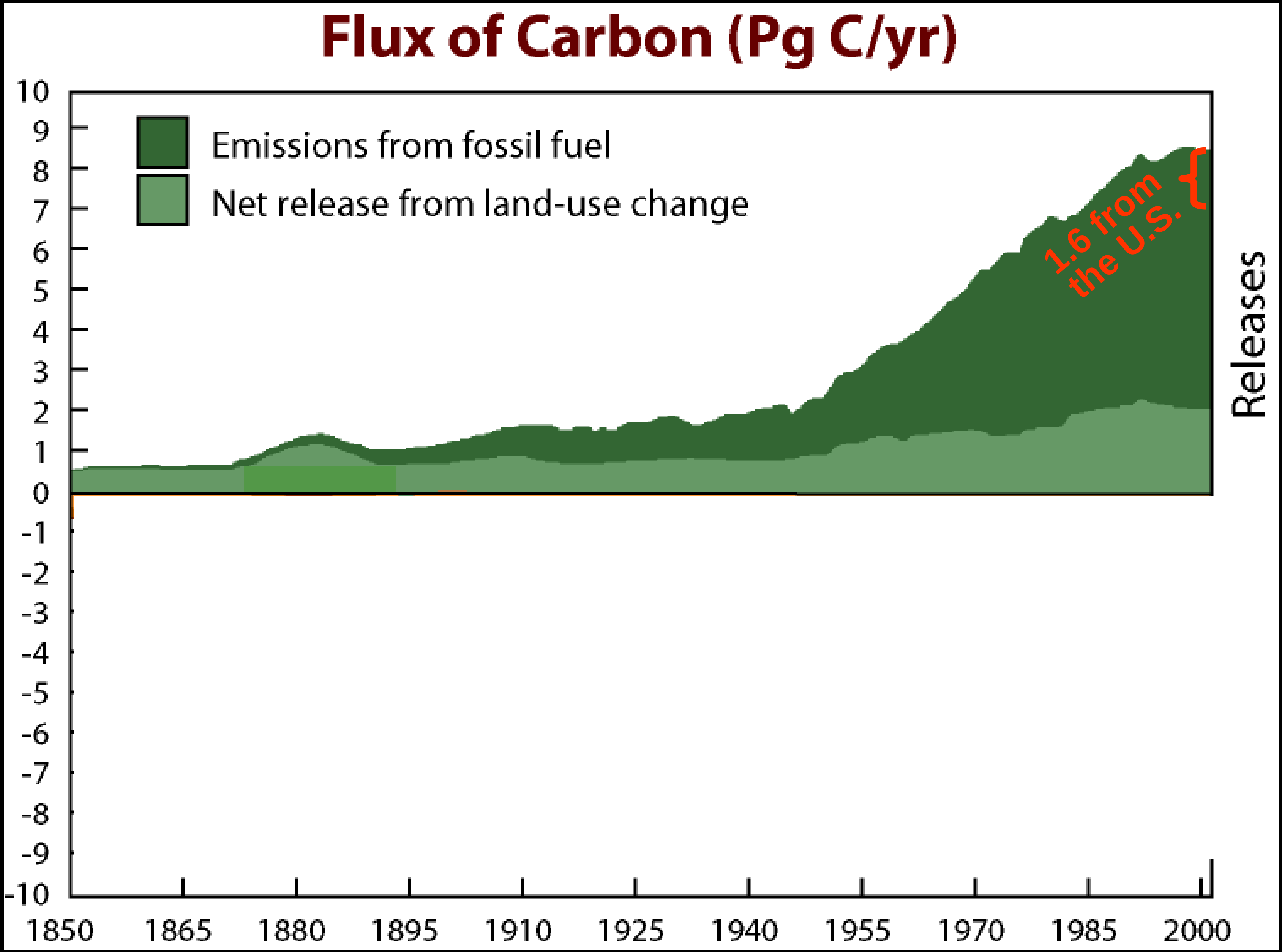
Rattan Lal, President SSSA 2007

CONVERTING CROP RESIDUES TO ETHANOL SEEMS A WEAK SOLUTION

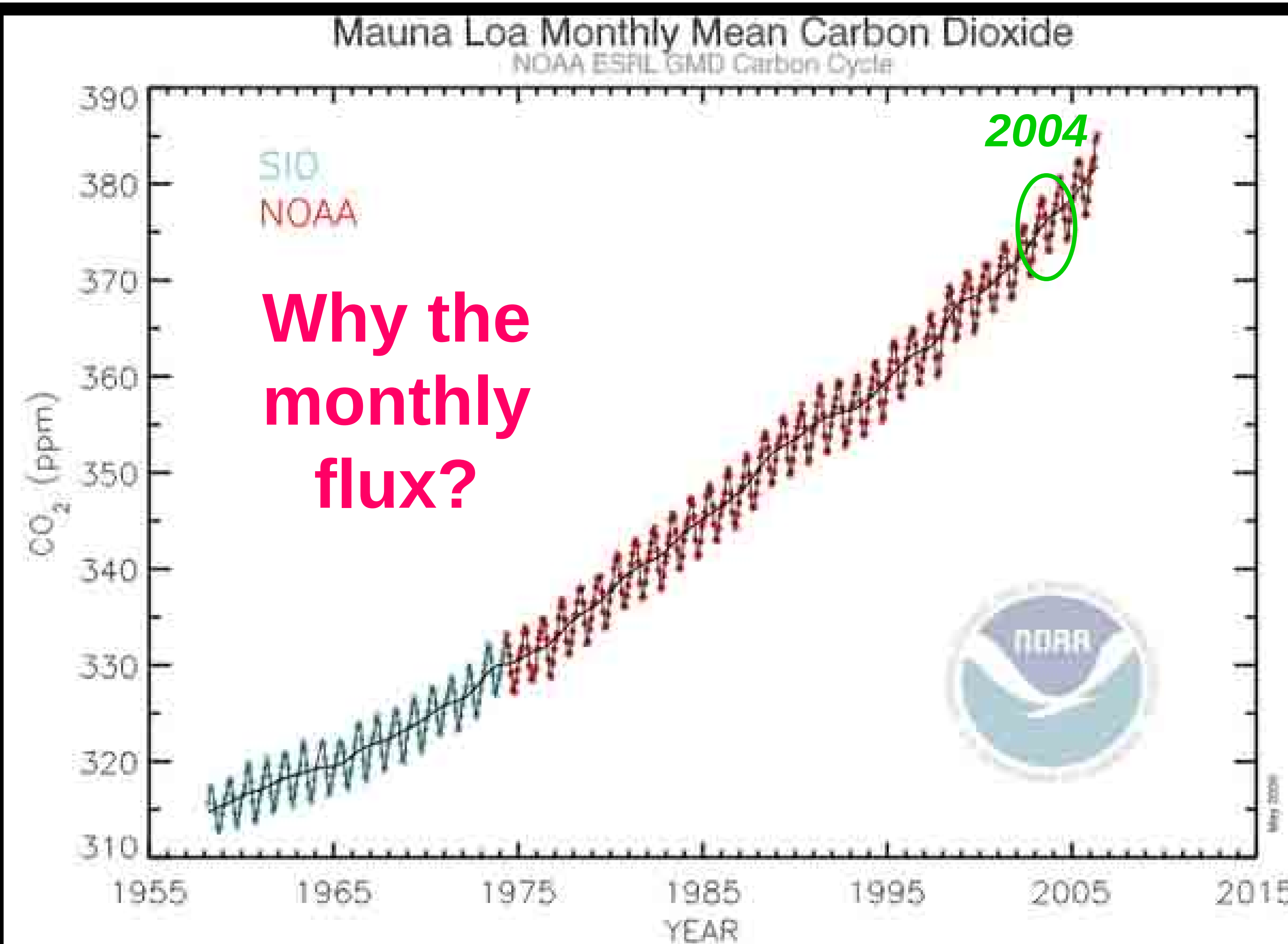
We need better ways of reducing emissions, or sequestering more C

By convention, GHG emission offsets and allowances are determined in metric tons CO_2 equivalent (C x 3.7 ~ CO_2)

