

SOURCES

ReGen



A New Future
for Farming,
Food, and Health

DAVID R. MONTGOMERY



W. W. NORTON & COMPANY

Independent Publishers Since 1923

SOURCES

1. THE PROBLEM OF AGRICULTURE

- Albrecht, W. A. 1938. Variable levels of biological activity in Sanborn Field after fifty years of treatment. *Soil Science Society of America Proceedings* 3:77–82.
- Baumhardt, R. L., B. A. Stewart, and U. M. Sainju. 2015. North American soil degradation: Processes, practices, and mitigating strategies. *Sustainability* 7:2936–2960.
- Diaz, R. J., and R. Rosenberg. 2008. Spreading dead zones and consequences for marine ecosystems. *Science* 321:926–929.
- Dirzo, R., et al. 2014. Defaunation in the Anthropocene. *Science* 345:401–406.
- Doran, J. W. 2002. Soil health and global sustainability: Translating science into practice. *Agriculture, Ecosystems and Environment* 88:119–127.
- FAO. 2015. *Status of the World's Soil Resources—Technical Summary*. Intergovernmental Technical Panel on Soils, UN Food and Agriculture Organization.
- Khan, S. A., R. L. Mulvaney, T. R. Ellsworth, and C. W. Boast. 2007. The myth of nitrogen fertilization for soil carbon sequestration. *Journal of Environmental Quality* 36:1821–1832.
- Kibblewhite, M. G., K. Ritz, and M. J. Swift. 2008. Soil health in agricultural systems. *Philosophical Transactions of the Royal Society B* 363:685–701.
- Lu, C., and H. Tian. 2017. Global nitrogen and phosphorus fertilizer use for agricultural production in the past half century: Shifted hot spots and nutrient imbalance. *Earth Systems Science Data* 9:181–192.
- Montgomery, D. R. 2007. *Dirt: The Erosion of Civilizations*. University of California Press.
- Montgomery, D. R. 2017. *Growing a Revolution: Bringing Our Soil Back to Life*. W. W. Norton.
- Mulvaney, R. L., S. A. Khan, and T. R. Ellsworth. 2009. Synthetic nitrogen fertilizers deplete soil nitrogen: A global dilemma for sustainable cereal production. *Journal of Environmental Quality* 38:2295–2314.
- Newton, P., et al. What is regenerative agriculture? A review of scholar and practi-

SOURCES

- tioner definitions based on processes and outcomes. *Frontiers in Sustainable Food Systems* 4:577723.
- Pimental, D., et al. 1995. Environmental and economic costs of soil erosion and conservation benefits. *Science* 267:1117–1123.
- Puckett, L. J. 1995. Identifying the major sources of nutrient water pollution. *Environmental Science and Technology* 29:408–414.
- Raun, W. R., and G. V. Johnson. 1999. Improving nitrogen use efficiency for cereal production. *Agronomy Journal* 91:357–363.
- Sattari, S. Z., et al. 2012. Residual soil phosphorus as the missing piece in the global phosphorus crisis puzzle. *Proceedings of the National Academy of Sciences* 109:6348–6353.
- Tan, Z. X., R. Lal, and K. D. Wiebe. 2005. Global soil nutrient depletion and yield reduction. *Journal of Sustainable Agriculture* 26:123–146.
- Waksman, S. A., and F. G. Tenney. 1928. Composition of natural organic materials and their decomposition in the soil: III. The influence of nature of plant upon the rapidity of its decomposition. *Soil Science* 26:155–171.
- White, J. W. 1927. Soil organic matter and manurial treatments. *Journal of the American Society of Agronomy* 19:389–396.
- ### 2. PEAK SOIL
- Baumhardt, R. L., B. A. Steward, and U. M. Sainju. 2015. North American soil degradation: Processes, practices, and mitigating strategies. *Sustainability* 7:2936–2960.
- Dale, T., and V. G. Carter. 1955. *Topsoil and Civilization*. University of Oklahoma Press.
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). 2018. *Summary for Policymakers of the Thematic Assessment Report on Land Degradation and Restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Edited by R. Scholes et al. IPBES.
- Jenny, J.-P., et al. 2019. Human and climate global-scale imprint on sediment transfer during the Holocene. *Proceedings of the National Academy of Sciences* 116:22972–22976.
- Kemp, D. B., P. M. Sadler, and V. Vanacker. 2020. The human impact on North American erosion, sediment transfer, and storage in a geologic context. *Nature Communications* 11:6012.
- Lehmann, J., et al. 2020. The concept and future prospects of soil health. *Nature Reviews Earth and Environment* 1:544–553.
- Meade, R. H. 1982. Sources, sinks, and storage of river sediment in the Atlantic drainage of the United States. *Journal of Geology* 75:13–23.
- Montgomery, D. R. 2007. *Dirt: The Erosion of Civilizations*. University of California Press.
- Montgomery, D. R. 2007. Soil erosion and agricultural sustainability. *Proceedings of the National Academy of Sciences* 104:13268–13272.
- Penprase, S. B., et al. 2025. Plow versus Ice Age: Erosion rate variability from glacial-interglacial climate change is an order of magnitude lower than agricultural erosion in the Upper Mississippi River Valley, USA. *Geology* 53:535–539.
- Pimentel, D. 2006. Soil erosion: A food and environmental threat. *Environment, Development and Sustainability* 87:119–137.
- Pimentel, D., et al. 1995. Environmental and economic cost of soil erosion and conservation benefits. *Science* 267:1117–1123.
- Quarrier, C. L., et al. 2023. Pre-agricultural soil erosion rates in the midwestern United States. *Geology* 51:44–48.
- Quinton, J. N., G. Govers, K. van Oost, and R. D. Bardgett. 2010. The impact of agricultural soil erosion on biogeochemical cycling. *Nature Geoscience* 3:311–314.

SOURCES

- Reusser, L., P. Bierman, and D. Rood. 2015. Quantifying human impacts on rates of erosion and sediment transport at landscape scale. *Geology* 43:171–174.
- Rothacker, L., et al. 2018. Impact of climate change and human activity on soil landscapes over the past 12,300 years. *Scientific Reports* 8:247.
- Thaler, E. A., et al. 2022. Rates of historical anthropogenic soil erosion in the mid-western United States. *Earth's Future* 10:e2021EF002396.
- Thaler, E. A., I. J. Larsen, and Y. Qian. 2021. The extent of soil loss across the US Corn Belt. *Proceedings of the National Academy of Sciences* 118:e1922375118.

3. BUSTING MYTHS

- Badgery, W., et al. 2023. Reducing enteric methane of ruminants in Australian grazing systems—a review of the role for temperate legumes and herbs. *Crop and Pasture Science* 74:661–679.
- Badgley, C., et al. 2007. Organic agriculture and the global food supply. *Renewable Agriculture and Food Systems* 22:86–108.
- Distel, R. A., J. I. Arroquy, S. Lagrange, and J. J. Villalba. 2020. Designing diverse agricultural pastures for improving ruminant production systems. *Frontiers in Sustainable Food Systems* 4:596869.
- Eugene, M., K. Klumpp, and D. Sauvant. 2021. Methane mitigating options with forages fed to ruminants. *Grass and Forage Science* 76:196–204.
- Fess, T. L., and V. A. Benedito. 2018. Organic versus conventional cropping sustainability: A comparative system analysis. *Sustainability* 10:272.
- Gassmann, A. J., et al. 2025. Sequential evolution of resistance by western corn rootworm to multiple *Bacillus thuringiensis* traits in transgenic maize. *Proceedings of the National Academy of Sciences* 122:e2422337122.
- Hristov, A. N. 2011. Historic, pre-European settlement, and present-day contribution of wild ruminants to enteric methane emissions in the United States. *Journal of Animal Science* 90:1371–1375.
- Montgomery, D. R., and A. Bikké. 2022. *What Your Food Ate: How to Heal Our Land and Reclaim Our Health*. W. W. Norton.
- National Academies of Sciences, Engineering, and Medicine. 2016. *Genetically Engineered Crops: Experiences and Prospects*. National Academies Press.
- Ponisio, L. C., et al. 2015. Diversification practices reduce organic to conventional yield gap. *Proceedings of the Royal Society B* 282:20141396.
- Ricciardi, V., et al. 2021. Higher yields and more biodiversity on smaller farms. *Nature Sustainability* 4:651–657.
- Stanhill, G. 1990. The comparative productivity of organic agriculture. *Agriculture, Ecosystems and Environment* 30:1–26.
- Ziwei, Y., et al. 2025. Too much of a good thing: Lessons from compromised rootworm Bt maize in the US Corn Belt. *Science* 387:984–989.

4. REGENERATIVE FARMING

- Alhameid, A., et al. 2017. Soil organic carbon changes impacted by crop rotational diversity under no-till farming in South Dakota, USA. *Soil Science Society of America Journal* 81:868–877.
- Blanco-Canqui, H., and S. J. Ruis. 2018. No-tillage and soil physical environment. *Geoderma* 326:164–200.
- Bowles, T. M., et al. 2020. Long-term evidence shows that crop-rotation diversification increases agricultural resilience to adverse growing conditions in North America. *One Earth* 2:1–10.
- Bullock, D. G. 1992. Crop rotation. *Critical Reviews in Plant Sciences* 11:309–326.
- Chahal, I., et al. 2020. Cumulative impact of cover crops on soil carbon sequestration and profitability in a temperate humid climate. *Scientific Reports* 10:13381.

