Testing the Effectiveness of Citizen Science Using a Volunteer Butterfly Monitoring Program

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is the true copy of the thesis, including any required revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

An increasingly popular method of collecting scientific data is to use citizen scientists in community-based monitoring programs. Numerous formal and community-based monitoring programs use butterflies as indicator species to detect and understand changes in ecosystems. A butterfly monitoring program was established with the City of Kitchener in 2012, in order to measure the effectiveness of citizen science observations in identifying butterfly assemblages. Two monitoring sites were used: Lakeside Park contained relatively simple butterfly habitats, and Huron Natural Area which included complex butterfly habitats.

The program consisted of training volunteers to collect data on the butterfly assemblages. Volunteers were given the choice to monitor an established trail at either natural area once every two weeks from the beginning of May to the end of August using the modified Pollard method. It was important to train volunteers how to monitor butterflies, so they were required to attend an instruction workshop to learn the methods to be employed, identification of butterflies, use of the recording form, and proper net and butterfly handling techniques. Quality control measures were another important component of the program, and included comparing volunteer observations at each natural area to those collected by an expert. Each species observation was reviewed to determine the likelihood of the species observation. The species and its habitat were compared to the information and status recorded in *The Butterflies of Waterloo Region*.

The data collected by the participants was analyzed separately by study site and included the calculation of species richness, Shannon-Wiener Diversity Index (*H*), evenness value, Simpson Index (*D*), and Simpson Reciprocal (*1/D*) values. A two-tailed t-test was conducted to compare the data (as represented by Shannon indexes) collected by volunteers and the expert.

The species richness for Lakeside Park was 29, which was slightly higher than the 26 species identified at Huron Natural Area. However, the Shannon-Wiener Diversity Index (*H*), evenness value (*E*), Simpson Diversity Index (*D*), and Simpson Reciprocal Index (*1/D*) all demonstrated that there was a more even and diverse butterfly population at Huron Natural Area than at Lakeside Park.

A high level of validity of volunteer observations was found during this study, as 93% of submitted observations at Lakeside Park and 94% of submitted observations at Huron Natural Area passed the review process. Based on the high level of validity of observations it was determined that the volunteers were successful in characterizing butterfly assemblages, and establishing baseline conditions at each site. The City of Kitchener will be collecting long-term butterfly data, which they can compare over time to provide insight into the diversity at these natural areas.

This research program has contributed to the field of science and to the literature by establishing a review process for citizen science, particularly for butterfly programs. It has also provided further validation of citizen science data.

Acknowledgements

I would like to thank my advisor Stephen Murphy and my committee member David Stephenson for their guidance and review of this paper. I would also like to thank the City of Kitchener and Josh Shea, for without them this program would not exist. Also, I would like to thank all the volunteers who donated their time to be part of this program - your efforts are truly appreciated! Finally, I would like to thank my parents, Susan and Steven Moore, my second parents, Don and Cathy Teat, and Bryan Teat who have all loved and supported me throughout this process. I couldn’t have done it without you!

Table of Contents

List of Figures

List of Tables

Chapter 1
Introduction to Community-based Monitoring

One method of monitoring ecosystems is to use citizen scientists, who are volunteers collecting data for scientific research (Kruger & Shannon, 2000). Citizen science programs are implemented for several different reasons, including scientific data collection, education, and community participation in conservation (Matteson et al., 2012). A program that utilizes citizen scientists is known as community-based monitoring (CBM). The use of CBM is increasing in Canada, as the function and importance of this kind of monitoring is acknowledged (Conrad & Daoust, 2008; Devictor et al., 2010; Dickson et al., 2010; Conrad & Hilchey, 2011; Pollock & Whitelaw, 2005). CBM can be useful for filling gaps in existing data sets (Conrad & Hichey, 2011), which can be a consequence of widespread cutbacks in municipal, provincial and federal government environmental programs (Pollock & Whitelaw, 2005; Savan et al., 2003).

Community-based monitoring can also introduce challenges to programs. These challenges can include issues with program organization, data accuracy and communication of program results (Whitelaw et al., 2003). For the purposes of this program, accuracy refers to the ability of volunteers to correctly identify butterfly species. Other concerns include lack of validation of the data collected by volunteers, as well as issues with incompleteness and comparability of data (Gouveia et al., 2004; Bradshaw, 2003). The definition of validation is the ability to confirm species identification through a review process. These challenges can lead to difficulties in justifying the data as useful to decision-makers (Milne et al., 2006; Conrad & Daoust, 2008).

This study utilized community-based monitoring of butterflies in the City of Kitchener (Ontario, Canada) to analyze the contribution of volunteer observations in identifying butterfly assemblages at two sites; Huron Natural Area and Lakeside Park.

To date, there are relatively few studies that evaluate the contribution of citizen scientists to monitoring butterfly assemblages in North America, particularly in an urban landscape where citizen scientists may be the most useful for detecting species' trends (Matteson et al., 2012; Cooper et al., 2007).

1.1 Using Butterflies as Indicator Species

Butterflies use a wide variety of habitats and larval food plants (Ehrlich & Raven, 1964), which make this taxa appropriate for monitoring in many different types of ecosystems. Butterfly assemblages can be used as an indicator of change, including changes resulting from anthropogenic influences on landscapes. Human developments frequently cause habitat fragmentation and isolation, which reduces the size of many animal populations (Shippers et al., 1996; Richter-Dyn & Goel, 1972). As fragmentation occurs, the probability of the disappearance of local populations increases because of limited dispersal from one population to another (Shippers et al., 1996; Richter-Dyn & Goel, 1972). Habitat protection and connectivity of habitat are vital to butterfly populations (Smallidge & Leopold, 1997) because human development – especially roads and buildings - have altered and destroyed habitats used in their larval and adult stages and have reduced connectivity among habitats (Forister et al., 2010).

Concentrated human developments, such as urban landscapes, present a particular threat to butterfly populations along with pollution, the introduction of exotic species, natural succession and road mortality (Smallidge & Leopold, 1997). Butterflies are affected by urbanization because they are sensitive to change as a result of development (Gilbert, 1980; Pyle, 1980; Brown 1982; Murphy et al., 1990; Kremen, 1992), and studies have demonstrated a decrease in butterfly species in areas that are intensely developed (Blair & Launer, 1997; Yamamoto, 1977; Dennis & Hardy, 2001; Ruszczyk, & De Araujo, 1992; Ruszczyk, 1986). Although, it has been demonstrated that diverse butterfly communities can exist in urbanized habitats if suitable habitats are created and maintained (Hogsden & Hutchinson, 2004). As well, moderate levels of disturbance in urban areas can increase the species richness of certain butterflies (Hogsden & Hutchinson, 2004).

Butterflies can provide indications of other taxa, as butterflies have a complex life cycle, providing a good indication of the health of herbaceous communities (Ehrlich & Raven, 1964), herbivorous arthropods and other taxonomic groups (Waltz & Covington, 2004; Fleishman et al., 2005). Butterflies are useful indicators because they are sensitive to changes in local climate and light levels (Gilbert, 1980; Pyle 1980; Brown, 1982; Murphy et al., 1990; Kremen, 1992; Watt et al., 1968; Ehrlich et al., 1972; Weiss et al., 1987). In addition, butterflies are a useful indicator species for this program in terms of their charismatic ability to engage people in their environment. Butterflies are fairly easy to identify, have a high level of interest to the public and have a well-known life history (Blair, 1999). Butterflies are the most frequent conservation targets among invertebrates and can foster public sympathy for conservation (Samways, 1994; New, 1997).

Finally, studies show that some species of butterflies are expanding their northern range in Canada as changes in climate occur (Dennis, 1993; Kharouba et al., 2009; Roy et al., 2001). Butterflies can be used to track changes in vegetation communities, predict future composition and provide evidence for adapting natural area boundaries (Lemieux & Scott, 2005). For these reasons, butterflies were the target species in this monitoring program.

1.2 Need for Community-based Monitoring Programs

Community-based monitoring programs are needed to conduct scientific investigation, increase citizen and community education, and to enhance community participation in conservation (Matteson et al., 2012). Education and knowledge of the diversity of ecosystems are the first phase of conservation (Niell et al., 2007). Citizen science can also be a method of empowering people to become involved in environmental issues that are of interest to them (Kim et al., 2011). There is a need to test the effectiveness of volunteer programs, as to date, very few studies have examined the reliability of this type of data (Newman et al., 2003).

Urban areas present an opportunity for community-based monitoring programs to collect scientific data because they contain a large number of potential volunteers (Cooper et al., 2007; Devictor et al., 2010; Dickinson et al., 2010). A considerable amount of data can be gathered in reasonably short periods of time using volunteers to conduct ecological surveys (Foster-Smith & Evans, 2003). As well, citizen science is useful for the newly developed field of urban ecology and to further the outlook of coupled systems research (Dickinson et al., 2010; Lepczyk et al., 2009; McCaffrey, 2005; Machlis et al., 1997). Within urban and suburban ecosystems, citizen science can pair ecological monitoring data with information on human activities, including residential habitat management, in order to recognize the effects of humans on environmental response variables (Dickinson et al., 2010; Field et al., 2010).

Citizen science programs provide opportunities to collect data to supplement and/or replace (due to cutbacks) government-funded environmental monitoring programs. CBM is an economical method for the City of Kitchener to monitor their natural areas, as this program can contribute to a long-term data set (Pollock & Whitelaw, 2005) at very little cost to the city.

CBM may also facilitate the democratization of science by sharing information between scientists (researchers) and non-scientists (public members) (Conrad & Hilchey, 2011). Carr (2004) stated that it is necessary to include the community in scientific interests and inappropriate to allow institutions to solely manage scientific activities.

Furthermore, citizen science can play an important role in environmental education, as scientific literacy has been shown to increase when participants actively engage in scientific activities (Conrad & Hilchey, 2011). Social capital is the value of social linkages and societal norms, which has been shown to expand when community members are involved in environmental projects, which can increase public support for conservation (Schwartz, 2006). Social capital has been measured in terms of increases in levels of trust, harmony and cooperation in communities that participate in CBM activities (Sultana & Abeyasekera, 2008). Increases in social capital have led to an increase in volunteer engagement, agency connection, leadership building, problem solving and identification of resources (Whitelaw et al., 2003). Along with these benefits, CBM has been documented to engage community members in local issues, which leads to increased community development and influence on policy-makers (Whitelaw et al., 2003; Pollock & Whitelaw, 2005; Lynam et al., 2007).

The reasons outlined above demonstrate the need to implement community-based monitoring programs, especially in urban areas.

1.3 Research Objective

The objective of my research was to analyze the usefulness of volunteer observations in establishing baseline conditions for each site. The effectiveness of observations was determined by comparing participant observations to expert observations and reviewing the volunteer data for unlikely observations. A long-term goal of this CBM program is to analyze changes that occur in butterfly assemblages over time and provide insight into diversity within City of Kitchener natural areas.

1.4 Study Sites

Two study sites were monitored by the expert and volunteers. The Lakeside Park study site contains simple, homogenous habitat and Huron Natural contains complex, heterogeneous habitats. These two natural areas were chosen because they are located close to residential areas and have an existing volunteer base to conduct butterfly monitoring.

Lakeside Park is a 10.1 hectare (ha) natural area that consists mainly of forest ecosystems (City of Kitchener, 2010b), although the study area for this program consisted mostly of mowed parkland. This natural area is located near residential areas and has an active volunteer base to participate in the program. Lakeside Park consists of 12 vegetation communities, while the study site within this natural area consists mainly of parkland (CGL-2), as well as forest, marsh and plantation (NRSI, 2010). See Table 1 for a full list of vegetation communities within and bordering the study site. See

Figure 1 for a map of Lakeside Park, including the delineation of all 12 vegetation communities.

Table 1. Lakeside Park Vegetation Communities Within and Bordering the Study Site

ELC Code[1]	Vegetation Community	Distance to Study Site
CGL_2	Parkland	Within
SAF_1-1	Water lily-bullhead lily floating leaved shallow aquatic	Bordering
FODM4	Dry-fresh upland deciduous forest	Within
TAGM2	Coarse mineral mixed plantation	Within
MAMM1	Graminoid mineral meadow marsh	Within
MAMM1-3	Reed canary grass graminoid mineral meadow marsh	Within
SWTM3	Willow mineral deciduous thicket swamp	Bordering

[1]Data collected by Natural Resources Solutions Inc. (NRSI, 2010)

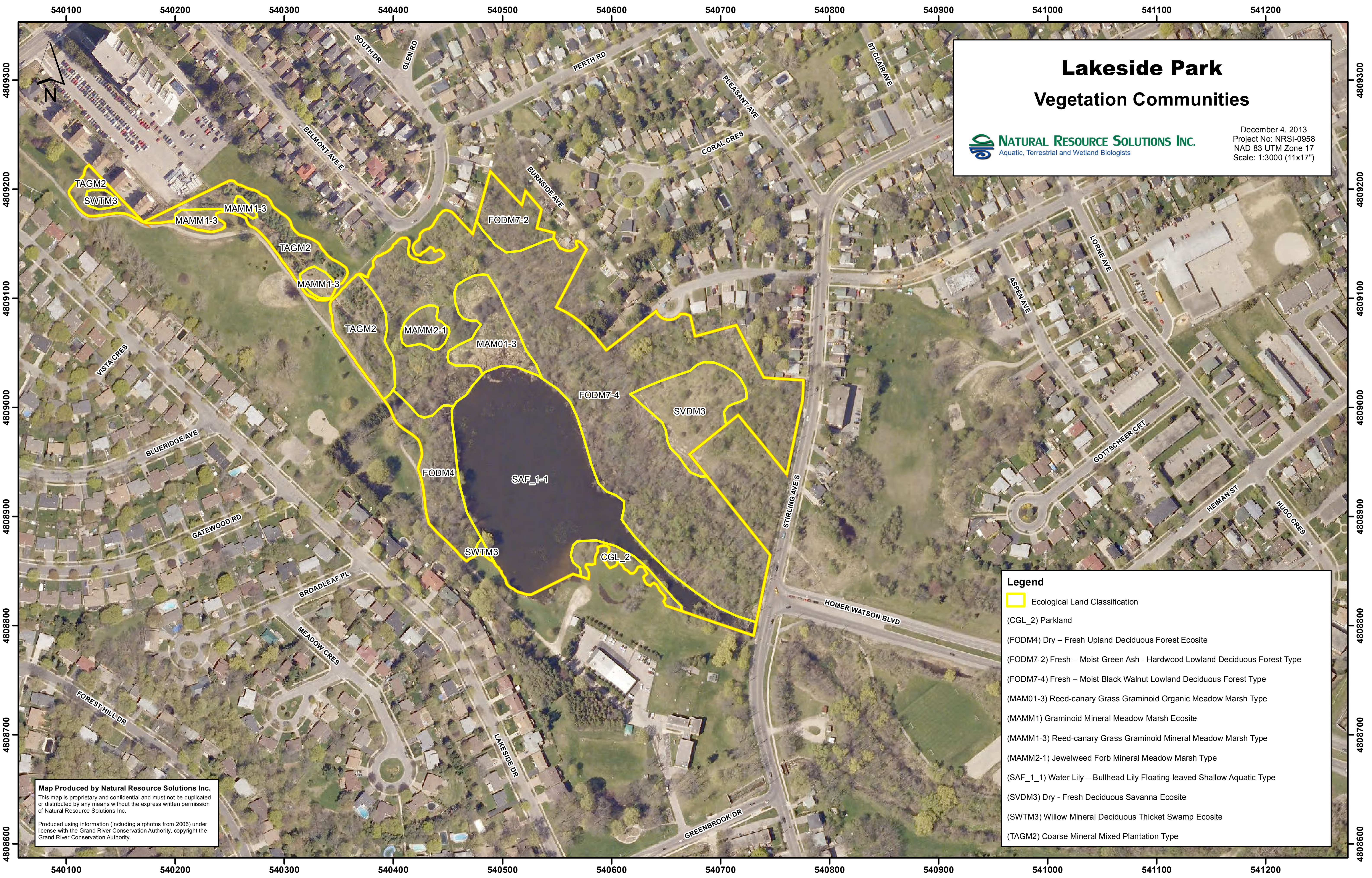
Huron Natural Area is the City of Kitchener's largest natural area, which consists of 107 ha of land (City of Kitchener, 2010a). This land contains Strasburg Creek, Provincially Significant Wetlands, forests, meadows and significant species (City of Kitchener, 2010a). Based on the southern Ontario Ecological Land Classification (ELC) system (Lee, 2008), there are 63 different vegetation communities within the boundaries of Huron Natural Area, including forests, marshes, meadows, aquatic areas, swamps, thickets and woodlands, as well as green/parkland, sewage and water treatment and stormwater management areas (NRSI 2011). The study site within the Huron Natural Area consisted of heterogeneous dry-fresh forb meadow that is bordered by 13 different vegetation communities, including a plantation, forests, marshes and thickets (see Table 2). See Figure 2 for a map of the study site, including the delineation of all 63 vegetation communities.

