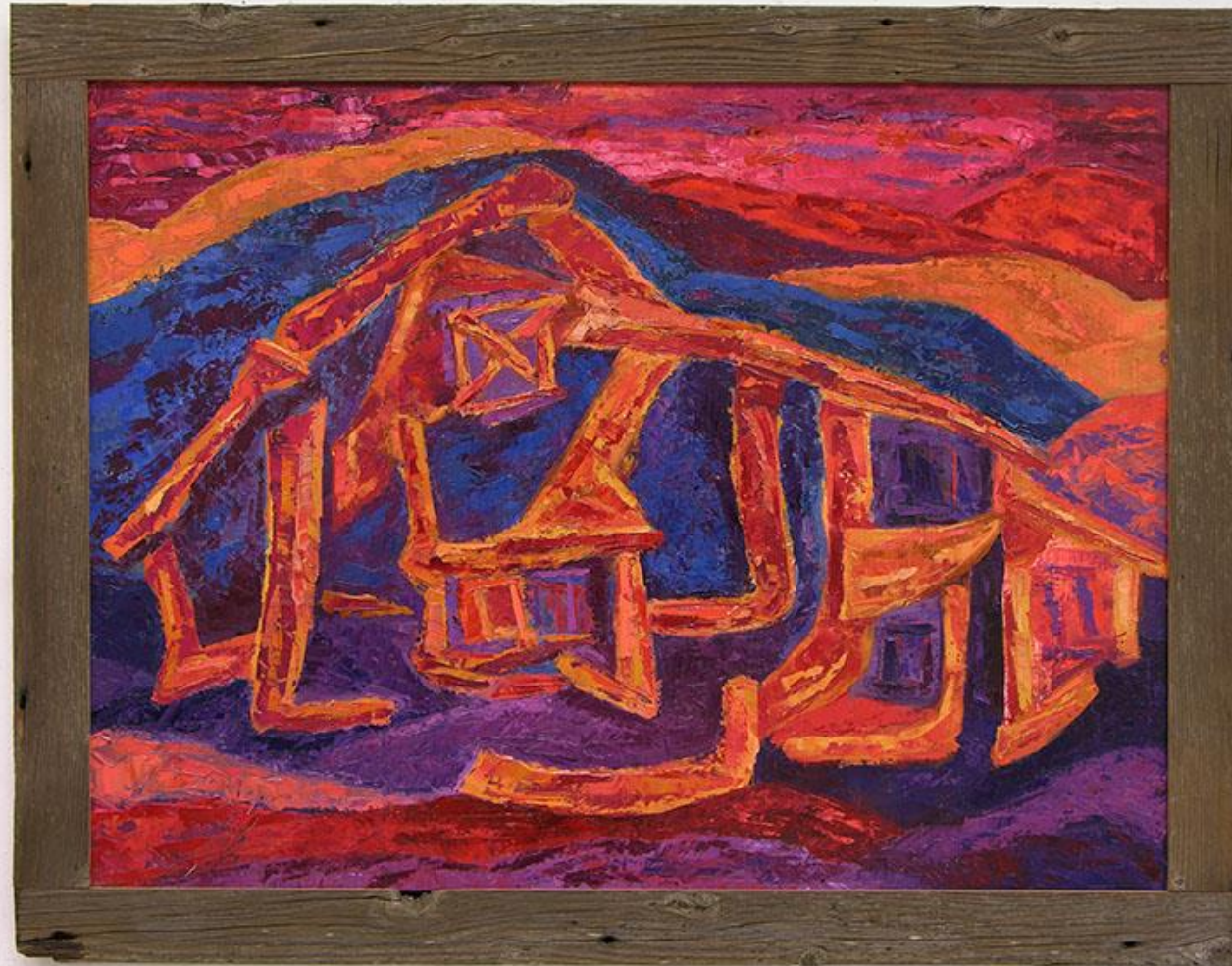


GLOBAL CLIMATE CHANGE AND SOIL CARBON SEQUESTRATION

KEN FROST, NOV. 8, 2023



Fundamentals of Global Climate Change and What Might Be Done



Artist Jeanne Bailly

Opening Day on the Bay, 1943



Steaming Off to the Safety of the East Bay



SOME BASICS ABOUT EARTH

- We are warmed by the Sun which is about 93 million miles away.
 - The Sun's surface temperature is 5800 K (9980°F).
 - The Earth's average temperature today is 288 K (15°C or 59°F).
 - Without the Greenhouse Effect the Earth's temperature would be 255 K (-18°C or 0°F).
 - Both the Sun and the Earth behave as “Black Body Radiators”.
-