SOURCES

- Cotton, J., and V. Acosta-Martínez. 2018. Intensive tillage converting grassland to cropland immediately reduces soil microbial community size and organic carbon. *Agricultural and Environmental Letters* 3:180047.
- Davidson, E. A., and I. L. Ackerman. 1993. Changes in soil carbon inventories following cultivation of previously untilled soils. *Biogeochemistry* 20:161–164.
- Davin, E. L., et al. 2014. Preferential cooling of hot extremes from cropland albedo management. *Proceedings of the National Academy of Sciences* 111:9757–9761.
- Evans, D. L., et al. 2020. Soil lifespans and how they can be extended by land use and management change. *Environmental Research Letters* 15:0940b2.
- Hobbs, P. R., K. Sayre, and R. Gupta. 2008. The role of conservation agriculture in sustainable agriculture. *Philosophical Transactions of the Royal Society B* 363:543–555.
- Karlen, D. L., and J. F. Obyrcki. 2018. Measuring rotation and manure effects in an Iowa farm soil health assessment. *Agronomy Journal* 110:63–73.
- Kassam, A., T. Friedrich, and R. Derpsch. 2022. Successful experiences and lessons from conservation agriculture worldwide. *Agronomy* 12:769.
- Kaye, J. P., and M. Quemada. 2017. Using cover crops to mitigate and adapt to climate change. A review. *Agronomy and Sustainable Development* 37:4.
- Kwang, J. S., E. A. Thaler, and I. J. Larsen. 2023. The future of soils in the Midwestern United States. *Earth's Future* 11:e2022EF003104.
- LaCanne, C. E., and J. G. Lundgren. 2018. Regenerative agriculture: Merging farming and natural resource conservation profitably. *PeerJ* 6:e4428.
- Lehmann, J., et al. 2020. The concept and future prospects of soil health. *Nature Reviews Earth and Environment* 1:544–553.
- Martínez, I., et al. 2016. Two decades of no-till in the Oberacker long-term field experiment: Part 1. Crop yield, soil organic carbon and nutrient distribution in the soil. *Soil Tillage Research* 163:141–151.
- McDaniel, M., L. Tiemann, and A. S. Grandy. 2014. Does agricultural crop diversity enhance soil microbial biomass and organic matter dynamics? A meta-analysis. *Ecological Applications* 24:560–570.
- Montgomery, D. R. 2017. *Growing a Revolution: Bringing Our Soil Back to Life*. W. W. Norton.
- Nouri, A., et al. 2019. Thirty-four years of no-tillage and cover crops improve soil quality and increase cotton yield in Alfisols, Southeastern USA. *Geoderma* 337:998–1008.
- Nunes, M. R., D. L. Karlen, and T. B. Moorman. 2020. Tillage intensity effects on soil structure indicators—a US meta-analysis. *Sustainability* 12:2071.
- Paustian, K., et al. 2000. Management options for reducing CO₂ emissions from agricultural soils. *Biogeochemistry* 48:147–163.
- Renard, D., and D. Tilman. 2019. National food production stabilized by crop diversity. *Nature* 571:257–260.
- Schipanski, M. E., et al. 2016. Realizing resilient food systems. *Bioscience* 66:600–610.
- Seifert, C. A., G. Azzari, and D. B. Lobell. 2018. Satellite detection of cover crops and their effects on crop yield in the Midwestern United States. *Environmental Research Letters* 13:064033.
- Tiessen, H., E. Cuevas, and P. Chacon. 1994. The role of soil organic matter in sustaining soil fertility. *Nature* 371:783–785.
- Vendig, I., et al. 2023. Quantifying direct yield benefits of soil carbon increases from cover cropping. *Nature Sustainability* 6:1125–1134.
- Wood, S. A., and M. Bowman. 2021. Large-scale farmer-led experiment demonstrates positive impact of cover crops on multiple soil health indicators. *Nature Food* 2:97–103.

SOURCES

5. BIOLOGICAL BAZAAR

- Anderson, C., M. Beare, H. L. Buckley, and G. Lear. 2017. Bacterial and fungal communities respond differently to varying tillage depth in agricultural soils. *PeerJ* 5:e3930.
- Antunes, P. M., et al. 2012. Linking soil biodiversity and human health: Do arbuscular mycorrhizal fungi contribute to food nutrition? In *Soil Ecology and Ecosystem Services*. Edited by D. H. Wall et al. Oxford University Press, pp. 153–172.
- Balfour, E. B. 1943. *The Living Soil: Evidence of the Importance to Human Health of Soil Vitality, with Special Reference to National Planning*. Faber and Faber.
- Baumert, V. L., et al. 2018. Root exudates induce soil macroaggregation facilitated by fungi in subsoil. *Frontiers in Environmental Science* 27:140.
- Deng, F., et al. 2022. Low-disturbance farming regenerates healthy deep soil toward sustainable agriculture—evidence from long-term no-tillage with stover mulching in Mollisols. *Science of the Total Environment* 825:153929.
- Douds Jr., D. D., R. R. Janke, and S. E. Peters. 1993. VAM fungus spore populations and colonization of roots of maize and soybean under conventional and low-input sustainable agriculture. *Agriculture, Ecosystems and Environment* 43:325–335.
- Douds Jr., D. D., and C. Reider. 2003. Inoculation with mycorrhizal fungi increases the yield of green peppers in a high P soil. *Biological Agriculture and Horticulture* 21:91–102.
- Drinkwater, L. E., P. Wagoner, and M. Sarrantonio. 1998. Legume-based cropping systems have reduced carbon and nitrogen losses. *Nature* 396:262–265.
- Eisenhauer, N., et al. 2017. Root biomass and exudates link plant diversity with soil bacterial and fungal biomass. *Scientific Reports* 7:44641.
- Faé, G. S., et al. 2009. Integrating winter annual forages into a no-till corn silage system. *Agronomy Journal* 101:1286–1296.
- Garland, G., et al. 2021. Crop cover is more important than rotational diversity for soil multifunctionality and cereal yields in European cropping systems. *Nature Food* 2:28–37.
- Hendrix, P. H., et al. 1986. Detritus food webs in conventional and no-tillage agro-ecosystems. *BioScience* 36:374–380.
- Idriss, E. E., et al. 2007. Tryptophan-dependent production of indole-3-acetic acid (IAA) affects level of plant growth promotion by *Bacillus amyloliquefaciens* FZB42. *Molecular Plant-Microbe Interactions* 20:619–626.
- Jansa, J., A. Wiemken, and E. Frossard. 2006. The effects of agricultural practices on arbuscular mycorrhizal fungi. In *Function of Soils for Human Societies and the Environment*. Edited by E. Frossard, W. E. H. Blum, and B. P. Warkentin. Special Publication 266. Geological Society, pp. 89–115.
- Kinoshita, R., R. R. Schindelbeck, and R. M. van Es. 2017. Quantitative soil profile-scale assessment of the sustainability of long-term maize residue and tillage management. *Soil Tillage Research* 174:34–44.
- Kuzyakov, Y., and G. Domanski. 2000. Carbon input by plants into the soil. Review. *Journal of Plant Nutrition and Soil Science* 163:421–431.
- Lal, R. 2015. Soil carbon sequestration and aggregation by cover cropping. *Journal of Soil and Water Conservation* 70:329–339.
- McDaniel, M., L. Tiemann, and A. S. Grandy. 2014. Does agricultural crop diversity enhance soil microbial biomass and organic matter dynamics? A meta-analysis. *Ecological Applications* 24:560–570.
- Peralta, A. L., et al. 2018. Crop rotational diversity increases disease suppressive capacity of soil microbiomes. *Ecosphere* 9:e02235.
- Rich, M. K., et al. 2021. Lipid exchanges drove the evolution of mutualism during plant terrestrialization. *Science* 372:864–868.

SOURCES

- Ritz, K., and I. M. Young. 2004. Interactions between soil structure and fungi. *Mycologist* 18:52–59.
- Sengupta, A., and W. A. Dick. 2015. Bacterial community diversity in soil under two tillage practices as determined by pyrosequencing. *Microbial Ecology* 70:853–859.
- Sharma, P., G. Singh, and R. P. Singh. 2013. Conservation tillage and optimal water supply enhances microbial enzyme (glucosidase, urease and phosphatase) activities in fields under wheat cultivation during various nitrogen management practices. *Archives of Agronomy and Soil Science* 59:911–928.
- Simmons, D. L., and D. C. Coleman. 2008. Microbial community response to transition from conventional to conservation tillage in cotton fields. *Applied Soil Ecology* 40:518–528.
- Singh, I., et al. 2023. Regenerative agriculture augments bacterial community structure for a healthier soil and agriculture. *Frontiers in Agronomy* 5:1134514.
- Tilman, D. 1998. The greening of the green revolution. *Nature* 396:211–212.
- Uphoff, N., F. Chi, F. B. Dazzo, and R. J. Rodriguez. 2013. Soil fertility as a contingent rather than inherent characteristic: Considering the contributions of crop-symbiotic soil microbiota. In *Principles of Sustainable Soil Management in Agroecosystems*. Edited by R. Lal and B. A. Stewart. CRC Press, pp. 141–166.
- Van der Heijden, M. G. A., et al. 1998. Mycorrhizal fungal diversity determines plant biodiversity, ecosystem variability and productivity. *Nature* 396:69–72.
- Verzeaux, J., et al. 2016. Cover crops prevent the deleterious effect of nitrogen fertilization on bacterial diversity by maintaining the carbon content of ploughed soil. *Geoderma* 281:49–57.
- Wright, S. F., J. L. Starr, and I. C. Paltineanu. 1999. Changes in aggregate stability and concentration of glomalin during tillage management transition. *Soil Science Society of America Journal* 63:1825–1829.