Table 2. Huron Natural Area Vegetation Communities Within and Bordering the Study Site

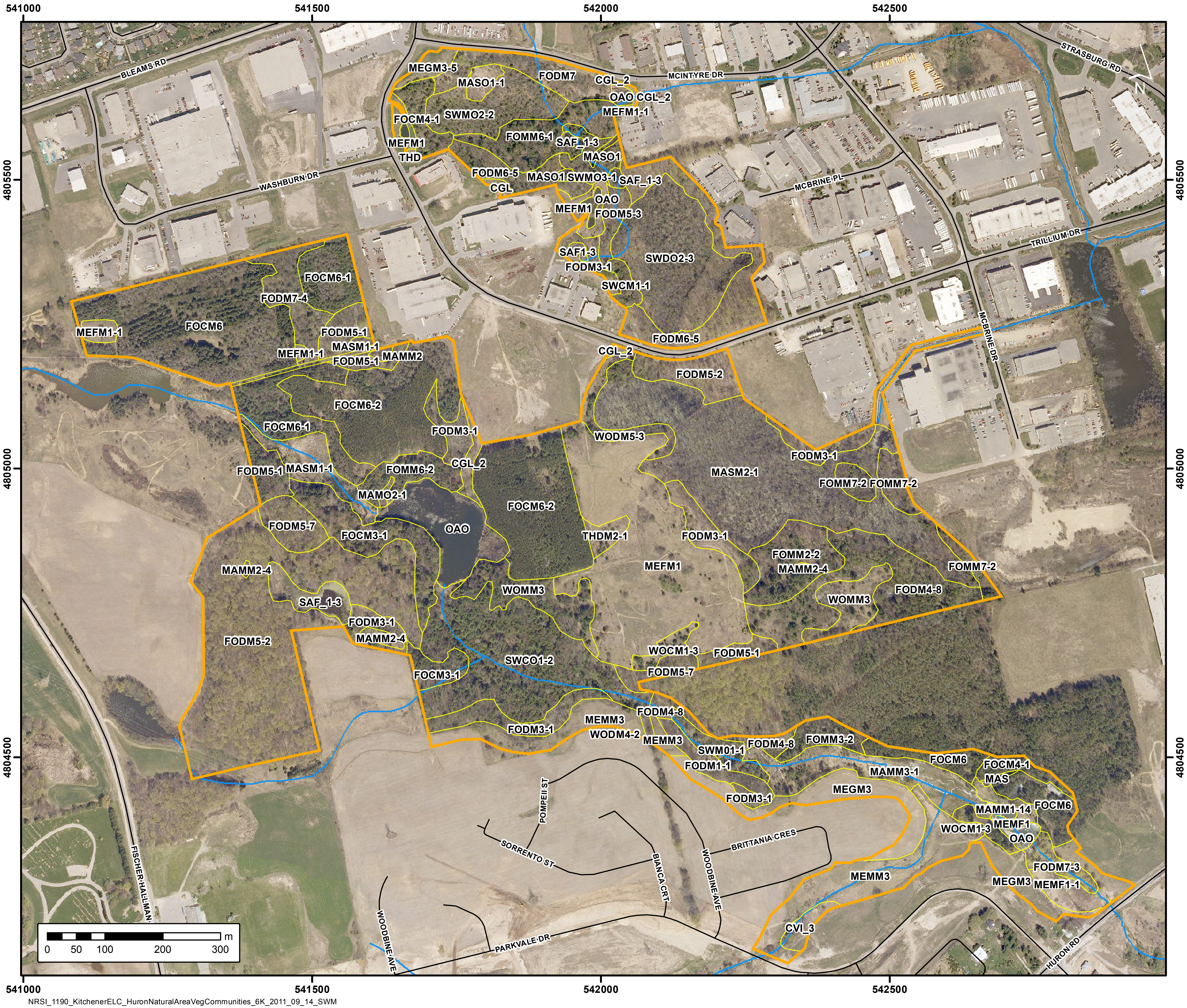
ELC Code[1]	Vegetation Community	Distance to Study Site
FOCM3-1	Fresh-moist hemlock coniferous forest	Bordering
FOCM6-2	Dry-fresh red pine naturalized coniferous plantation	Bordering
FODM3-1	Dry-fresh poplar deciduous forest	Bordering
FODM4-8	Dry-fresh black cherry deciduous forest	Bordering
FODM5-1	Dry-fresh sugar maple deciduous forest	Bordering
FODM5-7	Dry-fresh sugar maple-black cherry	Bordering

ELC Code[1]	Vegetation Community	Distance to Study Site
	deciduous forest	
MAMM2-4	Mixed forb mineral meadow marsh	Bordering
MASM2-1	Forb mineral shallow marsh	Bordering
MEFM1	Dry-fresh forb meadow	Within
THDM2-1	Sumac deciduous shrub thicket	Bordering
SWCO1-2	White cedar conifer organic coniferous swamp	Bordering
WOCM1-3	Dry-fresh white pine coniferous forest	Bordering
WODM5-3	Fresh-moist Manitoba maple deciduous woodland	Bordering
WOMM3	Dry-fresh mixed woodland	Bordering

[1]Data collected by Natural Resource Solutions Inc. (NRSI 2011)



NRSI_0958_KitchenerELC_LakesidePark_ELC_2010_07_27_GCS



Huron Natural Area

Vegetation Communities

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

December 4, 2013
Project No: NRSI-1190
NAD 83 UTM Zone 17
Scale: 1:6 500 (11x17")

Legend

- Huron Natural Area Boundary
- Ecological Land Classification
- (CGL) Greenlands
- (CGL_2) Parkland/ Greenlands
- (CVI_3) Sewage and Water Treatment
- (FOCM3-1) Fresh- Moist Hemlock Coniferous Forest type
- (FOCM4-1) Fresh - Moist White Cedar Coniferous Forest Type
- (FOCM6) Naturalized Coniferous Plantation
- (FOCM6-1) Dry- Fresh White Pine Naturalized Coniferous Planatation
- (FOCM6-2) Dry- Fresh Red Pine Naturalized Coniferous Plantation Type
- (FODM1-1) Dry-Fresh Oak Deciduous Forest Type
- (FODM3-1) Dry- Fresh Poplar Deciduous Forest Type
- (FODM4-8) Dry- Fresh Black Cherry Deciduous Forest Type
- (FODM5-1) Dry-Fresh Sugar Maple Deciduous Forest Type
- (FODM5-2) Dry - Fresh Sugar Maple - Beech Deciduous Forest Type
- (FODM5-3) Dry – Fresh Sugar Maple – Oak Deciduous Forest Type
- (FODM5-7) Dry - Fresh Sugar Maple - Black Cherry Deciduous Forest Type
- (FODM6-5) Fresh - Moist Sugar Maple - Hardwood Deciduous Forest Type
- (FODM7) Fresh- Moist Lowland Deciduous Forest Ecosite
- (FODM7-3) Fresh - Moist Willow Lowland Deciduous Forest Type
- (FODM7-4) Fresh-Moist Black Walnut Lowland Deciduous Forest type
- (FOMM2-2) Dry - Fresh White Pine -Sugar Maple Mixed Forest Type
- (FOMM3-2) Dry – Fresh Sugar Maple – Hemlock Mixed Forest Type
- (FOMM6-1) Fresh - Moist Sugar Maple - Hemlock Mixed Forest Type
- (FOMM6-2) Fresh-Moist Hemlock - Hardwood Mixed Forest type
- (FOMM7-2) Fresh - Moist White Cedar Hardwood Mixed Forest Type
- (MAMM1-14) Rice Cut Crass Graminoid Mineral Meadow Marsh
- (MAMM2) Forb Mineral Meadow Marsh Ecosite
- (MAMM2-4) Mixed Forb Mineral Meadow Marsh Type
- (MAMM3-1) Mixed Mineral Deadow Marsh Type
- (MAMO2-1) Jewelweed Forb Organic Meadow Marsh Type
- (MAS) Shallow Marsh
- (MASM1-1) Cattail Mineral Shallow Marsh Type
- (MASM2-1) Forb Mineral Shallow Marsh Type
- (MASO1) Graminoid Marsh
- (MASO1-1) Cattail Organic Shallow Marsh Type
- (MEFM1) Dry - Fresh Forb Meadow Ecosite
- (MEFM1-1) Goldenrod Ford Meadow
- (MEGM3) Dry - Fresh Graminoid Meadow Ecosite
- (MEGM3-5) Smooth Brome Graminoid Meadow Type
- (MEMF1) Open Aquatic
- (MEMF1-1) Goldenrod Forb Meadow Type
- (MEMM3) Dry - Fresh Mixed Meadow Ecosite
- (OAO) Open Aquatic
- (SAF1-3) Duckweed Floating Leaved Shallow Aquatic Type
- (SWCM1-1) White Cedar Mineral Coniferous Swamp Type
- (SWCO1-1) White Cedar Organic Coniferous Swamp Type
- (SWCO1-2) White Cedar - Conifer Organic Coniferous Swamp Type
- (SWDM2-3) Silver Maple Mineral Deciduous Swamp
- (SWM) Storm Water Management Pond
- (SWM01-1) White Cedar - Hardwood Organic Mixed Swamp
- (SWMO2-2) Mixed Maple - Conifer Swamp
- (SWMO3-1) Yellow Birch - Conifer Mixed Swamp Type
- (THD) Deciduous Thicket
- (THDM2-1) Sumac Deciuous Shrub Thicket Type
- (WOCM1-3) Dry Fresh White Pine Coniferous Woodland Type
- (WODM4-2) White Ash Deciduous Woodland Type
- (WODM5-3) Fersh - Moist Manitoba Maple Deciduous Woodland Type
- (WOMM3) Dry - Fresh Mixed Woodland Ecosite

Map Produced by Natural Resource Solutions Inc.

NRSI_1190_KitchenerELC_HuronNaturalAreaVegCommunities_6K_2011_09_14_SWM

Chapter 2
Methods

2.1 Volunteer Recruitment

Community-based monitoring projects rely on a strong volunteer base in order to provide accurate and representative scientific observations. The City of Kitchener Natural Areas Program has approximately 60 existing volunteers that were contacted to participate in this program, including volunteers who participated in the Huron Natural Area Annual Butterfly Count in 2011. A group of community members who live near Lakeside Park voiced an interest in monitoring and were contacted to monitor that natural area.

Volunteer recruitment information was distributed to other local environmental groups, including: Kitchener-Waterloo Field Naturalist (KWFN) Club, ***rare*** Charitable Research Reserve and the Toronto Entomologists' Association. I attended the KWFN public meeting on April 23, 2012 and announced the volunteer opportunity, as well as published a notice in the May 2012 issue of the KWFN Newsletter, the Heron. Information regarding this monitoring program was handed out at the butterfly booth set-up at the Earth Day event held at Huron Natural Area on April 21, 2012. This event was attended by hundreds of people and included a wider range of community members than those already involved in local environmental clubs and groups.

2.2 Volunteer Training

For this monitoring program, volunteers were trained during a half-day workshop that produced 25 sets (some gathered data in pairs) of trained individuals who could collect data on multiple days in a week with acceptable accuracy. This method was chosen rather than one expert surveying once every two weeks for the entire monitoring period.

Before data collection could begin in either natural area, volunteers were trained to collect monitoring observations. Training included attendance at a workshop, which was held on May 6, 2012. The workshop included a presentation that reviewed the training manual (see Appendix I) that was given to each volunteer, and explained how to correctly fill out the data sheets.

The training manual outlines the reasons why butterflies are being monitored in the City of Kitchener, which educates participants on the importance of the data they are collecting. The manual details the appropriate time of year and time of day to monitor butterflies, as well as the ideal weather conditions in which monitoring will generally occur. The manual explains how often and how long monitoring should be conducted, as well as how to record observations using the data form. At the end of the manual there is a section of helpful tips and reminders to ensure consistency among volunteers, and a thank you to volunteers for their contribution to the City of Kitchener and the University of Waterloo. The final page of the manual contains the Beaufort Wind Scale, which is used to determine the strength of wind to record on the data sheet during monitoring.

All monitoring observations were recorded on a standard monitoring form (see Appendix II). During the workshop, volunteers were shown a sample and a blank data sheet. Each blank space was filled in to demonstrate how to properly complete a data form for monitoring. The recording form includes the following information: date, recorder's name, site name, start time, end time, start temperature (ºC), end temperature (ºC), sun (percentage of open sky) and wind speed (it should be between 0-5 on the Beaufort Wind Scale).

Volunteers were educated about the butterfly life cycle and basic butterfly morphology in order to ensure volunteers understood the different parts of a butterfly that contain key identification features. The general differences between moths and butterflies were outlined, as this is a common question regarding Lepidoptera and important for volunteers to understand when making identifications in the field. The volunteers were trained on identification of different butterfly species, particularly species that are common to the area and likely to be encountered during monitoring. The presentation ended with suggestions for effective net techniques and how to handle and release butterflies.

Before going into the field, volunteers received a butterfly field guide and net to aid in field identification. Volunteers participated in a hands-on species identification program along the Huron Natural Area meadow trail to demonstrate how to conduct butterfly monitoring. This included species identification, proper net handling and release techniques, as well as proper use of the recording form and instruction on how to accurately count the number of individual butterflies present in a given area. During this portion of the training session volunteers caught and identified butterflies, which were placed in jars to be viewed by the group. In total, eight species were caught and viewed by the participants on the training day.

2.3 Butterfly Monitoring Methods

Butterfly survey methods follow a modified Pollard transect methodology (Pollard, 1977). These methods included walking an established trail at Lakeside Park or Huron Natural Area and making counts of butterflies. These counts occurred during suitable weather conditions from the beginning of May to the end of August. Limiting a transect to a trail is preferred as the boundaries of the trail are normally obvious (Pollard, 1977). The Pollard transect method is a widely used and accepted method of assessing butterfly populations and detecting changes in butterfly assemblages over time (Pollard, 1977; Thomas, 1983; Pollard & Yates, 1993; Caldas & Robbins, 2003). The methods are easily replicable from year to year and therefore produce reliable data that can be compared over time (Pollard, 1977; Swengel, 1998; Simonson et al., 2001; Croxton et al., 2005).

Volunteers monitored the meadow trail at Huron Natural Area or the community trail at Lakeside Park a minimum of once every two weeks from May to August in 2012. The trails are relatively short, as the meadow trail at Huron Natural Area is 0.6 kilometres (km) and the community trail at Lakeside Park is 1.0 km. Each trail takes less than one hour to walk and consists of relatively easy terrain. Each volunteer chose to monitor on the first and third weeks of the month, or the second and fourth weeks. Volunteers were asked to pick a day of the week when they would conduct monitoring and it was recommended to consistently monitor on that day whenever possible. If the volunteer was not available or the weather conditions were inadequate on that day, it was recommended to monitor as close to that day as possible.

The first week of observations began on Sunday May 6, 2012, following the training workshop. The last week of monitoring was the week of August 19, with the week of August 26 being an optional week of monitoring. See Table 3 for a breakdown of these weeks (denoted from Sunday to Saturday).

Table 3. Weeks Monitored by Volunteers in 2012

1st and 3rd Weeks	2nd and 4th Weeks
May 6-12/May 20-26	May 13-19/May 27-June 2
June 3-9/June 17-23	June 10-16/June 24-30
July 1-7/July 15-21	July 8-14/July 22-28
July 29-August 4/August 12-18	August 5-11/August 19-25

Participants were instructed to walk at an even pace and observe butterflies along the way, while stops were allowed to identify or catch butterflies as they walked the trail (Pollard, 1977). There was no minimum or maximum time allotted for monitoring the trail. Volunteers were asked to conduct monitoring on warm (at least 20º C) and fairly sunny days, with low wind speeds (Pollard, 1977). The Beaufort Wind Scale (see Appendix III) was utilized for this monitoring program as a method for volunteers to assess wind conditions. This wind scale ranks wind speeds from 0-12, ranging from calm to hurricane, and are assessed based on specifications for use on land, such as observing the movement of tree branches.

Volunteers also received guidance on the best time of day to monitor butterflies, which is generally between 10 am and 4 pm, during the appropriate weather conditions. The daily timing window can be extended, either earlier or later in the day, if the temperature is above 25º C. Since not all volunteers may be available on days with optimal weather conditions or during the ideal timing window, volunteers were instructed to monitor during the best conditions when they were available. As well, because the monitoring season is during the summer months when people often take vacations, the participants were advised to monitor every two weeks when possible and if they were away or unavailable for a period longer than two-weeks, they should monitor before they leave and as soon as they can when they return. If a volunteer was only available on one day within their two-week session, and that day had poor weather conditions, they were asked to monitor on that day instead of skipping that monitoring session.

The volunteer monitoring data from Huron Natural Area was compared to data collected for the City of Kitchener by an environmental consulting company, Natural Resource Solutions Inc. (NRSI). On each visit, two NRSI biologists conducted systematic area searches of the meadow habitat for at least 1.5 hours while actively searching for butterflies at the Huron Natural Area (NRSI, 2012). Surveys were conducted on May 27, July 16, and August 20 in 2010; on May 20, June 17, and July 9 in 2011; and on May 31 and June 20 in 2012. The 2011 and 2012 data also includes the observations made during the annual butterfly count in each of those years. In 2011, the count took place on July 9 and in 2012, the count was on July 7. All surveys were completed in suitable weather conditions, including days with more than 50% sun versus cloud cover, low wind, and with air temperatures over 20^{o} C (NRSI, 2012).

