nature sustainability

MATTERS ARISING

https://doi.org/10.1038/s41893-020-0580-z

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W. W. Oswald et al. reply

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REPLYING TO M. D. Abrams and G. J. Nowacki *Nature Sustainability* https://doi.org/10.1038/s41893-020-0578-6 (2020)
REPLYING TO C. I. Roos *Nature Sustainability* https://doi.org/10.1038/s41893-020-0579-5 (2020).

Commentaries on our recent paper[1] by Roos[2] and Abrams and Nowacki[3] misconstrue the study's goal, methods and findings. Here, we clarify the misunderstandings, focusing in particular on the flaws in the "mesophication" hypothesis that Abrams and Nowacki use to discount our work, and the fallibility of European accounts commonly relied on to reconstruct the ecological conditions and Indigenous subsistence activities that existed in southern New England (SNE) before European arrival.

Our goal was to test what has become the conventional understanding of human–environment interactions in pre-contact SNE. These quotes, from an earlier paper by Abrams and Nowacki[4] and from Charles Mann's best-selling book *1491*[5], exemplify this understanding of the region's past:

"[W]e believe that the vast majority of vegetation in the eastern USA was managed directly or indirectly by Native Americans, especially through the use of fire"[4].

"At the time of Columbus the Western Hemisphere had been thoroughly painted with the human brush… The forests of the eastern seaboard had been peeled back from the coasts, which were now lined with farms"[5].

This anthropogenic paradigm exerts a strong influence on modern conservation practices in SNE, including the use of fire to maintain open-land vegetation and its associated biodiversity.

We can appreciate how proponents of this paradigm arrived at this understanding. In parts of the Americas, Indigenous people had major ecological impacts. For example, the Maya deforested much of the Meso-American landscape, supporting a large, settled population with agriculture[6]. In interior areas of eastern North America, some Native groups farmed intensively around large villages for at least the few centuries immediately preceding European arrival[7]. However, as we assert in our paper, painting all regions with one "human brush" ignores "great geographical and temporal variation in the importance of human versus environmental controls on ecosystem patterns and processes"[1]. It also trivializes the great diversity among Indigenous peoples. Abrams and Nowacki's and Mann's portrayals extend those of Day[8], Cronon[9] and Whitney[10], who drew on sixteenth- to nineteenth-century European perceptions to interpret SNE as a humanized landscape, burned regularly and "lined with farms". Given that context, our study examined a specific place, scale and question: we asked whether the use of fire and agriculture by pre-contact Native Americans in SNE had major, regional ecological impacts. Our team of archaeologists and palaeoecologists developed an interdisciplinary dataset spanning the last 14,000 years, allowing us to address this question.

Roos misrepresents the project's nested study design. For 13 study sites located across SNE, we developed records of lake-sediment pollen and macroscopic charcoal for the past 9,600–14,000 years. Those palaeoecological data were compared with two reconstructions (for the northeastern US and for coastal SNE) of relative human population, both of which indicate high populations during the Late Archaic and Middle to Late Woodland periods. The regional-scale story is clear and consistent. The pollen data reflect closed-canopy forests of oak, pine and beech from 8,000 yr BP until the seventeenth century. Open vegetation is distinct in the pollen record (that is, relatively high pollen abundance of ragweed and grass), but restricted to one period of dry climate 10,000–8000 yr BP and a second period following European deforestation. The charcoal data suggest elevated fire activity during those two periods when the landscape was open, but not during the intervening periods of elevated Native population. We conducted a more-detailed analysis for the coastal area for the last 2,000 years, employing 21 palaeoecological records and archaeological data from >1,800 sites. During the Middle to Late Woodland, the period of highest Native American populations of the last 14,000 years, there is no pollen or charcoal evidence for regionally extensive human impacts or open-land vegetation. Meanwhile, the archaeological data indicate that horticulture played a minor role in subsistence. Thus, there is no evidence for forest clearance, widespread farming or increased fire associated with larger Native populations.

