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DISCUSSION

Comment on “Long-term decline of sugar maple following forest harvest, Hubbard Brook Experimental Forest, New Hampshire”[1]

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Abstract: Cleavitt et al. (2018, Can. J. For. Res. **48**(1): 23–31, doi:10.1139/cjfr-2017-0233) report a lack of sugar maple (*Acer saccharum* Marsh.) regeneration in Hubbard Brook Experimental Forest (HBEF), Watershed 5 (W5), following whole-tree clearcut harvesting and purport that harvesting-induced soil calcium depletion contributed to regeneration failure of this species. In New England, clearcutting is a silvicultural strategy used to promote less tolerant species, especially birch (*Betula* spp.; Marquis (1969), Birch Symposium Proceedings, USDA Forest Service; Leak et al. (2014), doi:10.2737/NRS-GTR-132), which is just the outcome that the authors report. While this study reports an impressive, long-term data set, given broad interest in sugar maple and sustainability of forest management practices, we feel that it is critical to more fully explore the role of nutrition on sugar maple dynamics, both prior to and during the experiment, and to more fully review the scientific record on the role of whole-tree clearcutting in nutrient-induced sugar maple dynamics.

Key words: sugar maple, whole-tree harvest, management implications, regeneration, calcium.

Résumé : Cleavitt et al. (2018, Can. J. For. Res. **48**(1): 23–31, doi:10.1139/cjfr-2017-0233) indiquent qu’il y a un problème de régénération de l’érable à sucre (*Acer saccharum* Marsh.) à la forêt expérimentale de Hubbard Brook dans le bassin versant 5 à la suite d’une coupe à blanc par arbre entier et prétendent que l’appauvrissement du sol en calcium causé par la récolte a contribué à l’échec de la régénération de cette espèce. En Nouvelle-Angleterre, la coupe à blanc est une stratégie sylvicole utilisée pour favoriser les espèces moins tolérantes, particulièrement le bouleau (*Betula* spp.; Marquis (1969), Birch Symposium Proceedings, USDA Forest Service; Leak et al. (2014), doi:10.2737/NRS-GTR-132), ce qui correspond justement au résultat que rapportent les auteurs. Alors que cette étude présente un ensemble impressionnant de données à long terme, étant donné qu’il y a un vaste intérêt pour l’érable à sucre et la durabilité des pratiques d’aménagement forestier, nous croyons qu’il est essentiel d’explorer davantage le rôle de la nutrition sur la dynamique de l’érable à sucre, tant avant que durant l’expérience, et de revoir en profondeur les données scientifiques sur le rôle de la coupe à blanc par arbre entier sur la dynamique de l’érable à sucre engendrée par les éléments nutritifs. [Traduit par la Rédaction]

Mots-clés : érable à sucre, récolte par arbre entier, conséquences de l’aménagement, régénération, calcium.

Cleavitt et al. (2018) report a lack of sugar maple (*Acer saccharum* Marsh.) regeneration in Hubbard Brook Experimental Forest (HBEF), Watershed 5 (W5), following whole-tree clearcut harvesting and purport that harvesting-induced soil calcium depletion contributed to regeneration failure of this species. In New England, clearcutting is a silvicultural strategy used to promote less tolerant species, especially birch (*Betula* spp.; Marquis 1969; Leak et al. 2014), which is just the outcome that the authors report. While this study reports an impressive, long-term data set, given broad interest in sugar maple and sustainability of forest management practices, we feel that it is critical to more fully explore the role of nutrition on sugar maple dynamics, both prior to and during the experiment, and to more fully review the scientific record on the role of whole-tree clearcutting in nutrient-induced sugar maple dynamics.

Differences in sugar maple seed supply periodicity and understory light limitation due to interference by beech (*Fagus* spp.) and other understory vegetation can limit survival of sugar maple seedlings and sprouts. No data were given on seed supply periodicity, nor was any data on understory light given. Both of these factors are important when considering regeneration. Leak (2005) reports that after 40–50 years of birch dominance on sites regenerated using small patch cutting, sugar maple recruits even on poor sites potentially due to changes in leaf litter quality and lighting, with this process playing out over a few decades. Evaluating regeneration in this experiment over a longer time may be necessary. A major limitation of the conclusions presented by Cleavitt et al. (2018) is that they are based on a specific harvesting treatment without reference to any alternatives or a control. Thus there is no way to gauge if the measured response was due to harvesting. In fact, other evidence suggests that trends in sugar maple regeneration and soil chemistry are part of regional phenomena that are common in complete absence of any type of forest harvest and have occurred on immediately adjacent, unmanipulated sites.