6. CARBON CONNECTION

- Angst, G., et al. 2023. Unlocking complex soil systems as carbon sinks: Multi-pool management as the key. *Nature Communications* 14:2967.
- Baumhardt, R. L., B. A. Stewart, and U. M. Sainju. 2015. North American soil degradation: Processes, practices, and mitigating strategies. *Sustainability* 7:2936–2960.
- Beillouin, D., et al. 2023. A global meta-analysis of soil organic carbon in the Anthropocene. *Nature Communications* 14:3700.
- Blanco-Canqui, H., et al. 2020. Soil carbon increased by twice the amount of biochar carbon applied after 6 years: Field evidence of negative priming. *Global Change Biology Bioenergy* 12:240–251.
- Blume, H.-P., and P. Leinweber. 2004. Plaggen soils: Landscape history, properties, and classification. *Journal of Plant Nutrition and Soil Science* 167:319–327.
- Bossio, D. A., et al. 2020. The role of soil carbon in natural climate solutions. *Nature Sustainability* 3:391–398.
- Crystal-Ornelas, R., R. Thapa, and K. L. Tully. 2021. Soil organic carbon is affected by organic amendments, conservation tillage, and cover cropping in organic farming systems: A meta-analysis. *Agriculture, Ecosystems and Environment* 312:107356.
- Davidson, E. A., and I. L. Ackerman. 1993. Changes in soil carbon inventories following cultivation of previously untilled soils. *Biogeochemistry* 20:161–193.
- Gattinger, A., et al. 2012. Enhanced topsoil carbon stocks under organic farming. *Proceedings of the National Academy of Sciences* 109:18226–18231.
- Gaudaré, U., et al. 2023. Soil organic carbon stocks potentially at risk of decline with organic farming expansion. *Nature Climate Change* 13:719–725.
- Georgiou, K., et al. 2022. Global stocks and capacity of mineral-associated soil organic carbon. *Nature Communications* 13:3797.
- Ghabbour, E. A., et al. 2017. National comparison of the total and sequestered

SOURCES

- organic matter contents of conventional and organic farm soils. *Advances in Agronomy* 146:1–35.
- Glaser, B., and J. J. Birk. 2012. State of the scientific knowledge on properties and genesis of anthropogenic dark earths in Central Amazonia (*terra preta de Índio*). *Geochimica e Cosmochimica Acta* 82:39–51.
- Govaerts, B., et al. 2009. Conservation agriculture and soil carbon sequestration: Between myth and farmer reality. *Critical Reviews in Plant Science* 28:97–122.
- Guo, I. B., and R. M. Gifford. 2002. Soil carbon stocks and land use change: A meta analysis. *Global Change Biology* 8:345–360.
- Han, P., et al. 2016. Changes in soil organic carbon in croplands subjected to fertilizer management: A global meta-analysis. *Scientific Reports* 6:27199.
- Hawkins, H.-J., et al. 2023. Mycorrhizal mycelium as a global carbon pool. *Current Biology* 33:R560–R573.
- Jeffery, S., et al. 2017. Biochar boosts tropical but not temperate crops yields. *Environmental Research Letters* 12:053001.
- Jesmin, T., D. T. Mitchell, and R. L. Mulvaney. 2021. Short-term effect of nitrogen fertilization on carbon mineralization during corn residue decomposition in soil. *Nitrogen* 2:444–460.
- Johnston, A. E., R. P. Poulton, and K. Coleman. 2009. Soil organic matter: Its importance in sustainable agriculture and carbon dioxide fluxes. *Advances in Agronomy* 101:1–57.
- Kan, Z.-R. 2021. Mechanisms of soil organic carbon stability and its response to no-till: A global synthesis and perspective. *Global Change Biology* 28:693–710.
- Kästner, M., et al. 2021. Microbial necromass in soils—linking microbes to soil processes and carbon turnover. *Frontiers in Environmental Science* 9:756378.
- Kibblewhite, M. G., K. Ritz, and M. J. Swift. 2008. Soil health in agricultural systems. *Philosophical Transactions of the Royal Society B* 363:685–701.
- Krull, E. S., J. A. Baldock, and J. O. Skjemstad. 2003. Importance of mechanisms and processes of the stabilization of soil organic matter for modelling carbon turnover. *Functional Plant Biology* 30:207–222.
- Lal, R. 2004. Soil carbon sequestration impacts on global climate change and food security. *Science* 304:1623–1627.
- Lefebvre, D., et al. 2023. Biomass residue to carbon dioxide removal: Quantifying the global impact of biochar. *Biochar* 5:65.
- Lehmann, J., J. Gaunt, and M. Rondon. 2006. Biochar sequestration in terrestrial ecosystems: A review. *Mitigation and Adaptation Strategies for Global Change* 11:395–419.
- Lenton, T. M., and N. E. Vaughan. 2009. The radiative forcing potential of different climate geoengineering options. *Atmospheric Chemistry and Physics Discussion* 9:2259–2608.
- Ma, Y., et al. 2023. Global crop production increase by soil organic carbon. *Nature Geoscience* 16:1159–1165.
- Macray, J. E., and D. R. Montgomery. 2023. Trends in soil organic matter and topsoil thickness under regenerative practices at the University of Washington student farm. *PeerJ* 11:e16336.
- Mason, A. R. G., M. J. Salomon, A. J. Lowe, and T. R. Cavagnaro. 2023. Microbial solutions to soil carbon sequestration. *Journal of Cleaner Production* 417:137993.
- Montgomery, D. R., and A. Bikié. 2023. *What Your Food Ate: How to Heal Our Land and Reclaim Our Health*. W. W. Norton.
- Montgomery, D. R., et al. 2022. Soil health and nutrient density: Preliminary comparison of regenerative and conventional farming. *PeerJ* 10:e12848.
- Mukasa Mugeraw, T. T., and P. A. McGee. 2017. Potential effect of melanised endophytic fungi on levels of organic carbon within an Alfisol. *Soil Research* 55:245–252.

SOURCES

- Nunes, M. R. 2020. Anthropogenic and inherent effects on soil organic carbon across the U.S. *Sustainability* 12:5695.
- Oberholzer, H. R., J. Leifeld, and J. Mayer. 2014. Changes in soil carbon and crop yield over 60 years in the Zurich Organic Fertilization Experiment, following land-use change from grassland to cropland. *Journal of Plant Nutrition and Soil Science* 5:696–704.
- Oldfield, E. E., M. A. Bradford, and S. A. Wood. 2019. Global meta-analysis of the relationship between soil organic matter and crop yields. *SOIL* 5:15–32.
- Paustian, K., J. Six, E. T. Elliott, and H. W. Hunt. 2000. Management options for reducing CO₂ emissions from agricultural soils. *Biogeochemistry* 48:147–163.
- Pitumpe Arachchige, P. S., et al. 2023. Direct evidence on the impact of organic amendments on carbon stabilization in soil microaggregates. *Soil Science Society of America Journal* 88:1529–1544.
- Rodale, R. 1984. Alternative agriculture. *Journal of Soil and Water Conservation* 39:294–296.
- Roe, S., et al. 2021. Land-based measures to mitigate climate change: Potential and feasibility by country. *Global Change Biology* 27:6025–6058.
- Schmidt, M. J., et al. 2023. Intentional creation of carbon-rich dark earth soils in the Amazon. *Science Advances* 9:eadh8499.
- Siddique, K. H. M., et al. 2024. Enhancing crop productivity for recarbonizing soil. *Soil and Tillage Research* 235:105863.
- Sisti, C. P. J., et al. 2004. Change in carbon and nitrogen stocks in soil under 13 years of conventional or zero tillage in southern Brazil. *Soil Tillage Research* 76:39–58.
- Solomon, D., et al. 2016. Indigenous African soil enrichment as a climate-smart sustainable agriculture alternative. *Frontiers of Ecology and Environment* 14:71–76.
- Spohn, M., S. Braun, and C. A. Sierra. 2023. Continuous decrease in soil organic matter despite increased plant productivity in an 80-years-old phosphorus-addition experiment. *Communications Earth and Environment* 4:251.
- Stewart, C., et al. 2007. Soil carbon saturation: Concept, evidence and evaluation. *Biogeochemistry* 86:19–31.
- Stuiver, M. 1978. Atmospheric carbon dioxide and carbon reservoir changes: Reduction in terrestrial carbon reservoirs since 1850 has resulted in atmospheric carbon dioxide increases. *Science* 199:253–258.
- West, T. O., and W. M. Post. 2002. Soil organic carbon sequestration rates by tillage and crop rotation. *Soil Science Society of America Journal* 66:1930–1946.
- Wiedner, K., et al. 2015. Anthropogenic dark earth in northern Germany: The nordic analogue to *terra preta de Índio* in Amazonia. *Catena* 132:114–125.
- Xia, L., et al. 2023. Integrated biochar solutions can achieve carbon-neutral staple crop production. *Nature Food* 4:236–246.
- Zomer, R. J., D. A. Bossio, R. Sommer, and L. V. Verchot. 2017. Global sequestration potential of increased organic carbon in cropland soils. *Scientific Reports* 7:15554.