Abrams and Nowacki reject our conclusions out of hand, unable to align our interdisciplinary results with their long-standing belief that oak and pine are "pyrogenic species" and that the cessation of Native American burning with European arrival led to a "mesophication" of eastern US forests characterized by a decline in those two taxa and an increase in more shade-tolerant and fire-intolerant species[11]. In fact, our work and other studies refute their persistent hypothesis. The "tension zone" that separates oak-dominated SNE from the hemlock, beech and birch forests of northern New England[12] arose at 8,000 yr BP[13], a time of declining fire activity, low human populations and rising moisture in SNE. Over subsequent millennia, the region became increasingly moist with corresponding changes in forest composition[14] and with low fire activity through the periods of greatest Native human population[1]. European arrival and forest clearance brought about an increase in fire and major declines in beech and hemlock, two quintessentially shade-tolerant, fire-prone species[15]. While oak and pine do tolerate many physical disturbances—including fire, repeated harvesting and land clearance—better than species such as hemlock and beech, there is no

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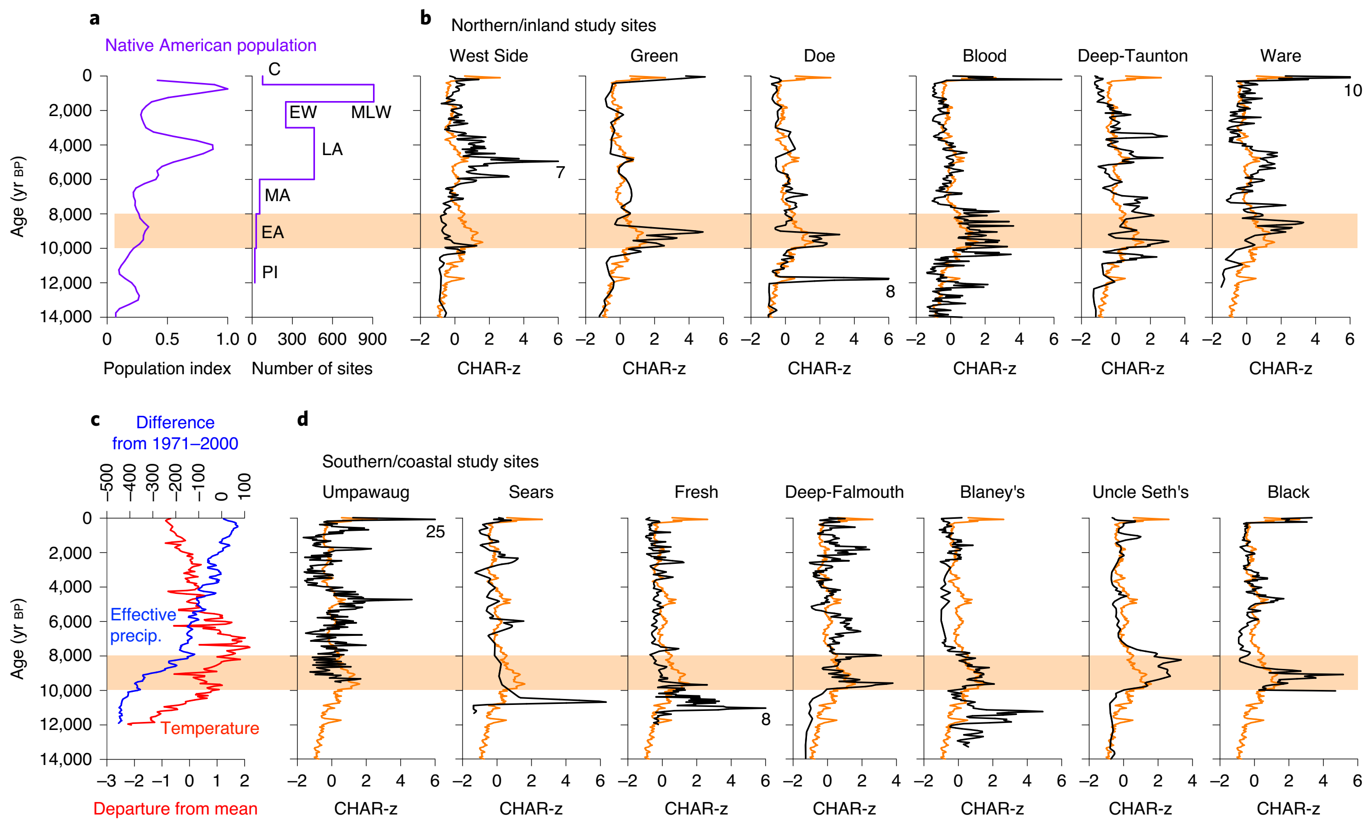

