J. Acad. Entomol. Soc. 21: 6-11 (2024)

Effect of trap type, trap maintenance, and trap height on trap catches of the beech leaf-mining weevil

Jon Sweeney, Ellen Hatt and N. Kirk Hillier

ABSTRACT

The beech leaf-mining weevil, *Orchestes fagi* (L.) (Coleoptera: Curculionidae), native to Europe, has established in Nova Scotia and parts of New Brunswick and Prince Edward Island, and is a serious threat to the health of American beech, *Fagus grandifolia* Ehrh. Due to their habit of overwintering under bark scales on both conifers and hardwood trees, adult *O. fagi* can be inadvertently moved long distances by human transport of firewood and logs. Therefore, effective methods are needed for detecting their presence and monitoring their spread. We conducted three experiments to determine ways of improving the efficacy of traps for monitoring the spread of the beech leaf-mining weevil. We tested the effect of trap type (sticky *vs.* non-sticky traps), trap height (upper *vs.* lower canopy of beech trees), and trap maintenance (replacing sticky bands on traps at regular intervals *vs.* no replacement) on numbers of *O. fagi* captured. We also compared the seasonal pattern of adult weevil activity as recorded by sticky traps *vs.* branch beating. Green sticky prism traps captured significantly more *O. fagi* than did green Fluon-coated 12-funnel Lindgren traps in spite of having much smaller surface area. There was no difference in mean catch per trap on sticky prism traps on which the sticky band was replaced regularly *vs.* not replaced, suggesting sticky bands should not require replacing during the entire season. Mean catch in traps placed at head height from a lower branch of an American beech tree was no different from that in traps placed in the upper canopy. Yellow sticky cards and branch beating were both effective in monitoring seasonal activity of adult *O. fagi* but branch beating appeared more effective in capturing adults later in the season when the new generation of *O. fagi* adults had emerged.

INTRODUCTION

Infiltration of invasive insect species triggers far-reaching consequences, with urban forests serving as poignant examples of their ecological impact (Panzavolta et al. 2021) as well as providing gateways for establishment and spread of invasive species into natural and planted forest ecosystems (Papp et al. 2017; Branco et al. 2019). Invasive insects pose a formidable threat to both urban and natural forests, disrupting ecosystem dynamics and compromising the essential services that forests provide (Potter et al. 2019; Thurston et al. 2022). For instance, the emerald ash borer, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), a destructive invasive beetle originating from Asia, has caused widespread devastation of native ash trees, *Fraxinus* spp. (Fraxinaceae), across North America, profoundly altering forest structures and disrupting wildlife habitat (Herms and McCullough 2014; Klooster et al. 2018). These alarming ecological shifts underscore the urgency of effective management strategies to reduce the impacts of invasive forest insects, and a critical component of their management is the development of effective tools for their survey, early detection and monitoring of spread (Brockerhoff et al. 2023). The beech leaf-mining weevil, *Orchestes fagi* (L.) (Coleoptera: Curculionidae) has recently emerged as an invasive pest of American beech, *Fagus grandifolia* Ehrh. (Fagaceae), in North America. In its native Europe, *O. fagi* is a common pest of European beech, *Fagus sylvatica* L., occasionally erupting in outbreaks that reduce tree growth

Received April 2024. Accepted for publication July 2024. Published on the Acadian Entomological Society website at www.acadianes.ca/journal on September 2024.

Jon Sweeney: Natural Resources Canada, Canadian Forest Service, Atlantic Forestry Centre, 1350 Regent Street, Fredericton, NB, Canada, E3C 2G6

Ellen Hatt and N. Kirk Hillier: Biology Department, Acadia University, Wolfville, NS, Canada