Global Carbon: Sources and Sinks



Woods Hole Research Inst. 2007



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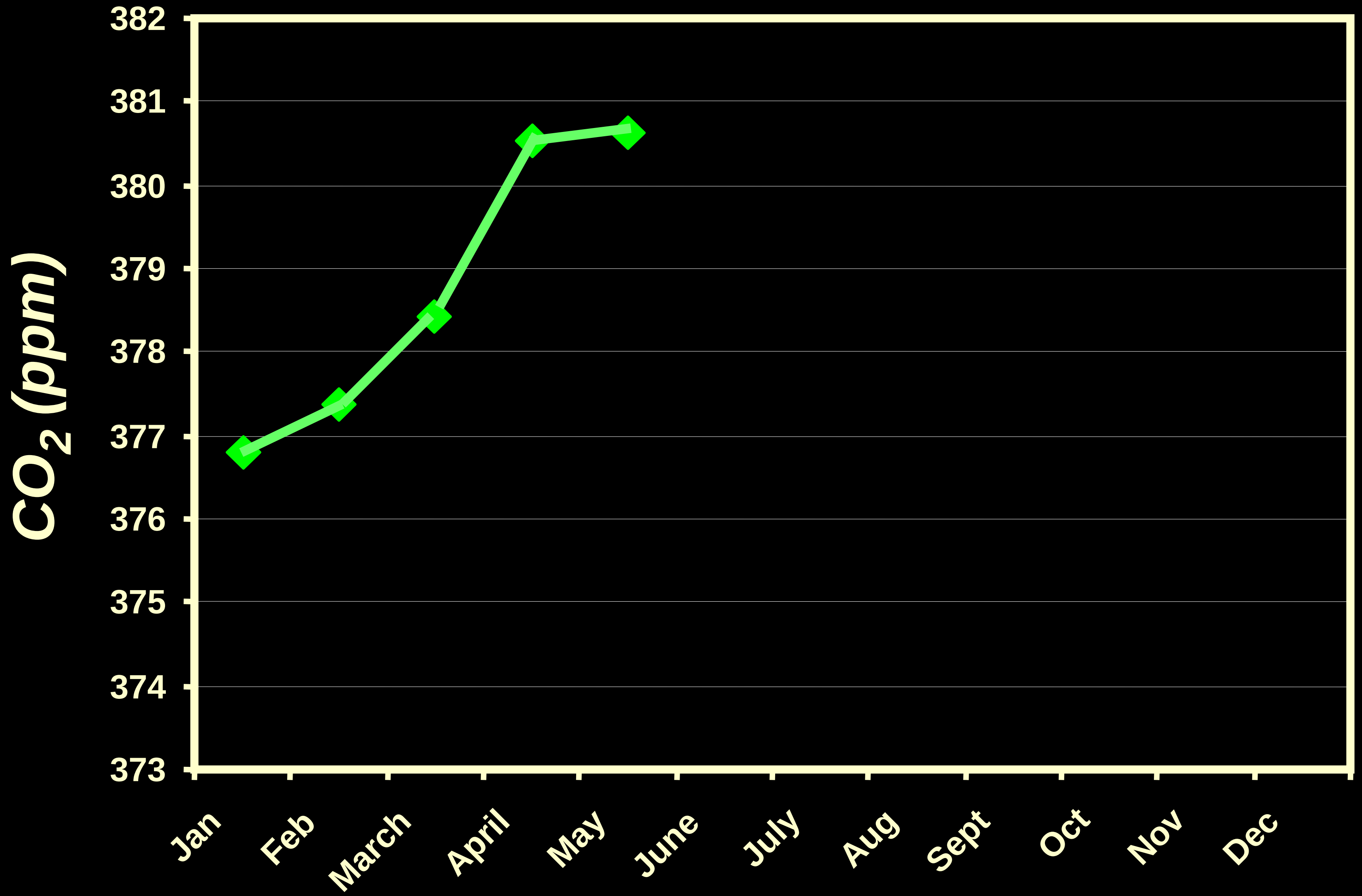
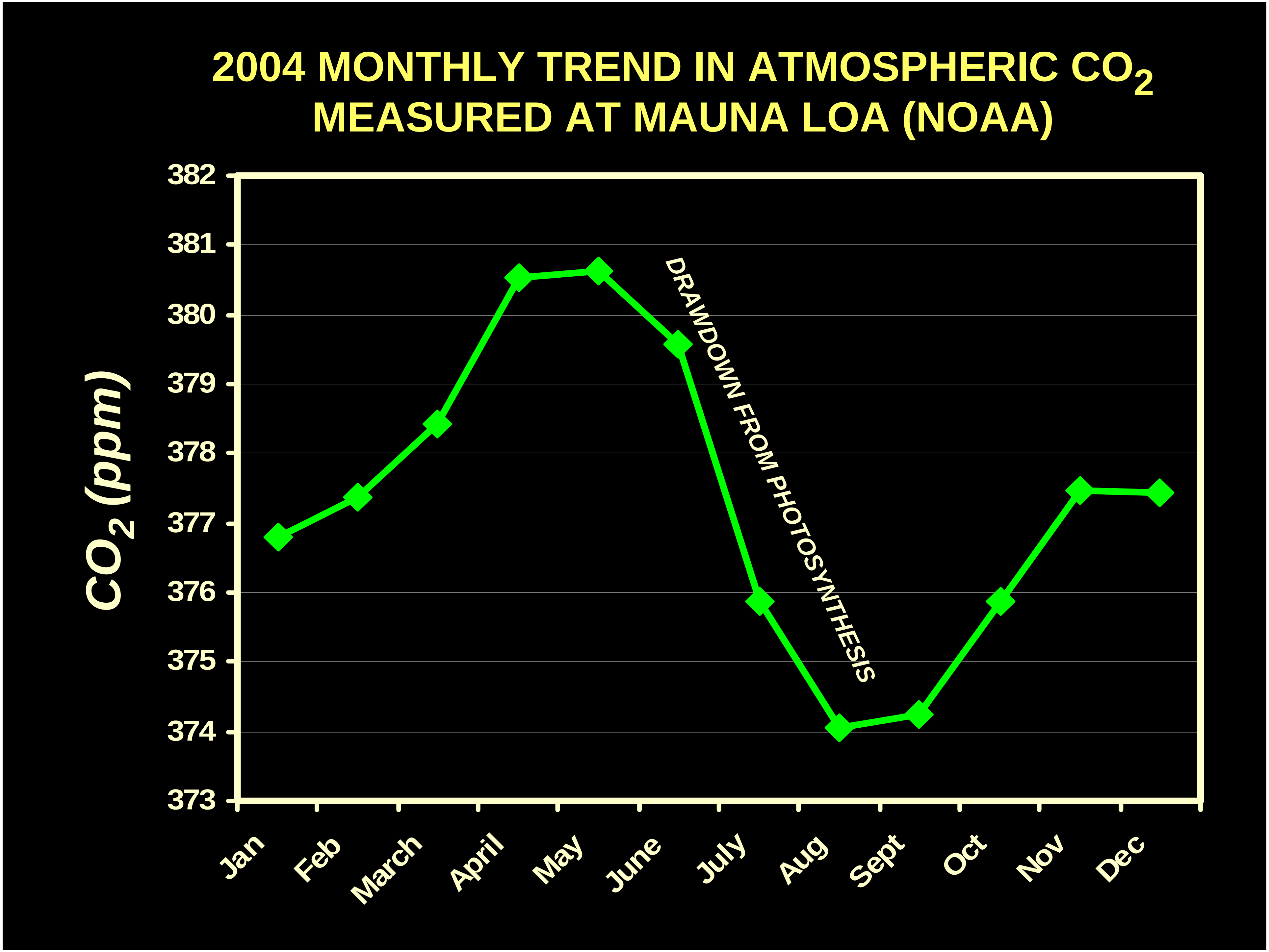
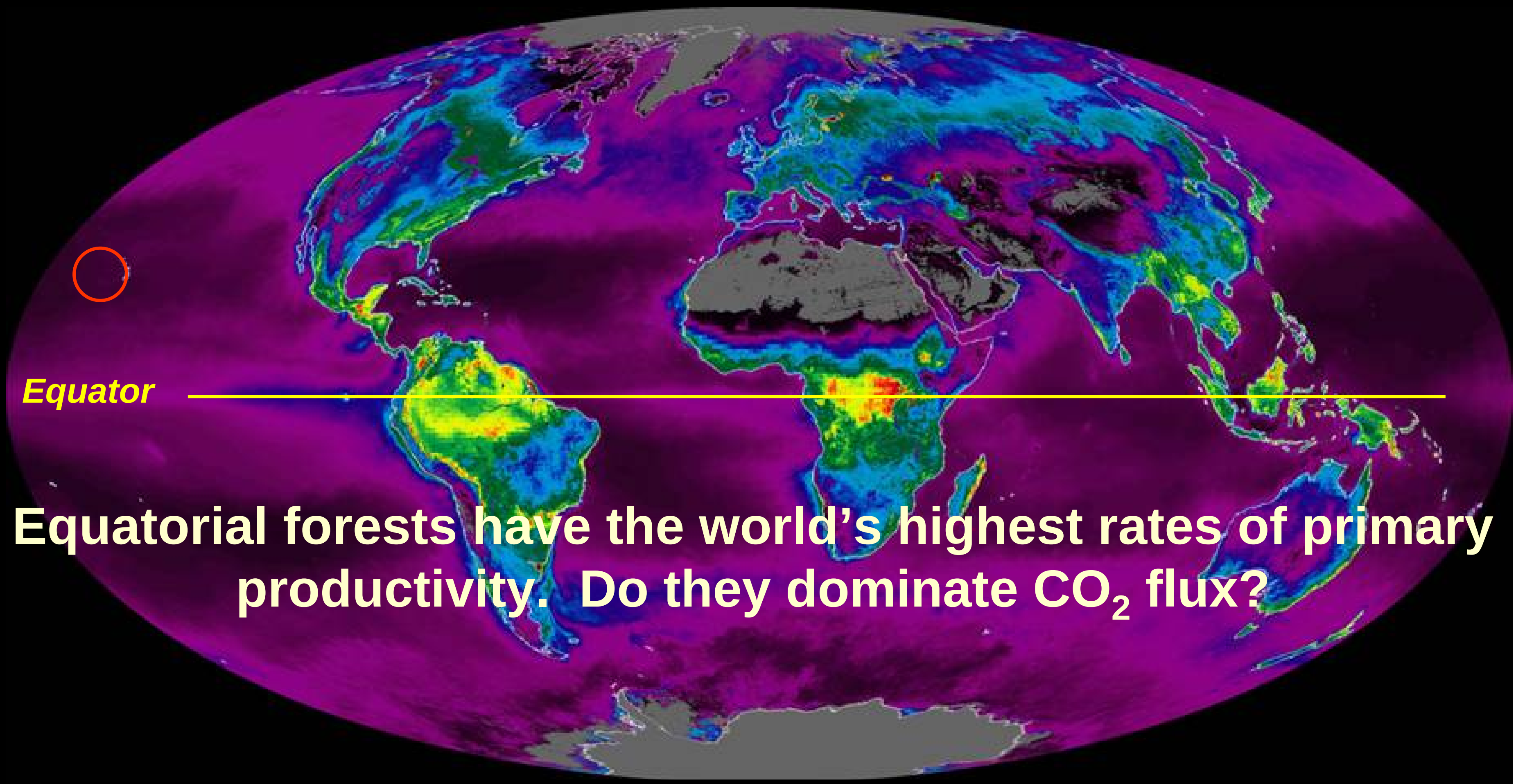
2004 MONTHLY TREND IN ATMOSPHERIC CO_2 MEASURED AT MAUNA LOA (NOAA)





2004 MONTHLY TREND IN ATMOSPHERIC CO_2 MEASURED AT MAUNA LOA (NOAA)
CO_2 (ppm)
382
381
380
379
378
377
376
375
374
373
DRAWDOWN FROM PHOTOSYNTHESIS
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec

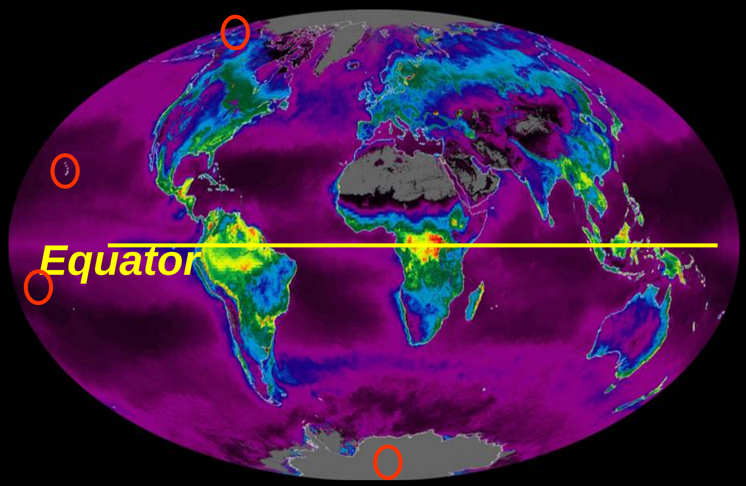
NASA 2002

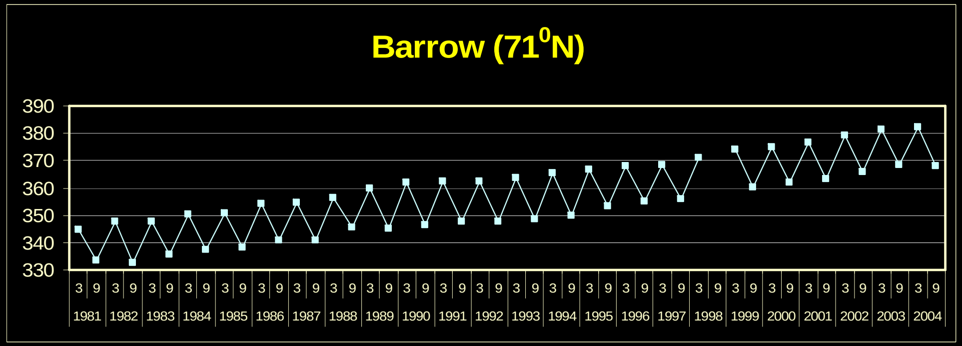


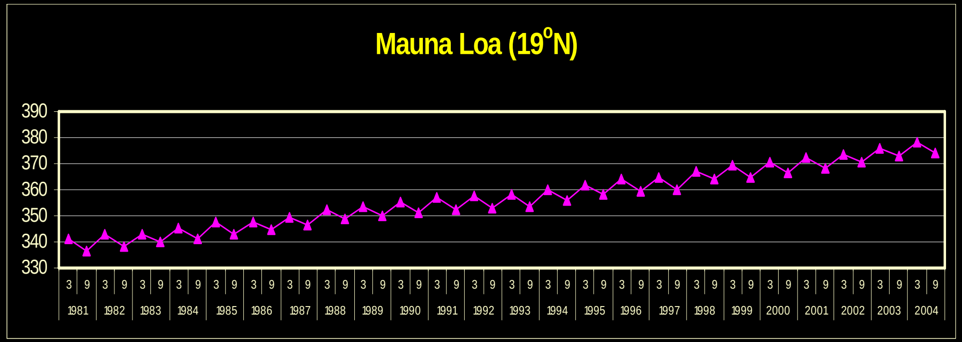
Equatorial forests have the world's highest rates of primary productivity. Do they dominate CO_2 flux?

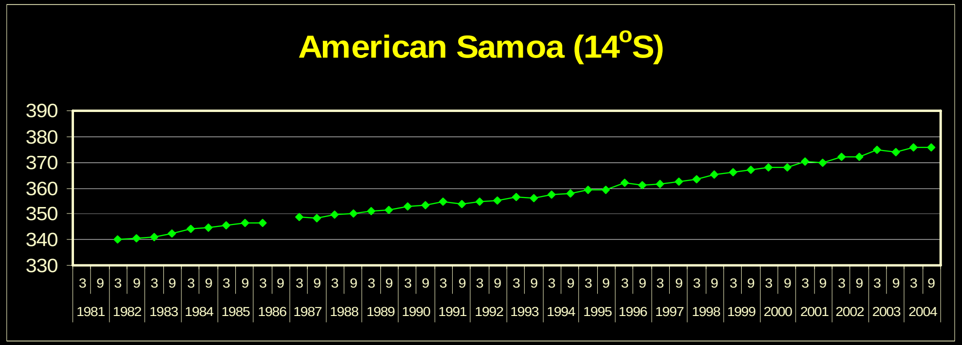
CO_2 has been measured at other locations since 1973

