Ground beetles (Coleoptera: Carabidae) of Stanley Park, Vancouver, British Columbia following the storms of December 2006

JOHN A. MCLEAN[1,2] and AGNES LI[1]

ABSTRACT

Ground beetles in Stanley Park were surveyed using pitfall traps in two areas in 2007 that had little damage from the 2006 winter storms and in two areas in 2008 after extensive windfall material had been cleared away and the sites replanted. The most numerous species trapped were *Pterostichus algidus*, *P. herculaneus*, *P. lama* and *Scaphinotus angusticollis*. Seasonal patterns of occurrence and rank order abundance plots are presented.

INTRODUCTION

Winds exceeding 110 km/h during the winter storms of 2006/2007 caused massive areas of blow down in the forests of Stanley Park, a prized recreational and educational area in the city of Vancouver. Stanley Park is Vancouver's oldest and largest park. It was opened by Lord Stanley, Earl of Preston, the Governor General of Canada in 1888 (Steele 1988). The central feature of the park is the 300 ha of uneven-aged coastal temperate rainforest that is largely classified under the BEC system as CWHdm (Green and Klinka 1994). Stanley Park was the site of several First Nations (aboriginal) villages before the arrival of Europeans in the 19th century. The forest was selectively logged between 1860 and 1880 and later protected from further development when it was designated as a military reserve (Vancouver Park Board 2003-09).

The first records of insects in Stanley Park were made by Swaine (1914). Major control operations were carried out in Stanley Park for the western hemlock looper, *Lambdina fiscellaria lugubrosa* (Hulst) in 1930 and again in 1959 when there was an outbreak of the western hemlock looper and the greenstriped forest looper, *Melanolophia imitata* (Walker) (Richmond, 1986). The most recent control program was against the Asian Gypsy Moth, *Lymantria dispar* L. in 1992 (Van Sickle and Wood, 1994). Humble (2008) reported that 99 species of beetles, 122 species of moths and 11 species of sawflies have been recorded from Stanley Park and adjacent forest habitats on the North Shore by the Forest Insect and Disease Survey between 1949 and 1995.

A restoration plan was developed to guide the recovery of the park after the 2006/07 winter storms (Vancouver Park Board 2007). As part of the restoration plan, seasonal surveys of the moths were carried out (deWaard *et al*. 2009) as well as trapping for bark beetles and wood borers with semiochemical-baited traps. A series of pitfall traps were set out to survey epigaeic fauna. The rove beetles (Coleoptera:Staphylinidae) caught in these traps and in the funnel traps have been listed by McLean et al. (2009a, b). The objective of this study is to report the results of the seasonal survey of the carabid ground beetles in undamaged areas in 2007 and to compare patterns of occurrence with areas where extensive blow down had been removed and areas replanted in 2008.

[1] Department of Forest Sciences, Faculty of Forestry, University of British Columbia, #3034-2424 Main Mall, Vancouver, BC V6T 1Z4
[2] Corresponding Author: john.mclean@ubc.ca

MATERIALS AND METHODS

The Study Areas. In 2007, a stand by the Vancouver Aquarium (49°18'02"N, 123°07'04"W) (Fig. 1, Site A) with a small amount of blow down (Fig. 2A) was designated as a natural disturbance site where no restorative actions would be undertaken. The second study site for 2007 was an undamaged mixed-age conifer forest to the east of Rawlings Trail south of the Hollow Tree (49°18'22"N, 123°09'11"W) (Fig. 1, Site B). This site experienced damage from Hurricane Freda in 1962 and has immature trees from that time as well as mature trees that survived the hurricane (Fig. 2B). The 2008 study sites included a stand to the west of the South Creek Trail (49°18'03", 123°08'25"W) (Fig. 1, Site C) which had been logged and also burned in the 1860 fire. The high stumps (Fig. 2C) are a remnant from that period. The site was cleared of all fallen trees and replanted in the fall of 2007 with clumps of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and western redcedar (*Thuja plicata* Donn). The second 2008 study site along Merilees Trail (Fig. 1,Site D) (49°18'40"N, 123° 09'02"W) had also been cleared and replanted in the same manner as Site C (Fig. 2D).