2.4 Quality Control Measures

Studies show that errors are made by recorders whether they are volunteers or experienced scientists, and have recommended that all ecological studies include quality control, regardless of the experience level of the recorder (Foster-Smith & Evans, 2003).

The first quality control measure implemented for this program was to have volunteers only monitor one site, as it has been shown that it is effective for trained volunteers to monitor a small number of sites to assess changes over time (Matterson et al., 2012). Along with volunteer observations, I monitored the trail at each natural area once every two weeks in order to provide a comparison for the data collected by volunteers. These observations were compared to those collected by citizen scientists in order to determine the validity and value of monitoring observations collected by volunteers.

As well, each observation that was submitted was reviewed to verify the collected data. This review compared observations to *The Butterflies of Waterloo Region* (Linton, 2012), which classifies butterflies as very common, common, uncommon, rare, possibly extirpated or unknown. Any observation that contained a species listed as uncommon, rare, possibly extirpated or unknown received a secondary review. The secondary review included a review of the number of occurrences in *The Butterflies of Waterloo Region* (Linton, 2012), as well as a habitat assessment of the area where the butterfly was observed, in order to determine the likelihood of the observation. As well, the species range, as per *The Ontario Butterfly Atlas* (Jones et al., 2012), was consulted to determine if the species occurrence is likely within the City of Kitchener. This review followed methods similar to other CBM projects, such as the Ontario Field Ornithologists' Ontario Bird Records Committee (Ontario Birds, 2010), and eButterfly (eButterfly, 2013).

Observations that were accompanied by written reports, photographs, prints, field notes or sketches were reviewed (Ontario Birds, 2010), whereas records with little to no documentation did not pass the secondary review, and therefore were not included in the final data set. The review also took into account the number of years of experience the observer had in butterfly identification. Those who were proficient in butterfly identification might observe an uncommon, rare, possibly extirpated or unknown butterfly species without further documentation, provided that the observer is certain of accurate species identification. Observations made by participants who were inexperienced or unsure of their butterfly identification needed to provide proper documentation of the species, including one or more of the records mentioned above in order to continue with the secondary review and have the potential to be included in the final data set.

These quality control measures were necessary to ensure accurate data was collected throughout the program, which can often be an issue in community-based monitoring programs.

2.5 Data Analysis

Data from each site were analyzed separately as the level of effort at each natural area differed. Furthermore, there was data available for butterfly surveys completed at the Huron Natural Area in 2010, 2011 and 2012, which were compared to the data collected by the community-based monitoring program. There was no comparative data for the Lakeside Park site and therefore there was less statistical analysis of this area.

Data analysis for each site included calculating species richness, which was calculated as the number of species observed at each site (Blair & Launer, 1997; Neill et al., 2007). Statistical analysis for both CBM data sets, and the 2010-2012 Huron Natural Area data, included analyzing species diversity and evenness. This was done using the Shannon-Wiener Diversity Index (*H*) that combined the number of species within a site in relation to the relative abundance of each species (Shannon & Weaver, 1949; Magurran, 1988; Blair & Launer, 1997), and the Simpson Index (*D*), as well as the Simpson Reciprocal (1/*D*) value. The Simpson Index demonstrates the contribution of each species by giving the probability that it will be chosen in a random sample of two individuals from the population (Smith & Grassle, 1977). The Simpson Reciprocal value calculates the number of uniformly common groups that make up the Simpson Index (Steele et al., 2005). The Shannon Diversity Index and Simpson Index were chosen because they are the two most widely used (Schulte & Buongiorno, 1998; Marurran, 1988).

A two-tailed t-test was conducted to compare the *H* values of the community-based monitoring data and the 2010-2012 data collected at the Huron Natural Area. As well, this test was used to measure the impact of the quality control conducted by the expert throughout the monitoring period. The complete observations from each natural area (including the expert observations) were compared to those of just the volunteers (excluding the expert), in order to determine the impact of the expert observations on the overall data set.

Chapter 3
Results

3.1 Volunteer Retention

An analysis of the volunteer retention at each site was conducted. The volunteer retention includes the number of volunteers who initially signed up for the monitoring program, the number who dropped out of the program, the number of volunteers that monitored inconsistently, and those who monitored consistently throughout the season. The initial number of volunteers includes everyone who signed up for the program, including those who did not collect any monitoring observations. The number of dropout volunteers includes those who informed me of being unable to complete the program or those who monitored only in the month in May and did not continue for the rest of the season. The number of volunteers who monitored inconsistently was calculated based on those who completed four or less monitoring sessions. Finally, the consistent volunteers are those who completed five or more monitoring sessions.

3.1.1 Lakeside Park

At Lakeside Park, 13 volunteers signed up to monitor this natural area. Two of the 13 (16%) dropped out within the first month, while three (23%) monitored inconsistently, and the remaining eight (61%) volunteers monitored consistently for the duration of the monitoring season. The average number of monitoring sessions completed by the Lakeside Park volunteers was six. The total number of monitoring sessions completed at Lakeside Park by volunteers and the expert in the 2012 monitoring period was 78. The monitoring sessions completed by the expert have been included in Table 4 below.

Table 4. Volunteer Retention at Lakeside Park

Monitoring Classification	Number of Surveys Completed
Drop-out	0
Inconsistent	12
Consistent	58
Expert	8

3.1.2 Huron Natural Area

At the Huron Natural Area, 12 volunteers initially signed up to monitor the natural area. Five of the 12 (42%) dropped out within the first month and gave no notification of leaving the program. One volunteer monitored inconsistently (8%) and the remaining six (50%) volunteers monitored consistently for the duration of the monitoring season. The average number of monitoring sessions completed by the Huron Natural Area volunteers was four. The total number of monitoring sessions completed at this natural area by all volunteers over the 2012 monitoring period was 43. The monitoring sessions completed by the expert have not been included in Table 5 below as the expert data was excluded from the final analysis of the Huron Natural Area site.

Table 5. Volunteer Retention at Huron Natural Area

Monitoring Classification	Number of Surveys Completed
Drop-out	3
Inconsistent	2
Consistent	38

3.2 Testing the Validity of Data

Quality control measures for this monitoring program included a review process for each observation that was submitted, as well as comparison to expert observations to determine the validity of observations and if there was a significant difference between the expert and volunteer observations.

3.2.1 High Validity of Lakeside Park Data

In total, there were 38 unconfirmed butterfly species identified at Lakeside Park, including several categories of individuals that could not be identified to the species level. Of these observations, 29 species were confirmed through the review process. The total number of individual butterflies observed at Lakeside Park by the expert and volunteers was 1,282 and of these observations, 1,193 passed the review process, which resulted in 93% of submitted observations passing the review process.

Species that did not pass the review process include those that could not be identified to the species level, including the categories: unknown, Duskywing sp. (*Erynnis* sp.) and

Skipper spp. The list of species that follows did not pass the review process as it was submitted without any further documentation and could not be confirmed based on the rarity of their occurrence in the Region of Waterloo.

An excluded species was the Common Roadside Skipper (*Amblyscirtes vialis*), which has only been observed twice in the Region of Waterloo, and not since 1967, so this species was excluded from the Regional Status Assignment (Linton, 2012). Another butterfly that did not pass the review process was the Juvenal's Duskywing (*Erynnis juvenalis*), which is designated as rare and has not been observed in the Region of Waterloo since the 1960s, until 2010 (Linton, 2012). A third species that was not included in the analysis was the Common Sootywing (*Pholisora catullus*), which is locally common in southern Ontario and listed as provincially imperiled (S3) and rare in the Region of Waterloo (Linton, 2012). This species has been historically documented in Kitchener occasionally, but in recent years has only been observed in Cambridge (Linton, 2012) and thus was not included in the final list of species. The Northern Cloudywing (*Thorybes pylades*) species was excluded from the final results of this study as this species is listed as rare in the Region of Waterloo and has only been documented in the Region four times (Linton, 2012).

Another species that was not included in the analysis was the Harvester (*Feniseca tarquinius*), which is ranked as rare within the Region of Waterloo, as it has been recorded only eight times in the Region and not since 1990 at a site in Cambridge (Linton, 2012). Lastly, the Banded Hairstreak (*Satyrium calanus*) is listed as uncommon in the Region of Waterloo and has not been included in the confirmed list of butterflies as individuals of the *Satyrium* genus can be easily confused with each other. The six species listed above, plus the three categories of individuals that were not identified to the species level, have not passed the review stage and are not included in the final data analysis for Lakeside Park. These species have not passed the review process because of the rarity of occurrences documented in the Region or length of time since the last observation, which indicates the unlikelihood of the species occurring at Lakeside Park.

Generally, the data collected by volunteers at Lakeside Park was valid, as indicated by the high number of observations that passed the review process.

3.2.2 High Validity of Huron Natural Area Data

In total, there were 32 possible species identified at Huron Natural Area, which includes several categories of unconfirmed individuals that could not be identified to the species level. Of these, 26 species of butterflies were confirmed during the review process, which excludes three species and three categories of unconfirmed individuals that could not be identified to the species level. A total of 657 individual butterflies were observed at the Huron Natural Area, while 620 individuals passed the review process, which resulted in 94% of observations passing the review process.

Species that did not pass the review process include those that were not identified to the species level in the following three categories: Crescent spp., Skipper spp. and unknown. The following species were not included in the Huron Natural Area data set because of the rarity of their occurrence in the Region of Waterloo, and because the observations were submitted with no accompanying documentation. One species that was excluded is the Common Sootywing, for the reasons listed above in Section 3.2.1. Another species that was not included is the Dion Skipper (*Euphyes dion*), which has been observed infrequently within the Region and only has known colonies in Cambridge (Linton, 2012). This species is listed as provincially imperiled (S3) and is listed as rare in the Region of Waterloo, so it has not been included in the final analysis. The final species that did not pass the review process is the Gray Hairstreak (*Strymon melinus*), which has only been documented once in the Region in 1957, and has been excluded from the Regional Status Assessment (Linton, 2012). In addition to the three categories of butterflies that were not identified to the species level, these three species of butterflies listed above have not been included in the final analysis for the Huron Natural Area because of the rarity of their occurrence in the Region of Waterloo and length of time since the last observation of the species.

Overall, the data collected by volunteers at Huron Natural Area was valid, based on 620 of a possible 657 records that passed the review process.

3.3 Butterfly Monitoring Results

As there was a difference in the monitoring effort at each natural area, direct comparisons of the data sets from Lakeside Park and the Huron Natural Area have not been made. Lakeside Park had 14 observers (including the expert), nine of which monitored consistently throughout the season, while Huron Natural Area had 12 observers, of which six were considered to have monitored consistently during the monitoring season. Lakeside Park had 78 visits between May and August, while the Huron Natural Area had 43.

3.3.1 Lakeside Park

Overall, there were 1,282 individual butterflies observed at Lakeside Park during the 2012 community-based monitoring program. This includes confirmed observations of 29 species and 1,193 individual butterflies, while nine species or categories of unknowns that could not be identified to the species level have been excluded from the final species numbers. See Table 6 for a complete list of butterflies observed; note that those followed by an asterisk (*) have not been included in the final number of species or any subsequent analysis. See Table 7 for the final list of butterflies confirmed at Lakeside Park.

A two-tailed t-test found there was no significant difference (p-value 0.94) between the observations collected by volunteers and the expert. Therefore, the expert observations have been included in the analysis for Lakeside Park in order to present a valid season of baseline data.

Table 6. Lakeside Park Complete List of Butterflies Observed in 2012. Note: this table includes observations that did not pass the review process and have been excluded in the Final List of Butterflies. Those that are excluded have been marked with an *.

Scientific Name	Common Name	SRANK[1]	Waterloo Regional Status[2]	Total # of Individuals Observed
	Unknown*	-	-	58
Hesperiidae				

Scientific Name	Common Name	SRANK[1]	Waterloo Regional Status[2]	Total # of Individuals Observed
*Amblyscirtes vialis**	Common Roadside Skipper	S4	Not included	1
Ancyloxypha numitor	Least Skipper	S5	Uncommon	17
*Erynnis juvenalis**	Juvenal's Duskywing	S5	Rare	1
*Erynnis sp.**	Duskywing sp.	-		1
Euphyes vestris	Dun Skipper	S5	Very Common	1
Hylephila phyleus	Fiery Skipper	SNA	Rare	8
*Pholisora Catullus**	Common Sootywing	S3	Rare	1
Poanes hobomok	Hobomok Skipper	S5	Common	1
Polites peckius	Peck's Skipper	S5	Very Common	7
*Thorybes pylades**	Northern Cloudywing	S5	Rare	6
Thymelicus lineola	European Skipper	SNA	Very Common	4
Wallengrenia egeremet	Northern Broken-dash	S5	Common	2
	Skipper spp.*	-	-	19
Papilionidae				
Papilio cresphontes	Giant Swallowtail	S3	Uncommon	1
Papilio glaucus	Eastern Tiger Swallowtail	S5	Very Common	8
Papilio polyxenes	Black Swallowtail	S5	Very Common	2
Pieridae				
Colias eurytheme	Orange Sulphur	S5	Very Common	20
Colias philodice	Clouded Sulphur	S5	Very Common	128
Pieris rapae	Cabbage White	SNA	Very Common	848
Lycaenidae				
Celastrina neglecta	Summer Azure	S5	Very Common	6
Cupido comyntas	Eastern Tailed Blue	S5	Uncommon	1
*Feniseca tarquinius**	Harvester	S4	Rare	1
Lycaena hyllus	Bronze Copper	S5	Very Common	2
*Satyrium calanus**	Banded Hairstreak	S4	Uncommon	1
Nymphalidae				
Coenonympha tullia	Common Ringlet	S5	Common	11
Danaus plexippus	Monarch	S2N, S4B	Very Common	19
Limenitis archippus	Viceroy	S5	Very Common	3
Limenitis arthemis astyanax	Red-spotted Purple	S5	Common	1
Megisto cymela	Little Wood-satyr	S5	Very Common	11
Nymphalis antiopa	Mourning Cloak	S5	Very Common	5
Phyciodes cocyta	Northern Crescent	S5	Uncommon	1
Phyciodes tharos	Pearl Crescent	S4	Common	5
Polygonia comma	Eastern Comma	S5	Very Common	1
Polygonia interrogationis	Question Mark	S5	Very Common	14
Speyeria cybele	Great Spangled Fritillary	S5	Very Common	3
Vanessa atalanta	Red Admiral	S5	Very Common	57

Scientific Name	Common Name	SRANK[1]	Waterloo Regional Status[2]	Total # of Individuals Observed
Vanessa cardui	Painted Lady	S5	Common	6
TOTAL	-	-	-	**1282**

[1] OMNR, 2012
S5 Very Common
S4 Common
S4B Common (Breeding Habitat)
S3 Vulnerable
S2N Imperiled (Non-breeding Habitat)
SNA Not Applicable
[2]Linton, 2012

Table 7. Lakeside Park Final List of Butterflies Observed in 2012. Note: this table only includes observations that passed the review process.

Scientific Name	Common Name	SRANK[1]	Waterloo Regional Status[2]	Total # of Individuals Observed
Hesperiidae				
Ancyloxypha numitor	Least Skipper	S5	Uncommon	17
Euphyes vestris	Dun Skipper	S5	Very Common	1
Hylephila phyleus	Fiery Skipper	SNA	Rare	8
Poanes hobomok	Hobomok Skipper	S5	Common	1
Polites peckius	Peck's Skipper	S5	Very Common	7
Thymelicus lineola	European Skipper	SNA	Very Common	4
Wallengrenia egeremet	Northern Broken-dash	S5	Common	2
Papilionidae				
Papilio cresphontes	Giant Swallowtail	S3	Uncommon	1
Papilio glaucus	Eastern Tiger Swallowtail	S5	Very Common	8
Papilio polyxenes	Black Swallowtail	S5	Very Common	2
Pieridae				
Colias eurytheme	Orange Sulphur	S5	Very Common	20
Colias philodice	Clouded Sulphur	S5	Very Common	128
Pieris rapae	Cabbage White	SNA	Very Common	848
Lycaenidae				
Celastrina neglecta	Summer Azure	S5	Very Common	6
Cupido comyntas	Eastern Tailed Blue	S5	Uncommon	1
Lycaena hyllus	Bronze Copper	S5	Very Common	2
Nymphalidae				
Coenonympha tullia	Common Ringlet	S5	Common	11
Danaus plexippus	Monarch	S2N, S4B	Very Common	19
Limenitis archippus	Viceroy	S5	Very Common	3
Limenitis arthemis astyanax	Red-spotted Purple	S5	Common	1
Megisto cymela	Little Wood-satyr	S5	Very Common	11

Scientific Name	Common Name	SRANK[1]	Waterloo Regional Status[2]	Total # of Individuals Observed
Nymphalis antiopa	Mourning Cloak	S5	Very Common	5
Phyciodes cocyta	Northern Crescent	S5	Uncommon	1
Phyciodes tharos	Pearl Crescent	S4	Common	5
Polygonia comma	Eastern Comma	S5	Very Common	1
Polygonia interrogationis	Question Mark	S5	Very Common	14
Speyeria cybele	Great Spangled Fritillary	S5	Very Common	3
Vanessa atalanta	Red Admiral	S5	Very Common	57
Vanessa cardui	Painted Lady	S5	Common	6
TOTAL	-	-	-	**1193**

[1] OMNR, 2012
S5 Very Common
S4 Common
S4B Common (Breeding Habitat)
S3 Vulnerable
S2N Imperiled (Non-breeding Habitat)
SNA Not Applicable
[2]Linton, 2012

The data analysis results for Lakeside Park can be found below in Table 8. The species richness for Lakeside Park was 29, while the Shannon-Wiener Diversity Index (*H*) was 1.28, with an evenness value (*E*) of 0.38 and a variance of 0.0022. The Simpson Diversity Index (*D*) was 0.52, while the Simpson Reciprocal Index (*1/D*) was 1.92. These numbers were generated based on the data found in Table 7, which only includes observations that passed the review process.

