THE RESPONSESOF INSECT POLLINATORS AND UNDERSTORY PLANTS TO GROUP SELECTION TREE HARVESTING IN ALGONQUIN PROVINCIAL PARK

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ABSTRACT

The Responses of Insect Pollinators and Understory Plants to Group Selection Tree Harvesting in Algonquin Provincial Park

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I compared the Syrphidae (Diptera), bee (Hymenoptera: Apoidea), and flowering plant communities in hardwood stands of Algonquin Park. Group-selection harvesting increased the abundance of pollinators and flowering stems, but only after canopy-closure. Wild red raspberry (*Rubus strigosus*) and bees benefitted most from the creation of canopy gaps. The combination of increased light, warm, bare soils, and abundant nectar-rich raspberry flowers likely created ideal habitat for soil-nesting bees, factors which are relatively absent from unharvested stands. In contrast, before canopy-closure, spring ephemerals and high light-levels were universal and the pollinators were even across treatments. More pollinators were caught in canopy gaps than in forested areas, and the proportion of fertilized ovules of spring beauty (*Claytonia caroliniana*) was higher in gaps than in the forest, suggesting that pollinators prefer foraging in gaps, even in spring. The group-selection techniques investigated proved beneficial to native pollinating insects, at least in the short-term.

KEYWORDS: Syrphidae, Apoidea, bees, hardwood forest, spring ephemeral, group-selection harvesting, Algonquin Provincial Park, floral understory, *Rubus strigosus*, *Claytonia caroliniana*

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INTRODUCTION

Pollination is one of the most important processes in terrestrial ecosystems (Kevan 1999; Sheffield et al. 2003). It occurs when ripe pollen is transferred from the anther of a plant to a receptive stigma, resulting in the fertilization on an ovule (Dafni et al. 2005). Successful pollination is followed by successful plant reproduction, a necessary step in maintaining key components of the structure and composition of a habitat. Plants not only provide food and shelter for animals; they play vital roles in ecosystem functioning such as photosynthesis, nutrient cycling, preventing erosion, and the maintenance of species diversity (Vitousek 1982; Gilliam 2007; Madritch et al. 2009). Pollination in angiosperms is mostly animal-mediated and the interactions between plants and their pollinators provide critical services for sustainable ecosystems (Buchmann and Nabhan 1996; Kearns et al. 1998). Although animal pollinators include birds, bats and other small mammals, the vast majority of pollinators are insects (Sheffield et al. 2003; Fleming and Muchhala 2008). Moths and butterflies (Lepidoptera), and some beetles (Coleoptera) possess adaptations for anthophily (i.e. flower visiting), but the insect orders that contain the most specialized flower-visiting members are the flies (Diptera), the bees and wasps (Hymenoptera; Kevan and Baker 1983; Larson et al. 2001).

The family Syrphidae (Diptera) is a large and conspicuous group of flies. Their hovering flight, the ease in distinguishing them from other flies (by a spurious vein in the wing), and their mimicry of Hymenoptera have all contributed to their extensive study (Sommaggio 1999). There are almost 6000 described species worldwide, with almost 900 species found in North America (Vockeroth and Thompson 1987). As adults, almost all syrphids are obligate flower visitors, with females requiring protein in pollen to produce eggs and both sexes depending on nectar to power their flight (Gilbert 1981;

Branquart and Hemptinne 2000; Larson et al. 2001). As such, they are among the most common flower-visiting insects (Branquart and Hemptinne 2000). Larvae of syrphids, on the other hand, are extremely varied in their habitats and feeding guilds. There are three subfamilies of Syrphidae and larvae in the subfamily Syrphinae are almost exclusively aphid-predators. Many in the subfamily Eristalinae are saprophagous, feeding in wood, decaying organic matter, and water bodies with high organic content (Vockeroth and Thompson 1987). Members of the last subfamily, Microdontinae, are scavengers and predators in ant nests (Vockeroth and Thompson 1987; Sommaggio 1999). Once mated, adult females from all subfamilies find appropriate habitat for their young (e.g. an aphid colony on a herbaceous plant or a rot-hole in a live tree) to lay their eggs (Sommaggio 1999).

Bees (Apoidea) are the most important and highly-adapted anthophiles. Unlike syrphids, almost all bees are completely reliant on floral resources as both larvae and adults, with females provisioning their nests with pollen and nectar for developing young (Kevan and Baker 1983). There are approximately 19000 described bee species worldwide, with over 700 species in Canada (Packer et al. 2007). There are six families of bee in Canada but one, Melittidae, is rarely found in Ontario. The remaining five families (Megachilidae, Apidae, Andrenidae, Halictidae, and Colletidae) can be distinguished from other Hymenoptera by the presence of branched body hairs (Packer et al. 2007). Most bees nest in the ground, but some species nest in the pithy stems of plants, pre-existing cavities, or tunnels in rotten wood that they excavate themselves (Sheffield et al. 2003; Packer et al. 2007). Unlike syrphids, which roam freely to find floral resources and appropriate larval habitat, female bees are limited in their foraging distances because they must continually return to their nests with provisions and show a

strong preference for foraging close to those nests (Kevan and Baker 1983; Cresswell et al. 2000).

In forested ecosystems, the floral understory (vascular plants <1m tall, excluding tree species) comprise most of plant-species diversity, and flowers from these plants provide the main food source for anthophilous insects (Roberts 2004; Gillliam 2007). This vegetative layer represents less than 1% of the biomass of the forest, yet can contain 90% or more of the plant species of the forest and contribute up to 20% of foliar litter to the forest floor (Gilliam 2007). In northern hardwood forests in the spring, before the canopy leafs out, a community of spring ephemerals takes advantage of the high light levels. These plants emerge, flower, and produce their fruit all before the canopy is fully developed. Once the fruit has been dispersed, the above-ground parts die and wither, completely disappearing from the forest floor (Lapointe 2001). These spring ephemerals can, through their rapid uptake, prevent loss of nutrients in soilat a time when uptake by trees is minimal. The rapid decomposition of spring ephemeral foliage makes these nutrients available to trees later in the spring when they are more capable of taking up soil nutrients in a phenomenon known as the vernal dam hypothesis (Muller 2003; Gilliam 2007). After the spring ephemerals have died, the floral understory then comprises later-blooming plants, which grow in the relatively dim light that filters through the canopy. With canopy removal (either by natural disturbance such as windthrow, fire, and insect defoliation, or through anthropogenic disturbances such as harvesting) comes an increase in light reaching the forest floor (Canham et al. 1990; Beaudet and Messier 2002). This light is associated with higher understory plant richness, abundance and diversity, especially in shade-intolerant early-successional species (Fye 1972; Bouget and Duelli 2004; Shields and Webster 2007; Falk et al. 2010). As herbaceous cover increases, so

does the amount of floral resources (Romey et al. 2007; Quintero et al. 2010) and, as such, disturbances to intact forests may benefit some insect pollinators (Steffan-Dewenter et al. 2002; Romey et al. 2007). Despite evidence that forest-loss in fragmented landscape can be deleterious to plant-pollinator interactions (Didham et al. 1996; Kearns et al. 1998; Steffan-Dewenter et al. 2002; Taki et al. 2007) many studies in continuously forested ecosystems have shown that disturbance increases abundance, diversity and richness of insect pollinators (e.g., Nol et al. 2006; Campbell et al. 2007; Romey et al. 2007; Deans et al. 2007).

Despite examples that suggest enhancement of the pollinator community in response to disturbance, silviculture may also negatively affect forest plant and insect communities. For insects, machinery can disrupt and compact soil nest sites, soil moisture may be altered which affects the microclimate in an area, and the number of natural cavity nest-sites may be reduced (Wiegmann and Waller 2006; Romey et al. 2007). The establishment of non-native plant and animal species is also possible, while at the same time, the diversity of forest-specialists may be reduced (Roberts 2004; Gilliam 2007; Romey et al. 2007). Today, foresters emulate natural disturbance patterns as a means to reduce the negative impacts of logging but there remains a lack of guidance on how to design silvicultural systems in harmony with natural patterns (Seymour et al. 2002).

The single-tree selection system is the main harvesting prescription used in hardwood forests of the Great Lakes region (Schwartz et al. 2005; Neuendorff et al. 2007). Although single-tree selection is based on the principle of natural gap dynamics, this method of harvesting may lead to a homogenization of forest structure and composition through the encouragement of shade-tolerant hardwoods such as sugar maple (*Acer saccharum*) and American beech (*Fagus grandifolia*; Angers et al. 2005) because

gaps are all single-tree sized, whereas natural disturbance events often result in larger gaps (Seymour et al. 2002). Less shade-tolerant species such as yellow birch (*Betula alleghaniensis*) and black cherry (*Prunus serotina*) need canopy gaps larger than those created by single tree selection to outcompete maple and beech (McClure et al. 2000). Group-selection has been proposed as a potential remedy for the homogenization of our hardwood forests: canopy gaps are created by removing small groups of trees rather than singly (Coates and Burton 1997). Questions remain about how many and how large those gaps must be to encourage the mid-tolerant trees and species diversity overall, but small enough to maintain forest-specialist species and discourage weedy and exotic species.

The aim of this project is to assess the effects of two experimental group-selection harvest prescriptions on the floral understory and the communities of syrphids and bees in the hardwood forests of Algonquin Provincial Park, Ontario. If light is the main factor required to enhance the herbaceous understory, then I predict no differences in spring ephemeral plant communities between harvested and unharvested sites, but differences in later-blooming species. If light is the main factor that increases pollinators, then, similarly, I predict that harvested sites would have higher pollinator abundance, diversity, and richness during the summer than the unharvested sites. If pollinators are more attracted to the light-filled canopy gaps, then the reproductive success of flowering plants would be higher in these gaps than in the forested matrices. Finally, if pollinators are sensitive to the amount and pattern of timber harvest, then I predict that sites that undergo different types of harvest would have different communities of pollinators and different pollinator success.

METHODS

Study Sites

This study was conducted in the continuous forest of Algonquin Provincial Park (45°35'N, 78°29'W) in central Ontario (Figure 1), part of the Great Lakes-St. Lawrence Forest Region (Site Region 5E; Chambers et al.1997). Nine upland hardwood stands were chosen to study the effects of two experimental harvesting prescriptions, as part of a larger study on sustainable forest management. All stands are characterised by the dominant trees species, sugar maple and American beech, but stands also have yellow birch and Eastern hemlock (*Tsuga canadensis*) as part of the canopy (approximately 15% each). The understories comprise regenerating hardwoods, and shrubs such as hobblebush (*Viburnum alnifolium*), striped maple (*Acer pennsylvanicum*), fly honeysuckle (*Lonicera canadensis*), and beaked hazel (*Corylus cornuta*). Common herbs in the sites include red trillium (*Trillium erectum*), starflower (*Trientalis borealis*), rose twisted-stalk (*Streptopus roseus*), Canada mayflower (*Maianthemum canadense*), and the spring ephemerals spring beauty (*Claytonia caroliniana*), and trout lily (*Erythronium americanum*).

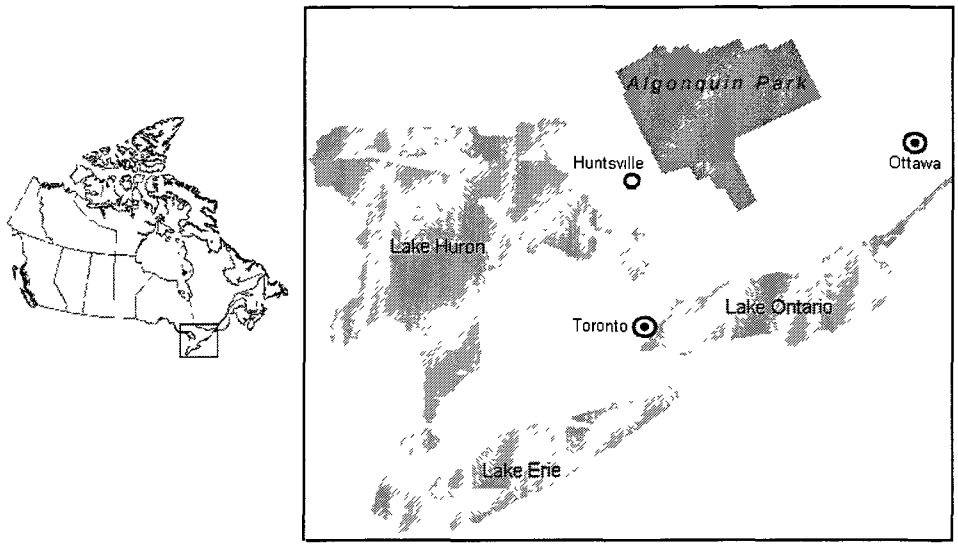

Figure 1: Algonquin Provincial Park in relation to southern Ontario and the rest of Canada.

Three of the nine sites have been left unmanaged for at least 60 years, and function as Controls. The other six sites were previously managed under the single-tree selection system (20 to 25 years since last harvest), then underwent experimental group-selection harvesting in the winter of 2006/2007. Three sites, hereafter 'Regulars', were harvested under regular group selection prescriptions. Each site contained approximately ten small (~0.03ha each) and ten large (~0.07ha each) canopy gaps, placed adjacent to mature seed trees of either yellow birch or black cherry. Interspersed amongst these group-gaps are single-tree gaps, with residual tree densities of approximately 18 to 20m^2/ha, as outlined in the Ontario provincial tree-marking guidelines (OMNR 2004). This combination of group- and single tree- selection resulted in the removal of approximately 33% of the basal area from the sites. The other three sites, hereafter 'Intensives', contain medium canopy gaps (0.05ha each) laid out in a grid pattern. Gaps were placed regardless of the location of specific seed trees. There are about 25m

between gap edges with no cutting within the intervening matrix, except for the creation of skid trails connecting the gaps. This grid-pattern of harvest resulted in the removal of approximately 20% of the basal area from the sites (Falk et al. 2010; Figure 2).

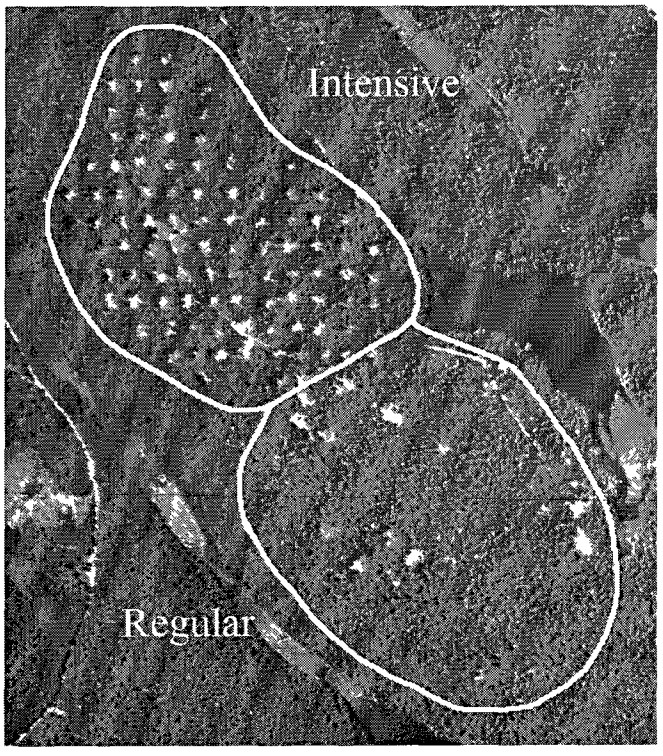

Figure 2: The two group-selection treatments in this study: Intensive and Regular. The single-tree canopy gaps within the Regular site are difficult to detect.

Data Collection

Site Conditions: At four locations per site (two gap and two neighbouring forest matrices) air and soil temperatures, light levels, and wind speeds were recorded every three to four days from early May to mid-August in both 2008 and 2009. Air temperature (in shade; 1m above-ground) and soil temperature (8cm below surface) were measured using Thermor's Model PS100 digital thermometer. Light levels (in footcandles) were measured using General Electric's Light Meter Type 214. In 2008, wind speed (in knots)

was measured 2m above-ground using Davis Instruments' (Hayward, California) Turbo Meter Wind Speed Indicator. In 2009, I used Speedtech Instruments' (Great Falls, Virginia) Skymate-18 to measure wind speed in km/h. The 2008 knot measurements were transformed to km/h by multiplying by 1.852 for comparison to the 2009 data.

Soil Moisture: In 2008, I took soil samples of approximately 175mL from approximately 8cm below surface from four locations per site (two gaps and two neighbouring forest matrices) at the beginning of each month from May to August. Soil samples were weighed immediately, left to air dry for five days, dried for 96h at 38°C (100°F) in a drying oven, and then re-weighed in order to determine the percent soil moisture. In late July 2009, I installed permanent precision access soil moisture tubes (40cm, Delta-T Devices) in two locations per site (one gap and one matrix) and measured soil moisture with Delta-T Devices' (Cambridge, England) Profile Probe Type PR2 and HH2 Moisture Meter. All nine sites were visited twice for soil moisture readings in 2009 and were revisited in May of 2010 for spring soil moisture readings. At each soil tube, soil moisture (in percent by volume) was measured three times each at 10, 20, 30, and 40cm below the surface, and the three values were averaged for each depth.

Plant Surveys: As part of a larger project on sustainable forest management (see Falk et al. 2010), between six (Controls) and ten (Intensives/Regulars) circular permanent growth plots (PGPs) were established to measure the growth, survival and regeneration of the vegetation within the forested matrix of each site. In addition, within each harvested site, ten canopy gaps were randomly selected and permanent monitoring plots were established (gap-PGPs). Within each forest-PGP are three circular $4m^2$ regeneration

growth plots (RGPs) and within each gap-PGP there are six RGPs. In 2009, I used the data gathered from these RGPs to assess the abundance and diversity of the floral understory. I used a random number generator to select three PGPs and three canopy gaps in each site to survey the understory. Because the gaps had six RGPs, I always sampled the three RGPs that were closest to the centre of the gap. For the Controls, I first located ten natural canopy gaps through ground truthing and then randomly selected three gaps to survey. With six PGPs per site, each with three-4m^2 RGPs, I surveyed 72m^2 of the understory per site, for a total of 216m^2 per treatment. Within each PGP plot (54 in all), I recorded the species of flowering plants that originated within the confines of the three RGPs, each species' percent cover, and the number of flowering stems per species. I did not record the presence, cover, or flowering stems of tree species [sugar maple, American beech, yellow birch, black cherry, ironwood (*Ostrya virginiana)*, American elm (*Ulmus americana*), or any conifer (*Pinus* spp., *Tsuga canadensis, Picea* spp., *Abies balsamea*)] because the young trees do not produce flowers, the mature trees have flowers well above the understory, and many tree species are wind-pollinated (Dafni et al. 2005). I also did not record the presence, cover, or flowering stems of graminoids (grasses, sedges, rushes) or beaked hazel because the majority of these plants are wind-pollinated (Dafni et al. 2005) and graminoids can be difficult to identify in the field. I surveyed the vegetation in early spring (by mid-May) to assess spring ephemerals whose above-ground parts wither and die after fruiting. I revisited all plots again in June/July to assess the later-blooming species. I used Chambers et al. (1996) to aid in plant identification in the field. In cases of difficult identifications, specimens were collected from outside the plots, brought back from the field and identified with Voss (1972, 1985, 1996) and a dissecting microscope (Wild-Heerbrugg 70-140x). Non-flowering stems of violet (*Viola*

spp.) and rattlesnake root/wild lettuce (*Prenanthes* spp.) could not be identified to species.

Plant Fecundity and Seed-Set: To determine if the fecundity and seed-set of flowers differed between gaps and matrices, at least 20 plants each of Carolina spring beauty, Dutchman's breeches (*Dicentra cucullaria*), and trout lily were marked in canopy gaps and 20 of each were marked in closed-canopy areas upon bud formation. The number of flowers per plant was recorded, and the marked individuals were revisited once the fruits had ripened. The fruits were picked, brought back from the field, and dissected. The total number of available ovules (for fecundity) and the number of fertilized ovules were recorded. Seeds or aborted seeds were distinguished from unfertilized ovules using guidelines in Davis (1966), Wolfe (1983), and Fukuhara (1999). I also marked foamflower (*Tiarella cordifolia*) in the gaps and matrices but it was difficult to differentiate between fertilized and unfertilized ovules if the capsules were picked too early and, if picked too late, their capsules were already split open and seeds would be missing. I therefore only compared the number of flowers per flowering stem between the gaps and the matrices for this species.

Insect Sampling:In 2007, insects were sampled passively using Malaise traps. In 2008 and 2009, in addition to Malaise traps, pan traps and sweep netting were used.

Malaise Traps: Malaise traps are tent-like traps made of mesh that randomly intercept aerial insects and which are particularly effective at collecting Diptera and Hymenoptera (BSC 1994; Dafni et al. 2005). Insects hit a central panel, fly upwards, and are funnelled

into a collecting head filled with alcohol. In this study, four different styles of Malaise trap were used (Figure 3) and a summary of all trap-type locations and sampling-times can be found in Appendix A.

A) "2875DG Malaise Trap" from Bioquip Products, Inc. (Rancho Dominguez, CA) made of green mesh, with one central panel and equipped with a translucent wet/dry collecting head (model 2875 WDH). These traps made up the bulk of the traps and were used in all three years.

B) Townes' style Malaise traps (Townes 1972) made of white and brown mesh with one central panel and equipped with a 500mL clear plastic bottle. These traps were only used in the 2007 sampling season.

C) "2875AG Malaise Trap" from BioQuip Products, Inc. made of green mesh with four central panels in a square configuration and equipped with a translucent wet/dry collecting head (model 2875WDH). These traps were only used in the 2007 sampling season.

D) Handmade aerial Malaise traps (M. Falconer) with four central panels of black mesh in a square configuration and equipped with a 500mL clear plastic bottle. These traps were only used in the 2009 sampling season and were raised between 3.5-5m above ground, using ropes thrown over tree branches.

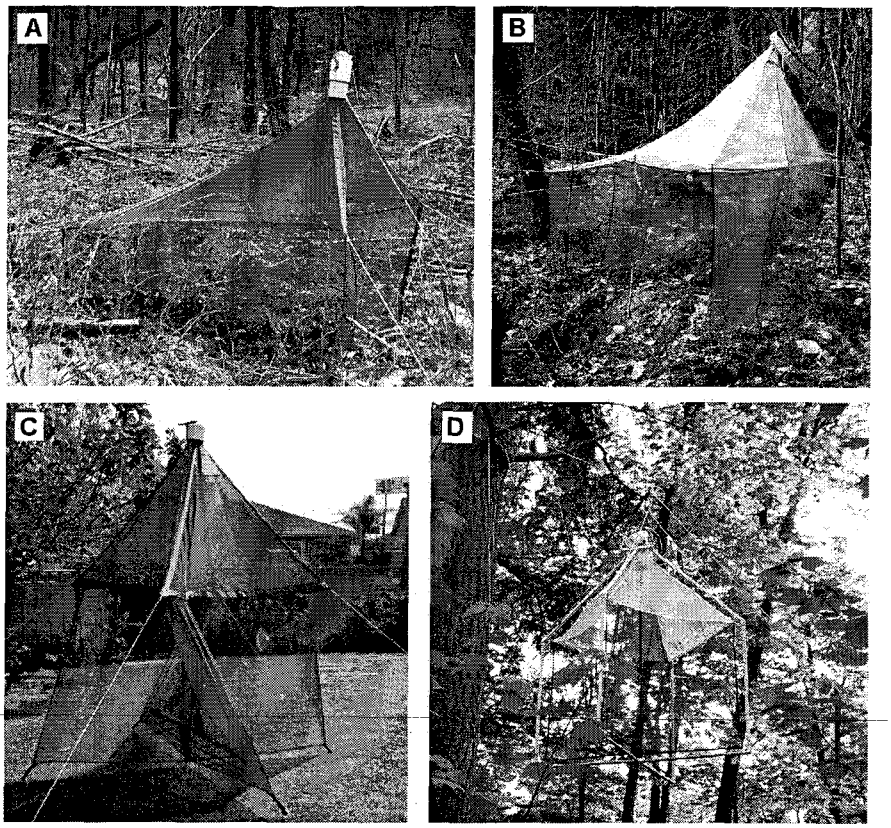

Figure 3: Malaise traps used in the study: A. BioQuip's Model 2875DG used in all three years; B. Townes' style trap used in 2007; C. BioQuip's Model 2875AG used in 2007; D. Handmade aerial trap used in 2009.

In 2007, within the Intensives and Regulars, two Malaise traps were placed in the centres of canopy gaps and two were placed in adjacent forested matrices (within 40-100m of gap-traps). The locations of traps were chosen after eliminating the gaps that were too close to roads and/or wet areas to ensure that the insects caught in the traps were representative of the sites sampled. Traps in Controls (3 per site) were placed along fixed-transects in the centres of the sites. Sampling began in late April/early May and continued until mid-July, with one two-week inactive period in June. I attempted to collect samples at 14d intervals but logistical issues caused sampling lengths to vary from

8-16d. As the season progressed, traps were removed from the sites because they were needed elsewhere in the project. Four Malaise trap samples were destroyed by wildlife or faulty collecting heads.

In 2008, I set two Malaise traps in each of the nine sites: one in a canopy gap and one in a neighbouring forested matrix. For each Control, ten natural canopy gaps were located through ground-truthing and one was randomly selected for the trap placement. Sampling began in early May and continued until the beginning of August. Samples were ideally collected every 14d but logistics caused sampling periods to vary from 2-19d. Four samples were destroyed by wildlife and yielded no samples, and four more were disturbed and yielded very small samples.

In 2009, Malaise traps were placed in the same locations as in 2008 and were active from early May to early August. In addition, one aerial trap per site was erected at the edge of a randomly selected canopy gap. Aerial traps were hoisted into the air with rope thrown over tree branches and were between 3.5-5m above-ground. I aimed to collect all traps every 14d, but sampling varied from 5-19d. Ten samples were destroyed by wildlife and five more were disturbed and yielded very small samples.

In all cases, ground-traps were placed on level ground with the long axis of the trap in line with a randomly chosen direction. I kept anticipated insect flight-paths in mind, so if obstructions such as thick shrubs or conifers blocked either side of the long axis, a new direction was chosen. Collecting heads were filled with a 50:50 water/denatured ethanol solution. All insects were preserved in 70% denatured ethanol upon removal from the collecting heads.

Pan traps: Some insects are not susceptible to Malaise trapping (Potts et al. 2005). Thus, I employed pan trapping as an additional passive technique (Potts et al. 2005). Pan traps consist of coloured bowls filled with soapy water. Many insects (including bees) are attracted to the coloured bowls and drown in the water. I set up permanent pan trap sampling stations in each site. Stations consisted of two 50m transects in an "X" configuration (as per LeBuhn et al. 2003) laid out in a canopy gap and its surrounding forested matrix (Figure 4). A randomly chosen direction was used to set the first transect of each plot, with the second lying perpendicular to it. Pan traps were placed every ~3.6m along each transect for a total of 14 traps/transect. No pan traps were placed at the intersection of the two transects but, in order to have an equal number of pans in the gap as in the matrix, four additional pans were placed inside the gap. This layout resulted in 32 pan traps, with half in the gap and half in the matrix. Control sites also received 32 pan traps but in a different configuration, determined by the size and shape of natural canopy gaps. Pan traps consisted of plastic 12oz. salad bowls painted either fluorescent yellow, fluorescent blue, or white half-filled with a water-dish detergent mix (approximately 15mL Ultra Concentrated Original Scent Blue Dawn Dish Detergent per 4L water). Traps were distributed in equal proportions in the morning (by 10am) and collected later that afternoon (by 5pm). Since pollinators are most active on warm (at least 12°C), calm, sunny days (Le Buhn et al. 2003), pan trapping was restricted to these conditions. Logistics and weather conditions made pan trapping sporadic so the sites were sampled once a season (in 2008 and 2009). Bees and syrphid flies were rinsed and preserved in 70% denatured ethanol upon collection.

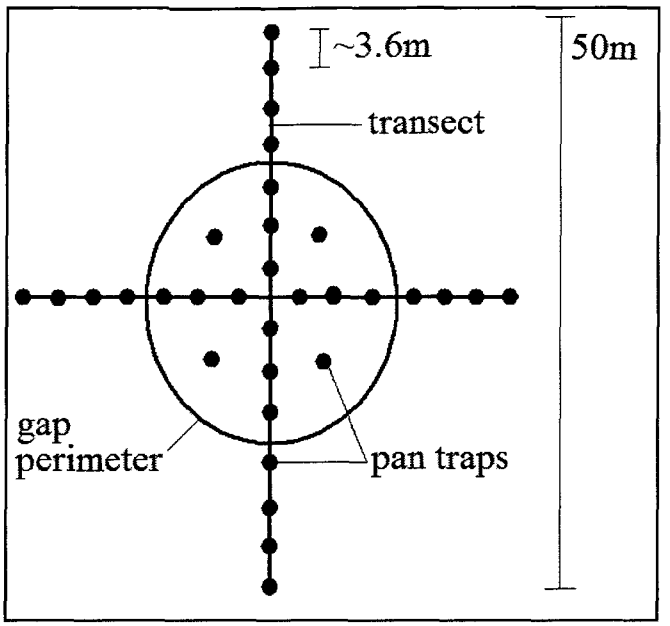

Figure 4: Pan trapping layout for Regular and Intensive sites (the layouts for the Control sites varied with the size and shape of natural canopy gaps).

Sweep Netting: Some insects are not susceptible to either form of passive sampling (BSC 1994; Cane et al. 2000; Potts et al. 2005) so I used a sweep net to actively collect pollinators. On the same days as the pan traps were active, I collected insect pollinators from flowers and the air. Because different insects are active at different times of the day, I sampled both in the morning and the afternoon. Captured bees and syrphid flies were placed in a killing jar with ethyl acetate, and were preserved in 70% denatured ethanol upon return from the field.

Insect Processing

For the Malaise trap samples, all insects were counted and identified to Order. Borror and White (1998), Marshall (2006) and McAlpine et al. (1981) were used to identify the

insects with a Wild-Heerbrugg 70-140x dissecting microscope. Syrphids and bees were separated from the samples. The flies were rinsed, pinned, labelled and sent to William J. Crins of the Ministry of Natural Resources (Peterborough), for identification to species. The bees were washed, dried, pinned, labelled and sent to Cory Sheffield and Jason Gibbs at York University (Toronto), for identification to species. A sub-sample of bees and flies were sent to Algonquin Provincial Park, but most flies will be housed at the University of Guelph and the bees will be housed in the Laurence Packer Collection at York University.

Analyses

Site Conditions: Site condition measurements from 2008 and 2009 were combined. All data were normally distributed (K-S tests $P>0.05$). For treatment effects, I used two-way ANOVAs with treatment and location (gap/matrix) as fixed factors.

