MO DIRT - A citizen science project to monitor soil health in Missouri: Soil respiration in natural and anthropogenic habitats and its relationship to soil temperature and water content (2016-2017)

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The Project

MO DIRT– **M**issourians **D**oing **I**mpact **R**esearch **T**ogether, is an educational initiative of the **Missouri Transect,** a $20 million effort supported by the National Science Foundation EPSCoR Program. The Transect focuses on enhancing Missouri's capacity to model and respond to the effects of climate change on agriculture, native vegetation and community resilience. MO DIRT aims to educate citizens on soil health and reciprocal soil-climate interactions across the state. Four components are being offered to the public: Citizen Science Soil Health Monitoring, K-12 Soil Science Curricula, Research Opportunities for High School Student Scientists and Public Enrichment Activities. These components are supported by the MO DIRT website and an online data portal (modirt.missouriepscor.org).

MO DIRT Goals

- To educate citizens on soil science and soil-climate interactions.
- To train citizens on data collection, analysis, and reporting of soil properties.
- To monitor soil health with particular emphasis on soil respiration.
- To maintain a web-based portal for MO DIRT data.
- To contribute valuable data to scientists involved in Missouri Transect research.
- To create public awareness of soil threats and conservation actions .

Citizen Science Soil Health Monitoring

Citizen Science Soil Health Monitoring is conducted by volunteer citizens (e.g. teachers, students, master naturalists, farmers, homeschool families, etc.), to provide soil health baseline information to landowners for management decisions, educators for teaching purposes, and scientists to better understand the health status of Missouri soils under a changing climate. Volunteers measure physical, chemical and biological soil health indicators at natural (forest, woodland, prairie, grassland) and anthropogenic habitats (cropland, pastureland) for at least one year (Feb-Nov). Participants receive training, a soil kit, and a manual to collect, store and use soil health data. This data is stored in an on-line data portal with open-access (modirt.missouriepscor.org/soilhealthsurveys/search-data).

Since October 2015, 273 citizens have been trained on how to conduct soil health surveys during 21 sessions in 11 cities across the state. With more than 700 participants, data have been collected at 76 monitoring sites in forests (15), woodlands (13), prairies (16), grasslands (17), croplands (8) and pasturelands (7).

Acknowledgements. The advice and unconditional support of several citizens and soil scientists have made possible the implementation of MO DIRT. Hundreds of volunteers across Missouri had collected soil health data and stored it online. The following soil scientists have provided their advice for the implementation of the soil health surveys: Dr. Kristen Veum, Assistant Adjunct Professor, University of Missouri-Columbia; Dave Skaer, Area Resource Soil Scientist, USDA-NRCS; Dr. William F. Brinton and Lucas Rumler, Solvita, Woods End Laboratories; Jorge L. Lugo-Camacho, State Soil Scientist, USDA-NRCS; and Ross Brown, soil scientist and educator extraordinaire. Amy Walsh, database programmer analyst at the University of Missouri-Columbia, develops and maintains the MO DIRT website and portals. Allison Blevins, Allison Tielking, Anna McAtee and Aleah Brooks, high school students at the time, have worked on data collection and entry, testing the data portal. Supplemental funding and interest from Maritz LLC is greatly appreciated.

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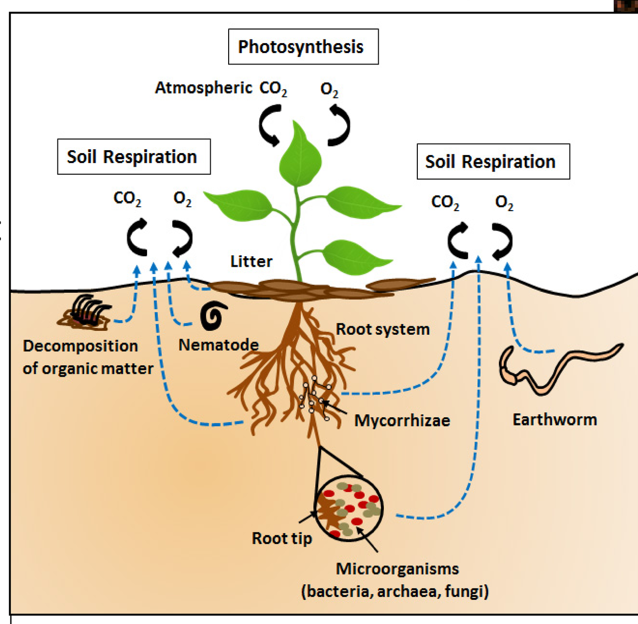
Soil Respiration