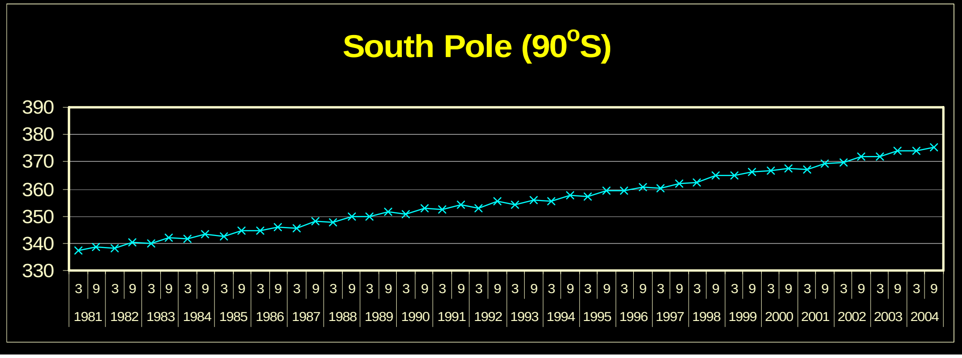
EXPANDED ATMOSPHERIC MONITORING SINCE 1981





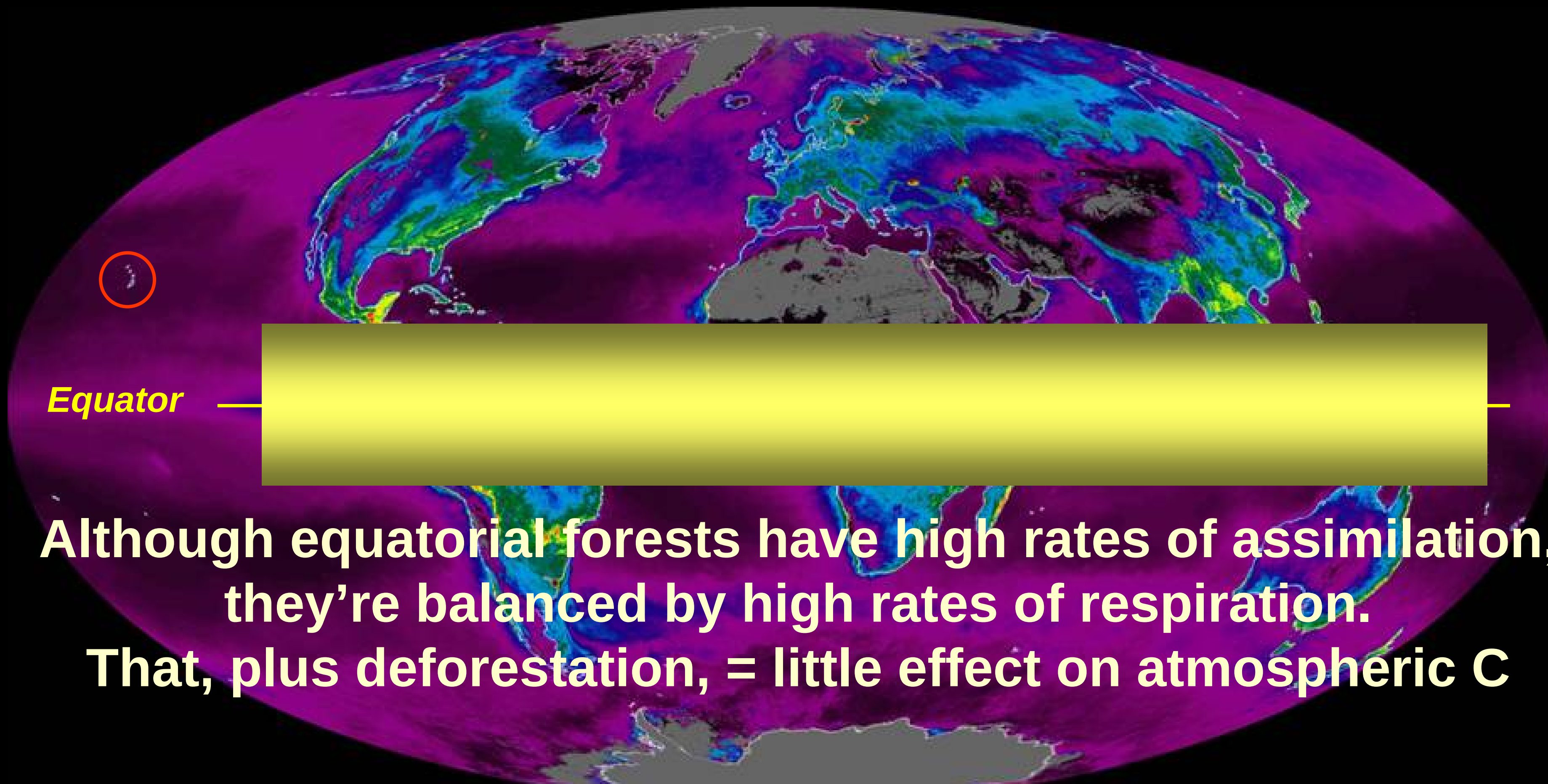






Keeling and Whorf 2005

NASA 2002



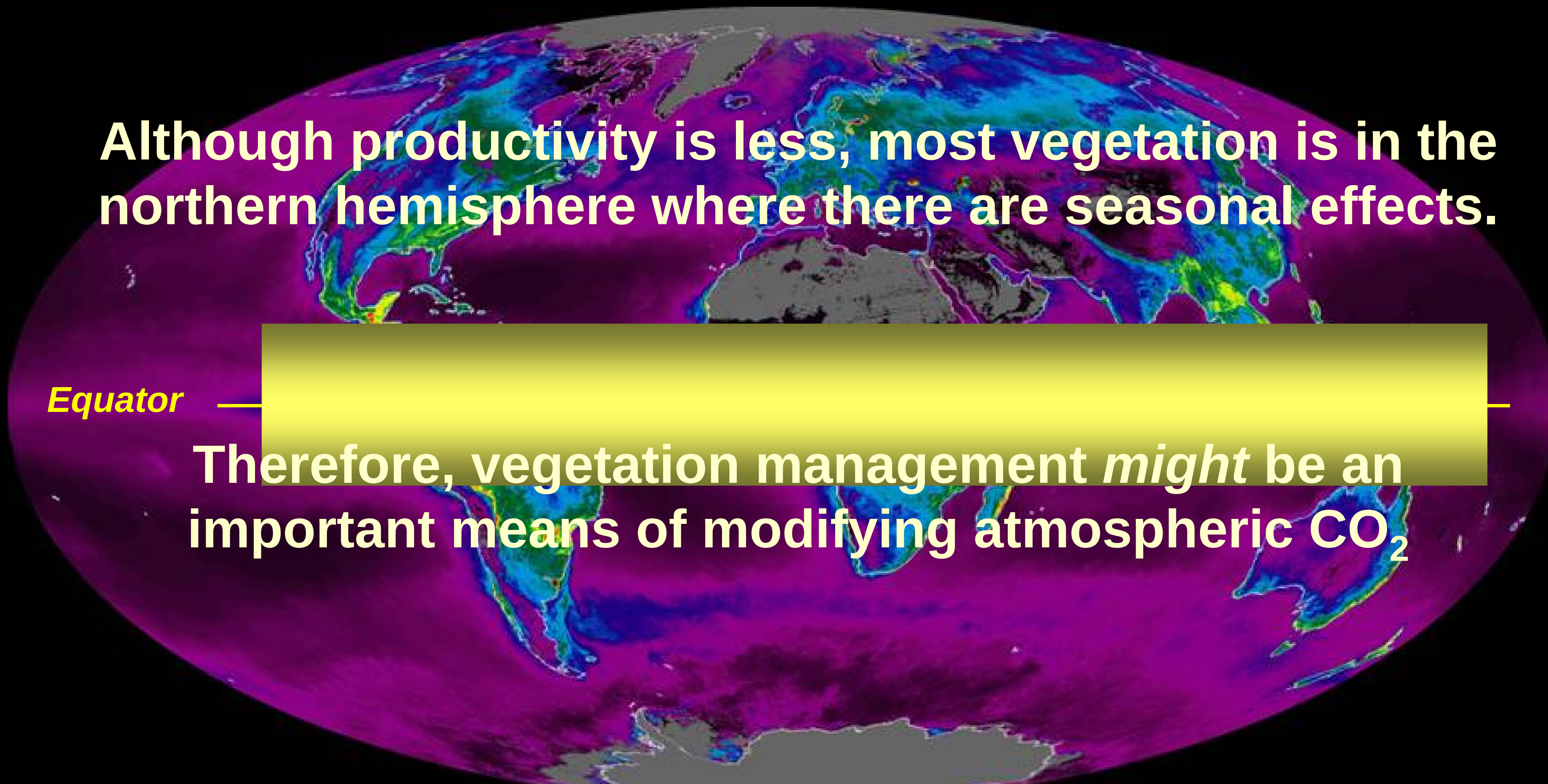
Although equatorial forests have high rates of assimilation, they're balanced by high rates of respiration.

That, plus deforestation, = little effect on atmospheric C

Net Primary Productivity (kg C/m^2/year)

NASA 2002

Although productivity is less, most vegetation is in the northern hemisphere where there are seasonal effects.



Therefore, vegetation management *might* be an important means of modifying atmospheric CO_2

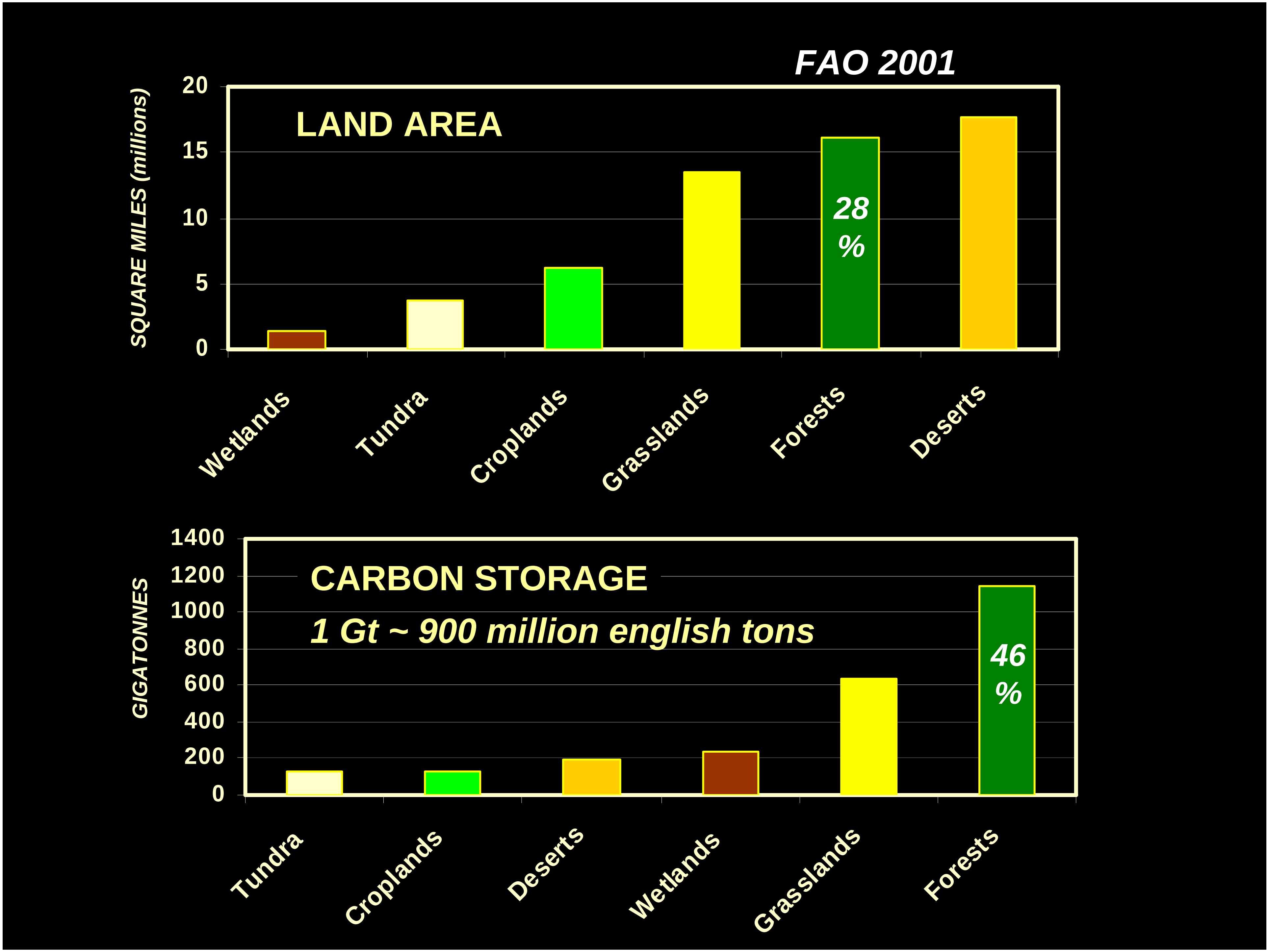
Net Primary Productivity (kg C/m^2/year)

0 1 2 3

GLOBAL STORES OF CARBON (Eswaran et al. 1993)

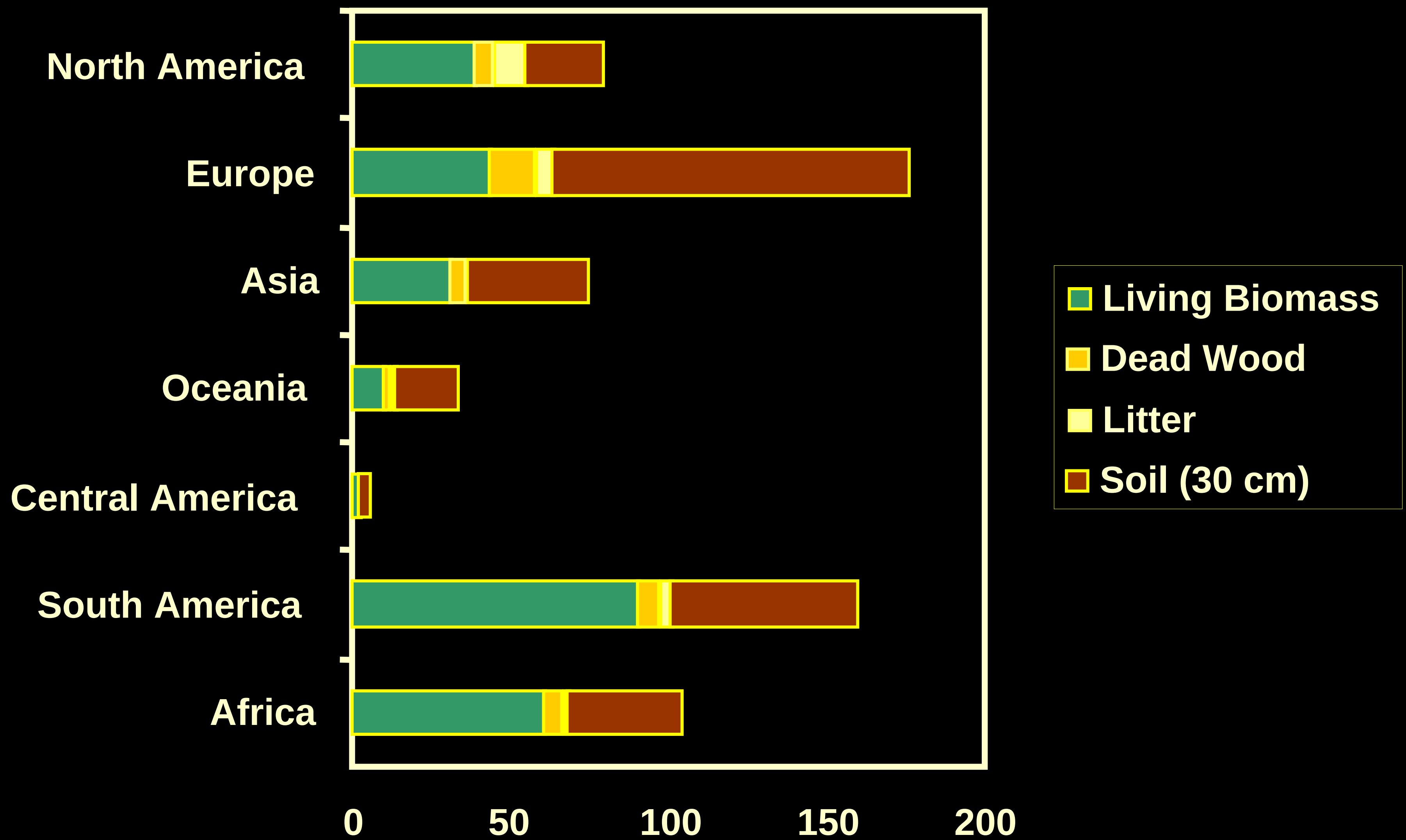
	Gt
Atmosphere	750
Geologic	4,000
Oceans	38,000