Table 8. Lakeside Park Data Results

Shannon-Wiener	Value	Simpson Diversity	Value
H	1.28	D	0.52
E	0.38	1/D	1.92
Variance	.0022		

3.3.2 Huron Natural Area

In total, there were 29 species and 657 individual butterflies observed at the Huron Natural Area by the volunteers during the monitoring program in the 2012 season. The total number of confirmed species of butterflies was 26, which was comprised of 620 individuals. The confirmed butterfly list excludes three species that could not be confirmed and does not include three categories of butterflies that could not be identified to the species level. See Table 9 for a complete list of butterflies observed at this natural area; note that those with an asterisk (*) have been excluded from the final list of species and have not been incorporated in any succeeding data analysis. Table 10 contains all volunteer butterfly observations that passed the review process.

A two-tailed t-test found there was a significant difference (p-value 0.02) between the confirmed observations collected by volunteers and the expert. Therefore, the expert observations have not been included in Table 9, Table 11 or in the data analysis for Huron Natural Area. A comparison of volunteer and expert observations can be found below in Section 3.3.2.1.

Table 9. Huron Natural Area Complete List of Butterflies Observed in 2012. Note: this table includes observations that did not pass the review process and have been excluded in the Final List of Butterflies. Those that are excluded have been marked with an *.

Scientific Name	Butterfly Species Common Name	SRANK[1]	Waterloo Regional Status[2]	Total Individuals Observed
	Unknown*	-	-	17
Hesperiidae				
*Euphyes dion**	Dion Skipper	S3	Rare	1
*Pholisora catullus**	Common Sooty wing	S3	Rare	1
Poanes hobomok	Hobomok Skipper	S5	Common	2
Thymelicus lineola	European Skipper	SNA	Very Common	3
-	Skipper spp.*	-	-	3
Papilionidae				
Papilio glaucus	Eastern Tiger Swallowtail	S5	Very Common	9
Papilio polyxenes	Black Swallowtail	S5	Very Common	4
Pieridae				
Colias eurytheme	Orange Sulphur	S5	Very Common	37
Colias philodice	Clouded Sulphur	S5	Very Common	109
Pieris rapae	Cabbage White	SNA	Very Common	189
Lycaenidae				
Celastrina ladon	Spring Azure	S5	Common	3
Celastrina neglecta	Summer Azure	S5	Very Common	3
Cupido comyntas	Eastern Tailed Blue	S5	Uncommon	4
*Strymon melinus**	Gray Hairstreak	S4	N/A	9
Nymphalidae				
Cercyonis pegala	Common Wood-nymph	S5	Very Common	24
Coenonympha tullia	Common Ringlet	S5	Common	80
Danaus plexippus	Monarch	S2N, S4B	Very Common	25
Enodia anthedon	Northern Pearly-eye	S5	Common	1

Scientific Name	Butterfly Species Common Name	SRANK[1]	Waterloo Regional Status[2]	Total Individuals Observed
Junonia coenia	Common Buckeye	SNA	Uncommon	3
Limenitis archippus	Viceroy	S5	Very Common	6
Limenitis arthemis arthemis	White Admiral	S5	Uncommon	1
Nymphalis antiopa	Mourning Cloak	S5	Very Common	4
*Phyciodes spp.**	Crescent spp.			6
Phyciodes cocyta	Northern Crescent	S5	Uncommon	12
Phyciodes tharos	Pearl Crescent	S4	Common	2
Polygonia comma	Eastern Comma	S5	Very Common	1
Polygonia interrogationis	Question Mark	S5	Very Common	17
Speyeria cybele	Great Spangled Fritillary	S5	Very Common	1
Vanessa atalanta	Red Admiral	S5	Very Common	59
Vanessa cardui	Painted Lady	S5	Common	16
Vanessa virginiensis	American Lady	S5	Common	5
TOTAL	-	-	**-**	**657**

[1] OMNR, 2012
S5 Very Common
S4 Common
S4B Common (Breeding Habitat)
S3 Vulnerable
S2N Imperiled (Non-breeding Habitat)
SNA Not Applicable
[2]Linton, 2012

Table 10. Huron Natural Area Final List of Butterflies Observed in 2012. Note: this table only includes observations that passed the review process.

Scientific Name	Butterfly Species Common Name	SRANK[1]	Waterloo Regional Status[2]	Total Individuals Observed
Hesperiidae				
Poanes hobomok	Hobomok Skipper	S5	Common	2
Thymelicus lineola	European Skipper	SNA	Very Common	3
Papilionidae				
Papilio glaucus	Eastern Tiger Swallowtail	S5	Very Common	9
Papilio polyxenes	Black Swallowtail	S5	Very Common	4
Pieridae				
Colias eurytheme	Orange Sulphur	S5	Very Common	37
Colias philodice	Clouded Sulphur	S5	Very Common	109
Pieris rapae	Cabbage White	SNA	Very Common	189
Lycaenidae				
Celastrina ladon	Spring Azure	S5	Common	3
Celastrina neglecta	Summer Azure	S5	Very Common	3
Cupido comyntas	Eastern Tailed Blue	S5	Uncommon	4
Nymphalidae				

Scientific Name	Butterfly Species Common Name	SRANK[1]	Waterloo Regional Status[2]	Total Individuals Observed
Cercyonis pegala	Common Wood-nymph	S5	Very Common	24
Coenonympha tullia	Common Ringlet	S5	Common	80
Danaus plexippus	Monarch	S2N, S4B	Very Common	25
Enodia anthedon	Northern Pearly-eye	S5	Common	1
Junonia coenia	Common Buckeye	SNA	Uncommon	3
Limenitis archippus	Viceroy	S5	Very Common	6
Limenitis arthemis arthemis	White Admiral	S5	Uncommon	1
Nymphalis antiopa	Mourning Cloak	S5	Very Common	4
Phyciodes cocyta	Northern Crescent	S5	Uncommon	12
Phyciodes tharos	Pearl Crescent	S4	Common	2
Polygonia comma	Eastern Comma	S5	Very Common	1
Polygonia interrogationis	Question Mark	S5	Very Common	17
Speyeria cybele	Great Spangled Fritillary	S5	Very Common	1
Vanessa atalanta	Red Admiral	S5	Very Common	59
Vanessa cardui	Painted Lady	S5	Common	16
Vanessa virginiensis	American Lady	S5	Common	5
TOTAL	**-**	-	-	**620**

[1] OMNR, 2012
S5 Very Common
S4 Common
S4B Common (Breeding Habitat)
S2N Imperiled (Non-breeding Habitat)
SNA Not Applicable
[2] Linton, 2012

The results of the data analysis for the Huron Natural Area can be found in Table 11. The species richness was 26, while the Shannon-Wiener Diversity Index was 2.27, with an evenness value of 0.70 and a variance of 0.0021. The Simpson Diversity Index was 0.16, while the Simpson Reciprocal Index was 6.36. These numbers were generated based on the results in Table 10, which only includes observations that passed the review process.

Table 11. Huron Natural Area Data Results

Shannon-Wiener	Value	Simpson Diversity	Value
H	2.27	D	.16
E	.70	1/D	6.36
Variance	.0021		

3.3.2.1 Comparison to Expert Observations

There was a significant difference (p-value <0.5) between the confirmed volunteer observations and the expert observations. Table 12 presents the differences between the data sets. Overall, there were 26 species observed by volunteers, while the expert observed 22 species during the monitoring period. Species that were observed by the volunteers but not by the expert include: Hobomok Skipper (*Poanes hobomok*), Viceroy (*Limenitis archippus*), White Admiral (*Limenitis arthemis*), Northern Crescent (*Phyciodes cocyta*), Eastern Comma (*Polygonia comma*), and Painted Lady (*Vanessa cardui*). Species that were observed by the expert and not by the volunteers include: Wild Indigo Duskywing (*Erynnis baptisiae*), and Juvenal's Duskywing (*Erynnis juvenalis*).

Table 12. Comparison Between Expert Observations and the Final List of Volunteer Observations at the Huron Natural Area. Note: this table only includes confirmed observations that passed the review process.

Scientific Name	Butterfly Species Common Name	SRANK	Waterloo Regional Status	Volunteer Total Individuals Observed	Expert Total Individuals Observed
Hesperiidae					
Erynnis baptisiae	Wild Indigo Duskywing	S4	Unknown	0	13
Erynnis juvenalis	Juvenal's Duskywing	S5	Rare	0	4
Poanes hobomok	Hobomok Skipper	S5	Common	2	0
Thymelicus lineola	European Skipper	SNA	Very Common	3	20
Papilionidae					
Papilio glaucus	Eastern Tiger Swallowtail	S5	Very Common	9	7
Papilio polyxenes	Black Swallowtail	S5	Very Common	4	2
Pieridae					
Colias eurytheme	Orange Sulphur	S5	Very Common	37	10
Colias philodice	Clouded Sulphur	S5	Very Common	109	34
Pieris rapae	Cabbage White	SNA	Very Common	189	78
Lycaenidae					
Celastrina ladon	Spring Azure	S5	Common	3	1
Celastrina neglecta	Summer Azure	S5	Very Common	3	2
Cupido comyntas	Eastern Tailed Blue	S5	Uncommon	4	1
Nymphalidae					
Cercyonis pegala	Common Wood-nymph	S5	Very Common	24	24
Coenonympha tullia	Common Ringlet	S5	Common	80	21
Danaus plexippus	Monarch	S2N, S4B	Very Common	25	7

Scientific Name	Butterfly Species Common Name	SRANK	Waterloo Regional Status	Volunteer Total Individuals Observed	Expert Total Individuals Observed
Enodia anthedon	Northern Pearly-eye	S5	Common	1	1
Junonia coenia	Common Buckeye	SNA	Uncommon	3	1
Limenitis archippus	Viceroy	S5	Very Common	6	0
Limenitis arthemis arthemis	White Admiral	S5	Uncommon	1	0
Nymphalis antiopa	Mourning Cloak	S5	Very Common	4	1
Phyciodes cocyta	Northern Crescent	S5	Uncommon	12	0
Phyciodes tharos	Pearl Crescent	S4	Common	2	12
Polygonia comma	Eastern Comma	S5	Very Common	1	0
Polygonia interrogationis	Question Mark	S5	Very Common	17	6
Speyeria cybele	Great Spangled Fritillary	S5	Very Common	1	4
Vanessa atalanta	Red Admiral	S5	Very Common	59	33
Vanessa cardui	Painted Lady	S5	Common	16	0
Vanessa virginiensis	American Lady	S5	Common	5	5
TOTAL	-	-	-	**620**	**287**

[1] OMNR, 2012
S5 Very Common
S4 Common
S4B Common (Breeding Habitat)
S2N Imperiled (Non-breeding Habitat)
SNA Not Applicable
[2]Linton, 2012

3.3.2.2 Comparison to NRSI Data

During the 2010 butterfly surveys conducted by NRSI, there were 18 species of butterflies observed, while 22 species were observed during the 2011 surveys, and 21 species during the 2012 surveys. Overall, a total of 31 species were identified during the NRSI surveys and the annual butterfly counts. In comparison, 26 species of butterflies were identified by the community-based monitoring participants in one year of data collection. One important note regarding the annual butterfly count data is that it includes butterfly observations from areas other than the meadow habitat, while the CBM data only includes data from the meadow trail.

Table 13 summarizes the observations from each year of data collection and compares the results to those collected by the community-based monitoring program, which does not include expert observations.

Table 13. Summary of Butterflies Observed by NRSI at the Huron Natural Area in 2010-2012, Compared to Observations made by Volunteers in 2012 Note: this table only includes volunteer data that passed the review process.

Scientific Name	Common Name	SRANK[1]	Waterloo Regional Status[2]	Total Individuals Observed By NRSI in 2010	Total Individuals Observed by NRSI in 2011	Total Individuals Observed by NRSI in 2012	Total Individuals Observed by CBM Program in 2012
Hesperiidae							
Anatrytone logan	Delaware Skipper	S4	Common	0	2	2	0
Cartercephalus palaemon	Arctic Skipper	S5	Rare	3	0	0	0
Epargyreus clarus	Silver-spotted Skipper	S4	Unknown	0	0	1	0
Erynnis Baptisiae	Wild Indigo Duskywing	S4	Unknown	7	0	8	0
Poanes hobomok	Hobomok Skipper	S5	Common	0	0	0	2
Thymelicus lineola	European Skipper	SNA	Very Common	0	25	4	3
Papilionidae							
Papilio cresphontes	Giant Swallowtail	S3	Uncommon	0	1	0	0
Papilio glaucus	Eastern Tiger Swallowtail	S5	Very Common	0	4	8	9
Papilio polyxenes	Black Swallowtail	S5	Unknown	0	0	1	4
Pieridae							
Colias eurytheme	Orange Sulphur	S5	Very Common	4	0	7	37
Colias philodice	Common (Clouded) Sulphur	S5	Very Common	17	2	23	109
Pieris rapae	Cabbage White	SNA	Very Common	10	10	37	189
Lycaenidae							
Callophrys niphon	Eastern Pine Elfin	S5	Rare	1	0	0	0
Celastrina ladon	Spring Azure	S5	Common	0	6	0	3

Scientific Name	Common Name	SRANK[1]	Waterloo Regional Status[2]	Total Individuals Observed By NRSI in 2010	Total Individuals Observed by NRSI in 2011	Total Individuals Observed by NRSI in 2012	Total Individuals Observed by CBM Program in 2012
Celastrina neglecta	Summer Azure	S5	Very Common	1	4	2	3
Everes comyntas	Eastern Tailed Blue	S5	Uncommon	0	1	0	4
Nymphalidae							
Cercyonis pegala	Common Wood Nymph	S5	Very common	3	12	20	24
Coenonympha tullia	Common Ringlet	S5	Common	45	2	11	80
Coenonympha tullia inornata	Inornate Ringlet	SNA	Unknown	0	23	0	0
Danaus plexippus	Monarch	S2N, S4B	Very Common	1	3	6	25
Enodia anthedon	Northern Pearly-Eye	S5	Common	0	3	1	1
Junonia coenia	Common Buckeye	SNA	Uncommon	0	0	0	3
Limenitis archippus	Viceroy	S5	Very Common	3	0	0	6
Limentis arthemis arthemis	White Admiral	S5	Uncommon	0	0	0	1
Limentis arthemis astyanax	Red-Spotted Purple	S5	Common	2	1	1	0
Megisto cymela	Little Wood-Satyr	S5	Very Common	1	4	1	0
Nymphalis antiopa	Mourning Cloak	S5	Very Common	0	1	1	4
Phyciodes pascoensis	Northern Crescent	S5	Uncommon	0	3	0	12
Phyciodes tharos	Pearl Crescent	S4	Common	1	5	10	2
Polygonia comma	Eastern Comma	S5	Very Common	0	4	0	1
Polygonia interrogationis	Question Mark	S5	Very common	1	1	4	17
Speyeria cybele	Great Spangled Fritillary	S5	Very Common	3	0	4	1
Vanessa atalanta	Red Admiral	S5	Very Common	8	0	5	59

Scientific Name	Common Name	SRANK[1]	Waterloo Regional Status[2]	Total Individuals Observed By NRSI in 2010	Total Individuals Observed by NRSI in 2011	Total Individuals Observed by NRSI in 2012	Total Individuals Observed by CBM Program in 2012
Vanessa cardui	Painted Lady	S5	Common	0	0	0	16
Vanessa virginiensis	American Painted Lady	S5	Common	1	3	0	5
TOTAL	---	---	---	**112**	**120**	**157**	**620**

[1] OMNR, 2012
S5 Very Common
S4 Common
S4B Common (Breeding Habitat)
S2N Imperiled (Non-breeding Habitat)
SNA Not Applicable
[2]Linton, 2012

The results of the Shannon-Wiener Diversity Index, Simpson Index and two-tailed t-test can be found in Table 14. The Shannon-Wiener Diversity Index for the 2010-2012 data collected by NRSI and the data from the annual butterfly counts was 2.85, with an evenness value of 0.8284 and a variance of .0023, while the data set collected by the CBM program had an *H* value of 2.41, an evenness of .6977, and a variance of .0015. The Simpson Index for the NRSI data was .08, with a Reciprocal Index of 12.66, while the CBM data had a *D* value of .16 and a *1/D* value of 6.36.

