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A technical guide to installing beetle traps in the upper crown of trees

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ABSTRACT

The upper tree crown represents an important habitat for many insect herbivores but, being much less commonly sampled than the understory, remains poorly understood. Here, we provide detailed instructions and quantitative cost (time) estimates for setting up insect traps in the upper crown of trees using methods adapted from tree-climbing canopy ecologists. In a sample experiment, we recorded the time it took for a two-person crew ("shooter" and assistant) to install traps in the upper crown vs. the understory of a mature stand of eastern hemlock (Tsuga canadensis (L.) Carrière (Pinaceae)), with trees 18–24 m tall. A crew with 3 yrs experience with these methods took an average of 5 min 38 s (range 3 min 13 s to 17 min 39 s) to install a trap in the upper crown, whereas an inexperienced field technician took an average of 7 min 1 s per tree (range 5 min 47 s to 9 min 19 s). In comparison, it required on average only 1 min 19 s (experienced) and 1 min 48 s (inexperienced) to install a trap in the understory. We used an average of 50 m (range 31–61 m) of rope per crown trap compared with 4.5 m (range 3.5– 5.5 m) per understory traps, which translated to a difference in cost of CDN$2.50 per trap, based on 2013 prices. Our results demonstrate that it costs more in time and materials to place traps in the upper crown vs. the understory, but the additional costs are modest. Furthermore, we show that an inexperienced person can learn how to set high traps quickly by following the step-by-step instructions laid out in this paper. We hope this both encourages and enables more use of traps in the upper crown as well as the understory when surveying for species of bark- and wood-boring beetles and other forest insects.

RÉSUMÉ

Les cimes des arbres procurent un habitat important à de nombreux insectes herbivores. Cependant, comme elles sont soumises à des travaux d'échantillonnage beaucoup moins fréquemment que le sous bois, elles sont assez mal connues des chercheurs. Nous fournissons ici des directives détaillées et des délais estimatifs nécessaires pour la pose de pièges à insectes à la cime des arbres à l'aide de méthodes inspirées de celles employées par les écologistes du couvert forestier qui grimpent aux arbres. Au cours de travaux expérimentaux, nous avons consigné le temps qu'a mis une équipe de deux personnes (le « marqueur » et l'adjoint) à installer des pièges dans les cimes et dans le sous-bois d'un peuplement mature de pruches du Canada [Tsuga canadensis (L.) Carrière (pinacées)] caractérisé par des arbres de 18 à 24 m de hauteur. Une équipe possédant trois années d'expérience de travail avec ces méthodes a mis en moyenne 5 min 38 s (fourchette de 3 min 13 s à 17 min 39 s) à installer un piège dans la cime, alors qu'un technicien de terrain inexpérimenté a dû y consacrer en moyenne 7 min 1 s par arbre (fourchette de 5 min 47 s à 9 min 19 s). Par comparaison, il n'a fallu en moyenne que 1 min 19 s (équipe chevronnée) et 1 min 48 s (technicien inexpérimenté) pour installer un piège dans le sous-bois. Nous avons utilisé en moyenne 50 m de corde (fourchette de 31 à 61 m) par piège de cime comparativement à 4,5 m (fourchette de 3,5 à 5,5 m) par piège de sous-bois, ce qui se traduit par un écart de coût de 2,50 $ CA par piège, selon les prix de 2013. Nos résultats montrent qu'il est plus coûteux sur le plan du temps et du matériel de poser des pièges dans les cimes que dans le sous-bois, mais que les coûts supplémentaires demeurent modestes. De plus, nous montrons qu'une personne inexpérimentée peut rapidement apprendre à poser des pièges en hauteur en suivant les directives décrites étape par étape dans le présent document. Nous espérons que ces conclusions encourageront et habiliteront les chercheurs à poser un nombre accru de pièges à la cime des arbres et dans le sous-bois pendant leurs relevés des scolytes, des buprestidés et d'autres insectes forestiers.

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INTRODUCTION

Forests host a tremendous variety of insect species, many of which reside primarily or exclusively in the upper crown, especially in tropical forests (e.g., Sutton et al. 1983). In temperate forests, the diversity of insect species collected in upper crown traps has been reported as either lower (Preisser et al. 1998; Su and Woods 2001; Dodds 2014) or not different (Vance et al. 2003; Graham et al. 2012) than that collected in understory traps. However, most of these studies found that species composition differed between the upper crown and the understory and emphasized the need to sample both strata (Figure 1), or along a vertical gradient, to accurately estimate the species diversity within a site (Su and Woods 2001; Vance et al. 2003; Graham et al. 2012; Dodds 2014).