Soil Moisture: Moisture levels were normally distributed (K-S tests $P>0.05$). I used fixed-factor ANOVAs with three factors: treatment, location (gap/matrix), and month with soil moisture as the dependent variable. The variances were not homogeneous between gaps and matrices in 2009 (Bartlett Chi-Square=8.98, $P<0.05$) but the difference in variance was less than 4 times and the sample sizes were equal so I proceeded with the ANOVA (Zar 1999).

Plant Surveys: I used PERMANOVA (see below) to evaluate the communities of plants found in the sites. As PERMANOVA compares communities as a whole, I also analyzed the differences in the four most abundant plant species among treatments and locations using Friedman ANOVA. I chose this non-parametric test because the probability of

committing a Type II error is reduced with this testwhen data are not normally distributed (Zar 1999), which was the case with these data. In conservation studies, failing to detect effects (i.e. Type II errors) can result in serious losses in an environment (Field et al. 2004). Box and whisker plots were examined to determine which factors(s) contributed to significant differences.

Plant Fecundity and Seed-Set: Independent t-tests between gaps and matrices were performedon the number of flowers/plant, the number of available ovules, and the proportion of fertilized ovules. For spring beauty, the flowers/plant and proportion of fertilized ovules were not normally distributed, nor were the available ovules and proportion of fertilized ovules for Dutchman's breeches. Therefore I used Mann-Whitney U tests.

General Insect Community Analyses: For syrphid and bee communities caught in Malaise traps, the abundance (number of organisms) and richness (number of species) were calculated for each treatment. As a measure of diversity, the Shannon Index (H) was used,

$$H=-\Sigma(p_i \ln p_i)$$

where p_i is the relative abundance of each species, calculated as the proportion of individuals of a given species (n_i) to the total number of individuals in the community (N). Shannon's Diversity Index takes into account not only the number of species but also their evenness in a sample (the equitability with which individuals are distributed among the different species). Values for the Index typically run from 1.5 (low diversity)

to 3.5 (high diversity), with the index increasing either by having additional unique species, or by having greater species evenness. Evenness itself was calculated by dividing the Shannon Index by the natural logarithm of species richness (Krebs 1989).

A problem with comparing community samples arises when sample sizes differ (Krebs 1989). In my study, Malaise traps in the Intensive treatment caught more syrphids and bees than in the other two treatments, and it is expected that with larger sample sizes comes higher richness. To determine if there were significant differences in the species richness of the treatments, I used rarefaction with EcoSim (Gotelli and Entsminger 2010). Rarefaction is a method for estimating the number of species expected in a random sample of individuals taken from a collection, to overcome the different sample sizes (Krebs 1989).

Sampling Effort: Malaise sampling effort was not even across treatments (see Appendix A). In 2007, Malaise traps in Controls were placed in forested areas but not in natural canopy gaps. For this reason, the main tests (PERMANOVA, see below) on syrphid and bee communities were applied to only the 2008 and 2009 catches. However, there was still disparity in sampling times for 2008 and 2009: Although the Intensive and Regular treatments both had approximately 1030 sampling days, Controls had 869 days, largely due to disturbance of traps by black bear (*Ursus americanus*) and moose (*Alces alces*). With fewer trap days, I was concerned that the Malaise traps in the Controls had not caught the full communities of syrphids and bees present in the sites. The sampling efficiency for Controls was assessed by creating species accumulation curves in relation to the sampling effort applied over the three years of the study. The shape of the curve is a good indicator of sampling efficiency because, as the slope approaches the asymptote,

the species estimate becomes closer to the true community value (Fayt et al. 2006). The number of species collected with Malaise traps approached the true community in Controls for both syrphids (Figure 5) and bees (Figure 6).

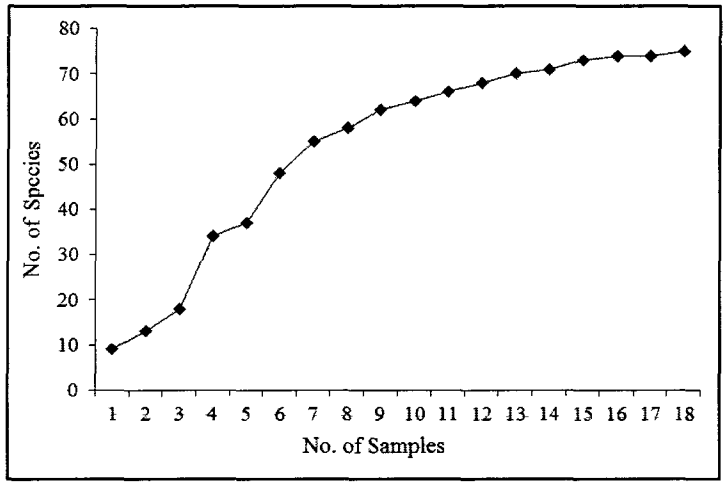

Figure 5: Syrphid species accumulation curve for Control sites

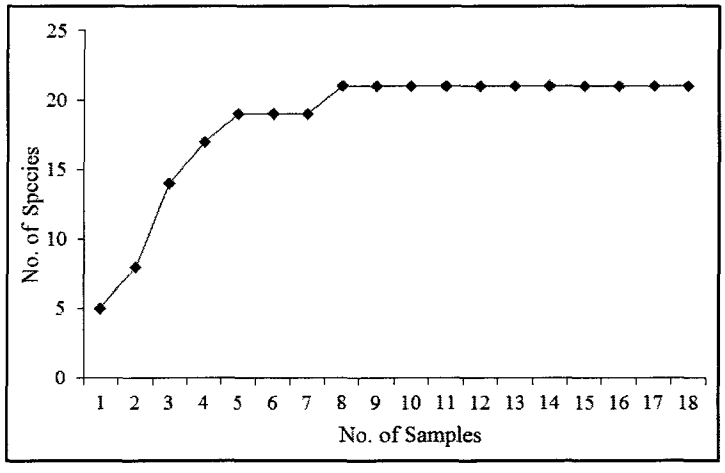

Figure 6: Bee species accumulation curve for Control sites.

Malaise traps function better in sunlight than in shaded conditions (Gittings et al. 2006; Irvine and Woods 2007). Malaise traps located in the forested matrices of the sites caught fewer insects than the neighbouring gap traps (1274.01±74.50 and 1609.43±112.18 insects, respectively; paired t_{17}=3.37, P=0.004). With smaller sample sizes, I would expect fewer pollinators too, so in order to compare the presence of pollinators in gaps versus matrices I needed to compare the proportions rather than abundances of pollinators in Malaise trap samples. I used an independent t-test on the arcsine of the square root of the proportion of pollinators in Malaise trap samples from gaps and matrices to determine whether or not pollinators were more abundant in canopy gaps.

PERMANOVA: The communities of syrphids and bees caught in the Malaise traps and the communities of plants from the plant surveys were analysed by permutational multivariate analysis of variance (PERMANOVA; Anderson 2005).

Multivariate analysis of variance (MANOVA) relies on the assumption of normality, which is not often met by ecological data: Abundances of organisms are in discrete values as opposed to continuous, distributions of individual species are usually highly clumped or skewed, and rare species contribute many zeros to some portions of the data set. Not only are MANOVA test statistics not particularly robust to these departures from multivariate normality, but many of the test statistics are impossible to calculate when there are more variables (species) than sampling units (Anderson 2001).

Bray-Curtis Distances and Dissimilarity Matrices:PERMANOVA is a non-parametric method to test for differences among groups of observations (in this case, communities of

flies, bees, or flowering plants), based on measures of difference between each pair of samples. The technique involves calculating a dissimilarity matrix which measures the difference between each sample and all others. The Bray-Curtis measure of ecological distance (B) is usedto express these differences,

$$B = \frac{\Sigma \mid \chi_{ij} - \chi_{ik} \mid}{\Sigma \mid \chi_{ij} + \chi_{ik} \mid}$$

where χ_{ij} and χ_{ik} are the number of individuals in species *i* in each sample. Bray-Curtis values range from zero to one and are well suited to species abundances because they ignore variables that have zeros for both objects (joint absences). The measure of dissimilarity is determined mainly by variables with high values (e.g. species with high abundances) because these variables are likely to be more different between objects (Krebs 1989; Quinn and Keough 2002).

The comparison of plant and insect communities among treatments was made by PERMANOVA on Bray-Curtis distances calculated on fourth-root transformed data. Fourth-root transformation reduces differences in scale among variables (species) while preserving information about the relative abundance of species (Clarke and Warwick 2001). All data were standardized by sample sums as well, because my samples varied in total number of insects and standardization removes the effects of different total abundances in different sampling units (Quinn and Keough 2002).

*Calculating the PERMANOVA Test Statistic:*In PERMANOVA, a statistic is constructed that uses Bray-Curtis values to compare differences among samples in one group (e.g. all

Malaise trap samples from Controls) to those in other groups (e.g. the Malaise trap samples from Intensives or Regulars), following the same framework of ANOVA (Anderson 2001). Traditional tabled P-values cannot be used with the PERMANOVA method because (as previously noted) individual variables (i.e. species) are rarely normally distributed and also Euclidean distances are not used. Instead, a distribution of the statistics under the null hypothesis can be created using the permutations of the samples and a P-value calculated from that (Anderson 2001).

For example, if the null hypothesis of no difference is true and the groups are not different in terms of their composition of insects, then the samples would be exchangeable between the groups, and the labels on the rows that identify them could be randomly shuffled (permuted) and a similar F-value obtained. Theoretically, the random reshuffling and recalculation of F could be repeated for all possible re-orderings of the rows relative to their labels. Comparison of this distribution of F's to the original value calculated from the initial ordering of the rows yields a P-value. However, because it is not practical to calculate all possible permutations, P can be calculated using a large random subset of all possible permutations, with the precision of P increasing with increasing numbers of permutations. Though Anderson (2001) suggests at least 1000 permutations should be done for tests with an alpha-level of 0.05, I chose 5000 permutations (the recommended number for tests with an alpha-level of 0.01) because it is a common choice for ecological studies on species assemblages (e.g. Anderson 2001; Claudet et al. 2006; Massimillano et al. 2006; Marignani et al. 2007).

There are three options for the general method of permutation used in a PERMANOVA: unrestricted permutation of raw data, permutation of residuals under the full model, and permutation of residuals under the reduced model. The three methods

give similar results but the raw data method, though less powerful than those with residuals, does not need large sample sizes to work and is, computationally, the fastest option (Anderson 2001). Because my sample sizes were small (n=3 samples for each combination of treatment*location*year) I used the raw data method.

Follow-up Tests: Although the full PERMANOVA provides an ideal test for examining differences among groups (e.g. the three treatments in this study), once it is known that the main test is significant the issue remains as to how to determine where the specific differences lie. This can be addressed with individual pairwise comparisons between particular groups. Similar to the main test's use of the F-statistic, for the follow-up tests a t-statistic can be calculated using Bray-Curtis distances with the general multivariate hypothesis of no difference between the groups. P-values for each test are obtained using separate sets of permutations that are used only across each pair of groups being compared (Anderson 2001).

For plant community tests I had two factors: treatment with three levels (Control, Intensive, Regular) as a fixed orthogonal factor and location with two levels (gap, matrix) as a fixed orthogonal factor. I surveyed the plant communities twice, once in early spring and again in summer, and these communities were analyzed separately. For the spring surveys, only species that had buds or blooms at the time of sampling were included in the analyses.

Though percent cover is bounded by 0 and 100% in each RGP, there are three RGPs in every PGP and Gap-PGP. Because of this, percent cover can have values greater than 100 in my study and the sum is treated as a measure of abundance (i.e., total cover of

76 for spring beauty in one treatment can be compared without transformation to a value of 165 in another).

For syrphid and bee communities I tested the effects of three factors: treatment with three levels (Control, Intensive, Regular) as a fixed orthogonal factor, year with two levels (2008, 2009) as a randomorthogonal factor, and location with two levels (gap, matrix) as a fixed orthogonal factor. Each combination of treatment-year-location had three replicates (sites). Tests were done on the communities caught throughout the season, as well as on the communities caught only in May. Aerial traps were used only in 2009 and there was little replication in pan trapping and netting, so the insects from these samples could not be analyzed with PERMANOVA (due to an unbalanced design). Therefore all insect community analyses were performed only on the catches from ground-level Malaise traps. The insects from Aerial traps, pan traps and netting are summarized instead.

Non-Metric Multidimensional Scaling (MDS) Ordination:The only assumption of PERMANOVA is that the observations are exchangeable under a true null hypothesis (i.e. that the observations are independent and have similar distributions or multivariate dispersions of points). Thus, like ANOVA, which is sensitive to heterogeneity of variances, PERMANOVA is sensitive to differences in the dispersion of points (Anderson 2001). PERMANOVA, however, does not create visual representations of the data, so multidimensional scaling ordination (MDS) must be used to visualize the dispersion of points.

Multidimensional scaling ordination (MDS) is designed to graphically represent relationships between objects in multidimensional space. Using the same similarity

matrix calculated for the PERMANOVA, MDS places the objects (in my case, samples) on a plot with the most similar samples closest together. It does this by starting with a random configuration of points on the plot. It then moves the points using an iterative algorithm, so that at each step, the match between the inter-object distances in the configuration and the actual similarities improves. The final position of the objects, and therefore the final configuration of the plot, is achieved when further iterative moving of objects can no longer improve the match between the inter-object distances in the configuration and the actual similarities (Quinn and Keough 2002). With MDS, there is some distortion (termed stress) which indicates how faithfully the high-dimensional relationships among the samples are represented on the ordination plots (Clarke and Gorley 2006). The principle of the MDS algorithm is to choose a configuration of points which minimizes the degree of stress (Clarke and Warwick 2001). MDS plots can be in any number of dimensions and with increasing dimensions comes lower stress. However, two-dimensional plots are the most convenient for interpretation and are the type of plot that I use. For two-dimensional ordinations, Clarke and Warwick (2001) suggest that stress values below 0.2 give useful pictures though values under 0.1 correspond to a good ordination with no real prospect of a misleading interpretation. Unfortunately, as the quantity of data increases so does stress (Clarke and Warwick 2001) and in my study I include up to 5493 individuals from 108 species (variables). In the instances of high stress, I reduced the number of variables by eliminating species with only one individual. These rare species do not contribute much to the Bray-Curtis values but add to the stress of the MDS. By removing them the MDS becomes more accurate at representing the data. If, after removing rare species, the stress was still too high, the differences in communities are summarized in table-form.

I used PRIMER version 6.1.13 (Clarke and Gorley 2006) to create MDS plots for the communities of plants in the treatments, and for the Malaise trap samples of syrphids and bees. Samples with zero catches (which was the case in some Control-Matrix bee samples) cannot be placed on the plot, so are omitted from the MDS.

Rare Syrphids and Bees: Rare species often have very specific habitat requirements (see Harrison et al. 2008). The presence of rare species is of interest to my study because they not only contribute to the diversity of a habitat (Myers et al. 2000), but their presence indicates that their specific habitat needs are being met (Harrison et al. 2008). To determine whether rare species (those that were represented by only one or two individuals) were more prevalent in a specific treatment, I used Kruskal Wallis tests on the number of rare species in the Malaise trap samples. Though the rarity of some of these species may be a consequence of sampling methods (i.e. they are abundant in the sites but were not caught), these effects would be even across treatments.

Abundant Syrphids and Bees: Although PERMANOVA assesses the similarities between entire communities it does not show the specifics as to which taxa may be contributing to these differences. As such, I analyzed the most abundant syrphid genera (with at least 100 individuals) and the most abundant bee species (with at least 20 individuals) with Kruskal Wallis tests to determine if the abundance measures varied among treatments. The rationale for using genus for syrphids and species for bees is based on their bionomics: Syrphid species of the same genus are apt to behave in similar ways (e.g. members of *Toxomerus* have aphidophagous young and polylectic adults that are found in open areas), species within the same genus of bee can behave in very different ways (e.g.

some *Andrena* are oligolecticbut others are polylectic; some *Lasioglossum* are solitary but others are primitively eusocial) (Batra 1987, Sommaggio 1999; Sheffield et al. 2003; Packer et al. 2007).

Pollinators in Spring:I used a two-way fixed factor ANOVA to assess if the number of syrphids and bees differed between treatments and location in the month of May. Syrphid data were normal and variances were homogeneous but bee data had to be transformed with log10(x+1) to become normal.

Pollinators and Flowering Stems in Summer: I used linear regression to compare the number of flowering stems and total cover (independent variables) found in each site during the summer (for both gaps and matrices) to the number of syrphids and bees (dependent variable) caught in each corresponding location. With nine sites, each with gap and matrix communities, there were 18 pairs of data.

RESULTS

Site Conditions

Controls tended to have cooler soils than both harvested treatments, though this was only significant between Controls and Intensives (Tukey HSD tests: Control-Intensive $P=0.05$, Control-Regular $P=0.09$, Intensive-Regular $P=0.97$). Controls had significantly less wind than both harvested treatments (Tukey HSD tests: Control-Intensive $P<0.001$, Control-Regular $P<0.001$, Intensive-Regular $P=0.45$) and significantly less light than both harvested treatments (Tukey HSD tests: Control-Intensive $P<0.001$, Control-Regular $P<0.001$, Intensive-Regular $P=0.75$; Table 1). There was an interaction between

Table 1: Air and soil temperatures, wind and light levels by treatment and location. Mean and standard error are reported.

	Control		Intensive		Regular		ANOVA	
Site							Treatment	Location
Condition	Gap	Matrix	Gap	Matrix	Gap	Matrix	$F_{2,30}$, P	$F_{1,30}$, P
Air (°C)	16.8±0.5	16.4±0.5	16.8±0.6	16.2±0.5	17.2±0.5	16.7±0.5	0.85, 0.44	3.03, 0.09
Soil (°C)	11.5±0.4	11.1±0.4	12.6±0.4	11.3±0.3	12.3±0.4	11.5±0.3	3.57, 0.04	12.45, 0.001
Wind (km/h)	1.3±0.1	0.9±0.1	2.3±0.2	2.4±0.2	2.9±0.3	2.3±0.2	32.33, <0.001	3.06, 0.09
Light (fc)[1]	573.6±31.0	327.1±34.9	835.3±29.0	349.2±36.3	800.4±27.8	421.5±33.3	21.82, <0.001	278.13, <0.001

1Interaction $F_{2,30}$=9.46, P<0.001

treatment and location for light levels: Control gaps were significantly shadier than both types of harvested gaps (Tukey HSD tests: Control-Intensive $P<0.001$, Control-Regular $P<0.001$, Intensive-Regular $P=0.97$) but there was no difference between the three treatments' matrix light levels (Tukey HSD tests: Control-Intensive $P=0.98$, Control-Regular $P=0.16$, Intensive-Regular $P=0.59$; Table 1).

Soil Moisture 2008

While the soil moisture measurements are inherently variable due to differences in weather on sampling days and my inability to measure moisture at all sites on the same day, I found statistically significant effects of treatment on soil moisture ($F_{2,112}=7.18$, $P=0.001$). Regular sites (32.32±1.39% moisture) were significantly drier than Controls (39.91±2.00%; Tukey HSD test $P=0.004$) and Intensives (39.92±1.51%; Tukey HSD test $P=0.005$).

Soil Moisture 2009/2010

In the summer of 2009 and the spring of 2010, soil moisture did not vary significantly between treatment ($F_{2,32}=0.87$, $P=0.43$), location ($F_{1,32}=0.05$, $P=0.83$), or month ($F_{2,32}=0.45$, $P=0.64$; Table 2). Though not significant, moisture increased with soil depth, Intensives had the highest moisture levels (except at 20cm), and moisture was also higher in the month of May.

Table 2: Treatment, location (gap/matrix) and monthly soil moisture (%/volume) means and standard errors for all depths combined and for each depth (10cm, 20cm, 30cm, 40cm). Bolded values indicate the trend of Intensives and May having the highest moisture levels.

Factor	Level	Overall	10cm	20cm	30cm	40cm
Treatment	Control	23.2±1.8	15.1±2.3	18.0±2.8	28.5±2.8	32.9±2.7
	Intensive	**27.6±2.4**	**22.9±3.4**	24.7±2.9	**31.2±3.1**	**31.8±2.9**
	Regular	25.0±2.4	17.4±2.4	**25.7±3.1**	29.6±2.5	28.5±3.0
Location	Gap	25.0±1.2	17.6±1.7	19.5±1.6	29.6±1.7	31.8±1.8
	Matrix	25.2±2.3	17.4±2.5	24.9±2.9	29.8±2.70	30.2±2.5
Month	May	**26.9±2.1**	**18.4±2.3**	**24.5±3.0**	**31.88±2.9**	**33.5±2.7**
	July	24.2±2.3	16.9±2.8	20.2±2.9	28.6±2.6	30.4±2.5
	August	24.3±2.3	17.2±2.8	22.3±2.7	28.7±2.8	29.2±2.9

Plant Surveys

General Results: Forty-one species of flowering plants were recorded in the 9 sites (Appendix B). The most commonly encountered species (in at least 20% of the plots) were trout lily, red trillium, Carolina spring beauty, wild red raspberry (*Rubus strigosus*), starflower, rose twisted-stalk, black-fringed bindweed (*Polygonum cilinode*), Canada mayflower, and hobblebush.

Of species encountered at least twice, Canada goldenrod (*Solidago canadensis*), northern willowherb (*Epilobium glandulosum*), and common blackberry (*Rubus*

allegheniensis) were found only in the canopy gaps, although willowherb contributed very little to cover (5%) overall. Goldthread (*Coptis trifolia*), shinleaf (*Pyrola elliptica*), and prickly gooseberry (*Ribes cynosbati*) occurred only in the forested matrices though they each had low cover (21, 4, and 4%, respectively). There were two non-native plants in the surveys, hemp nettle (*Galeopsis tetrahit*) and rough cinquefoil (*Potentilla norvegica*), both of which occurred rarely. Another non-native plant, common mullein (*Verbascum thapsus)*, was observed in one site but was not in any plot. Nine of 162 RGP plots contained no flowering plants, 7 of which were in the forested matrices, though this proportion compared across gaps and matrices was not significant (Fisher's exact P=0.17).

Of the most commonly occurring species, 78.9% of all wild red raspberry plants and 74.4% of all black-fringed bindweed were found in the gaps (see Appendix B). None of the commonly encountered species occurred so disproportionately within the matrices. Trout lily, which was found in 71.6% of all plots, occurred very evenly, with 49.1% in gaps and 50.9% in matrices.

Spring Plant Presence:There were 13 species of plant that had buds or blooms in the early spring. Using PERMANOVA, there was a significant interaction between treatment and location ($F_{2,53}$=2.68, P=0.01): The community of plants occurring in gaps varied significantly among treatments (Control-Intensive t_{17}=3.07, P<0.001; Control-Regular t_{17}=2.81, P=0.001; Intensive-Regular t_{17}=1.86, P=0.04), but there were no differences between the matrices of the three treatments (Control-Intensive t_{17}=1.33, P=0.18; Control-Regular t_{17}=1.62, P=0.08; Intensive-Regular t_{17}=0.43, P=0.97). Control communities differed significantly from Intensives (t_{35}=2.51, P<0.001) and Regulars (t_{35}=2.45,

P<0.001) but Intensives and Regulars did not differ from each other (t_{35}=1.05, P=0.38). Gap communities differed significantly from matrices ($F_{1,53}$=3.86, P=0.008; Figure 7).

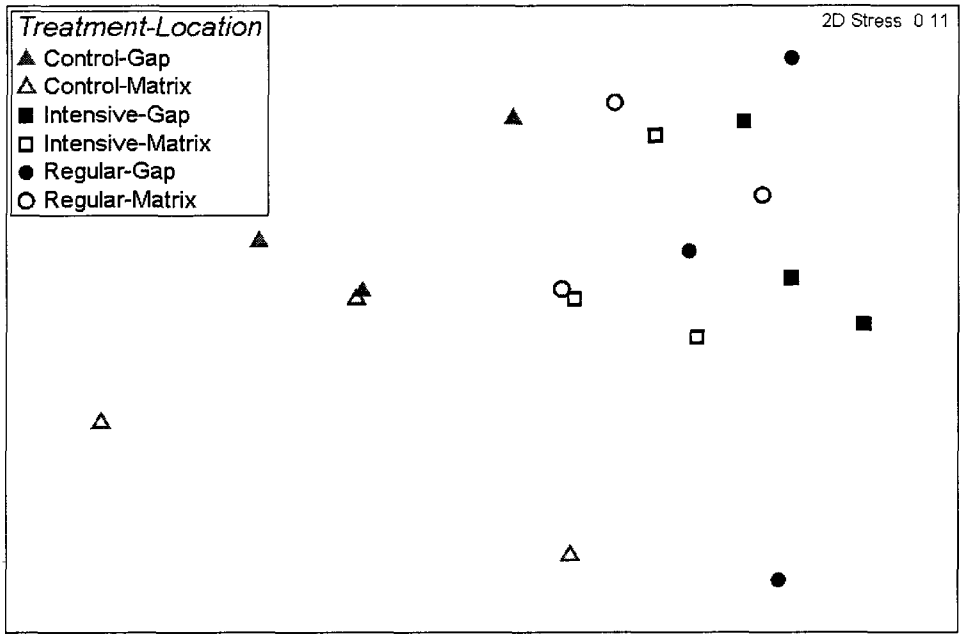

Figure 7: Multidimensional Scaling Ordination for the presence of spring-flowering plants in PGP plots, by treatment and location.

Out of 54 plots, the four species that were encountered in the most plots were trout lily (39 plots), spring beauty (34), red trillium (34), and sweet white violet (*Viola blanda*; 19). Control sites had significantly fewer occurrences of trout lily than did Intensive and Regular sites, and sweet white violet occurred more in the Regulars than in the Controls. Red trillium was found significantly less in Intensive gaps than in other locations (Table 3).

Table 3: Mean presence (proportion of plots) of the four most common spring-flowering plants by treatment and location. Bolded values indicate significantly lower presence.

Species	Control		Intensive		Regular		Friedman ANOVA	P
	Gap	Matrix	Gap	Matrix	Gap	Matrix	χ^2_5	
Trout Lily	**0.3**	**0.3**	1	1	1	1	30	<0.001
Spring Beauty	0.8	0.3	0.8	0.6	0.6	0.8	6.9	0.23
Red Trillium	1	0.6	**0.3**	0.7	1	1	17.28	0.004
Sweet White Violet	**0.1**	**0**	0.3	0.3	0.9	0.4	19.09	0.002

Spring Plant Percent Cover: The percent cover of spring plants varied significantly between treatments ($F_{2,53}$=7.08, P<0.001; Figure 7). Control plant cover was different than that of Intensives (t_{35}=2.54, P<0.001) and Regulars (t_{35}=2.34, P<0.001) but Intensive and Regulars did not differ from one another (t_{35}=1.08, P=0.34; Figure 8). Gaps and matrices differed significantly in their percent plant cover as well ($F_{1,53}$=2.87, P=0.02).

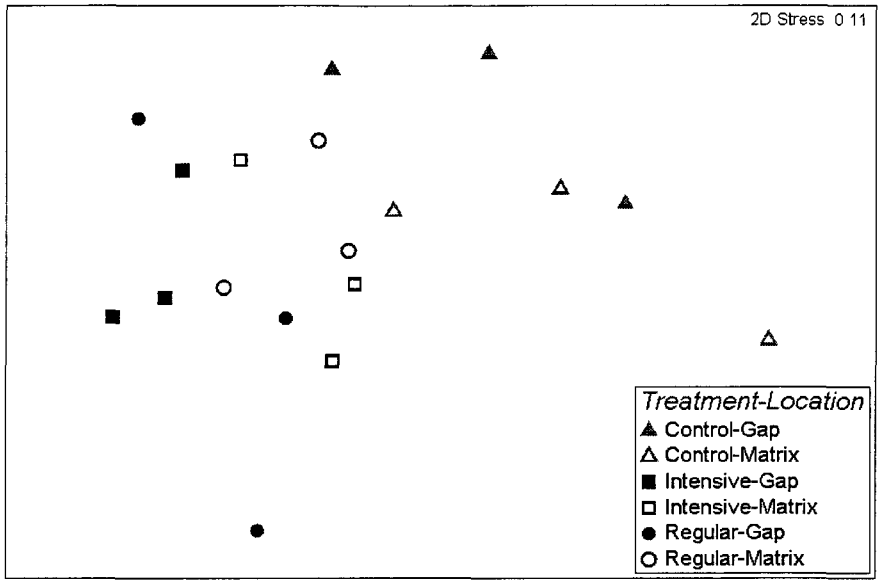

Figure 8: Multidimensional Scaling Ordination for the percent cover of spring-flowering plants by treatment and location.

Trout lily contributed the most cover in the spring (1659), followed by spring beauty (310), red trillium (127), and sweet white violet (122). Sweet white violet and red trillium had significantly different cover between the treatments: Controls had less cover of sweet white violet than the Intensives and the Regulars, and gaps in Intensive sites had less cover of red trillium than the other locations (Table 4).

Table 4: Mean (and range) of plant cover for four spring-flowering plants by treatment and location. Bolded values indicate which locations differed significantly from the others.

Species	Control		Intensive		Regular		Friedman	P
	Gap	Matrix	Gap	Matrix	Gap	Matrix	ANOVA χ^2_5	
Trout Lily	18.11 (0-62)	23.89 (0-90)	43.11 (16-80)	30.56 (1-80)	25.78 (1-75)	42.89 (2-85)	6.95	0.22
Spring Beauty	8.55 (0-26)	2.78 (0-17)	5.78 (0-23)	2.89 (0-12)	6.77 (0-25)	7.66 (0-34)	5.56	0.35
Red Trillium	5.22 (1-11)	2.44 (0-7)	**0.33 (0-1)**	2.56 (0-7)	1.77 (0-10)	1.78 (0-5)	13.14	0.02
Sweet White Violet	**0.56 (0-5)**	**0**	2.89 (0-15)	1.33 (0-6)	6.89 (0-33)	1.89 (0-11)	18.51	0.002

Spring Flowering Stems: The number of flowering stems did not differ significantly between treatments ($F_{2,53}$=1.03, P=0.43) or location ($F_{1,53}$=0.77, P=0.58), nor was there a significant interaction ($F_{2,53}$=1.43, P=0.16). Visible in Figure 9 as outliers, two samples had very low flowering stem diversity: the matrices of one Control site had one flowering stem of red trillium and the gaps of one Regular site only had flowering stems of sweet white violet.