Bodies Emit “Light” of Specific Wave Lengths Based on Their Temperatures



Picture taken from Wikipedia

Simplified View of How Global Warming Works



“Light Source-
Earth”



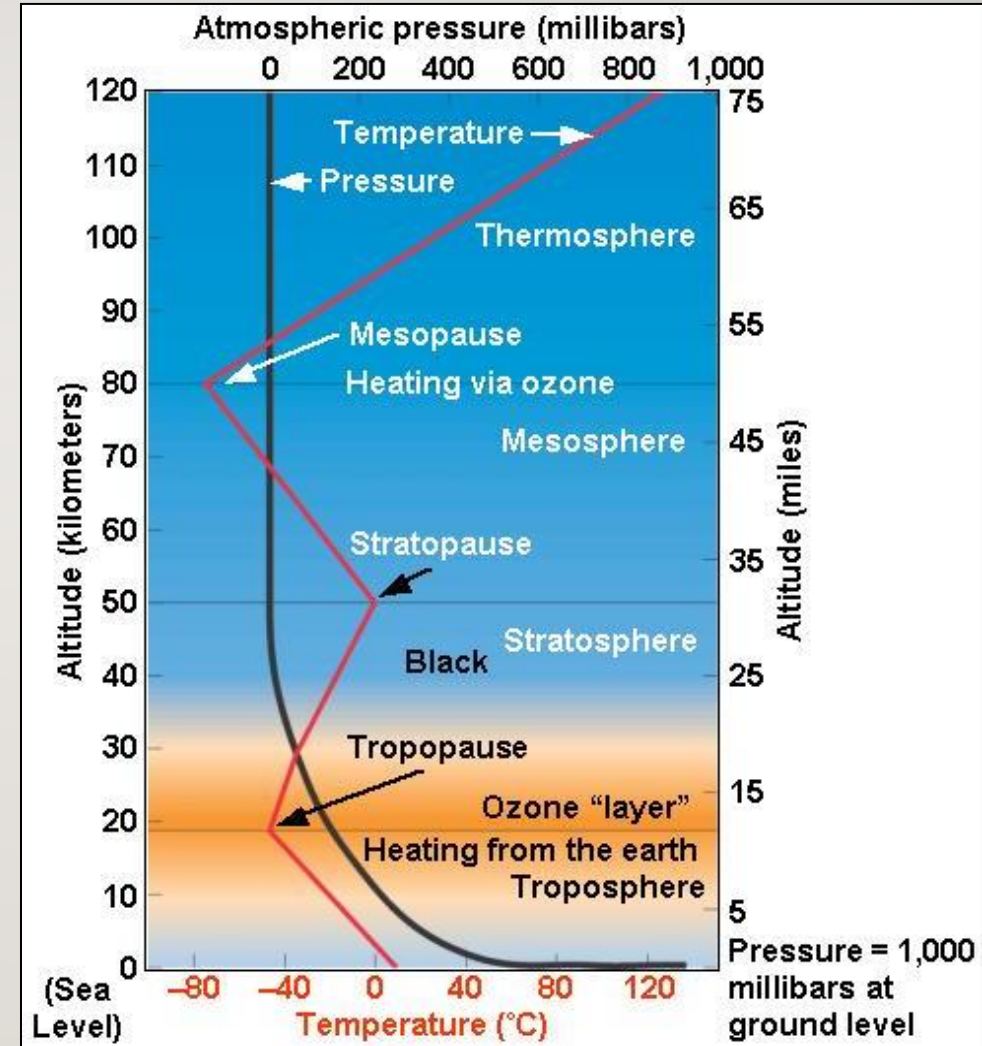
Light Filter,
Atmosphere



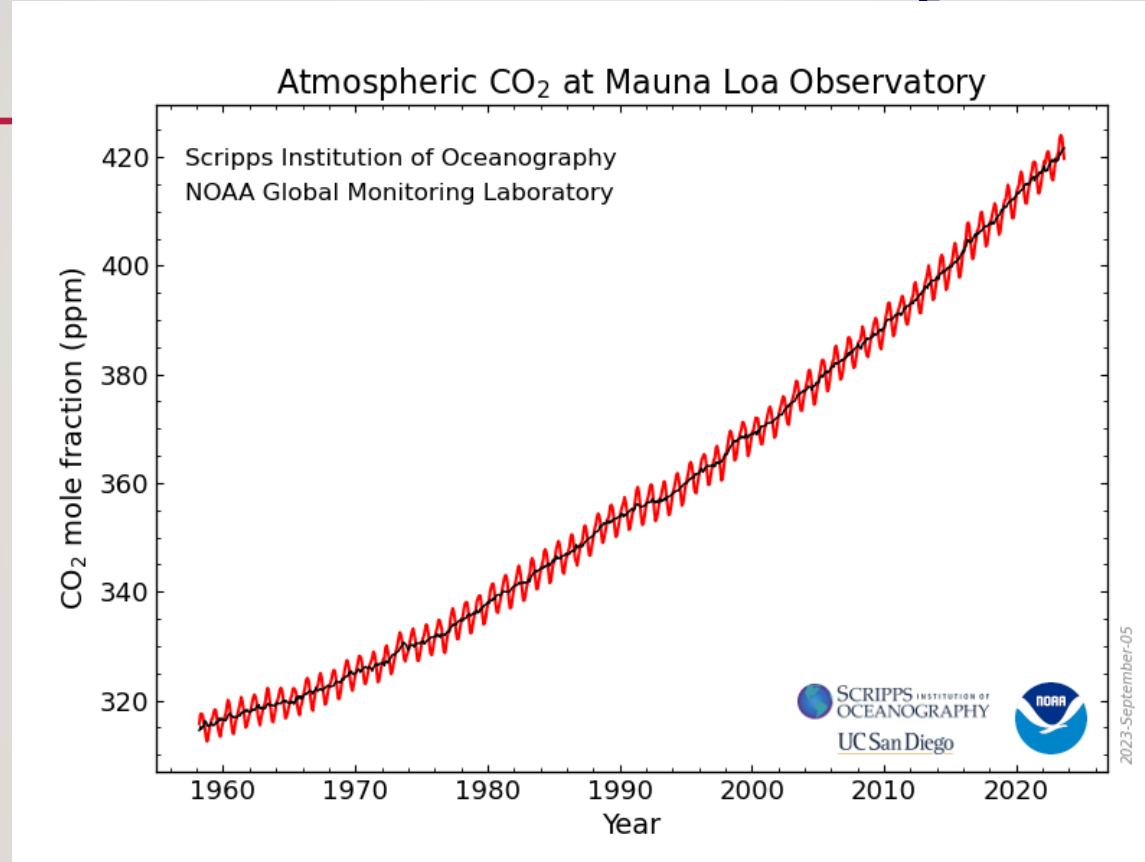
Light Source-Sun

The Atmosphere is Thin and Fragile

- The important portions are:
 - The Troposphere where 75-80% of the air mass is found.
 - The Stratosphere where the ozone layer is found.
- Major gases are O_2 , 21%, and N_2 , 78%.
- Other gases include H_2O , CO_2 , Ar, dust, soot, CH_4 , O_3 , and N_2O .