Field Collections. In 2007, five pitfall traps were set out in each of Sites A and B. These traps were set out in association with a series of semiochemical-baited multiple funnel traps set out at 25m intervals to survey bark beetles and wood borers. In 2008, a sixth baited multiple funnel trap was added to the survey along with a sixth pitfall trap in Sites C and D. Cavities for the pit fall traps were excavated with a bulb planter. This allowed for minimal disturbance of the litter layer and the installation of two plastic 450mL plastic cups, 8 cm lip diameter and 10 cm deep, that were inserted so that the inner cup lip was at litter level. The outer cup retained the soil allowing easy removal of the inside cup for sample collection. The 75mL of polypropylene glycol was changed at each collection. Each pitfall trap was covered by a 30 cm by 30 cm square of marine plywood supported on 3 cm risers on each corner to act as a rain and debris cover. Phillips and Cobb (2005) showed that opaque covers over pitfall traps do not adversely affect carabid catch rates. Traps were set out in 2007 on April 20th and collected every two weeks until the end of August. In 2008, traps were set out on April 23rd and collected monthly until the end of October.

Sample analyses. Samples were sorted at UBC Forestry and the ground beetles identified with the aid of the Lindroth (1961-69) keys to the ground-beetles of Canada and Alaska. Total catches for each year were tabulated and a rank abundance graph (Southwood and Henderson 2000) was prepared for each site to demonstrate species abundance and species richness. Graphs of the seasonal occurrence of the dominant species were also prepared.

Sørenson's similarity coefficient (C_s) (Southwood and Henderson 2000) was determined among all sites. $C_s = 2J/(2J + A + B)$ where A = the number of species unique to Site A, B = the number of species unique to Site B and J = the number species common to both. This index is rated as one of the better similarity measures by Smith (1986).

RESULTS AND DISCUSSION

A total of 629 carabid beetle specimens (15 species in 8 genera) were captured, of which only 10 specimens (3 species in 3 genera) were non-native. The most numerous species collected in 2007 at Sites A and B were *Pterostichus algidus* LeConte and *P. herculaneus* Mannerheim. At Site B, moderately large numbers of the larger species *Scaphinotus angusticollis* (Fischer von Waldheim) and *P. lama* (Ménétriés) were also collected (Table 1); see also the rank abundance curves for 2007 (Fig. 3). In 2008, *P. herculaneus* and *S. angusticollis* were the more numerous species at Site C