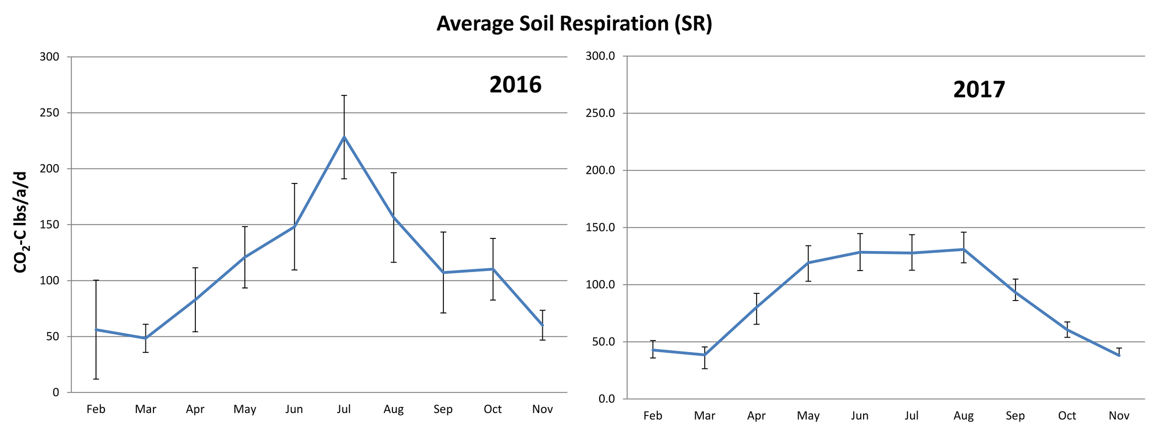
Of particular interest is an investigation of soil respiration across the state and how it may change and contribute to models of climate change effects on future agricultural productivity and native flora. Soil respiration is the carbon dioxide (CO_2) flux from soils to the atmosphere and it represents one of the largest fluxes in the global carbon cycle. Soil respiration results from the biological activity in the soil of live roots, microorganisms and macroorganisms. Soils store a vast amount of organic carbon. The decomposition of soil organic matter is temperature-dependent, therefore it is expected that increases in temperatures due to changes in climate will increase soil respiration rates. Consequently, atmospheric CO_2 is expected to be influenced by changes in soil respiration. Such changes in soil respiration are significantly influenced by agricultural practices and other human activities.



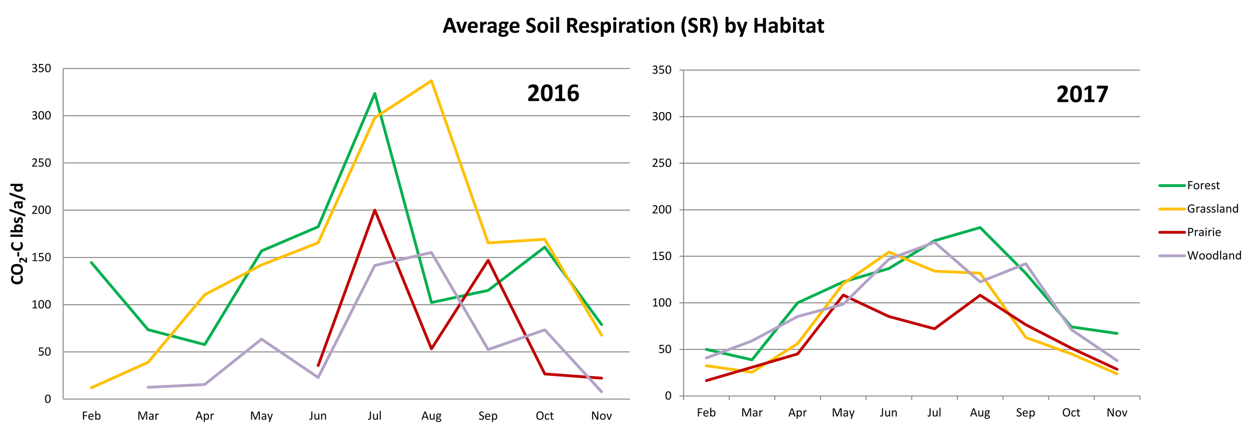
Atmospheric CO_2 is captured by plants through photosynthesis. The CO_2 is transformed into organic forms that are stored in plant tissues or consumed by soil organisms. The stored organic carbon is put back into the atmosphere through CO_2 fluxes from soil respiration. The source of soil respiration is biological activity.