FULL MAUNA LOA CO₂ RECORD



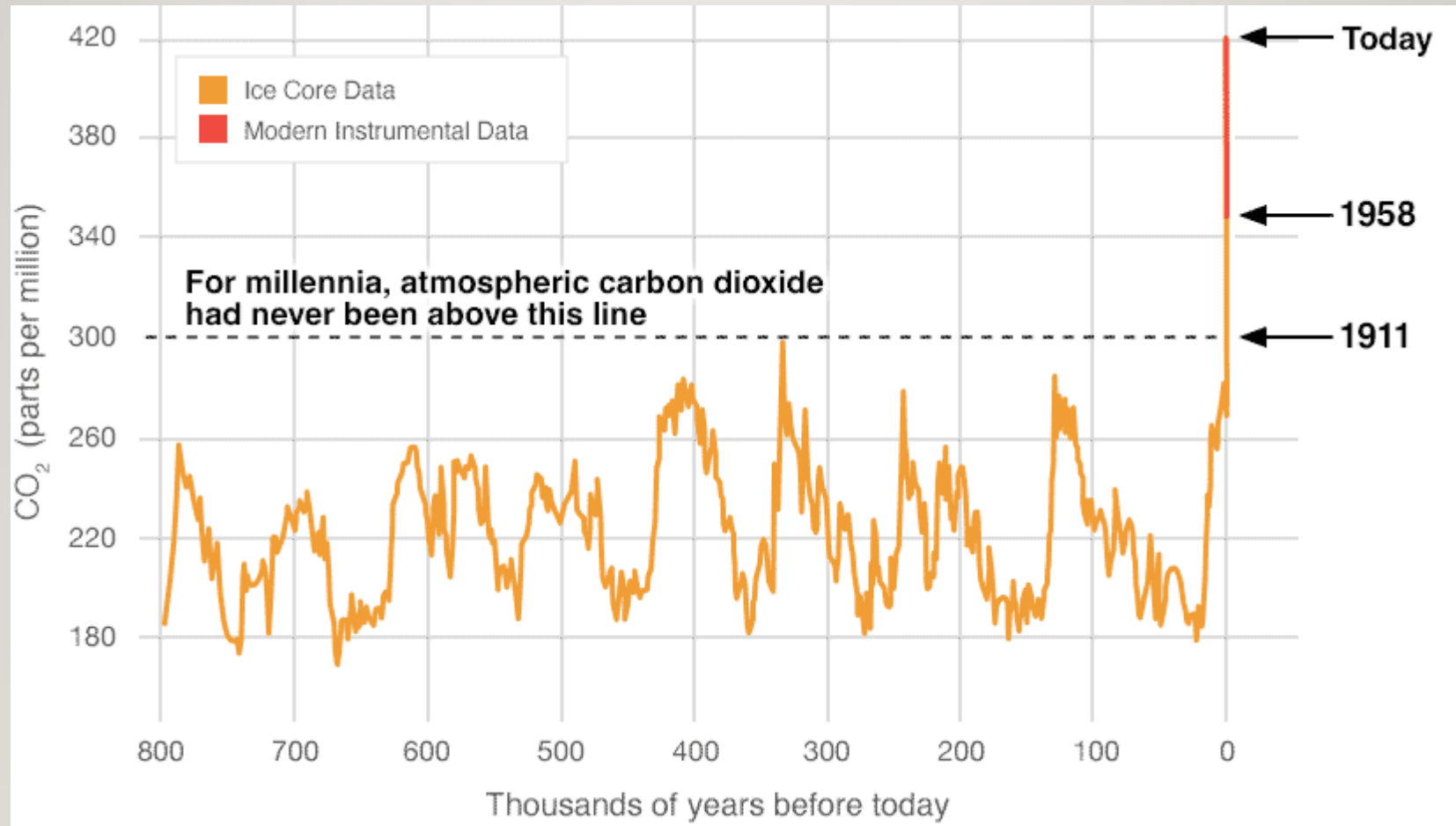
October 6, 2023, the CO₂ was 418.88 ppm

Chart Taken from NOAA Covering Last 800,000 Years

PROXY (INDIRECT) MEASUREMENTS

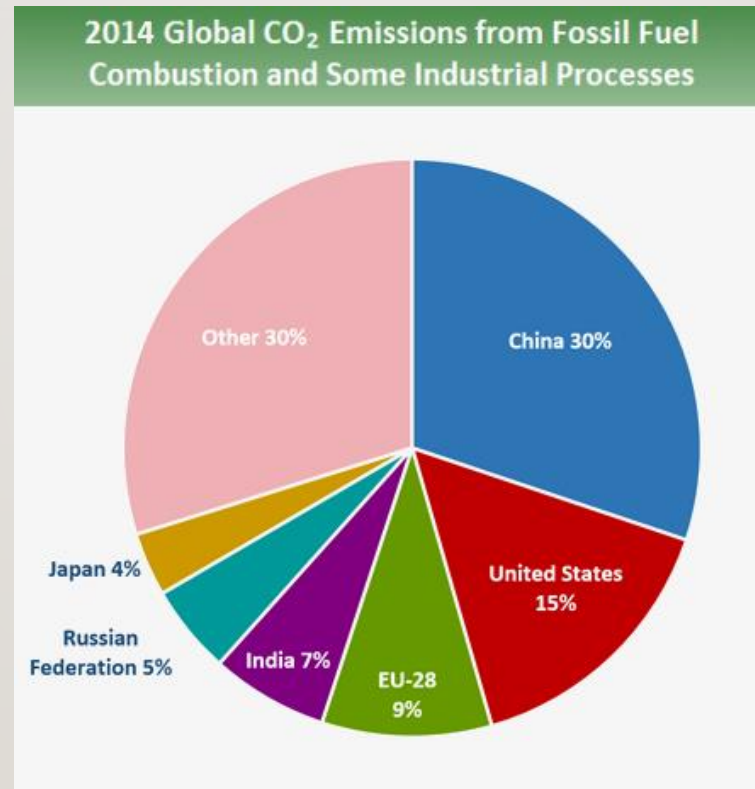
Data source: Reconstruction from ice cores.