7. CULTIVATING HEALTH

- Ames, B. N. 2018. Prolonging healthy aging: Longevity vitamins and proteins. *Proceedings of the National Academy of Sciences* 115:10836–10844.
- Antunes, P. M., et al. 2012. Linking soil biodiversity and human health: Do arbuscular mycorrhizal fungi contribute to food nutrition? In *Soil Ecology and Ecosystem Services*. Edited by D. H. Wall et al. Oxford University Press, pp. 153–172.
- Askari, G., et al. 2012. The effect of quercetin supplementation on selected markers of inflammation and oxidative stress. *Journal of Research in Medical Sciences* 17:637–641.
- Bulluck III, L. R., III, M. Brosius, G. K. Evanylo, and J. B. Ristaino. 2002. Organic

SOURCES

- and synthetic fertility amendments influence soil microbial, physical and chemical properties on organic and conventional farms. *Applied Soil Ecology* 19:147–160.
- Ceramella, J., et al. 2024. Phytochemicals involved in mitigating silent toxicity induced by heavy metals. *Foods* 13:978.
- Cordain, L. 1999. Cereal grains: Humanity's double-edged sword. *World Review of Nutrition and Dietetics* 84:19–73.
- Craig, W. J. 1997. Phytochemicals: Guardians of our health. *Journal of the American Dietetic Association* 97:S199–S204.
- Drewnowski, A. 2009. Defining nutrient density: Development and validation of the nutrient rich foods index. *Journal of the American College of Nutrition* 28:421S–426S.
- Eaton, S. B., and M. Konner. 1985. Paleolithic nutrition—a consideration of its nature and current implications. *New England Journal of Medicine* 312:283–289.
- Eaton, S. B., M. Konner, and M. Shostak. 1988. Stone agers in the fast lane: Chronic degenerative diseases in evolutionary perspective. *American Journal of Medicine* 84:739–749.
- Goff, S. A., and H. J. Klee. 2006. Plant volatile compounds: Sensory cues for health and nutritional value? *Science* 311:815–819.
- Graham, R. D., M. Knez, and R. M. Welch. 2012. How much nutritional iron deficiency in humans globally is due to an underlying zinc deficiency? *Advances in Agronomy* 115:1–40.
- Han, K., et al. 2021. Generation of systemic antitumour immunity via the in situ modulation of the gut microbiome by an orally administered inulin gel. *Nature Biomedical Engineering* 5:1377–1388.
- Hardy, K., et al. 2015. The importance of dietary carbohydrate in human evolution. *Quarterly Review of Biology* 90:251–268.
- Helser, M. A., J. H. Hotchkiss, and D. A. Roe. 1992. Influence of fruit and vegetable juices on the endogenous formation of N-nitrosoproline and N-nitrosothiazolidine-4-carboxylic acid in humans on controlled diets. *Carcinogenesis* 13:2277–2280.
- Hepperly, P. R., E. Omondi, and R. Seidel. 2018. Soil regeneration increases crop nutrients, antioxidants and adaptive responses. *MOJ Food Processing and Technology* 6:196–203.
- Hossain, M. S., et al. 2025. Dietary phytochemicals in health and disease: Mechanisms, clinical evidence, and applications—a comprehensive review. *Food Science and Nutrition* 13:e70101.
- Jarrell, W. M., and R. B. Beverly. 1981. The dilution effect in plant nutrition studies. *Advances in Agronomy* 34:197–224.
- Kitani, K., T. Yokozawa, and T. Osawa. 2004. Interventions in aging and age-associated pathologies by means of nutritional approaches. *Annals of the New York Academy of Sciences* 1019:424–426.
- Lehmann, A., S. D. Versoglou, E. F. Leifheit, and M. C. Rillig. 2014. Arbuscular mycorrhizal influence on zinc nutrition in crop plants—a meta-analysis. *Soil Biology and Biochemistry* 69:123–131.
- Ley, R. E., et al. 2008. Worlds within worlds: Evolution of the vertebrate gut microbiota. *Nature Reviews Microbiology* 6:776–788.
- Li, B. Y., et al. 2011. Soil micronutrient availability to crops as affected by long-term inorganic and organic fertilizer applications. *Soil Tillage Research* 96:166–173.
- Li, J., et al. 2020. Dietary inflammatory potential and risk of cardiovascular disease among men and women in the U.S. *Journal of the American College of Cardiology* 76:2181–2193.
- Lima, G. P. P., and F. Vianello. 2011. Review on the main differences between organic and conventional plant-based foods. *International Journal of Food Science and Technology* 46:1–13.

SOURCES

- Lima, G. P. P., et al. 2008. Comparison of polyamine, phenol and flavonoid contents in plants grown under conventional and organic methods. *International Journal of Food Science and Technology* 43:1838–1843.
- Luo, Z., et al. 2025. Association of dietary inflammatory index, composite dietary antioxidant index and risk of death among adult cancer survivors: Findings from the National Health and Nutrition Examination Survey 2001–2018. *Frontiers in Immunology* 16:1556828.
- Manzeke-Kangara, M. G., et al. 2023. Do agronomic approaches aligned to regenerative agriculture improve the micronutrient concentrations of edible portions of crops? A scoping review of evidence. *Frontiers in Nutrition* 10:1078667.
- Marles, R. J. 2017. Mineral nutrient composition of vegetables, fruits and grains: The context of reports of apparent historical declines. *Journal of Food Composition and Analysis* 56:93–103.
- Mattioli, R., A. Francioso, L. Mosca, and P. Silva. 2020. Anthocyanins: A comprehensive review of their chemical properties and health effects on cardiovascular and neurodegenerative diseases. *Molecules* 25:3809.
- Mishra, B. N., R. Prasad, B. Gangaiah, and B. G. Shivakumar. 2006. Organic manures for increased productivity and sustained supply of micronutrients Zn and Cu in a rice-wheat cropping system. *Journal of Sustainable Agriculture* 28:55–66.
- Montgomery, D. R., and A. Biklé. 2016. *The Hidden Half of Nature: The Microbial Roots of Life and Health*. W. W. Norton.
- Montgomery, D. R., and A. Biklé. 2022. *What Your Food Ate: How to Heal Our Land and Reclaim Our Health*. W. W. Norton.
- Montgomery, D. R., et al. 2022. Soil health and nutrient density: Preliminary comparison of regenerative and conventional farming. *PeerJ* 10:e12848.
- Mozaffarian, D. 2016. Dietary and policy priorities for cardiovascular disease, diabetes, and obesity. *Circulation* 133:187–225.
- Mozaffarian, D., I. Rosenberg, and R. Uauy. 2018. History of modern nutrition science—implications for current research, dietary guidelines, and food policy. *British Medical Journal* 361:k2392.
- Oliver, M. A., and P. J. Gregory. 2015. Soil, food security and human health: A review. *European Journal of Soil Science* 66:257–276.
- Park, K. 2023. The role of dietary phytochemicals: Evidence from epidemiological studies. *Nutrients* 15:1371.
- Raghupathi, W., and V. Raghupathi. 2018. An empirical study of chronic diseases in the United States: A visual analytics approach to public health. *International Journal of Environmental Research and Public Health* 15:431.
- Rockefeller Foundation. 2021. *True Cost of Food: Measuring What Matters to Transform the U.S. Food System*. Rockefeller Foundation.
- Schillheim, B., et al. 2018. Sulforaphane modifies histone H3, unpacks chromatin, and primes defense. *Plant Physiology* 176:2395–2405.
- Turnbaugh, P. J. 2017. Microbes and diet-induced obesity: Fast, cheap, and out of control. *Cell Host and Microbe* 21:278–281.
- Vermeer, I. T., et al. 1999. Effect of ascorbic acid and green tea on endogenous formation of N-nitrosodimethylamine and N-nitrosopiperidine in humans. *Mutation Research* 428:353–361.
- Vogtmann, H., et al. 1984. Accumulation of nitrates in leafy vegetables grown under contrasting agricultural systems. *Biological Agriculture and Horticulture* 2:51–68.
- Ward, M. H., et al. 2018. Drinking water nitrate and human health: An updated review. *International Journal of Environmental Research and Public Health* 15:1557.
- Wood, B., and A. Brooks. 1999. Human evolution: We are what we ate. *Nature* 400:219–220.