Corresponding author (email jon.sweeney@nrcan-rncan.gc.ca)

rates and nut production, but do not cause tree mortality (Verkaik et al. 2009; Rullán-Silva et al. 2015). First recorded in Halifax, Nova Scotia in 2012, this beetle has spread rapidly through the province, and into neighboring New Brunswick and Prince Edward Island, likely aided by inadvertent human-assisted movement (Klymko and Anderson 2022; Morrison et al. 2017; Sweeney et al. 2012). Contrary to its relatively minor impact on European beech, several consecutive years of heavy infestation in Nova Scotia has resulted in severe defoliation and mortality of American beech in both urban- and natural forests (Sweeney et al. 2020). As the weevil spreads in North America, it threatens the health of American beech, a species already suffering significant damage from other invasive pests, i.e., beech bark disease (Houston 1994) and beech leaf disease (Ewing et al. 2018; Reed et al. 2022). Studies have explored the behavior and ecology of *O. fagi*, revealing insights into its impact on American beech (Edwards et al. 2022; Sweeney et al. 2020) and the efficacy of various trap colours and trap designs for its survey and detection (Goodwin et al. 2020; Silk et al. 2017). Yellow, green, or white traps captured more weevils than did light blue, dark blue, or red traps (Goodwin et al. 2020). Beech weevil trap catches were greater on yellow sticky cards than in green non-sticky boll weevil traps (Silk et al. 2017) and greater on yellow sticky prism traps than on yellow sticky cards (Goodwin et al. 2020). Sticky prism traps caught more beech weevils than did non-sticky, Fluon-treated intercept panel traps, regardless of colour (Goodwin et al 2020). However, the efficacy of multi-funnel Lindgren traps for detection of *O. fagi* has not been investigated and this could be useful because these traps have been widely adopted by regulatory agencies for detection of potentially invasive bark- and woodboring beetles (Rabaglia et al. 2019; Rassati et al. 2014). Sticky trap efficacy can decrease over time as the trap surface becomes saturated with insects and debris (e.g., Brown 1984) but the effect of trap saturation on beech weevil catch is unknown. Goodwin et al. (2020) found greater beech weevil catches in traps placed in the upper vs. lower canopy of beech trees but the effect was only marginally significant suggesting further investigation was warranted. Finally, we wished to compare the relative efficacy of yellow sticky traps vs. branch beating as a method for monitoring seasonal abundance and activity of adult beech weevils. In the spring and summer of 2019 and 2020, we conducted a series of experiments designed to test ways of improving the efficacy of trapping surveys for monitoring the spread of the beech leaf-mining weevil. Our objectives were to: 1) determine the effect of trap height and trap design on mean catch per trap *O. fagi*; 2) determine whether sticky strips on prism traps need replacing during the trapping season; and 3) compare seasonal trends of adult beech weevil activity/abundance measured by yellow sticky cards vs. branch beating.

MATERIALS AND METHODS

Experiment 1 - Effect of trap type and trap height on mean catch per trap

This was a 2 x 2 factorial experiment comparing two trap types, a custom-made miniature sticky prism trap (Goodwin et al. 2020) and a 12-funnel Lindgren trap (WestGreen Global Technologies, Canadian distributer for ChemTica Internacional, Santa Domingo, Costa Rica), placed at two different heights in American beech trees (lower crown, about 1.5 m; upper third of beech canopy, 10–12 m above the ground) for a total of four trap type-height combinations. Both traps were "EAB-green", a color attractive to the emerald ash borer (Francese et al. 2010), with peak reflectance at 540 nm (Goodwin et al. 2020). The triangular prism traps were made from corrugated polypropylene plastic sheets (green Pantone 360 C, Laird Plastics, Moncton, New Brunswick) cut into 20 cm x 40 cm pieces and folded to make triangular traps measuring 12.5 cm wide on each side and 20 cm tall. Prisms were wrapped with transparent adhesive roll tape (Alpha Scents Incorporated, Portland, Oregon, United States of America) to trap insects. Advantages of using the adhesive roll tape instead of applying a sticky material directly on the surface of the prism traps were: 1) we could easily replace the sticky strip with a fresh strip and reuse the prism trap; and 2) the sticky material on the adhesive roll does not stick to one's fingers. The funnel traps were coated with Fluon diluted 50% in water to reduce friction and increase beetle catches (Allison et al. 2016) and the collecting cups contained a saturated solution of table salt in water to drown and preserve specimens. Treatments were replicated 10 times in a randomized complete block design. Mature American beech trees served as block-replicates, that is, each replicate consisted of all four trap treatments placed in the same tree. Trees 1–5 were in McDonald Park, Waverly, NS (44.792398, -63.610167) and were spaced 50–200 m from each other. Trees 6–10 were in Fall River Village, Fall River, NS (44.786815, -63.629860) and were 30–400 m spaced from each other. Traps were deployed 11 June 2019, checked every 6–11 days and taken down 15 August. On each trap check, the sticky prism traps were replaced with fresh traps and the used traps returned to the lab where weevils were removed from the sticky strip using Histo-Clear II (National Diagnostics, Atlanta, Georgia, United States of America). The prism traps were then wrapped in a fresh sticky strip for use on the next trap check, using the method described by Goodwin et al. (2020). Insects in the funnel traps were collected by straining catch through a fine mesh colander and the salty water returned to the collecting cup; water and/or salt were added as required. All specimens were examined under a binocular microscope at 10–20X magnification to identify and record the number of *O. fagi* captured. Voucher specimens were deposited in the insect collection at the Atlantic Forestry Centre, Fredericton, NB.