Citizen-collected data on microbial soil respiration (SR), an indicator of biological activity in the soil, was measured once a month in each of the monitoring sites using the Solvita method (modirt.missouriepscor.org/soilhealthsurveys/manual). SR is expressed as average content of carbon in carbon dioxide (CO_2-C pounds/acre/day).

SR shows a seasonal unimodal response with higher levels during the warmer months and lower levels during the colder months. Inter-annual variation in SR was found with higher levels during 2016.

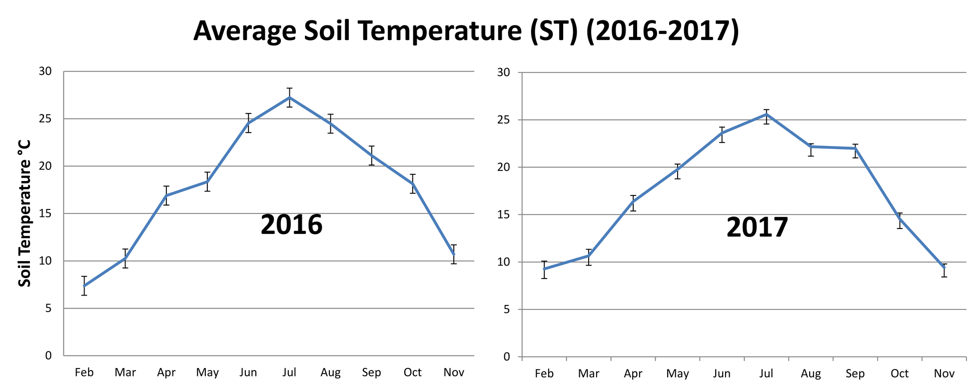


When SR is examined by habitat, only natural habitats showed this seasonal unimodal response. The pattern for prairies was not as clear. This habitat also showed the lowest SR levels.

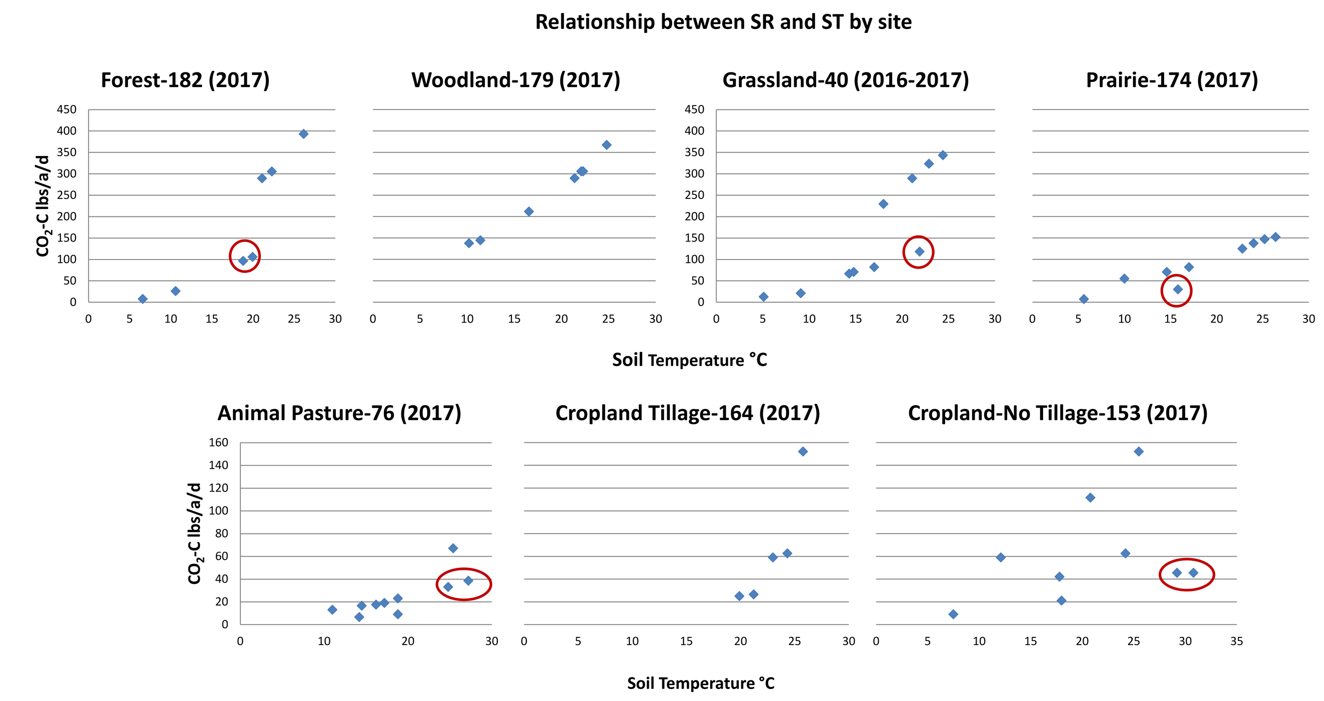


Soil Respiration and Soil Temperature

Soil temperature showed a unimodal response in both years with relatively lower levels during 2017.

