NATURAL CLIMATE SOLUTIONS HEROES: NATIVE PLANTS!

We're facing unprecedented climate change due to greenhouse gases

What can we do in our landscapes?

Virtually eliminate fossil fuel use
and
pull greenhouse gasses out of the atmosphere*
and
create resilient landscapes

These are
NATURAL CLIMATE SOLUTIONS

And Native Plants excel at all of these!

*Sequestering carbon is pulling carbon dioxide out of the atmosphere and holding it in plants and the soil

The Nature Conservancy

GLOBAL INSIGHTS | PERSPECTIVES

A Natural Path for U.S. Climate Action

The country could mitigate a fifth of its carbon emissions through natural solutions

November 14, 2018

The U.S. study shows that if all 21 pathways were implemented to their full potential, they could prevent or sequester more than one-fifth of annual U.S. greenhouse gas pollution—the equivalent of removing the emissions from all U.S. cars and trucks from the road. Or, to frame it another away, the equivalent of the entire annual emissions from Brazil.

PNAS Proceedings of the National Academy of Sciences of the United States of America

RESEARCH ARTICLE

Natural climate solutions

Bronson W. Griscom, Justin Adams, Peter W. Ellis, Richard A. Houghton, Guy Lomax, Daniela A. Miteva, William H. Schlesinger, David Shoch, Juha V. Siikamäki, Pete Smith, Peter Woodbury, Chris Zganjar, Allen Blackman, João Campari, Richard T. Conant, Christopher Delgado, Patricia Elias, Trisha Gopalakrishna, Marisa R. Hamsik, Mario Herrero, Joseph Kiesecker, Emily Landis, Lars Laestadius, Sara M. Leavitt, Susan Minnemeyer, Stephen Polasky, Peter Potapov, Francis E. Putz, Jonathan Sanderman, Marcel Silvius, Eva Wollenberg, and Joseph Fargione

PNAS October 31, 2017 114 (44) 11645-11650; first published October 16, 2017
https://doi.org/10.1073/pnas.1710465114

Contributed by William H. Schlesinger, September 5, 2017 (sent for review June 26, 2017; reviewed by Jason Funk and Will R. Turner)

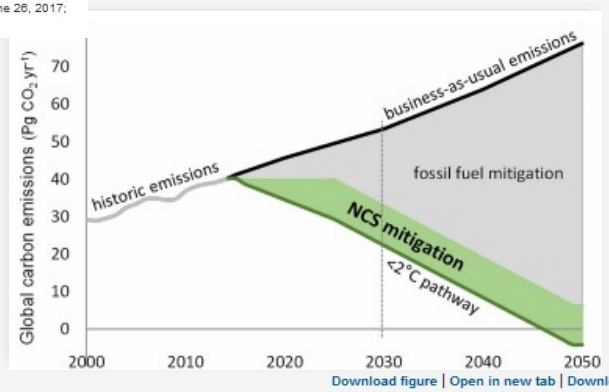


Fig. 2.

Download figure | Open in new tab | Download powerpoint

Contribution of natural climate solutions (NCS) to stabilizing warming to below 2 °C. Historical anthropogenic CO_2 emissions before 2016 (gray line) prelude either business-as-usual (representative concentration pathway, scenario 8.5, black line) or a net emissions trajectory needed for >66% likelihood of holding global warming to below 2 °C (green line). The green area shows cost-effective NCS (aggregate of 20 pathways), offering 37% of needed mitigation through 2030, 29% at year 2030, 20% through 2050, and 9% through 2100. This scenario assumes that NCS are ramped up linearly over the next decade to <2 °C levels indicated in Fig. 1 and held at that level (=10.4 $PgCO_2$ y^{-1}, not including other greenhouse gases). It is assumed that fossil fuel emissions are held level over the next decade then decline linearly to reach 7% of current levels by 2050.

Carbon as a resource, not just a problem!