Table 14. Shannon Index, Simpson Index and Two-tailed T-test Comparing Huron Natural Area Data from 2010-2012 and CBM Data in 2012

	2010-2012 NRSI Data	CBM 2012 Data
Shannon Index (*H*)	2.85	2.41
Evenness (*E*)	0.8284	0.6977
Variance	0.0023	0.0015
Simpson Index (*D*)	.08	.16
Reciprocal Index (1/*D*)	12.66	6.36
N	389	907
t-value	8.6214	
Df	941.1306	
p value	0.0000	

Chapter 4
Discussion

The main objective of this short-term research was to analyze the usefulness of volunteer observations in establishing baseline conditions at the study sites. As of 2013, the City of Kitchener has been managing the program and will be collecting long-term data of the butterfly assemblages at these natural areas. The City of Kitchener's long-term goal of the broader program is to compare changes over time and provide insight into the diversity of the ecosystems at each natural area.

4.1 Volunteer Data was Effective

Studies show that citizen scientists are a fundamental solution to restricted funding and limited staffing (Delaney et al., 2008). This study demonstrated that with proper training, citizen scientists were able to identify most butterfly species, and assist the City of Kitchener by providing additional data on the butterfly populations in two natural areas.

The long-term use of CBM programs demonstrates the effectiveness of this method of data collection. Citizen science programs have been established as evidenced by the Christmas Bird Count, which began in 1900, and currently more than 200 research projects involve using volunteer citizens to collect scientific data (Cohn, 2008). Studies show that citizen scientists can learn to operate equipment and collect data that is accurate, usable, and as reliable as professional researchers (Cohn, 2008). An important aspect of ensuring that citizen scientists collect usable data is to design research projects and study protocols for volunteers (Cohn, 2008; Foster-Smith & Evans, 2003). Program designers should ensure volunteers are recording the proper amount of detail. Data that is too vague will not be useful for the research project, while on the other hand, requiring volunteers to collect data that is too complex or detailed may cause issues with accuracy and reliability of the data (Cohn, 2008).

Other citizen science studies have also demonstrated the difficulty in assigning complex tasks to volunteers (Foster-Smith & Evans, 2003). In this case, volunteers had difficulty identifying butterflies in the *Hesperiidae* family, which is an indication of a task too complex for citizen scientists. Increased training on this family of butterflies, as well as any rare species that may occur within the study areas, should be given in future years. Increased training is likely to provide enough information to overcome problems of this nature (Foster-Smith & Evans, 2003). In terms of rare species identification, volunteers identified several butterfly species that are listed as unknown, uncommon or rare in *The Butterflies of Waterloo Region* (Linton, 2012). With little or no supporting evidence for their identification, these species were not included in the analysis. It should be noted that although there was a lack of substantiating evidence, this does not mean that the species were not present in the study sites (Lepcyzk, 2005). Species that were not included in the final analysis will still be retained on the comprehensive list of butterflies that may occur within the area, and further studies should be completed by an expert before these species are definitively ruled out of occurring at the study sites.

Another way to avoid assigning overly complex tasks is to ensure the program is designed for people with little to no scientific background and to provide adequate training. Cohn (2008) pointed out that volunteers may have a background in science, as those who volunteer often care about the environment and have some level of awareness of the process. This can help increase the reliability of data, but it should not be assumed that volunteers have a background or previous understanding of scientific protocols.

The literature demonstrates that citizen science data can be validated and useful. With proper training, studies show that volunteers can collect data with a high level of accuracy (Delaney et al., 2008; Darwall & Dulvy, 1996; Fore et al., 2001; Boudreau & Yan, 2004). The ability to collect accurate data makes citizen scientists an important supply of information for early detection (Delaney et al., 2008; Lodge et al. 2006). Overall, the average accuracy of volunteers at the two natural areas in this study was 93.75%. This is very high in comparison to other citizen science studies that have found participants to have accuracy ratings of 80-95% (Delaney et al., 2008).

In particular, examples of volunteers successfully conducting butterfly surveys include several European projects that monitor butterfly assemblages, such as the United Kingdom Butterfly Monitoring Scheme and the France Butterfly Garden Observatory (Matteson et al., 2012; Pollard & Yates, 1993; van Swaay et al., 2008). As well, there are several programs in North America that record the migration and population trends of the Monarch (*Danaus plexippus*) using citizen scientists, including Journey North, Monarch Larva Monitoring Project and Monarch Watch (Matteson et al., 2012; Oberhauser & Prysby, 2008; Howard & Davis, 2009).

Another example of a North American butterfly monitoring project is the newly launched eButterfly program, which is an online tool for citizens to record butterflies they observe in Canada or the United States. Social media tools are beneficial to citizen science programs as demonstrated by eButterfly, which can help scientists to understand how climate and environmental change impact the distribution of butterflies (Ogden, 2013; ebutterfly, 2013). The review process for the eButterfly program is similar to the one employed for this CBM project. Observations that are submitted in southern Ontario are reviewed by a local expert who examines each individual record. The review process includes analyzing the latitude and longitude of the location of each observation, the date recorded and any photos of the specimen, if provided (M. Larrivée, personal communication, April 30, 2013). Any observations that do not pass the review process are not included in the eButterfly data set, as with this particular citizen science program.

In order to evaluate the effectiveness of data, there are several factors to consider. According to Newman et al. (2003), there are two primary questions to focus on when evaluating volunteer data: are the survey methods that will be employed by or taught to volunteers reliable (method calibration); and given that the methods are acceptably reliable, how do amateurs compare with experts (data validation)? In the first place, the transect methods employed for this program have been established by a butterfly expert and used to assess butterfly populations since the early 1970s (Pollard et al., 1975). This method has been validated over time and is a standard butterfly survey protocol

(Pollard, 1977; Thomas, 1983; Pollard & Yates, 1993; Caldas & Robbins, 2003). Secondly, the review process for this program compared volunteer observations with expert observations to validate the data. This process included a direct comparison of observations, as well as comparison to expert documentation, such as *The Butterflies of Waterloo Region* (Linton, 2012) and *The Ontario Butterfly Atlas (*Jones et al., 2012).

An analysis of the validity and effectiveness of the data collected at each site is found below.

4.1.1 Validity of Data Collected at Lakeside Park

The first indication of the validity of data collected at Lakeside Park is the number of observations that passed the review process. The number of unconfirmed individual butterflies at Lakeside Park was 1,282, while the confirmed number of individual butterflies was 1,193, which results in 93.1% of butterflies passing the review process and being identified correctly to the species level. The percentage of correctly identified individuals generally indicates the usefulness of the collected data. In this case, 93% of the observations were confirmed. This high level of accuracy indicates the volunteers were able to correctly identify the butterfly assemblages at Lakeside Park.

The Lakeside Park data is a useful year of baseline data for comparing future years of data collection because of the high level of accuracy of observations. Of the nine species that did not pass the review process, six were from the *Hesperiidae* family, two from the *Lycaenidae* family, and one general category of unknown individuals. Of the 69 observations of *Hesperiidae* family that were reviewed, including one submission of a Duskywing sp. and 19 Skipper spp., 40 passed the review process. These results confirm the *Hesperiidae* family is especially difficult to correctly identify. This family of butterflies is often overlooked due to their drab appearance (Linton, 2012), and can be incredibly difficult to identify to the species level because of their small size and the similarity between species.

Although identifying individuals in the *Hesperiidae* family was a difficult task for volunteers, overall, the identification of other species was successful and consistent with expert observations. The Shannon-Wiener Diversity Index value was 1.28 for this site, which is fairly low and is likely a direct result of the majority of the study area consisting of grassland park habitat. The low level of diversity at the site likely led to easier identification of species for volunteers, as the majority of observations consisted of a few common and easily identifiable butterflies, including the Cabbage White (*Pieris rapae)* and Clouded Sulphur (*Colias philodice*), which together accounted for over 80% of the individuals observed at the site. The ease of identification resulted in fairly consistent observations by volunteers and the expert. A two-tailed t-test found there was no significant difference (p-value 0.94) between the confirmed list of observations collected by volunteers and the expert observations. The lack of significant difference between the volunteer data set and the expert data set indicates both parties were collecting similar data and that volunteers are as useful as one expert in collecting butterfly assemblage data in a simple butterfly habitat.

The lack of significant difference between observations collected by citizen scientists and the expert, as well as an accuracy level of 93.1% indicate the data collected by the volunteers is valid. This data set indicates the effectiveness of using volunteers to determine butterfly assemblages and characterize a site representing simple butterfly habitats.

4.1.2 Validity of Data Collected at Huron Natural Area

An indication of the validity of data collected at the Huron Natural Area is the high number of observations that passed the review process. The number of unconfirmed individual butterflies at the Huron Natural Area was 657, while the confirmed number of individual butterflies was 620, which results in 94.4% of butterflies passing the review process and being correctly identified to the species level. This high level of accuracy indicates the volunteers were able to correctly identify the butterfly assemblages at the Huron Natural Area. Of the six species or categories of unknown individuals that did not pass the review process, three were from the *Hesperiidae* family, one from the

Lycaenidae family, one from the *Nymphalidae* family, and one general category of unknown individuals. As well, the volunteers only correctly identified five individual skippers, of a possible 20 individuals submitted for review, including four individuals recorded as Skipper spp., while the expert identified 37 individuals of three species in the *Hesperiidae* family. These results confirm the *Hesperiidae* family is especially difficult to correctly identify by volunteer monitors.

The significant difference between volunteer and expert observations is an indication of the benefit of using multiple volunteers to monitor complex habitats. Overall, the volunteers correctly identified 26 species and 620 individual butterflies, while the expert identified 22 species and 287 individuals. The significant different between the expert observations and the volunteer data is likely due to the increased number of species and individuals observed by the volunteers. This result demonstrates that volunteers can be more useful at identifying butterfly assemblages in complex habitats, over one expert.

Diverse habitats can provide further rationalization for the use of volunteers over one expert, as considerably more site visits were conducted by the volunteers and more species were identified by this group than the expert. The volunteers observed six species the expert did not record and in turn, the expert identified two species that were not observed by the volunteers. This indicates the usefulness of having multiple volunteers recording butterflies on different days, as the volunteers were able to observe more species than one expert. This also demonstrates the diversity of habitats found at Huron Natural Area and the variation experienced on a daily, weekly and monthly basis at the site.

In summary, an accuracy level of 94.4% indicates the data collected by the volunteers is valid. The volunteer observations were found to be statistically different than the data collected by the expert, which indicates that the volunteers were more effective in identifying butterfly assemblages at this site. Overall, effective data was collected by volunteers at the Huron Natural Area based on the accuracy level of observations and the number of species that were observed by volunteers that the expert did not observe. This data set demonstrates the usefulness of volunteers in characterizing complex butterfly habitats and identifying butterfly assemblage at Huron Natural Area.

4.2 Establishment of Baseline Conditions

The butterfly assemblage data collected by the expert and volunteers has established baseline data for these two natural areas. Once a long-term data set has been collected, the City of Kitchener can analyze changes in butterfly assemblages over time and analyze changes in diversity and evenness of the populations, while providing insight into changes occurring in the ecosystems.

4.2.1 Poor Diversity at Lakeside Park

Analyzing the diversity of butterfly species over time can provide insight into the ecosystems at Lakeside Park. The species richness at Lakeside Park was 29, while the Shannon-Wiener Diversity Index for Lakeside Park was 1.28, which is a fairly low level of diversity. The Simpson Diversity Index was 0.48, which indicates there is a 48% chance that two randomly selected individuals in the sample will belong to the same species. This level of probability indicates there is a low to moderate level of diversity in the Lakeside Park butterfly community. The Simpson Reciprocal Index was 1.92, with a potential maximum of 29. This index also indicates there is a low level of diversity within the butterfly community.

The Shannon-Wiener Diversity Index and Simpson Index values indicate that Lakeside Park has a low level of diversity of butterfly species and does not contain an even distribution of species, as the Shannon Evenness value was 0.38. This site was largely dominated by a few species of butterflies, including the Cabbage White, which accounted for 71% of the population and the Clouded Sulphur, which made up 10% of the population at Lakeside Park. All other individual species at the site accounted for 4% or less of the population, indicating a very uneven distribution of species.

The vegetation communities at Lakeside Park do not contain diverse habitats to support butterfly species, as the study area contains mainly mowed parkland, which consists of urban grass species (see Figure 1). The diversity of plant species is positively correlated with species richness and diversity of butterflies (Hogsden & Hutchinson, 2004) and the plant community at Lakeside Park does not contain a high diversity of plant species to support butterfly populations. Butterflies are excellent indicators of the effects of urbanization, as the diversity of butterfly species decreases in sites that have been developed (Blair, 1999; Blair & Launer, 1997; Yamamoto, 1977; Dennis & Hardy, 2001; Ruszczyk & De Araujo, 1992; Ruszczyk, 1986). The natural area is surrounded by an urban area with very little connective habitat to support butterfly populations, which limits the amount of dispersal between local populations (Schippers et al., 1996). Furthermore, lack of connection to other habitats limits the ability of populations from adjacent ecosystems to intersperse with this population should disappearance of local functional groups occur at the site (Naeem, 1998). The low diversity and uneven butterfly community at Lakeside Park indicate a lack of species redundancy (De Leo & Levin, 1997; Naeem, 1998).

The simple habitat at Lakeside Park has resulted in a low level of diversity of butterfly species. The City of Kitchener can use this baseline data to compare future data sets and provide insight into the ecosystems at this site.

4.2.2 Rich Diversity at Huron Natural Area

An analysis of the diversity of butterfly species present over time at Huron Natural Area can provide basic knowledge of ecosystems at the site. The species richness at Huron Natural Area was 26, while the Shannon-Wiener Diversity Index for Huron Natural Area was 2.27, which is a fairly high level of diversity and substantially higher than that observed in Lakeside Park. The Simpson Diversity Index was 0.16, which indicates there is a 16% chance that two randomly chosen individuals in the sample will belong to the same species. This value demonstrates the high level of diversity of the Huron Natural Area butterfly community. In comparison, the Lakeside Park value was 0.48, which indicates that Huron Natural Area has a much higher level of diversity, although the species richness observed by volunteers at Huron Natural Area was lower than at Lakeside Park. The Simpson Reciprocal Index was 6.36, of a potential maximum of 26, which also indicates a moderate to high level of diversity. The vegetation community that was analyzed for this monitoring program consists of entirely meadow habitat and contains a high level of diverse habitats to host a diverse population of butterflies in a complex habitat.

The Shannon-Wiener Diversity Index and Simpson Index values demonstrate the moderate to high level of diversity at the Huron Natural Area site, as a higher Shannon-Wiener Diversity Index and Simpson Reciprocal value indicate the community has a diverse number of species and an even distribution of species (Gomez-Alvarez et al., 2007). The population at this site has a more even distribution than Lakeside Park, with a Shannon Evenness value of 0.70. The site is dominated by Cabbage White, with 30% of the butterfly population consisting of Cabbage White, 17% consisting of Clouded Sulphurs, 12% consisting of Common Ringlets (*Coenonympha tullia*), 10% consisting of Red Admirals (*Vanessa atalanta*), and 6% consisting of Orange Sulphurs (*Colias eurytheme*), while the other 22 individual species made up 4% or less of the population. These distributions indicate there is a more even butterfly population at Huron Natural Area than at Lakeside Park.

As well as containing diverse butterfly habitats, Huron Natural Area also contains connective habitat to other natural areas. It is a large naturalized park that consists of 107 ha of land, which is adjacent to other naturalized areas and provides connective habitat for increased dispersal of butterflies. This park is located on the outskirts of the City of Kitchener, and the butterfly population contains a higher level of diversity compared to Lakeside Park, which contains less naturalized habitat and is almost entirely surrounded by developed urban areas. At Huron Natural Area, the high level of diversity and fairly even species distribution indicate there is likely a higher level of species redundancy in this population than at Lakeside Park, as a higher level of diversity demonstrates greater ecosystem stability (McArthur, 1955; Elton, 1958; Odum, 1959; Margalef, 1969; Tilman et al., 2006; May, 1973; Lehman & Tilman, 2000; Tilman, 1999).

The complex habitats at Huron Natural Area host a diverse and even population of butterfly species. This year of data will be part of a long-term data set compiled by the City of Kitchener to analyze changes over time to provide insight into the ecosystems at Huron Natural Area.

4.2.2.1 Similarity of Professional Firm and Volunteer Results

It has been noted that the NRSI data includes data from two annual butterfly counts that occurred in 2011 and 2012 and includes observations collected outside of the meadow habitat where CBM data was collected. A comparison of data collected by NRSI and the citizen scientists has been made to compare the diversity of observations and provide insight into the likelihood of citizen scientists establishing valid baseline conditions for Huron Natural Area.

A comparison of data collected by NRSI in 2010-2012 and data collected by citizen scientists has been made. The overall species richness from 2010-2012 was 31, while the species richness of the data collected by the volunteers in 2012 was 26. The species richness from individual years of data collected by NRSI was lower than the species richness collected by volunteers. The Shannon Diversity Index of the two data sets was similar, although there was a larger difference between the Simpson Index values for both data sets. The difference in Simpson values is likely due to the increased survey period, consisting of three years of data collection, compared to one year of citizen science data collection. The high Shannon Diversity and Simpson Reciprocal values, along with low Simpson Index values of both data sets demonstrate the high level of diversity found at a complex site, as explained in the section above.