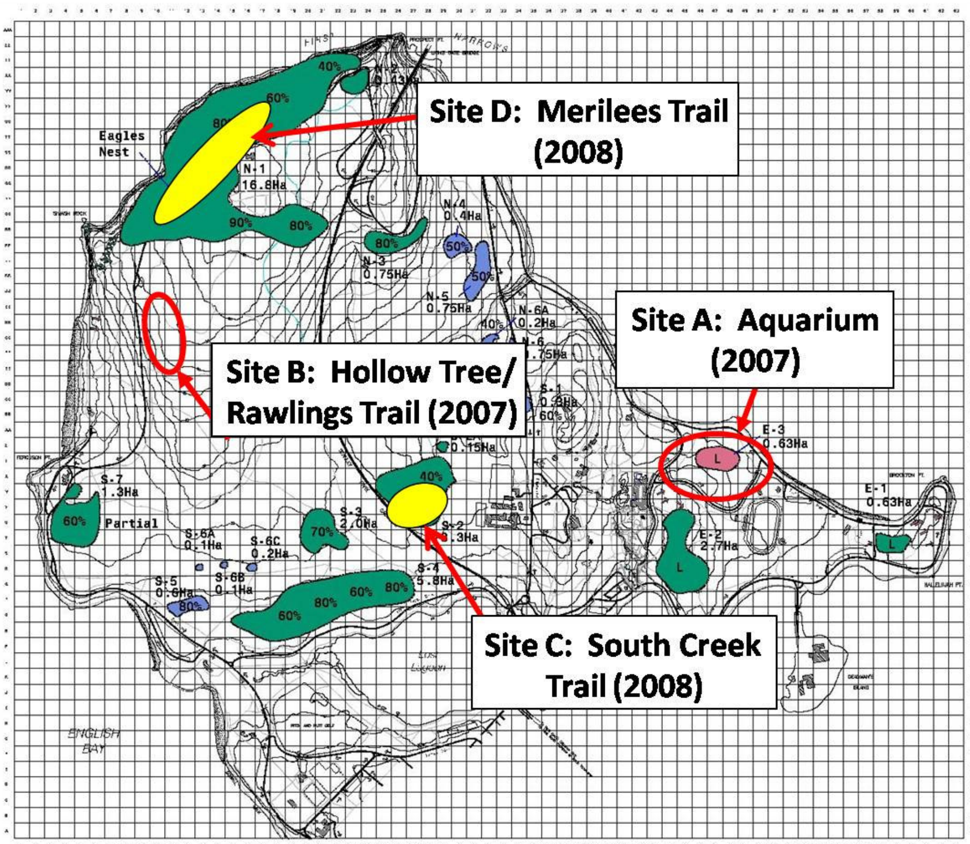

Figure 1. Map of Stanley Park showing the locations of pit fall traps in 2007 and 2008.

while *P. algidus* and *P. herculaneus* were more numerous at Site D (Table 1). The major difference between Site C and the other three sites was that the duff layer in Site C had been considerably disturbed during log removal and the subsequent fine woody debris redistribution activities. The rank abundance curves for 2008 show that two species were dominant on sites C and D (Fig. 3). Just three non-native species, *Carabus nemoralis* O.F. Müller, *Calathus fuscipes* (Goeze) and *Pterostichus melanarius* (Illiger), were captured over the two years. Sørenson's coefficients between pairs of sites (Table 2) showed considerable commonality of species in this CWHdm environment of Stanley Park.

Other ground beetles captured included *Calathus fuscipes* (Goeze), *Lebia marginicollis* Dejean, *Leistus ferruginosus* Mannerheim, *Notiophilus sylvaticus* Eschscholtz, *P. crenicollis* LeConte, *S. angulatus* (T.W. Harris), *S. marginatus* (Fischer von Waldheim) and *Trachypachus holmbergi* Mannerheim.

Pterostichus herculaneus was caught most consistently throughout the trapping period on each of the four study sites with individuals being caught during each collecting period (Fig. 4). Johnson *et al.* (1966) reported this species in a dense stand of Douglas-fir as well as a recently logged stand in Washington State and that it fed readily on Douglas-fir seed. Niwa and Peck (2002) recorded consistent activity of *P. herculaneus* from July through October in a Douglas-fir forested area in Oregon.

Very few *Pterostichus algidus* were captured in July of both years (Fig. 4). This species is more active in the spring and fall. Very low catches were recorded at Site C which was the most disturbed site as a re-

