

ASSESSING POTENTIAL LONG-TERM CHANGES IN SOUTHERN APPALACHIAN MOUNTAIN FOREST SOIL CHEMISTRY FROM REPEATED USE OF FUEL REDUCTION TREATMENTS

Christopher J. Dukes, T. Adam Coates, Donald L. Hagan,
W. Michael Aust, Thomas A. Waldrop, and Dean M. Simon

Extended abstract—In 1999, the national Fire and Fire Surrogate study was undertaken to address concerns regarding wildfire hazard reduction and the restoration of forest structure and function in many fire-excluded locations nationwide (Coates and others 2010, Schwilk and others 2009). Thirteen regions were included in this nationwide project, including the Southern Appalachian Mountains, with study sites located on the Green River Game Lands near Hendersonville, NC. As fuel reduction treatments were implemented across the country, a broad array of ecosystem properties and processes were measured and monitored to determine potential treatment effects, including soil chemistry.

The fuel reduction treatments implemented for the Southern Appalachian Mountains Fire and Fire Surrogate study included prescribed burning only, cutting only, and a combination of cutting and burning. Three replications of each treatment and three untreated controls were established in 2001. The initial cutting operation was conducted from December 2001–March 2002. All trees >1.8 m tall and <10.2 cm diameter at breast height (d.b.h.) were felled by chainsaw crews. All shrubs were cut and piled (piles <1.3 m high). The initial prescribed burns for the burn-only and combination treatments were conducted in March 2003 and consisted of strip headfires and spot fires that produced mean flame lengths of 2 m or less (Tomcho 2004).

Soils (Clifffield and Evard series, Ultisols) were sampled within the treated areas and adjacent controls in 2005 to determine short-term post-treatment forest soil responses (Coates and others 2010). This included assessments of O horizon and mineral soil (0- to 10-cm depth) carbon (C), nitrogen (N), and C:N ratios; and mineral soil bulk density, pH, aluminum (Al), boron (B), calcium (Ca), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), phosphorus (P), potassium (K), soluble sulfur (S), sodium (Na), zinc (Zn), N mineralization, nitrification, and proportional nitrification. Briefly, Coates and others (2010) determined that a few soil properties and processes were affected 3 to 4 years post-treatment in 2005. Mean soil pH differed significantly ($p = 0.0457$) between the cutting-only treatments ($pH = 4.60$) and the control ($pH = 4.72$). Soil Fe for the combination treatment (93.38 mg kg^{-1}) and control ($113.36 \text{ mg kg}^{-1}$) differed significantly ($p = 0.0143$) in 2005 (note that soil Fe values were highly variable prior to treatment and between the replications). Although statistically significant, these results were thought to have little biological meaning (Coates and others 2010).

Since that time, additional treatments have been conducted: prescribed fire only in 2006, 2012, and 2015; cutting only in 2012; and a combination of cutting and burning in 2012. Long-term treatment impacts on overstory and understory vegetation and fuels have been evaluated (Oakman and others 2019, Waldrop and others 2016), but soils have not been re-assessed. Few long-term soils research studies have been implemented in the Southern Appalachian Mountains, particularly ones that address potential long-term impacts of repeated prescribed fire (Callahan and others 2012). This lack of knowledge comes in light of an increase in prescribed fire acreage goals within portions of the Appalachian region (Brose and others 2001, Lorber and others 2018, Melvin 2018).

Wildland fires may impact forest soils, but potential impacts are difficult to characterize and are uniquely site specific. Soil responses to wildland fire may be related to aboveground vegetation, fire intensity and severity, time since fire when sampling occurs, method of soil sampling, soil sampling depth, and other factors (Alcañiz and others 2018, Coates and others 2018, Fairchild and Trettin 2006, Hahn and others 2019). As a result of this lack

Author information: Christopher J. Dukes, Graduate Research Assistant, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061; T. Adam Coates, Assistant Professor, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061; Donald L. Hagan, Assistant Professor, Clemson University, Clemson, SC 29634; W. Michael Aust, Professor, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061; Thomas A. Waldrop, Team Leader (retired), U.S. Department of Agriculture, Forest Service, Southern Research Station, Center for Forest Disturbance Science, Clemson, SC 29634; and Dean M. Simon, North Carolina Wildlife Resources Commission, Lawndale, NC 28090.