1 Gigatonne (Gt) = 1 billion tonnes = 900 million english tons



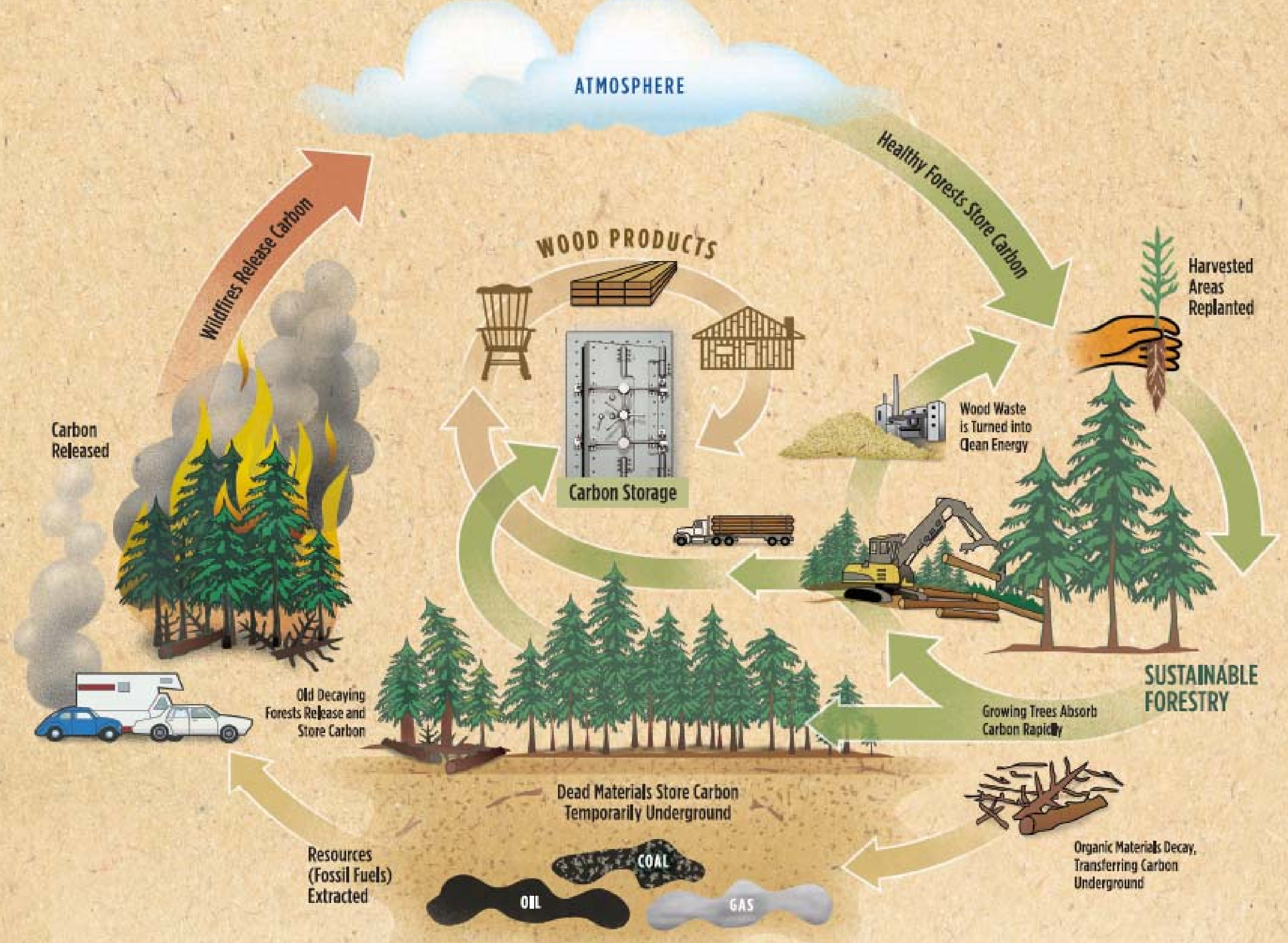
FAO 2001
LAND AREA
SQUARE MILES (millions)
20
15
10
5
0
28 %
Wetlands
Tundra
Croplands
Grasslands
Forests
Deserts
CARBON STORAGE
1 Gt ~ 900 million english tons
GIGATONNES
1400
1200
1000
800
600
400
200
0
46 %
Tundra
Croplands
Deserts
Wetlands
Grasslands
Forests

SO ABOUT HALF OF THE WORLD’S TERRESTRIAL CARBON IS IN FORESTS. ABOUT EQUALLY DIVIDED ABOVE- AND BELOW GROUND



The Carbon Cycle

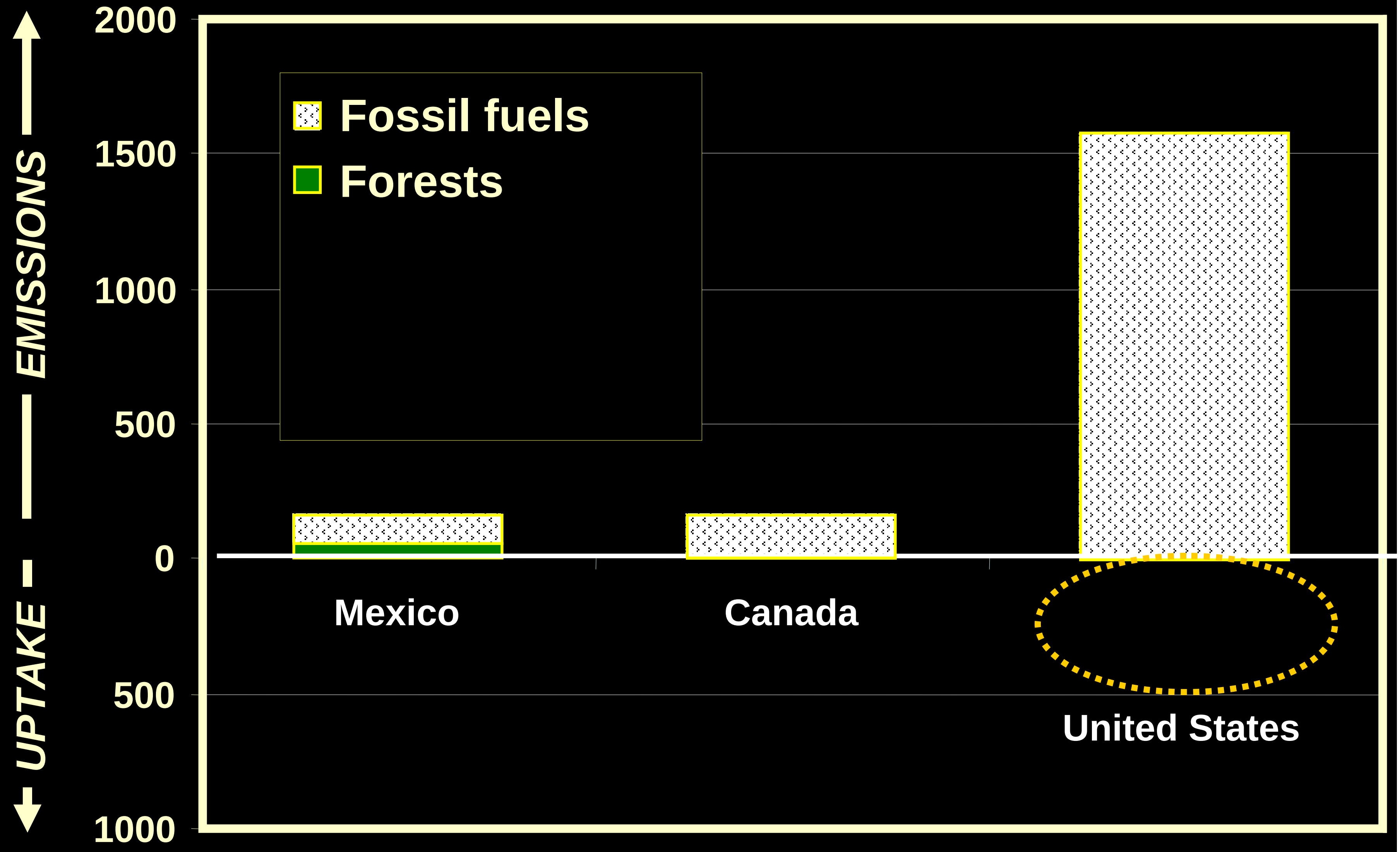
FORESTRY NEVER LOOKED SO COOL



www.calforestfoundation.org

NET ANNUAL CARBON EMISSIONS OR UPTAKE FROM NORTH AMERICA IN 2003 (Pacala 2007)

Millions of tonnes C



WE NEED BETTER WAYS OF REDUCING EMISSIONS OR SEQUESTERING MORE C

Offsets generated in the U.S. can't be sold to Europe because U.S. has not ratified Kyoto limiting national emissions

But be aware…


CHALLENGES FOR FORESTRY IF YOU WANT TO CLAIM OFFSETS
• Finding an incentive. Greg Morris, Jeff Kline
• Establishing a baseline for status quo emissions. John Nickerson
• Demonstrate that the project actually caused an improvement.
• Validate your claims. Steve Mader

CALIFORNIA CLIMATE ACTION REGISTRY

John Nickerson
Mark Nechodom

CALIFORNIA STATS (Christensen et al. 2007)

Total forest area: 13.2 million hectares

Total forest carbon: 1.24 Gigatonne

Four ownership pools:

Federal:	***60%***
State and local:	***5%***
Nonindustrial:	***20%***
Industrial:	***15%***

Productive timberland = 7.8 million hectares

Timberland carbon: 0.87 Gt (786 million tons)

CARBON STORED IN OLD GROWTH IS, AT BEST, STATIC

CARBON CONVERTED TO FOREST PRODUCTS HAS A LONG SHELF LIFE

And the Residual Forest Continues to Grow

CONVERTING BIOMASS TO FOREST PRODUCTS IS A DELAYING ACTION.

SOONER OR LATER IT ALL REVERTS TO CO_2.

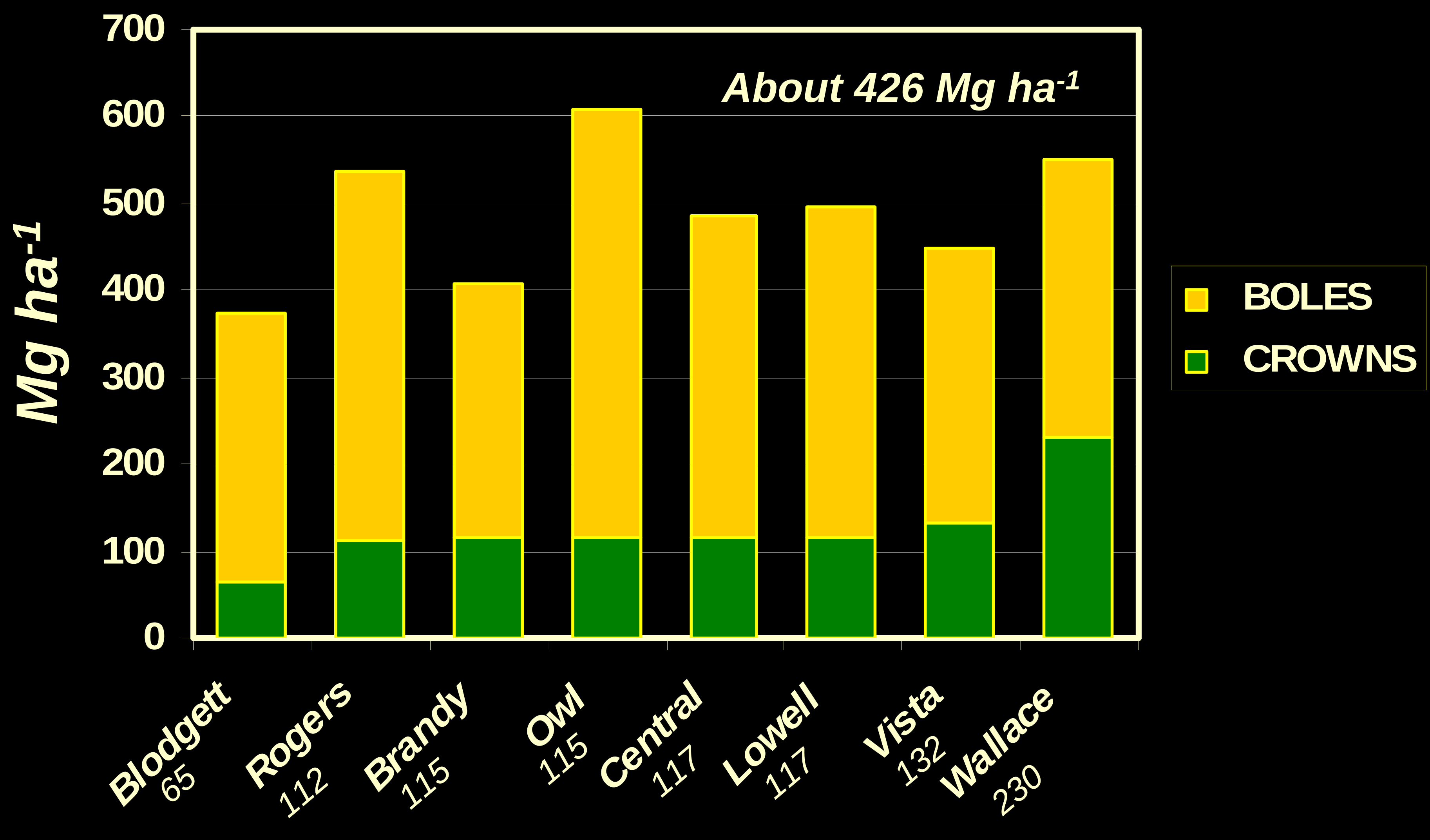
On the other hand, forest biomass offers a renewable, alternative energy source to offset emissions from nonrenewable energy sources.