How much carbon does an average Rocky Mountain forest contain? (6)	65 tons/acre	146 Mg/hectare
How much carbon do Boulder's urban trees sequester? (8)	2,000 tons/year	1814 Mg/year
How much CO_2 do ALL of Colorado's trees sequester? (7)	13,000,000 tons/year	11,793,400 Mg/year
How much CO_2 does the City of Boulder emit annually? (9)	2,204,000 tons/year	2,000,000 Mg/year
How much CO_2 could we sequester with a 1% increase in soil carbon of ALL City of Boulder lands and ALL OSMP lands? (10)	3,900,000 tons	3,540,000 Mg

892 pounds per *acre* = 1 metric *ton* per *hectare* 3.66 units of CO_2 makes 1 unit of C
1 US ton /acre = 2.2417 metric tons/hectare 1 US ton = 0.907185 metric tons (Mg, Megagram)

Courtesy of Elizabeth Black. Here is a link to her handout on Soil Sequestration of Carbon:

In agriculture, it is being done through Regenerative Farming: organic no-till agriculture.

So - we'll plant trees?

Yes, but prairies are just as important:

The combined C *(carbon)* losses from tall-, mixed-, and shortgrass prairies likely released nearly 5 Pg *(pentagrams)* of C, a magnitude roughly similar to the C losses associated with the deforestation of the Brazilian Amazon rainforest (Houghton *et al*. 2000). Between 1870 and 1900, land conversion in Great Plains tallgrass prairie states averaged 1.8 to 2.1 million ha yr^{-1}, resulting in emissions of roughly 0.1 Pg C yr^{-1}. Similar rates of deforestation in the Brazilian Amazon have taken place over the past 30 years, resulting in the release of 0.1 to 0.3 Pg C yr^{-1}

Prairie ecosystems and the carbon problem;Thomas H DeLuca;Catherine A Zabinski; Frontiers in Ecology and the Environment;15 March 2011

My yard is so small….how can it matter?

There are approximately 40 million acres of lawns in the United States:

- **Ten times more than the acreage in certified organic farms**
- **Three times more than irrigated corn (most corn is not irrigated)**
- **Half of the land in un-irrigated corn**

In the City of Boulder there are 30,000 acres of permeable surface, presumably landscapes, and about 15,000 acres of that is single family home landscapes. This is roughly equal to the agricultural land owned by City of Boulder Open Space

---

Homegrown National Park:

The most effective thing we can do to save wildlife as they loose their native habitat, and climate change affects their range and seasonal life, is to
TRANSFORM OUR HOME LANDSCAPES INTO HABITAT

If half of every lawn was converted to native plant communities, it would be more than 20 million acres, which is greater than the combined area of the following National Parks:

- Everglades
- Yellowstone
- Yosemite
- Grand Teton
- Canyonlands
- Mount Rainier
- North Cascades
- Badlands
- Olympic
- Sequoia
- Grand Canyon
- Denali
- Great Smoky Mountains

Our Home Landscapes Matter

+

Natural Climate Solutions

= **CSL**

Climate Solution Landscaping
Carbon Sequestering Landscapes
Cost Saving Landscapes
?

HOW DO WE DO THIS?

- Reduce Production of Greenhouse Gasses
  - Reduce Fossil Fuel use
  - Keep organic materials out of landfills
- Sequester Carbon
  - And as we do this we also help create landscapes that are more resilient to climate change and will help wildlife survive!

And here our native prairie (and steppe) plants are heroes!

They help us sequester carbon:

- In their roots and tops
- In the soil
- By creating many layered ecosystems
- By creating a landscape that does not need fossil fuels to be maintained
- By creating a landscape that conserves fossil fuel use by buildings
- By cleaning the air and water

Reduce Fossil Fuel Use: Landscape Care

- Reduce or eliminate lawn mower and blower use
    - Reduce your lawn area
    - Replace your lawn grass with a grass needing less mowing
    - Fertilize and water less
- Replace gas powered lawn mower and blower with electric mower and renewable electricity
- Don't use chemical fertilizers (which are also a significant source of water pollution)
- Use locally produced plants and materials (reduces fossil fuel use in transportation)
- Reduce water use (in California, moving water uses ~ 10% of total energy and produces ~ 10% of greenhouse gas emissions)

FACT: one hour of mowing is the equivalent of driving 350 miles in terms of volatile organic compounds.