Credit: NOAA

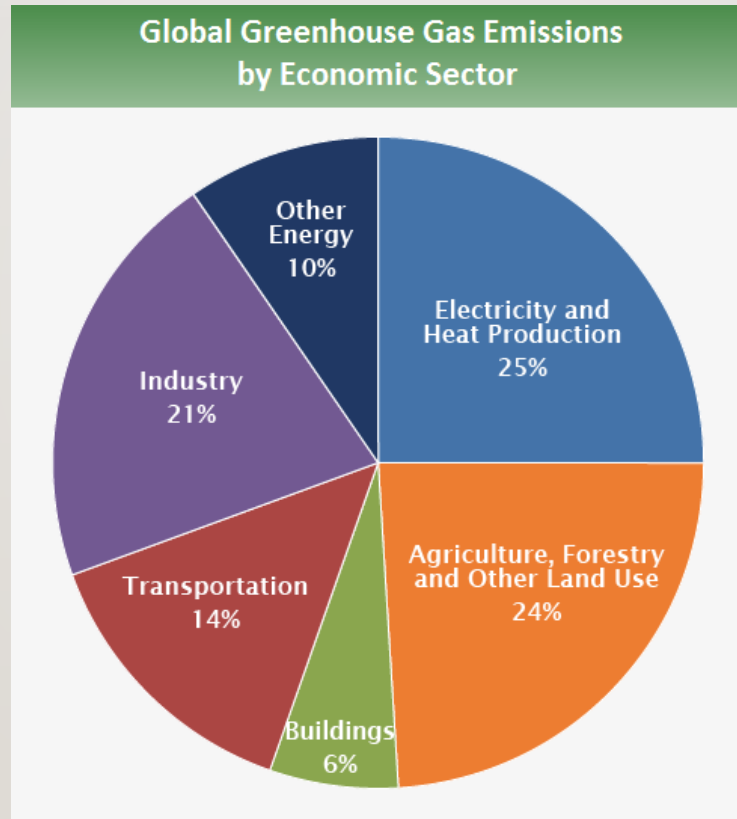


% OF GLOBAL CO₂ EMISSIONS BY COUNTRY

TOTAL EMISSION, 36.3 BILLION TONNES IN 2021

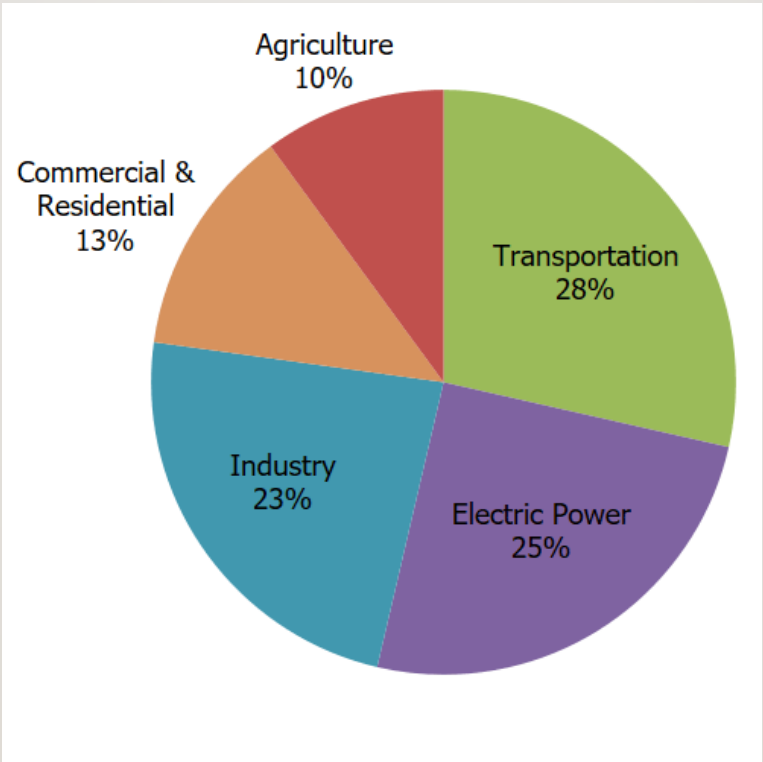


GLOBAL EMISSION BY INDUSTRIAL SECTOR



US GREENHOUSE GAS EMISSIONS BY SECTOR

TOTAL US EMISSION 6.34 BILLION TONNES



SUMMARY OF US TRANSPORTATION SECTOR, 2021

- Greenhouse gas emissions from transportation accounted for 28% (1,775 million tonnes) of total U.S. greenhouse gas emissions of 6,340 million tonnes.
- It is the largest contributor of U.S. greenhouse gas emissions divided as follows:
 - Light-duty trucks, which include sport utility vehicles, pickup trucks, and minivans (37%) or 10.5% of total. (666 million tonnes)
 - Medium- and heavy-duty trucks (23%) or 6.5%. (412 million tonnes)
 - Passenger cars (21%) or 6% (380 million tonnes)
 - Commercial aircraft (7%) or 2% of total. (127 million tonnes)
 - Other aircraft (2%) or 0.5% of total. (32 million tonnes)
 - Pipelines (4%) or 1% of total. (64 million tonnes)
 - Ships and boats (3%) or 1% of total. (63 million tonnes)
 - Rail (2%) or 0.5% of total. (32 million tonnes)

HOW MUCH CO₂ IS RELEASED BY FOREST FIRES?

- 1.76 billion tons of CO₂, was released from burning boreal forests in North America and Eurasia in 2021.
- “Boreal fires released nearly twice as much CO₂ as global aviation in 2021 or **nearly as much as US transportation emissions**.
- If this scale of emissions from unmanaged lands becomes the new normal, stabilizing Earth’s climate will be even more challenging.