SOURCES

- Wu, S., et al. 2020. Carotenoid intake and circulating carotenoids are inversely associated with the risk of bladder cancer: A dose-response meta-analysis. *Advances in Nutrition* 11:630–643.
- Yeh, T.-S., et al. 2021. Long-term dietary flavonoid intake and subjective cognitive decline in US men and women. *Neurology* 97:e1041–e1056.
- Zhang, Y.-Q., et al. 2012. The reduction in zinc concentration of wheat grain upon increased phosphorus-fertilization and its mitigation by foliar zinc application. *Plant and Soil* 361:143–152.
- Zhang, Y.-J., et al. 2015. Antioxidant phytochemicals for the prevention and treatment of chronic diseases. *Molecules* 20:21138–21156.
- Zhao, Y., X. Hu, X. Zuo, and M. Wang. 2018. Chemopreventive effects of some popular phytochemicals on human colon cancer: A review. *Food and Function* 9:4548–4568.

8. SILENT FIELDS

- Abawi, G. S., and T. L. Widmer. 2000. Impact of soil health management practices on soilborne pathogens, nematodes and root diseases of vegetable crops. *Applied Soil Ecology* 15:37–47.
- Abrahams, P. W. 2002. Soils: Their implications to human health. *Science of the Total Environment* 291:1–32.
- Akter, S., N. R. Hulugalle, J. Jasonsmith, and C. L. Strong. 2023. Changes in soil microbial communities after exposure to neonicotinoids: A systematic review. *Environmental Microbiology Reports* 15:431–444.
- Baker, B. P., C. M. Benbrook, E. Groth, III, and K. Lutz Benbrook. 2002. Pesticide residues in conventional, integrated pest management (IPM)—grown and organic foods: Insights from three US data sets. *Food Additives and Contaminants* 19:427–446.
- Bakker, L., et al. 2020. Neonicotinoids in global agriculture: Evidence for a new pesticide treadmill? *Ecology and Society* 25:26.
- Battaglin, W. A., et al. 2014. Glyphosate and its degradation product AMPA occur frequently and widely in U.S. soils, surface water, groundwater, and precipitation. *Journal of the American Water Resources Association* 50:275–290.
- Bengtsson, J., J. Ahnstrom, and A. C. Weibull. 2005. The effects of organic agriculture on biodiversity and abundance: A meta-analysis. *Journal of Applied Ecology* 42:261–269.
- Bennett, A. J., et al. 2012. Meeting the demand for crop production: The challenge of yield decline in crops grown in short rotations. *Biological Reviews* 87:52–71.
- Berendsen, R. L., C. M. J. Pieterse, and P. A. H. M. Bakker. 2012. The rhizosphere microbiome and plant health. *Trends in Plant Science* 17:478–486.
- Bernhardt, E. S., E. J. Rosi, and M. O. Gessner. 2017. Synthetic chemicals as agents of global change. *Frontiers in Ecology* 15:84–90.
- Betarbet, R., et al. 2000. Chronic systemic pesticide exposure reproduces features of Parkinson's disease. *Nature Neuroscience* 3:1301–1306.
- Birkhofer, K., et al. 2008. Long-term organic farming fosters below and aboveground biota: Implications for soil quality, biological control and productivity. *Soil Biology and Biochemistry* 40:2297–2308.
- Blair, A., et al. 1985. Cancer among farmers: A review. *Scandinavian Journal of Work and Environmental Health* 11:397–407.
- Blair, A., and S. H. Zahm. 1995. Agricultural exposures and cancer. *Environmental Health Perspectives* 103(suppl 8):205–208.
- Bonanomi, G., et al. 2010. Identifying the characteristics of organic soil amendments that suppress soilborne plant diseases. *Soil Biology and Biochemistry* 42:136–144.
- Bouchard, M. F., D. C. Bellinger, R. O. Wright, and M. G. Weisskopf. 2010.

SOURCES

- Attention-deficit/hyperactivity disorder and urinary metabolites of organophosphate pesticides. *Pediatrics* 125:e1270–e1277.
- Brennan, F. P., et al. 2022. Harnessing agricultural microbiomes for human pathogen control. *ISME Communications* 2:44.
- Buckley, J. D., et al. 2000. Pesticide exposures in children with non-Hodgkin lymphoma. *Cancer* 89:2315–2321.
- Curl, C. L., et al. 2015. Estimating pesticide exposure from dietary intake and organic food choices: The Multi-Ethnic Study of Atherosclerosis (MESA). *Environmental Health Perspectives* 123:475–483.
- Dainese, M., et al. 2019. A global synthesis reveals biodiversity-mediated benefits for crop production. *Science Advances* 5:eaax0121.
- De Corato, U. 2020. Disease-suppressive compost enhances natural soil suppressiveness against soil-borne plant pathogens: A critical review. *Rhizosphere* 13:100192.
- De Roos, A. J., et al. 2003. Integrative assessment of multiple pesticides as risk factors for non-Hodgkin's lymphoma among men. *Occupational and Environmental Medicine* 60(9):e11.
- Donald, P. F., F. J. Sanderson, I. J. Burfield, and F. P. J. van Bommel. 2006. Further evidence of continent-wide impacts of agricultural intensification on European farmland birds, 1990–2000. *Agriculture, Ecosystems and Environment* 116:189–196.
- Drinkwater, L. E., et al. 1995. Fundamental differences between conventional and organic tomato agroecosystems in California. *Ecological Applications* 5:1098–1112.
- Edlinger, A., et al. 2022. Agricultural management and pesticide use reduce the functioning of beneficial plant symbionts. *Nature Ecology and Evolution* 6:1145–1154.
- Edwards, C. B., et al. 2025. Rapid butterfly declines across the United States during the 21st century. *Science* 387:1090–1094.
- Eilers, E. J., et al. 2011. Contribution of pollinator-mediated crops to nutrients in the human food supply. *PLoS One* 6:e21363.
- Eriksson, M. L., et al. 2008. Pesticide exposure as risk factor for non-Hodgkin lymphoma including histopathological subgroup analysis. *International Journal of Cancer* 123:1657–1663.
- Esiobu, N., L. Armenta, and J. Ike. 2002. Antibiotic resistance in soil and water environments. *International Journal of Environmental Health Research* 121:133–144.
- Eskenazi, B., et al. 2007. Organophosphate pesticide exposure and neurodevelopment in young Mexican-American children. *Environmental Health Perspectives* 115:792–798.
- FAO. 2020. *State of Knowledge of Soil Biodiversity—Status, Challenges and Potentialities: Report 2020*. Food and Agriculture Organization of the United Nations.
- Feng, X., et al. 2025. Associations between environmental glyphosate exposure and glucose homeostasis indices in US general adults: A national population-based cross-sectional study. *Scientific Reports* 15:1627.
- Fenster, T. L. D., P. Y. Oikawa, and J. G. Lundgren. 2021. Regenerative almond production systems improve soil health, biodiversity, and profit. *Frontiers in Sustainable Food Systems* 5:664359.
- Fess, T. L., and V. A. Benedito. 2018. Organic versus conventional cropping sustainability: A comparative system analysis. *Sustainability* 10:272.
- Green, R. E., S. J. Cornell, P. W. Scharlemann, and A. Bamford. 2005. Farming and the fate of wild nature. *Science* 307:550–555.
- Gunstone, T., et al. 2021. Pesticides and soil invertebrates: A hazard assessment. *Frontiers in Environmental Science* 9:643847.
- Hessler, L. S., et al. 1993. Arthropod fauna of conventional and organic rice fields in California. *Journal of Economic Entomology* 86:149–158.
- Hill, R. H., S. L. Head Jr., and S. Baker. 1995. Pesticide residues in urine of adults liv-