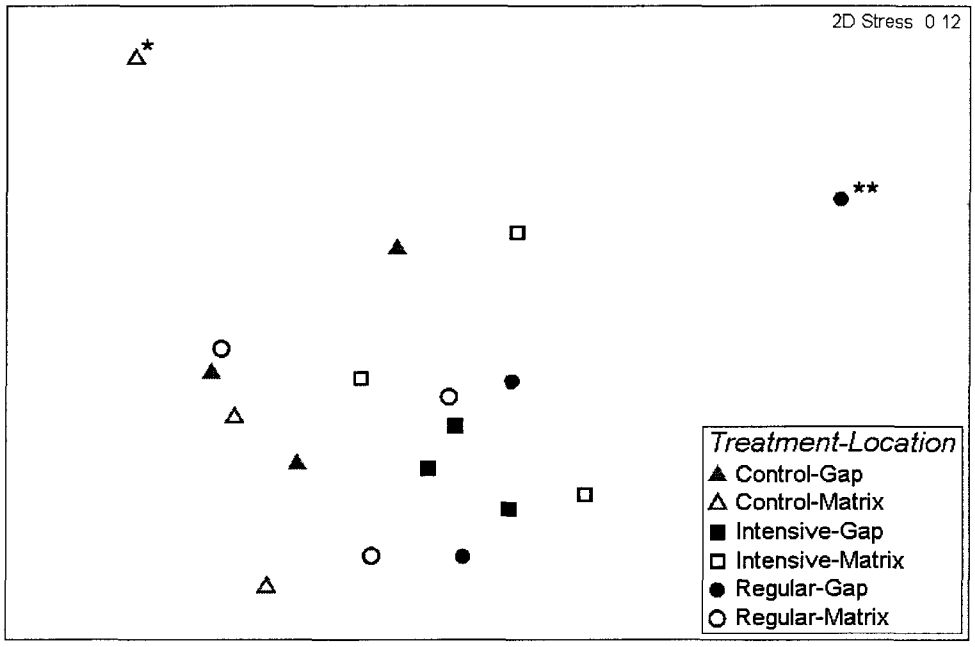

Figure 9: Multidimensional Scaling Ordination for the flowering stems of spring-flowering plants by treatment and location.

*Control-Matrix with one flowering stem of red trillium

**Regular-Gap with only 16 flowering stems of sweet white violet

Spring Beauty had the most flowering stems (1402), followed by sweet white violet (179), trout lily (50) and red trillium (48). Only red trillium varied significantly in the

number of flowering stems: Intensive gaps had fewer flowers of this species than the other locations (Table 5). Though not significant, sweet white violet had far more flowers in the harvested treatments and the gaps than in the Control sites and matrices.

Summer Plant Presence: Thirty-eight species of flowering plants were found in the summer. Presence of plants varied significantly between treatment ($F_{2,53}$=2.78, P=0.003) and location ($F_{1,53}$=2.87, P=0.008), but there were no interactions ($F_{2,53}$=1.01, P=0.46). Pairwise comparisons showed that the presence of plants in Controls differed significantly from that in Intensives (t_{35}=1.68, P=0.01) and Regulars (t_{35}=1.86, P=0.003) but that Intensives and Regulars were not different (t_{35}=1.16, P=0.25). The multidimensional scaling ordination plot had a high stress level, so it was inadequate for use in presenting these data, but Controls sites had fewer species than the other two treatments (Table 6). The gap and matrix differences are less distinct though gaps had significantly more occurrences of raspberry (n=23) than matrices (n=11; Table 7).

Table 5: Mean (and range) of flowering stems for four spring-flowering plants by treatment and location. Bolded value indicates which location differed significantly from the others.

Species	Control		Intensive		Regular		Friedman	P
	Gap	Matrix	Gap	Matrix	Gap	Matrix	ANOVA χ^2_5	
Spring Beauty	49.44	15.22	26.44	12	25	27.67	6.85	0.23
	(0-50)	(0-96)	(0-110)	(0-57)	(0-86)	(0-118)		
Sweet White Violet	0.67	0	4.44	0.78	11.78	2.22	10.35	0.07
	(0-6)		(0-22)	(0-5)	(0-67)	(0-13)		
Trout Lily	0.33	0.78	1.00	0.56	1.67	1.22	2.50	0.78
	(0-2)	(0-5)	(0-7)	(0-3)	(0-10)	(0-7)		
Red Trillium	1.78	0.67	**0**	1.11	1.11	0.67	11.97	0.03
	(0-6)	(0-5)		(0-4)	(0-8)	(0-2)		

Table 6: Presence in RGP plots of summer-flowering plants by treatment and location.

	Control		Intensive		Regular	
	Gap	Matrix	Gap	Matrix	Gap	Matrix
No. of occurrences	42	36	36	49	51	41
Average per plot	4.67	4	4	5.44	5.67	4.56
No. of species	15	13	20	25	21	20

The most commonly encountered species were wild red raspberry (34 plots), hobblebush (21), starflower (20) and rose-twisted stalk (18). Only raspberry was distributed unevenly: there were significantly fewer occurrences of this plant in matrices of Control and Intensive sites than in other locations (Table 8).

Table 7: Mean presence of the four most common summer-flowering plants by treatment and location. Bolded values indicate which locations differed significantly from the others.

Species	Control		Intensive		Regular		Friedman ANOVA	P
	Gap	Matrix	Gap	Matrix	Gap	Matrix	χ^2_5	
Wild red raspberry	0.56	**0.22**	1	**0.33**	1	0.67	18.57	0.002
Hobblebush	0.22	0.67	0.22	0.44	0.44	0.33	5.00	0.42
Starflower	0.56	0.33	0.11	0.33	0.56	0.33	5.15	0.40
Rose twisted-stalk	0.56	0.33	0.11	0.33	0.56	0.33	3.53	0.62

Omitting raspberry eliminated the location effect ($F_{1,53}$=0.97, P=0.46) but the treatment effect was still present ($F_{2,53}$=2.36, P=0.006): Control communities were still significantly different from the other two (Intensive t_{35}=1.60, P=0.03, Regular t_{35}=1.54, P=0.05). The stress level for this test was also too high to adequately represent the data.

Summer Percent Cover:Cover varied significantly by treatment($F_{2,53}$=3.27, P<0.001) and location ($F_{1,53}$=6.16, P<0.001). Controls had significantly lower summer plant cover than Intensives (t_{35}=1.86, P=0.003) and Regulars (t_{35}=1.83, P=0.001) but Intensives and Regulars did not differ (t_{35}=1.03, P=0.40). The MDS plot had high stress and therefore did not represent the data effectively. Controls and matrices have far less cover than the harvested treatments and the gaps (Table 8).

Table 8: Cover of summer-flowering plants by treatment and location.

	Control		Intensive		Regular	
	Gap	Matrix	Gap	Matrix	Gap	Matrix
Total cover	551	366	1971	512	1989	550
Average cover	61.22	40.67	219	56.89	221	61.11

Wild red raspberry comprised the highest cover (3248), followed by hobblebush (580), black-fringed bindweed (341) and wild sarsaparilla (*Aralia nudicaulis*; 246). Gaps in Intensive and Regular sites had significantly more raspberry cover than the other locations (Table 9).

By omitting raspberry I eliminated the location effect ($F_{1,53}$=1.27, P=0.26) but the treatment effect was still present ($F_{2,53}$=2.31, P=0.003): Controls continued to have lower summer plant cover than Intensives (t_{35}=1.60, P=0.02) and Regulars (t_{35}=1.47, P=0.05).

Table 9: Mean (and range) of plant cover for four summer-flowering plants by treatment and location. Bolded values indicate which locations differed significantly from the others.

Species	Control		Intensive		Regular			
	Gap	Matrix	Gap	Matrix	Gap	Matrix	Friedman χ^2_5	P
Wild red raspberry	19.44 (0-100)	0.44 (0-2)	**172.44 (65-245)**	3.88 (0-26)	**161.11 (14-295)**	3.56 (0-13)	33.63	<0.001
Hobblebush	3.44 (0-25)	14.11 (0-70)	4.44 (0-25)	23 (0-77)	10 (0-40)	9.44 (0-45)	3.60	0.61
Black-fringed bindweed	1.11 (0-8)	0	23.89 (0-80)	2.56 (0-18)	7.44 (0-37)	2.89 (0-24)	6.41	0.27
Wild Sarsaparilla	3.44 (0-31)	3.22 (0-20)	1.11 (0-10)	7.11 (0-40)	5.11 (0-40)	7.33 (0-24)	4.04	0.54

Summer Flowering Stems: There was a significant interaction between treatment and location ($F_{2,53}$=2.54, P=0.003). Gaps of Controls differed significantly from the gaps of Intensives (t_{17}=2.81, P=0.002) and Regulars (t_{17}=1.99, P=0.003), but the gaps of Intensives and Regulars did not differ from one another (t_{17}=0.90, P=0.56) and none of the matrices differed from one another (Control-Intensive t_{17}=1.01, P=0.40; Control-Regular t_{17}=0.85, P=0.59; Intensive-Regular t_{17}=0.99, P=0.45). The number of flowering stems varied significantly by treatment ($F_{2,53}$=2.76, P=0.003): Controls were different from Intensives (t_{17}=1.76, P=0.009) and Regulars (t_{17}=1.46, P=0.04) but Intensives and Regulars did not differ (t_{17}=0.82, P=0.69). Gaps and matrices also differed significantly in the number of flowering stems ($F_{1,53}$=9.89, P<0.001; Figure 10).

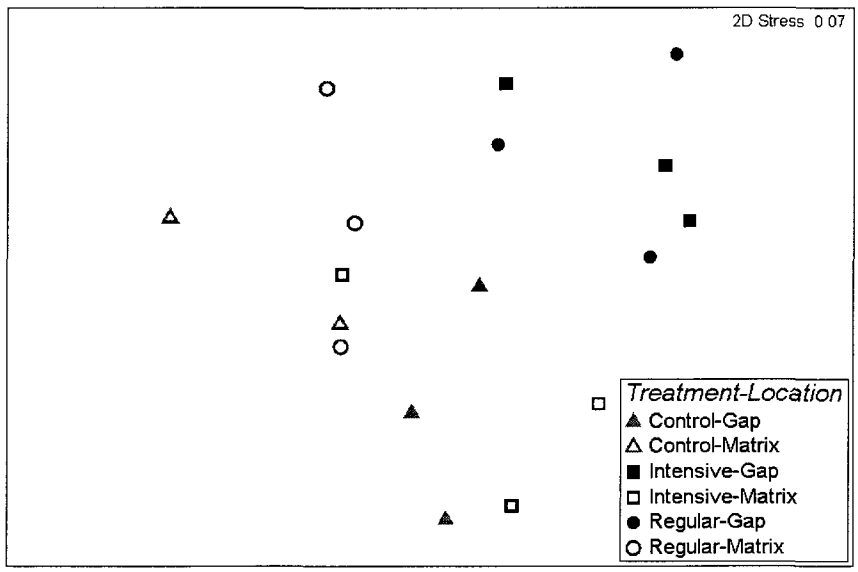

Figure 10: Multidimensional Scaling Ordination for the flowering stems of summer-flowering plants by treatment and location. Note: One Control-Matrix did not have any flowering stemsand is therefore absent from the plot.

Wild red raspberry had the most flowering stems (717), followed by black-fringed bindweed (126), starflower (82) and wood sorrel (*Oxalis acetosella*; 33). Jewelweed (*Impatiens capensis*) also had many flowering stems (61) but it was localized in the wet areas of one Regular site.

Wild red raspberry had significantly more flowering stems in the gaps than in the matrices, wood sorrel had significantly more flowering stems in the matrices than in the gaps, and starflower had significantly more flowering stems in Control sites and the matrices of harvested sites than in the gaps of harvested sites (Table 10).

Table 10: Mean (and range) of flowering stems for four summer-flowering plants by treatment and location. Bolded values indicate which locations had significantly more flowering stems.

Species	Control		Intensive		Regular		Friedman χ^2_5	P
	Gap	Matrix	Gap	Matrix	Gap	Matrix		
Wild red raspberry	**1.78 (0-8)**	0	**34.33 (4-70)**	0	**43.56 (0-130)**	0	37.52	<0.001
Black-fringed bindweed	0	0	11 (0-40)	0.56 (0-5)	2.22 (0-12)	0.22 (0-2)	10.08	0.07
Starflower	**6.22 (0-36)**	**0.44 (0-3)**	0	**0.33 (0-2)**	0.11 (0-1)	**2 (0-11)**	10.95	0.05
Wood Sorrel	0	**1.44 (0-8)**	0	**0.11 (0-1)**	0	**2.11 (0-12)**	12.54	0.03

By omitting raspberry I eliminated both the treatment ($F_{2,53}$=1.47, P=0.13) and location ($F_{1,53}$=0.95, P=0.44) effects. Without raspberry there is no significant difference in the number of flowering stems between treatments or between gaps and matrices (Figure 11).

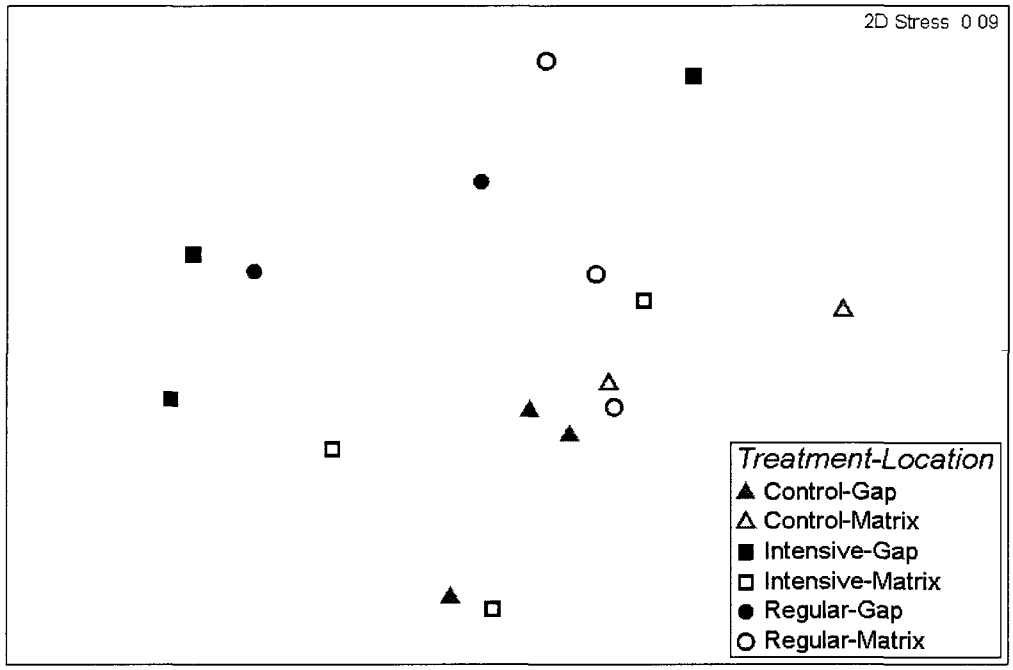

Figure 11: Multidimensional Scaling Ordination for the flowering stems of summer-flowering plants by treatment and location, omitting wild red raspberry. Note: One Regular-Gap and one Control-Matrix did not have any flowering and are therefore absent from the plot.

Fecundity and Seed Set

Spring Beauty: There was no difference in the number of flowers per plant for gap and matrix spring beauties (median: 5, range: 2-11 and 6, 3-8, respectively; Mann-Whitney U=786, P=0.45). All spring beauty flowers had a fecundity of 6±0 ovules per flower. The

proportion of fertilized ovules was significantly higher in gap than in matrix spring beauties (median: 50%, range: 0-100% and 33.3%, 0-100%, respectively; Mann-Whitney U=5091, P< 0.001).

Trout Lily: Flowering stems of trout lilies always have only one flower. Fecundity was significantly higher in gap than matrix trout lilies (t_{71}=3.80, P<0.001; Figure 12). There was no difference in the proportion of fertilized ovules in gap and matrix trout lilies (56.2±4.4% and 63.4±5.5% fertilized, respectively; t_{71}=1.01, P=0.31).

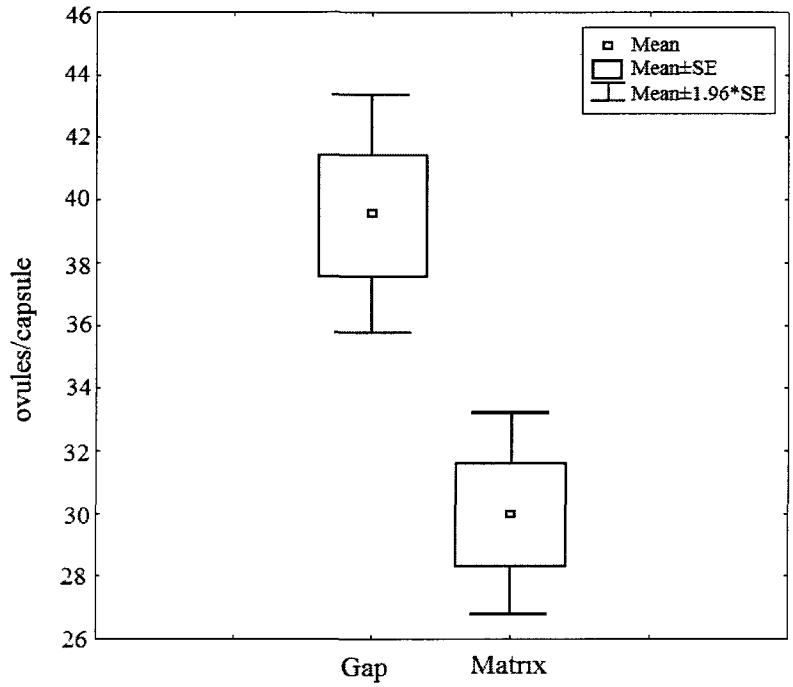

Figure 12: Trout lily (*Erythronium americanum*) ovules per capsule in canopy gaps and forested matrices.

Dutchman's Breeches: There was no significant difference in the number of flowers per plant between gap and matrix Dutchman's breeches (2.9±0.4 and 3.2±0.3 flowers per

plant, respectively; t_{39}=0.41, P=0.68). Fecundity was significantly higher in matrix than in gap Dutchman's breeches (median: 12, range: 6-16 and 10, 4-22 ovules per plant, respectively; Mann-Whitney U=987, P=0.001). There was no significant difference in the percentage of fertilized ovules in gap and matrix plants (median of 84.6, range: 25-100% and 90.1, 14.3-100%, respectively, Mann Whitney U = 1499.5, P=0.81).

Foamflower: There was no significant difference in the number of flowers per flowering stem between gap and matrix foamflowers (14.9±0.9 and 16.6±1.0 flowers per stem, respectively; t_{58}=1.29, P=0.20).

General Insect Communities

Gap and Matrix Pollinator Proportions:The percentage of pollinators in samples (bees and syrphids combined) was significantly higher in gap Malaise trap samples (3.43±0.33%) than in matrix Malaise trap samples (0.96±0.20%; t_{105}=7.83, P<0.001).

Syrphids:Malaise traps, pan traps, and sweep netting caught 7992 syrphids from 140 species (50 genera; Appendix C). Nine-hundred and eighty-one flies could be identified only to genus (639 *Eupeodes*, 213 *Platycheirus*, 52 *Sphaerophoria*, 39 *Parasyrphus*, 34 *Syrphus*, 2 *Lejops*, 1 *Epistrophe*, and 1 *Xylota*) and were excluded from all analyses. Of the remaining 7011 flies, the four most abundant species (making up at least 5% of the total) were *Toxomerus geminatus* (17.0%), *T. marginatus* (12.9%), *Melanostoma mellinum* (9.8%), and *Platycheirus obscurus* (6.9%). Twenty-six species were represented only by a single individual.

The Intensives had the highest abundance of syrphids and Controls had the lowest (Table 11). Richness was highest in the Regulars and lowest in the Controls. Controls were the most even and Intensives were the least even. The treatments had similar diversity indices although Regulars had the highest diversity and Intensives had the lowest. Regulars had the most unique species (i.e. there were 21 species that were found only in the Regulars) while Controls had no unique species. Using rarefaction, if I had caught 1265 syrphids each in Intensives and Regulars, I would expect between 83 and 96 species, and between 91 and 105 species, respectively, with 95% confidence. As 75 species were captured in Controls, I can conclude that the Controls are significantly less rich than the other two treatments. If I sampled 2595 from 3151, I would expect between 105 and 112 species. As 121 species were captured in Regulars, they are significantly more species rich than Intensives.

Table 11: Syrphid communities by treatment.

Community Measure	**Control**	**Intensive**	**Regular**
Abundance	1265	**3151**	2595
Catch/day (individuals)	0.96	**1.89**	1.70
Richness	75*	113	**121****
Evenness	**0.75**	0.70	0.71
Shannon's H	3.22	3.17	**3.39**
Most common species	*Melanostoma mellinum* (17%)	*Toxomerus marginatus* (21%)	*Toxomerus geminatus* (19%)
Unique species	0	15	21

*significantly less rich than the other two treatments

**significantly more rich than Intensives

Aerial Malaise traps in 2009 caught 67 syrphids from 28 species. Pan traps in 2008 and 2009 caught 91 syrphids from 18 species, and yielded the only specimen of *Xylota segnis.* Sweep netting caught 98 syrphids from 39 species and yielded the only specimen of *Mallota bautias (*Appendix C).

Bees: Traps caught 1826 bees from 80 species (13 genera; Appendix D). Twenty-one bees could not be identified to species (1 *Andrena*, 1 *Hylaeus*, 19 unknown). These bees have been sent to York University for identification and DNA-barcoding, and were

excluded from all analyses. Of the remaining 1805 bees, the seven most abundant species were *Lasioglossum cressonii* (18.1%), *L. atwoodi* (14.6%), *L. versans* (7.3%); *L. divergens* (6.2%), *L. subdirivatum* (6.2%), *Andrena erigeniae* (6.2%), and *A. rufosignata* (6.1%). Twenty-one species were represented only by a single individual.

The Intensive sites had the highest abundance of bees, the highest richness, and the most unique species (Table 12). Controls had the lowest abundance and lowest richness, and had only one unique species. Controls were the most even and Intensives were the least even. Using Shannon's Diversity Index, Regulars had the highest diversity and Controls had the lowest. Using rarefaction, if I had caught 96 bees each in Intensives and Regulars, I would expect between 21 and 32 species, and between 23 and 34 species, respectively, with 95% confidence. As 24 species were captured in Controls, there was therefore no significant difference in species richness between treatments. If I sampled 782 from 917, I would expect between 60 and 66 species so there is no significant difference in Regular and Intensive richness.

Table 12: Bee communities by treatment

Community Measure	Control	Intensive	Regular
Abundance	96	**917**	782
Catch per day	0.07	**0.55**	0.51
Richness*	24	67	64
Evenness	**0.80**	0.70	0.75
Shannon's	2.54	2.93	**3.14**
Most common species	*Andrena rufosignata* (26%)	*Lasioglossum cressonii* (22%)	*Lasioglossum cressonii* (16%)
Unique species	1	15	10

* no significant difference between the richness of treatments

Aerial Malaise traps in 2009 did not catch any bees. Pan traps in 2008 and 2009 caught 194 bees from 37 species, and yielded the only specimens of *Bombus frigidus*, *Colletes thoracius*, *Hylaeus annulatus*, and *Sphecode saroniae*. Sweep netting caught 105 bees from 36 species and caught the only specimens of *Andrena miserabilis*, *Lasioglossum leucozonium*, and *Osmia tursula*. The three specimens of *Lasioglossum* nr *comagenense* were also caught only with these methods (2 in pans and 1 in net). See Appendix D for a breakdown of the bee-catches by treatment, year, and location.

Treatment and Location Effects: Syrphids

I found a significant difference in the syrphid communities between the three treatments ($F_{2,35}$=1.85, P=0.03) and pairwise comparisons revealed that syrphid communities caught in the Controls differed significantly from those in Intensives (t_{23}=1.40, P=0.04), but not

Regulars (t_{23}=1.17, P=0.17; Figure 13). In the MDS plot, two Regular-Gaps are in close proximity to the Control-Gaps and this explains why the test found no difference between these two treatments. There was also a location effect: Gaps communities were significantly different from Matrix communities ($F_{1,35}$=11.74, P<0.001), and Figure 13 shows the Matrix communities were more variable than gap communities and are the farthest away from the harvested-treatments' gap samples. There was a year effect as well: 2008 communities were significantly different from 2009 ($F_{1,35}$=4.13, P<0.001, Figure 14).

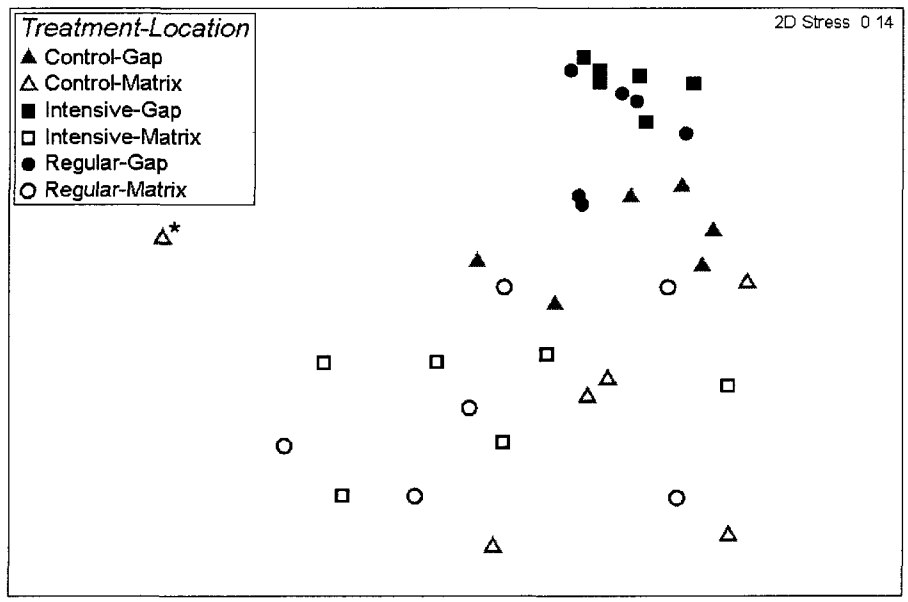

Figure 13: Multidimensional scaling ordination plot for syrphids caught in Malaise traps in 2008 and 2009 by treatment and location. *This 2009 outlier was a Control-Matrix sample that was frequently disturbed by wildlife.

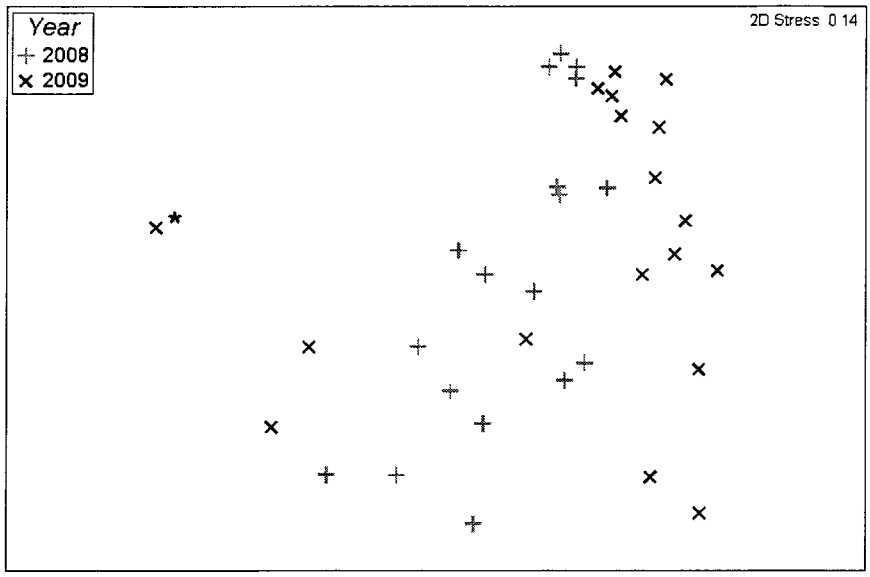

Figure 14: Multidimensional scaling ordination plot for syrphids caught in Malaise traps in 2008 and 2009 by year. *This 2009 outlier was a Control-Matrix sample that was frequently disturbed by wildlife.

For syrphids caught only in Matrix traps (1485 from 86 species), there was no treatment effect ($F_{2,26}$=1.84, P=0.09; Figure 15) but there was a year effect ($F_{2,26}$=3.83, P<0.001). Pairwise comparison revealed that 2007 differed significantly from 2008 (t_{17}=2.32, P<0.001) and 2009 (t_{17}=1.97, P<0.001), and 2008 differed significantly from 2009 (t_{17}=1.66, P=0.003; Figure 16).

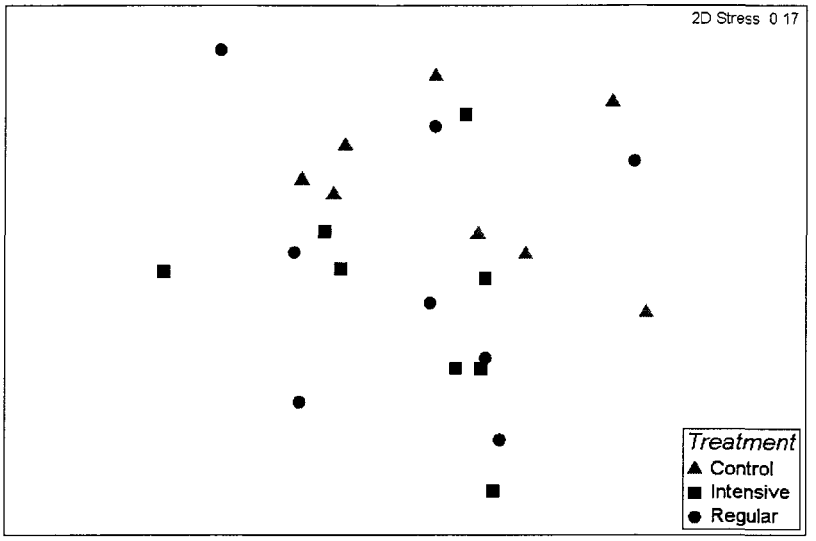

Figure 15: Multidimensional Scaling Ordination for syrphid communities caught in Matrix Malaise traps in 2007, 2008, and 2009 by treatment.

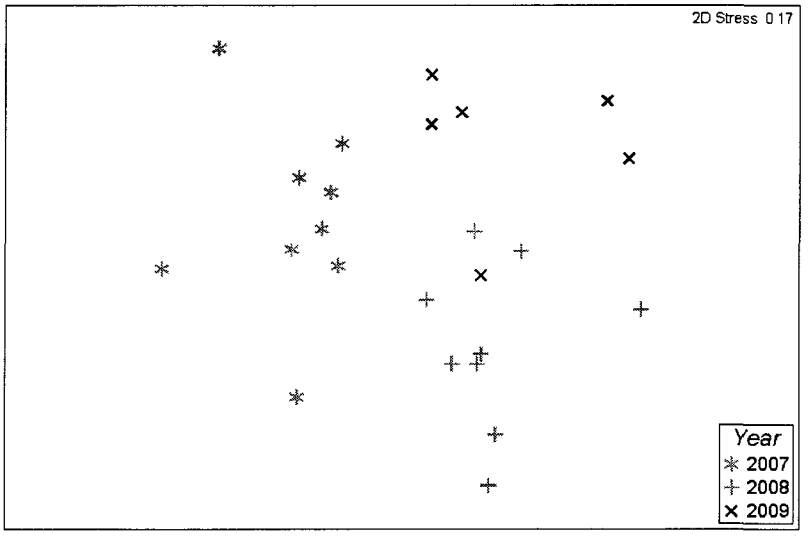

Figure 16: Multidimensional Scaling Ordination for syrphid communities caught in Matrix Malaise traps in 2007, 2008, and 2009 by year.