What are the Predicted Consequences of Global Warming as a Function of Carbon Dioxide Level? Today's Level is 419 ppmv

- [CO₂]= 450 ppmv, +2 deg
- Forest Fires Worsen
- Prolonged Droughts Intensify
- Major Heat Waves Common
- Fewer Winter Deaths in Higher Latitudes
- Modest Increase in Crop yield in Temperate Areas
- Crop Yields Fall 5-10% in Tropical Africa
- Coral Reefs Affected by Bleaching
- Glaciers Melt and threaten Water Supplies
- Sea Levels Rise enough to Flood Low-lying Coasts
- More Exposure to Malaria
- Extinction of Arctic Species like Polar bear

Ellesmere Island Diorama for Extreme Mammal Exhibit.

Above the Arctic Circle During the Eocene Period.



The Azolla Event Impacts Us Today!

- The **Azolla event** occurred in the middle *Eocene* period, [1] around 49 million years ago, when blooms of the freshwater fern *Azolla* occurred in the *Arctic Ocean*. As they sank to the stagnant sea floor, they were incorporated into the sediment; ***the resulting draw down of carbon dioxide from the atmosphere helped transform the planet from a “greenhouse Earth” state, hot enough for turtles and palm trees to prosper at the poles, to the icehouse Earth it has been since***



WHERE DO WE GO FROM HERE?

- It is still primarily about carbon dioxide.
- Growth in consumption of China and India put huge stresses on emissions.
- Impact of forest fires adds additional stresses.
- What do we need to do?
 - Conserve
 - Really grow alternatives.
 - Sequester carbon dioxide.
 - Find capital to fund necessary projects.