SOURCES

- ing in the United States: Reference range concentrations. *Environmental Research* 71:99–108.
- Hu, J., et al. 2021. Low-dose exposure of glyphosate-based herbicides disrupt the urine metabolome and its interaction with gut microbiota. *Scientific Reports* 11:3265.
- Jansa, J., A. Wiemken, and E. Frossard. 2006. The effects of agricultural practices on arbuscular mycorrhizal fungi. In *Function of Soils for Human Societies and the Environment*. Edited by E. Frossard, W. E. H. Blum, and B. P. Warkentin. Geological Society, pp. 89–115.
- Joseph, N., et al. 2022. Investigation of relationships between the geospatial distribution of cancer incidence and estimated pesticide use in the U.S. West. *GeoHealth* 6:e2021GH000544.
- Kavitha, B., et al. 2018. Benefits and limitations of biochar amendment in agricultural soils: A review. *Journal of Environmental Management* 227:146–154.
- Kleijn, D., et al. 2009. On the relationship between farmland biodiversity and land-use intensity in Europe. *Proceedings of the Royal Society B* 276:903–909.
- Klein, A.-M., et al. 2007. Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B* 274:303–313.
- Kremen, C., N. M. Williams, and R. W. Thorp. 2002. Crop pollination from native bees at risk from agricultural intensification. *Proceedings of the National Academy of Sciences* 99:16812–16816.
- Kruger, M., A. A. Shehata, W. Schrödl, and A. Rodloff. 2013. Glyphosate suppresses the antagonistic effect of *Enterococcus* spp. on *Clostridium botulinum*. *Anaerobe* 20:74–78.
- LaCanne, C. E., and J. G. Lundgren. 2018. Regenerative agriculture: Merging farming and natural resource conservation profitably. *PeerJ* 6:e4428.
- Landau-Ossondo, M., et al. 2009. Why pesticides could be a common cause of prostate and breast cancers in the French Caribbean Island, Martinique. An overview on key mechanisms of pesticide-induced cancer. *Biomedicine and Pharmacotherapy* 63:383–395.
- Lehman, P. C., et al. 2023. Low-dose glyphosate exposure alters gut microbiota composition and modulates gut homeostasis. *Environmental Toxicology and Pharmacology* 100:104149.
- Leino, L., et al. 2020. Classification of the glyphosate target enzyme (5-enolpyruvylshikimate-3-phosphate synthase) for assessing sensitivity of organisms to the herbicide. *Journal of Hazardous Materials* 408:124556.
- Liebman, M., et al. 2013. Using biodiversity to link agricultural productivity with environmental quality: Results from three field experiments in Iowa. *Renewable Agriculture and Food Systems* 28:115–128.
- Ma, G., et al. 2021. Fungicides alter the distribution and diversity of bacterial and fungal communities in ginseng fields. *Bioengineered* 12:8043–8056.
- Martin, M. J., S. E. Thottathil, and T. B. Newman. 2015. Antibiotics overuse in animal agriculture: A call to action for health care providers. *American Journal of Public Health* 105:2409–2410.
- Martinez, D. A., U. E. Loening, M. C. Graham, and A. Gathorne-Hardy. 2021. When the medicine feeds the problem; do nitrogen fertilisers and pesticides enhance the nutritional quality of crops for their pests and pathogens? *Frontiers in Sustainable Food Systems* 5:701310.
- McKinlay, R., et al. 2008. Endocrine disrupting pesticides: Implications for risk assessment. *Environment International* 34:168–183.
- Metson, G. S., et al. 2016. Feeding the Corn Belt: Opportunities for phosphorus recycling in U.S. agriculture. *Science of the Total Environment* 542:1117–1126.
- Mnif, W., et al. 2011. Effect of endocrine disruptor pesticides: A review. *International Journal of Environmental Research in Public Health* 8:2265–2303.

SOURCES

- Morales-Suárez-Varela, M. M., A. Llopis-Gonzalez, and M. L. Tejerizo-Perez. 1995. Impact of nitrates in drinking water on cancer mortality in Valencia, Spain. *European Journal of Epidemiology* 11:15–21.
- Mostafalou, S., and M. Abdollahi. 2013. Pesticides and human chronic diseases: Evidences, mechanisms, and perspectives. *Toxicology and Applied Pharmacology* 268:157–177.
- National Research Council. 1993. *Pesticides in the Diets of Infants and Children*. National Academies Press.
- Nicolopoulou-Stamati, P., et al. 2016. Chemical pesticides and human health: The urgent need for a new concept in agriculture. *Frontiers in Public Health* 4:148.
- Oates, L., et al. 2014. Reduction in urinary organophosphate pesticide metabolites in adults after a week-long organic diet. *Environmental Research* 132:105–111.
- Oliver, M. A., and P. J. Gregory. 2015. Soil, food security and human health: A review. *European Journal of Soil Science* 66:257–276.
- Paganelli, A., et al. 2010. Glyphosate-based herbicides produce teratogenic effects on vertebrates by impairing retinoic acid signaling. *Chemical Research in Toxicology* 23:1586–1595.
- Parizadeh, M., B. Mimeo, and S. W. Kembel. 2021. Neonicotinoid seed treatments have significant non-target effects on phyllosphere and soil bacterial communities. *Frontiers in Microbiology* 11:619827.
- Pearce, N., and D. McLean. 2005. Agricultural exposures and non-Hodgkin's lymphoma. *Scandinavian Journal of Work, Environment and Health* 31(suppl 1):18–25.
- Pelosi, C., et al. 2021. Residues of currently used pesticides in soils and earthworms: A silent threat? *Agriculture, Ecosystems and Environment* 305:107167.
- Pepper, I. L., et al. 2009. Soil: A public health threat or savior? *Critical Reviews in Environmental Sciences and Technology* 39:416–432.
- Pimentel, D., et al. 1992. Conserving biological diversity in agricultural/forestry systems. *BioScience* 42:354–362.
- Pleasants, J. M., and K. S. Oberhauser. 2012. Milkweed loss in agricultural fields because of herbicide use: Effect on the monarch butterfly population. *Insect Conservation and Diversity* 6:135–144.
- Postma, J., et al. 2008. Soil suppressiveness and functional diversity of the soil microflora in organic farming systems. *Soil Biology and Biochemistry* 40:2394–2406.
- Redhead, J. W., et al. 2022. The effects of a decade of agri-environment intervention in a lowland farm landscape on population trends of birds and butterflies. *Journal of Applied Ecology* 59:2486–2496.
- Relyea, R. A., and D. K. Jones. 2009. The toxicity of Roundup Original Max® to 13 species of larval amphibians. *Environmental Toxicology and Chemistry* 28:2004–2008.
- Ricciardi, V., et al. 2021. Higher yields and more biodiversity on smaller farms. *Nature Sustainability* 4:651–657.
- Roskopf, E., et al. 2020. Organic amendments for pathogen and nematode control. *Annual Review of Phytopathology* 58:277–311.
- Ryan, S. D., et al. 2013. Isogenic human iPSC Parkinson's model shows nitrosative stress-induced dysfunction in MEF2-PGC1α transcription. *Cell* 155:1652–1653.
- Samaddar, S., et al. 2021. Role of soil in the regulation of human and plant pathogens: Soils' contributions to people. *Transactions of the Royal Society B* 376:20200179.
- Schinasi, L., and M. E. Leon. 2014. Non-Hodgkin lymphoma and occupational exposure to agricultural pesticide chemical groups and active ingredients: A systematic review and meta-analysis. *International Journal of Environmental Research and Public Health* 11:4449–4527.
- Schrödl, W., et al. 2014. Possible effects of glyphosate on *Mucorales* abundance in the rumen of dairy cows in Germany. *Current Microbiology* 69:817–823.

SOURCES

- Sengonca, C., and K. U. Bruggen. 1989. Occurrence of winter wheat pests and their natural enemies on farms with different farming systems. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz* 96:100–106.
- Shatz, A., E. Bugie, and S. A. Waksman. 1944. Streptomycin, a substance exhibiting antibiotic activity against gram-positive and gram-negative bacteria. *Proceedings of the Society of Experimental Biology and Medicine* 55:66–69.
- Shehata, A. A., et al. 2013. The effect of glyphosate on potential pathogens and beneficial members of poultry microbiota in vitro. *Current Microbiology* 66:350–358.
- Steffan, J. J., E. C. Brevik, L. C. Burgess, and A. Cerdà. 2017. The effect of soil on human health: An overview. *European Journal of Soil Science* 69:159–171.
- Stur, E., et al. 2019. Glyphosate-based herbicides at low doses affect canonical pathways in estrogen positive and negative breast cancer cell lines. *PLoS One* 14:e0219610.
- Tamburini, G., et al. 2020. Agricultural diversification promotes multiple ecosystem services without compromising yield. *Science Advances* 6:eaba1715.
- Thongprakaisang, S. 2013. Glyphosate induces human breast cancer cells growth via estrogen receptors. *Food Chemistry and Toxicology* 59:129–136.
- Van Bruggen, A. H. C., et al. 2018. Environmental and health effects of the herbicide glyphosate. *Science of the Total Environment* 616–617:255–268.
- Verdenelli, R. A., et al. 2023. Effect of two broad-spectrum fungicides on the microbial communities of a soil subjected to different degrees of water erosion. *Applied Soil Ecology* 190:104984.
- Waksman, S. A., and H. A. LeChavallier. 1949. Neomycin, a new antibiotic active against streptomycin-resistant bacteria including tuberculosis organisms. *Science* 109:305–307.
- Waksman, S. A., and R. L. Starkey. 1923. Partial sterilization of soil, microbiological activities and soil fertility. *Soil Science* 16:343–358.
- Wall, D. H., U. N. Nielsen, and J. Six. 2015. Soil biodiversity and human health. *Nature* 528:69–76.
- Ward, M. H., et al. 2018. Drinking water nitrate and human health: An updated review. *International Journal of Environmental Research and Public Health* 15:1557.
- Winchester, P. D., J. Huskins, and J. Ying. 2009. Agrichemicals in surface water and birth defects in the United States. *Acta Paediatrica* 98:664–669.
- Winter, C. K. 2015. Chronic dietary exposure to pesticide residues in the United States. *International Journal of Food Contamination* 2:11.
- Winter, C. K., and J. M. Katz. 2011. Dietary exposure to pesticide residues from commodities alleged to contain the highest contamination levels. *Journal of Toxicology* 2011:589674.
- Zhang, L., et al. 2019. Exposure to glyphosate-based herbicides and risk for non-Hodgkin lymphoma: A meta-analysis and supporting evidence. *Mutation Research/Reviews in Mutation Research* 781:186–206.