Experiment 2 - Effect of sticky surface replacement on performance of sticky prism traps

In this experiment, we used custom-made miniature sticky prism traps but made of yellow instead of green coroplast (Goodwin et al. 2020). We compared two treatments: 1) traps on which the sticky band was replaced with a fresh band every trap check (3–14 days); or 2) traps on which the sticky band was not replaced for the entire trapping period. Traps were suspended 1.5 m off the ground from branches of American beech trees in the KC Irving Gardens on the Acadia University Campus, Wolfville, NS (45.08767, -64.36837). Treatments were replicated 10 times in a paired design, i.e., one of each trap treatment on each of 10 different beech trees. In 2019, the traps were deployed 6 July, serviced 12, 18, 26, 29 July and 9 August, and taken down 15 August. In 2020, this experiment was repeated, with traps deployed on 14 May, serviced on 27 May, 9, 29 June, 15 July, and 1 August, and taken down 15 August.

Experiment 3 - Seasonal activity of adult *O. fagi* measured by catch in sticky cards vs. branch beating

This experiment was done to compare the relative sensitivity of yellow sticky card traps and branch beating for detecting beech weevils, and to monitor the seasonal trend in numbers of adult *O. fagi* on American beech in Nova Scotia. We suspended one 13 cm × 7 cm yellow sticky card (number 611; bright yellow; Contech Incorporated, Delta, British Columbia, Canada) that had been pretreated with Tanglefoot Tangle-Trap sticky coating on both sides (The Scotts Company, Marysville, Ohio, United States of America) from a branch about 1.5 m above the ground in each of ten American beech trees in the KC Irving Gardens on the Acadia University Campus on 7 May 2019. The traps were checked 2–3 times per week until 17 June and then once per week until 12 August 2019. During each trap check, we collected *O. fagi* adults from the same 10 trees by beating one branch per tree (separate from the branch containing the sticky trap but at a similar height) over a 90 x 90 cm beating sheet. The branch was struck five times with a beating stick and weevils collected from the beat sheet using an aspirator. The sticky cards were replaced with fresh cards once per week. Adult *O. fagi* are small but fairly easy to distinguish from other species of beetles we collected from beech trees on cards or beat sheets. Therefore, our counts of adult *O. fagi* captured on sticky cards during each (2–7-day) interval between trap checks was initially made by naked eye in the field at each trap check and subsequently confirmed by microscopic examination (as described earlier) after sticky cards and aspirated weevils were returned to the lab. There were no instances when a specimen counted as *O. fagi* in the field was subsequently determined to be a different species.