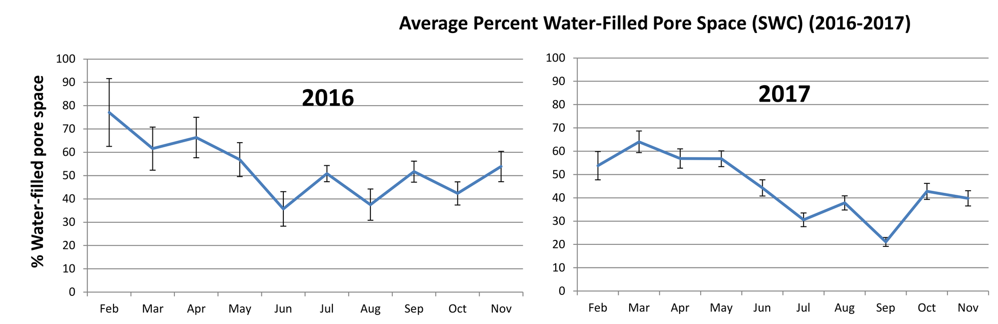


There was a positive relationship between SR and ST. Both SR and ST peaked during the summer and had lower values during the spring and fall. In addition, both SR and ST had higher levels during 2016 than 2017. When this relationship was examined by study site, a positive correlation was found between SR and ST in sites from all habitat types. The outliers in the charts below (red circles) were mostly during the months of May, August and September during seasonal transitions.

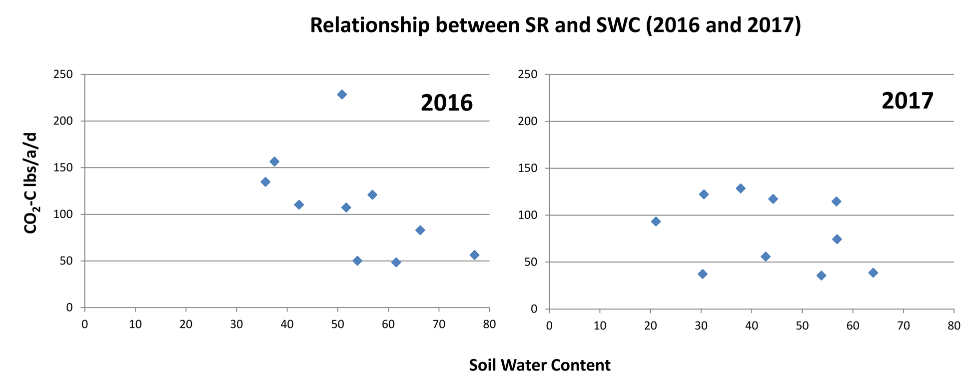


Soil Respiration and Soil Water Content

Soil water content (SWC) refers to percent water-filled pore space. SWC peaked at the beginning of the year, decreasing in the summer months and increasing again in the fall. Overall, higher SWC was found in 2016 than 2017, with optimal SWC (~ 60%) during the Spring months.



No relationship was found between SR and SWC across all data or by site for each year. However, when data was examined by years, there was an indication of a negative relationship with SR decreasing as SWC increases.



Conclusions

- Citizen-collected data was useful for examining soil health in Missouri habitats.
- SR varies seasonally being positively related to ST. This supports the idea that SR increases as ST increases or vice versa, up to a point when temperature is too high or too low for biological activity.
- This relationship was only found in natural habitats. Differences in vegetation cover and human management may partially explained why this response was not found in anthropogenic habitats.
- SR and SWC showed a weak relationship.
- The MO DIRT SR results are consistent with previous research showing a closer relationship with ST than with soil water content.
- Inter-annual variation in the responses of SR, ST and SWC was partially due to lower sample sizes in 2016 as well as differences in weather patterns between years.
- Site-specificity influenced these results as sites of the same habitat differed in management history, natural disturbances, soil types, etc.
- The inclusion of additional monitoring sites and analytical testing will improve our understanding of the dynamics of SR.