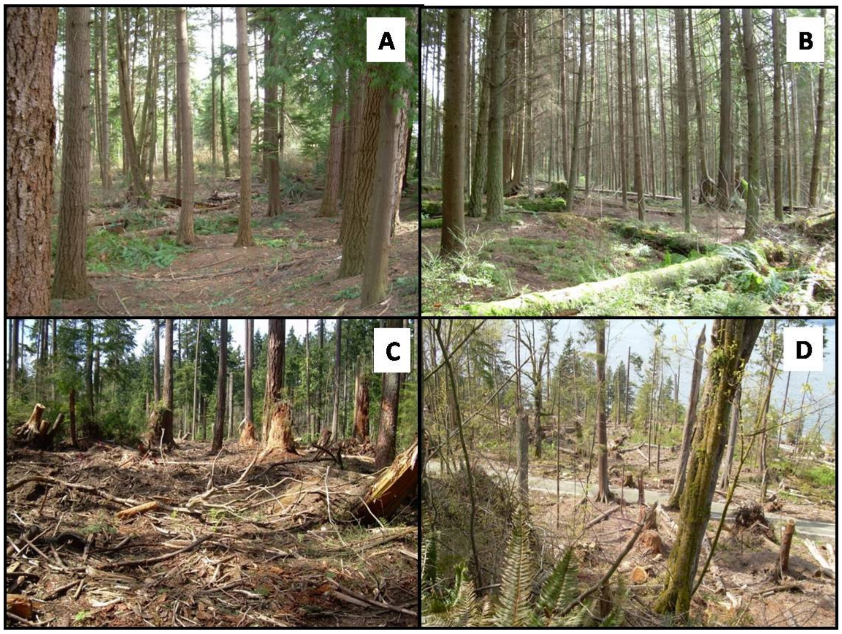

Figure 2. Photographs of study sites with pit fall traps to survey ground fauna in 2007 and 2008. A. A stand near the Vancouver Aquarium (2007); B. The forest to the eastern side of Rawlings Trail south of the Hollow Tree (2007); C. The cleared forest to the west of the South Creek Trail (2008); D. A view of the restored area along Merilees Trail (2008).

sult of repeated traveling of heavy logging equipment over the same trails even though brush mats were used. Another taxon that showed a similar reduction in catch numbers at Site C was the Isopoda, dominated by the wood louse *Oniscus ascellus* L. (Isopoda: Oniscidae) where we collected 894, 83, 43 and 313, at Sites A, B, C and D respectively, during the same collecting periods.

Pterostichus algidus was reported by Johnson *et al*. (1966) to have a similar temporal catch profile in Washington State and that the beetle was a consistent eater of Douglas-fir seed. The larger *Pterostichus lama* was trapped most frequently in the June/July period at both Site B (2007) and Site C (2008) (Fig. 4). Johnson *et al.* (1966) reported that *P. lama* would eat Douglas-fir seed only as a last resort. We have no additional data on this species' trophic relationships. The largest catches of *S. angusticollis* were in the fall of 2007 at Site B and in the fall of 2008 at Site C (Fig. 4). *S. angusticollis* is reported as feeding on snails, slugs, earthworms and spiders (Larochelle and Larivière 2003) as well as juvenile western red-backed salamanders (*Plethodon vehiculum* Cooper) in captivity (Ovaska and Smith 1988). Ovaska and Smith (1988) further noted that *S. angusticollis* preferred slugs <25 mm long, the larvae feed on live snails and adults will feed only on crushed snails.

A search among rotting logs on Site A in February 2008 found two overwintering *P. algidus* along with a large number *O. ascellus* and a small colony of dampwood termites, *Zootermopsis angusticollis* (Hagen) (Isoptera: Hodotermitidae). The two *P. algidus* were placed in a small terrarium with rotting wood, 5 wood lice and 5 termite nymphs along with one soldier termite as well as two piles of 10 Douglas-fir seed. The soldier termite was eaten, one wood louse was dismembered and one and a half seeds were eaten over a six week period. More accurate detailed feeding studies should be carried out to fully characterize the ecological niche of the ground beetles, including the habits of developing larvae, if we are to more fully appreciate

Table 1.
Ground beetles captured in Stanley Park in 2007 (April to October) and 2008 (May to October), n = number of pit fall traps per site.