Data analysis

For experiments 1 and 2 we summed total catch per trap over the entire trapping period. In experiment 1, traps were found on the ground on three occasions: a lower crown prism trap in tree # 4 on 14 June and the canopy prism traps in trees # 1 and # 8 on 12 July. To avoid bias, our season total catch per trap of *O. fagi* did not include weevils captured in any of the four trap treatments in tree # 4 on the 14 June trap check or trees # 1 and 8 on the 12 July trap check. No traps were found disturbed in experiment 2. In experiment 1, we tested for the effects of trap type, trap height, and their interaction on total seasons catch per trap using generalized linear mixed models (SAS PROC GLIMMIX), with trap type and trap height as fixed effects and blocks random. The generalized linear models were run with Gaussian, Poisson, and negative binomial distributions and goodness of fit tested with Aikaike's Information Criterion corrected for small sample sizes (AICc). We report results from the models run with negative binomial distributions as they had the best fit (lowest AICc). For experiment 2, catch on sticky prism traps on which the sticky bands were replaced vs. not replaced were compared using a 2-tailed paired t-test. For experiment 3, catches on all 10 sticky traps were summed on each trap check date, as were numbers of weevils collected by branch beating. Both trap catch and branch beat data were transformed by log10(y+1) to make it easier to compare seasonal trends measured by traps vs. branch beating, on a single graph.

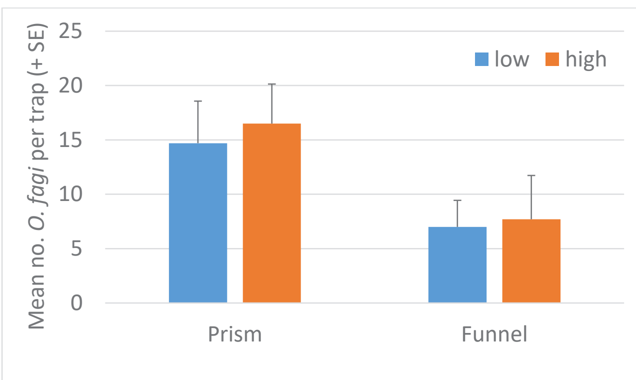
RESULTS AND DISCUSSION

Experiment 1 - Effect of trap type and trap height on mean catch per trap

Mean catch of *O. fagi* was significantly affected by trap type ($F_{1,36}$ = 56.4, P < 0.0001) but not trap height ($F_{1,36}$

= 1.11, P = 0.30) or the interaction between trap height and trap type ($F_{1,36}$ = 0.01, P = 0.92) (Figure 1). Results suggest the green sticky prism traps are more efficient at catching beech weevils than the funnel traps, in spite of the latter's much larger surface area. Goodwin et al. (2020) had similar results when comparing catch on sticky prism traps and non-sticky Fluon-treated intercept panel traps.

Figure 1 Mean catch per trap of *Orchestes fagi* on green sticky prism traps vs. green 12-funnel Lindgren traps that were placed high in the upper canopy (10-12 m high) or on a lower branch (1.5 m high) of American beech trees (n = 10). Mean catch differed significantly between prism and funnel traps (P < 0.0001) but did not differ with trap height (P = 0.30).



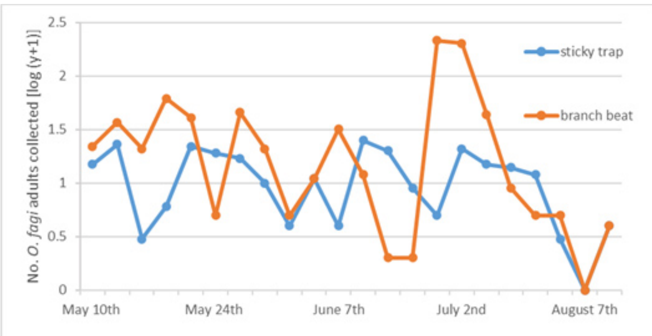
Experiment 2 - Effect of sticky surface replacement on performance of sticky prism traps

In 2019, there was no difference in mean total catch per trap on sticky prism traps on which the sticky band was replaced regularly (4.1 ± 1.3) *vs.* not replaced (4.8 ± 1.5) (Paired t-test, t = 0.83, df = 9, P = 0.43). This experiment was conducted relatively late in the season, missing much of the active period of *O. fagi* adults. Therefore, possible effects of trap saturation of sticky trap performance may have been more apparent had traps been out the entire flight season. However, when this experiment was repeated in 2020 and traps were out for the entire flight season, there was again no difference in total mean catch between traps on which the sticky band was replaced (17.6 ± 5.4) vs. not replaced (12.0 ± 4.5) (Paired t-test, t = 1.23, df = 9, P = 0. 22).

