Does prescribed burning increase soil carbon sequestration in grasslands?

Evidence suggests **prescribed burning usually does not increase – and can often reduce – soil carbon stocks** in grasslands, with some system-specific exceptions.

FIGURE 1 Overall research consensus on prescribed burning and soil carbon.

Global and Grassland-Focused Evidence

- A global grassland meta-analysis (235 sites) found that **burning decreased soil organic carbon (SOC) by ~9% on average**, with only 31% of cases showing increases, especially in moist–humid climates where losses were larger (Mutema et al., 2021).
- Another meta-analysis across ecosystems reported that **frequent prescribed fire generally showed little net effect on soil C**, but fire (especially infrequent/high-severity) often **reduced SOC in upper layers** and recovery after repeated fire was limited within 20 years (Xu et al., 2022).
- A 64-year humid subtropical grassland experiment showed **annual burning reduced SOC by 5% and N by 12% in the top 30 cm and increased soil CO_2 efflux** relative to unburned plots, indicating net C loss (Abdalla et al., 2021).
- In long-term grazing-excluded steppe in Inner Mongolia, prescribed fire **decreased 0–30 cm soil C**, most strongly under frequent burning, and altered C distribution among particle-size fractions (Nianpeng et al., 2012).

Important Exceptions and Nuance

- In a South African mesic rangeland, **early-season, frequent prescribed burns (with grazing excluded) increased SOC concentrations and subsoil C sequestration below 5 cm over 20 years**, suggesting some fire-dependent mesic grasslands can gain soil C under particular regimes (Nicolay et al., 2025).
- A global management meta-analysis found **burning had mixed effects, with short-term burns sometimes promoting C accumulation but frequent burning causing C loss** (Murindangabo et al., 2025).
- Several studies show prescribed fire can **reduce soil respiration in the short term**, which may partially offset aboveground C losses but does not consistently translate into higher long-term SOC (De La Cruz Domínguez et al., 2024; Godwin et al., 2017; Fultz et al., 2016; Pellegrini et al., 2021).

Summary Table

Pattern	Typical SOC effect	Notes	Citations
Frequent/long-term burning	Decrease	Humid & subtropical grasslands	(Mutema et al., 2021; Nianpeng et al., 2012; Xu et al., 2022; Abdalla et al., 2021)
Short-term/low-severity burns	Neutral to slight increase	Effects often transient, context-dependent	(Nicolay et al., 2025; Mutema et al., 2021; Murindangabo et al., 2025; Úbeda et al., 2005)
Mesic, fire-dependent systems (grazing excluded)	Possible increase	Careful timing/frequency critical	(Nicolay et al., 2025; Nicolay et al., 2024)

FIGURE 2 Context-dependent SOC responses to prescribed fire.

Conclusion

Across grasslands globally, prescribed burning more often **reduces or does not change** soil carbon sequestration; clear increases occur only in specific mesic, fire-adapted systems under carefully managed regimes (often without grazing).

These papers were sourced and synthesized using Consensus, an AI-powered search engine for research. Try it at https://consensus.app

References

Nicolay, R., Tedder, M., Mkhize, N., & Kirkman, K. (2025). Frequent Prescribed Burning Contributes to the Sequestration of Soil Carbon in South African Mesic Rangeland Systems. *African Journal of Ecology*. https://doi.org/10.1111/aje.70063

Mutema, M., Buthelezi, N., Muchaonyerwa, P., Cerri, C., & Chaplot, V. (2021). On the impact of grassland management on soil carbon stocks: a worldwide meta-analysis. *Geoderma Regional*. https://doi.org/10.1016/j.geodrs.2021.e00479

De La Cruz Domínguez, J., Reyna, T., Gutierrez, C., Moreno, V., & Balbuena, J. (2024). Effects of Prescribed Burns on Soil Respiration in Semi-Arid Grasslands. *Fire*. https://doi.org/10.3390/fire7120450

Nianpeng, ., Xingguo, ., Guirui, ., & Jingzhong, . (2012). Effects of prescribed fire on carbon sequestration of long-term grazing-excluded grasslands in Inner Mongolia. *Acta Ecologica Sinica*, 32, 4388-4395. https://doi.org/10.5846/stxb201106270956

Godwin, D., Kobziar, L., & Robertson, K. (2017). Effects of Fire Frequency and Soil Temperature on Soil CO2 Efflux Rates in Old-Field Pine-Grassland Forests. *Forests*, 8, 274. https://doi.org/10.3390/f8080274

Xu, S., Eisenhauer, N., Pellegrini, A., Wang, J., Certini, G., Guerra, C., & Lai, D. (2022). Fire frequency and type regulate the response of soil carbon cycling and storage to fire across soil depths and ecosystems: A meta-analysis.. *The Science of the total environment*, 153921. https://doi.org/10.1016/j.scitotenv.2022.153921

Murindangabo, Y., Frouz, J., Frouzová, J., Bartuška, M., & Mudrák, O. (2025). Synergistic interplay of management practices and environmental factors in shaping grassland soil carbon stocks: Insights into the effects of fertilization, mowing, burning, and grazing.. *Journal of environmental management*, 382, 125236. https://doi.org/10.1016/j.jenvman.2025.125236

Fultz, L., Moore-Kucera, J., Dathe, J., Davinić, M., Perry, G., Wester, D., Schwilk, D., & Rideout-Hanzak, S. (2016). Forest wildfire and grassland prescribed fire effects on soil biogeochemical processes and microbial communities: Two case studies in the semi-arid Southwest. *Applied Soil Ecology*, 99, 118-128. https://doi.org/10.1016/j.apsoil.2015.10.023

Pellegrini, A., Harden, J., Georgiou, K., Hemes, K., Malhotra, A., Nolan, C., & Jackson, R. (2021). Fire effects on the persistence of soil organic matter and long-term carbon storage. *Nature Geoscience*, 15, 5 - 13. https://doi.org/10.1038/s41561-021-00867-1

Úbeda, X., Lorca, M., Outeiro, L., Bernia, S., & Castellnou, M. (2005). Effects of prescribed fire on soil quality in Mediterranean grassland (Prades Mountains, north-east Spain). *International Journal of Wildland Fire*, 14, 379-384. https://doi.org/10.1071/wf05040

Abdalla, K., Chivenge, P., Ciais, P., & Chaplot, V. (2021). Long-term (64 years) annual burning lessened soil organic carbon and nitrogen content in a humid subtropical grassland. *Global Change Biology*, 27, 6436 - 6453. https://doi.org/10.1111/gcb.15918

Nicolay, R., Mkhize, N., Tedder, M., & Kirkman, K. (2024). Fire suppression interacts with soil acidity to maintain stable recalcitrant pyrogenic carbon fractions in South African mesic grasslands soil. *African Journal of Range & Forage Science*, 41, 204 - 212. https://doi.org/10.2989/10220119.2024.2355909