ALTERNATIVE ENERGY SOURCES FROM FOREST RESIDUES

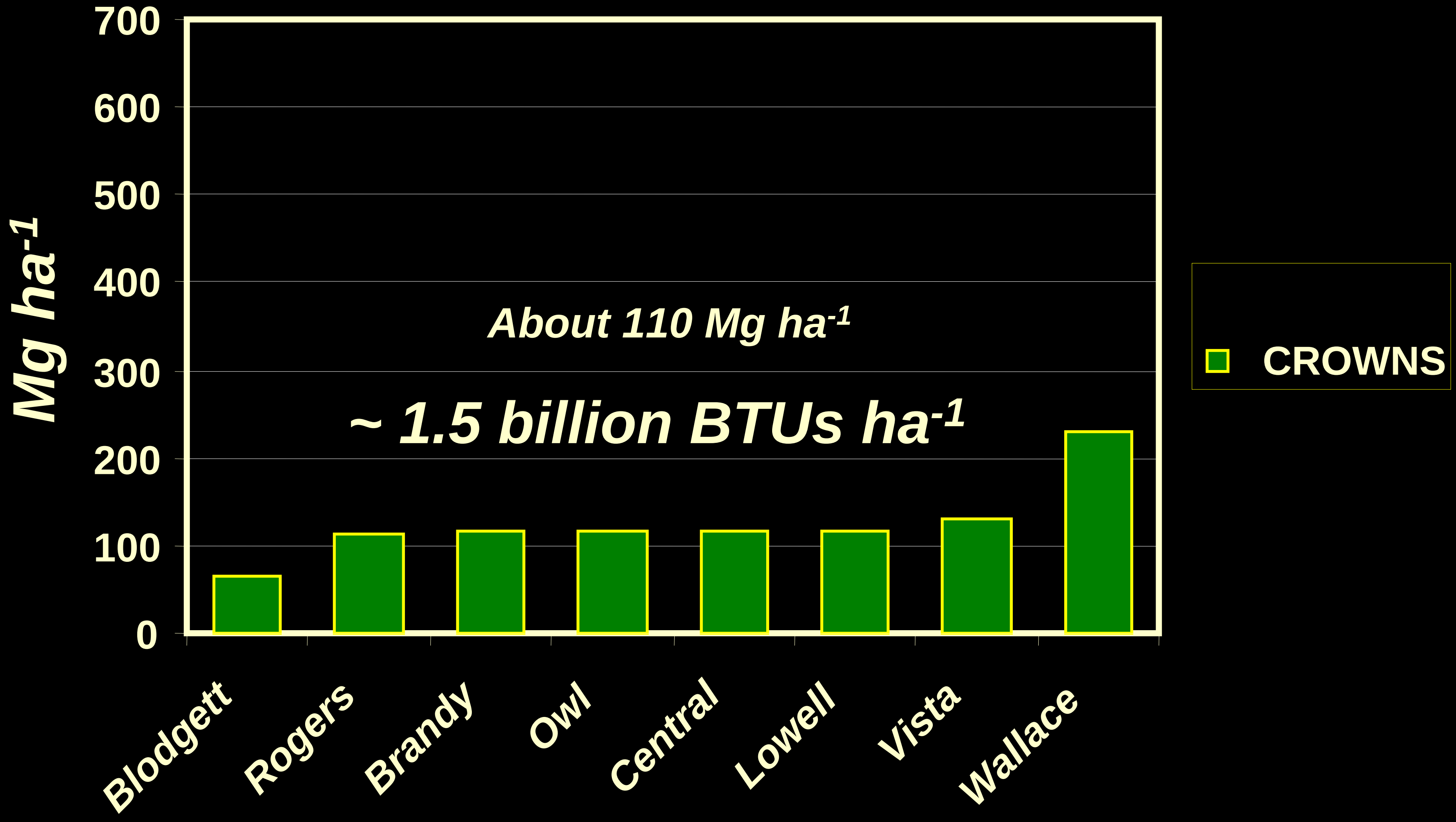
Logging slash to chips



STANDING BIOMASS IN MATURE MIXED CONIFER FORESTS IN CALIFORNIA



SLASH BIOMASS IN MATURE MIXED CONIFER FORESTS IN CALIFORNIA



ALTERNATIVE ENERGY SOURCES USING FOREST RESIDUES

Brush to Chips?

Ladder fuels removed.

Stand more resilient to wildfire.

Untapped resource?