As a result of the use of solid wood packaging to brace cargo in ships and shipping containers and the high volume of goods moved in global trade, bark- and wood-boring insects are frequently intercepted at international ports (Allen and Humble 2002; Brockerhoff et al. 2006; Haack 2006). Some of these exotic species become invasive, i.e., establish, spread, and cause ecological or economic damage in their new habitat (Mack et al. 2000). For example, Nowak et al. (2001) estimated the potential economic impact of the Asian longhorned beetle, *Anoplophora glabripennis* Motschulsky (Coleoptera: Cerambycidae), in US cities alone at $669 billion. For these reasons, early detection of exotic bark- and wood-boring insects is a priority for regulatory agencies such as the Canadian Food Inspection Agency (CFIA), and annual trapping surveys are conducted in areas considered at high risk for introductions, e.g., major ports. However, these surveys currently place traps in the understory only, about 1.5 m above the ground (Jackson and Molet 2014; Rob Favrin, CFIA, personal communication) and, therefore, may be missing those species of bark beetles and wood borers that are more common in the upper crown.

It is obviously less convenient to install and check traps in the upper tree canopy than in the understory but few quantitative cost comparisons have been made (Graham et al. 2012). If placing traps in both the understory and upper canopy improves the overall estimate of bark and wood boring beetle species diversity at a site (Graham et al. 2012; Dodds 2014), and by extension, increases the efficacy of invasive species surveillance, then a modest increase in the costs of doing so may be justified.

Here, we describe in step-by-step detail the methods we have found to be the most effective for installing multiple-funnel traps (Lindgren 1983; Contech Inc. Delta, BC) in the mid to upper crown of trees within the forest canopy. The basic methods were developed by arborists and tree canopy researchers (e.g., Lowman et al. 2012); we have adapted and refined these methods based on 4 years of experience trapping beetles in the upper canopy of New Brunswick forests. We also describe how to avoid common pitfalls that we encountered while refining the methods. Although we used multiple-funnel traps while developing these techniques, we expect that any large, solid-bodied trap could be substituted. Along with our description of the methodology, we provide a case study to quantitatively measure and compare the costs in time and materials for installing traps in the upper crown vs. the understory of individual trees, by both experienced and inexperienced field staff.

Figure 1. A 12-unit Multiple-funnel trap installed in a mature green ash (*Fraxinus pennsylvanica* Marshall) at (a) the conventional height of chest level and (b) in the upper crown of the tree.

METHODS

Stand and tree selection considerations

Once a forest type or area for sampling has been selected, several factors may influence where, when, and how traps are placed. For instance, conifers usually tend to be more cumbersome because of the often high density of branches along the trunk. In contrast, large, mature hardwoods typically have fewer branches in the lower crown and may allow for an easier installation. It may also be advantageous to install high traps in the spring, before leaves have flushed, as the leaves sometimes interfere with installation; at the same time, however, it is important to consider the vertical path along which the trap will travel during regular maintenance and to avoid areas likely to become heavily foliated.

Whatever the forest or tree type being studied, installation should always begin with a preliminary investigation of the area to identify potential environmental hazards. Potential hazards include dead standing trees (snags), leaning trees, or structurally unsound limbs too weak to support the weight of a trap. Dead branches also tend to snag or bind throwlines and ropes due to the bark's softness. As a general rule, dead tree materials (in any form) should be avoided. When selecting a suitable branch from which to suspend the trap, several factors should be considered. First, the branch should be sturdy enough to support the trap type being suspended. To support a 7–10 lb. baited 12-unit multiple-funnel trap, for example, a branch should be at least 4-5 cm in diameter or approximately the thickness of your wrist. A simple "stress test" (described below) should be conducted to test the strength of the target branch before trap deployment. Second, the selected branch should be highly visible, with little obstruction between the observer and the target limb. Third, there should be ample space below the branch to allow room for the trap to hang, as well as space for the trap to move laterally in the wind without getting tangled or broken (i.e., at least 1–2 m from the trunk). In some instances, pole pruners may be used to clear a path along the trunk to the target branch. Flexibility in experimental design is important as trees that meet the above criteria rarely occur at desired intervals, thus making it difficult to set strict spacing protocols.