Cleavitt et al. (2018) compare the 40% basal area of sugar maple in the pretreatment overstory with the lack of regeneration of sugar maple after treatment as evidence that harvesting caused

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"decline" of sugar maple from the site. As sugar maple is a calcium-demanding species, making its best growth on calcium-rich sites (Long et al. 2009), this may be taken to imply that the 40% sugar maple basal area reported before the experiment is an indication that this was a calcium-rich site prior to the influences of air pollution or the experiment. In fact, pre-European settlement witness tree data suggest that sugar maple made up only 0%–6% of the pre-European settlement forest in this elevational range in the vicinity of HBEF (Hamburg and Cogbill 1988; Cogbill et al. 2002). The large component of sugar maple in the treated watershed follows multiple disturbances during the late 19th through 20th centuries, including repeated forest harvests, hurricane damage and salvage logging, and air pollution. Moreover, adjacent, unmanipulated watersheds show similar overstory sugar maple components coupled with poor sugar maple regeneration, especially in mid to upper elevations (Juice et al. 2006; Cleavitt et al. 2011). Sugar maple regeneration and its ability to compete with beech have been shown to be dependent on a sufficient supply of calcium (Lawrence et al. 2018). These are naturally low calcium sites due to the mineralogic composition of the soil parent material (Bailey et al. 2003), with calcium availability further reduced by acid deposition induced leaching, inferred from a mass balance model (Likens et al. 1996).

Cleavitt et al. (2018) show a reduction in the calcium concentration of the forest floor Oa horizon but stable Ca concentration in the B horizon following harvest and claim it as a mechanism by which harvesting has impacted regeneration. Yet, previously published studies of soil response to the W5 treatment, which have focused on soil pools rather than concentrations, have determined that whole-profile soil Ca pools were stable after harvest, within the range of measurement uncertainty, compared with preharvest levels (Johnson et al. 1997). The Oa horizon is relatively thin under hardwoods and is a small portion of the whole-profile soil calcium pool (Likens et al. 1998; Johnson et al. 1997), while the majority of the available calcium pool is in the B horizon. Furthermore, Bailey et al. (2004) showed that sugar maple foliar nutrient concentrations and health responses were better represented by B horizon calcium concentrations, with Oa and A horizon nutrient levels having little or no predictive value.

While this reduction in Oa calcium concentrations may not be significant to sugar maple nutrition, Cleavitt et al. (2018), with no comparison to a reference site, also do not provide any evidence that this change was due to the harvesting treatment. The HBEF mass balance model of calcium loss from acid deposition suggests continued losses of Ca from unharvested W6 through the 1980s, past the time when W5 was cut (Likens et al. 1996), with losses, presumably driven by acid deposition, continuing to at least 1999 in the extension of this analysis by Bailey et al. (2003).

While whole-tree clearcutting certainly maximizes the removal of nutrients from a site compared with other harvesting methods and theoretically could remove enough nutrients to affect site productivity, this remains a hypothetical impact in the northeastern USA. In the only whole-tree clearcutting experiment of which we are aware that included soil sampling before and after treatment, in harvested sites and in a reference site, no decline in soil nutrient pools was measured (McLaughlin and Phillips 2006). Also, in a comparison of 14 whole-tree harvested sites with 15 conventionally harvested sites in New Hampshire and Maine, no significant effects of whole-tree harvesting on regeneration were observed (Roxby and Howard 2013).

While this study is likely to be cited in legal reviews of public forest management proposals, it is important to note that this was designed as an extreme experiment in a fairly atypical setting compared with managed sites in the region. Best management practices, including leaving an unharvested buffer along perennial streams, minimizing skid trails, and orienting them to prevent erosion (Cullen 2001), are effective in limiting the impacts from forest harvesting operations (Aust and Blinn 2004) and for preserving advance regeneration, especially for species such as sugar maple (Leak et al. 2014). To prevent entry into the adjacent watersheds, which are monitored for other purposes, skid trails were confined within W5. Because the watershed is steep and narrow, skid trail length was maximized rather than minimized and was oriented parallel to the slope, the opposite of what would be practiced in operational forestry to reduce soil disturbance and protect advance regeneration. These differences with operational forestry in the region should be considered when interpreting this study in a management context.

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