In terms of differences between the data sets, there were seven species that were observed by NRSI or during the Annual Butterfly Count, which were not observed during the community-based monitoring program. These included the following species: Silver-spotted Skipper (*Epargyreus clarus*), Red-spotted Purple (*Limentis arthemis astyanax*), Little Wood Satyr (*Megisto cymela*), Arctic Skipper (*Cartercephalus palaemon)*, Giant Swallowtail (*Papilio cresphontes*), Eastern Pine Elfin (*Callophrys* *niphon*) and Delaware Skipper (*Anatrytone logan*). Along with these species, the Wild Indigo Duskywing (*Erynnis baptisiae*) was not observed by the volunteers, although this species was included in the expert data set.

Two species observed during the 2012 Annual Butterfly Count were the Silver-spotted Skipper and the Red-spotted Purple, both of which were observed along the Plantation trail, which is northwest of the meadow habitat (C. Moore, personal observation, July 7, 2012). Also observed was the Little Wood Satyr, which is a forest dwelling butterfly (Government of Canada, 2010), and it was likely observed in a forested part of the natural area, not in the meadow habitat. Another butterfly, the Arctic Skipper, has a Waterloo Regional Status of rare and has only been documented in seven locations throughout the Region (Linton, 2012). This butterfly was observed in 2010 and has not been observed at Huron Natural Area since that single observation. The Giant Swallowtail had numerous sightings throughout the Region of Waterloo in 2011 (Linton, 2012), but only one individual was observed at the Huron Natural Area in 2011. This species uses Northern Prickly Ash (*Zanthoxylum americanum*) and Common Hoptree (*Ptelea trifoliata*) as larval host plants (Linton, 2012), which are not present in the Huron Natural Area, indicating the single Giant Swallowtail observed was likely passing through and does not breed at the site.

Another butterfly observed by NRSI was the Eastern Pine Elfin (*Callophrys niphon*), which has only two records in the Region of Waterloo, including the sighting at Huron Natural Area (Linton, 2012). This species uses White Pine (*Pinus strobus*) and Jack Pine (*Pinus banksiana*) as a host plant (Government of Canada, 2010), and is likely found in the Pine Plantation located northwest of the meadow. Lastly, the Delaware Skipper was observed in 2011 and 2012 during the NRSI surveys and was not recorded by the volunteers. This butterfly is found in dry meadows and uses various grasses as a larval host plant (Government of Canada, 2010; Butterflies and Moths of North America, 2013). The majority of these species were observed in areas other than the meadow habitat where CBM surveys took place or consisted of migrant species for which breeding habitat does not exist within Huron Natural Area.

In addition to the species observed by NRSI, the community-based monitoring participants observed four species that were not documented during the 2010-2012 NRSI surveys or at the Annual Butterfly Counts. These species include: Hobomok Skipper, Common Buckeye (*Junonia coenia*), White Admiral and Painted Lady. The Hobomok Skipper is common in the Region of Waterloo and has been observed in numerous locations in the last five years (Linton, 2012). The Common Buckeye is a migrant butterfly in Canada, although it has been known to establish temporary breeding colonies in favourable migration years. This species was observed at Huron Natural Area in 2010 (Linton, 2012). The White Admiral is common throughout Canada, although there are only five documented observations in the Region of Waterloo since 2001 (Linton, 2012). Finally, the Painted Lady is a common seasonal colonist of southern Ontario and is common in the Region of Waterloo (Linton, 2012). These species observed by the volunteers represent a mix of common and rare migrant species in the Region of Waterloo.

Overall, there were different common and rare species observed by NRSI and the citizen science volunteers at Huron Natural Area, although the similar species richness of three years of NRSI data collection and one year of CBM data collection indicates the accuracy of observations collected by citizen scientists. Both data sets demonstrated a similar level of diversity and evenness at the site and this is an indication of the value of volunteer data, which produced similar results as a professional biological firm. The variation between species observations demonstrates the high diversity present in the complex habitat at this site. The high Shannon Diversity, evenness and Simpson Index values, coupled with the low Simpson Reciprocal values of both data sets indicate the high level of diversity found at Huron Natural Area, as established by the community-based monitoring program in their year of baseline data.

4.3 Ensuring the Success of the Program

Numerous steps were taken to ensure the success of this community-based monitoring program, which included familiarization with common challenges of these types of programs. These challenges can include problems with program organization and data accuracy. Organizational issues can stem from a lack of volunteer interest and/or networking opportunities, as well as funding and information access difficulties (Whitelaw et al., 2003). Challenges that occur during the data collection process can include data fragmentation, when data is not collected consistently and inaccuracy, as well as lack of participant objectivity (Whitelaw et al., 2003). Other issues include a lack of credibility for data collected by community members, as well as non-comparability between data sets collected by volunteers and incompleteness of data (Gouveia et al., 2004; Bradshaw, 2003). These last challenges often lead to difficulties in presenting the data as useable and worthwhile to decision-makers (Milne et al., 2006; Conrad & Daoust, 2008).

This research program was designed to overcome the challenges that are often faced by CBM programs. First of all, the program was designed to maximize volunteer retention. There are several recognized principles of volunteer retention, which include establishing motivation and upholding connectedness (McCurley & Lynch, 1997). Motivation and positive feedback were provided to volunteers to maintain interest in the program and retain volunteers for the season and for future years. This included responding to all data submissions with positive feedback regarding volunteer performance and their contribution to research. As well, monthly emails were sent to volunteers outlining species they were likely to observe in the coming month and providing a summary of observations from the last month. Several volunteers responded to these messages regarding the helpfulness of the emails in terms of narrowing down the number of species they were likely to see, as well as aiding in positive identification of individuals they had observed.

In order to establish connectedness and recognize volunteer efforts, a volunteer appreciation event was held at Huron Natural Area on September 17, 2012. A summary of observations from the monitoring period was presented, which encouraged volunteers to analyze the abundance and diversity of butterflies observed at each location. Preliminary results and analysis were presented, and an open discussion took place to engage volunteers and encourage them to think analytically about the data they had collected, including the implications of trends they had observed. Refreshments were provided at this event and each volunteer was given a native plant from a local nursery to plant at their home to attract butterflies and encourage native plant gardening. This event provided connectedness between volunteers and the program organizer as well as among participants, which is a valuable component of a successful community-based monitoring program.

Other measures should be taken to retain volunteers in future years, as this can increase the accuracy of species identification and improve the capacity for analyzing data quality (Bell et al., 2008). There was a higher rate of consistent monitoring at Lakeside Park than at Huron Natural Area. A reason for the difference in volunteer retention may be that a group of citizens who live near Lakeside Park approached the City of Kitchener to request butterfly monitoring occur in their natural area. This group was actively seeking to be involved in monitoring activities and their proximity to the natural area provides additional investment in the Lakeside Park monitoring. Although it can be difficult to find volunteers with this type of investment in natural area monitoring, it would be an asset to seek similar volunteers at Huron Natural Area in the future.

A recommendation from the literature is to have volunteers conduct monitoring over multiple years in order to reduce “first-year” effects, as participants improve their data collection skills over time (Dicksinson et al., 2010; Bas et al., 2008; Jiguet, 2009; Kendall et al. 1996; Sauer et al., 1994; Schemeller et al., 2009). Therefore, moving forward with the project it will be important to contact volunteers from the 2012 program and attempt to recruit as many of these volunteers as possible to contribute to long-term data collection for the City of Kitchener. In subsequent years, the program will be managed by the City of Kitchener, who will be responsible for volunteer recruitment and retention. The City has an existing volunteer base to draw from and will be encouraged to reach out to other citizens who may not already be engaged in their natural areas.

Another suggestion for overcoming barriers to CBM programs is to assess volunteers' skill sets and match their skills to appropriate tasks (Cuthill, 2000). For example, if a volunteer was not able to meet the time commitment required for this program or was not confident in their ability to identify butterflies, the volunteer was advised to participate in the Huron Natural Area Annual Butterfly Count. This is an annual volunteer opportunity in coordination with butterfly experts who help volunteers identify butterfly species and is a much smaller time commitment for those who cannot commit to a longer research program.

An additional suggestion to overcome challenges with volunteer programs is to create a framework to convey information collected by the program to decision-makers (Pollock & Whitelaw, 2005). It is recommended that the Project Manager present a formal report to the City of Kitchener following each year of data collection to demonstrate the usefulness of the monitoring program. It is recommended that this report is made available to the public and is published in the Kitchener-Waterloo Field Naturalist newsletter and the Lakeside Park newsletter. The Toronto Entomologists' Association should be approached in the future to publish the results, as well as other local environmental organizations, such as the ***rare*** Charitable Research Reserve.

To ensure the success of a volunteer program, Yarnell & Gayton (2003) also proposed that a program must continue to obtain funding; in terms of the current project, this is supplied by the City of Kitchener, as of 2013. It is also suggested that experts be involved in the design of the monitoring protocols (Conrad & Daoust, 2008). The protocol for this program was designed by a butterfly expert. The protocol is also a well-recognized method for analyzing butterfly assemblages. As well, methods should be simple to understand, well tested and tailored to the local community (Pollock & Whitelaw, 2005). Utilizing nation-wide protocols is useful for consistency and accuracy, but small adjustments must be made to ensure the protocol is appropriate for the local community members and the monitoring sites. The adapted Pollard method employed for this program was used because it is a widely accepted method for butterfly monitoring. This method was tailored to the local community and volunteers by eliminating the point counts in the transect method, which were removed to ensure consistency between volunteers.

It is also recommended that training of volunteers be undertaken in order to ensure that consistent monitoring is completed (Au et al., 2000; Stokes et al., 1990). Citizen science programs have demonstrated the importance of training volunteers in monitoring techniques and protocols used in research, as well as in practical field training and through demonstrations (Newman et al., 2003; Delaney et al., 2008; Oscarson & Calhoun, 2007; Bonney et al., 2009). Training can be time-consuming, although many volunteers can be trained simultaneously, which is a timely and cost-effective method for increasing the number of trained people who will collect scientific data (Newman et al., 2003). Training of volunteers was achieved during a hands-on workshop and through a training manual. Both of these methods are further explained above in the methods section.

Quality control is also a vital part of citizen science projects and is built into most studies (Silvertown, 2009; Galloway et al., 2006; Delaney et al., 2008; Lepczyk, 2005; Butcher et al., 1990; Foster-Smith & Evans, 2003; Newman et al., 2003). It is essential to provide quality assurance and validation of data, by ensuring volunteers follow the survey protocol. This will increase the likelihood of the scientific community recognizing the research as valid, and the likelihood of the researcher effectively using the data collected by volunteers (Delaney et al., 2008; Boudreau & Yan, 2004). Citizen science programs have shown that volunteer effectiveness benefited significantly from a substantial investment in feedback, training and professional supervision (Newman et al., 2003). A formal review process was implemented for this program in order to validate the data collected by citizen scientists, which can ensure the program is recognized as useful.

The most successful CBM programs are those that are locally appropriate and adaptive to the community, are conducted with strong coordination, offer meaningful opportunities to volunteers, and establish mechanisms for information delivery (Pollock

& Whitelaw, 2005). This program was created specifically for this community and the two natural areas that were monitored in 2012. The program was coordinated by myself and Josh Shea, the Natural Areas Coordinator for the City of Kitchener, and the program received positive feedback from the participants regarding its organization. The volunteer opportunity to monitor butterflies is meaningful, as butterflies are a charismatic species that interest volunteers and act as an indicator species. Finally, this program has established a mechanism for information delivery with the recommendation to prepare a summary report following each monitoring year, which should be made available to the public and decision-makers.

The literature demonstrates the importance of communication in successful community-based monitoring programs. In order to ensure efficient communication, information should be delivered at all levels and stages of the program, which includes communication among participants and to the media and the broader community (Pollock & Whitelaw, 2005). This program strives to maintain participant engagement and ensure the validity of monitoring data by communicating the understanding of science and environmental education to the local community. Proper communication expresses the need for collecting long-term data records and conveying the usefulness of standard methodology (Pollock & Whitelaw, 2005).

Furthermore, it is important that data be compiled into a meaningful form that is easily conveyed to the public and decision-makers (Pollock & Whitelaw, 2005). A successful program should be formally connected to decision-makers to ensure the sustainability of the program (Bens, 1994; Craig et al., 2003; Milne et al., 2006; Sharpe & Conrad, 2006). This program is formally connected to the City of Kitchener, who is now managing this study as a long-term research project. Community-based monitoring programs should also ensure relevant results of the project are communicated in a usable, timely and accessible manner to inform decision-makers and the broader public effectively (Vaughan et al., 2001). The monitoring summary report prepared each year will communicate the results to decision-makers and convey information to the public. It will also serve as a promotional tool for the program that can be used for volunteer recruitment.

There are many components of a successful long-term community-based monitoring program, as outlined above. Numerous steps were taken to ensure the success of this program, including tailoring this particular program to the local community, using several methods to convey volunteer appreciation and ensure their retention, and using effective communication tools to convey the results of the monitoring program to decision-makers and the broader community. As Blair (1999) has found, when these issues can be addressed, the benefits of CBM far outweigh the challenges.

4.4 Contribution to Research, the Community and the Broader Public

Community-based monitoring programs using citizen scientists can collect scientific data that may otherwise be unattainable. The use of volunteers in ecological studies has turned into a mainstay of studies that are targeting biological conservation (Dickinson et al., 2010). This section focuses on the specific contributions of this community-based monitoring program to the scientific community, broader public and local community.

The establishment of this program and the validation of volunteer data has benefitted the scientific community and contributed to literature in several meaningful ways. First of all, the program has established a review process for validating observations made by volunteers. The review process consisted of an expert checking each observation for the likelihood of occurrence within the site and within the larger landscape. This particular review process included the comparison of species to the status provided in *The Butterflies of Waterloo Region* (Linton, 2012), whereas other programs could compare observations to a provincial atlas, a comparable document, or they could use a local expert, as the eButterfly program does.

Furthermore, the validation of volunteer data through a review process is another benefit to the scientific community, as there are few studies that analyze the accuracy of citizen science data, especially in an urban environment (Matteson et al., 2012; Cooper et al., 2007). Quality control is a mainstay of citizen science programs and it must be sustained to validate the observations made by volunteers. This study has contributed to the literature on citizen science, validation of volunteer data and the use of butterflies as an indicator species. In general, citizen science is underrepresented in the literature, and one study found that, as of January 2009, there were 56 articles in the ISI Web of Knowledge database pertaining to “citizen science” (Silvertown, 2009). Of these articles, the majority (80%) had been written in the last five years (Silvertown, 2009). Delaney et al. (2008) indicate the scientific community is reluctant to acknowledge citizen science because of a lack of certified audits to evaluate the authenticity of data for use in academic research. This study has demonstrated the ease with which citizen science observations can be reviewed and validated. Implementing this as a national program could overcome the reluctance of the scientific community to accept this form of data collection and provide further validation of volunteer data. If this project gave rise to a national program, it could be implemented in other places in Canada and other areas of the world. This project is easily transferable to other locations and areas of study because of the widely recognized survey methods.

This study has contributed to the literature and the scientific community through the establishment of a review process for citizen science programs, particularly for butterfly programs. It has provided further validation of citizen science data, created a program that is expandable to a national butterfly monitoring program, and further contributed to the available literature on the use of butterflies as an indicator species.

This program has made a contribution to the broader public through the establishment of a long-term monitoring program that can benefit other communities by setting an example of municipal-level ecological management. As previously mentioned, the monitoring protocol for this program is easily transferable to another location, and another community could collect butterfly monitoring data using the established program as a model. There are several things to consider when setting up a new program, according to Sharpe & Conrad (2006), such as ensuring there is a mentoring program for any new groups establishing the monitoring program. This includes having contact with a person to advise on the protocol, study design and information management for the program (Sharpe & Conrad, 2006).

This program would be beneficial to other communities, as it is to the City of Kitchener. The program can increase citizen engagement in ecosystems, improve community influence in the decision-making process, as well as establish participation in a program that collects long-term data and helps the community and decision-makers understand ecological change (Pollock & Whitelaw, 2005).

Furthermore, establishing butterfly monitoring programs in other communities can help create networks in other regions and/or provinces. A network for community-based monitoring is desperately needed in Canada because the Ecological Monitoring and Assessment Network was disbanded in 2010, which had supported volunteer monitoring programs throughout the country (Government of Canada, 2012). The Canadian Community Monitoring Network was previously established by Whitelaw et al. (2003), but also had its entire budget cut and no longer exists. In order to establish a successful monitoring network, it is imperative to have stable funding and a wide range of partnerships (Savan et al., 2003). In Canada, there is almost no government support for citizen science and there is no network to link programs throughout the country, such as the River Network in the northeastern United States (Savan et al., 2003). When the EMAN network was in existence, there were programs in place to compile directories of monitoring programs and groups, and methods for connecting these groups to allow much needed communication among monitoring programs (Savan et al., 2003). Since the disbandment of EMAN, there is a desperate need for a community-based monitoring network in Canada to compile monitoring information and provide communication between programs. The establishment of this program could lead to a connection of monitoring programs, which would be a significant benefit to other communities.

Another benefit of a community-based monitoring network is the large pool of human, financial and technical support for those involved. As well, there is the ability to provide inspiration and encouragement from fellow volunteers who may be able to provide insight into program setbacks and successes (Savan et al., 2003). Savan et al. (2003) point out that maintaining a volunteer network with communication between programs provides mutual learning, however, it is a difficult task that remains to be completed. One suggestion is to use universities and their partnerships to create and maintain this type of network, which can provide space, leadership, support for students, grant services and credibility to establish collaboration with government, NGOs and scientific institutions (Savan et al., 2003). Numerous benefits are provided to the broader public with the establishment of a long-term ecological monitoring program, including setting an example for other communities to follow.