Fact: One gas mower spews 87 lbs. of the greenhouse gas CO2, and 54 lbs. of other pollutants into the air every year.

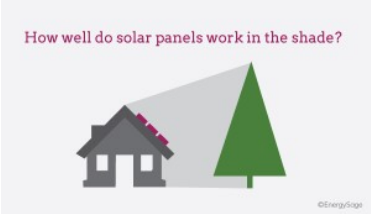
Fact: Over 17 million gallons of gas are spilled each year refueling lawn and garden equipment – more oil than was spilled by the Exxon Valdez.

Reduce Fossil Fuel Use: Landscape Installation

- Use locally produced plants and materials (reduces fossil fuel use in transportation)
- Use re-used and recycled materials
- Use materials that are re-usable and recyclable:
    - Flagstone or bricks instead of poured concrete
    - Drylaid sandstone stripstone or retaining wall concrete blocks instead of mortared walls or poured concrete walls
- Use materials with low embodied energy – the energy it took to manufacture
    - Flagstone instead of concrete
    - Local recycled wood mulch instead of Redwood bark mulch from the northwest
- Design and install for reduced maintenance:
    - Reduce lawn area to what will be actively used and enjoyed
    - Group plants together with similar water and fertility requirements
    - Use plants that are well adapted to our climate and soil : don't need supplemental water and fertilizer
    - Plant densely to reduce weeds
    - Use mulch as needed to cover bare soil until plants grow in

Reduce Fossil Fuel Use: By buildings

- Use trees, tall shrubs and vines to shade homes, commercial buildings and paving. This can dramatically reduce energy used for cooling, and keep people cooler as the climate warms



- Don't plant trees where they will block solar access for PV panels and passive solar heating

- Allow daylighting for buildings

- Plant windbreaks for building energy conservation

NATIVE PLANTS CAN DO ALL OF THIS!

Keep Organic Material out of Landfills

- Organic materials are 60 -70% of the waste dumped in landfills. This organic waste produces methane and other greenhouse gases
  - Methane only stays in the atmosphere around 8-12 years while carbon dioxide can last for centuries. But methane has a big effect in its short time—**methane is responsible for 75% as much warming as carbon dioxide measured over any given 20 years** (Watson, 2009). This means methane reductions could have an immediate beneficial effect on our climate, faster than comparable reductions to CO2.
  - Organic waste can be transformed into materials valuable for landscapes:
    - Compost can be made from a wide variety of organic waste:
      - Food
      - Fine textured landscape debris: lawn clippings, prunings, leaves…
      - Paper
      - And more…

- Wood mulch can be made from tree trimmings and construction wood waste

Soil Carbon Sequestration: a revolution in understanding soils

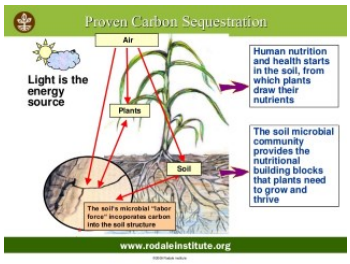
How do we sequester carbon in the soil?

How do we sequester carbon for a long time?

Carbon can be stored in the soil in at least two fundamental ways*:

Particulate Organic Matter – **CHECKING ACCOUNT** - Lightweight, partly decomposed plants and fungi residues that are short lived. " It turns over continuously and supports nutrient cycling but requires regular deposits to stay vital".