Experiment 3 - Seasonal activity of adult *O. fagi* measured by catch in sticky cards vs. branch beating

Orchestes fagi were collected on yellow sticky cards and by branch beating on every trap check date between 10 May and 12 August except for 7 August (when neither method collected any weevils), suggesting that both sampling methods were suitable for monitoring adult weevil activity at the population densities present (Figure 2). Over the entire sampling period, we collected 782 *O. fagi* by branch beating *vs.* 241 on the sticky traps. Numbers collected per date fluctuated greatly, from 0–22 for sticky traps and from 0–214 for branch beating and followed a similar trend on only about half of the sampling periods (Figure 2). The largest peak in beech weevil numbers collected by branch beating occurred on 24 June (214 weevils) and 2 July (201 weevils), which, based on the 30–35-day period reported for development of *O. fagi* from egg to adult in Europe (Bale and Luff 1978), likely coincided with emergence of the 2019 generation of adult weevils. In contrast, only 4 and 20 weevils were captured on yellow sticky traps on the same dates, respectively. The lower numbers of weevils collected on the yellow sticky traps compared to those collected by branch beating in late June-early July suggests the yellow traps may be less effective at collecting new generation *O. fagi* adults than overwintered adults. Prokopy (1972) suggested that yellow was attractive to apple maggot flies, *Rhagoletis pomonella* (Walsh) (Diptera: Tephritidae), because it reflected a lot of energy in the same wavelengths as foliage and acted as a "supernormal" foliage-type stimulus that elicited food- or host plant-seeking behavior. Beech weevils that emerge from overwintering sites must actively seek food, mates, and oviposition sites whereas the new generation of adults may (Dieter 1964; Bale and Luff 1978) or may not feed (Moise et al. 2017) before seeking overwintering sites and may therefore be less responsive to foliage and foliage-like visual stimuli like bright yellow. Metspalu et al. (2015) collected larger numbers of the pollen beetle, *Melagethnes aeneus* L. (Coleoptera: Nitidulidae), by beating foliage than by using yellow pan traps. They also found the relative efficacy of foliage beating *vs.* yellow pan traps differed when sampling overwintered *vs.* newly emerged adults: beating of host foliage captured more overwintered pollen beetles but significantly fewer new generation pollen beetles than did yellow pan traps. The authors suggested this was because overwintered pollen beetles are searching for oviposition sites and respond strongly to volatiles of their cruciferous host plants with or without visual stimuli, whereas the summer generation of adults mainly seek food and may respond more strongly to the yellow colours and flower volatiles (Jönnson et al. 2007). Whether or not the new generation of *O. fagi* adults differ from overwintered adults in their response to visual stimuli is purely speculative, however,

Figure 2. Numbers of *Orchestes fagi* adults captured on yellow sticky card traps (total per 10 traps per day) and in branch beat samples from 7 May to 12 August 2019, KC Irving Gardens, Acadia University, Wolfville, NS.



and should be tested in laboratory behavioral bioassays. The results of this study may improve methods for monitoring the activity and relative abundance of the invasive European beech leaf-mining weevil, *O. fagi,* in North America. Green sticky prism traps captured more *O. fagi* than did green Lindgren funnel traps, irrespective of the height of traps in the canopy. As well, servicing of sticky prism traps through regular replacement of sticky bands did not significantly increase trap capture compared to non-serviced traps. Yellow sticky cards and branch beating were both effective in monitoring seasonal activity in May and June but branch beating was more effective in capturing adults later in the season when the new generation of *O. fagi* adults had emerged. Based on these experiments, we suggest that *O. fagi* may be effectively monitored using either yellow sticky cards or yellow sticky prism traps, with minimal servicing (i.e., no replacement of sticky bands) as a reliable indicator of early season populations of *O. fagi*. While such traps continue to detect adult *O. fagi* throughout the season, branch beating appears to be more effective at collecting *O. fagi* later in the season after the new generation of adults has emerged.