BRUSHY UNDERSTORIES

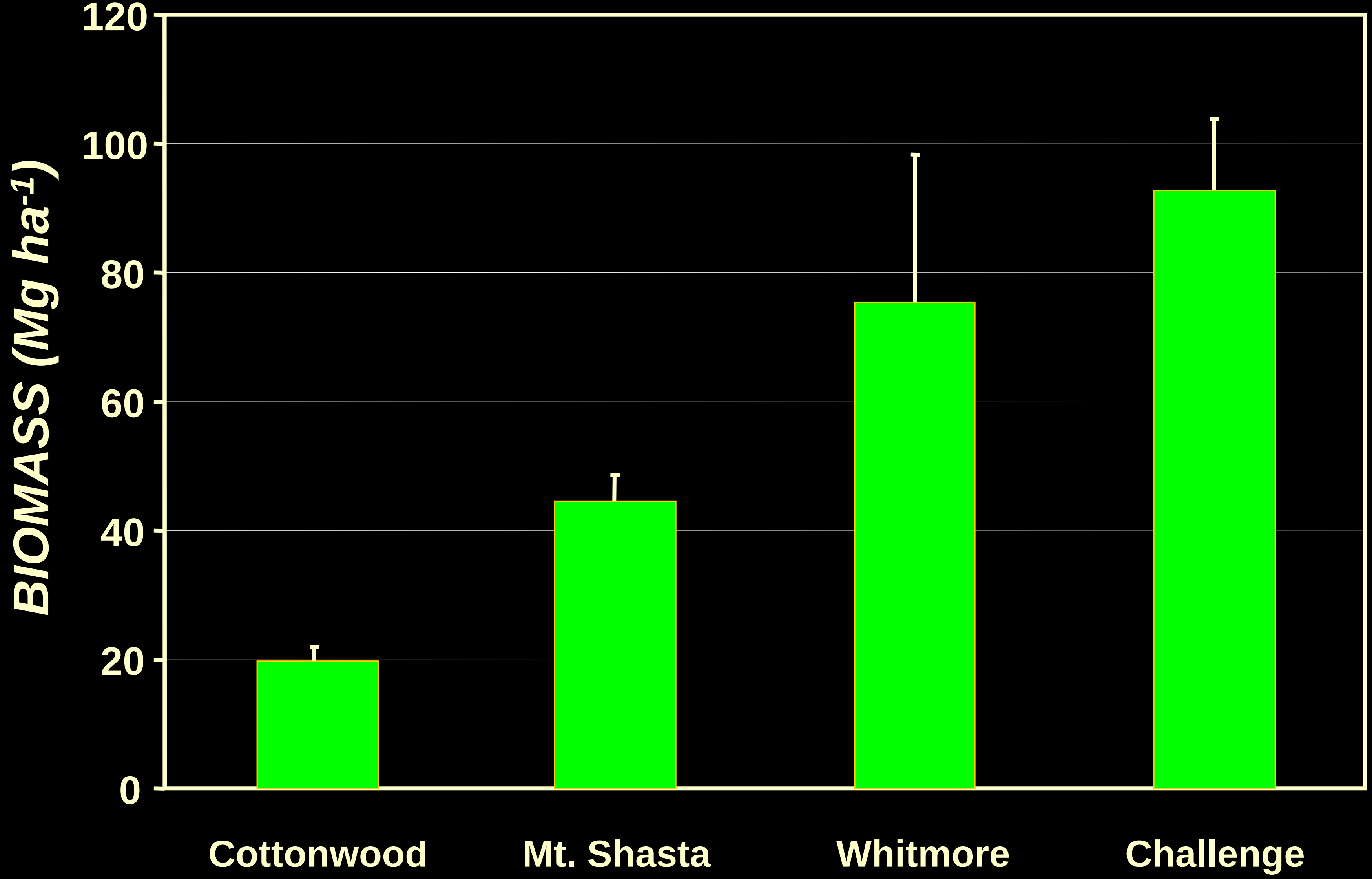
Cottonwood

Mt. Shasta

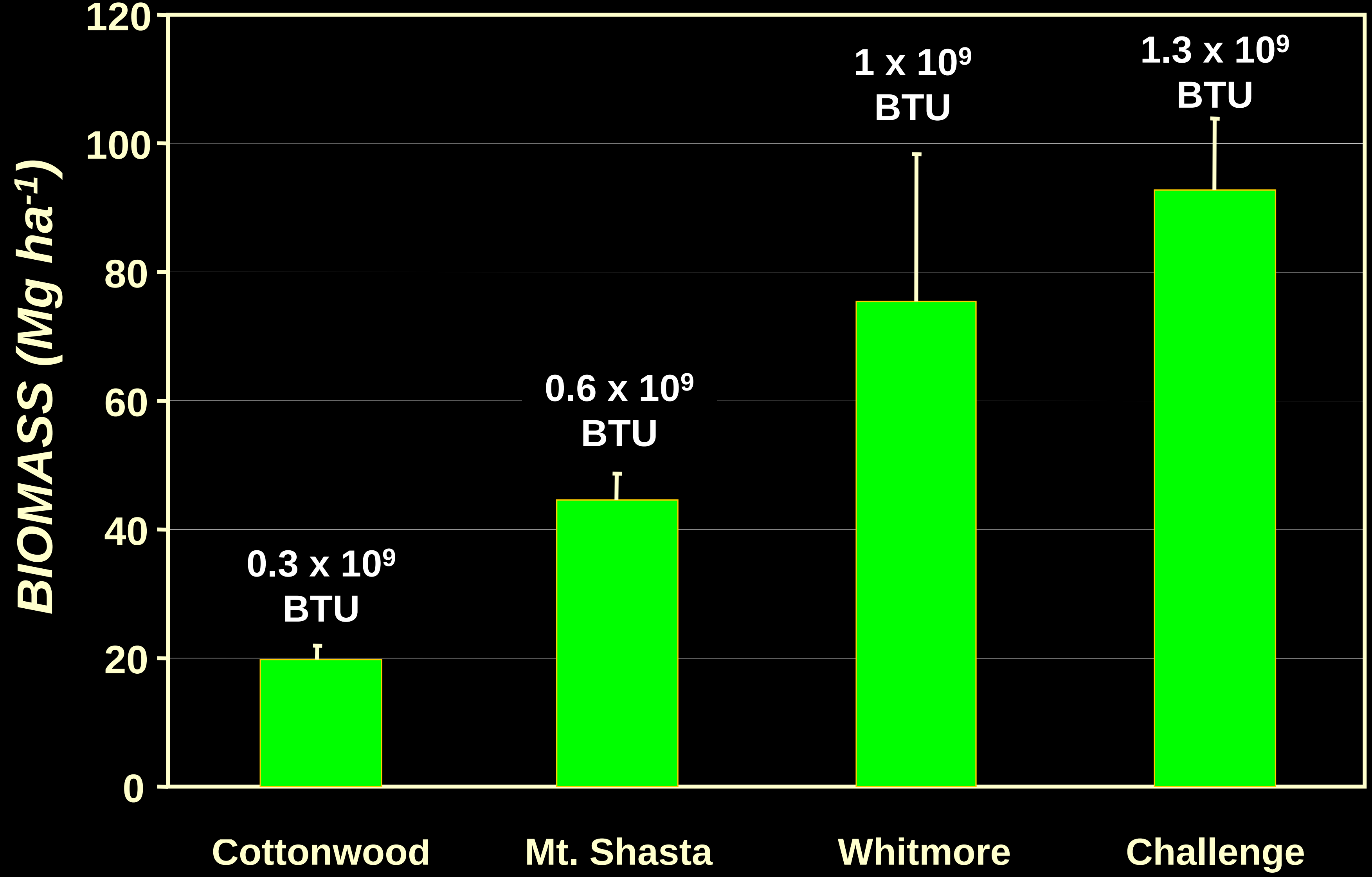
Whitmore

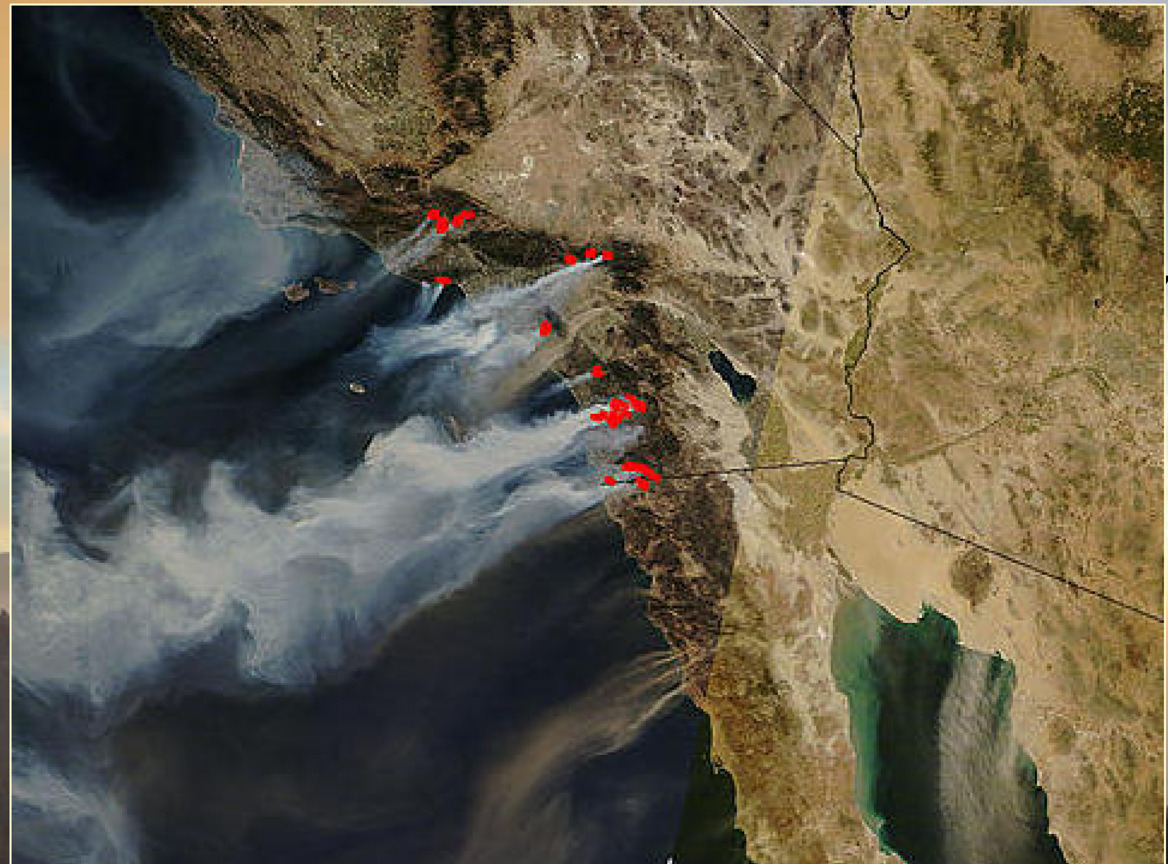
Challenge

PRETREATMENT BIOMASS OF ALL POTENTIAL FUELS



APPROXIMATE ENERGY VALUE OF ALL POTENTIAL FUELS

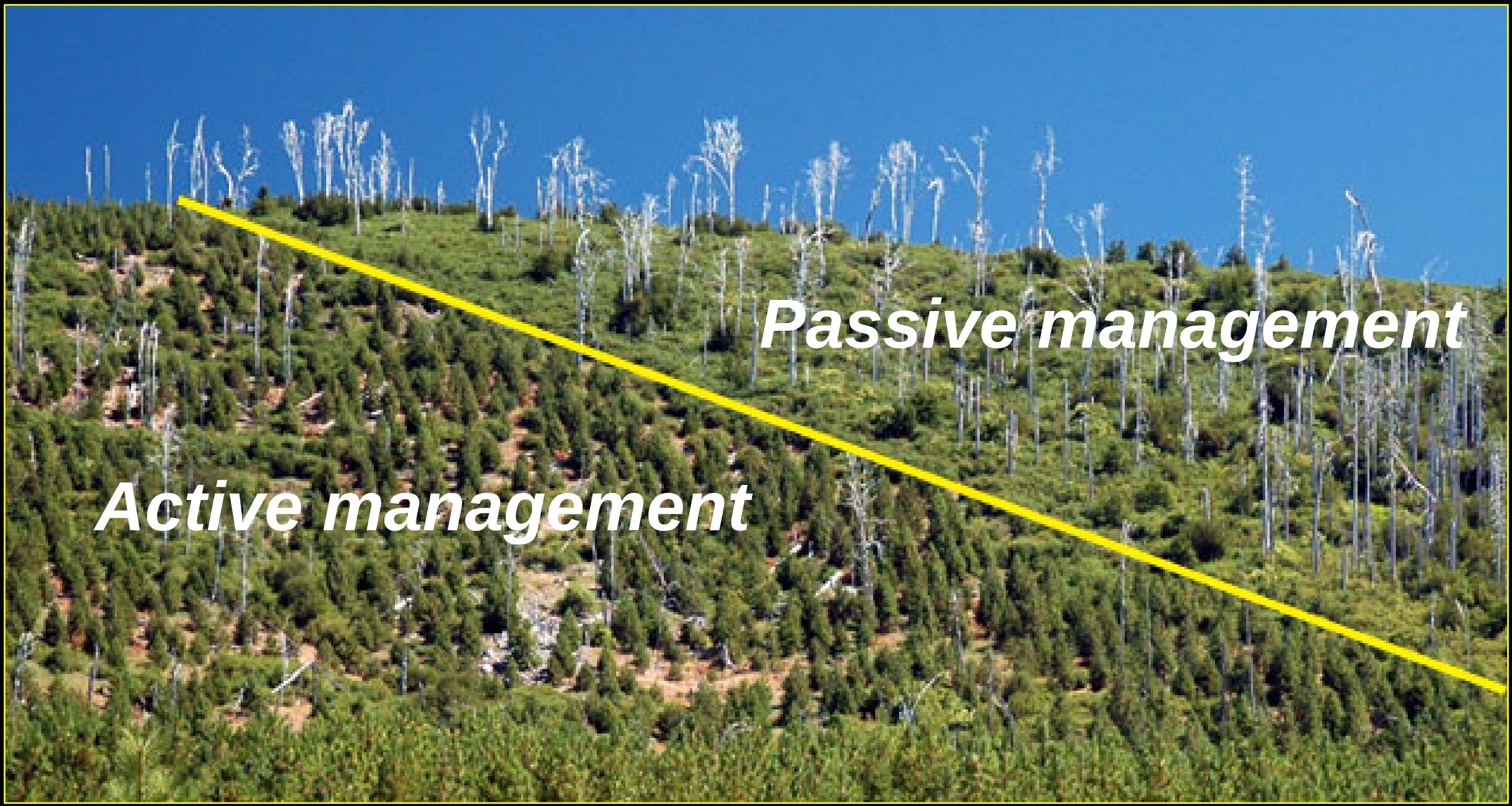




Fires Account for One-Fifth of Global CO_2 and Other GHG Emissions

(Levine & Cofer 2000, Schimel 1995)

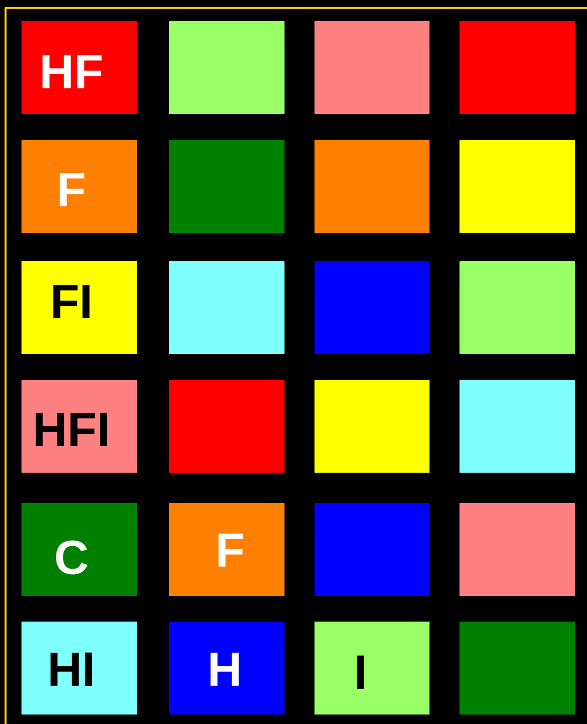
FOUNTAIN FIRE



Which Strategy Best Conserves Carbon in the Long Run?

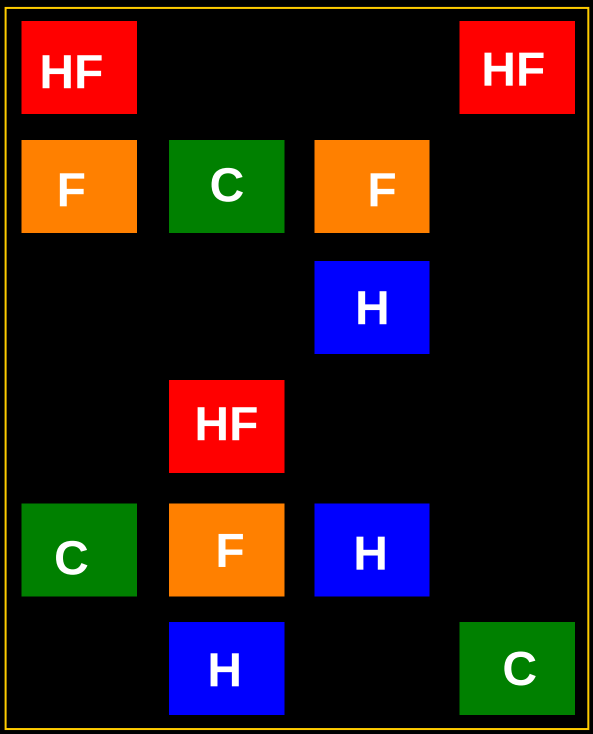
Whitmore
W.M Beaty

Let's Start with the Short Run



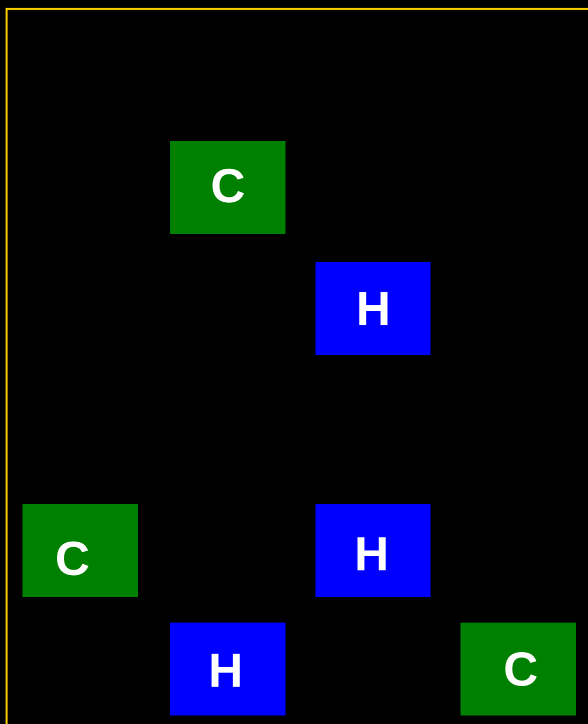
Whitmore
W.M Beaty

Destructive sampling at 21 years



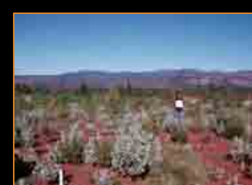
Whitmore
W.M Beaty

What does vegetation control buy you?