9. GREEN GRAZING

- Apfelbaum, S. I., et al. 2022. Vegetation, water infiltration, and soil carbon response to adaptive multi-paddock and conventional grazing in southeastern USA ranches. *Journal of Environmental Management* 308:114576.
- Ailhaud, G., et al. 2006. Temporal changes in dietary fats: Role of *n*-6 polyunsaturated fatty acids in excessive adipose tissue development and relationship to obesity. *Progress in Lipid Research* 45:203–236.
- Ailhaud, G., P. Guesnet, and S. C. Cunnane. 2008. An emerging risk factor for obesity: Does disequilibrium of polyunsaturated fatty acid metabolism contribute to excessive adipose tissue development? *British Journal of Nutrition* 100:461–470.

SOURCES

- Allothman, M., et al. 2019. The “grass-fed” milk story: Understanding the impact of pasture feeding on the composition and quality of bovine milk. *Foods* 8:350.
- Benbrook, C. M., et al. 2018. Enhancing the fatty acid profile of milk through forage-based rations, with nutrition modeling of diet outcomes. *Food Science and Nutrition* 6:681–700.
- Bendall, J. G. 2001. Aroma compounds of fresh milk from New Zealand cows fed different diets. *Journal of Agriculture and Food Chemistry* 49:4825–4832.
- Bjorklund, E. A., et al. 2014. Fatty acid profiles, meat quality, and sensory attributes of organic versus conventional dairy beef steers. *Journal of Dairy Science* 97:1828–1834.
- Bourre, J. M. 2006. Effects of nutrients (in food) on the structure and function of the nervous system: Update on dietary requirements for brain. Part 1: Micronutrients. *Journal of Nutrition, Health and Aging* 5:377–385.
- Capuano, E., et al. 2014. Verification of fresh grass feeding, pasture grazing and organic farming by cows farm milk fatty acid profile. *Food Chemistry* 164:234–241.
- Cassidy, E. S., et al. 2013. Redefining agricultural yields from tonnes to people nourished per hectare. *Environmental Research Letters* 8:034015.
- Castellini, C., C. Mungnai, and A. Dal Bosco. 2002. Effect of organic production system on broiler carcass and meat quality. *Meat Science* 60:219–225.
- Chaplot, V., P. Dlamini, and P. Chivenge. 2016. Potential of grassland rehabilitation through high density–short duration grazing to sequester atmospheric carbon. *Geoderma* 271:10–17.
- Couvreux, S., et al. 2006. The linear relationship between the proportion of fresh grass in the cow diet, milk fatty acid composition, and butter properties. *Journal of Dairy Science* 89:1956–1969.
- Croissant, A. E., et al. 2007. Chemical properties and consumer perception of fluid milk from conventional and pasture-based production systems. *Journal of Dairy Science* 90:4942–4953.
- Da Conceição, M. C. G., et al. 2017. Changes in soil carbon stocks under integrated crop-livestock-forest system in the Brazilian Amazon region. *Agricultural Sciences* 8:904–913.
- Davis, H., et al. 2020. Evidence that forage-fed cows can enhance milk quality. *Sustainability* 12:3688.
- Dehghan, M., et al. 2018. Association of dairy intake with cardiovascular disease and mortality in 21 countries from five continents (PURE): A prospective cohort study. *Lancet* 392:2288–2297.
- Duckett, S. K., et al. 2013. Effects of forage species or concentrate finishing on animal performance, carcass and meat quality. *Journal of Animal Science* 91:1454–1467.
- Franzuebbers, A. J. 2010. Achieving soil organic carbon sequestration with conservation agricultural systems in the southeastern United States. *Soil Science Society of America Journal* 74:347–357.
- Galindo, F. S., et al. 2020. Cropping system and rotational grazing effects on soil fertility and enzymatic activity in an integrated organic crop-livestock system. *Agronomy* 10:803.
- Gaspardo, B., et al. 2010. Use of milk fatty acids composition to discriminate area of origin of bulk milk. *Journal of Dairy Science* 93:3417–3426.
- Gesch, C. B., et al. 2002. Influence of supplementary vitamins, minerals and essential fatty acids on the antisocial behaviour of young adult prisoners. Randomised, placebo-controlled trial. *British Journal of Psychiatry* 181:22–28.
- Givens, D. I. 2005. The role of animal nutrition in improving the nutritive value of animal-derived foods in relation to chronic disease. *Proceedings of the Nutrition Society* 64:395–402.
- Gómez-Cortés, P., M. Juárez, and M. A. de la Fuente. 2018. Milk fatty acids and

SOURCES

- potential health benefits: An updated vision. *Trends in Food Science and Technology* 81:1–9.
- Gross, A., and B. Glaser. 2021. Meta-analysis on how manure application changes soil organic carbon storage. *Scientific Reports* 11:5516.
- Hackman, T. J., and J. N. Spain. 2010. Ruminant ecology and evolution: Perspectives useful to ruminant livestock research and production. *Journal of Dairy Science* 93:1320–1334.
- Hayek, M. N., and R. D. Garrett. 2018. Nationwide shift to grass-fed beef requires larger cattle population. *Environmental Research Letters* 13:084005.
- Hofmann, R. R. 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: A comparative view of their digestive system. *Oecologia* 78:443–457.
- Hristov, A. N. 2011. Historic, pre-European settlement, and present-day contribution of wild ruminants to enteric methane emissions in the United States. *Journal of Animal Science* 90:1371–1375.
- Ingram, L. J., et al. 2008. Grazing impacts on soil carbon and microbial communities in a mixed-grass ecosystem. *Soil Science Society of America Journal* 72:939–948.
- Ingvartsen, K. L., and K. Moyes. 2013. Nutrition, immune function and health of dairy cattle. *Animal* 7(suppl 1):112–122.
- Johnson, D. C., et al. 2022. Adaptive multi-paddock grazing management's influence on soil food web community structure for: increasing pasture forage production, soil organic carbon, and reducing soil respiration rates in southeastern USA ranches. *PeerJ* 10:e13750.
- Lal, R. 2004. Soil carbon sequestration to mitigate climate change. *Geoderma* 123:1022.
- Leiber, F., et al. 2005. A study on the causes for the elevated n-3 fatty acids in cows' milk of alpine origin. *Lipids* 40:191–202.
- Lopez-Bote, C. J., et al. 1998. Effect of free-range feeding on n-3 fatty acid and α -tocopherol content and oxidative stability of eggs. *Animal Feed Science Technology* 72:33–40.
- Lovegrove, A. J., and D. I. Givens. 2016. Dairy food products: Good or bad for cardiometabolic disease? *Nutrition Research Review* 29:249–267.
- Machmuller, M. B., et al. 2015. Emerging land use practices rapidly increase soil organic matter. *Nature Communications* 6:6995.
- Meyer, B. J., et al. 2015. Baseline omega-3 index correlates with aggressive and attention deficit disorder behaviours in adult prisoners. *PLoS One* 10:e120220.
- Mitani, T., et al. 2016. Discrimination of “grazing milk” using milk fatty acid profile in the grassland dairy area in Hokkaido. *Animal Science Journal* 87:233–241.
- Montgomery, D. R., and A. Bickel. 2022. *What Your Food Ate: How to Heal Our Land and Reclaim Our Health*. W. W. Norton.
- Mosier, S., et al. 2021. Adaptive multi-paddock grazing enhances soil carbon and nitrogen stocks and stabilization through mineral association in southeastern U.S. grazing lands. *Journal of Environmental Management* 288:112409.
- O'Callaghan, T. F., et al. 2016. Quality characteristics, chemical composition, and sensory properties of butter from cows on pasture versus indoor feeding systems. *Journal of Dairy Science* 99:9441–9460.
- Orgill, S. E., et al. 2018. Removing grazing pressure from a native pasture decreases soil organic carbon in southern New South Wales, Australia. *Land Degradation and Development* 29:274–283.
- Paustian, K., et al. 1997. Agricultural soils as a sink to mitigate CO₂ emissions. *Soil Use and Management* 13:230–244.
- Rayne, N., and L. Aula. 2020. Livestock manure and the impacts on soil health: A review. *Soil Systems* 4:64.