For syrphids caught only in the Intensive and Regular sites (5493 syrphids from 108 species), the communities did not differ significantly ($F_{1,35}$=1.18, P=0.26), but there

were significant differences between the years ($F_{2,35}$=4.44, P<0.001) and trap-locations ($F_{1,35}$=14.17, P<0.001). Pairwise comparisons revealed that 2007 was different from 2008 (t_{23}=1.97, P=0.003) and 2009 (t_{23}=1.84, P=0.004) but 2008 and 2009 were not significantly different (t_{23}=1.38, P=0.09; Figure 17).

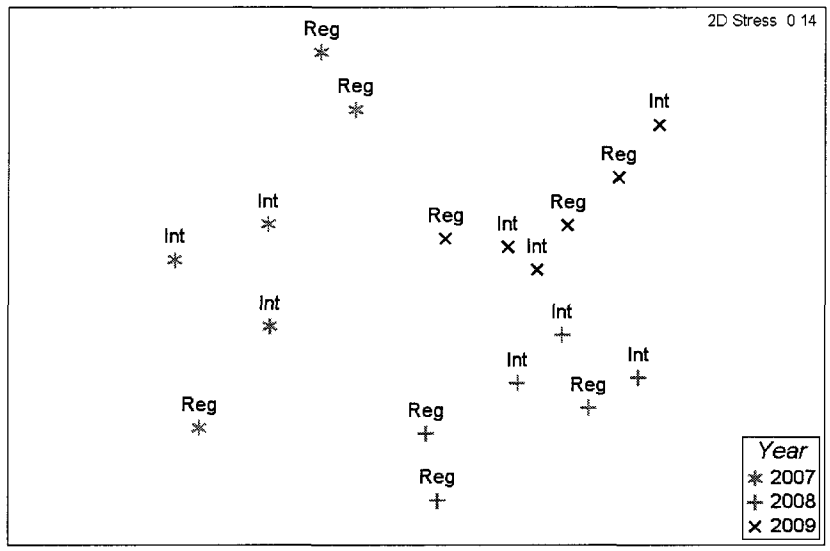

Figure 17: Multidimensional Scaling Ordination for syrphids caught in Intensive and Regular sites in 2007, 2008 and 2009.

Rare Syrphids

There were 38 species of syrphids caught in Malaise traps that were represented only by one or two individuals. Controls had three individuals from three species, Intensives had 26 individuals from 20 species, and Regulars had 22 individuals from 28 species. The number of rare syrphids in the samples differed significantly by treatment ($H_{2,27}$ = 12.70, P=0.002). Control samples had significantly fewer rare flies (1; range 0-3) than Intensive (10; range 4-12; non-parametric post-hoc analysis P=0.006) and Regular samples (8; range 5-9; non-parametric post-hoc analysis P=0.01).

Abundant Syrphid Genera

For the 16 syrphid genera that had at least 100 individuals, only *Xylota* was not distributed evenly between the treatments when using a Bonferoni-adjusted α value (0.05/16tests=0.003; Table 13). Controls had significantly fewer *Xylota* (2; range 0-6) than Intensives (15; range 6-69; non-parametric post-hoc analysis P=0.001) and Regulars (7; range 1-56; non-parametric post-hoc analysis P=0.04). *Toxomerus* was also close to being significantly different between treatments (P=0.006), with Controls having caught fewer (16; range 1-48) than either Intensives (67; range 16-566; non-parametric post-hoc analysis P=0.02) or Regulars (71; range 20-143; non-parametric post-hoc analysis P=0.01). Without the adjustment, *Sericomyia* and *Sphaerophoria* also vary by treatment.

Table 13: The mean (and range) abundance of the 16 most abundant syrphid genera by treatment.

Genus	Control	Intensive	Regular	$H_{2,27}$	P
Brachyopa	1.89 (0-4)	6.89 (0-24)	5.11 (0-13)	4.27	0.11
Chalcosyrphus	6.33 (1-14)	12.33 (3-23)	13.56 (2-31)	3.84	0.15
Dasysyrphus	4.89 (1-9)	8.11 (1-12)	7.33 (2-14)	5.04	0.08
Helophilus	4.89 (0-17)	17 (0-70)	7.22 (0-41)	0.71	0.70
Lejota	1.78 (1-4)	5.56 (0-15)	6.44 (1-14)	4.70	0.10
Melanostoma	24.22 (5-49)	23 (9-37)	29.44 (5-44)	1.80	0.41
Meliscaeva	2.11 (0-7)	5.33 (0-20)	4.67 (0-14)	2.01	0.37
Platycheirus	13.56 (5-38)	29.78 (9-82)	29.33 (3-88)	3.47	0.18
Rhingia	7.22 (0-28)	9.67 (3-21)	6.67 (0-20)	2.40	0.30
Sericomyia	1.56 (0-5)	5.11 (1-11)	8.33 (1-33)	8.53	**0.01**
Sphaerophoria	2.11 (0-11)	8.56 (0-21)	8.89 (1-30)	6.97	**0.03**
Sphegina	11.78 (1-45)	4.56 (0-24)	5.33 (0-17)	3.57	0.17
Syrphus	20.11 (10-38)	25.44 (4-54)	26.33 (8-60)	0.45	0.80
Temnostoma	4.67 (1-13)	5.78 (2-13)	5 (0-16)	1.00	0.60
Toxomerus	21 (1-48)	133.8 (16-566)	78.44 (20-143)	**10.2**	**0.006**
Xylota	2 (0-6)	19 (6-69)	19 (1-56)	**13.4**	**0.001**

Treatment and Location Effects: Bees

Bee communities differed significantly among treatments ($F_{2,35}$=2.02, P=0.02) and pairwise comparisons revealed that bee communities caught in the Controls differed significantly, and were more variable, than those in Intensives (t_{23}=1.60, P=0.03; Figure 17). There was also a location effect: gap communities were significantly different from matrix communities ($F_{1,35}$=6.03, P<0.001). Intensive and Regular gap bee communities were very similar (Figure 18), and unlike with the syrphids, there was no effect of year ($F_{1,35}$=1.06, P=0.37).

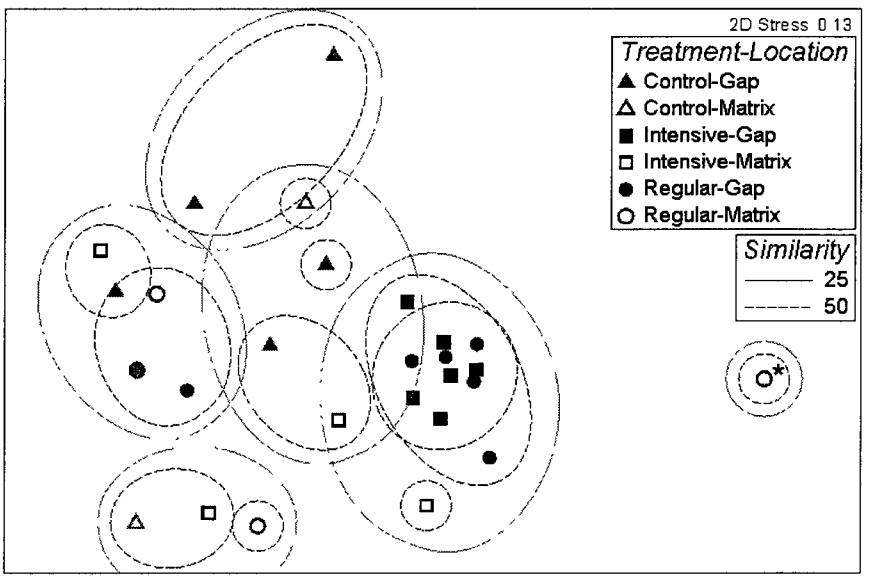

Figure 18: Multidimensional scaling ordination plot for Malaise trap samples of bees by treatment and location. Note: Samples that caught only one bee or none at all cannot be placed onto the plot (because I standardized by sample totals). For this reason there are only two Control-Matrix samples, four Intensive-Matrix samples, and four Regular matrix samples on this plot. *The outlying Regular-Matrix caught two bees that were not caught

in any other Matrix sample, including one of only two *Andrea rugosa* that were caught in Malaise traps.

For bees caught in the Intensive and Regular sites (1417 bees, 69 species), there was no treatment effect ($F_{1,35}$=0.57, P=0.88) but there was a strong location effect ($F_{1,35}$=6.50, P<0.001; Figure 19). There was also an effect of year ($F_{2,35}$=1.85, P=0.02) and pairwise comparisons revealed that bee communities caught in 2007 differed significantly from those caught in 2009 (t_{23}=1.50, P=0.04), but the MDS plot did not graphically represent this well.

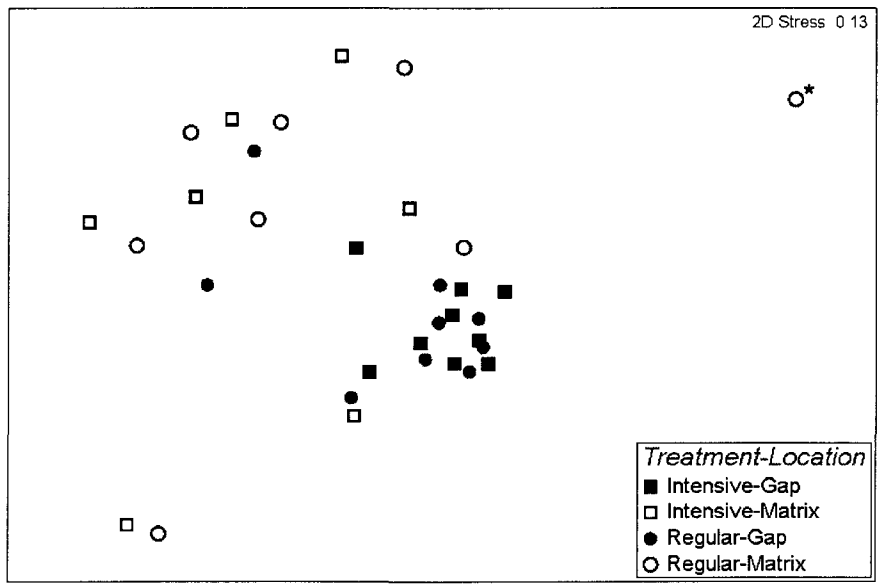

Figure 19: Multidimensional scaling ordination for bees from Intensive and Regular Malaise trap samples from 2007, 2008, and 2009. *The outlying Regular-Matrix caught two bees that were not caught in any other Matrix sample, including one of only two *Andrea rugosa* that were caught in Malaise traps.

Rare Bees

Twenty-eight bee species were represented by one or two individuals. Controls had two individuals from two species, Intensives had 18 individuals from 17 species, and Regulars had 15 individuals from 14 species ($H_{2,24} = 7.26$, P=0.03). Control samples had significantly fewer rare bees (0; range 0-1) than Regulars (1.5; range 0-4; non-parametric post-hoc analysis P=0.03) but not Intensives (1; range 0-8; non-parametric post-hoc analysis P=0.32).

Abundant Bee Species

For the 14 bee species that had at least 20 individuals, four species (*Lasioglossum atwoodi*, *L. cressonii*, *L. laevissimum*, and *L. versans*) were not distributed evenly between the treatments when using a Bonferoni-adjusted α value (0.05/14tests=0.004; Table 14). Controls had significantly fewer *L. atwoodi*, *L. cressonii*, and *L. versans* than did both Intensives (post hoc P-values all < 0.01) and Regulars (post hoc P-values all <0.01) and *L. laevissimum* occurred less frequently in Controls than in Intensives (post hoc P<0.05). Without the Bonferoni-adjustment, *Bombus ternarius*, *L. ephialtum*, and *L. subviridatum* also vary by treatment.

Table 14: The mean (and range) abundance of the 14 most abundant bee species by treatment.

Species	Control	Intensive	Regular	$H_{2,27}$	P
Andrena erigeniae	1.89 (0-4)	4.11 (0-10)	6.44 (0-37)	1.23	0.54
A. rufosignata	2.78 (0-7)	7.22 (1-12)	4.78 (0-18)	1.62	0.44
A. tridens	0.22 (0-1)	1.22 (0-6)	0.89 (0-7)	0.68	0.71
Bombus ternarius	0.22 (0-2)	2.22 (0-7)	2.33 (0-7)	8.88	**0.01**
Lasioglossum atwoodi	0	17.11 (2-58)	12.22 (0-30)	15.1	**<0.001**
L. cresonii	0	23.11 (4-78)	14.22 (3-52)	18.96	**<0.001**
L. divergens	0	3.56 (0-8)	8.89 (0-27)	8.21	0.06
L. ephialtum	0.11 (0-1)	2.78 (0-15)	2.22 (0-5)	9.1	**0.02**
L. laevissimum	0	5.89 (0-12)	2.11 (0-7)	15.66	**<0.001**
L. nigroviride	0.22 (0-1)	1.67 (0-4)	1.33 (0-4)	5.35	0.07
L. planatum	0.11 (0-1)	1.67 (0-5)	2.11 (0-8)	6.18	0.07
L. rufitarse	0	1.78 (0-8)	2.11 (0-7)	6.37	0.06
L. subviridatum	0.89 (0-3)	7.22 (0-17)	4.33 (0-13)	9.21	**0.01**
L. versans	0.11 (0-1)	8.89 (0-45)	5.67 (0-22)	13.39	**0.001**

Pollinators in Spring

In the spring, because there was no significant difference in the number of flowering stems between treatments, I also tested if the communities of syrphids and bees caught in May differed between treatments and location. For syrphids and bees there was no difference between the three treatments ($F_{2,30}$=0.18, P=0.84 and $F_{2,30}$=3.139, P=0.06,

respectively), but gap traps caught significantly more syrphids and bees than matrices (syrphids: 52.67±5.83 and 21.67±3.70, respectively; $F_{1,30}$=18.11, P<0.001; bees: 11.56±2.95 and 1.72±0.56, respectively; $F_{1,30}$=32.11, P<0.001; Table 15).

Table 15: Total and mean (with standard error) syrphid and bee catches in Malaise traps from May 2008 and 2009.

	Control		Intensive		Regular	
	Gap	Matrix	Gap	Matrix	Gap	Matrix
Total Syrphids	298	112	335	123	315	155
Syrphids/Trap	49.67± 8.42	18.67± 5.94	55.83± 9.94	20.5± 6.25	52.5± 13.18	25.83± 7.73
Total Bees	25	6	91	16	92	9
Bees/Trap	4.17± 1.56	1± 0.63	15.17± 7.68	2.67± 1.38	15.33± 3.29	1.5± 0.76

Pollinators and Flowering Stems in Summer

Though both the number of flowering stems and the amount of plant cover found in a location are both good predictors of the number of pollinators found there, I found that the number of flowers in a location was a better predictor ($F_{1,16}$=51.75, P<0.001, adj R^2=0.75; Figure 20 and $F_{1,16}$=41.41, P<0.001, adj R^2=0.70; Figure 21, respectively).

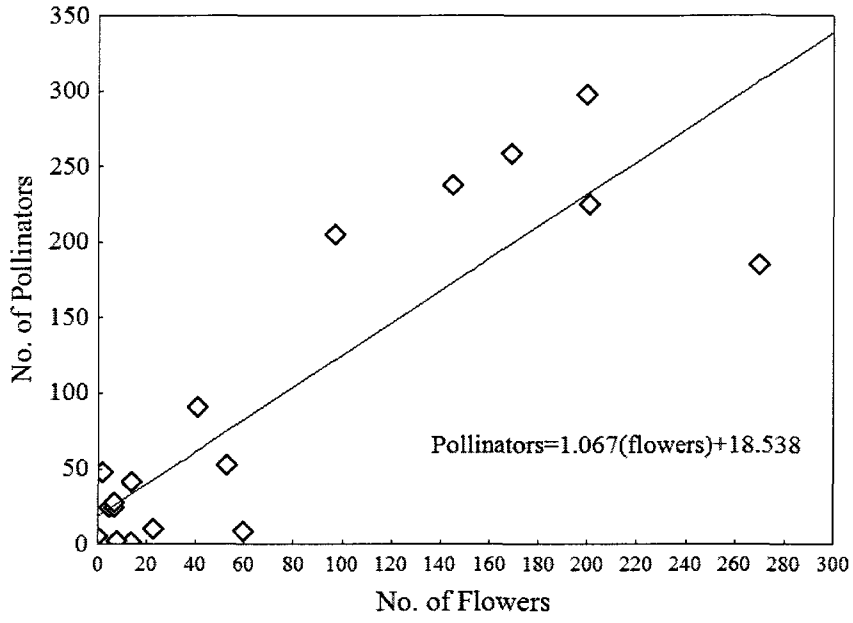

Figure 20: Linear regression between the number of flowering stems in a location and the number of syrphids and bees caught there ($F_{1,18}$=51.85, P<0.001, adj R^2=0.75).

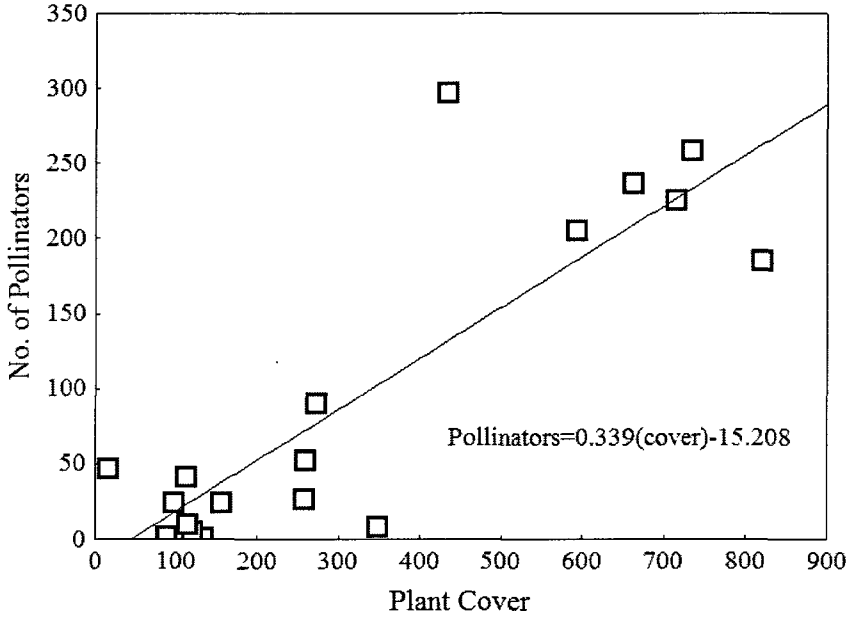

Figure 21: Linear regression between the amount of plant cover in a location and the number of syrphids and bees caught there ($F_{1,16}$=41.41, P<0.001, adj R^2=0.7).

DISCUSSION

Three of the four hypotheses of this study were supported, at least in part. Although, in spring, when all sites had open canopies, there was no difference between the treatments in the number of flowering stems of spring ephemerals, there were fewer flowers in the Controls than the two harvested treatments during summer. This suggests that light is the primary factor required to enhance flower production of the understory. Harvested treatments also had higher abundances and species richness of both syrphids and bees than Controls, but not during spring before the canopy had closed. During summer, harvested treatments had higher light levels in their gaps than Control gaps, indicating that light increases flower production, and, in turn, the numbers of pollinating insects. The reproductive success of one plant species (spring beauty) was higher in gaps than in forested matrices, suggesting that insect pollinators are also more effective in gaps than in matrices, even in spring. This was supported by the fact that in May, even though there were no differences between treatments, syrphids and bees were more abundant in the gaps than in the matrices. The fourth hypothesis was not supported: Regulars and Intensives had similar pollinator communities. This result coincides with similar site conditions, including air and soil temperatures, wind, light and soil moisture. Given the different treatment of matrix habitats between these two logging prescriptions, these results are surprising.

Controls were less windy than the other two treatments but I suggest that light is the principal abiotic variable causing the differences in the plant and pollinator communities between Controls and the harvested-treatments: When examining gaps and matrices, which had different communities, light varied while wind did not. With more light comes warmer and drier soils (Roberts 2004; Bouget and Duelli 2004; Romey et al.

2007). Although drier soils were not documented in the Intensives, I did find that soils in Regulars were drier than those in Controls, and Regulars had higher wind levels than did Controls. With single-tree selection in the matrices of the Regulars, canopies were perforated, resulting in more light reaching the forest floor than in Intensives (with undisturbed matrices) and Controls. Although not significant, light level measurements did follow a gradient of darkest in the Controls, followed by Intensives and then Regulars.

Despite similar numbers of flowering stems between treatments in the spring, Controls had fewer individual plants, fewer species, and less cover of spring-flowering plants than the harvested treatments. A major contributor to these differences was the absence of trout lily from two of the Control sites. In a study by Hughes (1992), trout lily increased in abundance with canopy removal, but increased even more with the removal of co-occurring summer plants. The Control site that contained trout lily in the spring had less than half the herbaceous cover in summer than the other two Control sites. With few herbaceous plants to compete with, trout lily is apparently able to overcome high canopy cover. A further examination of the role of interspecific competition on the occurrence and reproductive success of this species is warranted.

Controls contained fewer and lower cover of sweet white violet than harvested treatments and, though only marginally significant, there were also fewer flowers of this plant in Controls and matrices. Sweet white violet is a common, early-blooming understory species in the forests of North America (Newell et al. 1981). This violet reproduces both sexually, through the dispersion of seeds with elaiosomes (nutritive packets that attract ants), and asexually, through stoloniferous growth (Newell et al. 1981; Griffith 1996). In his study of sweet white violet in Kentucky, Griffith (1996) found that

the canopy above violets was more open than that above random points, a result consistent with my findings.

Despite the enhancement of trout lily and sweet white violet in harvested sites compared with Controls, all three treatments produced a similar number of flowering stems in spring as did the gaps and matrices, probably as a result of universal high light levels prior to canopy leaf out in these forests. By contrast, in summer, plant communities were more variable across both treatments and locations. Controls and matrices had fewer plants and flowering stems, and less flowering plant cover than did harvested-treatments and gaps. These differences were caused mainly by wild red raspberry. This plant dominated gaps of the harvested sites both in cover and flowering stems and the exclusion of raspberry from analyses resulted in no differences between gaps and matrices. Wild red raspberry is an aggressive invader of recently harvested areas and other disturbed sites (Oleskevich et al. 1996; Falk et al. 2010). It is a competitive factor in reforestation one to five years post-harvest (Oleskevich et al. 1996), but also dominates forested landscapes up to 10 (Archambault et al. 1998), and even 25 years (Ruel 1992) post-harvest. Once established, it spreads and reproduces mainly through root suckers and rhizomes, forming monospecific communities that monopolize resources such as nutrients, moisture, space, and light (Oleskevish et al. 1996). Other studies have documented large increases in raspberry post-harvest; in spruce stands in northwestern Ontario (Fye 1972), in strip-cuts in New Hampshire (Whitney 1984), and in hardwood forests (Roberts and Dong 1992; Romey et al 2007; Falk et al 2010).

Although raspberry had no flowering stems in the matrices, wood sorrel had no flowering stems in the gaps. Wood sorrel is an extremely sun-intolerant plant: It produces more seeds and lives longer in shaded sites than in well-lit ones (Packham and

Willis 1977; Kuusipalo 1987) and is sensitive to drought and strong sunlight (Berg and Redbo-Torstensson 1998). Thus, it is not surprising that this plant failed to produce flowers in the sun-filled canopy gaps of this study.

Starflower was another plant that produced more flowers in the Controls and in the matrices of harvested treatments than in the harvested gaps, despite occurring relatively evenly across treatments and locations. Previous studies also found it sensitive to disturbance: it became locally extirpated from hardwood-conifer stands that underwent group-selection harvest in Vermont (Smith et al. 2008) and decreased in cover and frequency after canopy removal and ground disturbance in mixed-oak forests in Connecticut (Aikens et al. 2007). However, this species seems to recover well, as it returned to pre-disturbance levels in the mixed-oak study after three years (Aikens et al. 2007). Further study into how this plant reacts to, and recovers from, disturbance caused by group selection in a maple dominated landscape would help our understanding of forest plant regeneration.

Red trillium also showed varying response to harvest: Its occurrence, cover and flowering stems in Intensive gaps were very low. This is likely a short-term effect, as this plant can regenerate in forests post-harvest through the establishment of new seedlings (Jenkins and Webster 2009), but it is unknown why it was not similarly rare in Regular gaps.Perhaps the frequency of group-canopy gaps and the resultant ground disturbance therein and on skid trails reduced the number of mature flowering individuals in the Intensives more so than in the Regulars, resulting in lower recruitment.

Although raspberry, wood sorrel, starflower and red trillium were the only species to differ significantly in flowering stems between gaps and matrices, there were a small number of less-common species that tended to favour either gaps or matrices. Black-

fringed bindweed, common blackberry, northern willowherb, and Canada goldenrod favoured gaps while goldthread, prickly gooseberry, bunchberry (*Cornus canadensis*), and shinleaf favoured the matrices. The patchy nature of forest herbaceous cover (Motten et al. 1981; Hughes 1992; Griffith 1996) and the lower occurrence of these species in the plant communities meant that these differences were not found to be significant by the PERMANOVA. More intensive sampling is required to determine if these plants are affected by canopy-removal.

Trout lilies in the gaps had more ovules per plant than those in the matrices probably owing to higher light levels in the gaps (Hughes 1992). This contrasts with Dutchman's breeches, which had higher fecundity in the matrices. McLachlan and Bazely (2001) suggest that, although spring ephemerals are adapted to high light levels, some can be displaced by fast-growing species in disturbed environments. In the case of Dutchman's breeches in gaps, the dominance of raspberry later in the season may cause the decline in productivity for Dutchman's breeches. Dutchman's breeches are characterized as highly vulnerable to disturbance: they were absent 35 years post-disturbance from forested study sites in southern Ontario (McLachlan and Bazely 2001).

Though spring beauty had greater fertilization success in gaps, and trout lily and Dutchman's breeches had higher fecundity in gaps and matrices, respectively, these results did not translate into greater flower production per flowering stem in either location. Even foamflower, a species which blooms later than the spring ephemerals (Chambers et al. 1996) and would therefore likely benefit from having more flowers per plant in the canopy gaps, did not produce more flowers there. This result suggests that fecundity and fertilization are dependent on the environment and pollinators more so than on the number of flowers per plant, which may be more influenced by genotype than the

environment (Vogler et al. 1999). Though there was no difference in the number of flowering stems between treatments or gaps and matrices during the spring, spring beauties in gaps had higher seed-set than those in matrices. This suggests that pollinating insects foraged more so in gaps than in matrices. This is supported by the insect community analyses. Even in the spring when light levels were relatively even throughout the study areas, there were significantly more syrphids and bees caught in the gaps than in the matrices. Malaise traps are reportedly not as effective at catching insects in shaded conditions as in well-lit conditions (Gitting et al. 2006; Irvine and Woods 2007), but the argument that there were fewer pollinators in matrix traps because these traps were less efficient at catching them cannot be made in this instance, since the canopy had not yet leafed-out.

In two of my years of study, syrphid and bee communities in Controls differed from those in Intensives but not Regulars and for both pollinator communities. Control sites contained fewer species and individuals than harvested sites. Additionally,syrphid and bee communities in gaps Intensives were extremely similar to one another. The Control-gap communities, on the other hand, were spaced further apart from one another on the MDS plots, indicative of varying compositions. The similarity of pollinator communities among the Intensives gaps is probably partly due to the skid trails between the gaps. Though care was taken to avoid cutting trees on the trails between the group-selection canopy gaps, the herbaceous and sapling cover originally present in the sites was removed through the skidding of harvested trees, creating an interconnected grid of canopy gaps throughout the sites. These trails may be acting as 'fly-through' zones for the aerial insects in the sites (Deans et al. 2005). Butterflies in a forested landscape are more likely to use open corridors to move between patches of cleared area than to move

through the surrounding forest (Tewksbury et al. 2002). Cleared corridors can also act as 'drift-fences' that intercept individuals moving through matrix habitat, diverting them into connected patches (Tewksbury et al. 2002). In the Controls, cleared corridors are absent, effectively keeping gap communities less uniform in composition. Regular sites also had skid trails, between the group-selection gaps and among the single-tree gaps within the matrix, but the large group gaps were, in general, farther apart in these sites than in Intensives, so the pollinator communities within these gaps were more variable. This variability in both the Controls and (less so) the Regulars, likely contributed to the failure to detect statistically significant differences between the pollinator communities in these treatments. Had Regular-gaps been more uniform in their composition, PERMANOVA would have certainly found a difference because Regulars had not only far more individuals and species than Controls, but were dominated by different species.

The two most abundant syrphid species and a third of all identified syrphids (2099 out of 7011) were in the genus *Toxomerus*. *Toxomerus* is frequently the most abundant genus visiting flowers in its habitat (Erickson and Morse 1997) and can attain extremely high densities on field flowers (Morse 1981). *Toxomerus marginatus* was the most abundant species in other studies in a variety of landscapes: tall-grass prairies (Robson 2008), agricultural areas (Hogg et al. 2011) and black spruce forests (Deans et al. 2007). In the black spruce forests of Ontario, it made up 21% of all syrphids caught and was found more in clearcut stands than in stands with partial harvesting. It was common to areas where the canopy was open and flowering plants were present to provide habitat for larvae and flowers for adults (Deans et al 2007). *Toxomerus marginatus* was associated with 114 species of flowering plants in 33 years of surveying in Illinois, the highest number of floral hosts for all 186 fly species surveyed (Tooker et al. 2006). In

comparison, its sister species, *T. geminatus*, was found on 60 plant species in Illinois (Tooker et al. 2006) and was affiliated with unharvested stands in Deans et al.'s (2007) study. In Algonquin, both species were present, but *T. marginatus* was the most abundant species in Intensive sites while *T. geminatus* was the most abundant in Regulars. If these two species prefer different degrees of open habitat, then Intensives, with their frequent and connected canopy gaps provide the open habitat preferred by *T. marginatus*.

Controls were dominated by *Melanostoma mellinum*, a species that feeds on pollen of anemophilous plants (Vockeroth 1992). This species was also more prevalent in unharvested areas in a matrix of harvested black spruce stands in northwestern Ontario (Deans et al. 2007), and in 20-year recovering stands in Algonquin Park that underwent single-tree selection (Nol et al. 2006). With significantly fewer flowering herbaceous stems in the Controls, these small flies feed on graminoid and tree pollen. There were significantly fewer *Xylota* in Controls than in the harvested-treatments, a result confirmed in black spruce forests (Deans et al. 2007). *Xylota* use decomposing wood material to lay their eggs and though there would be plenty of such material in Controls, the amount of sun-exposed wood would be higher in the harvested treatments, and sun-exposed wood is favoured by saproxylic invertebrates (Jonsell et al. 1998; Bouget and Duelli 2004).