The establishment of this program has benefitted the local community of Kitchener, its citizens and the local government. The program has provided insight into several ecosystems within the City of Kitchener. The health of these ecosystems is important for the local community in maintaining a healthy environment for all living beings, including humans. Ecosystem goods (such as food) and services (such as waste assimilation) signify benefits to humans, whether direct or indirect, based on the function of an ecosystem (Costanza et al., 1997). As well, the results of the citizen science and NRSI surveys found that Huron Natural Area has a wider diversity of butterfly species and naturalized habitat than Lakeside Park. As a result of the butterfly program at Lakeside Park, a local community group has approached the City of Kitchener and asked to be involved in a restoration program to naturalize their park and increase the amount of butterfly habitat present (J. Shea, personal communication, April 11, 2013). This request demonstrates how the program educates volunteers on the importance of naturalized areas and the benefits of diverse habitats and butterfly populations. It also sustains volunteer engagement in the local community.

A benefit of community-based monitoring programs is that they often engage citizens in their local natural areas by increasing their connection with the natural world, other volunteers and agencies (Conrad & Hilchey, 2011; Whitelaw et al., 2003). The volunteers became more educated (Pollock & Whitelaw, 2005; Cooper et al. 2007) and confident in their butterfly species identification, which could be an important step in career development. Volunteers were empowered by this program, as they were able to demonstrate the need for habitat restoration, based on scientific data they had collected themselves. An important aspect of community-based monitoring was fulfilled through this engagement, as Kim et al. (2011) state that a program only has scientific influence when the collected data is used for some purpose. These citizens took it upon themselves to use the data they collected to prove there was a need for Lakeside Park to improve its natural habitat.

Another substantial benefit to the local government is the economic savings of utilizing volunteers to collect data, instead of employees or professional scientists. The City of Kitchener has saved substantial amounts of money and gained benefits from collecting scientific data on the state of their ecosystems. Dickinson et al. (2010) state that creating a volunteer monitoring program is an exceptional method for inventorying species, particularly for cost benefits. The program benefits from a continual source of government funding for the meager amount of operating costs and the Project Manager's time. Other community-based monitoring projects have found that volunteer Project Managers are unable to generate funding on top of fulfilling other program requirements, such as day-to-day activities and management (Pollock & Whitelaw, 2005). These participants believed government support was necessary to fund a significant portion of the cost of project operations and to provide expertise (Pollock & Whitelaw, 2005). This program has government support for operations and expertise, which will facilitate long-term data collection.

Finally, the establishment of a long-term monitoring program in the City of Kitchener has multiple benefits for the community members. The City of Kitchener has taken over the program and committed to collecting long-term data sets using citizen scientists. This commitment ensures the continuation of the program and also acts as an important connection between community members and decision-makers. Monitoring is a vital component of environmental science and government agencies need to commit to long-term data collection programs (Lovett et al., 2007). Long-term data collection is needed as ecosystems change slowly over time, and continued monitoring of critical variables provides a record of change (Lovett et al., 2007). The local community benefits from this record of change as the City of Kitchener has the ability to adapt to changing conditions observed during the long-term monitoring program.

In summary, the benefits to the local community from this program include the collection of monitoring information in their local ecosystems, education and empowerment of the community, economic benefits for citizens and local government, engagement of citizens in their natural areas, and the establishment of a long-term monitoring program for the City of Kitchener.

The establishment of this long-term monitoring program has resulted in numerous benefits for the scientific community, the broader public and the local community. The City of Kitchener has gained community support and will continue to monitor their natural areas and act as an innovator for scientific data collection.

4.5 Concluding Remarks

The benefits and value of a community-based monitoring program has been demonstrated throughout this study. There are also additional benefits that could be provided by the program in the future if children and teachers become involved in the program. This CBM program could contribute to increased environmental education and engagement of children in natural areas in the community.

There are several recommendations that have come out of the establishment of this program. The results of the program should be used to improve the management of Lakeside Park and Huron Natural Area and any additional areas that are monitored as part of the program in future years.

Specifically, it is recommended that the City of Kitchener continue to increase the amount of naturalized habitat within Lakeside Park. Volunteers have voiced an interest in restoring and creating additional butterfly habitat to increase the diversity of butterflies fulfilling their life cycle in the park. Naturalizing additional habitat will have multiple benefits to the community, park and surrounding habitat. Other species such as birds and other insect pollinators will prosper from naturalized habitat, and the community will benefit from the creation of a more diverse ecosystem in their neighbourhood.

The City of Kitchener should continue to promote the program in order to foster community involvement and support. Engaging new volunteers and supporters of the program will be vital to the success of the long-term monitoring program. New sources of volunteers, such as environmental groups, students/teachers, and citizens not already involved in community organizations should continue to be sought in order to engage as many citizens as possible in their natural areas.

The results of the program must continue to be reported to participants and decision-makers, on local and wider scales. Many studies show the usefulness of a monitoring program is closely tied to the communication of the results. The results should be posted on the City of Kitchener website for participants and non-participants to view and should consider incorporation into the school curriculum.

As the program continues, ongoing evaluation by participants and decision-makers should be undertaken to ensure adaptations are made, if necessary. It is important to collect data that can be compared to other years, but also critical to continually evaluate the program in order to avoid any fatal flaws.

Lastly, it is recommended that pre- and post-monitoring interviews be conducted with participants to determine the amount of education that volunteers gain from the program. These interviews could also be compared to random interviews conducted with non-participants to determine the effectiveness of education in the monitoring program.

References

Au, J., Bagchi, P., Chen, B., Martinez, R., Dudley, S.A., & Sorger, G.J. (2000). Methodology for public monitoring of total coliforms, *Escherichia coli*, and toxicity in waterways by Canadian high school students. *Journal of Environmental Management, 58*, 213-230.

Bas, Y., Devictor, V., Moussus, J.P., & Jiguet, F. (2008). Accounting for weather and time-of-day parameters when analyzing count data from monitoring programs. *Biodiversity & Conservation, 17*, 3403–3416.

Bell, S., Marzano, M., Reinert, H., Cent, J., Kobierska, H., Podjed, D., …& Mursic, R. (2008). What counts? Volunteers and their organizations in the recording and monitoring of biodiversity. *Biodiversity and Conservation, 17*, 3443-3454.

Bens, C. (1994). Effective citizen involvement: how to make it happen. *National Civic Review*, 32-39.

Blair, R.B. (1999). Birds and Butterflies along an Urban Gradient: Surrogate Taxa for Assessing Biodiversity? *Ecological Applications, 9*(1), 164-170.

Blair, R.B., & Launer, A.E. (1997). Butterfly diversity and human land use: Species assemblages along an urban gradient. *Biological Conservation, 80*, 113-125.

Bonney, R., Cooper, C.B.,Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K.V., & Shirk, J. (2009). Citizen science: a developing tool for expanding science knowledge and scientific literacy. *BioScience, 59*(11), 977-984.

Boudreau, S., & Yan, N. (2004). Auditing the accuracy of a volunteer-based surveillance program for an aquatic invader Bythotrephes. *Environmental Monitoring and Assessment, 91*, 17–26.

Bradshaw, B. (2003). Questioning the credibility and capacity of community-based resource management. *The Canadian Geographer, 47*, 137–150.

Brown, K.S. (1982). Paleoecology and regional patterns of evolution in neotropical forest butterflies. *Biological diversification in the tropics,* ed. G.T. Prance. Columbia University Press: New York.

Butcher, G.S., Fuller, M.R., McAllister, L.S., & Geissler, P.H. (1990). An evaluation of the Christmas Bird Count for monitoring population trends of selected species. *Wildlife Society Bulletin, 18*, 129–134.

Butterflies and Moths of North America. (2013). Attributes of *Anatrytone logan*. Retrieved from http://www.butterfliesandmoths.org/species/Anatrytone-logan.

Caldas A., & Robbins, R. K. (2003). Modified Pollard transects for assessing tropical butterfly abundance and diversity. *Biological Conservation, 110,* 211–19.

Carr, A. (2004). Why do we all need community science? *Society Natural Resources*, 17, 841–849.

City of Kitchener. (2010a). *Parks, Trails, Natural areas*. Retrieved from http://www.kitchener.ca/en/livinginkitchener/ParksTrailsNaturalAreas.asp?_mid_=11842

City of Kitchener. (2010b). *Parks Strategic Plan*. City of Kitchener, September 2010.

Cohn, J.P. (2008). Citizen Science: Can Volunteers Do Real Research? *BioScience*, *58*(3), 192-197.

Conrad, C.C., & Hilchey, K.G. (2011). A review of citizen science and community-based environmental monitoring: issues and opportunities. *Environmental Monitoring Assessment, 176*, 273-291.

Conrad, C.T., & Daoust, T. (2008). Community-based monitoring frameworks: Increasing the effectiveness of environmental stewardship. *Environmental Management,41*, 356–358.

Cooper, C.B., Dickinson, J., Philips, T., & Bonney, R. (2007). Citizen science as a tool for conservation in residential ecosystems. *Ecology and Society, 12*(2), 11.

Costanza, R., d'Arge, R., de Groot, R., Farberk, S., Grasso, M., Hannon, B., Limburg, K.,…& van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature, 387*, 253-260.

Craig, B., Whitelaw, G., Robinson, J., & Jongerden, P. (2003). *Community-based Ecosystem Monitoring: A tool for developing and promoting ecosystem-based management and decision making in the Long Point World Biosphere Reserve*. Proceedings of the Fifth Science and Management of Protected Areas Association Conference.

Croxton, P. J., Hann, J. P., Greatorex-Davies, J. N., & Sparks, T.H. (2005). Linear hotspots? The floral and butterfly diversity of green lanes. *Biological Conservation, 121,* 579–584.

Cuthill, M. (2000). An Interpretive Approach to Developing Volunteer-based Coastal Monitoring Programs. *Local Environment, 5*(2), 127-137.

Darwall, W.R.T., & Dulvy, N.K. (1996). An evaluation of the suitability of non-specialist volunteer researchers for coral reef fish surveys. Mafia Island, Tanzania - A case study. *Biological Conservation, 78*(3), 223-231.

Delaney, D.G., Sperling, C.D., Adams, C.S., & Leung, B. (2008) Marine invasive species: validation of citizen science and implications for national monitoring networks. *Biological Invasions, 10*, 117–128.

De Leo, G.A., & Levin, S. (1997). The Multifaceted Aspects of Ecosystem Integrity. *Conservation Ecology* [online], *1*(1), 3.

Dennis, L.H.R., & Hardy P.B. (2001). Loss rates of butterfly species with urban development. A test of atlas data and sampling artefacts at a fine scale. *Biodiversity and Conservation, 10*, 1831-1837.

Dennis, R.L. (1993). *Butterflies and climate change*. Manchester University Press, Manchester, United Kingdom.

Devictor, V., Whittaker, R.J. & Betrame, C. (2010). Beyond scarcity: citizen science programmes as useful tools for conservation bio-geography. *Diversity and Distributions, 16*, 354-362.

Dickinson, J., Zuckerberg, B., & Bonter, D.N. (2010). Citizen science as an ecological research tool: challenges and benefits. *Annual Review of Ecology, Evolution, and Systematics, 41*, 149-172.

eButterfly.org. (2013). *Welcome to eButterfly*. Retrieved from http://www.ebutterfly.ca

Ehrlich, P. R., Breedlove, D.E., Brussard, P.E., & Sharp, M.A. (1972). Weather and the "regulation" of subalpine populations. *Ecology, 53,* 243-247.

Ehrlich, P.R., & Raven, P.H. (1964). Butterflies and plants: a study in coevolution. *Evolution, 18,* 586-608.

Elton, C. S. (1958). *The ecology of invasions by animals and plants.* Methuen, London.

Field, D., Voss, P., Kuczenski, T., Hammer, R., & Radeloff, V. (2010). Reaffirming social landscape analysis in landscape ecology: a conceptual framework. *Society & Natural Resources, 16,* 349–361.

Fleishman, E., Thomson, J.R., MacNally, R., Murphy, D.D., & Fay, P.F. (2005). Using Indicator Species to Predict Species Richness of Multiple Taxonomic Groups. *Conservation Biology, 19*(4), 1125-1137.

Fore, L.S., Paulsen, K., & O'Laughlin, K. (2001). Assessing the performance of volunteers in monitoring streams. *Freshwater Biology, 46*(1), 109-123.

Forister, M.L., McCall, A.C., Sanders, N.J., Fordyce, J.A., Thorne, J.H., O'Brien, J., …& Shapiro, A.M. (2010). Compounded effects of climate change and habitat alteration shift patterns of butterfly diversity. *Proceedings of the National*

Academy of Sciences, 107(5), 2088-2092.

Foster-Smith, J., & Evans, S.M. (2003). The value of marine ecological data collected by volunteers. *Biological Conservation, 113*, 199–213.

Galloway, A.W.E., Tudor, M.T., & Vander Haegen, W.M. (2006). The reliability of citizen science: a case study of Oregon white oak stand surveys. *Wildlife Society Bulletin, 34*, 1425–1429.

Gilbert, L.E. (1980). Food web organization and the conservation of neotropical diversity. *Conservation Biology: an evolutionary-ecological perspective, ed.* M.E. Soule & B.A. Wilcox. Sinauer Associates: Sunderland, M.A.

Gomez-Alvarez, V., King, G.M., & Nusslein, K. (2007). Comparative bacterial diversity in recent Hawaiian volcanic deposits of different ages. *Federation of European Microbiological Sciences Microbiology Ecology, 60,* 60–73.

Gouveia, C., Fonseca, A., Camara, A., & Ferrira, F. (2004). Promoting the use of environmental data collected by concerned citizens through information and communication technologies. *Journal of Environmental Management, 71*, 135–154.

Government of Canada. (2010). *Butterflies of Canada*. Retrieved from http://www.cbif.gc.ca/spp_pages/butterflies/index_e.php

Government of Canada. (2012). *Environment Canada – Science and Technology – Ecology Monitoring*. Retrieved from http://www.ec.gc.ca/faunescience-wildlifescience/default.asp?lang=En&n=B0D89DF1-1

Hogsden, K.L., & Hutchinson, T.C. (2004). Butterfly assemblages along a human disturbance gradient in Ontario, Canada. *Canadian Journal of Zoology*, *82*(5), 739-748.

Howard, E., & Davis, A.K. (2009). The fall migration flyways of monarch butterflies in eastern North America revealed by citizen scientists. *Journal of Insect Conservation, 13*, 279–286.

Hunsberger C. (2004). *Citizen environmental monitoring in Comox Valley, British Columbia*. Background paper prepared for the Canadian Environmental Assessment Agency Research and Development Program.

Jiguet, F. (2009). Method learning caused a first-time observer effect in a newly started breeding bird survey. *Bird Study, 56*, 253–58.

Jones, C.D., Layberry, R., & Macnaughton, A. (2012, April 10). *The Ontario Butterfly Atlas Online*. Toronto Entomologists' Association. Retrieved from http://www.ontarioinsects.org/atlas_online.htm

Kendall, W.L., Peterjohn, B.G., & Sauer, J.R. (1996). First-time observer effects in the North American Breeding Bird Survey. *Auk, 113,* 823–829.

Kharouba, H.M., Algar, A.C., & Kerr, J.T. (2009). Historically calibrated predictions of butterfly species' range shift using global change as a pseudo-experiment. *Ecology, 90*(8), 2213-2222.

Kim, S., Robson, C., Zimmerman, T., Pierce, J., & Haber, E. M. (2011). Proceedings from Human factors in computing systems 2011: *Creek watch: pairing usefulness and usability for successful citizen science*. ACM.

Kremen, C. (1992). Assessing the indicator properties of species assemblages for natural areas monitoring. *Ecological Applications, 2,* 207-217.

Kruger, L. E., & Shannon, M. A. (2000). Getting to know ourselves and our places through participation in civic social assessment. *Society and Natural Resources, 13*, 461–478.

Lee, H.T. (2008). *Southern Ontario Ecological Land Classification: Vegetation Type List*. Southern Information Management and Spatial Analysis Section, Onatio Ministry of Natural Resources.

Lehman, C.L., & Tilman, D. (2000). Biodiversity, stability, and productivity in competitive communities. *American Naturalist, 156*(5), 534-552.

Lemieux, C.J., & Scott, D.J. (2005). Climate change, biodiversity conservation and protected areas planning in Canada. *The Canadian Geographer,* 49(4), 384-399.

Lepczyk, C.A. (2005). Integrating published data and citizen science to describe bird diversity across a landscape. *Journal of Applied Ecology, 42*, 672–677.

Lepczyk, C.A., Boyle, O.D., Vargo, T.L., Gould, P., Jordan, R., Liebenberg, L., …& Vaughan, H. (2009). Citizen science in ecology: the intersection of research and education. *Bulletin of the Ecological Society of America,* 308–317.

Linton, J.E. (2012). *The Butterflies of Waterloo Region: An Annotated Checklist, a Species Scarcity Ranking, and a Transect-Based Analysis of Urban vs. Rural Populations*. Toronto: Toronto Entomologists Association.