Installation techniques

Once a suitable tree and branch are selected, the next step is to hang a rope over the branch. Equipment required includes: A) SherrillTree BigShot® with extension, B) Deluxe Folding Cube RopeBoss® (storage cube), C) 10 oz or 12 oz Neo Throwbags (SherrillTree, Greensboro, NC) and D) Zing-It Throwline (Samson, Bellingham, WA) 1.75 mm diam x 300 m long, (Figure 2). Additional equipment includes extra throwbags (weights), a 2.5 m ladder (or larger, depending on height of the trees), knives, pole pruners, and a handsaw for pruning lower branches to allow a clear path for the trap. Field crew should be equipped with appropriate safety equipment (e.g., hardhat with chin strap or climbing helmet, gloves, and eye protection).

Figure 2. Upper crown trap installation gear: (a) BigShot® with 4' extension and Bigshot® Head; (b) Deluxe Folding Cube RopeBoss® (storage cube); (c) 10 oz and 12 oz Neo throwbags (weights); and (d) Zing-It throwline 1.75 mm diam x 300 m long,. (Photo credit SherrillTree®).

To enhance efficiency, we recommend using two-person teams, i.e., a shooter and an assistant. The first step is to unwind throwline from the spool and "flake" it loosely into the storage cube (Figure 3a). Flaking is an arborist's term for hand guiding throwline into a storage cube or similar container, with each pass loosely coiling on top of the previous one. The purpose of flaking is to minimize throwline tangling. Patience and throwline management are the keys to saving yourself wasting time untangling a mass of throwline. In the event of a significant tangle, it is usually best to untangle the line—do not be tempted to cut the line and retie it as the additional knots in the throwline are more likely to get caught when being pulled across branches. The amount of throwline in the storage cube should be about 2.5–3 times the height of the tallest tree you want to put a trap in. One end of the throwline should be tied to a weight and the other to the loop provided in the storage cube. A double overhand knot (Grog LLC 2014) is sufficient to secure the line to the weight. When traveling between trees, the weight should be stored in the storage cube pouch to prevent tangles (Figure 3b). After selecting the tree and branch from which to suspend

Figure 3. Setting the support rope for high trap installation: (a) 'flaking' of throwline into the storage cube to prevent tangles; (b) storage of throwbags in the provided pouches on the sides of the throwline storage cube; (c) shooter positioning himself for a clear view to use the Bigshot® to fire the throwbag with throwline over the target branch; (d) positioning of the throwbag in the Bigshot® sling prior to launch; (e) proper body position for shooting the BigShot®; and (f) an example of a technician performing a "stress test" on target branch to ensure that it can hold the weight of the trap.

the trap, the shooter with the assembled BigShot should stand with a clear line of site to the branch (Figure 3c). Next, the shooter takes the weight tied to the loose end of the throwline and places it in the sling of the BigShot, making sure that it sits evenly in the pouch (Figure 3d). With the storage cube positioned in front of the BigShot and the throwline clear of obstructions, the shooter should aim the BigShot roughly 0.5–1 m above the target branch and carefully pull back the sling with two fingers hooked into the underside of the pull loop (Figure 3e). It will take some practice to get a feel for the amount of pull needed to shoot the weight to the desired height. The angle between the observer and the branch should range between 45 and 60 degrees; targeting from directly beneath the branch or from too far away is generally more challenging. If the target branch is undershot or the placement unsatisfactory, the shooter must reel in the throwline and flake it carefully back into the storage cube. Do not reshoot the weight without flaking the throwline back into the storage cube, or the throwline may become entangled with sticks contacted on the ground during the previous throw. Hitting the target spot takes practice, and depending on the target, even an experienced shooter may require several shots to get the right placement of the throwline over the branch. Once the throwline is positioned satisfactorily over the target branch, the weight can be lowered to the ground by providing slack on the throwline. The shooter, holding both ends of the throwline, pulls downward firmly and at an angle to "stress test" the strength and flexibility of the target branch (Figure 3f). Remember the safety zone and be vigilant for falling debris.