Citation for proceedings: Bragg, Don C.; Koerth, Nancy E.; Holley, A. Gordon, eds. 2020. Proceedings of the 20th Biennial Southern Silvicultural Research Conference. e–Gen. Tech. Rep. SRS–253. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 338 p.

of knowledge, soils were re-sampled at this site in summer 2018. O horizon and mineral soil C, N, and C:N and mineral soil Ca, Mg, K, P, and pH will be assessed to determine if there were significant chemical changes from 2001 to 2018.

With this research, we hope to better understand how soils respond to long-term implementation of fuel reduction treatments in the Appalachian region. This will ensure that soil conservation is incorporated into long-term management strategies. Additionally, we hope to distinguish potential relationships between vegetation, fuels, and soil properties that might better inform restoration goals and objectives in light of prescriptions and recommendations.

LITERATURE CITED

- Alcañiz, M.; Outeiro, L.; Francos, M.; Ubeda, X. 2018. Effects of prescribed fires on soil properties: a review. *Science of the Total Environment*. 613–614: 944–957. <https://doi.org/10.1016/j.scitotenv.2017.09.144>.
- Brose, P.; Schuler, T.; Van Lear, D.; Berst, J. 2001. Bringing fire back: the changing regimes of the Appalachian mixed-oak forests. *Journal of Forestry*. 99(11): 30–35.
- Callahan, M.A., Jr.; Scott, D.A.; O'Brien, J.J.; Stanturf, J.A. 2012. Cumulative effects of fuel management on the soils of Eastern U.S. watersheds. In: Lafayette, R.; Brooks, M.T.; Potyondy, J.P. [and others], eds. *Cumulative watershed effects of fuel management in the Eastern United States*. Gen. Tech. Rep. SRS-161. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 202–228. Chapter 10.
- Coates, T.A.; Hagan, D.L.; Aust, W.M. [and others]. 2018. Mineral soil chemical properties as influenced by long-term use of prescribed fire with differing frequencies in a southeastern Coastal Plain pine forest. *Forests*. 9: 739. 14 p. <https://doi.org/10.3390/f9120739>.
- Coates, T.A.; Shelburne, V.B.; Waldrop, T.A. [and others]. 2010. Forest soil response to fuel reduction treatments in the Southern Appalachian Mountains. In: Stanturf, J.A., ed. *Proceedings of the 14th biennial southern silvicultural research conference*. Gen. Tech. Rep. SRS-121. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 283–287.
- Fairchild, L.H.; Trettin, C.C. 2006. History of fire effects in the South Carolina piedmont and coastal regions. Gen. Tech. Rep. SRS-98. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 27 p.
- Hahn, G.E.; Coates, T.A.; Latham, R.E.; Majidzadeh, H. 2019. Prescribed fire effects on water quality and freshwater ecosystems in moist-temperate Eastern North America. *Natural Areas Journal*. 39(1): 46–57. <https://doi.org/10.3375/043.039.0104>.
- Lorber, J.; Thomas-Van Gundy, M.; Croy, S. 2018. Characterizing effects of prescribed fire on forest canopy cover in the George Washington and Jefferson National Forests. Res. Pap. NRS-31. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 30 p. <https://doi.org/10.2737/NRS-RP-31>.
- Melvin, M.A. 2018. 2018 National Prescribed Fire Use Survey report. Tech. Rep. 03-18. Coalition of Prescribed Fire Councils. 23 p. <http://www.prescribedfire.net>. [Date accessed: June 8, 2019].
- Oakman, E.C.; Hagan, D.L.; Waldrop, T.A.; Barrett, K. 2019. Understory vegetation responses to 15 years of repeated fuel reduction treatments in the Southern Appalachian Mountains, USA. *Forests*. 10(4): 350. 21 p. <https://doi.org/10.3390/f10040350>.
- Schwilk, D.W.; Keeley, J.E.; Knapp, E.E. [and others]. 2009. The national Fire and Fire Surrogate study: effects of fuel reduction methods on forest vegetation structure and fuels. *Ecological Applications*. 19(2): 285–304. <https://doi.org/10.1890/07-1747.1>.
- Tomcho, A.L. 2004. Effects of prescribed fire and understory removal on bird communities in a Southern Appalachian forest. M.S. thesis. Clemson, SC: Clemson University. 72 p.
- Waldrop, T.A.; Hagan, D.L.; Simon, D.M. 2016. Repeated application of fuel reduction treatments in the Southern Appalachian Mountains, USA: implications for achieving management goals. *Fire Ecology*. 12(2): 28–47.