The five most abundant bee species and 70% (1258 out of 1805) of all identified bees were in the genus *Lasioglossum*. There are four subgenera of these small bees in Canada (*Lasioglossum*, *Evylaeus*, *Dialictus* and *Sphecodogastra*), and most species are ground nesters. The genus is very common in temperate Canada and often comprises a large proportion of survey specimens (Packer et al. 2007; Gibbs 2010). The three most abundant species in this study, *Lasioglossum cressonii*, *L. atwoodi*, and *L. versans,* were, with the exception of one individual of *L. versans*, absent from the Controls and the

Lasioglossum spp. caught in the Control sites made up only 1.3% of all Lasioglossum caught in this study. Similarly, in hardwood stands in New York, only 1 of 348 *Lasioglossum* spp. was caught in unharvested stands, while 21 were captured in single-tree stands (30% tree-volume removed; Romey et al. 2007). In a previous study of insects in Algonquin Park (Nol et al. 2006), only two out of 36 *Lasioglossum* were found in the park's wilderness stands. The low catch of *Lasioglossum* in general in this study (compared to *Andrena*) is further evidence that *Lasioglossum* are indicative of relatively open areas in forests.

The depauperate community of *Lasioglossum* (and bees in general) in unharvested forest stands can be potentially explained by their body-size and nesting requirements. Gathmann and Tscharntke (2002) and Zurbuchen et al. (2010) found that body-size was the best predictor of foraging range for wild bees: As body size increases so does the average and maximum foraging range. They also found that foraging trip duration reflected habitat quality, in that bees in plant species-rich areas have shorter foraging trips (Gathmann and Tscharntke 2002). If small bees are unable to travel as far as larger bees, then they would be concentrated in areas where there are enough floral resources and nesting sites to satisfy their needs, especially since bees show a strong preference for foraging close to their nest (Kevan and Baker 1983; Cresswell et al. 2000). The harvested treatments in this study not only had higher plant cover and more flowering stems in their canopy gaps, but there was also more bare soil (Falk et al. 2010). Some bee species nest in areas with thinner organic layers than surrounding areas (Cane 1991) and Hopwood (2008) found that percentage of bare ground was a factor that led to greater bee abundance and species richness in her study of roadsides. These results suggest that a thick carpet of leaf litter can deter nesting, a factor which is common in the Controls

(Falk et al. 2010). The harvested treatments, with their flower-filled canopy gaps and bare, warm soil may be fulfilling the habitat requirements of these bees, whereas Controls do not. Controls caught very few bees, more than half of which were from the genus *Andrena*. Members of this genus are mostly vernal in North America (Larkin et al. 2008), and indeed, all but two in Controls (one *Andrena nivalis* and one *A. thaspii*) were caught in May. Very few bees were caught after mid-June, and of these, 8 were in the genus *Bombus*. Bumblebees are large-bodied and eusocial (Sheffield et al. 2003), and some species are capable of foraging over two kilometres from their nest to supply nest-mates with pollen and nectar (Kreyer et al. 2004). Control sites, with fewer flowers in the summer, are limited in their bee habitat. The bee community is mainly limited to early-flying species (*Andrena* spp. and *Lasioglossum subviridatum*) which are able to take advantage of abundant spring-ephemerals, and the large-bodied bumblebees capable of flying greater distances in their search for floral resources.

Harvested treatments were dominated by *Lasioglossum cressonii, L. atwoodi*, and *L. versans*. All three species are in the subgenus *Dialictus*, a group that bee taxonomists find challenging, and with few resources for their identification, many of their life histories are unknown (Gibbs 2010). The second most abundant bee species I found in this study, *L. atwoodi*, has recently been recognized as new to science and its ecology is unknown (Gibbs 2010). *Lasioglossum cressonii* nests in rotten wood (Giles and Ascher 2006; Romey et al. 2007) and is a generalist flower visitor (Taki and Kevan 2007). With plenty of rotting wood in the form of stumps, slash and even large felled trees (personal observation) and lots of flowering stems of raspberry, Intensives and Regulars provided the habitat needed by these small bees. *Lasioglossum versans*, a eusocial soil-nester

typical of northern forests (Giles and Ascher 2006) would also have found the appropriate habitat it requires in the cleared areas of the harvested sites.

Controls were dominated by *Andrena rufosignata* and *A. erigeniae*. Although*A. rufosignata* is polylectic, collecting pollen and nectar from a variety of plant species, (Giles and Ascher 2006), *A. erigeniae* is oligolectic, using spring beauty almost exclusively as a food source (Dailey and Scott 2006). Spring beauty had the most flowering stems of any spring-flowering plant in this study and was common to all sites. It produces ample and accessible nectar, has a long flowering period, and is a key resource for spring-flying bees and flies (Robertson 1928; Dailey and Scott 2006). It is therefore no wonder that these two bee species were not only dominant in the Controls but were found in high number in Intensives and Regulars as well.

Although spring beauty produced the most flowering stems in the spring, the plant that produced the most flowering stems in summer was wild red raspberry. Whitney (1984) found that raspberry attracted mainly bees but I found that syrphids utilized it extensively as well. I caught 24 syrphid species and 14 bee species on the flowers of raspberry (Appendices C and D). The flowers are self-infertile and seeds are produced mainly through insect-mediated cross pollination (Oleskevich et al. 1996). Its reliance on pollinators explains why it produces copious, high-quality nectar. Whitney (1984) found it produced an average of 4.29mg sugar/flower/day, or about 18kg/ha for four-year old strip-cut sites in New Hampshire. This amount of nectar is an order of magnitude more than other species he studied (e.g. dwarf raspberry produced 0.12mg; Whitney 1984). Raspberry has a long flowering period with a peak in mid-June, and Whitney (1984) suggested that when it is peaking other flowers have evolved not to bloom because they will not win many pollinators. In the harvested treatments, raspberry dominated in the

canopy gaps, and it was there where the majority of syrphids and bees were caught. When the flowering stems of raspberry were omitted from the PERMANOVA there was no difference between treatments or between gaps and matrices, which suggests that the presence of flowering raspberry is the primary contributor to the pollinator communities of gaps during the summer. Indeed, as flowering stems increased in the sites, so did the number of pollinators caught there. Other factors could be attracting the insects to the gaps, such as the high amount of herbaceous cover (which has been linked to abundances of aphidophagous syrphids; Gittings et al. 2006), exposed soil, and the higher light-levels and resultant warmer temperatures. Cartar (2005) postulated that bumblebees in the boreal forest preferred to forage in clearcut areas because these warmer areas made for metabolically cheaper foraging. This conclusion could be applicable to all insect pollinators, because all are poikilothermic.

With increasing temperatures come increased metabolism, activity and development in insects (Gullan and Cranston 2005). Thus, syrphids and bees in the gaps were probably more active than conspecifics in the shaded and cooler matrices. As such, gap traps would catch more insects than their matrix-neighbours. Malaise traps also function better in sunlight, because insects that are intercepted by the mesh 'see the light' above them in the sun-lit collecting head and move towards it. If the collecting head is shaded the insects are less likely to move up towards it (BSC 1994) and such would be the case for most of the matrix traps during the summer. As gap traps are therefore better at catching the insect pollinators, it is difficult to conclude definitively that matrices have fewer pollinators, but several lines of evidence support this conclusion. Spring beauty plants were better pollinated in gaps, and the proportion of pollinators was much higher in the Malaise samples from gaps than those from matrices.

Aerial malaise traps were ineffective at sampling pollinators above the ground. They caught only a few syrphids (67), yielded no additional new species, and caught no bees. Pan trapping and netting were also inefficient at catching syrphids. Out of the 189 individuals caught by these methods, only two species (*Xylota segnis* and *Mallota baustias*) were not caught in Malaise traps, and a large proportion of the catches were *Toxomerus*. However, pan trapping and netting proved to be valuable for sampling bees, as these methods yielded eight additional species (10% of all bee species) to those caught in Malaise traps.

For both syrphids and bees, communities varied significantly between years, though in different ways. Syrphid communities differed between 2008 and 2009, but the bee communities did not. When the 2007 samples were added and Controls omitted, both syrphid and bee communities differed between 2007 and 2009, but not between 2008 and 2009. Malaise traps in Controls were heavily disturbed in 2009 compared to 2008 and the lower sample catches would have fewer individuals and species (Krebs 1989). Controls caught different syrphid but not bee communities between 2008 and 2009. Bees may not have differed among years in part because so few bees were caught in Controls (74) and the variation among the samples would have shielded the differences. By contrast, syrphids were relatively abundant in Controls so the test was better at finding the differences in the years' communities.

Without the Controls, 2008 and 2009 syrphid and bee communities are similar, but 2007's are not. All six sites in the harvested treatments were logged during the winter of 2006/07 and the gaps and skid trails may not have had the time to regenerate by the spring sampling period and there was abundant bare soil and pooling water (personal observation) on the sites. The dominant species in 2007 was *Helophilus fasciatus*, a

species whose larvae filter-feed in organic rich water (Howarth and Edmunds 2000); few individuals of this species were caught in the successive years. Additionally, I used more traps in 2007 than in the other two years (each site had two in gaps and two in matrices at the start of the sampling season) but the sampling times were different (there was a two-week period in June when traps were inactive). The extra traps in combination with a missing sampling period would greatly add to the difference between years. In 2007 I used three types of Malaise trap (2875DG, 2875AG, and Townes-style) but in 2008 and 2009 I only used one type (2875DG), and Malaise trap catches can vary widely by trap design, mesh size, and colour (BSC 1994). Finally, communities of insects can show tremendous variability through time and space (Williams et al. 2001), and the difference between years may be due, in part, to this variability.

Though I found no significant differences between Intensive and Regular site conditions, plant communities, or syrphid and bee composition, there are subtle differences worth discussing. Regulars were more species-rich in syrphids but Intensives caught more individuals in each taxon than Regulars. Intensives were heavily dominated by *Toxomerus*, and though traps in Regulars also caught many individuals of this genus, the combination of the dominance of *Toxomerus* and fewer species gave Intensives a lower diversity H than Regulars. For bees, the interconnected canopy gaps of the Intensives seem to be contributing to the higher catches there. Bees, with their small foraging ranges that are closely associated with their nest location (Kevan and Baker 1983; Cresswell et al. 2000), would be able to find all the resources they require within these sites, whereas Regulars, which have raspberry-filled canopy gaps spaced further apart, may not be providing enough ideal habitat for them.

It is not surprising that Controls had fewer rare species of syrphids than both Intensives and Regulars, and fewer rare bees than Regulars. With disturbances in forests come increased light (Beaudet and Messier 2002) and more variable habitat (Quintero et al. 2010). In this study, harvesting increased vegetation for the larvae of aphidophagous syrphids, sun-lit dead wood for saprophagous syrphid larvae and cavity-nesting bees, exposed soil for ground-nesting bees, and flowers for the adults. In their study of landscape-scale effects on insect pollinators, Steffan-Dewenter et al. (2002) concluded that generalists profit from diverse habitats but specialists require large connected areas, and in the hardwood forests of Algonquin Park, both the needs of specialists and generalists are met through group-selection harvesting. This method of harvest is encouraging the plant and insect-pollinator communities, and is likely more effective at this than single-tree selection.

FURTHER RESEARCH

Long-term study of the response of the insect pollinator community and the floral understory to harvesting is needed. The increase in pollinators observed in this study and others can potentially be a short-term effect, as is the proliferation of flowering plants. There is potential for loss of species diversity if sensitive forest plants, and thus their pollinators, decrease over the long-term. Spring ephemerals, especially, have been shown to be highly vulnerable to disturbance (Meier et al. 1995; McLachlan and Bazely 2001; Wiegmann and Waller 2006; Gilliam 2007) but so have many other common forest plants found in these sites such as hobblebush, wild sarsaparilla, blue bead lily, bunchberry, rose twisted-stalk, Canada mayflower, cucumber root, painted trillium, and wood sorrel (Wiegmann and Waller 2006; Romey et al. 2007). More intensive vegetation sampling is

required, both in spring and summer, to monitor the progress of these plant species in the longer term. Target sampling of pollinators on the plants in these forest sites would add vital details to our knowledge-base on the plant-pollinator interactions in our forests. Spring beauty and sweet white violet had the most flowering stems in the spring, while wild red raspberry and black-fringed bindweed had the most in summer. A thorough study of the flower-visitors, fecundity, and fertilization of these plants is required to see how they provide for, and benefit from, the specific insect pollinators in these forests.

Despite the importance of syrphids and bees as pollinators, the importance of other taxa such as Tachinidae (Diptera) and Elateridae (Coleoptera) should not be overlooked and would benefit from investigation. Tachinidae were abundant in the Malaise samples, especially in spring, and were seen visiting spring beauty. Some members of Elateridae are known to be flower-visitors (Johnson 2002) and this family was abundant in the Aerial malaise traps. Another important aspect not investigated in this study was the pollination of tree species found in hardwood forests. Both black cherry and striped maple are known to be pollinated by insects (Grisez 1975; Hibbset al. 1989), and a study of which species are responsible for this pollination would add to our knowledge on plant reproduction in forested ecosystems.

Malaise traps were the main method used to trap the syrphids and bees in this study. Though traps were disturbed by wildlife on occasion (especially in 2009) they were by far the most efficient method of catching the insects of this study. Pan trapping and netting added a few new species to the data sets but these trapping methods were not performed with enough frequency and the insects caught were not used in the community-level analyses. Logistics and weather conditions contributed to the infrequent use of these two methods, two factors that do not affect Malaise traps. Once set up, the

Malaise traps (that were not disturbed) only required a visit every two weeks to collect the samples. Pan trapping, in comparison, required extensive set-up and collection at every sampling, and netting was hard to standardize between visits and sites. Malaise traps were by far the most effective trapping technique in this study, and though pan trapping and netting did add 10% of bee species to the data-set, these bees could not be analyzed with the PERMANOVA. Future researchers should carefully weigh the benefits of pan trapping and netting in forested sites, especially when visiting many sites, as was the case with this study.

Group-selection harvesting proved to be beneficial to insect pollinators in these study sites, at least in the short-term. The proliferation of wild red raspberry in the canopy gaps created by harvesting was not seen in the naturally created canopy gaps of the Control sites nor in the single-tree gaps of Regular sites. Further long-term study of the regeneration in these group-selection gaps is needed, as is a contrast to the regeneration of the floral understory within single-tree selection stands.

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APPENDIX A -- MALAISE TRAPS (without 2007)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)	
Control	Brewer	Gap	2875DG	2008	7-May-08	21-May-08	14	
Control	Brewer	Gap	2875DG	2008	21-May-08	5-Jun-08	15	
Control	Brewer	Gap	2875DG	2008	5-Jun-08	14-Jun-08	9	
Control	Brewer	Gap	2875DG	2008	22-Jun-08	8-Jul-08	16	
Control	Brewer	Gap	2875DG	2008	8-Jul-08	22-Jul-08	14	
Control	Brewer	Gap	2875DG	2008	22-Jul-08	5-Aug-08	14	
Control	Brewer	Gap	2875DG	2009	5-May-09	17-May-09	12	
Control	Brewer	Gap	2875DG	2009	17-May-09	2-Jun-09	16	
Control	Brewer	Gap	2875DG	2009	2-Jun-09	19-Jun-09	0	disturbed
Control	Brewer	Gap	2875DG	2009	19-Jun-09	3-Jul-09	14	
Control	Brewer	Gap	2875DG	2009	3-Jul-09	17-Jul-09	14	
Control	Brewer	Gap	2875DG	2009	17-Jul-09	4-Aug-09	18	
Control	Brewer	Matrix	2875DG	2008	7-May-08	21-May-08	14	
Control	Brewer	Matrix	2875DG	2008	21-May-08	15-May-08	0	disturbed
Control	Brewer	Matrix	2875DG	2008	5-Jun-08	19-Jun-08	14	
Control	Brewer	Matrix	2875DG	2008	22-Jun-08	8-Jul-08	16	
Control	Brewer	Matrix	2875DG	2008	8-Jul-08	22-Jul-08	14	
Control	Brewer	Matrix	2875DG	2008	22-Jul-08	5-Aug-08	14	
Control	Brewer	Matrix	2875DG	2009	5-May-09	10-May-09	5	
Control	Brewer	Matrix	2875DG	2009	18-May-09	2-Jun-09	14	
Control	Brewer	Matrix	2875DG	2009	2-Jun-09	19-Jun-09	0	disturbed
Control	Brewer	Matrix	2875DG	2009	19-Jun-09	3-Jul-09	14	
Control	Brewer	Matrix	2875DG	2009	3-Jul-09	17-Jul-09	14	
Control	Brewer	Matrix	2875DG	2009	17-Jul-09	4-Aug-09	0	disturbed
Control	Cranjelly	Gap	2875DG	2008	10-May-08	24-May-08	14	
Control	Cranjelly	Gap	2875DG	2008	24-May-08	7-Jun-08	14	
Control	Cranjelly	Gap	2875DG	2008	7-Jun-08	21-Jun-08	14	
Control	Cranjelly	Gap	2875DG	2008	21-Jun-08	30-Jun-08	10	
Control	Cranjelly	Gap	2875DG	2008	12-Jul-08	25-Jul-08	13	
Control	Cranjelly	Gap	2875DG	2008	25-Jul-08	8-Aug-08	14	
Control	Cranjelly	Gap	2875DG	2009	7-May-09	21-May-09	14	
Control	Cranjelly	Gap	2875DG	2009	21-May-09	4-Jun-09	14	
Control	Cranjelly	Gap	2875DG	2009	4-Jun-09	18-Jun-09	0	disturbed
Control	Cranjelly	Gap	2875DG	2009	18-Jun-09	2-Jul-09	14	
Control	Cranjelly	Gap	2875DG	2009	2-Jul-09	16-Jul-09	14	
Control	Cranjelly	Gap	2875DG	2009	16-Jul-09	4-Aug-09	19	
Control	Cranjelly	Matrix	2875DG	2008	10-May-08	24-May-08	14	
Control	Cranjelly	Matrix	2875DG	2008	24-May-08	7-Jun-08	14	
Control	Cranjelly	Matrix	2875DG	2008	7-Jun-08	21-Jun-08	14	
Control	Cranjelly	Matrix	2875DG	2008	21-Jun-08	4-Jul-08	13	
Control	Cranjelly	Matrix	2875DG	2008	4-Jul-08	17-Jul-08	13	
Control	Cranjelly	Matrix	2875DG	2008	17-Jul-08	30-Jul-08	13	
Control	Cranjelly	Matrix	2875DG	2009	7-May-09	21-May-09	14	
Control	Cranjelly	Matrix	2875DG	2009	21-May-09	4-Jun-09	14	
Control	Cranjelly	Matrix	2875DG	2009	4-Jun-09	18-Jun-09	0	disturbed
Control	Cranjelly	Matrix	2875DG	2009	18-Jun-09	2-Jul-09	14	
Control	Cranjelly	Matrix	2875DG	2009	2-Jul-09	16-Jul-09	14	
Control	Cranjelly	Matrix	2875DG	2009	16-Jul-09	4-Aug-09	19	
Control	Two Rivers	Gap	2875DG	2008	4-May-08	18-May-08	14	
Control	Two Rivers	Gap	2875DG	2008	18-May-08	1-Jun-08	14	
Control	Two Rivers	Gap	2875DG	2008	1-Jun-08	15-Jun-08	14	
Control	Two Rivers	Gap	2875DG	2008	15-Jun-08	29-Jun-08	14	
Control	Two Rivers	Gap	2875DG	2008	29-Jun-08	13-Jul-08	14	
Control	Two Rivers	Gap	2875DG	2008	13-Jul-08	28-Jul-08	15	
Control	Two Rivers	Gap	2875DG	2009	3-May-09	11-May-09	0	disturbed
Control	Two Rivers	Gap	2875DG	2009	11-May-09	25-May-09	14	

APPENDIX A -- MALAISE TRAPS (without 2007)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)	
Control	Two Rivers	Gap	2875DG	2009	28-May-09	8-Jun-09	0	disturbed
Control	Two Rivers	Gap	2875DG	2009	19-Jun-09	3-Jul-09	14	
Control	Two Rivers	Gap	2875DG	2009	3-Jul-09	17-Jul-09	14	
Control	Two Rivers	Gap	2875DG	2009	17-Jul-09	29-Jul-09	12	
Control	Two Rivers	Matrix	2875DG	2008	4-May-08	18-May-08	0	disturbed
Control	Two Rivers	Matrix	2875DG	2008	20-May-08	1-Jun-08	12	
Control	Two Rivers	Matrix	2875DG	2008	1-Jun-08	15-Jun-08	14	
Control	Two Rivers	Matrix	2875DG	2008	15-Jun-08	29-Jun-08	14	
Control	Two Rivers	Matrix	2875DG	2008	29-Jun-08	13-Jul-08	14	
Control	Two Rivers	Matrix	2875DG	2008	13-Jul-08	28-Jul-08	15	
Control	Two Rivers	Matrix	2875DG	2009	3-May-09	11-May-09	8	
Control	Two Rivers	Matrix	2875DG	2009	11-May-09	20-May-09	9	
Control	Two Rivers	Matrix	2875DG	2009	28-May-09	10-Jun-09	13	
Control	Two Rivers	Matrix	2875DG	2009	19-Jun-09	3-Jul-09	14	
Control	Two Rivers	Matrix	2875DG	2009	3-Jul-09	17-Jul-09	14	
Control	Two Rivers	Matrix	2875DG	2009	17-Jul-09	4-Aug-09	18	
Intensive	Crossbar	Gap	2875DG	2008	9-May-08	24-May-08	15	
Intensive	Crossbar	Gap	2875DG	2008	24-May-08	7-Jun-08	14	
Intensive	Crossbar	Gap	2875DG	2008	7-Jun-08	21-Jun-08	14	
Intensive	Crossbar	Gap	2875DG	2008	21-Jun-08	4-Jul-08	13	
Intensive	Crossbar	Gap	2875DG	2008	4-Jul-08	17-Jul-08	13	
Intensive	Crossbar	Gap	2875DG	2008	17-Jul-08	30-Jul-08	13	
Intensive	Crossbar	Gap	2875DG	2009	1-May-09	15-May-09	14	
Intensive	Crossbar	Gap	2875DG	2009	15-May-09	29-May-09	14	
Intensive	Crossbar	Gap	2875DG	2009	29-May-09	8-Jun-09	0	disturbed
Intensive	Crossbar	Gap	2875DG	2009	12-Jun-09	26-Jun-09	14	
Intensive	Crossbar	Gap	2875DG	2009	26-Jun-09	10-Jul-09	14	
Intensive	Crossbar	Gap	2875DG	2009	10-Jul-09	24-Jul-09	14	
Intensive	Crossbar	Gap	2875DG	2009	24-Jul-09	7-Aug-09	14	
Intensive	Crossbar	Matrix	2875DG	2008	9-May-08	20-May-08	11	
Intensive	Crossbar	Matrix	2875DG	2008	24-May-08	7-Jun-08	14	
Intensive	Crossbar	Matrix	2875DG	2008	7-Jun-08	21-Jun-08	14	
Intensive	Crossbar	Matrix	2875DG	2008	21-Jun-08	4-Jul-08	13	
Intensive	Crossbar	Matrix	2875DG	2008	4-Jul-08	17-Jul-08	13	
Intensive	Crossbar	Matrix	2875DG	2008	17-Jul-08	30-Jul-08	13	
Intensive	Crossbar	Matrix	2875DG	2009	1-May-09	15-May-09	14	
Intensive	Crossbar	Matrix	2875DG	2009	15-May-09	29-May-09	14	
Intensive	Crossbar	Matrix	2875DG	2009	29-May-09	12-Jun-09	14	
Intensive	Crossbar	Matrix	2875DG	2009	12-Jun-09	26-Jun-09	14	
Intensive	Crossbar	Matrix	2875DG	2009	26-Jun-09	10-Jul-09	14	
Intensive	Crossbar	Matrix	2875DG	2009	10-Jul-09	24-Jul-09	14	
Intensive	Crossbar	Matrix	2875DG	2009	24-Jul-09	7-Aug-09	14	
Intensive	Florence	Gap	2875DG	2008	3-May-08	17-May-08	14	
Intensive	Florence	Gap	2875DG	2008	17-May-08	31-May-08	14	
Intensive	Florence	Gap	2875DG	2008	31-May-08	14-Jun-08	14	
Intensive	Florence	Gap	2875DG	2008	14-Jun-08	28-Jun-08	14	
Intensive	Florence	Gap	2875DG	2008	28-Jun-08	13-Jul-08	15	
Intensive	Florence	Gap	2875DG	2008	13-Jul-08	28-Jul-08	15	
Intensive	Florence	Gap	2875DG	2009	5-May-09	19-May-09	14	
Intensive	Florence	Gap	2875DG	2009	19-May-09	3-Jun-09	14	
Intensive	Florence	Gap	2875DG	2009	3-Jun-09	17-Jun-09	14	
Intensive	Florence	Gap	2875DG	2009	17-Jun-09	1-Jul-09	14	
Intensive	Florence	Gap	2875DG	2009	1-Jul-09	15-Jul-09	14	
Intensive	Florence	Gap	2875DG	2009	15-Jul-09	21-Jul-09	6	
Intensive	Florence	Gap	2875DG	2009	21-Jul-09	6-Aug-09	16	
Intensive	Florence	Matrix	2875DG	2008	3-May-08	17-May-08	14	

APPENDIX A -- MALAISE TRAPS (without 2007)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)	
Intensive	Florence	Matrix	2875DG	2008	17-May-08	31-May-08	14	
Intensive	Florence	Matrix	2875DG	2008	31-May-08	14-Jun-08	14	
Intensive	Florence	Matrix	2875DG	2008	14-Jun-08	28-Jun-08	14	
Intensive	Florence	Matrix	2875DG	2008	28-Jun-08	10-Jul-08	12	
Intensive	Florence	Matrix	2875DG	2008	21-Jul-08	4-Aug-08	14	
Intensive	Florence	Matrix	2875DG	2009	5-May-09	19-May-09	14	
Intensive	Florence	Matrix	2875DG	2009	19-May-09	30-May-09	11	
Intensive	Florence	Matrix	2875DG	2009	3-Jun-09	17-Jun-09	14	
Intensive	Florence	Matrix	2875DG	2009	17-Jun-09	1-Jul-09	14	
Intensive	Florence	Matrix	2875DG	2009	1-Jul-09	15-Jul-09	14	
Intensive	Florence	Matrix	2875DG	2009	21-Jul-09	6-Aug-09	16	
Intensive	Sitting Duck	Gap	2875DG	2008	5-May-08	21-May-08	16	
Intensive	Sitting Duck	Gap	2875DG	2008	21-May-08	4-Jun-08	14	
Intensive	Sitting Duck	Gap	2875DG	2008	4-Jun-08	19-Jun-08	15	
Intensive	Sitting Duck	Gap	2875DG	2008	19-Jun-08	8-Jul-08	19	
Intensive	Sitting Duck	Gap	2875DG	2008	8-Jul-08	21-Jul-08	13	
Intensive	Sitting Duck	Gap	2875DG	2008	21-Jul-08	4-Aug-08	14	
Intensive	Sitting Duck	Gap	2875DG	2009	6-May-09	20-May-09	14	
Intensive	Sitting Duck	Gap	2875DG	2009	20-May-09	3-Jun-09	14	
Intensive	Sitting Duck	Gap	2875DG	2009	3-Jun-09	17-Jun-09	14	
Intensive	Sitting Duck	Gap	2875DG	2009	17-Jun-09	1-Jul-09	14	
Intensive	Sitting Duck	Gap	2875DG	2009	1-Jul-09	10-Jul-09	0	disturbed
Intensive	Sitting Duck	Gap	2875DG	2009	21-Jul-09	5-Aug-09	15	
Intensive	Sitting Duck	Matrix	2875DG	2008	5-May-08	21-May-08	16	
Intensive	Sitting Duck	Matrix	2875DG	2008	21-May-08	4-Jun-08	14	
Intensive	Sitting Duck	Matrix	2875DG	2008	4-Jun-08	19-Jun-08	15	
Intensive	Sitting Duck	Matrix	2875DG	2008	19-Jun-08	8-Jul-08	19	
Intensive	Sitting Duck	Matrix	2875DG	2008	8-Jul-08	21-Jul-08	13	
Intensive	Sitting Duck	Matrix	2875DG	2008	21-Jul-08	4-Aug-08	14	
Intensive	Sitting Duck	Matrix	2875DG	2009	6-May-09	20-May-09	14	
Intensive	Sitting Duck	Matrix	2875DG	2009	20-May-09	3-Jun-09	14	
Intensive	Sitting Duck	Matrix	2875DG	2009	3-Jun-09	17-Jun-09	14	
Intensive	Sitting Duck	Matrix	2875DG	2009	17-Jun-09	1-Jul-09	14	
Intensive	Sitting Duck	Matrix	2875DG	2009	1-Jul-09	15-Jul-09	14	
Intensive	Sitting Duck	Matrix	2875DG	2009	15-Jul-09	21-Jul-09	6	
Intensive	Sitting Duck	Matrix	2875DG	2009	21-Jul-09	5-Aug-09	15	
Regular	Cecil	Gap	2875DG	2008	3-May-08	17-May-08	14	
Regular	Cecil	Gap	2875DG	2008	17-May-08	31-May-08	14	
Regular	Cecil	Gap	2875DG	2008	6-Jun-08	20-Jun-08	14	
Regular	Cecil	Gap	2875DG	2008	20-Jun-08	8-Jul-08	18	
Regular	Cecil	Gap	2875DG	2008	8-Jul-08	21-Jul-08	13	
Regular	Cecil	Gap	2875DG	2008	21-Jul-08	4-Aug-08	14	
Regular	Cecil	Gap	2875DG	2009	5-May-09	19-May-09	14	
Regular	Cecil	Gap	2875DG	2009	19-May-09	3-Jun-09	14	
Regular	Cecil	Gap	2875DG	2009	3-Jun-09	17-Jun-09	14	
Regular	Cecil	Gap	2875DG	2009	17-Jun-09	1-Jul-09	14	
Regular	Cecil	Gap	2875DG	2009	1-Jul-09	15-Jul-09	14	
Regular	Cecil	Gap	2875DG	2009	15-Jul-09	30-Jul-09	15	
Regular	Cecil	Gap	2875DG	2009	30-Jul-09	12-Aug-09	13	
Regular	Cecil	Matrix	2875DG	2008	3-May-08	17-May-08	14	
Regular	Cecil	Matrix	2875DG	2008	17-May-08	31-May-08	14	
Regular	Cecil	Matrix	2875DG	2008	31-May-08	6-Jun-08	0	disturbed
Regular	Cecil	Matrix	2875DG	2008	6-Jun-08	20-Jun-08	14	
Regular	Cecil	Matrix	2875DG	2008	20-Jun-08	8-Jul-08	18	
Regular	Cecil	Matrix	2875DG	2008	10-Jul-08	24-Jul-08	14	
Regular	Cecil	Matrix	2875DG	2008	24-Jul-08	7-Aug-08	14	