Next, the assistant ties the rope that will be used to suspend the trap in the tree to the loop of the weight using an overhand knot (Figure 4a). The shooter then pulls the throwline/rope back over the branch by reeling in the throwline (Figure 4b). We use yellow polypropylene rope (4.8 mm diameter) that comes in spools of 648 m (Dartmouth Cordage, Halifax, NS). It is very useful to deploy rope directly from a spool, e.g., by feeding a smooth stick or broom handle through the center of the spool. From our experience, trying to use smaller bundles of rope, like those commonly sold in retail hardware stores, invariably results in much time spent untangling rope from sticks and underbrush. The "support" rope is now looped over the branch, and the shooter can untie the support rope from the loop of the weight and tie it to the top of the trap with three overhand knots (Figure 4c). The shooter also ties another piece of rope to the bottom of the trap (two overhand knots) to allow him or her to guide the trap around branches and other obstacles as it is being pulled up into the tree by the assistant (Figure 4d). Once the trap has reached the desired height, the support rope is tied off to a nearby tree trunk. A bowline knot (Grog LLC 2014) is recommended for tying the support rope. Because the trap will have to be serviced at regular intervals, the bowline knot can be easily untied while still providing sufficient strength to support the trap. There will be a lot of slack rope once the trap is suspended in the crown and this should be neatly and loosely coiled at the base of the tree or over a lower branch. Do not cut away the extra line; you will need this to lower the trap (Figure 4e). The guide line attached to the bottom of the trap must also be tied to the trunk of a different tree, far enough away from the tree to which the support rope is tied to ensure that the ropes do not become tangled (Figure 4f). The guide rope will also be used to help control trap

Figure 4. Installing the rope and trap into the forest crown. (a) Tying the permanent support rope to the throwline and weight so that it can be pulled over the target branch; (b) the throwline and weight attached to the rope being pulled over the target branch; (c) the support rope tied to the top of a multiple-funnel trap with a triple knot; (d) the guide rope tied to the bottom of the funnel trap with a double knot; (e) securing the support rope to the tree to keep the trap suspended in the upper tree crown while properly storing excess rope when not in use; and (f) securing the guide rope to a tree opposite of the support rope.

descent as the trap is lowered to collect samples. Unlike the support rope, the guide rope should have some slack to allow for lateral movement of the trap. If the line is too taut it may pull the trap apart during high winds. The installation is now complete (Figure 5). The throwline should be flaked into the storage cube and moved with the rest of the gear and traps to the next sample tree.

Case study to compare the costs of upper crown vs. understory traps

To gain a better understanding of the relative costs of using crown traps vs. understory traps, we conducted a small experiment in a mature stand of eastern hemlock (*Tsuga canadensis* (L.) Carriere (Pinaceae)) mixed with various hardwood species in Odell Park, Fredericton, New Brunswick, Canada (45.9567°N, 66.6673°W), using 12-unit, multiple-funnel traps. These hemlocks were considered to

Figure 5. A fully installed 12-unit multiple-funnel trap in the upper crown of a largetooth aspen (*Populus grandidentata* Michx.). **NOTE** the large angle between the support rope on the left of the trap and the guide rope beneath it, to reduce the risk of tangling.

be moderately easy trees in which to install crown traps because there was little understory and a low density of lower crown branches. The experiment was carried out 14 February 2014 (experienced crew) and 25 February 2014 (inexperienced crew) during a period when little snow was on the ground and conditions were typical of our springtime installations. We selected 10 mature hemlock trees (18–24 m tall) in open sections of the stand and used them for both the high- and low-hanging traps. For each tree, we had an experienced (i.e., ~3 yrs experience) shooter and assistant install both high- and low-hanging traps and record the time taken to set up each trap, the number of attempts to shoot the throwline over the high branches, and the total duration of installation. The time per tree was recorded from the moment the shooter and assistant reached the trunk of the target tree until the trap was completely installed. The installation of high traps followed the methods detailed above, whereas installation of low traps involved tying a rope between adjacent trees (span >1 m), attaching a trap, and installing a collecting cup/stopper. After this setup was complete, all traps were removed, and the length of rope required for each crown trap and understory trap set was recorded. The same process was repeated by a novice shooter (no previous experience) and an experienced assistant using the same trees, 11 days later, but length of rope used was not recorded. The novice shooter read the instructions included in this article before setting up the traps.