ACKNOWLEDGEMENTS

We thank the Atlantic Innovation Fund of the Atlantic Canada Opportunities Agency for providing financial support, the McDonald Sports Park, Waverly, Nova Scotia for permission to work on their property, and Joel Goodwin for expert technical assistance in the lab and field.

REFERENCES

Allison, J.D., Graham, E.E., Poland, T.M., Strom, B.L. 2016. Dilution of Fluon before trap surface treatment has no effect on longhorned beetle (Coleoptera: Cerambycidae) captures. Journal of Economic Entomology 109: 1215–1219.

Bale, J.S., Luff, M.L. 1978. The food plants and feeding preferences of the beech leaf mining weevil, *Rhynchaneus fagi* L. Ecological Entomology **3**: 245–249.

Brockerhoff, E.G., Corley, J.C., Jactel, H., Miller, D.R., Rabaglia, R. J., Sweeney, J. 2023. Monitoring and Surveillance of Forest Insects. *In* Allison, J., Paine, T.D., Slippers, B., Wingfield, M.J. (Eds), Forest Entomology and Pathology: Volume 1: Entomology, pp. 669–705. Cham: Springer International Publishing.

Brown, M.W., 1984. Saturation of pheromone sticky traps by *Platynota idaeusalis* (Walker) (Lepidoptera: Tortricidae). Journal of Economic Entomology **77**: 915–918.

Dieter, A. 1964. Beitrag zur Epidemiologie und Biologie des Buchenspringrüblers *Rhynchaenus (Orchestes) fagi* L. an Obstgewächsen. Anzeiger fűr Schädlingskunde **37**: 161–163.

Edwards, S., Brodersen, G., Hughes, C., Moore, K., Morin, B., Morrison, A., Owens, E., Sweeney, J., Johns, R.C. 2022. Relationships between pest density and associated leaf necrosis for an invasive leaf-mining weevil, *Orchestes fagi*, on American beech (*Fagus grandifolia*). Canadian Journal of Forest Research **52**: 301–308.

Ewing, C.J., Hausman, C.E., Pogacnik, J., Slot, J., Bonello, P. Beech leaf disease: an emerging epidemic. Forest Pathology **49**: e12488.

Francese, J.A., Crook, D.J., Fraser, I., Lance, D.R., Sawyer, A.J., Mastro, V.C. 2010. Optimization of trap color for emerald ash borer (Coleoptera: Buprestidae). Journal of Economic Entomology **103**: 1235–1241.

Goodwin J.T.L., Pawlowski S.P., Mayo P.D., Silk P.J., Sweeney J.D., Hillier N.K. 2020. Influence of trap colour, type, deployment height, and a host volatile on monitoring *Orchestes fagi* (Coleoptera: Curculionidae) in Nova Scotia, Canada. The Canadian Entomologist **152**: 98–109.

Herms, D. A., McCullough, D. G. 2014. Emerald ash borer invasion of North America: history, biology, ecology, impacts, and management. Annual Review of Entomology **59**:13–30.

Houston, D.R. 1994. Major new tree disease epidemics: beech bark disease. Annual Review of Phytopathology **32**: 75–87.

Jönnson, M., Rosdahl, K., Anderson, P. 2007. Responses to olfactory and visual cues by over-wintered and summer generations of the pollen beetle, *Meligethes aeneus*. Physiological Entomology **32**: 188–193.

Klooster, W.S., Gandhi, K.J., Long, L.C., Perry, K.I., Rice, K.B., Herms, D.A. 2018. Ecological impacts of emerald ash borer in forests at the epicenter of the invasion in North America. Forests **9**: 250.

Klymko, J., Anderson, K. 2022. First records of the invasive beech leaf-mining weevil (*Orchestes fagi*) in New Brunswick and Prince Edward Island, Canada. Journal of the Acadian Entomological Society **18**: 23–25.