Lodge, D.M., Williams, S., MacIsaac, H.J., Hayes, K.R., Leung, B., Reichard, S., …& McMichael, A. (2006). Biological invasions: recommendations for U.S. policy and management. *Ecological Applications, 16*, 2035.

Lovett, G.M., Burns, D.A., Driscoll, C.T., Jenkins, J.C., Mitchell, M.J., Rustad, L., …& Haeuber, R. (2007). Who needs environmental monitoring? *Frontiers in Ecology* *and Environment, 5*(5), 253-260.

Lynam, T., Jong,W., Sheil, D., Kusumanto, T., & Evans, K. (2007). A review of tools for incorporating community knowledge, preferences and values into decision making in natural resources management. *Ecology and Society, 12*, 5–18.

MacArthur, R. H. (1955). Fluctuations of animal populations and a measure of community stability. *Ecology, 36*, 533-536.

Machlis, G., Force, J., & Burch, W.J. (1997). The human ecosystem part I: the human ecosystem as an organizing concept in ecosystem management. *Society & Natural Resources, 10*, 347–367.

Magurran, A.E. (1988). *Ecological diversity and its measurement*. Princeton University Press: Princeton, NJ.

Margalef, R. (1969). *Diversity and stability: a practical proposal and a model of interdependence*. Pages 25–37 in Diversity and stability in ecological systems. Brookhaven Symposium in Biology 22. Brookhaven National Laboratory: Upton, N.Y.

Matteson, K.C., Taron, D.J. & Minor, E.S. (2012). Assessing citizen contributions to butterfly monitoring in two large cities. *Conservation Biology, 0,* 1-8.

May, R.M. (1973). Qualitative stability in model ecosystems. *Ecology, 54*(3), 638-641.

McCaffrey, R. (2005). Using citizen science in urban bird studies. *Urban Habitats, 3*,1–86.

McCurley, S. & Lynch, R. (1997). *Volunteer management*. Downers Grove, Illinois: Heritage Arts.

Milne, R., Rosolen, S., Whitelaw, G., & Bennett, L. (2006). Multi-party monitoring in Ontario: Challenges and emerging solutions. *Environments, 34*, 11–23.

Murphy, D.D., Freas, K.E., & Weiss, S.B. (1990). An environment-metapopulation approach to population viability analysis for a threatened invertebrate. *Conservation Biology, 4*, 41-51.

Naeem, S. (1998). Species Redundancy and Ecosystem Reliability. *Conservation Biology, 12*(1), 39-45.

Natural Resource Solutions Inc. (NRSI). (2010). *Lakeside Park Vegetation Communities*. Waterloo, ON: Gerry Schaus.

Natural Resource Solutions Inc. (NRSI). (2011). *Huron Natural Area Vegetation*

Communities. Waterloo, ON: Shawn MacDonald.

Natural Resource Solutions Inc. (NRSI). (2012). *City of Kitchener 2012 Butterfly Survey Summary: Huron Natural Area*. Waterloo, ON: Jessica Linton.

New, T.R. (1997). Are Lepidoptera an effective ‘umbrella group‘ for biodiversity conservation? *Journal of Insect Conservation, 1*(1), 5-12.

Newman, C., Buesching, C.D., & Macdonald, D.W. (2003). Validating mammal monitoring methods and assessing the performance of volunteers in wildlife conservation - ‘‘Sed quis custodiet ipsos custodies?’’. *Biological Conservation, 113*, 189–197.

Niell, R.S., Brussard, P.F., & Murphy, D.D. (2007). Butterfly community composition and oak woodland vegetation response to rural residential development. *Landscape and Urban Planning, 81,* 235-245.

Oberhauser, K., & Prysby, M.D. (2008). Citizen science: creating a research army for conservation. *American Entomologist, 54*, 103–104.

Odum, E. P. (1959). *Fundamentals of ecology*. 2nd edition. Saunders, Philadelphia.

Ogden, L.E. (2013). Tags, blogs, tweets: social media as science tool? *BioScience, 63*(2), 148.

Ontario Birds. (2010). Ontario Bird Records Committee Report for 2009. *Ontario Field Ornithologists, 28*(2), 58-86.

Oscarson, D.B., & Calhoun, A.J.K. (2007). Developing vernal pool conservation plans at the local level using citizen-scientists. *Wetlands, 27*(1), 80–95.

Pollard, E. (1977). A method for assessing changes in the abundance of butterflies. *Biological Conservation, 12*, 115-134.

Pollard, E., Elias, D.O., Skelton, M.J., & Thomas, J.A. (1975). A method for assessing the abundance of butterflies in Monk’s Wood National Nature Reserve in 1973. *Entomologist’s Gazette, 26*, 79-88.

Pollard, E., & Yates, T.J. (1993). *Monitoring butterflies for ecology and conservation: the British Butterfly Monitoring scheme*. Chapman and Hall: London.

Pollock, R. M., & Whitelaw, G.S. (2005). Community-based monitoring in support of local sustainability. *Local Environment, 10*(3), 211-228.

Pyle, R.M. (1980). Butterfly eco-geography and biological conservation in Washington. *Atala, 8*, 1-26.

Richter-Dyn, N., & Goel, N. S. (1972). On the extinction of a colonizing species. *Theoretical Population Biology, 3*, 406-433.

Roy, D.B., Rothery, P., Moss, D., Pollard, E., & Thomas, J.A. (2001). Butterfly numbers and weather: predicting historical trends in abundance and the future effects of climate change. *Journal of Animal Ecology, 70*(2), 201-217.

Ruszczyk, A. (1986). Distribution and abundance of butterflies in the urbanization zones of Porto Alegre Brazil. *Journal of Research of Lepidoptera, 25*, 157-178.

Ruszczyk, A., & De Araujo, A.M. (1992). Gradients in butterfly species diversity in an urban area in Brazil. *Journal of Lepidopterists Society, 46,* 255-264.

Samways, M.J. (1994). *Insect Conservation Biology*. London: Chapman & Hall.

Sauer, J.R., Peterjohn, B.G., & Link, W.A. (1994). Observer differences in the North-American breeding bird survey. *Auk, 111*, 50–62.

Savan, B., Morgan, A.J., & Gore, C. (2003). Volunteer Environmental Monitoring and the Role of the Universities: The Case of Citizens' Environment Watch. *Environmental Management*, *31*(5), 561-568.

Schippers, P., Verboom, J., Knaapen, J.P., & van Apeldoorn, R.C. (1996). Dispersal and habitat connectivity in complex heterogeneous landscapes: an analysis with a GIS-based random walk model. *Ecography, 19*, 97-106.

Schmeller, D.S., Henry, P.Y., Julliard, R., Gruber, B., Clobert, J., Dziock, F., …& Henle, K. (2009). Advantages of volunteer-based biodiversity monitoring in Europe. *Conservation Biology, 23,* 307–316.

Schulte, B.J., & Buongiorno, J. (1998). Effects of uneven-aged silviculture on the stand structure, species composition, and economic returns of loblolly pine stands. *Forest Ecology and Management*, *111*, 83-101.

Schwartz, M. W. (2006). How conservation scientists can help develop social capital for biodiversity. *Conservation Biology, 20*, 1550–1552.

Shannon, C. E., & Weaver, W. (1949). *The mathematical theory of communication*. Urbana, Illinois, USA: University of Illinois Press.

Sharpe, A., & Conrad, C. (2006). Community based ecological monitoring in Nova Scotia: challenges and opportunities. *Environmental Monitoring and Assessment, 113*, 395-409.

Silvertown, J. (2009). A new dawn for citizen science. *Trends in Ecology and Evolution, 24*(9), 467-471.

Simonson, S. E., Opler, P. A., Stohlgren, T. J., & Chong, G. W. (2001). Rapid assessment of butterfly diversity in a montane landscape. *Biodiversity & Conservation, 10,* 1369–86.

Smallidge, P.J., & Leopold, D.J. (1997). Vegetation management for the maintenance and conservation of butterfly habitats in temperate human-dominated landscapes. *Landscape and Urban Planning, 38*, 259-280.

Smith, W., & Grassle, J.F. (1977). Sampling Properties of a Family of Diversity Measures. *Biometrics*, *33*(2), 283-292.

Steele, J.A., Ozis, F., Fuhrman, J.A., & Devinny, J.S. (2005). Structure of microbial communities in ethanol biofilters. *Chemical Engineering Journal, 113,* 135–143.

Stokes, P., Havas, M., & Bridges, T. (1990). Public participation and volunteer help in monitoring programs: An assessment. *Environmental Monitoring and Assessment, 15(*3), 225-229.

Sultana, P., & Abeyasekera, S. (2008). Effectiveness of participatory planning for community management of fisheries in Bangladesh. *Journal of Environmental Management, 86*, 201–213.

Swengel, A. B. (1998). Comparisons of butterfly richness and abundance measures in prairie and barrens. *Biodiversity & Conservation, 7*,1639–59.

Thomas, J.A. (1983). A quick method for estimating butterfly numbers during surveys. *Biological Conservation, 27*(3), 195-211.

Tilman, D. (1999). The Ecological Consequences of Changes in Biodiversity: A Search for General Principles. *Ecology, 80*(5), 1455-1474.

Tilman, D., Reich, P.B., & Knops, J,M.H. (2006). Biodiversity and ecosystem stability in a decade-long grassland experiment. *Nature, 441*, 629-632.

van Swaay, C. A. M., Nowicki, P., Settele, J., & van Strien, A.J. (2008). Butterfly monitoring in Europe: methods, applications and perspectives. *Biodiversity and Conservation, 17,* 3455–3469.

Vaughan, H., Brydges, T., Fenech, A., & Lumb, A. (2001). Monitoring long-term ecological changes through the ecological monitoring and assessment network: Science-based and policy relevant. *Environmental Monitoring And Assessment, 67*(1-2), 3-28.

Waltz, A.E.M., & Covington, W.W. (2004). Ecological Restoration Treatments Increase Butterfly Richness and Abundance: Mechanisms of Response. *Restoration Ecology*, *12*(1), 85-96.

Watt, W. B., Chew, F.S., Snyder, L.R.G., Watt, A.G., & Rothschild, D.E. (1968). Population structure of pierid butterflies. I. numbers and movements of some montane *Colias* species. *Oecologia* (*Berlin*), *27*,1-22.

Weiss, S. B., White, R.R., Murphy, D.D., & Ehrlich, P.R. (1987). Growth and dispersal of larvae of the checkerspot butterfly *Euphydryas editha*. *Oikos, 50*, 161-166.

Whitelaw, G., Vaughan, H., Craig, B., & Atkinson, D. (2003). Establishing the Canadian Community Monitoring Network. *Environmental Monitoring and Assessment, 88*, 409–418.

Yamamoto, M. (1977). A comparison of butterflies assemblages in and near Sapporo City, northern Japan. *Journal of the Faculty of Science. Hokkaido University Ser. 6 Zoology, 20*, 621-646.

Yarnel, P., & Gayton, D. V. (2003). *Community-Based Ecosystem Monitoring in British Columbia: A Survey and Recommendations for Extension*. Kamloops: Forest Research Extension Partnership, FORREX Series 13.

Appendix I

Training Manual

Training Manual for Community-based Butterfly Monitoring in City of Kitchener Natural Areas

Acknowledgements
I would like to thank the Ecological Monitoring and Assessment Network (EMAN) and Jessica Linton for providing information and materials for this training manual.

Why should we monitor butterflies in the City of Kitchener?
Butterflies act as important indicators of environmental change. Monitoring the abundance of butterflies within the City of Kitchener can provide insight into the quantity and quality of butterfly habitat within the area. Butterflies have been chosen because they are generally easily recognized, observed, and identified.

Short Life Spans
Butterflies have short life spans, so changes in their populations over several generations can be detected in a short time period.

Changes in Climate
Butterflies are sensitive to changes in climate as they require a wing temperature of at least 25°C in order to fly. Cold periods, unexpected frosts and severe weather events can affect butterfly populations. New evidence indicates that butterflies are extending their northern range in Canada as climate changes increase areas of suitable habitat. Monitoring programs such as this one can help track these changes.

How to Monitor Butterflies
When
Different species of butterflies begin to emerge at different times of the year. Some will come out in early spring (even as early as February!) and can remain in the area until as late as November or December, depending on the local weather conditions. We will be monitoring from May-August, as this period contains the flight time of the largest number of butterfly species in the area. The best weather conditions to monitor butterflies are warm (at least 20°C) and sunny days that are not too windy. The best time to monitor butterflies is generally between 10am and 4pm, during the appropriate weather conditions. This time window can be extended on sunny days if the temperature is at least 25°C. If there is a limited time period when you are available to go out (e.g. one day) and the weather conditions are poor, I would suggest monitoring anyways, instead of skipping that monitoring session.

Where
Each volunteer will chose to monitor one transect at either Huron Natural Area or Lakeside Park.

Huron Natural Area

The transect at Huron Natural Area is the meadow trail, which is located south of the parking lot area. This trail is well marked on the trail map at the natural area. The meadow trail is a loop that contains natural and restored meadow communities, as well as shrubs and trees.

Lakeside Park

The transect at Lakeside Park is located along the community trail, which is a well maintained trail that runs northwest to southeast through the park. This trail contains grass on the south side, and trees and shrubs on the north side along the water.

How Often?

Volunteers should visit their site once every two weeks from May-August. You should choose to monitor during the 1st and 3rd weeks or the 2nd and 4th weeks of every month. If you are away for two weeks, try to monitor before you go and soon after you return.

How Long?

You should walk the trail at a regular walking pace, observing butterflies along the way. Feel free to stop along the way to identify butterflies or catch them with your net for closer observation (remember to bring your field guide!). There is no minimum or maximum time to spend along the trail.

Recording Your Observations

It is very important to carefully record your butterfly observations using the recording form provided. A completed sample form has been provided to demonstrate the type of information that is required. Please remember to fill in all blank spaces. When you have completed your data collection, please transfer the data to the blank data form using excel on your computer and email it to me. Or you can print a data form to fill out during your monitoring and scan and email the completed form to Joshua.Shea@kitchener.ca.

Helpful tips and reminders:

- Please use your first and last name for the “recorder” entry
- You can use the local weather observations from the weather station, newspaper, etc. for the start and end temperature of your survey
- Please remember to include am or pm for the start and end time
- See below for an explanation of the Beaufort Wind Scale – monitoring should occur on days with a 0-5 on this scale
- Remember to record any species you observe, even if you do not know what it is - simply describe the colour, shape and size of the butterfly. It is very helpful to carry a camera and take pictures of specimens to examine later or send to Charlotte Moore or another volunteer for identification.
- Information that is useful to include in the “notes” section would be observations of other taxa, such as plants or birds

Contribution to the City of Kitchener and the University of Waterloo

Thank you for taking time to help the City of Kitchener monitor species that are important to the city and its residents, as well as contributing to research for the University of Waterloo. I hope to see you out butterflying!

Beaufort Wind Scale

FORCE	DESCRIPTION	SPECIFICATIONS FOR USE ON LAND
0	Calm	Calm; smoke rises vertically.
1	Light air	Direction of wind shown by smoke drift, but not by wind vanes.
2	Light Breeze	Wind felt on face; leaves rustle; ordinary vanes moved by wind.
3	Gentle Breeze	Leaves and small twigs in constant motion; wind extends light flag.
4	Moderate Breeze	Raises dust and loose paper; small branches are moved.
5	Fresh Breeze	Small trees in leaf begin to sway; crested wavelets form on inland waters.
6	Strong Breeze	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.
7	Near Gale	Whole trees in motion; inconvenience felt when walking against the wind.
8	Gale	Breaks twigs off trees; generally impedes progress.
9	Severe Gale	Slight structural damage occurs chimney-pots and slates removed).
10	Storm	Seldom experienced inland; trees uprooted; considerable structural damage occurs.
11	Violent Storm	Very rarely experienced; accompanied by wide-spread damage.
12	Hurricane	--

Appendix II

Standard Monitoring Form

Butterfly Recording Form - City of Kitchener

Year:	Date:	Recorder:	
Site Name:			
Start Time:	End Time:	Start Temp (°C):	End Temp (°C):
Sun (% of sky):	Wind Speed (0-5 on the Beaufort Scale):		

Species Observed	**Number of individuals**	**Habitat description**	**Total**
Total Butterflies			

Notes:	Beaufort Wind Scale:	
	0 - Calm	7 - Near Gale
	1 - Light air	8 - Gale
	2 - Light breeze	9 - Severe Gale
	3 - Gentle breeze	10 - Storm
	4 - Moderate breeze	11 - Violent storm
	5 - Fresh breeze	12 - Hurricane
	6 - Strong breeze	

Appendix III

Beaufort Wind Scale

FORCE	DESCRIPTION	SPECIFICATIONS FOR USE ON LAND
0	Calm	Calm; smoke rises vertically.
1	Light air	Direction of wind shown by smoke drift, but not by wind vanes.
2	Light Breeze	Wind felt on face; leaves rustle; ordinary vanes moved by wind.
3	Gentle Breeze	Leaves and small twigs in constant motion; wind extends light flag.
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11	Violent Storm	Very rarely experienced; accompanied by wide-spread damage.
12	Hurricane	--