Fig. 1 | Postglacial palaeoenvironmental and archaeological data from SNE. a, Left: index of past changes in the relative size of the Indigenous human population of the northeastern US over the past 14,000 years. Note that an incorrect version of this dataset appeared in our paper[1] in Figs. 2c and 4d, erroneously showing an index value of zero at 0 yr BP. Right: numbers of archaeological sites in the coastal region of SNE during different periods: PI, Palaeo-Indian; EA, Early Archaic; MA, Middle Archaic; LA, Late Archaic; EW, Early Woodland; MLW, Middle–Late Woodland; C, Colonial. **b**, Lake-sediment charcoal data from six sites in the northern/inland part of the study area. CHAR-z values are *z* scores of charcoal accumulation rates (pieces cm^{-2} yr^{-1}) interpolated at 50-yr intervals and based on the means and standard deviations for the period >500 yr BP. The black lines are the data from each site; the orange lines are the mean for all 13 charcoal records. Numbers are shown for CHAR-z values exceeding the *x* axis. **c**, The blue line is a reconstruction of effective precipitation (mm yr^{-1}) for SNE; the red line is a sea surface temperature reconstruction from site GGC30 (°C). **d**, Lake-sediment charcoal data from seven sites in the southern/coastal part of the study area, plotted as in **b**. In all graphs, the orange shading marks the 10,000–8,000 yr BP period of elevated fire activity and open *Quercus* woodlands across the region. See Oswald et al.[1] for references.

evidence that they are solely reliant on fire. Instead, various studies provide strong support that oak and pine respond to a complex of factors, such as climatic variability and myriad disturbances, including land use[16,17]. Thus, the forest changes observed in SNE over the last 150 years are not driven by fire suppression, as is the case in many parts of western North America, but instead are controlled primarily by post-agriculture successional dynamics[18] interacting with the long-term trend of increasing moisture[14,16].

Roos suggests that, by calculating charcoal averages, we overlook the signal of Native American "fire management". We presented average values to highlight regional patterns, as that is the scale of the question we set out to test. We also plotted the data from all 13 charcoal records, and we can examine them individually (Fig. 1). The charcoal data feature a substantial amount of variability. However, two features—high values at 10,000–8,000 yr BP and after European colonization—are shared by multiple records and are interpretable in terms of climate and land-use history. Abrams and Nowacki claim that we "ignored at least 15–20 sites in the study area with clear evidence of frequent pre-European fires", but they fail to provide a single citation or any data to support this assertion. The two palaeoecological studies that Abrams and Nowacki cite to support their claim of widespread Native use of fire in SNE do not appear in peer-reviewed journals[19,20].

Both Roos and Abrams and Nowacki overlook our evidence for, and discussion of, local-scale ecological impacts, including fire. We wrote:

"Middle–Late Woodland subsistence practices, such as hunting, fishing, plant gathering and small-scale farming (Fig. 1b), apparently resulted in local ecological impacts without transforming the broader forested landscape"[1].

"Archaeological evidence indicates a dense pre-contact population that utilized a range of upland, estuarine, near-shore and marine resources (Fig. 1b), undoubtedly resulting in fine-scale ecological impacts. Charcoal peaks at some sites (4 of 13) during the Late Archaic and, to a lesser extent (2 of 21), the Middle–Late Woodland suggest a dispersed pattern of fire that may represent local human influence"[1].

Given the large population and widespread distribution of Native American groups before contact, it seems highly likely that people set some wildfires, purposefully or accidentally. Compared with charcoal records from various forest types and fire regimes across North America[21–24], the charcoal accumulation rates in our records are relatively high (averaging >5 pieces cm^{-2} yr^{-1}), probably reflecting low-severity surface fires with incomplete combustion of fuels. However, we conclude that to understand the spatial and temporal dynamics of SNE forests there is no need to invoke the impacts of Native Americans, except at local scales. This study and our other recent work show that shifts in temperature and moisture, interacting with the inland-coast environmental gradient and soil variability, explain the patterns of forest composition throughout the postglacial interval[13,14].