	Site A: Aquarium 2007 (n = 5)			Site B: Hollow Tree 2007 (n = 5)			Site C: South Creek Trail 2008 (n = 6)			Site D: Merilees Trail 2008 (n = 6)		
Rank		#	%		#	%		#	%		#	%
1	*Pterostichus algidus*	75	58.6	*P. algidus*	63	35.8	*P. herculaneus*	66	47.8	*P. algidus*	81	43.8
2	*Pterostichus herculaneus*	44	34.4	*P. herculaneus*	62	35.2	*S. angusticollis*	49	35.5	*P. herculaneus*	74	40.0
3	*Notiophilus sylvaticus*	3	2.3	*S. angusticollis*	22	12.5	*P. lama*	13	9.4	*S. angusticollis*	9	4.9
4	*Scaphinotus marginatus*	3	2.3	*P. lama*	20	11.4	*P. algidus*	4	2.9	*C. nemoralis*[1]	7	3.8
5	*Calathus fuscipes*[1]	1	0.8	*L. ferruginosus*	2	1.1	*S. angulatus*	2	1.4	*Harpalus cordifer*	4	2.2
6	*Leistus ferruginosus*	1	0.8	*S. angulatus*	2	1.1	*S. marginatus*	2	1.4	*P. crenicollis*	3	1.6
7	*Scaphinotus marginatus*	1	0.8	*S. marginatus*	2	1.1	*Lebia marginicollis*	1	0.7	*P. lama*	2	1.1
8				*Carabus nemoralis*[1]	1	0.6	*N. sylvaticus*	1	0.7	*L. marginicollis*	1	0.5
9				*P. crenicollis*	1	0.6				*N. sylvaticus*	1	0.5
10				*P. melanarius*[1]	1	0.6				*S. angulatus*	1	0.5
11										*S. marginatus*	1	0.5
12										*Trachypachus holmbergi*	1	0.5
Totals		128	100		176	100		138	100		185	100

[1] Species of recent European origin in British Columbia (Spence and Spence 1988)

Table 2.
Sørenson's coefficient (C_s) for pairwise comparisons of the species similarity between the four sites sampled in 2007 and 2008 in Stanley Park.

	Site B (2007)	Site C (2008)	Site D (2008)
Site A (2007)	0.63	0.67	0.53
Site B (2007)		0.71	0.76
Site C (2008)			0.80

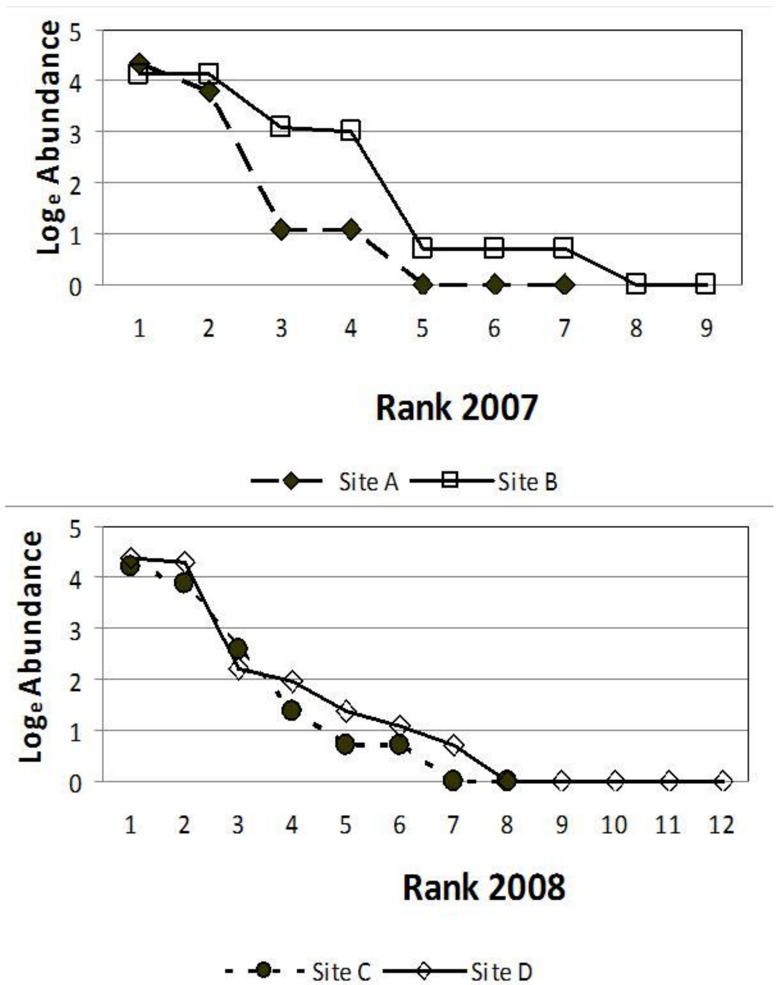

Figure 3. Rank abundance curves for the carabid beetles collected in Stanley Park in 2007 and 2008.

their roles and to more clearly understand the processes that are presumed to be disrupted by forest management activities. Work et al. (2008) have evaluated carabid beetles as indicators of forest change in Canadian boreal forests east of the Rocky Mountains. Unfortunately only 5 of the 93 species they ranked were found in this study and then only as minor species. The carabid fauna in BC is quite distinct and needs further detailed investigation.