APPENDIX A -- MALAISE TRAPS (without 2007)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)	
Regular	Cecil	Matrix	2875DG	2009	5-May-09	19-May-09	14	
Regular	Cecil	Matrix	2875DG	2009	19-May-09	3-Jun-09	14	
Regular	Cecil	Matrix	2875DG	2009	3-Jun-09	17-Jun-09	14	
Regular	Cecil	Matrix	2875DG	2009	17-Jun-09	1-Jul-09	14	
Regular	Cecil	Matrix	2875DG	2009	1-Jul-09	15-Jul-09	14	
Regular	Cecil	Matrix	2875DG	2009	15-Jul-09	30-Jul-09	0	disturbed
Regular	Louisa Flats	Gap	2875DG	2008	6-May-08	21-May-08	15	
Regular	Louisa Flats	Gap	2875DG	2008	21-May-08	31-May-08	10	
Regular	Louisa Flats	Gap	2875DG	2008	6-Jun-08	19-Jun-08	13	
Regular	Louisa Flats	Gap	2875DG	2008	19-Jun-08	8-Jul-08	19	
Regular	Louisa Flats	Gap	2875DG	2008	8-Jul-08	10-Jul-08	2	
Regular	Louisa Flats	Gap	2875DG	2008	25-Jul-08	7-Aug-08	13	
Regular	Louisa Flats	Gap	2875DG	2009	6-May-09	20-May-09	14	
Regular	Louisa Flats	Gap	2875DG	2009	20-May-09	3-Jun-09	14	
Regular	Louisa Flats	Gap	2875DG	2009	3-Jun-09	17-Jun-09	14	
Regular	Louisa Flats	Gap	2875DG	2009	17-Jun-09	1-Jul-09	14	
Regular	Louisa Flats	Gap	2875DG	2009	1-Jul-09	15-Jul-09	6	
Regular	Louisa Flats	Gap	2875DG	2009	15-Jul-09	30-Jul-09	15	
Regular	Louisa Flats	Gap	2875DG	2009	30-Jul-09	12-Aug-09	13	
Regular	Louisa Flats	Matrix	2875DG	2008	6-May-08	21-May-08	15	
Regular	Louisa Flats	Matrix	2875DG	2008	21-May-08	4-Jun-08	14	
Regular	Louisa Flats	Matrix	2875DG	2008	4-Jun-08	19-Jun-08	15	
Regular	Louisa Flats	Matrix	2875DG	2008	19-Jun-08	28-Jun-08	0	disturbed
Regular	Louisa Flats	Matrix	2875DG	2008	10-Jul-08	24-Jul-08	14	
Regular	Louisa Flats	Matrix	2875DG	2008	25-Jul-08	7-Aug-08	13	
Regular	Louisa Flats	Matrix	2875DG	2009	6-May-09	20-May-09	14	
Regular	Louisa Flats	Matrix	2875DG	2009	20-May-09	3-Jun-09	14	
Regular	Louisa Flats	Matrix	2875DG	2009	3-Jun-09	17-Jun-09	14	
Regular	Louisa Flats	Matrix	2875DG	2009	17-Jun-09	1-Jul-09	14	
Regular	Louisa Flats	Matrix	2875DG	2009	1-Jul-09	15-Jul-09	14	
Regular	Louisa Flats	Matrix	2875DG	2009	15-Jul-09	30-Jul-09	15	
Regular	Louisa Flats	Matrix	2875DG	2009	30-Jul-09	12-Aug-09	13	
Regular	Madawaska	Gap	2875DG	2008	9-May-08	24-May-08	15	
Regular	Madawaska	Gap	2875DG	2008	24-May-08	7-Jun-08	14	
Regular	Madawaska	Gap	2875DG	2008	7-Jun-08	21-Jun-08	14	
Regular	Madawaska	Gap	2875DG	2008	21-Jun-08	4-Jul-08	13	
Regular	Madawaska	Gap	2875DG	2008	4-Jul-08	17-Jul-08	13	
Regular	Madawaska	Gap	2875DG	2008	17-Jul-08	30-Jul-08	13	
Regular	Madawaska	Gap	2875DG	2009	1-May-09	15-May-09	14	
Regular	Madawaska	Gap	2875DG	2009	15-May-09	29-May-09	14	
Regular	Madawaska	Gap	2875DG	2009	29-May-09	12-Jun-09	14	
Regular	Madawaska	Gap	2875DG	2009	12-Jun-09	26-Jun-09	14	
Regular	Madawaska	Gap	2875DG	2009	26-Jun-09	10-Jul-09	14	
Regular	Madawaska	Gap	2875DG	2009	10-Jul-09	24-Jul-09	14	
Regular	Madawaska	Gap	2875DG	2009	24-Jul-09	7-Aug-09	14	
Regular	Madawaska	Matrix	2875DG	2008	9-May-08	24-May-08	15	
Regular	Madawaska	Matrix	2875DG	2008	24-May-08	7-Jun-08	14	
Regular	Madawaska	Matrix	2875DG	2008	7-Jun-08	21-Jun-08	14	
Regular	Madawaska	Matrix	2875DG	2008	21-Jun-08	4-Jul-08	13	
Regular	Madawaska	Matrix	2875DG	2008	4-Jul-08	17-Jul-08	13	
Regular	Madawaska	Matrix	2875DG	2008	17-Jul-08	30-Jul-08	13	
Regular	Madawaska	Matrix	2875DG	2009	1-May-09	15-May-09	14	
Regular	Madawaska	Matrix	2875DG	2009	15-May-09	29-May-09	14	
Regular	Madawaska	Matrix	2875DG	2009	29-May-09	12-Jun-09	14	
Regular	Madawaska	Matrix	2875DG	2009	12-Jun-09	26-Jun-09	14	
Regular	Madawaska	Matrix	2875DG	2009	26-Jun-09	10-Jul-09	14	

APPENDIX A -- MALAISE TRAPS (without 2007)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)
Regular	Madawaska	Matrix	2875DG	2009	10-Jul-09	24-Jul-09	14
Regular	Madawaska	Matrix	2875DG	2009	24-Jul-09	7-Aug-09	14
						TOTAL	**2932**

Treatment	Gap	Matrix	Total
Control	449	420	869
Intensive	506	523	1029
Regular	527	507	1034
TOTAL	**1482**	**1450**	**2932**

APPENDIX A -- Malaise Traps (including 2007)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)	
Control	Brewer	Gap	2875DG	2008	7-May-08	21-May-08	14	
Control	Brewer	Gap	2875DG	2008	21-May-08	5-Jun-08	15	
Control	Brewer	Gap	2875DG	2008	5-Jun-08	18-Jun-08	14	
Control	Brewer	Gap	2875DG	2008	22-Jun-08	8-Jul-08	16	
Control	Brewer	Gap	2875DG	2008	8-Jul-08	22-Jul-08	14	
Control	Brewer	Gap	2875DG	2008	22-Jul-08	5-Aug-08	14	
Control	Brewer	Gap	2875DG	2009	5-May-09	17-May-09	12	
Control	Brewer	Gap	2875DG	2009	17-May-09	2-Jun-09	16	
Control	Brewer	Gap	2875DG	2009	2-Jun-09	19-Jun-09	0	disturbed
Control	Brewer	Gap	2875DG	2009	19-Jun-09	3-Jul-09	14	
Control	Brewer	Gap	2875DG	2009	3-Jul-09	17-Jul-09	14	
Control	Brewer	Gap	2875DG	2009	17-Jul-09	4-Aug-09	18	
Control	Brewer	Matrix	2875DG	2007	30-Apr-07	14-May-07	14	
Control	Brewer	Matrix	2875DG	2007	14-May-07	25-May-07	11	
Control	Brewer	Matrix	2875DG	2007	25-May-07	8-Jun-07	14	
Control	Brewer	Matrix	2875DG	2007	8-Jun-07	20-Jun-07	12	
Control	Brewer	Matrix	2875DG	2007	29-Jun-07	13-Jul-07	14	
Control	Brewer	Matrix	2875DG	2008	7-May-08	21-May-08	14	
Control	Brewer	Matrix	2875DG	2008	21-May-08	15-May-08	0	disturbed
Control	Brewer	Matrix	2875DG	2008	5-Jun-08	19-Jun-08	14	
Control	Brewer	Matrix	2875DG	2008	22-Jun-08	8-Jul-08	16	
Control	Brewer	Matrix	2875DG	2008	8-Jul-08	22-Jul-08	14	
Control	Brewer	Matrix	2875DG	2008	22-Jul-08	5-Aug-08	14	
Control	Brewer	Matrix	2875DG	2009	5-May-09	10-May-09	5	
Control	Brewer	Matrix	2875DG	2009	18-May-09	2-Jun-09	14	
Control	Brewer	Matrix	2875DG	2009	2-Jun-09	19-Jun-09	0	disturbed
Control	Brewer	Matrix	2875DG	2009	19-Jun-09	3-Jul-09	14	
Control	Brewer	Matrix	2875DG	2009	3-Jul-09	17-Jul-09	14	
Control	Brewer	Matrix	2875DG	2009	17-Jul-09	4-Aug-09	0	disturbed
Control	Brewer	Matrix2	2875DG	2007	30-Apr-07	14-May-07	14	
Control	Brewer	Matrix2	2875DG	2007	14-May-07	19-May-07	5	
Control	Brewer	Matrix3	Townes	2007	30-Apr-07	14-May-07	14	
Control	Brewer	Matrix3	Townes	2007	14-May-07	25-May-07	11	
Control	Brewer	Matrix3	Townes	2007	25-May-07	8-Jun-07	14	
Control	Brewer	Matrix3	Townes	2007	8-Jun-07	20-Jun-07	12	
Control	Cranjelly	Gap	2875DG	2008	10-May-08	24-May-08	14	
Control	Cranjelly	Gap	2875DG	2008	24-May-08	7-Jun-08	14	
Control	Cranjelly	Gap	2875DG	2008	7-Jun-08	21-Jun-08	14	
Control	Cranjelly	Gap	2875DG	2008	21-Jun-08	30-Jun-08	10	
Control	Cranjelly	Gap	2875DG	2008	12-Jul-08	25-Jul-08	13	
Control	Cranjelly	Gap	2875DG	2008	25-Jul-08	8-Aug-08	14	
Control	Cranjelly	Gap	2875DG	2009	7-May-09	21-May-09	14	
Control	Cranjelly	Gap	2875DG	2009	21-May-09	4-Jun-09	14	
Control	Cranjelly	Gap	2875DG	2009	4-Jun-09	18-Jun-09	0	disturbed
Control	Cranjelly	Gap	2875DG	2009	18-Jun-09	2-Jul-09	14	
Control	Cranjelly	Gap	2875DG	2009	2-Jul-09	16-Jul-09	14	
Control	Cranjelly	Gap	2875DG	2009	16-Jul-09	4-Aug-09	19	
Control	Cranjelly	Matrix	2875DG	2007	28-Apr-07	12-May-07	14	
Control	Cranjelly	Matrix	2875DG	2007	12-May-07	26-May-07	14	
Control	Cranjelly	Matrix	2875DG	2007	26-May-07	9-Jun-07	0	disturbed
Control	Cranjelly	Matrix	2875DG	2007	12-Jun-07	25-Jun-07	13	
Control	Cranjelly	Matrix	2875DG	2007	25-Jun-07	9-Jul-07	14	
Control	Cranjelly	Matrix	2875DG	2008	10-May-08	24-May-08	14	

APPENDIX A -- Malaise Traps (including 2007)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)	
Control	Cranjelly	Matrix	2875DG	2008	24-May-08	7-Jun-08	14	
Control	Cranjelly	Matrix	2875DG	2008	7-Jun-08	21-Jun-08	14	
Control	Cranjelly	Matrix	2875DG	2008	21-Jun-08	4-Jul-08	13	
Control	Cranjelly	Matrix	2875DG	2008	4-Jul-08	17-Jul-08	13	
Control	Cranjelly	Matrix	2875DG	2008	17-Jul-08	30-Jul-08	13	
Control	Cranjelly	Matrix	2875DG	2009	7-May-09	21-May-09	14	
Control	Cranjelly	Matrix	2875DG	2009	21-May-09	4-Jun-09	14	
Control	Cranjelly	Matrix	2875DG	2009	4-Jun-09	18-Jun-09	0	disturbed
Control	Cranjelly	Matrix	2875DG	2009	18-Jun-09	2-Jul-09	14	
Control	Cranjelly	Matrix	2875DG	2009	2-Jul-09	16-Jul-09	14	
Control	Cranjelly	Matrix	2875DG	2009	16-Jul-09	4-Aug-09	19	
Control	Cranjelly	Matrix2	Townes	2007	28-Apr-07	12-May-07	14	
Control	Cranjelly	Matrix2	Townes	2007	12-May-07	26-May-07	14	
Control	Cranjelly	Matrix2	Townes	2007	26-May-07	9-Jun-07	14	
Control	Cranjelly	Matrix2	Townes	2007	9-Jun-07	23-Jun-07	14	
Control	Cranjelly	Matrix2	Townes	2007	23-Jun-07	9-Jul-07	16	
Control	Cranjelly	Matrix3	2875DG	2007	1-May-07	12-May-07	11	
Control	Two Rivers	Gap	2875DG	2008	4-May-08	18-May-08	14	
Control	Two Rivers	Gap	2875DG	2008	18-May-08	1-Jun-08	14	
Control	Two Rivers	Gap	2875DG	2008	1-Jun-08	15-Jun-08	14	
Control	Two Rivers	Gap	2875DG	2008	15-Jun-08	29-Jun-08	14	
Control	Two Rivers	Gap	2875DG	2008	29-Jun-08	13-Jul-08	14	
Control	Two Rivers	Gap	2875DG	2008	13-Jul-08	28-Jul-08	15	
Control	Two Rivers	Gap	2875DG	2009	3-May-09	11-May-09	0	disturbed
Control	Two Rivers	Gap	2875DG	2009	11-May-09	25-May-09	14	
Control	Two Rivers	Gap	2875DG	2009	28-May-09	8-Jun-09	0	disturbed
Control	Two Rivers	Gap	2875DG	2009	19-Jun-09	3-Jul-09	14	
Control	Two Rivers	Gap	2875DG	2009	3-Jul-09	17-Jul-09	14	
Control	Two Rivers	Gap	2875DG	2009	17-Jul-09	29-Jul-09	12	
Control	Two Rivers	Matrix	2875DG	2007	30-Apr-07	14-May-07	14	
Control	Two Rivers	Matrix	2875DG	2007	14-May-07	25-May-07	11	
Control	Two Rivers	Matrix	2875DG	2007	25-May-07	8-Jun-07	14	
Control	Two Rivers	Matrix	2875DG	2007	8-Jun-07	20-Jun-07	12	
Control	Two Rivers	Matrix	2875DG	2007	26-Jun-07	11-Jul-07	15	
Control	Two Rivers	Matrix	2875DG	2008	4-May-08	18-May-08	0	disturbed
Control	Two Rivers	Matrix	2875DG	2008	20-May-08	1-Jun-08	12	
Control	Two Rivers	Matrix	2875DG	2008	1-Jun-08	15-Jun-08	14	
Control	Two Rivers	Matrix	2875DG	2008	15-Jun-08	29-Jun-08	14	
Control	Two Rivers	Matrix	2875DG	2008	29-Jun-08	13-Jul-08	14	
Control	Two Rivers	Matrix	2875DG	2008	13-Jul-08	28-Jul-08	15	
Control	Two Rivers	Matrix	2875DG	2009	3-May-09	11-May-09	8	
Control	Two Rivers	Matrix	2875DG	2009	11-May-09	20-May-09	9	
Control	Two Rivers	Matrix	2875DG	2009	28-May-09	10-Jun-09	13	
Control	Two Rivers	Matrix	2875DG	2009	19-Jun-09	3-Jul-09	14	
Control	Two Rivers	Matrix	2875DG	2009	3-Jul-09	17-Jul-09	14	
Control	Two Rivers	Matrix	2875DG	2009	17-Jul-09	4-Aug-09	18	
Control	Two Rivers	Matrix3	2875DG	2007	30-Apr-07	14-May-07	14	
Control	Two Rivers	Matrix3	2875DG	2007	14-May-07	25-May-07	11	
Control	Two Rivers	Matrix3	2875DG	2007	25-May-07	8-Jun-07	14	
Control	Two Rivers	Matrix3	2875DG	2007	8-Jun-07	20-Jun-07	12	
Intensive	Crossbar	Gap	2875DG	2007	28-Apr-07	12-May-07	14	
Intensive	Crossbar	Gap	2875DG	2007	12-May-07	27-May-07	15	
Intensive	Crossbar	Gap	2875DG	2007	7-Jun-07	19-Jun-07	12	

APPENDIX A -- Malaise Traps (including 2007)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)	
Intensive	Crossbar	Gap	2875DG	2007	1-Jul-07	12-Jul-07	11	
Intensive	Crossbar	Gap	2875DG	2008	9-May-08	24-May-08	15	
Intensive	Crossbar	Gap	2875DG	2008	24-May-08	7-Jun-08	14	
Intensive	Crossbar	Gap	2875DG	2008	7-Jun-08	21-Jun-08	14	
Intensive	Crossbar	Gap	2875DG	2008	21-Jun-08	4-Jul-08	13	
Intensive	Crossbar	Gap	2875DG	2008	4-Jul-08	17-Jul-08	13	
Intensive	Crossbar	Gap	2875DG	2008	17-Jul-08	30-Jul-08	13	
Intensive	Crossbar	Gap	2875DG	2009	1-May-09	15-May-09	14	
Intensive	Crossbar	Gap	2875DG	2009	15-May-09	29-May-09	14	
Intensive	Crossbar	Gap	2875DG	2009	29-May-09	8-Jun-09	0	disturbed
Intensive	Crossbar	Gap	2875DG	2009	12-Jun-09	26-Jun-09	14	
Intensive	Crossbar	Gap	2875DG	2009	26-Jun-09	10-Jul-09	14	
Intensive	Crossbar	Gap	2875DG	2009	10-Jul-09	24-Jul-09	14	
Intensive	Crossbar	Gap	2875DG	2009	24-Jul-09	7-Aug-09	14	
Intensive	Crossbar	Gap2	2875DG	2007	28-Apr-07	12-May-07	14	
Intensive	Crossbar	Gap2	2875DG	2007	12-May-07	27-May-07	15	
Intensive	Crossbar	Gap2	2875DG	2007	7-Jun-07	19-Jun-07	12	
Intensive	Crossbar	Matrix	2875DG	2007	28-Apr-07	12-May-07	14	
Intensive	Crossbar	Matrix	2875DG	2007	12-May-07	27-May-07	15	
Intensive	Crossbar	Matrix	2875DG	2007	7-Jun-07	19-Jun-07	12	
Intensive	Crossbar	Matrix	2875DG	2007	1-Jul-07	11-Jul-07	10	
Intensive	Crossbar	Matrix	2875DG	2008	9-May-08	20-May-08	11	
Intensive	Crossbar	Matrix	2875DG	2008	24-May-08	7-Jun-08	14	
Intensive	Crossbar	Matrix	2875DG	2008	7-Jun-08	21-Jun-08	14	
Intensive	Crossbar	Matrix	2875DG	2008	21-Jun-08	4-Jul-08	13	
Intensive	Crossbar	Matrix	2875DG	2008	4-Jul-08	17-Jul-08	13	
Intensive	Crossbar	Matrix	2875DG	2008	17-Jul-08	30-Jul-08	13	
Intensive	Crossbar	Matrix	2875DG	2009	1-May-09	15-May-09	14	
Intensive	Crossbar	Matrix	2875DG	2009	15-May-09	29-May-09	14	
Intensive	Crossbar	Matrix	2875DG	2009	29-May-09	12-Jun-09	14	
Intensive	Crossbar	Matrix	2875DG	2009	12-Jun-09	26-Jun-09	14	
Intensive	Crossbar	Matrix	2875DG	2009	26-Jun-09	10-Jul-09	14	
Intensive	Crossbar	Matrix	2875DG	2009	10-Jul-09	24-Jul-09	14	
Intensive	Crossbar	Matrix	2875DG	2009	24-Jul-09	7-Aug-09	14	
Intensive	Crossbar	Matrix2	Townes	2007	28-Apr-07	12-May-07	14	
Intensive	Crossbar	Matrix2	Townes	2007	12-May-07	27-May-07	15	
Intensive	Crossbar	Matrix2	Townes	2007	7-Jun-07	19-Jun-07	12	
Intensive	Florence	Gap	2875DG	2007	29-Apr-07	13-May-07	14	
Intensive	Florence	Gap	2875DG	2007	13-May-07	29-May-07	16	
Intensive	Florence	Gap	2875DG	2007	9-Jun-07	21-Jun-07	12	
Intensive	Florence	Gap	2875DG	2007	26-Jun-07	11-Jul-07	15	
Intensive	Florence	Gap	2875DG	2008	3-May-08	17-May-08	14	
Intensive	Florence	Gap	2875DG	2008	17-May-08	31-May-08	14	
Intensive	Florence	Gap	2875DG	2008	31-May-08	14-Jun-08	14	
Intensive	Florence	Gap	2875DG	2008	14-Jun-08	28-Jun-08	14	
Intensive	Florence	Gap	2875DG	2008	28-Jun-08	13-Jul-08	15	
Intensive	Florence	Gap	2875DG	2008	13-Jul-08	28-Jul-08	15	
Intensive	Florence	Gap	2875DG	2009	5-May-09	19-May-09	14	
Intensive	Florence	Gap	2875DG	2009	19-May-09	3-Jun-09	14	
Intensive	Florence	Gap	2875DG	2009	3-Jun-09	17-Jun-09	14	
Intensive	Florence	Gap	2875DG	2009	17-Jun-09	1-Jul-09	14	
Intensive	Florence	Gap	2875DG	2009	1-Jul-09	15-Jul-09	14	
Intensive	Florence	Gap	2875DG	2009	15-Jul-09	21-Jul-09	6	

APPENDIX A -- Malaise Traps (including 2007)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)	
Intensive	Florence	Gap	2875DG	2009	21-Jul-09	6-Aug-09	16	
Intensive	Florence	Gap2	2875DG	2007	29-Apr-07	13-May-07	14	
Intensive	Florence	Gap2	2875DG	2007	13-May-07	29-May-07	16	
Intensive	Florence	Gap2	2875DG	2007	9-Jun-07	21-Jun-07	12	
Intensive	Florence	Matrix	2875DG	2007	29-Apr-07	13-May-07	14	
Intensive	Florence	Matrix	2875DG	2007	13-May-07	29-May-07	16	
Intensive	Florence	Matrix	2875DG	2007	9-Jun-07	21-Jun-07	12	
Intensive	Florence	Matrix	2875DG	2007	26-Jun-07	11-Jul-07	15	
Intensive	Florence	Matrix	2875DG	2008	3-May-08	17-May-08	14	
Intensive	Florence	Matrix	2875DG	2008	17-May-08	31-May-08	14	
Intensive	Florence	Matrix	2875DG	2008	31-May-08	14-Jun-08	14	
Intensive	Florence	Matrix	2875DG	2008	14-Jun-08	28-Jun-08	14	
Intensive	Florence	Matrix	2875DG	2008	28-Jun-08	10-Jul-08	12	
Intensive	Florence	Matrix	2875DG	2008	21-Jul-08	4-Aug-08	14	
Intensive	Florence	Matrix	2875DG	2009	5-May-09	19-May-09	14	
Intensive	Florence	Matrix	2875DG	2009	19-May-09	30-May-09	11	
Intensive	Florence	Matrix	2875DG	2009	3-Jun-09	17-Jun-09	14	
Intensive	Florence	Matrix	2875DG	2009	17-Jun-09	1-Jul-09	14	
Intensive	Florence	Matrix	2875DG	2009	21-Jul-09	6-Aug-09	16	
Intensive	Florence	Matrix	2875DG	2009	1-Jul-09	15-Jul-09	14	
~~Intensive~~	~~Florence~~	~~Matrix2~~	~~Townes~~	~~2007~~	~~29-Apr-07~~	~~13-May-07~~	~~14~~	
Intensive	Florence	Matrix2	Townes	2007	13-May-07	29-May-07	16	
Intensive	Florence	Matrix2	Townes	2007	9-Jun-07	21-Jun-07	9	
Intensive	Sitting Duck	Gap	2875DG	2007	2-May-07	16-May-07	14	
Intensive	Sitting Duck	Gap	2875DG	2007	16-May-07	28-May-07	12	
Intensive	Sitting Duck	Gap	2875DG	2007	10-Jun-07	22-Jun-07	12	
Intensive	Sitting Duck	Gap	2875DG	2007	27-Jun-07	11-Jul-07	14	
Intensive	Sitting Duck	Gap	2875DG	2008	5-May-08	21-May-08	16	
Intensive	Sitting Duck	Gap	2875DG	2008	21-May-08	4-Jun-08	14	
Intensive	Sitting Duck	Gap	2875DG	2008	4-Jun-08	19-Jun-08	15	
Intensive	Sitting Duck	Gap	2875DG	2008	19-Jun-08	8-Jul-08	19	
Intensive	Sitting Duck	Gap	2875DG	2008	8-Jul-08	21-Jul-08	13	
Intensive	Sitting Duck	Gap	2875DG	2008	21-Jul-08	4-Aug-08	14	
Intensive	Sitting Duck	Gap	2875DG	2009	6-May-09	20-May-09	14	
Intensive	Sitting Duck	Gap	2875DG	2009	20-May-09	3-Jun-09	14	
Intensive	Sitting Duck	Gap	2875DG	2009	3-Jun-09	17-Jun-09	14	
Intensive	Sitting Duck	Gap	2875DG	2009	17-Jun-09	1-Jul-09	14	
Intensive	Sitting Duck	Gap	2875DG	2009	1-Jul-09	10-Jul-09	0	
Intensive	Sitting Duck	Gap	2875DG	2009	21-Jul-09	5-Aug-09	15	
Intensive	Sitting Duck	Gap	2875DG	2009	6-May-09	20-May-09	14	
Intensive	Sitting Duck	Gap	2875DG	2009	20-May-09	3-Jun-09	14	
Intensive	Sitting Duck	Gap	2875DG	2009	3-Jun-09	17-Jun-09	14	
Intensive	Sitting Duck	Gap	2875DG	2009	17-Jun-09	1-Jul-09	14	
Intensive	Sitting Duck	Gap	2875DG	2009	1-Jul-09	10-Jul-09	0	disturbed
Intensive	Sitting Duck	Gap	2875DG	2009	21-Jul-09	5-Aug-09	15	
Intensive	Sitting Duck	Matrix	2875DG	2007	2-May-07	16-May-07	14	
Intensive	Sitting Duck	Matrix	2875DG	2007	16-May-07	28-May-07	12	
Intensive	Sitting Duck	Matrix	2875DG	2007	10-Jun-07	22-Jun-07	12	
Intensive	Sitting Duck	Matrix	2875DG	2007	27-Jun-07	11-Jul-07	14	
Intensive	Sitting Duck	Matrix	2875DG	2008	5-May-08	21-May-08	16	
Intensive	Sitting Duck	Matrix	2875DG	2008	21-May-08	4-Jun-08	14	
Intensive	Sitting Duck	Matrix	2875DG	2008	4-Jun-08	19-Jun-08	15	
Intensive	Sitting Duck	Matrix	2875DG	2008	19-Jun-08	8-Jul-08	19	

APPENDIX A -- Malaise Traps (including 2007)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)	
Intensive	Sitting Duck	Matrix	2875DG	2008	8-Jul-08	21-Jul-08	13	
Intensive	Sitting Duck	Matrix	2875DG	2008	21-Jul-08	4-Aug-08	14	
Intensive	Sitting Duck	Matrix	2875DG	2009	6-May-09	20-May-09	14	
Intensive	Sitting Duck	Matrix	2875DG	2009	20-May-09	3-Jun-09	14	
Intensive	Sitting Duck	Matrix	2875DG	2009	3-Jun-09	17-Jun-09	14	
Intensive	Sitting Duck	Matrix	2875DG	2009	17-Jun-09	1-Jul-09	14	
Intensive	Sitting Duck	Matrix	2875DG	2009	1-Jul-09	15-Jul-09	14	
Intensive	Sitting Duck	Matrix	2875DG	2009	15-Jul-09	21-Jul-09	6	
Intensive	Sitting Duck	Matrix	2875DG	2009	21-Jul-09	5-Aug-09	15	
Intensive	Sitting Duck	Matrix2	Townes	2007	2-May-07	16-May-07	14	
Intensive	Sitting Duck	Matrix2	Townes	2007	16-May-07	28-May-07	12	
Intensive	Sitting Duck	Matrix2	Townes	2007	10-Jun-07	18-Jun-07	8	
Regular	Cecil	Gap	2875DG	2007	3-May-07	17-May-07	14	
Regular	Cecil	Gap	2875DG	2008	3-May-08	17-May-08	14	
Regular	Cecil	Gap	2875DG	2008	17-May-08	31-May-08	14	
Regular	Cecil	Gap	2875DG	2008	6-Jun-08	20-Jun-08	14	
Regular	Cecil	Gap	2875DG	2008	20-Jun-08	8-Jul-08	18	
Regular	Cecil	Gap	2875DG	2008	8-Jul-08	21-Jul-08	13	
Regular	Cecil	Gap	2875DG	2008	21-Jul-08	4-Aug-08	14	
Regular	Cecil	Gap	2875DG	2009	5-May-09	19-May-09	14	
Regular	Cecil	Gap	2875DG	2009	19-May-09	3-Jun-09	14	
Regular	Cecil	Gap	2875DG	2009	3-Jun-09	17-Jun-09	14	
Regular	Cecil	Gap	2875DG	2009	17-Jun-09	1-Jul-09	14	
Regular	Cecil	Gap	2875DG	2009	1-Jul-09	15-Jul-09	14	
Regular	Cecil	Gap	2875DG	2009	15-Jul-09	30-Jul-09	15	
Regular	Cecil	Gap	2875DG	2009	30-Jul-09	12-Aug-09	13	
Regular	Cecil	Gap2	2875DG	2007	3-May-07	17-May-07	14	
Regular	Cecil	Gap2	2875DG	2007	17-May-07	29-May-07	12	
Regular	Cecil	Gap2	2875DG	2007	9-Jun-07	21-Jun-07	12	
Regular	Cecil	Gap2	2875DG	2007	26-Jun-07	11-Jul-07	15	
Regular	Cecil	Matrix	2875DG	2007	3-May-07	17-May-07	14	
Regular	Cecil	Matrix	2875DG	2007	17-May-07	29-May-07	12	
Regular	Cecil	Matrix	2875DG	2007	9-Jun-07	21-Jun-07	12	
Regular	Cecil	Matrix	2875DG	2007	26-Jun-07	5-Jul-07	0	disturbed
Regular	Cecil	Matrix	2875DG	2008	3-May-08	17-May-08	14	
Regular	Cecil	Matrix	2875DG	2008	17-May-08	31-May-08	14	
Regular	Cecil	Matrix	2875DG	2008	31-May-08	6-Jun-08	0	disturbed
Regular	Cecil	Matrix	2875DG	2008	6-Jun-08	20-Jun-08	14	
Regular	Cecil	Matrix	2875DG	2008	20-Jun-08	8-Jul-08	18	
Regular	Cecil	Matrix	2875DG	2008	10-Jul-08	24-Jul-08	14	
Regular	Cecil	Matrix	2875DG	2008	24-Jul-08	7-Aug-08	14	
Regular	Cecil	Matrix	2875DG	2009	5-May-09	19-May-09	14	
Regular	Cecil	Matrix	2875DG	2009	19-May-09	3-Jun-09	14	
Regular	Cecil	Matrix	2875DG	2009	3-Jun-09	17-Jun-09	14	
Regular	Cecil	Matrix	2875DG	2009	17-Jun-09	1-Jul-09	14	
Regular	Cecil	Matrix	2875DG	2009	1-Jul-09	15-Jul-09	14	
Regular	Cecil	Matrix	2875DG	2009	15-Jul-09	30-Jul-09	0	disturbed
Regular	Cecil	Matrix2	Townes	2007	3-May-07	17-May-07	14	
Regular	Cecil	Matrix2	Townes	2007	17-May-07	29-May-07	12	
Regular	Cecil	Matrix2	Townes	2007	9-Jun-07	17-Jun-07	8	
Regular	Louisa Flats	Gap	2875DG	2007	2-May-07	16-May-07	14	
Regular	Louisa Flats	Gap	2875DG	2007	16-May-07	28-May-07	12	
Regular	Louisa Flats	Gap	2875DG	2007	10-Jun-07	22-Jun-07	12	