The data were analyzed using a generalized linear mixed model (Proc GLIMMIX) (SAS Institute 1999–2003) by maximum likelihood estimation, with trees treated as random (block) replicates, and both shooter experience level (experienced vs. inexperienced) and trap height (crown vs. understory) treated as fixed effects: time = tree + experience level + trap height + experience * trap height + error. Time (in seconds) was transformed by log(y+1) and modelled with the Gaussian distribution and identity link. Least square means were compared using *t* tests. Standard errors accompany all means reported in the text.

RESULTS AND DISCUSSION

It took approximately four times longer to install a trap in the upper crown (2–17 min) than in the understory (1–2 min) ($F_{1,27}$ = 179, P < 0.0001) (Table 1). Traps were suspended a mean of 16 ± 0.6 m (14–20 m) above the ground. Experience level significantly affected the time it took to set up traps ($F_{1,27}$ = 12.4, P = 0.0014), but the actual difference in time was not great. On average it took the inexperienced shooter about 2 min longer to set up a high trap than it did the experienced shooter (Table 1). Our results are comparable to those of Graham et al. (2012), who reported a range of about 5–20 min per upper-crown trap and 1 min per understory traps. Graham et al. (2012) used very similar methods for their crown traps but suspended understory traps from 1.5 m tall steel reinforcing bar poles, i.e., "rebar". The mean length of rope required per trap was 50.2 ± 1.9 m for the upper crown traps (35.8 ± 1.5 m of support rope plus 14.4 ± 0.7 m of guide rope) and 4.5 ± 0.3 m for the understory traps. Based on our 2013 cost for a 648 m spool of rope (CDN$35.50 per spool or 5.5 cents per m), the cost for rope averaged CDN$2.75 per upper crown trap vs. CDN$0.25 per understory trap, a difference of only CDN$2.50 per trap.

Our results suggest learning how to set upper crown traps is fairly simple, and the method may be easily incorporated in trapping surveys. The trees used in our study here were relatively easy to work with due to their open growing condition and the general lack of understory plants, so the mean time to set up crown traps in more difficult sites, e.g., with thicker crowns and dense understory vegetation, may be higher than what we encountered in this study. However, even in these conditions, our experienced shooter had one particularly vexing tangle of the throwline on Tree 7 that more than tripled the time required to set up the crown trap in that tree (Table 1). This example reinforces the importance of managing the throwline and rope and the consequences of failing to do so. For sites dominated by large conifers with dense crowns not suitable for this method, it may be more feasible to suspend upper crown traps from rope tied between the upper crowns of two trees, as described by Vance et al. (2003). The total time required to install all 10 crown traps (including travel time between trees) was approximately 1 h 50 min for the team with the experienced shooter and 2 h 9 min for the team with the inexperienced shooter, indicating that moving between the 10 trap locations took about an hour in total or 6–7 min per move.

Table 1. Results from an experiment to determine the time and number of attempts (i.e., throwline shots into the tree) required for an experienced vs. an inexperienced field technician to install a 12-unit multiple-funnel trap in the upper and lower crown of ten mature eastern hemlock trees using the methods described in this paper. The experienced technician had three field seasons of experience installing high crown traps, whereas the inexperienced technician had none. Both had experience installing low traps.

	Upper crown traps				Lower crown traps	
	Experienced		Inexperienced		Experienced	Inexperienced
Tree	Time	Attempts	Time	Attempts	Time	Time
1	04:54	1	09:19	2	01:37	02:10
2	03:13	1	05:11	1	01:06	01:56
3	04:43	1	05:47	1	01:03	01:41
4	04:05	1	06:57	1	01:18	01:39
5	04:34	2	08:11	2	01:04	01:37
6	04:19	1	08:00	2	01:36	01:43
7	17:49	3	05:48	1	01:17	01:59
8	03:34	1	05:50	1	01:27	01:39
9	07:03	2	06:51	2	01:18	01:45
10	02:09	1	08:22	2	01:29	01:55
Mean	**05:38**	**1.4**	**07:01**	**1.5**	**01:19**	**01:48**

A potential drawback when placing beetle traps in the upper crown *versus* the understory is increased damage during extreme wind events. In July 2014 several of our trapping sites in New Brunswick experienced strong winds (gusting to 100 km per hr) and heavy rainfall (>100 mm) from a severe tropical storm (Arthur), and about 18 of 56 high traps were damaged or became stuck in the trees, necessitating re-installation of several traps. However, in storm events as extreme as Arthur, even understory traps may be affected. For example, at one or our sites we lost 4 of 56 understory traps that were damaged by falling trees as a result of high winds.