The Marin Carbon Project Seeks to use Photosynthesis to Reduce CO₂ from the Air.



CARBON SEQUESTRATION POTENTIAL OF RANGELAND SOILS

- Marin Carbon Project demonstrated that by adding 1/2 inch of compost to rangeland carbon levels in the soil are significantly increased.
 - A net offset in carbon as CO₂ of 1 tonne per acre annually over 30 years.
 - A Protocol has been developed that would allow carbon credits to be sold.
 - \$1 Billion was in the 2022 Ag budget to fund commodity crop demonstration projects.
 - Composting all ag lands in CA would meet CA Net Zero Plan for 2030 carbon capture goal.

Marin research on human waste compost could benefit the planet



Front Page Marin Independent Journal, March 18, 2014

RESTAURANT FIRE

No word yet on when the Tavern at Lark Creek will re-open after a damaging two-alarm blaze shuttered the historic Larkspur structure Saturday.

MARIN SPORTS B9 MORRIS, JONES PREPS OF WEEK

Branson baseball pitcher Colby Morris and Terra Linda softball shortstop Savannah Jones are the LJ's preps of the week.

MARIN LIFE B2 MISSING OLD HOLLYWOOD

Beth Ashley: They just don't make movies — or movie stars for that matter — like they used to.

MARIN OBITUARIES A7

William Alston Cheek Jr., Felzia Loureiro, Paul L. Lindberg, Thomas M. Meadoff, MD, Ken Nunes, Laurie W. Stoelting

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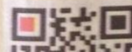
WEATHER B12

Today: Sunny and mild.

69/45



MARIN IJ NEWS APPS



WEST MARIN

Research on human waste compost could result in many benefits for planet

PROJECT WITH 'YUCK' FACTOR



Researcher Gabrielle Pecora talks to Dominican University students about using human waste compost (background) as fertilizer on Monday in Nicasio.

Frankie Frost photos/Marin Independent Journal



Rancher John Wick (third from left) explains the carbon cycle to Dominican University students on Monday in Nicasio. The Thermopile Project is developing sanitation systems that uses no water to treat and transport waste.

By Mark Prado
Marin Independent Journal

ON A RANCH in West Marin researchers are looking at ways human waste could help stem global warming while keeping pasture lands fertile and healthy.

Backers of the research also say using the material could save millions of gallons of fresh water and keep chemicals out of aquatic ecosystems.

But can people get past the "yuck" factor? "There is a yuck factor," said Gabrielle Pecora, who is managing the project on the Nicasio ranch of John Wick, as she stood near a pile of what looked like garden-variety mulch.

See WASTE, page 8

marinij.com IS TURNING HUMAN WASTE INTO FERTILIZER A GOOD IDEA? VOTE

SAN RAFAEL

Council mulls changes to Ritter permit

Demand for aid from center has city in quandary

By Megan Hansen
Marin Independent Journal

A high demand for services from a San Rafael nonprofit group that helps homeless and low-income residents has led city officials to believe more people are congregating in downtown, causing the San Rafael City Council to rethink the agency's permit.

marinij.com
Comment on this story online at marinij.com

Nine months ago the City Council scolded Ritter Center, which has been operating since 1981, for exceeding the number of people it can see each day at its modular medical clinic and day services building, based on a 1993 permit that continues to be updated. Since June the center has complied with the revised cap of seeing an average of 60 people per day during an operational workweek, but

See RITTER, page 8



HEALTH CARE

The “Sweet” Smell of Thermophilic Composting



Students Isolating Compost DNA to be sure it is Pathogen Free



Dominican Student Tour of West Marin Compost Company



Experimental Compost Pile at West Marin Compost



Sensors monitor emissions from composting process

Thank You



QUESTIONS?

How Does the Earth Stay Warm?

(The Greenhouse Effect)

Key Greenhouse
Gases: CO₂,
CH₄, N₂O,
others

Solar energy
enters
without
absorbance
by gas
molecules to
warm
surface.

Blue =
atmosphere



IR Radiation
from the
surface passes
through air.
Some is
absorbed and
re-released as
heat.