APPENDIX A -- Malaise Traps (including 2007)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)	
Regular	Louisa Flats	Gap	2875DG	2007	28-Jun-07	13-Jul-07	15	
Regular	Louisa Flats	Gap	2875DG	2008	6-May-08	21-May-08	15	
Regular	Louisa Flats	Gap	2875DG	2008	21-May-08	31-May-08	10	
Regular	Louisa Flats	Gap	2875DG	2008	6-Jun-08	19-Jun-08	13	
Regular	Louisa Flats	Gap	2875DG	2008	19-Jun-08	8-Jul-08	19	
Regular	Louisa Flats	Gap	2875DG	2008	8-Jul-08	10-Jul-08	2	
Regular	Louisa Flats	Gap	2875DG	2008	25-Jul-08	7-Aug-08	13	
Regular	Louisa Flats	Gap	2875DG	2009	6-May-09	20-May-09	14	
Regular	Louisa Flats	Gap	2875DG	2009	20-May-09	3-Jun-09	14	
Regular	Louisa Flats	Gap	2875DG	2009	3-Jun-09	17-Jun-09	14	
Regular	Louisa Flats	Gap	2875DG	2009	17-Jun-09	1-Jul-09	14	
Regular	Louisa Flats	Gap	2875DG	2009	1-Jul-09	15-Jul-09	6	
Regular	Louisa Flats	Gap	2875DG	2009	15-Jul-09	30-Jul-09	15	
Regular	Louisa Flats	Gap	2875DG	2009	30-Jul-09	12-Aug-09	13	
Regular	Louisa Flats	Matrix	2875DG	2007	2-May-07	16-May-07	14	
Regular	Louisa Flats	Matrix	2875DG	2008	6-May-08	21-May-08	15	
Regular	Louisa Flats	Matrix	2875DG	2008	21-May-08	4-Jun-08	14	
Regular	Louisa Flats	Matrix	2875DG	2008	4-Jun-08	19-Jun-08	15	
Regular	Louisa Flats	Matrix	2875DG	2008	19-Jun-08	28-Jun-08	0	disturbed
Regular	Louisa Flats	Matrix	2875DG	2008	10-Jul-08	24-Jul-08	14	
Regular	Louisa Flats	Matrix	2875DG	2008	25-Jul-08	7-Aug-08	13	
Regular	Louisa Flats	Matrix	2875DG	2009	6-May-09	20-May-09	14	
Regular	Louisa Flats	Matrix	2875DG	2009	20-May-09	3-Jun-09	14	
Regular	Louisa Flats	Matrix	2875DG	2009	3-Jun-09	17-Jun-09	14	
Regular	Louisa Flats	Matrix	2875DG	2009	17-Jun-09	1-Jul-09	14	
Regular	Louisa Flats	Matrix	2875DG	2009	1-Jul-09	15-Jul-09	14	
Regular	Louisa Flats	Matrix	2875DG	2009	15-Jul-09	30-Jul-09	15	
Regular	Louisa Flats	Matrix	2875DG	2009	30-Jul-09	12-Aug-09	13	
Regular	Louisa Flats	Matrix2	Townes	2007	2-May-07	16-May-07	14	
Regular	Louisa Flats	Matrix2	Townes	2007	16-May-07	28-May-07	12	
Regular	Louisa Flats	Matrix2	Townes	2007	10-Jun-07	18-Jun-07	8	
Regular	Louisa Flats	Matrix2	Townes	2007	28-Jun-07	4-Jul-07	0	disturbed
Regular	Louisa Flats	Matrix3	2875AG	2007	2-May-07	16-May-07	14	
Regular	Louisa Flats	Matrix3	2875AG	2007	16-May-07	28-May-07	12	
Regular	Louisa Flats	Matrix3	2875AG	2007	10-Jun-07	22-Jun-07	12	
Regular	Madawaska	Gap	2875DG	2007	28-Apr-07	12-May-07	14	
Regular	Madawaska	Gap	2875DG	2007	12-May-07	27-May-07	15	
Regular	Madawaska	Gap	2875DG	2007	7-Jun-07	19-Jun-07	0	disturbed
Regular	Madawaska	Gap	2875DG	2007	1-Jul-07	12-Jul-07	11	
Regular	Madawaska	Gap	2875DG	2008	9-May-08	24-May-08	15	
Regular	Madawaska	Gap	2875DG	2008	24-May-08	7-Jun-08	14	
Regular	Madawaska	Gap	2875DG	2008	7-Jun-08	21-Jun-08	14	
Regular	Madawaska	Gap	2875DG	2008	21-Jun-08	4-Jul-08	13	
Regular	Madawaska	Gap	2875DG	2008	4-Jul-08	17-Jul-08	13	
Regular	Madawaska	Gap	2875DG	2008	17-Jul-08	30-Jul-08	13	
Regular	Madawaska	Gap	2875DG	2009	1-May-09	15-May-09	14	
Regular	Madawaska	Gap	2875DG	2009	15-May-09	29-May-09	14	
Regular	Madawaska	Gap	2875DG	2009	29-May-09	12-Jun-09	14	
Regular	Madawaska	Gap	2875DG	2009	12-Jun-09	26-Jun-09	14	
Regular	Madawaska	Gap	2875DG	2009	26-Jun-09	10-Jul-09	14	
Regular	Madawaska	Gap	2875DG	2009	10-Jul-09	24-Jul-09	14	
Regular	Madawaska	Gap	2875DG	2009	24-Jul-09	7-Aug-09	14	
Regular	Madawaska	Gap2	2875DG	2007	28-Apr-07	12-May-07	14	

APPENDIX A -- Malaise Traps (including 2007)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)
Regular	Madawaska	Gap2	2875DG	2007	12-May-07	27-May-07	15
Regular	Madawaska	Gap2	2875DG	2007	7-Jun-07	19-Jun-07	12
Regular	Madawaska	Gap2	2875DG	2007	2-May-07	16-May-07	14
Regular	Madawaska	Gap2	2875DG	2007	16-May-07	28-May-07	12
Regular	Madawaska	Gap2	2875DG	2007	10-Jun-07	22-Jun-07	12
Regular	Madawaska	Matrix	2875DG	2007	28-Apr-07	12-May-07	14
Regular	Madawaska	Matrix	2875DG	2007	12-May-07	27-May-07	15
Regular	Madawaska	Matrix	2875DG	2007	7-Jun-07	19-Jun-07	12
Regular	Madawaska	Matrix	2875DG	2007	1-Jul-07	12-Jul-07	11
Regular	Madawaska	Matrix	2875DG	2008	9-May-08	24-May-08	15
Regular	Madawaska	Matrix	2875DG	2008	24-May-08	7-Jun-08	14
Regular	Madawaska	Matrix	2875DG	2008	7-Jun-08	21-Jun-08	14
Regular	Madawaska	Matrix	2875DG	2008	21-Jun-08	4-Jul-08	13
Regular	Madawaska	Matrix	2875DG	2008	4-Jul-08	17-Jul-08	13
Regular	Madawaska	Matrix	2875DG	2008	17-Jul-08	30-Jul-08	13
Regular	Madawaska	Matrix	2875DG	2009	1-May-09	15-May-09	14
Regular	Madawaska	Matrix	2875DG	2009	15-May-09	29-May-09	14
Regular	Madawaska	Matrix	2875DG	2009	29-May-09	12-Jun-09	14
Regular	Madawaska	Matrix	2875DG	2009	12-Jun-09	26-Jun-09	14
Regular	Madawaska	Matrix	2875DG	2009	26-Jun-09	10-Jul-09	14
Regular	Madawaska	Matrix	2875DG	2009	10-Jul-09	24-Jul-09	14
Regular	Madawaska	Matrix	2875DG	2009	24-Jul-09	7-Aug-09	14
Regular	Madawaska	Matrix2	Townes	2007	28-Apr-07	12-May-07	14
Regular	Madawaska	Matrix2	Townes	2007	12-May-07	27-May-07	15
Regular	Madawaska	Matrix2	Townes	2007	7-Jun-07	15-Jun-07	8
						TOTAL	**4402**

Treatment	Gap	Matrix	Total
Control	449	874	1323
Intensive	835	835	1670
Regular	772	754	1526
TOTAL	**2056**	**2463**	**4519**

APPENDIX A – Malaise Traps (Aerial)

Treatment	Site	Trap	Trap-Type	Year	Date-In	Date-Out	Sampling Time (days)	Treatment Total
Control	Brewer	Gap	Aerial	2009	18-May-09	2-Jun-09	15	
Control	Brewer	Gap	Aerial	2009	2-Jun-09	16-Jun-09	14	
Control	Brewer	Gap	Aerial	2009	16-Jun-09	1-Jul-09	15	
Control	Brewer	Gap	Aerial	2009	1-Jul-09	15-Jul-09	14	
Control	Brewer	Gap	Aerial	2009	15-Jul-09	29-Jul-09	14	
Control	Brewer	Gap	Aerial	2009	29-Jul-09	12-Aug-09	14	
Control	Cranjelly	Gap	Aerial	2009	21-May-09	4-Jun-09	14	
Control	Cranjelly	Gap	Aerial	2009	4-Jun-09	18-Jun-09	14	
Control	Cranjelly	Gap	Aerial	2009	18-Jun-09	2-Jul-09	14	
Control	Cranjelly	Gap	Aerial	2009	2-Jul-09	16-Jul-09	14	
Control	Cranjelly	Gap	Aerial	2009	16-Jul-09	4-Aug-09	19	
Control	Two Rivers	Gap	Aerial	2009	20-May-09	4-Jun-09	15	
Control	Two Rivers	Gap	Aerial	2009	4-Jun-09	19-Jun-09	15	
Control	Two Rivers	Gap	Aerial	2009	19-Jun-09	3-Jul-09	14	
Control	Two Rivers	Gap	Aerial	2009	3-Jul-09	17-Jul-09	14	
Control	Two Rivers	Gap	Aerial	2009	17-Jul-09	4-Aug-09	18	Control=237
Intensive	Crossbar	Gap	Aerial	2009	15-May-09	29-May-09	14	
Intensive	Crossbar	Gap	Aerial	2009	29-May-09	12-Jun-09	14	
Intensive	Crossbar	Gap	Aerial	2009	12-Jun-09	26-Jun-09	14	
Intensive	Crossbar	Gap	Aerial	2009	26-Jun-09	10-Jul-09	14	
Intensive	Crossbar	Gap	Aerial	2009	10-Jul-09	24-Jul-09	14	
Intensive	Crossbar	Gap	Aerial	2009	24-Jul-09	7-Aug-09	14	
Intensive	Florence	Gap	Aerial	2009	16-May-09	30-May-09	14	
Intensive	Florence	Gap	Aerial	2009	30-May-09	13-Jun-09	14	
Intensive	Florence	Gap	Aerial	2009	13-Jun-09	27-Jun-09	14	
Intensive	Florence	Gap	Aerial	2009	27-Jun-09	13-Jul-09	0	
Intensive	Florence	Gap	Aerial	2009	13-Jul-09	27-Jul-09	14	
Intensive	Florence	Gap	Aerial	2009	27-Jul-09	9-Aug-09	13	
Intensive	Sitting Duck	Gap	Aerial	2009	13-May-09	27-May-09	14	
Intensive	Sitting Duck	Gap	Aerial	2009	27-May-09	10-Jun-09	14	
Intensive	Sitting Duck	Gap	Aerial	2009	10-Jun-09	23-Jun-09	13	
Intensive	Sitting Duck	Gap	Aerial	2009	23-Jun-09	8-Jul-09	15	
Intensive	Sitting Duck	Gap	Aerial	2009	8-Jul-09	23-Jul-09	15	
Intensive	Sitting Duck	Gap	Aerial	2009	23-Jul-09	5-Aug-09	13	Intensive=237
Regular	Cecil	Gap	Aerial	2009	30-May-09	13-Jul-09	14	
Regular	Cecil	Gap	Aerial	2009	13-Jun-09	27-Jun-09	0	
Regular	Cecil	Gap	Aerial	2009	27-Jun-09	13-Jul-09	16	
Regular	Cecil	Gap	Aerial	2009	13-Jul-09	27-Jul-09	14	
Regular	Cecil	Gap	Aerial	2009	27-Jul-09	9-Aug-09	13	
Regular	Louisa Flats	Gap	Aerial	2009	12-May-09	26-May-09	14	
Regular	Louisa Flats	Gap	Aerial	2009	26-May-09	9-Jun-09	14	
Regular	Louisa Flats	Gap	Aerial	2009	9-Jun-09	23-Jun-09	14	
Regular	Louisa Flats	Gap	Aerial	2009	23-Jun-09	8-Jul-09	15	
Regular	Louisa Flats	Gap	Aerial	2009	8-Jul-09	23-Jul-09	15	
Regular	Louisa Flats	Gap	Aerial	2009	23-Jul-09	8-Aug-09	16	
Regular	Madawaska	Gap	Aerial	2009	15-May-09	29-May-09	14	
Regular	Madawaska	Gap	Aerial	2009	29-May-09	12-Jun-09	14	
Regular	Madawaska	Gap	Aerial	2009	12-Jun-09	26-Jun-09	14	
Regular	Madawaska	Gap	Aerial	2009	26-Jun-09	10-Jul-09	14	
Regular	Madawaska	Gap	Aerial	2009	10-Jul-09	24-Jul-09	14	
Regular	Madawaska	Gap	Aerial	2009	24-Jul-09	7-Aug-09	14	Regular=229

			OVERALL		GAPS (81plots)			MATRICES (81plots)		
Family	**Species**	**Common Name**	# of plots	% of plots	# of plots	% of plots	% in gaps	# of plots	% of plots	% in matrices
Adoxaceae	*Sambucus racemosa*	Red Elderberry	26	16 0	18	22 2	69 2	8	9 9	30 8
Araliaceae	*Aralia hispida*	Bristly Sarsaparilla	1	0 6	1	1 2	100 0	0	0 0	0 0
Araliaceae	*Aralia nudicaulis*	Wild Sarsaparilla	24	14 8	12	14 8	50 0	12	7 4	50 0
Asteraceae	*Aster macrophyllus*	Large-leaved Aster	1	0 6	0	0 0	0 0	1	0 6	100 0
Asteraceae	*Prenanthes spp*	Rattlesnake Root	2	1 2	1	1 2	50 0	1	0 6	50 0
Asteraceae	*Solidago canadensis*	Canada Goldenrod	6	3 7	6	7 4	**100.0**	0	0 0	0 0
Balsaminaceae	*Impatiens capensis*	Jewelweed	11	6 8	8	9 9	**72.7**	3	1 9	27 3
Caprifoliaceae	*Lonicera canadensis*	Fly Honeysuckle	16	9 9	7	8 6	43 8	9	5 6	56 3
Caprifoliaceae	*Viburnum alnifolium*	Hobblebush	35	21 6	14	17 3	40 0	21	13 0	60 0
Cornaceae	*Cornus canadensis*	Bunchberry	4	2 5	1	1 2	25 0	3	1 9	**75.0**
Fumariaceae	*Dicentra cucullaria*	Dutchman's Breeches	31	19 1	21	25 9	67 7	10	6 2	32 3
Grossulariaceae	*Ribes glandulosum*	Skunk Currant	6	3 7	4	4 9	66 7	2	1 2	33 3
Grossulariaceae	*Ribes cynosbati*	Prickly Gooseberry	2	1 2	0	0 0	0 0	2	1 2	100 0
Lamiaceae	*Galeopsis tetrahit*	Hemp Nettle	1	0 6	0	0 0	0 0	1	0 6	100 0
Lamiaceae	*Lycopus uniflorus*	Northern Bugleweed	1	0 6	0	0 0	0 0	1	0 6	100 0
Lamiaceae	*Scutellaria lateriflora*	Mad-dog Skullcap	1	0 6	1	1 2	100 0	0	0 0	0 0
Liliaceae	*Clintonia borealis*	Blue Bead Lily	6	3 7	1	1 2	16 7	5	3 1	**83.3**
Liliaceae	*Erythronium americanum*	Trout Lily	116	71 6	57	70 4	49 1	59	36 4	50 9
Liliaceae	*Maianthemum canadense*	Canada Mayflower	43	26 5	17	21 0	39 5	26	16 0	60 5
Liliaceae	*Medeola virginiana*	Cucumber Root	8	4 9	3	3 7	37 5	5	3 1	62 5
Liliaceae	*Polygonatum pubescens*	Hairy Solomon's Seal	7	4 3	2	2 5	28 6	5	3 1	**71.4**
Liliaceae	*Streptopus roseus*	Rose Twisted-stalk	46	28 4	18	22 2	39 1	28	17 3	60 9
Melanthiaceae	*Trillium erectum*	Red Trillium	80	49 4	39	48 1	48 8	41	25 3	51 3
Melanthiaceae	*Trillium undulatum*	Painted Trillium	6	3 7	2	2 5	33 3	4	2 5	66 7
Onagraceae	*Circaea alpina*	Dwarf Enchant Nightshade	1	0 6	0	0 0	0 0	1	0 6	100 0
Onagraceae	*Epilobium glandulosum*	Northern Willowherb	2	1 2	2	2 5	**100.0**	0	0 0	0 0
Orchidaceae	*Cypripedium acaule*	Pink Lady's Slipper	1	0 6	0	0 0	0 0	1	0 6	100 0
Oxalidaceae	*Oxalis acetosella*	Wood Sorrel	30	18 5	7	8 6	23 3	23	14 2	**76.7**
Polygonaceae	*Polygonum cilinode*	Black-fringed Bindweed	43	26 5	32	39 5	**74.4**	11	6 8	25 6
Portulacaceae	*Claytonia caroliniana*	Carolina Spring Beauty	72	44 4	42	51 9	58 3	30	18 5	41 7
Primulaceae	*Trientalis borealis*	Starflower	60	37 0	25	30 9	41 7	35	21 6	58 3
Pyrolaceae	*Pyrola elliptica*	Shinleaf	3	1 9	0	0 0	0 0	3	1 9	**100.0**
Ranunculaceae	*Coptis trifolia*	Goldthread	7	4 3	0	0 0	0 0	7	4 3	**100.0**
Rosaceae	*Fragaria virginiana*	Wild Strawberry	2	1 2	1	1 2	50 0	1	0 6	50 0
Rosaceae	*Potentilla norvegica*	Rough Cinquefoil	2	1 2	1	1 2	50 0	1	0 6	50 0
Rosaceae	*Rubus allegheniensis*	Common Blackberry	6	3 7	6	7 4	**100.0**	0	0 0	0 0
Rosaceae	*Rubus canadensis*	Smooth Blackberry	1	0 6	1	1 2	100 0	0	0 0	0 0
Rosaceae	*Rubus pubescens*	Dwarf Raspberry	5	3 1	2	2 5	40 0	3	1 9	60 0
Rosaceae	*Rubus strigosus*	Wild Red Raspberry	71	43 8	56	69 1	**78.9**	15	9 3	21 1
Rubiaceae	*Galium triflorum*	Fragrant Bedstraw	7	4 3	4	4 9	57 1	3	1 9	42 9
Saxifragaceae	*Tiarella cordifolia*	Foamflower	16	9 9	9	11 1	56 3	7	4 3	43 8
Violaceae	*Viola blanda*	Sweet White Violet	31	19 1	21	25 9	67 7	10	6 2	32 3
Violaceae	*Viola selkerkii*	Great-spurred Violet	5	3 1	4	4 9	**80.0**	1	0 6	20 0
Violaceae	Viola spp	Violets	33	20 4	20	24 7	60 6	13	8 0	39 4

Genus	Species	CONTROL				INTENSIVE				REGULAR				Species
		2007	2008	2009	Total	2007	2008	2009	Total	2007	2008	2009	Total	Total
Allograpta	*obliqua*		2		2		10		10		2		2	14
Baccha	*elongata*	3	3	2	8		1		1			1	1	10
Blera	*analis*				0				0	2	1		3	3
Blera	*armillata*	1			1				0	1			1	2
Blera	*badia**	1	1	2	4	4	6	5	15	8	2	2	12	31
Blera	*confusa*			1	1		1		1	1	1	1	3	5
Blera	*nigra*				0	2			2	1	1	1	3	5
Brachyopa	*ferruginea*				0				0	1	1		2	2
Brachyopa	*flavescens*	7	3	4	14	5	1	3	9	3	2	9	14	37
Brachyopa	*notata*				0	1		1	2	4			4	6
Brachyopa	*perplexa*	1		2	3	37	11	3	51	15	4	7	26	80
Brachyopa	*vacua*				0				0	1			1	1
Brachyopalpus	*oarus*	9		4	13	5	1	2	8	12			12	33
Callicera	*erratica*				0	1			1				0	1
Chalcosyrphus	*anomalus*				0	2			2				0	2
Chalcosyrphus	*anthreas*				0				0	1	2	1	4	4
Chalcosyrphus	*curvaria*			1	1			3	3	5			5	9
Chalcosyrphus	*inarmatus*				0		1		1				0	1
Chalcosyrphus	*libo*	3	3	8	14	6	4	7	17	8	2	16	26	57
Chalcosyrphus	*nemorum*	3	11	23	37	12	17	42	71	16	8	50	74	182
Chalcosyrphus	*piger*				0				0			1	1	1
Chalcosyrphus	*plesius*	2	2	1	5	8	4	4	16	3	3	3	9	30
Chalcosyrphus	*vecors*				0		1		1	1	1	1	3	4
Cheilosia	*new species*				0		1		1				0	1
Cheilosia	*ontario*	1			1				0	1			1	2
Cheilosia	*pontiacca*				0		1		1				0	1
Cheilosia	*prima*		8	3	11	1	2	3	6		1	1	2	19
Cheilosia	*rita*	1	1	1	3			1	1	3			3	7
Chrysogaster	*antitheus*	1		2	3		1	2	3	3			3	9
Chrysotoxum	*derivatum**		1		1		2	1	3		1	2	3	7
Chrysotoxum	*flavifrons*				0			2	2				0	2
Criorhina	*verbosa*				0				0	5			5	5
Cynorhinella	*longinasus*				0			1	1				0	1
Dasysyrphus	*pauxillus*			8	8	1	1	3	5	6	6	3	15	28
Dasysyrphus	*venustus*	11	9	14	34	25	19	24	68	25	10	16	51	153
Doros	*aequalis*			1	1		1	1	2				0	3
Epistrophe	*emarginata*	1	2		3		2		2	1	3		4	9
Epistrophe	*grossulariae*		2	2	4	1		1	2			1	1	7
Epistrophe	*nitidicollis*				0			2	2			1	1	3
Epistrophe	*terminalis*			1	1			1	1				0	2
Epistrophe	*xanthostoma*				0		3		3		1		1	4
Eristalis	*anthophorinus*				0		1		1				0	1
Eristalis	*cryptarum*				0				0			1	1	1
Eristalis	*dimidiata*	1		1	2	1	3		4	6	2	1	9	15
Eristalis	*flavipes*				0		1		1		1		1	2
Eristalis	*transversa*			1	1	2		2	4	2			2	7
Eupeodes	*americanus*		2		2	3	5	5	13	4	3	1	8	23
Eupeodes	*lapponicus*	6			6	3			3	5		1	6	15
Eupeodes	*latifasciatus*	1			1			1	1	2			2	4
Eupeodes	*luniger*				0		1		1			1	1	2
Eupeodes	*perplexus*	2			2		5	6	11	2	2	1	5	18
Eupeodes	*pomus*				0				0			2	2	2
Ferdinandea	*buccata*				0	34	2		36	3		4	7	43
Helophilus	*fasciatus*	40	1	3	44	149	1	1	151	63	1		64	259
Helophilus	*lapponicus*				0				0			1	1	1
Helophilus	*latifrons*				0		2		2				0	2
Heringia	*salax*			1	1	4	3	1	8	5		2	7	16
Hiatomyia	*cyanescens*				0				0		1		1	1
Lejops	*anausis*		1		1		2	4	6	1		4	5	12

APPENDIX C – Syrphids by Treatment

Genus	Species	CONTROL				INTENSIVE				REGULAR				Species Total
		2007	2008	2009	Total	2007	2008	2009	Total	2007	2008	2009	Total	
Lejops	*lineatus*		1	1	2	7	2	1	10		1		1	13
Lejota	*aerea*	5	8	2	15	17	6	9	32	9	2	16	27	74
Lejota	*cyanea*			1	1	12	1	5	18	19	1	11	31	50
Mallota	*bautias**				0				0			2	2	2
Mallota	*posticata**				0		1	3	4	2		2	4	8
Melangyna	*lasiophthalma*	7		3	10	5	2	9	16	8	3	7	18	44
Melangyna	*triangulifera*			2	2				0			2	2	4
Melanostoma	*mellinum**	29	59	130	218	54	44	109	207	80	59	126	265	690
Meliscaeva	*cinctella*	1	6	12	19	4	25	19	48		7	35	42	109
Microdon	*manitobensis*				0		1		1				0	1
Microdon	*megalogaster*				0				0	1			1	1
Microdon	*tristis*				0	2		3	5			1	1	6
Myolepta	*nigra*				0			2	2			1	1	3
Neoascia	*globosa*				0	1	1	3	5	4	2	7	13	18
Neoascia	*metallica*				0				0	1			1	1
Neoascia	*sandsi*			1	1	3	2	2	7	10	1	6	17	25
Ocyptamus	*fascipennis*				0		1	1	2			2	2	4
Orthonevra	*anniae*				0	1			1	16			16	17
Orthonevra	*pulchella*				0		10	8	18	2	3	4	9	27
Parasyrphus	*genualis*				0		2	2	4		1	4	5	9
Parasyrphus	*new species*			1	1			2	2				0	3
Parasyrphus	*semiinterruptus*			4	4			3	3	1		2	3	10
Parhelophilus	*obsoletus**				0		3	6	9			2	2	11
Pipiza	*femoralis*	1		1	2	8	3	5	16		3	4	7	25
Pipiza	*nigripilosa*				0		1	4	5	1		5	6	11
Pipiza	*puella*				0				0		1		1	1
Platycheirus	*confusus*	7	2	16	25	6	4	19	29	18	1	25	44	98
Platycheirus	*granditarsus*				0		1		1				0	1
Platycheirus	*hyperboreus*			1	1	1	1	7	9		1	4	5	15
Platycheirus	*immarginatus*				0				0			1	1	1
Platycheirus	*inversus*				0				0			1	1	1
Platycheirus	*nearcticus**		5	1	6	2	6	4	12	4	5	14	23	41
Platycheirus	*obscurus**	32	19	38	89	32	45	130	207	18	30	138	186	482
Platycheirus	*rosarum*				0	1	1		2				0	2
Platycheirus	*scambus*		1		1		4	4	8	1		3	4	13
Rhingia	*nasica**	7	38	20	65	12	32	43	87	3	21	36	60	212
Sericomyia	*bifasciata*			1	1			4	4			4	4	9
Sericomyia	*chrysotoxoides**	4	1	8	13	6	11	9	26	42	6	13	61	100
Sericomyia	*lata**				0		1	13	14	2	3	5	10	24
Sericomyia	*militaris*				0			1	1				0	1
Sericomyia	*transversa*				0			1	1			1	1	2
Somula	*decora*				0				0			1	1	1
Sphaerophoria	*abbreviata*				0				0		1		1	1
Sphaerophoria	*asymmetrica*				0				0			1	1	1
Sphaerophoria	*bifurcata*			1	1				0			2	2	3
Sphaerophoria	*contigua*				0	1	28	3	32	1	18	1	20	52
Sphaerophoria	*longipilosa*				0				0	1			1	1
Sphaerophoria	*novaeangliae**		14	4	18		15	23	38	5	25	23	53	109
Sphaerophoria	*philanthus**				0	1	1	4	6	1	1	1	3	9
Sphecomyia	*vittata*				0		1	1	2	4			4	6
Sphegina	*brachygaster*		1	5	6			2	2			1	1	9
Sphegina	*campanulata*	3	6	17	26	3		13	16	1	1	5	7	49
Sphegina	*flavimana*	3		4	7	1		1	2	17	1	2	20	29
Sphegina	*flavomaculata*	10	4	32	46			6	6			5	5	57
Sphegina	*keeniana*	2	8	5	15			8	8	3	2	7	12	35
Sphegina	*lobata*				0		1	1	2			1	1	3
Sphegina	*petiolata*		2	4	6			2	2				0	8
Sphegina	*rufiventris*				0	2	1		3	2			2	5
Syrphus	*knabi*	1	3	1	5		10	2	12	1	1	5	7	24