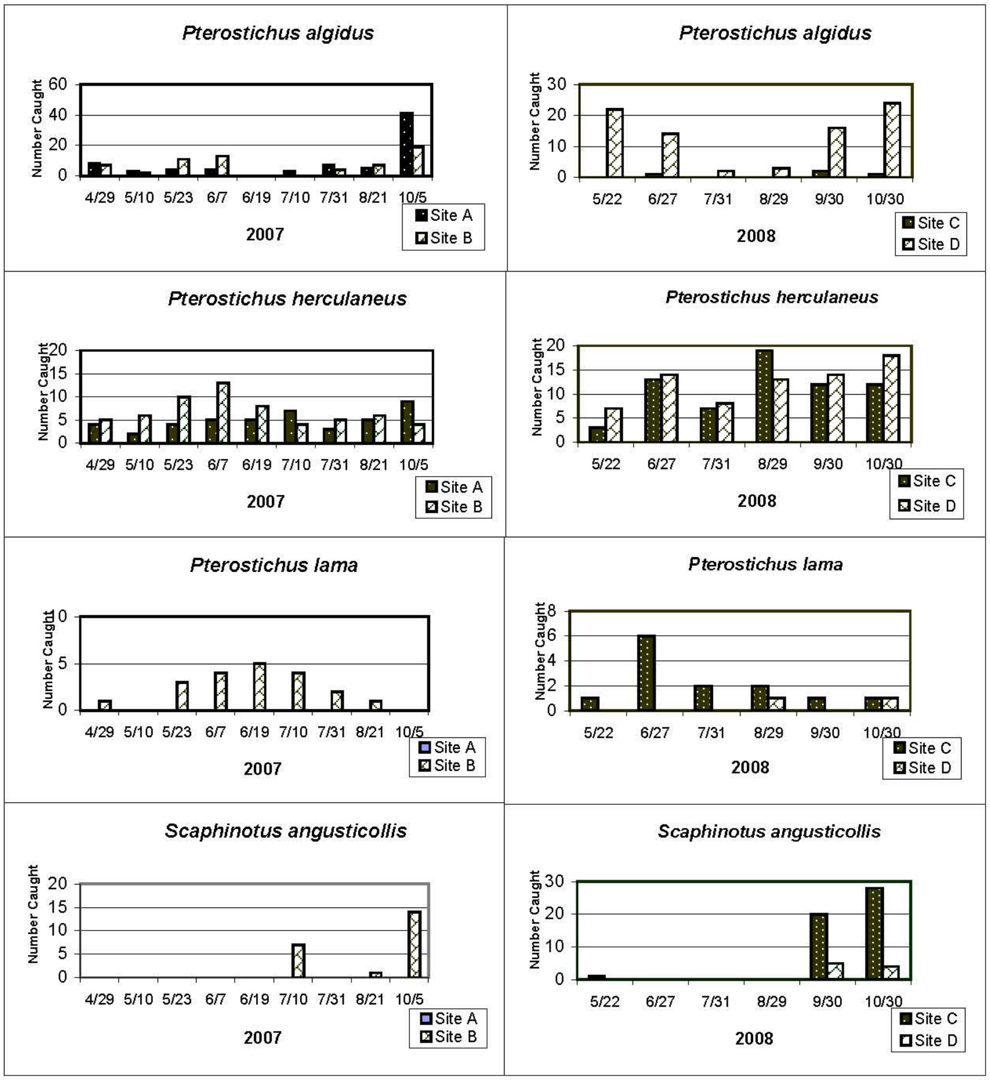

Figure 4. Seasonal abundance of the four most abundant species of ground beetles during 2007 and 2008. Numbers shown represent the total catches from 5 traps in 2007 and 6 traps in 2008.

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