How then do we reconcile this understanding of the pre-contact landscape of SNE with historical accounts suggesting widespread burning and farming by Native Americans? As discussed by many scholars, the early European reports were few, dispersed, varied and influenced by economic and sociopolitical agendas[25]. Much was unfamiliar for European observers, including the subsistence practices of the region's Native people and the ecology of its landscapes; descriptions of coastal meadows probably refer to SNE's ubiquitous salt marshes rather than Native farms. While some accounts describe settled villages with large open fields, other writings, such as this from Josselyn in 1674, paint a contrasting picture: "Towns they have none, being always removing from one place to another for conveniency of food. … I have seen half a hundred of their Wigwams together in a piece of ground and within a day or two, or a week they have all been dispersed"[26]. This and similar accounts underscore the mobility of Native peoples in this region, consistent with the archaeological record; there is no evidence for permanent villages, fortifications or intensive farming before European contact[27].

Moreover, all European accounts post-date contact (Cronon[9], for example, cites observations as late as 1796 to 1817 by Yale President Timothy Dwight) and describe cultures under transition. Since the early 1500s, thousands of Europeans interacted with Indigenous people along the northeastern US coast; this explains why in 1602 Gosnold encountered Native Americans off Martha's Vineyard paddling a Biscay shallop, wearing pantaloons and shouting "Hallo!"[28]. Europeans disrupted Native society through disease, violence and access to new materials and technologies. As a result of these upheavals, Native peoples concentrated at settled coastal locations, becoming increasingly sedentary and reliant on agriculture for food and trade[29]. European accounts of Native American lifestyle and subsistence are, by definition, post-contact and shaped by European influences. Archaeological and palaeoecological studies provide a more complete means for understanding the complex pre-contact cultural and natural landscapes of SNE. Thus, there is an irony in the suggestion that our findings are an affront to Native Americans when previous interpretations of thousands of years of Native culture were based on the narrow perspectives of European observers in the process of colonizing the land and people[8–10].

Throughout the Americas, various lines of evidence, including the archaeological record, palaeoecological data and oral histories, demonstrate complex human–environment dynamics over thousands of years. Eastern North America provides an instructive example of how those dynamics arise and vary across time and space through the interactions of the regional landscape, variations in natural resources and human agency. When maize arrived in the region during the late Holocene, it was embraced by Iroquoian-speaking people (including the Seneca, as mentioned by Abrams and Nowacki) in southern Ontario and upstate New York. Those Native peoples cleared forests with fire[22,30], farmed maize intensively and lived in large villages for decades at a time[7]. In SNE, however, horticulture remained supplemental to native foods obtained through seasonal movement across the landscape, including abundant resources from coastal waters, and thus widespread forest clearance and intensive use of fire were not required. Over more than 10,000 years of unfolding environmental challenges, these varied and flexible subsistence activities allowed the Native peoples of SNE to develop widespread, complex and highly successful societies[27,31].

Data availability

The data that support the findings of this study are available from the corresponding author upon request.

