Carbon stabilization in urban and urbanizing soils: the effects of historical land use

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Colleagues
Jason Kaye
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Mean Annual Precipitation, 1961-90

http://nationalatlas.gov
Precipitation map by C. Daly and G. Taylor.

483 cm  165  58  <13
Global Flows of Carbon
(Petagrams of Carbon/Year)

- Atmosphere: 750+
- Ocean: 800
- Coal, Oil, Gas: 10,000
- Plants, Soil: 2,000

* Deforestation contributes between 1 - 2

Borrowed from
www.whrc.org/carbon/index.htm

Graphic by Michael Ernst & Skee Houghton
The Woods Hole Research Center
combustion of fossil fuels

land use change

from: The Woods Hole Research Center
www.whrc.org
author S. Houghton
Land Use Change in Central Arizona, U.S.

GIS data from the Central Arizona-Phoenix LTER
Land Use Change in Central Arizona, U.S.
Land Use Change in Central Arizona, U.S.

- **Urban Area (km²)**
  - 1950s: Desert in the ’50s
  - 1990s: Desert in the ’50s + Ag in the ’50s

- **Irrigated Agriculture (km²)**
  - 1950s: 2000 km²
  - 1990s: 1000 km²

- **Legend**
  - Green: Irrigated Agriculture
  - Red: Desert
Land Use Change in Central Arizona, U.S.

1800 1850 1900 1950 2000
Land Use Change in Central Arizona, U.S.

Variation in Sequence

- 1800: desert → agrarian → residential
- 1850: desert → desert → residential
- 1900: desert → agrarian → agrarian
- 1950: desert → desert → desert
- 2000: desert → desert → residential
Land Use Change in Central Arizona, U.S.
Variation in Timing

agrarian  residential

agrarian  residential

agrarian  residential

1900  1925  1950  1975  2000
Hypothesis

The absolute and relative sizes of mobile C fractions are influenced by the sequence and timing and land use transition

Expectations

• mobile C pools will be greater in soils under agrarian and residential use than in soils of the native Sonoran Desert

• mobile C pools will be greater in soils with a longer history of human use

• mobile C pools will bear an agrarian legacy in presently residential lands
Land Use Change in Central Arizona, U.S.
still in 1912 use: $p = 0.004$

2004 status: $p < 0.001$

1912 x 2004: $p = 0.085$

use in 1912
- agrarian
- desert

C concentration (g C / kg soil)

- still in 1912 use
- presently residential
Still in use in 1912 and presently residential, the organic C concentration (g C / kg soil) is higher compared to the inorganic C concentration. The graph shows the concentration of organic and inorganic C in agrarian and desert areas.
inorganic C as proportion of total C

use in 1912
- agrarian
- desert

still in 1912 use
presently residential
year of transition: $p = 0.002$

prior use: $p < 0.001$

prior use x year of transition: $p = 0.223$

$R^2 = 0.63$
inorganic and organic C

- elevated in ag and residential soils
- relative abundance not influenced by land use
- agrarian legacy in today’s residential soils
- OC accumulation with duration of residential occupation
What’s in the carbon pie?
What's in the carbon pie?

- Stable organic
- Labile organic
- Soluble organic
- Insoluble inorganic
- Soluble inorganic
- Microbial
soil incubations
403-day incubation

soil respiration rate
(mg C x (kg soil x day)$^{-1}$)

day of incubation

labile C
600 1000 1400

desert
agrarian
land use in 1912
still in 1912 use
presently residential
labile C (mg CO₂-C / kg soil)
C loss from stable pool (mg C / kg soil)

- Labile C (CO₂)
- Microbial C
- Leached organic C
- Leached inorganic C

Land use in 1912:
- Agrarian
- Desert

Still in 1912 use vs. Presently residential
Type of C loss
- **leached DIC**
- **leached DOC**
- **microbial**
- **respiration**

C loss from stable pool (mg C / kg soil)

<table>
<thead>
<tr>
<th>Type</th>
<th>Agrarian 1912 Use</th>
<th>Desert 1912 Use</th>
<th>Agrarian Presently Residential</th>
<th>Desert Presently Residential</th>
</tr>
</thead>
<tbody>
<tr>
<td>leached DIC</td>
<td>600</td>
<td>1800</td>
<td>1200</td>
<td>2400</td>
</tr>
<tr>
<td>leached DOC</td>
<td>1200</td>
<td>1200</td>
<td>1800</td>
<td>2400</td>
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<tr>
<td>microbial</td>
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<td>1800</td>
<td>2400</td>
</tr>
<tr>
<td>respiration</td>
<td>1200</td>
<td>1200</td>
<td>1800</td>
<td>2400</td>
</tr>
</tbody>
</table>
Type of C loss
- leached DIC
- leached DOC
- microbial
- respiration

C loss from stable pool (% of total C)

1912 use
- agrarian
- desert

2004 use
- still in 1912 use
- presently residential
Expectations

- mobile C pools will be greater in soils under agrarian and residential use than in soils of the native Sonoran Desert
  - absolute: YES
  - relative: NO
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- mobile C pools will be greater in soils with a longer history of human use
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  - absolute: YES
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- mobile C pools will bear an agrarian legacy in presently residential lands
  - absolute: YES
  - relative: NO
Implications for C budgets

Relative to the native Sonoran Desert, human-dominated landscapes of the arid central Arizona, U.S. accumulate both stable and labile C, but accumulate stable C more quickly.
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