Mineral-associated Organic Matter – **SAVINGS ACCOUNT** - "… Largely made of byproducts of the decomposition of microbes that chemically bind to the minerals in the soil. This type of matter is more resilient and able to persist in the ground for centuries… It gets a smaller fraction of deposits but is inherently more stable



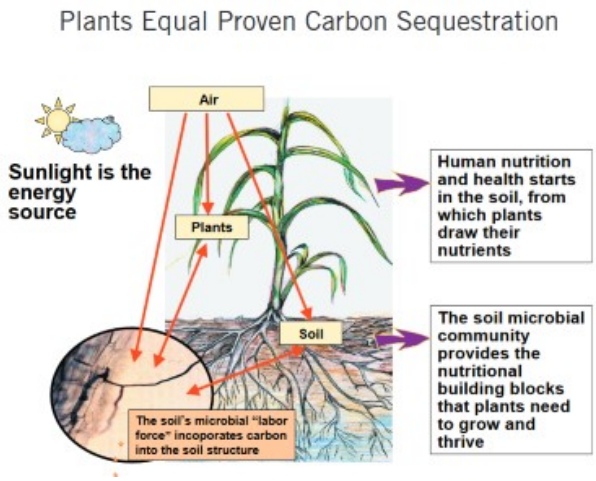
*Research by CSU Soil Scientist Francesco Cotrufo

Residence Times of Organic Matter, Organic Compounds and Biomarkers

(Lorenz and Lal, 2010)

Organic matter/chemical compound	Residence time
I Plant residues	
Leaf litter	Months to years
Root litter	Years
Bark	Decades to centuries
Wood	Decades to centuries
Soil organic matter (SOM)	Years to centuries
Available SOM	Years to decades
Stable SOM	**Millenia**
Black C (BC)	**Decades to millenia**
II Organic compounds	
Cellulose	Years to decades
Lignin	Years to decades
Lipids	Decades
Proteins	Decades
III Biomarker	
Lignin-derived phenols	Years to decades
Aliphatic structures	Years to centuries
Carbohydrates	Hours to decades
Proteins	Decades
Phospholipid fatty acids	Decades to centuries
Amino sugars	Years to decades

Mineral-associated Organic Matter or the Liquid Carbon Cycle*



Healthy plants capture energy through photosynthesis, and direct much of this energy into the soil in the form of root exudates. Somewhere between 85 to 90 percent of the nutrients plants require for healthy growth are acquired via carbon exchange– that is, where plant root exudates provide energy to microbes in order to obtain minerals and trace elements otherwise unavailable. This microbial life also forms complex organic compounds, including glomalin, a long lived carbon sequestering molecule formed by soil fungi.

*Research by Australian Soil Scientist Christine Jones

How do we create long-lived soil carbon in our home landscapes?

We're not sure……

Almost all research has been done in farming, with annual crops.
We can draw from this research to suggest:

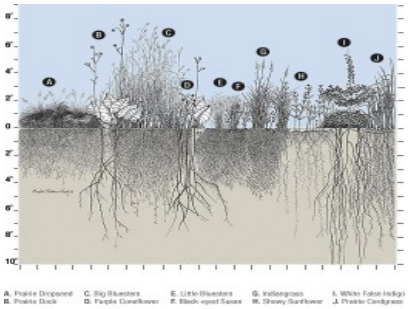
- Don't till your soil: This applies to vegetable gardens and any other garden beds. Tilling destroys the soil fungi that are so important for long lived carbon sequestration.
- Grow a variety of plants: The farming systems with healthy soil, leading to carbon sequestration, have a wide diversity of plants growing together.
- Minimize soil compaction: Healthy soil needs air as much as water. Do everything possible to avoid compacting your soil. Consider plowing or deep digging to loosed your soil if you are landscaping compacted soil
- If you are starting a new landscape, consider planting cover crops before planting your final landscape. This will bring life into the soil.
- Incorporate biochar into your soil: Biochar is a form of charcoal this is very long-lived, lasting centuries. It is made by burning organic materials in a controlled way, and is made in the Front Range. In addition to sequestering carbon, it holds water and nutrients in the soil.

ALL OF THESE CAN HAPPEN IN A NATIVE PLANT LANDSCAPE!

Sequester Carbon in Plants!