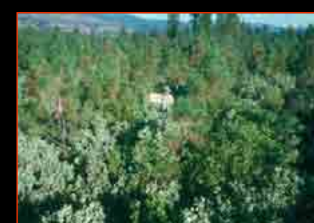
1986

Treated, 5 yrs



Control, 5 yrs

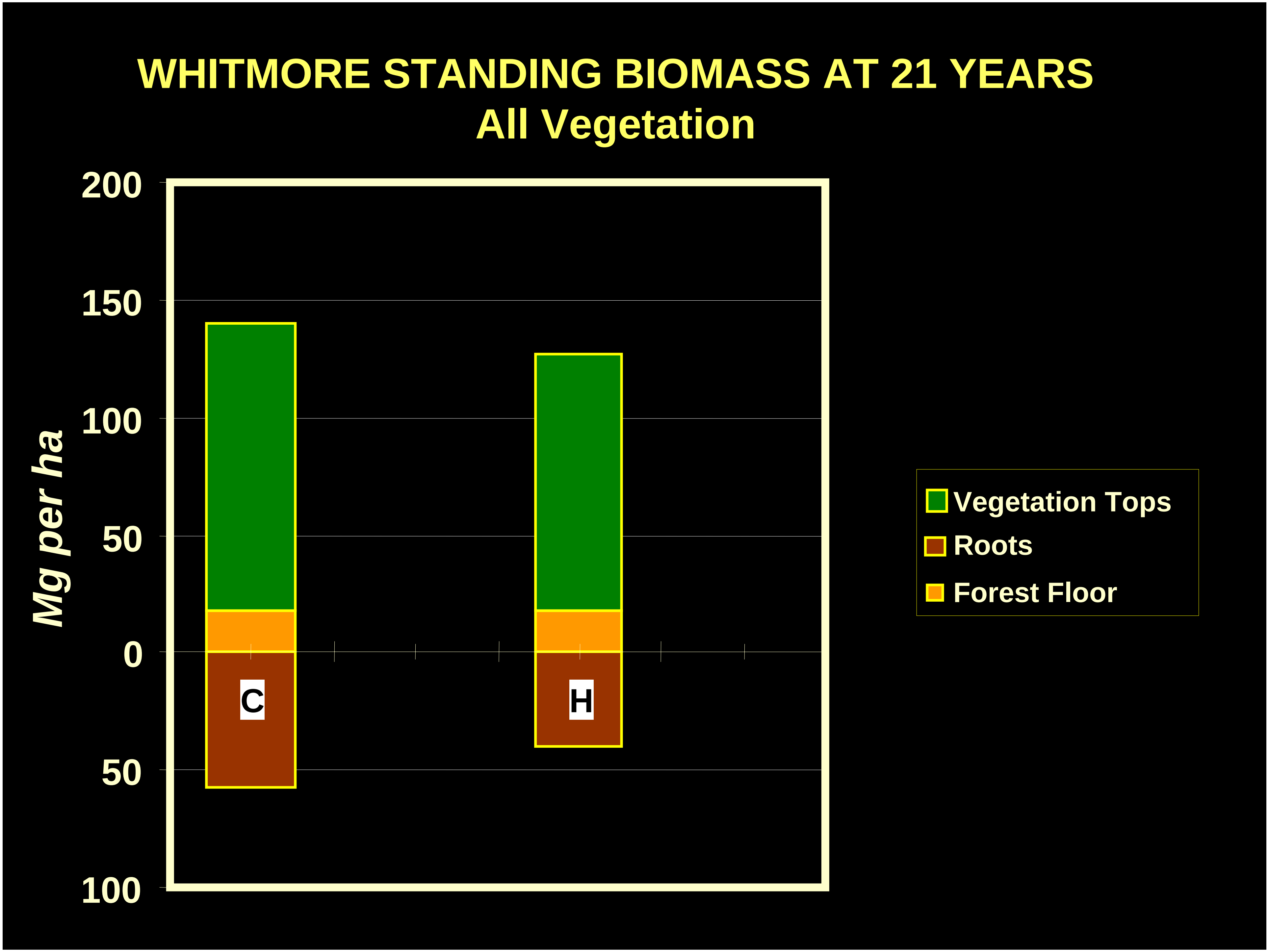
Treated, 10 yrs



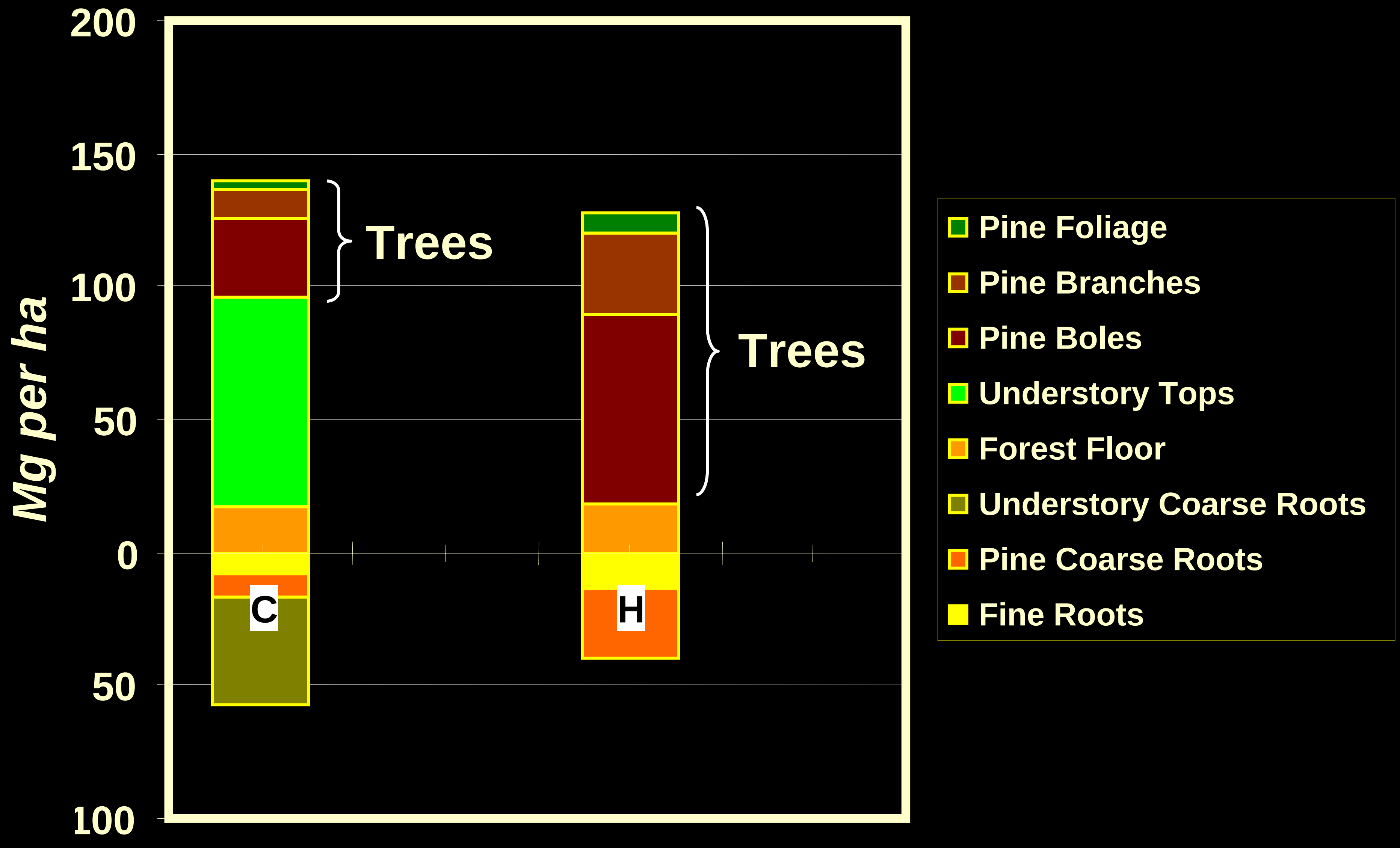
Control, 10 yrs

Treated, 15 yrs

Control, 15 yrs

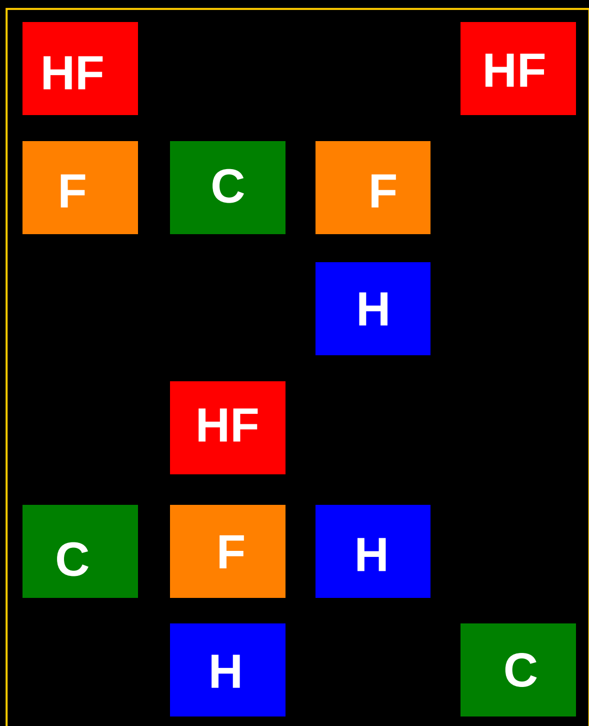

WHITMORE STANDING BIOMASS AT 21 YEARS
All Vegetation
Mg per ha
200
150
100
50
0
50
100
C
H
Vegetation Tops
Roots
Forest Floor

WHITMORE STANDING BIOMASS AT 21 YEARS
All Vegetation



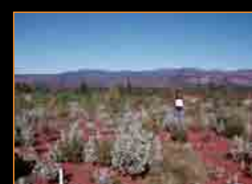
Whitmore
W.M Beaty

What does *further* intensive management buy you?



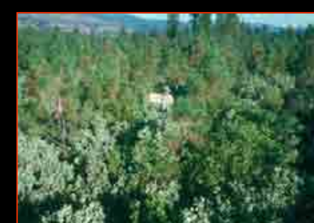
1986

Treated, 5 yrs



Control, 5 yrs

Treated, 10 yrs

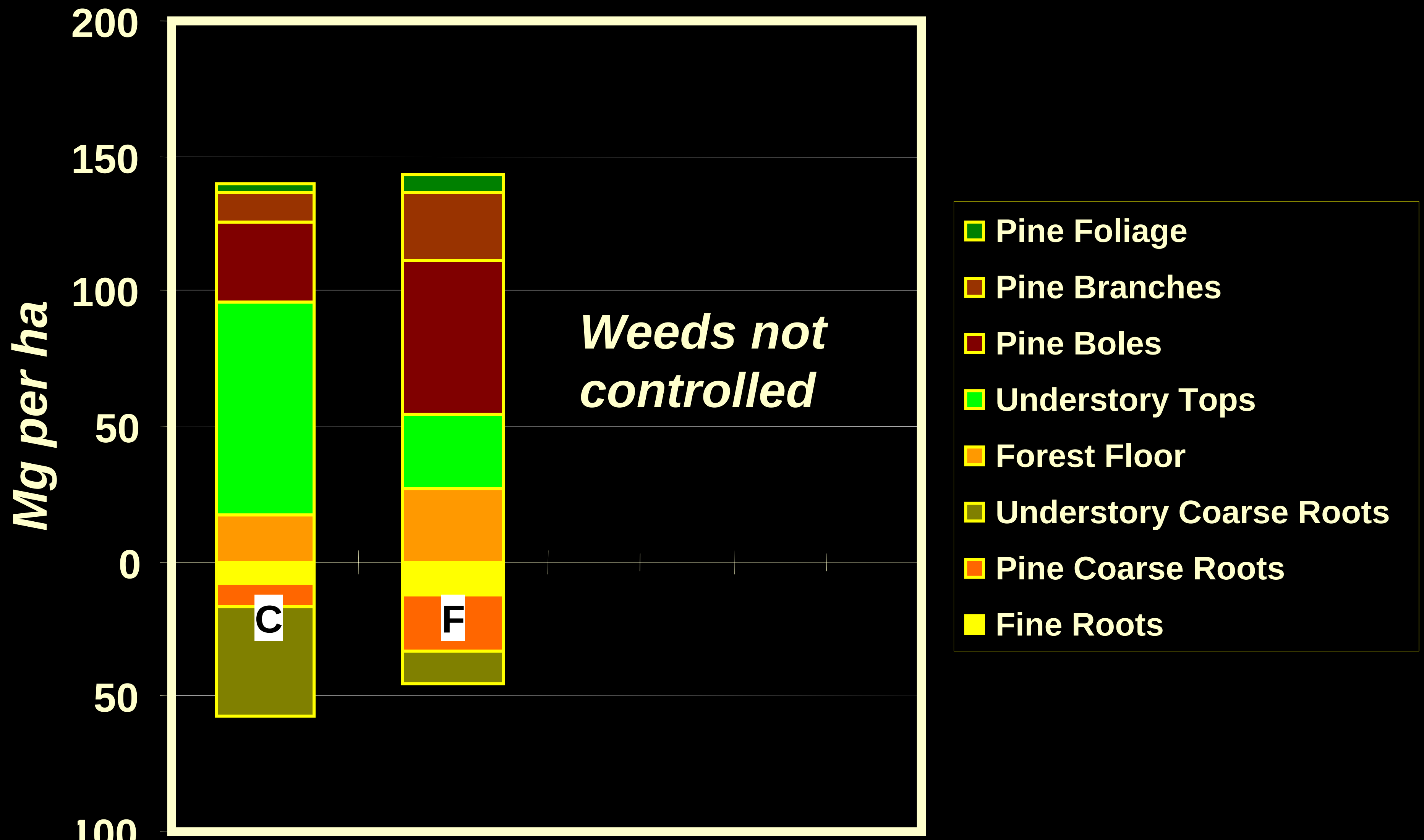


Control, 10 yrs

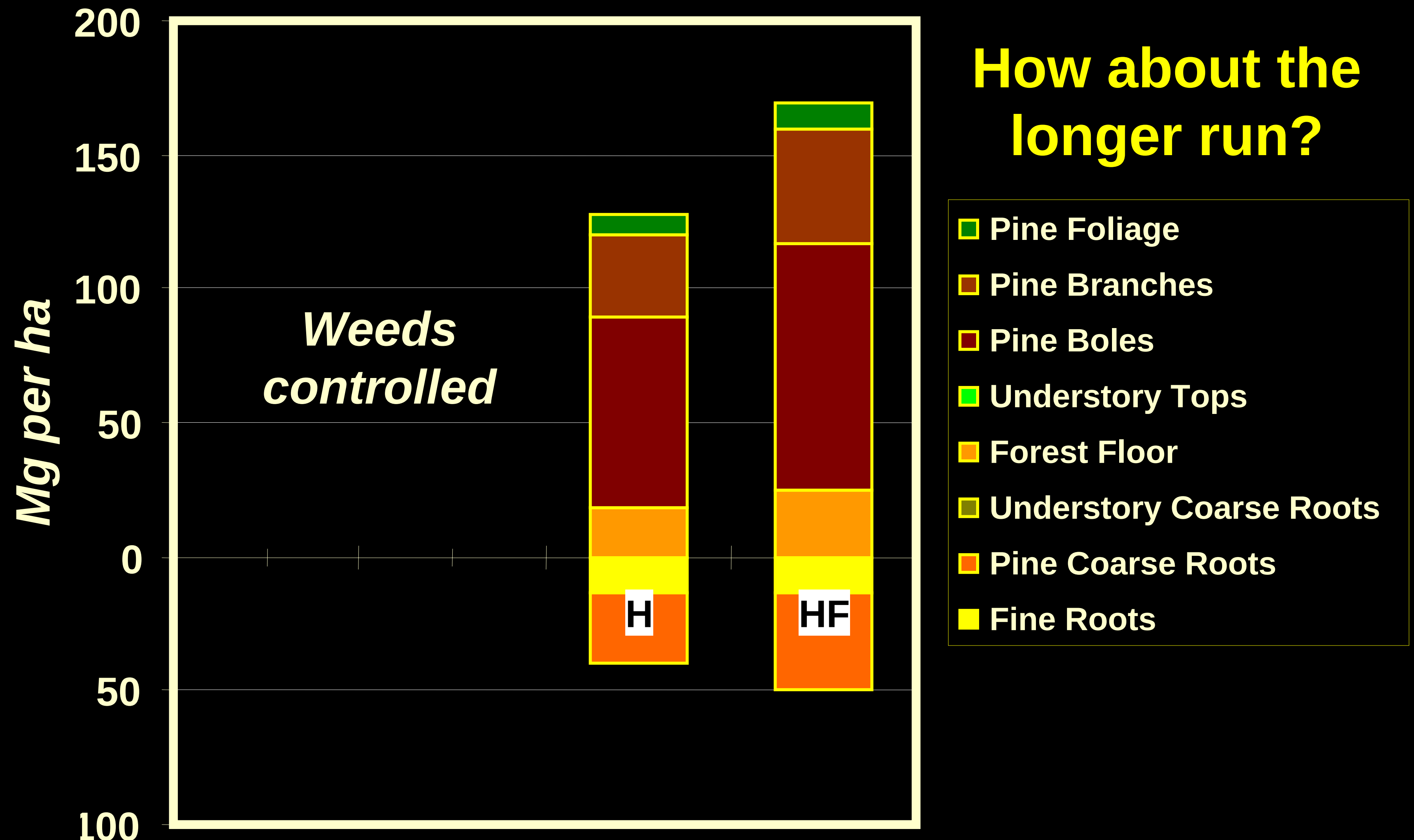
Treated, 15 yrs

Control, 15 yrs

WHITMORE STANDING BIOMASS AT 21 YEARS
Fertilization = More Mass, Larger Trees, More FF