Received: 3 April 2020; Accepted: 18 June 2020;
Published online: 20 July 2020

References

1. Oswald, W. W. et al. Conservation implications of limited Native American impacts in pre-contact New England. *Nat. Sustain.* **3**, 241–246 (2020).
2. Roos, C. I. Scale in the study of Indigenous burning. *Nat. Sustain.* https://doi.org/10.1038/s41893-020-0579-5 (2020).
3. Abrams, M. D. & Nowacki, G. J. Native American imprint in palaeoecology. *Nat. Sustain.* https://doi.org/10.1038/s41893-020-0578-6 (2020).
4. Abrams, M. D. & Nowacki, G. J. Native Americans as active and passive promoters of mast and fruit trees in the eastern USA. *Holocene* **18**, 1123–1137 (2008).
5. Mann, C. C. *1491: New Revelations of the Americas Before Columbus* (Knopf, 2005).
6. Canuto, M. A. et al. Ancient lowland Maya complexity as revealed by airborne laser scanning of northern Guatemala. *Science* **361**, 1355–1371 (2018).
7. Snow, D. *The Iroquois* (Wiley-Blackwell, 1996).
8. Day, G. M. The Indian as an ecological factor in the northeastern forest. *Ecology* **34**, 329–346 (1953).
9. Cronon, W. *Changes in the Land: Indians, Colonists, and the Ecology of New England* (Hill & Wang, 1983).
10. Whitney G. G. *From Coastal Wilderness to Fruited Plain* (Cambridge Univ. Press, 1994).
11. Nowacki, G. J. & Abrams, M. D. The demise of fire and "mesophication" of forests in the eastern United States. *BioScience* **58**, 123–138 (2008).
12. Cogbill, C. V., Burk, J. & Motzkin, G. The forests of presettlement New England, USA: spatial and compositional patterns based on town proprietor surveys. *J. Biogeogr.* **29**, 1279–1304 (2002).
13. Oswald, W. W. et al. Subregional variability in the response of New England vegetation to postglacial climate change. *J. Biogeogr.* **45**, 2375–2388 (2018).
14. Shuman, B. N., Marsicek, J., Oswald, W. W. & Foster, D. R. Predictable hydrological and ecological responses to Holocene North Atlantic variability. *Proc. Natl Acad. Sci. USA* **116**, 5985–5990 (2019).
15. Foster, D. R., Motzkin, G. & Slater, B. Land-use history as long-term broad-scale disturbance: regional forest dynamics in central New England. *Ecosystems* **1**, 96–119 (1998).
16. McEwan, R. W., Dyer, J. M. & Pederson, N. Multiple interacting ecosystem drivers: toward an encompassing hypothesis of oak forest dynamics across eastern North America. *Ecography* **34**, 244–256 (2011).
17. Pederson, N. et al. Climate remains an important driver of post-European vegetation change in the eastern United States. *Glob. Change Biol.* **20**, 2105–2110 (2014).
18. Thompson, J. R., Carpenter, D. N., Cogbill, C. V. & Foster, D. R. Four centuries of change in northeastern United States forests. *PLoS ONE* **8**, e72540 (2013).
19. Patterson, W. A. III in *Fire in Eastern Oak Forests: Delivering Science to Land Managers* (ed. Dickinson, M. B.) 2–19 (US Department of Agriculture, Forest Service, Northern Research Station, 2006).
20. Patterson, W. A. III & Sassaman, K. E. in *Holocene Human Ecology in Northeastern North America* (ed. Nicholas, G. P.) 107–135 (Plenum, 1988).
21. Marlon, J., Bartlein, P. J. & Whitlock, C. Fire–fuel–climate linkages in the northwestern USA during the Holocene. *Holocene* **16**, 1059–1071 (2006).
22. Munoz, S. E. & Gajewski, K. Distinguishing prehistoric human influence on late-Holocene forests in southern Ontario, Canada. *Holocene* **20**, 967–981 (2010).
23. Lynch, E. A., Hotchkiss, S. C. & Calcote, R. Charcoal signatures defined by multivariate analysis of charcoal records from 10 lakes in northwest Wisconsin (USA). *Quat. Res.* **75**, 125–137 (2011).
24. Calder, W. J. et al. Medieval warming initiated exceptionally large wildfire outbreaks in the Rocky Mountains. *Proc. Natl Acad. Sci. USA* **112**, 13261–13266 (2015).
25. Chilton, E. S. in *Northeast Subsistence-Settlement Change: A.D. 700–A.D. 1300* (eds Hart, J. & Reith, C.) 289–300 (New York State Museum, 2002).
26. Josselyn, J. *Two Voyages to New England* (E. W. Metcalf & Co., 1833).
27. Chilton, E. S. in *Ancient Complexities: New Perspectives in Pre-Columbian North America* (ed. Alt, S.) 96–103 (Univ. of Utah Press, 2010).
28. Archer, G. *Gosnold's Settlement at Cuttyhunk* (Old South Work, 1902).
29. Thomas, P. A. *In the Maelstrom of Change: The Indian Trade and Cultural Process in the Middle Connecticut River Valley 1635–1665*. PhD thesis, Univ. of Massachusetts, Amherst (1979).
30. Clark, J. S. & Royall, P. D. Transformation of a northern hardwood forest by aboriginal (Iroquois) fire: charcoal evidence from Crawford Lake, Ontario, Canada. *Holocene* **5**, 1–9 (1995).
31. Chilton, E. S. in *Oxford Handbook of North American Archaeology* (ed. Pauketat, T.) 262–272 (Oxford Univ. Press, 2012).

Author contributions
W.W.O. and D.R.F. wrote the first version of the paper. W.W.O., D.R.F., B.N.S., E.S.C., D.L.Doucette and D.L.Duranleau contributed to the final version.

Competing interests
The authors declare no competing interests.

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