SOURCES

- Retallack, G. J. 2001. Cenozoic expansion of grasslands and global cooling. *Journal of Geology* 109:407–426.
- Rowntree, J. E., et al. 2020. Ecosystem impacts and productive capacity of a multi-species pastured livestock system. *Frontiers in Sustainable Food Systems* 4:544984.
- Rui, Y., et al. 2022. Persistent soil carbon enhanced in Mollisols by well-managed grasslands but not annual grain or dairy forage cropping systems. *Proceedings of the National Academy of Sciences* 119:e2118931119.
- Schrama, M., et al. 2023. Cessation of grazing causes biodiversity loss and homogenization of soil food webs. *Proceedings of the Royal Society B* 290:20231345.
- Silva, C. C. G., et al. 2019. Physicochemical traits and sensory quality of commercial butter produced in the Azores. *International Dairy Journal* 88:10–17.
- Skrívan, M., and M. Englmaierová. 2014. The deposition of carotenoids and α -tocopherol in hen eggs produced under a combination of sequential feeding and grazing. *Animal Feed Science and Technology* 190:79–86.
- Soedamah-Muthu, S. S., et al. 2011. Milk and dairy consumption and incidence of cardiovascular diseases and all-cause mortality: Dose-response meta-analysis of prospective cohort studies. *American Journal of Clinical Nutrition* 93:158–171.
- Spears, M., et al. 2024. Comparative impact of organic grass-fed and conventional cattle-feeding systems on beef and human postprandial metabolomics—a randomized clinical trial. *Metabolites* 14:533.
- Stanley, P. L., et al. 2018. Impacts of soil carbon sequestration on life cycle greenhouse gas emissions in Midwestern USA beef finishing systems. *Agricultural Systems* 162:249–258.
- Stanley, P. L., et al. 2024. Ruminating on soil carbon: Applying current understanding to inform grazing management. *Global Change Biology* 30:e17223.
- Teague, W. R., et al. 2016. The role of ruminants in reducing agriculture's carbon footprint in North America. *Journal of Soil and Water Conservation* 71:156–164.
- Van Vliet, S., F. D. Provenza, and S. L. Kronberg. 2021. Health-promoting phytonutrients are higher in grass-fed meat and milk. *Frontiers in Sustainable Food Systems* 4:555426.
- Wang, E., et al. 2023. Feeding corn silage or grass hay as sole dietary forage sources: Overall mechanism of forages regulating health-promoting fatty acid status in milk of dairy cows. *Foods* 12:303.
- White, L. J., K. M. Yeater, and R. M. Lehman. 2023. Soil microorganisms respond distinctively to adaptive multi-paddock and conventional grazing in the southeastern United States. *Soil Science Society of America Journal* 87:1096–1108.
- Willett, W. C. 2002. Dietary fat plays a major role in obesity: No. *Obesity Reviews* 3:59–68.

10. RURAL REVIVAL

- Bender, S. F., C. Wagg, and M. G. A. van der Heijden. 2016. An underground revolution: Biodiversity and soil ecological engineering for agricultural sustainability. *Trends in Ecology and Evolution* 31:440–452.
- Crowder, D. W., and J. P. Reganold. 2015. Financial competitiveness of organic agriculture on a global scale. *Proceedings of the National Academy of Sciences* 112:7611–7616.
- Curl, C. L., et al. 2023. The effect of pesticide spray season and residential proximity to agriculture on glyphosate exposure among pregnant people in southern Idaho, 2021. *Environmental Health Perspectives* 131:127001.
- Delate, K., et al. 2013. The long-term agroecological research (LTAR) experiment supports organic yields, soil quality, and economic performance in Iowa. *Crop Management* 12:1–13.

SOURCES

- Delbridge, T. A., et al. 2011. Economic performance of long-term organic and conventional cropping systems in Minnesota. *Agronomy Journal* 103:1372–1382.
- Glover, J. D., J. P. Reganold, and C. M. Cox. 2012. Plant perennials to save Africa's soils. *Nature* 489:359–361.
- Hole, D. G., et al. 2005. Does organic farming benefit biodiversity? *Biological Conservation* 122:113–130.
- LaCanne, C. E., and J. G. Lundgren. 2018. Regenerative agriculture: Merging farming and natural resource conservation profitably. *PeerJ* 6:e4428.
- Lori, M., et al. 2017. Organic farming enhances soil microbial abundance and activity—a meta-analysis and meta-regression. *PLoS One* 12:e0180442.
- Mäder, P., et al. 2002. Soil fertility and biodiversity in organic farming. *Science* 296:1694–1697.
- McDaniel, M. D., L. K. Tiemann, and A. S. Grandy. 2014. Does agricultural crop diversity enhance soil microbial biomass and organic matter dynamics? A meta-analysis. *Ecological Applications* 24:560–570.
- Mhlanga, B., et al. 2022. Conservation agriculture practices drive maize yield by regulating soil nutrient availability, arbuscular mycorrhizas, and plant nutrient uptake. *Field Crops Research* 277:108403.
- Mhlanga, B., M. Mwila, and C. Thierfelder. 2021. Improved nutrition and resilience will make conservation agriculture more attractive for Zambian smallholder farmers. *Renewable Agriculture and Food Systems* 36:1–14.
- Montgomery, D. R. 2017. *Growing a Revolution: Bringing Our Soil Back to Life*. W. W. Norton.
- Öpik, M., et al. 2006. Composition of root-colonizing arbuscular mycorrhizal fungal communities in different ecosystems around the globe. *Journal of Ecology* 94:778–790.
- Park, J.-Y., et al. 2017. Evaluating the ranch and watershed scale impacts of using traditional and adaptive multi-paddock grazing on runoff, sediment and nutrient losses in North Texas, USA. *Agriculture, Ecosystems and Environment* 240:32–44.
- Qiao, L., et al. 2022. Soil quality both increases crop production and improves resilience to climate change. *Nature Climate Change* 12:574–580.
- Reganold, J. P., L. F. Elliott, and Y. L. Unger. 1987. Long-term effects of organic and conventional farming on soil erosion. *Nature* 330:370–372.
- Ricciardi, V., et al. 2021. Higher yields and more biodiversity on smaller farms. *Nature Sustainability* 4:651–657.
- Sanchez, P. A. 2002. Soil fertility and hunger in Africa. *Science* 295:2019–2020.
- Sanchez, P. A., and M. S. Swaminathan. 2005. Hunger in Africa: The link between unhealthy people and unhealthy soils. *Lancet* 365:442–444.
- Shah, T. M., et al. 2021. Intercropping in rice farming under the system of rice intensification—an agroecological strategy for weed control, better yield, increased returns, and social-ecological sustainability. *Agronomy* 11:1010.
- Tan, Z. X., R. Lal, and K. D. Wiebe. 2005. Global soil nutrient depletion and yield reduction. *Journal of Sustainable Agriculture* 26:123–146.
- Venter, Z. S., K. Jacobs, and H.-J. Hawkins. 2016. The impact of crop rotation on soil microbial diversity: A meta-analysis. *Pedobiologia* 59(4):1–9.
- Verbruggen, E., et al., 2010. Positive effects of organic farming on below-ground mutualists: Large-scale comparison of mycorrhizal fungal communities in agricultural soils. *New Phytologist* 186:968–979.
- Wood, S. A., and F. Baudron. 2018. Soil organic matter underlies crop nutritional quality and productivity in smallholder agriculture. *Agriculture, Ecosystems and Environment* 266:100–108.
- Woolf, D., D. Solomon, and J. Lehmann. 2018. Land restoration in food security programmes: Synergies with climate change mitigation. *Climate Policy* 18:1260–1270.

SOURCES

Zuber, S. M., and M. B. Villamil. 2016. Meta-analysis approach to assess effect of tillage on microbial biomass and enzyme activities. *Soil Biology and Biochemistry* 97:176–187.

11. FROM THE GROUND UP

Jeffery, S., and F. G. A. Verheijen. 2020. A new soil health policy paradigm: Pay for practice not performance! *Environmental Science and Policy* 112:371–373.

Kassam, A., T. Friedrich, and R. Derpsch. 2022. Successful experiences and lessons from conservation agriculture worldwide. *Agronomy* 12:769.

Liebman, M., et al. 2013. Using biodiversity to link agricultural productivity with environmental quality: Results from three field experiments in Iowa. *Renewable Agriculture and Food Systems* 28:115–128.

Montgomery, D. R. 2010. Soil. *Nature* 463:31–32.

Zhou, Q., et al. 2022. Recent rapid increase of cover crop adoption across the U.S. Midwest detected by fusing multi-source satellite data. *Geophysical Research Letters* 49:e2022GL100249.

12. A GREENER REVOLUTION

Averill, C., et al. 2022. Defending Earth's terrestrial microbiome. *Nature Microbiology* 7:1717–1725.

Montgomery, D. R. 2007. Soil erosion and agricultural sustainability. *Proceedings of the National Academy of Sciences* 104:13268–13272.

Montgomery, D. R., P. Rabinowitz, Y. Sipos, and E. E. Wheat. 2024. Soil health: A common focus for one health and planetary health interventions. *One Health* 18:100673.

Oldfield, E. E., M. A. Bradford, and S. A. Wood. 2019. Global meta-analysis of the relationship between soil organic matter and crop yields. *SOIL* 5:15–32.

Pittelkow, C. M., et al. 2015. Productivity limits and potentials of the principles of conservation agriculture. *Nature* 517:365–368.

Richardson, K., et al. 2023. Earth beyond six of nine planetary boundaries. *Science Advances* 9:eadh245.

Schreefel, L., et al. 2020. Regenerative agriculture—the soil is the base. *Global Food Security* 26:100404.

Singh, J. S. 2015. Microbes: The chief ecological engineers in reinstating equilibrium in degraded ecosystems. *Agriculture, Ecosystems and Environment* 203:80–82.