CONCLUSIONS

We have described a simple step-by-step procedure for setting insect traps in the upper crowns of trees that we hope results in greater use of high traps in operational surveys for exotic bark- and wood-boring beetles and also in studies estimating forest insect diversity. There are certainly challenges to setting up traps in the upper crown of mature trees, but we have shown that the costs of doing so, in both time and materials, is not much greater than those for setting up traps in the understory. We also demonstrated that the technique for setting traps in the upper crown can be picked up quickly by a person with no previous experience, simply by following the outlined instructions. Finally, we provide a quantitative estimate of the relative costs of setting up high crown vs. understory traps. We caution that results may differ somewhat at other sites, e.g., sites with thicker crowns will likely require more time to set up. Also, our sample size was limited in terms of people, with only one experienced and one inexperienced shooter; aptitude for learning and applying the technique will likely vary among people; and, additional measurements are warranted in future studies to provide a more robust cost comparison.

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REFERENCES

Allen, E.A., and Humble, L.M. 2002. Nonindigenous species introductions: a threat to Canada's forests and forest economy. Canadian Journal of Plant Pathology **24**: 103–110.

Brockerhoff, E.G., Bain, J., Kimberley, M., and Knízek, M. 2006. Interception frequency of exotic bark and ambrosia beetles (Coleoptera: Scolytinae) and relationship with establishment in New Zealand and worldwide. Canadian Journal of Forest Research **36**: 1–10.

Dodds, K.J. 2014. Effects of trap height on captures of arboreal insects in pine stands of northeastern United States of America. The Canadian Entomologist **146**: 80–89.

Graham, E.E., Poland, T.M., McCullough, D.G., and Millar, J.G. 2012. A comparison of trap type and height for capturing Cerambycid beetles (Coleoptera). Journal of Economic Entomology **105**: 837–846.

Grog L.L.C. 2014. Animated Knots by Grog. Webpage, hosted by Lunar Pages, Hawthorne, California, USA. [online]. Available from http://www.animatedknots.com/index.php?LogoImage=LogoGrog.jpg&Website=www.animatedknots.com [accessed 10 March 2014]

Haack, R.A. 2006. Exotic bark- and wood-boring Coleoptera in the United States: recent establishments and interceptions. Canadian Journal of Forest Research **36**: 269–288.

Jackson, L., and Molet, T. 2014. Exotic wood borer/bark beetle survey reference, Revised 2014. Manual. USDA APHIS PPQ [online]. Available from https://caps.ceris.purdue.edu/webfm_send/2201 [accessed 28 February 2014]

Lindgren, B.S. 1983. A multiple-funnel trap for scolytid beetles (Coleoptera). The Canadian Entomologist **115**: 299-302

Lowman, M., Schowalter, T.D., and Franklin, J.F. 2012. Methods in forest crown research. University of California Press, Ltd., London, UK.

Mack, R.N., Simberloff, D., Lonsdale, W.M., Evans, H., Clout, M., and Bazzaz, F.A. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications **10**: 689–710.

Nowak, D.J., Pasek, J., Ronaldo, A., Sequeira, R.A., Crane, D.E., and Mastro, V.C. 2001. Potential effect of *Anoplophora glabripennis* (Coleoptera: Cerambycidae) on urban trees in the United States. Journal of Economic Entomology **94**: 116–122.

Preisser, E., Smith, D.C., and Lowman, M.D. 1998. Crown and ground level insect distribution in a temperate forest. Selbyana **19**: 141–146.

SAS Institute. 1999–2003. Proprietary software release 9.1. SAS Institute, Cary, NC.

Su, J.C., and Woods, S.A. 2001. Importance of sampling along a vertical gradient to compare the insect fauna in managed woods. Environmental Entomology **30**: 400–408.

Sutton, S.L., Ash, C.P.J., and Grundy, A. 1983. The vertical distribution of flying insects in lowland rain-forests of Panama, Papua New Guinea and Brunnei. Zoological Journal of the Linnaean Society **78**: 287–297.Vance, C.C., Kirby, K.R., Malcolm, J.R., and Smith, S.M. 2003. Community composition of longhorned beetles (Coleoptera: Cerambycidae) in the crown and understory of sugar maple and white pine stands in south-central Ontario. Environmental Entomology **32**: 1066–1074.