Below Ground In Roots

… the perennial grasses that dominate grasslands are characterized by extensive fibrous root systems that o up 60 to 80 percent of the biomass carbon in these ecosystems. This belowground biomass may extend seve meters below the surface and contribute abundant carbon to soils, resulting in deep, fertile soils with high matter content. Because of this, soil carbon makes up approximately 81 percent of total ecosystem carbon fo grasslands[1]



Most of the prairie's carbon sequestration happens below ground, where prairie roots can dig into the soil to depths up to 15 feet and more. Prairies can store much more carbon below ground than a forest can store above ground, according to Dr. Cynthia A.Cambardella, a soil scientist with the U.S. Department of Agriculture's Agricultural Research Service National Laboratory for Agriculture and the Environment.[2]

1 USDA United States Department of Agriculture
Considering Forest and Grassland **Carbon** in Land Management

2 U.S. Fish & Wildlife Service
Open Spaces A Talk on the Wild Side.
Iowa: The Power of Prairies
June 27, 2011

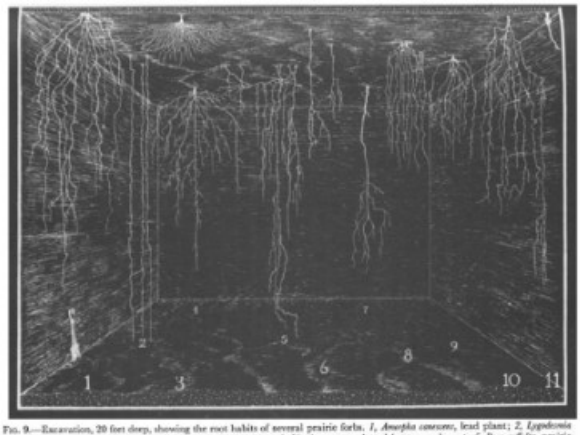


FIG. 9.—Excavation, 20 feet deep, showing the root habits of several prairie forbs. *1, Amorpha canescens*, lead plant; *2, Lygodesmia juncea*, rushlike lygodesmia; *3, Liatris spicata*, scaly blazing star; *4, Liatris punctata*, dotted button snakeroot; *5, Rosa suffulta*, prairie rose; *6, Echinacea pallida*, pale-purple coneflower; *7, Silphium laciniatum*, compassplant; *8, Aster ericoides*, many-flowered aster; *9, Astragalus caniculatus*, ground plum; *10, Glycyrrhiza lepidota*, licorice; *11, Psoralea esculenta*, prairie turnip (turning aside into wall). Redrawn from Weaver (1919–1920), and originally published in the *Botanical Gazette*.

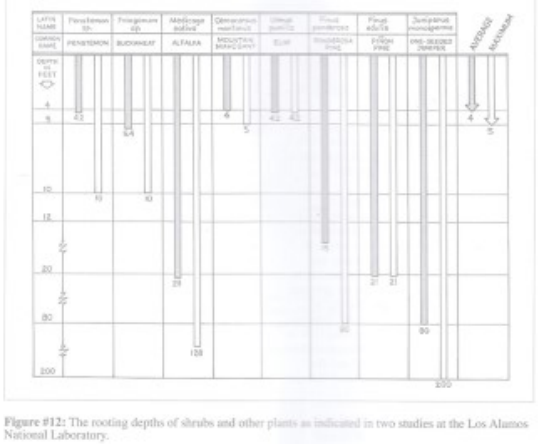
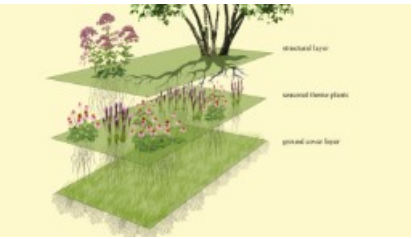


Figure #12: The rooting depths of shrubs and other plants as indicated in two studies at the Los Alamos National Laboratory.