APPENDIX C – Syrphids by Treatment

Genus	Species	CONTROL				INTENSIVE				REGULAR				Species
		2007	2008	2009	Total	2007	2008	2009	Total	2007	2008	2009	Total	Total
Syrphus	*rectus**	5	16	9	30	3	34	51	88	6	43	31	80	198
Syrphus	*ribesii**	3	26	2	31	6	45	12	63	12	37	26	75	169
Syrphus	*torvus**	41	50	22	113	20	21	23	64	23	24	25	72	249
Syrphus	*vitripennis*		2		2		2		2		3		3	7
Temnostoma	*alternans*				0	1	1	3	5		1	1	2	7
Temnostoma	*balyras*	13	6	11	30	8	6	13	27	11	8	4	23	80
Temnostoma	*barberi*			3	3	1	1	3	5			4	4	12
Temnostoma	*excentrica**	8		1	9	5	2	7	14	7	1	7	15	38
Temnostoma	*venustum**				0			1	1		1		1	2
Toxomerus	*geminatus**	17	112	44	173	50	346	139	535	100	160	227	487	1195
Toxomerus	*marginatus**	1	13	2	16	27	601	39	667	16	189	16	221	904
Trichopsomyia	*apisaon*			1	1	1	1	2	4			3	3	8
Volucella	*bombylans*				0				0	1			1	1
Xanthogramma	*flavipes*				0			2	2			1	1	3
Xylota	*annulifera*			3	3	20	7	4	31	15	2	6	23	57
Xylota	*atlantica**			1	1		2	1	3	1		1	2	6
Xylota	*augustiventris**				0		1		1				0	1
Xylota	*confusa*		1		1				0	1			1	2
Xylota	*hinei*				0		3	1	4			1	1	5
Xylota	*quadrimaculata**	1	2	6	9	74	32	25	131	94	9	39	142	282
Xylota	*segnis*				0			1	1				0	1
Xylota	*subfasciata*		1	3	4				0		2		2	6
	TOTAL	296	459	510	1265	705	1490	956	3151	785	743	1067	2595	**7011**

*members of this species were caught on flowers of wild red raspberry

APPENDIX C -- Syrphids by Year

Genus	Species	2007				2008				2009				Species
		Con.	Int.	Reg.	Total	Con.	Int.	Reg.	Total	Con.	Int.	Reg.	Total	Total
Allograpta	*obliqua*				0	2	10	2	14				0	14
Baccha	*elongata*	3			3	3	1		4	2		1	3	10
Blera	*analis*			2	2			1	1				0	3
Blera	*armillata*	1		1	2				0				0	2
Blera	*badia**	1	4	8	13	1	6	2	9	2	5	2	9	31
Blera	*confusa*			1	1		1	1	2	1		1	2	5
Blera	*nigra*		2	1	3			1	1			1	1	5
Brachyopa	*ferruginea*			1	1			1	1				0	2
Brachyopa	*flavescens*	7	5	3	15	3	1	2	6	4	3	9	16	37
Brachyopa	*notata*		1	4	5				0		1		1	6
Brachyopa	*perplexa*	1	37	15	53		11	4	15	2	3	7	12	80
Brachyopa	*vacua*			1	1				0				0	1
Brachyopalpus	*oarus*	9	5	12	26		1		1	4	2		6	33
Callicera	*erratica*		1		1				0				0	1
Chalcosyrphus	*anomalus*		2		2				0				0	2
Chalcosyrphus	*anthreas*			1	1			2	2			1	1	4
Chalcosyrphus	*curvaria*			5	5				0	1	3		4	9
Chalcosyrphus	*inarmatus*				0		1		1				0	1
Chalcosyrphus	*libo*	3	6	8	17	3	4	2	9	8	7	16	31	57
Chalcosyrphus	*nemorum*	3	12	16	31	11	17	8	36	23	42	50	115	182
Chalcosyrphus	*piger*				0				0			1	1	1
Chalcosyrphus	*plesius*	2	8	3	13	2	4	3	9	1	4	3	8	30
Chalcosyrphus	*vecors*			1	1		1	1	2			1	1	4
Cheilosia	*new species*				0		1		1				0	1
Cheilosia	*ontario*	1		1	2				0				0	2
Cheilosia	*pontiacca*				0		1		1				0	1
Cheilosia	*prima*		1		1	8	2	1	11	3	3	1	7	19
Cheilosia	*rita*	1		3	4	1			1	1	1		2	7
Chrysogaster	*antitheus*	1		3	4		1		1	2	2		4	9
Chrysotoxum	*derivatum**				0	1	2	1	4		1	2	3	7
Chrysotoxum	*flavifrons*				0				0		2		2	2
Criorhina	*verbosa*			5	5				0				0	5
Cynorhinella	*longinasus*				0				0		1		1	1
Dasysyrphus	*pauxillus*		1	6	7		1	6	7	8	3	3	14	28
Dasysyrphus	*venustus*	11	25	25	61	9	19	10	38	14	24	16	54	153
Doros	*aequalis*				0		1		1	1	1		2	3
Epistrophe	*emarginata*	1		1	2	2	2	3	7				0	9
Epistrophe	*grossulariae*		1		1	2			2	2	1	1	4	7
Epistrophe	*nitidicollis*				0				0		2	1	3	3
Epistrophe	*terminalis*				0				0	1	1		2	2
Epistrophe	*xanthostoma*				0		3	1	4				0	4
Eristalis	*anthophorinus*				0		1		1				0	1
Eristalis	*cryptarum*				0				0			1	1	1
Eristalis	*dimidiata*	1	1	6	8		3	2	5	1		1	2	15
Eristalis	*flavipes*				0		1	1	2				0	2
Eristalis	*transversa*		2	2	4				0	1	2		3	7
Eupeodes	*americanus*		3	4	7	2	5	3	10		5	1	6	23
Eupeodes	*lapponicus*	6	3	5	14				0			1	1	15
Eupeodes	*latifasciatus*	1		2	3				0		1		1	4
Eupeodes	*luniger*				0		1		1			1	1	2
Eupeodes	*perplexus*	2		2	4		5	2	7		6	1	7	18
Eupeodes	*pomus*				0				0			2	2	2
Ferdinandea	*buccata*		34	3	37		2		2			4	4	43
Helophilus	*fasciatus*	40	149	63	252	1	1	1	3	3	1		4	259
Helophilus	*lapponicus*				0				0			1	1	1
Helophilus	*latifrons*				0		2		2				0	2
Heringia	*salax*		4	5	9		3		3	1	1	2	4	16
Hiatomyia	*cyanescens*				0			1	1				0	1
Lejops	*anausis*			1	1	1	2		3		4	4	8	12

APPENDIX C – Syrphids by Year

Genus	Species	2007				2008				2009				Species
		Con.	Int.	Reg.	Total	Con.	Int.	Reg.	Total	Con.	Int.	Reg.	Total	Total
Lejops	*lineatus*		7		7	1	2	1	4	1	1		2	13
Lejota	*aerea*	5	17	9	31	8	6	2	16	2	9	16	27	74
Lejota	*cyanea*		12	19	31		1	1	2	1	5	11	17	50
Mallota	*bautias**				0				0			2	2	2
Mallota	*posticata**			2	2		1		1		3	2	5	8
Melangyna	*lasiophthalma*	7	5	8	20		2	3	5	3	9	7	19	44
Melangyna	*triangulifera*				0				0	2		2	4	4
Melanostoma	*mellinum**	29	54	80	163	59	44	59	162	130	109	126	365	690
Meliscaeva	*cinctella*	1	4		5	6	25	7	38	12	19	35	66	109
Microdon	*manitobensis*				0		1		1				0	1
Microdon	*megalogaster*			1	1				0				0	1
Microdon	*tristis*		2		2				0		3	1	4	6
Myolepta	*nigra*				0				0		2	1	3	3
Neoascia	*globosa*		1	4	5		1	2	3		3	7	10	18
Neoascia	*metallica*			1	1				0				0	1
Neoascia	*sandsi*		3	10	13		2	1	3	1	2	6	9	25
Ocyptamus	*fascipennis*				0		1		1		1	2	3	4
Orthonevra	*anniae*		1	16	17				0				0	17
Orthonevra	*pulchella*			2	2		10	3	13		8	4	12	27
Parasyrphus	*genualis*				0		2	1	3		2	4	6	9
Parasyrphus	*new species*				0				0	1	2		3	3
Parasyrphus	*semiinterruptus*			1	1				0	4	3	2	9	10
Parhelophilus	*obsoletus**				0		3		3		6	2	8	11
Pipiza	*femoralis*	1	8		9		3	3	6	1	5	4	10	25
Pipiza	*nigripilosa*			1	1		1		1		4	5	9	11
Pipiza	*puella*				0			1	1				0	1
Platycheirus	*confusus*	7	6	18	31	2	4	1	7	16	19	25	60	98
Platycheirus	*granditarsus*				0		1		1				0	1
Platycheirus	*hyperboreus*		1		1		1	1	2	1	7	4	12	15
Platycheirus	*immarginatus*				0				0			1	1	1
Platycheirus	*inversus*				0				0			1	1	1
Platycheirus	*nearcticus**		2	4	6	5	6	5	16	1	4	14	19	41
Platycheirus	*obscurus**	32	32	18	82	19	45	30	94	38	130	138	306	482
Platycheirus	*rosarum*		1		1		1		1				0	2
Platycheirus	*scambus*			1	1	1	4		5		4	3	7	13
Rhingia	*nasica**	7	12	3	22	38	32	21	91	20	43	36	99	212
Sericomyia	*bifasciata*				0				0	1	4	4	9	9
Sericomyia	*chrysotoxoides**	4	6	42	52	1	11	6	18	8	9	13	30	100
Sericomyia	*lata**			2	2		1	3	4		13	5	18	24
Sericomyia	*militaris*				0				0		1		1	1
Sericomyia	*transversa*				0				0		1	1	2	2
Somula	*decora*				0				0			1	1	1
Sphaerophoria	*abbreviata*				0			1	1				0	1
Sphaerophoria	*asymmetrica*				0				0			1	1	1
Sphaerophoria	*bifurcata*				0				0	1		2	3	3
Sphaerophoria	*contigua*		1	1	2		28	18	46		3	1	4	52
Sphaerophoria	*longipilosa*			1	1				0				0	1
Sphaerophoria	*novaeangliae**			5	5	14	15	25	54	4	23	23	50	109
Sphaerophoria	*philanthus**		1	1	2		1	1	2		4	1	5	9
Sphecomyia	*vittata*			4	4		1		1		1		1	6
Sphegina	*brachygaster*				0	1			1	5	2	1	8	9
Sphegina	*campanulata*	3	3	1	7	6		1	7	17	13	5	35	49
Sphegina	*flavimana*	3	1	17	21			1	1	4	1	2	7	29
Sphegina	*flavomaculata*	10			10	4			4	32	6	5	43	57
Sphegina	*keeniana*	2		3	5	8		2	10	5	8	7	20	35
Sphegina	*lobata*				0		1		1		1	1	2	3
Sphegina	*petiolata*				0	2			2	4	2		6	8
Sphegina	*rufiventris*		2	2	4		1		1				0	5
Syrphus	*knabi*	1		1	2	3	10	1	14	1	2	5	8	24

APPENDIX C – Syrphids by Year

Genus	Species	2007				2008				2009				Species
		Con.	Int.	Reg.	Total	Con.	Int.	Reg.	Total	Con.	Int.	Reg.	Total	Total
Syrphus	*rectus**	5	3	6	14	16	34	43	93	9	51	31	91	198
Syrphus	*ribesii**	3	6	12	21	26	45	37	108	2	12	26	40	169
Syrphus	*torvus**	41	20	23	84	50	21	24	95	22	23	25	70	249
Syrphus	*vitripennis*				0	2	2	3	7				0	7
Temnostoma	*alternans*		1		1		1	1	2		3	1	4	7
Temnostoma	*balyras*	13	8	11	32	6	6	8	20	11	13	4	28	80
Temnostoma	*barberi*		1		1		1		1	3	3	4	10	12
Temnostoma	*excentrica**	8	5	7	20		2	1	3	1	7	7	15	38
Temnostoma	*venustum**				0			1	1		1		1	2
Toxomerus	*geminatus**	17	50	100	167	112	346	160	618	44	139	227	410	1195
Toxomerus	*marginatus**	1	27	16	44	13	601	189	803	2	39	16	57	904
Trichopsomyia	*apisaon*		1		1		1		1	1	2	3	6	8
Volucella	*bombylans*			1	1				0				0	1
Xanthogramma	*flavipes*				0				0		2	1	3	3
Xylota	*annulifera*		20	15	35		7	2	9	3	4	6	13	57
Xylota	*atlantica**			1	1		2		2	1	1	1	3	6
Xylota	*augustiventris**				0		1		1				0	1
Xylota	*confusa*			1	1	1			1				0	2
Xylota	*hinei*				0		3		3		1	1	2	5
Xylota	*quadrimaculata**	1	74	94	169	2	32	9	43	6	25	39	70	282
Xylota	*segnis*				0				0		1		1	1
Xylota	*subfasciata*				0	1		2	3	3			3	6
	TOTAL	296	705	785	1786	459	1490	743	2692	510	956	1067	2533	7011

*members of this species were caught on flowers of wild red raspberry

NETTED

Genus	Species	# Caught
Blera	*badia*	2
Chalcosyrphus	*anthreas*	1
Chalcosyrphus	*vecors*	1
Chrysotoxum	*derivatum*	1
Dasysyrphus	*venustus*	3
Eristalis	*dimidiata*	3
Eristalis	*flavipes*	1
Mallota	***bautias***	**2**
Mallota	*posticata*	1
Melanostoma	*mellinum*	3
Meliscaeva	*cinctella*	3
Parasyrphus	*semiinterruptus*	1
Parhelophilus	*obsoletus*	2
Pipiza	*femoralis*	1
Platycheirus	*confusus*	1
Platycheirus	*nearcticus*	1
Platycheirus	*obscurus*	6
Rhingia	*nasica*	7
Sericomyia	*bifasciata*	1
Sericomyia	*chrysotoxoides*	7
Sericomyia	*lata*	1
Sphaerophoria	*contigua*	2
Sphaerophoria	*novaeangliae*	2
Sphaerophoria	*philanthus*	2
Sphegina	*flavimana*	1
Sphegina	*lobata*	1
Syrphus	*rectus*	3
Syrphus	*ribesii*	2
Syrphus	*torvus*	2
Temnostoma	*alternans*	3
Temnostoma	*balyras*	1
Temnostoma	*excentrica*	4
Temnostoma	*venustum*	2
Toxomerus	*geminatus*	11
Toxomerus	*marginatus*	7
Xylota	*atlantica*	1
Xylota	*augustiventris*	1
Xylota	*quadrimaculata*	3
Xylota	*subfasciata*	1
	TOTAL	**98**

PAN TRAP

Genus	Species	# Caught
Brachyopalpus	*oarus*	2
Chalcosyrphus	*nemorum*	2
Dasysyrphus	*pauxillus*	1
Dasysyrphus	*venustus*	2
Lejops	*anausis*	1
Melangyna	*triangulifera*	1
Melanostoma	*mellinum*	1
Meliscaeva	*cinctella*	1
Neoascia	*globosa*	1
Parasyrphus	*semiinterruptus*	1
Sericomyia	*chrysotoxoides*	1
Sphaerophoria	*novaeangliae*	1
Toxomerus	*geminatus*	45
Toxomerus	*marginatus*	26
Xylota	*hinei*	1
Xylota	*quadrimaculata*	2
Xylota	***segnis***	**1**
Xylota	*subfasciata*	1
	TOTAL	**91**

AERIAL

Genus	species	# Caught
Chalcosyrphus	*libo*	1
Chalcosyrphus	*nemorum*	1
Chrysotoxum	*derivatum*	1
Dasysyrphus	*pauxillus*	1
Dasysyrphus	*venustus*	4
Epistrophe	*grossulariae*	1
Ferdinandea	*buccata*	1
Heringia	*salax*	2
Melangyna	*lasiophthalma*	2
Melangyna	*triangulifera*	1
Melanostoma	*mellinum*	2
Meliscaeva	*cinctella*	3
Myolepta	*nigra*	1
Parasyrphus	*semiinterruptus*	1
Platycheirus	*confusus*	1
Platycheirus	*obscurus*	4
Rhingia	*nasica*	1
Sphaerophoria	*novaeangliae*	4
Syrphus	*knabi*	1
Syrphus	*rectus*	3
Syrphus	*ribesii*	1
Syrphus	*torvus*	5
Temnostoma	*barberi*	1
Toxomerus	*geminatus*	18
Toxomerus	*marginatus*	2
Xanthogramma	*flavipes*	1
Xylota	*quadrimaculata*	1
Xylota	*subfasciata*	2
	TOTAL	**67**

APPENCIX D -- Bees by Treatment

Family	Genus	Species	Control	Intensive	Regular	TOTAL
Andrenidae	*Andrena*	*bradleyi*		1	1	2
Andrenidae	*Andrena*	*carlini***	1	3	5	9
Andrenidae	*Andrena*	*carolina*		1	4	5
Andrenidae	*Andrena*	*crataegi*		1		1
Andrenidae	*Andrena*	*cressonii*		1		1
Andrenidae	*Andrena*	*distans*	6	4	6	16
Andrenidae	*Andrena*	*erigeniae**	17	37	58	112
Andrenidae	*Andrena*	*erythronii*	8	8	9	25
Andrenidae	*Andrena*	*forbesii**		2	1	3
Andrenidae	*Andrena*	*frigida?*		1		1
Andrenidae	*Andrena*	*milwaukeensis*			2	2
Andrenidae	*Andrena*	*miranda*		3	12	15
Andrenidae	*Andrena*	*miserabilis**			1	1
Andrenidae	*Andrena*	*nasonii*			1	1
Andrenidae	*Andrena*	*nivalis*	1	8	3	12
Andrenidae	*Andrena*	*rufosignata*,**	25	42	43	110
Andrenidae	*Andrena*	*rugosa***		3	4	7
Andrenidae	*Andrena*	*sigmundi*	1	4	6	11
Andrenidae	*Andrena*	*species A*	2	4	2	8
Andrenidae	*Andrena*	*thaspii*	1	2	6	9
Andrenidae	*Andrena*	*tridens**	2	11	8	21
Andrenidae	*Andrena*	*w-scripta**		4	3	7
Halictidae	*Augochlora*	*pura*		1	2	3
Halictidae	*Augochlorella*	*aurata*		11	4	15
Apidae	*Bombus*	*frigidus*		1		1
Apidae	*Bombus*	*perplexus***	4	1	2	7
Apidae	*Bombus*	*rufocinctus*	1			1
Apidae	*Bombus*	*sandersoni***	4	1	3	8
Apidae	*Bombus*	*ternarius***	3	18	22	43
Apidae	*Bombus*	*vagans***	2	3	7	12
Apidae	*Ceratina*	*dupla*		3	3	6
Colletidae	*Colletes*	*impunctatus*			1	1
Colletidae	*Colletes*	*thoracicus*			1	1
Halictidae	*Halictus*	*confusus*		2	1	3
Halictidae	*Halictus*	*rubicundus***		4	4	8
Colletidae	*Hylaeus*	*annulatus*		1		1
Colletidae	*Hylaeus*	*basalis*		2	1	3
Colletidae	*Hylaeus*	*modestus*		4	2	6
Colletidae	*Hylaeus*	*verticallis*		1	1	2
Halictidae	*Lasioglossum*	*athabascence*			1	1
Halictidae	*Lasioglossum*	*atwoodi*		152	112	264
Halictidae	*Lasioglossum*	*cinctipes*		2	6	8
Halictidae	*Lasioglossum*	*comagenense*		1	8	9
Halictidae	*Lasioglossum*	*coriaceum*		5		5
Halictidae	*Lasioglossum*	*cressonii*		203	123	326
Halictidae	*Lasioglossum*	*divergens***		32	80	112
Halictidae	*Lasioglossum*	*dreisbachi*		4	1	5
Halictidae	*Lasioglossum*	*ephialtum*	1	25	20	46
Halictidae	*Lasioglossum*	*foxii*		11	3	14
Halictidae	*Lasioglossum*	*laevissimum*		53	19	72
Halictidae	*Lasioglossum*	*leucozonium***		1		1

APPENCIX D -- Bees by Treatment

Family	Genus	Species	Control	Intensive	Regular	TOTAL
Halictidae	*Lasioglossum*	*lineatulum*		4		4
Halictidae	*Lasioglossum*	*nigroviride***	2	17	12	31
Halictidae	*Lasioglossum*	*nr comagenense*	1		2	3
Halictidae	*Lasioglossum*	*oblongum*	2	6	4	12
Halictidae	*Lasioglossum*	*pilosum*			4	4
Halictidae	*Lasioglossum*	*planatum*	1	15	19	35
Halictidae	*Lasioglossum*	*rufitarse*		16	19	35
Halictidae	*Lasioglossum*	*subversans*		1		1
Halictidae	*Lasioglossum*	*subviridatum*	8	64	40	112
Halictidae	*Lasioglossum*	*taylorae*		4	3	7
Halictidae	*Lasioglossum*	*tenax*		5	3	8
Halictidae	*Lasioglossum*	*versans***	1	80	51	132
Halictidae	*Lasioglossum*	*versatum*		2		2
Halictidae	*Lasioglossum*	*viridatum*		7	2	9
Megachilidae	*Megachile*	*gemula***		1	7	8
Apidae	*Nomada*	*cressonii*		1	6	7
Apidae	*Nomada*	*lehighensis*		1		1
Apidae	*Nomada*	*lepida*			1	1
Apidae	*Nomada*	*pygmae*	1		1	2
Megachilidae	*Osmia*	*atriventris**		3	4	7
Megachilidae	*Osmia*	*tersula***		1		1
Halictidae	*Sphecodes*	*aroniae*			1	1
Halictidae	*Sphecodes*	*carolinus*		1		1
Halictidae	*Sphecodes*	*confertus*		1	1	2
Halictidae	*Sphecodes*	*coronus*			1	1
Halictidae	*Sphecodes*	*cressonii*		1	1	2
Halictidae	*Sphecodes*	*davisii*		1		1
Halictidae	*Sphecodes*	*persimilis*		1		1
Halictidae	*Sphecodes*	*prosphorus*	1	2	8	11
		TOTAL	**96**	**917**	**792**	**1805**

*members of this species were caught on flowers of spring beauty

**members of this species were caught on flowers of wild red raspberry

APPENDIX D -- Bees by Year

Family	Genus	Species	2007	2008	2009	TOTAL
Andrenidae	*Andrena*	*bradleyi*	1	0	1	2
Andrenidae	*Andrena*	*carlini***	5	2	2	9
Andrenidae	*Andrena*	*carolina*	3	2	0	5
Andrenidae	*Andrena*	*crataegi*	1	0	0	1
Andrenidae	*Andrena*	*cressonii*	1	0	0	1
Andrenidae	*Andrena*	*distans*	0	7	9	16
Andrenidae	*Andrena*	*erigeniae**	72	11	29	112
Andrenidae	*Andrena*	*erythronii*	13	4	8	25
Andrenidae	*Andrena*	*forbesii**	1	1	1	3
Andrenidae	*Andrena*	*frigida?*	1	0	0	1
Andrenidae	*Andrena*	*milwaukeensis*	0	1	1	2
Andrenidae	*Andrena*	*miranda*	1	0	14	15
Andrenidae	*Andrena*	*miserabilis**	0	0	1	1
Andrenidae	*Andrena*	*nasonii*	1	0	0	1
Andrenidae	*Andrena*	*nivalis*	1	3	8	12
Andrenidae	*Andrena*	*rufosignata*,**	64	25	21	110
Andrenidae	*Andrena*	*rugosa***	3	2	2	7
Andrenidae	*Andrena*	*sigmundi*	3	3	5	11
Andrenidae	*Andrena*	*species A*	3	0	5	8
Andrenidae	*Andrena*	*thaspii*	4	2	3	9
Andrenidae	*Andrena*	*tridens**	18	0	3	21
Andrenidae	*Andrena*	*w-scripta**	4	1	2	7
Halictidae	*Augochlora*	*pura*	2	1	0	3
Halictidae	*Augochlorella*	*aurata*	8	3	4	15
Apidae	*Bombus*	*frigidus*	0	0	1	1
Apidae	*Bombus*	*perplexus***	1	6	0	7
Apidae	*Bombus*	*rufocinctus*	1	0	0	1
Apidae	*Bombus*	*sandersoni***	3	4	1	8
Apidae	*Bombus*	*ternarius***	9	17	17	43
Apidae	*Bombus*	*vagans***	3	4	5	12
Apidae	*Ceratina*	*dupla*	5	1	0	6
Colletidae	*Colletes*	*impunctatus*	1	0	0	1
Colletidae	*Colletes*	*thoracicus*	0	0	1	1
Halictidae	*Halictus*	*confusus*	0	3	0	3
Halictidae	*Halictus*	*rubicundus***	3	1	4	8
Colletidae	*Hylaeus*	*annulatus*	0	0	1	1
Colletidae	*Hylaeus*	*basalis*	2	0	1	3
Colletidae	*Hylaeus*	*modestus*	2	3	1	6
Colletidae	*Hylaeus*	*verticallis*	1	0	1	2
Halictidae	*Lasioglossum*	*athabascence*	0	1	0	1
Halictidae	*Lasioglossum*	*atwoodi*	114	62	88	264
Halictidae	*Lasioglossum*	*cinctipes*	0	6	2	8
Halictidae	*Lasioglossum*	*comagenense*	7	2	0	9
Halictidae	*Lasioglossum*	*coriaceum*	4	0	1	5
Halictidae	*Lasioglossum*	*cressonii*	183	61	82	326
Halictidae	*Lasioglossum*	*divergens***	35	39	38	112
Halictidae	*Lasioglossum*	*dreisbachi*	1	1	3	5
Halictidae	*Lasioglossum*	*ephialtum*	23	14	9	46
Halictidae	*Lasioglossum*	*foxii*	6	2	6	14
Halictidae	*Lasioglossum*	*laevissimum*	20	28	24	72
Halictidae	*Lasioglossum*	*leucozonium***	0	0	1	1

APPENDIX D -- Bees by Year

Family	Genus	Species	2007	2008	2009	TOTAL
Halictidae	*Lasioglossum*	*lineatulum*	1	3	0	4
Halictidae	*Lasioglossum*	*nigroviride***	9	5	17	31
Halictidae	*Lasioglossum*	*nr comagenense*	0	0	3	3
Halictidae	*Lasioglossum*	*oblongum*	3	5	4	12
Halictidae	*Lasioglossum*	*pilosum*	0	3	1	4
Halictidae	*Lasioglossum*	*planatum*	3	16	16	35
Halictidae	*Lasioglossum*	*rufitarse*	15	5	15	35
Halictidae	*Lasioglossum*	*subversans*	0	0	1	1
Halictidae	*Lasioglossum*	*subviridatum*	28	24	60	112
Halictidae	*Lasioglossum*	*taylorae*	1	3	3	7
Halictidae	*Lasioglossum*	*tenax*	1	1	6	8
Halictidae	*Lasioglossum*	*versans***	76	17	39	132
Halictidae	*Lasioglossum*	*versatum*	1	0	0	1
Halictidae	*Lasioglossum*	*viridatum*	1	9	0	10
Megachilidae	*Megachile*	*gemula***	3	5	0	8
Apidae	*Nomada*	*cressonii*	2	1	4	7
Apidae	*Nomada*	*lehighensis*	0	0	1	1
Apidae	*Nomada*	*lepida*	0	0	1	1
Apidae	*Nomada*	*pygmae*	0	0	2	2
Megachilidae	*Osmia*	*atriventris**	1	2	4	7
Megachilidae	*Osmia*	*tersula***	0	0	1	1
Halictidae	*Sphecodes*	*aroniae*	0	0	1	1
Halictidae	*Sphecodes*	*carolinus*	0	1	0	1
Halictidae	*Sphecodes*	*confertus*	2	0	0	2
Halictidae	*Sphecodes*	*coronus*	1	0	0	1
Halictidae	*Sphecodes*	*cressonii*	1	0	1	2
Halictidae	*Sphecodes*	*davisii*	1	0	0	1
Halictidae	*Sphecodes*	*persimilis*	1	0	0	1
Halictidae	*Sphecodes*	*prosphorus*	5	0	6	11
		TOTAL	**790**	**423**	**592**	**1805**

*members of this species were caught on flowers of spring beauty

**members of this species were caught on flowers of wild red raspberry

NETTED			PAN TRAP		
Genus	**Species**	**# Caught**	**Genus**	**Species**	**# Caught**
Andrena	*carlini*	1	*Andrena*	*carlini*	2
Andrena	*erigeniae*	4	*Andrena*	*distans*	2
Andrena	*erythronii*	5	*Andrena*	*erigeniae*	16
Andrena	*forbesii*	1	*Andrena*	*erythronii*	6
Andrena	***miserabilis***	1	*Andrena*	*nivalis*	9
Andrena	*nivalis*	1	*Andrena*	*rufosignata*	9
Andrena	*rufosignata*	9	*Andrena*	*species A*	1
Andrena	*rugosa*	2	*Andrena*	*tridens*	1
Andrena	*sigmundi*	1	*Augochlora*	*pura*	1
Andrena	*thaspii*	1	*Augochlorella*	*aurata*	3
Andrena	*tridens*	1	***Bombus***	***frigidus***	1
Andrena	*w-scripta*	2	*Bombus*	*ternarius*	8
Augochlorella	*aurata*	2	*Bombus*	*vagans*	1
Bombus	*perplexus*	6	***Colletes***	***thoracicus***	1
Bombus	*sandersoni*	5	*Halictus*	*rubicundus*	2
Bombus	*ternarius*	11	***Hylaeus***	***annulatus***	1
Bombus	*vagans*	6	*Hylaeus*	*modestus*	1
Halictus	*confusus*	1	*Lasioglossum*	*atwoodi*	17
Halictus	*rubicundus*	3	*Lasioglossum*	*cinctipes*	7
Hylaeus	*modestus*	1	*Lasioglossum*	*coriaceum*	1
Lasioglossum	*atwoodi*	5	*Lasioglossum*	*cressonii*	17
Lasioglossum	*comagense*	1	*Lasioglossum*	*divergens*	2
Lasioglossum	*cressonii*	5	*Lasioglossum*	*ephialtum*	10
Lasioglossum	*divergens*	1	*Lasioglossum*	*laevissimum*	10
Lasioglossum	*ephialtum*	1	***Lasioglossum***	***nr comagenense***	2
Lasioglossum	*foxii*	2	*Lasioglossum*	*oblongum*	3
Lasioglossum	*laevissimum*	1	*Lasioglossum*	*pilosum*	1
Lasioglossum	***leucozonium***	1	*Lasioglossum*	*planatum*	15
Lasioglossum	*nigroviride*	4	*Lasioglossum*	*rufitarse*	4
Lasioglossum	***nr comagenense***	1	*Lasioglossum*	*subviridatum*	22
Lasioglossum	*rufitarse*	7	*Lasioglossum*	*taylorae*	1
Lasioglossum	*taylorae*	1	*Lasioglossum*	*tenax*	3
Lasioglossum	*versans*	3	*Lasioglossum*	*versans*	6
Megachile	*gemula*	5	*Lasioglossum*	*viridatum*	1
Osmia	*atriventris*	2	*Nomada*	*cressonii*	2
Osmia	***tersula***	1	*Osmia*	*atriventris*	5
	TOTAL	**105**	***Sphecodes***	***aroniae***	1
				TOTAL	**195**