Metspalu, L., Veromann, E., Kaasik, R., Kovacs, G., Williams, I.H., Mänd, M. 2015. Comparison of sampling methods for estimating the abundance of *Meligethes aeneus* on oilseed crops, International Journal of Pest Management **61**: 312–319

Moise, E., Forbes, G.B.H., Morrison, A., Sweeney, J., Hillier, N.K., and Johns, R. 2015. Evidence for a substantial host use bottleneck following the invasion of an exotic, polyphagous weevil. Ecological Entomology **40**: 796–804.

Morrison, A., Sweeney, J., Hughes, C., and Johns, R.C. 2017. Hitching a ride: Firewood as a potential pathway for range expansion of an exotic beech leaf-mining weevil, *Orchestes fagi*(L.). The Canadian Entomologist **149**: 129–137.

Rassati, D., Marini, L., Marchioro, M., Rapuzzi, P., Magnani, G., Poloni, R., de Giovanni, F., Mayo, P., Sweeney, J. 2019. Developing trapping protocols for wood-boring beetles associated with broadleaf trees. Journal of Pest Science **92**: 267–279.

Panzavolta, T., Bracalini, M., Benigno, A., Moricca, S. 2021. Alien invasive pathogens and pests harming trees, forests, and plantations: Pathways, global consequences and management. Forests **12**: 1364.

Potter, K.M., Escanferla, M.E., Jetton, R.M., Man, G. 2019. Important insect and disease threats to United States tree species and geographic patterns of their potential impacts. Forests **10**: 304.

Prokopy, R.J. 1972. Response of apple maggot flies to rectangles of different colors and shades. Environmental Entomology **1**: 720–726.

Rabaglia, R.J., Cognato, A.I., Hoebeke, E.R., Johnson, C.W., LaBonte, J.R., Carter, M.E. and Vlach, J.J., 2019. Early detection and rapid response: a 10-year summary of the USDA Forest Service program of surveillance for non-native bark and ambrosia beetles. American Entomologist **65**: 29–42.

Rassati, D., Petrucco Toffolo, E., Roques, A., Battisti, A., Faccoli, M. 2014. Trapping wood boring beetles in Italian ports: a pilot study. Journal of Pest Science **87**: 61–69.

Reed, S.E., Volk, D., Martin, D.K.H., Hausman, C.E., Macy, T., Toman, T., Cousins, S. 2022. The distribution of beech leaf disease and the causal agents of beech bark disease (*Cryptoccocus fagisuga, Neonectria faginata*, *N. ditissima*) in forests surrounding Lake Erie and future implications. Forest Ecology and Management **503**: 119753.

Rullan-Silva, C., Olthoff, A.E., Pando, V., Pajares, J.A., and Delgado, J.A. 2015. Remote monitoring of defoliation by the beech leaf-mining weevil *Rhychaenus fagi* in northern Spain. Forest Ecology and Management 347: 200-208.

Sweeney, J., Robert S. Anderson R.S., Reginald P. Webster, R.P., Neville, R. 2012. First Records of *Orchestes fagi* (L.) (Coleoptera: Curculionidae: Curculioninae) in North America, with a Checklist of the North American Rhamphini. The Coleopterists Bulletin **66**: 297–304.

Sweeney, J.D., Hughes, C., Honghao, Z., Hillier, N.K., Morrison, A., and Johns, R. 2020. Impact of the invasive beech leaf-mining weevil, *Orchestes fagi,* on American beech in Nova Scotia, Canada. Frontiers in Forests and Global Change **3**: 46.

Thurston, G.S., Slater, A., Nei, I., Roberts, J., McLachlan Hamilton, K., Sweeney, J.D., and Kimoto, T. 2022. New Canadian and provincial records of Coleoptera resulting from annual Canadian Food Inspection Agency surveillance for detection of non-native, potentially invasive forest insects. Insects **13**: 708.

Verkaik, E., Moraal, L., and Nabuurs, G. 2009. Potential impacts of climate change on Dutch forests, mapping the risks. Wageningen, Alterra-rapport. Netherlands.