Above Ground in Trunks, Branches and Leaves

Layers of plants

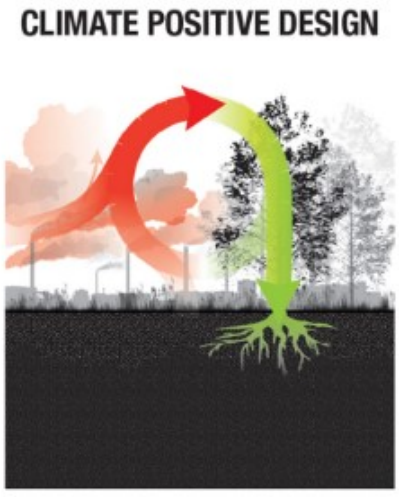


Thomas Rainer and Claudia West: "Gardening in a Post-Wild World"

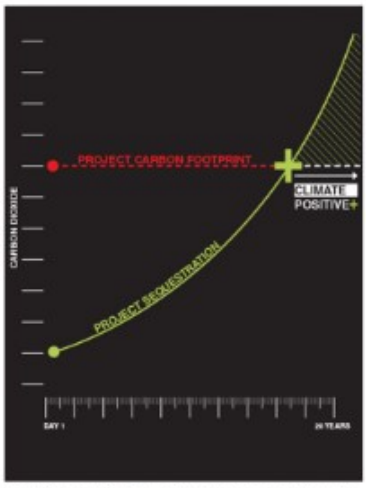
Also a permaculture strategy

Programs exist to calculate when a landscape becomes 'Climate Positive ':

Pathfinder: https://climatepositivedesign.com/pathfinder/



Climate Positive Design / Pamela Conrad, ASLA, CMG Landscape Architecture



Climate Positive Design / Pamela Conrad, CMG Landscape Architecture

Conrad argued that, through climate sensitive design, landscape architects could be responsible for the sequestration of as much as 0.24gigatons of carbon over the next thirty years, enough to place landscape architecture in the list of 80 solutions to climate change studied in Paul Hawken's *Drawdown* project.

And "if we were to include other work we do, like incorporating green roofs into projects or making cities more walkable andbikeable, that would put landscape architecture within the top 40 solutions."

Native plant landscapes with healthy soil and diverse plantings are more resilient and help us and wildlife

Native plants are very resilient – they can survive the extreme weather and droughts that shape this landscape

Healthy soil, full of micro-organisms, creates a more resilient landscape:

- It can absorb water more quickly, reducing run-off and increasing water holding
- Plant roots can grow deeper, allowing plants to harvest water from a larger soil volume, which results in less dependence on supplemental water
- Healthy soil provides more nutrients to plants, reducing or eliminating fertilization
- Healthy living soil cleans air and water, reducing pollution

Diverse landscapes, with a variety of plants (in layers), including many native plants, provide crucial habitat for wildlife

Our landscapes can reduce the need to heat and cool our homes, making our homes more resilient as climates become more extreme

Beautiful outdoor spaces increase our physical and mental health, helping us be resilient.

Native plants are inherently very resilient, but how we work with them is crucial:

- **Work with plants that are native to your bioregion, or a similar bioregion**
- **Place plants in the microclimates that they are native to**
- **Buy plants that are grown in soil, not a light planting mix**
- **Buy plants that are grown without persistent herbicides and insecticides**
- **Native plants must grow deep root systems to be healthy, resilient and carbon sequestering!**
  - **Our native plants are adapted to extended drought and do not need weekly watering**
  - **Water frequently after planting, but over months and years, increase the time between waterings, and increase the watering time. This encourages the plants to grow an extensive deep root system that allows the plants to be weaned off of regular watering**
  - **Drip irrigation is the best way to water native landscapes** (unless you are going to plant with the spring moisture and send them on their way with no supplemental watering)
  - We use 1 gph (gallons per hour) for shrubs and larger grasses and perennial flowers, and a grid of .6-12 in-line soaker line for areas of smaller perennial flowers, grasses and groundcovers. A standard watering schedule is:
    - Three times a week for an hour the first month
    - Twice a week for 1.5 hours the first year
    - Every 7-10 days for 2-3 hours the second year, depending on your soil, climate and plants

- Taper off regular watering over the next couple years until you are only watering during extended periods of heat and drought