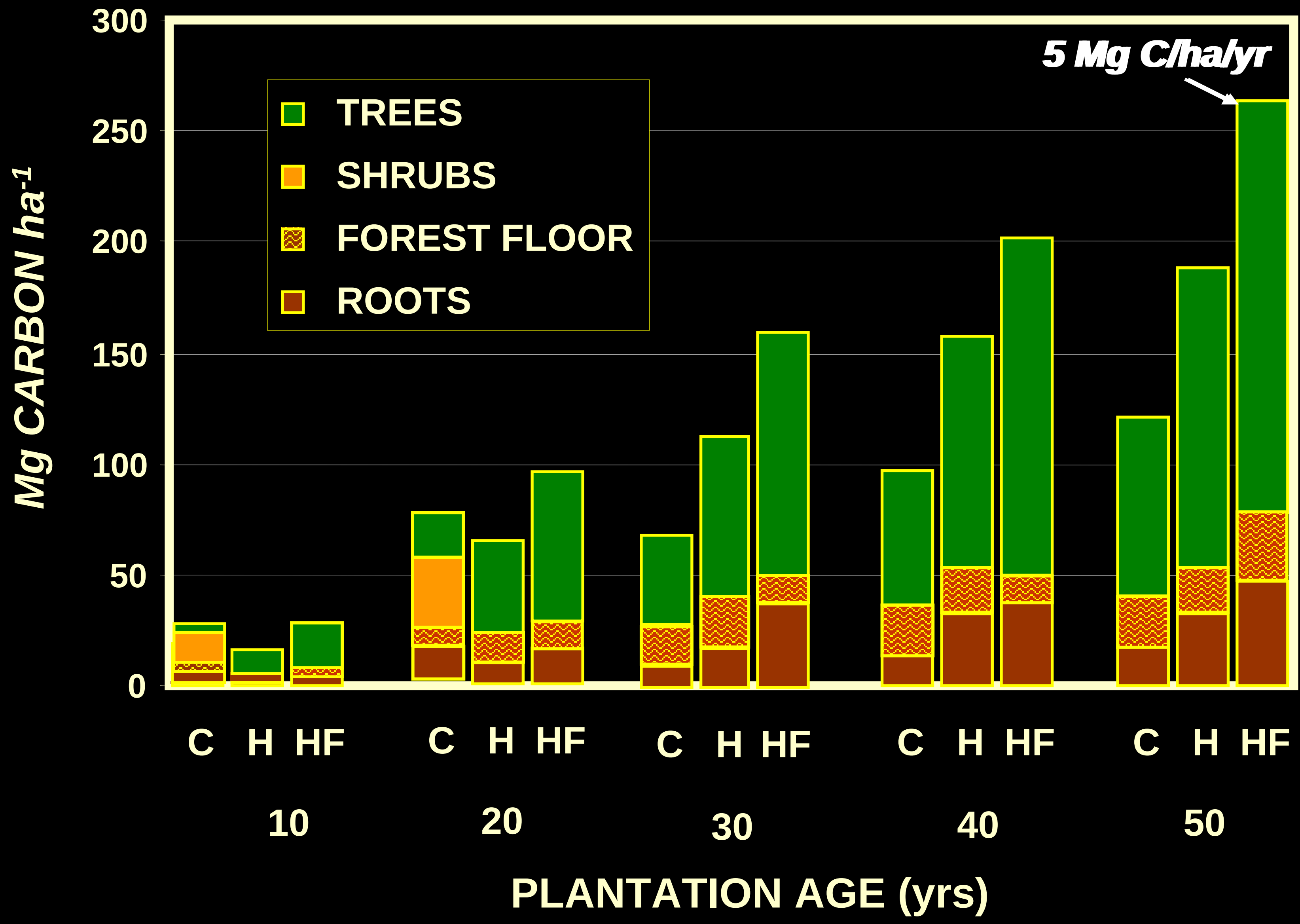


WHITMORE STANDING BIOMASS AT 21 YEARS
Fertilization = More Mass, Larger Trees, More FF

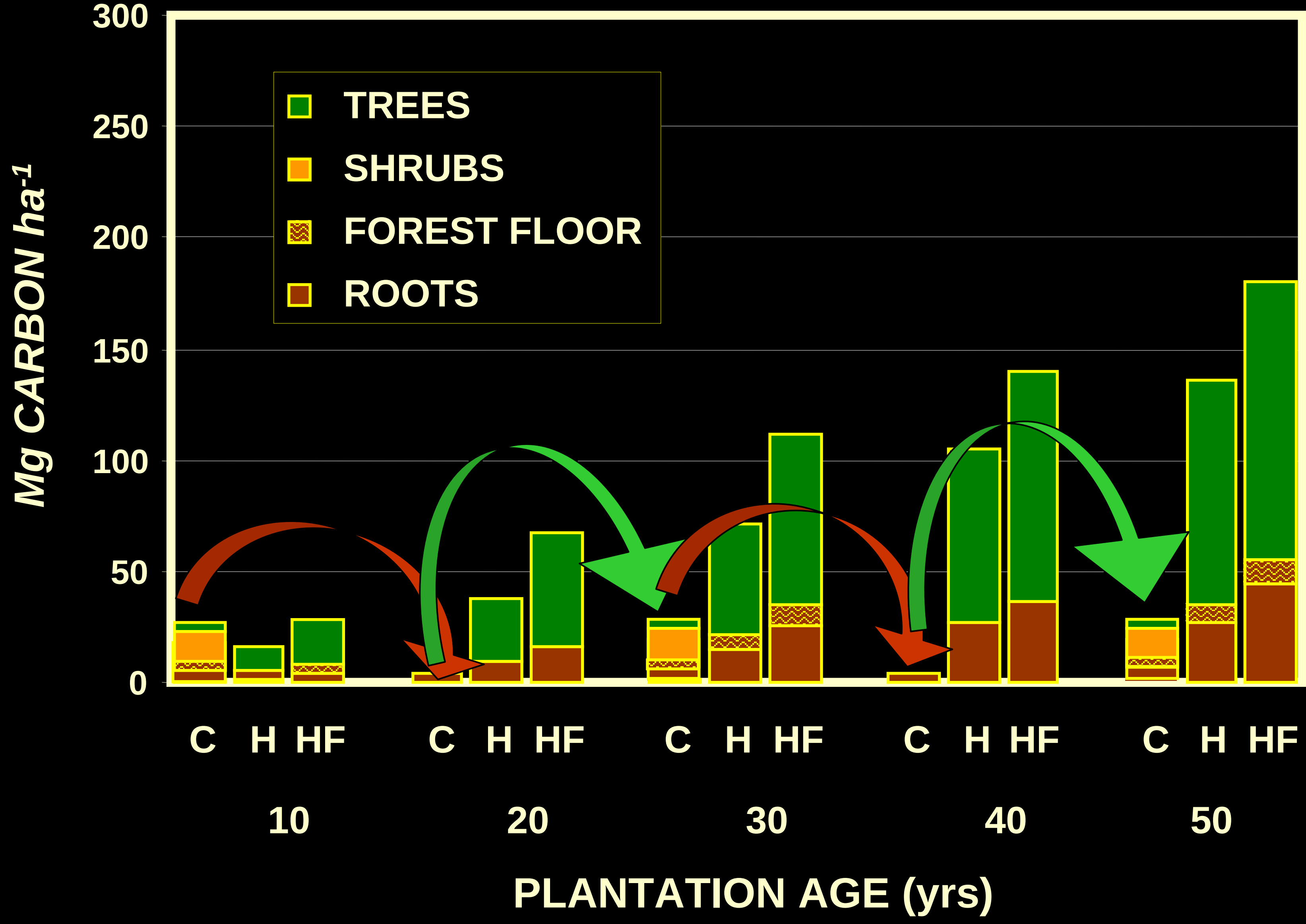


How about the longer run?

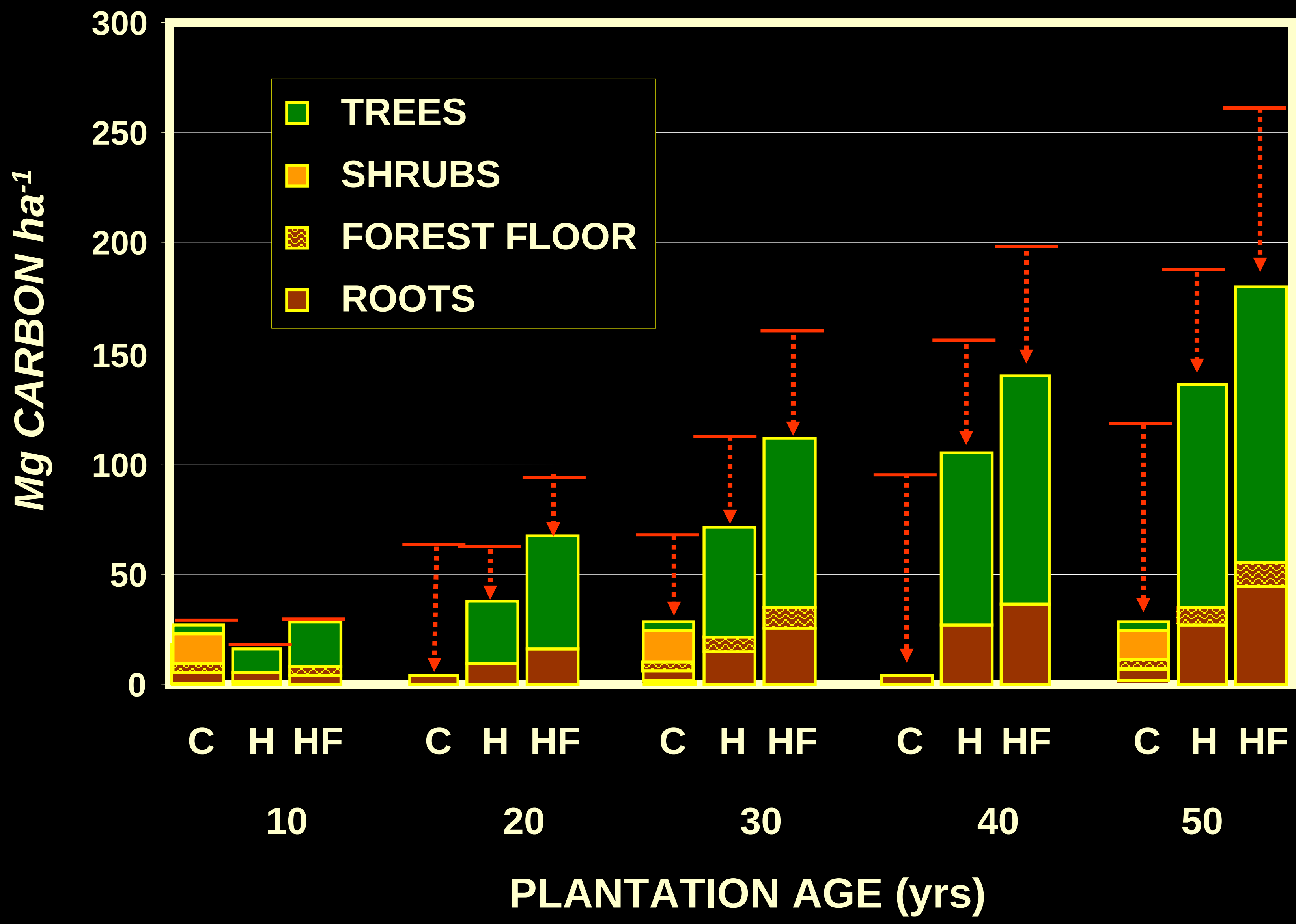
WHITMORE: WILDFIRE EXCLUDED



WHITMORE: WITH WILDFIRE



WHITMORE: WITH WILDFIRE



AND JUST WHEN YOU THINK YOU'VE GOT IT ALL FIGURED OUT…

Hurricane Katrina
Landfall 8/28/2005

NASA


From 92-112 million
tonnes carbon
came down
2005 9 21

DECAYING TIMBER FROM KATRINA AND RITA MAY RELEASE AS MUCH CO_2 AS IS FIXED ANNUALLY BY ALL FORESTS IN THE UNITED STATES

Chambers et al. Science 2007

IMMEDIATE NEEDS

- ***A better way of estimating forest carbon sequestration above and below ground for various silvicultural intensities***
- ***An effective means of forecasting how forests will respond to climatic change and how plantations might be extended to new sites***
- ***A better way to sell the environmental value of active forest management***

VEGETATION MANAGEMENT'S ROLE IN CARBON STORAGE

- **Carbon cycle and forestry** — ***Dale Johnson***
- **Biomass for power** — ***Greg Morris***
- **Accounting protocols** — ***Steve Mader***
- **Management contrasts** — ***Cajun James***
- **Modeling scenarios** — ***Jianwei Zhang***
- **Accounting assumptions** — ***John Nickerson***
- **Fire risk** — ***Carl Skinner***
- **Economics of carbon storage** — ***Jeff Kline***
- ***Salvage issues*** — ***Tom Bonnicksen***

"Connecting the Big Dots: Forest Carbon, Climate Change, and Renewable Energy"

Mark Nechodom