

The Grey Squirrel

Ecology & Management of an Invasive Species in Europe



Edited by

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EUROPEAN SQUIRREL INITIATIVE

2. Grey squirrel invasions in western Canada: History repeats itself (again, and again)

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Summary

Canada shares with the United States of America (USA) the dubious distinction of containing both native and introduced populations of the eastern grey squirrel (*Sciurus carolinensis*). One reason for this situation is that the two countries span the North American continent and thus encompass that region where the species is endemic. At the same time, geographic barriers, habitat discontinuity and the presence of species with overlapping niches historically have prevented the grey squirrel from spreading naturally into other areas of the continent that are now proving suitable for colonization. In Canada, as in other locations on the globe, introduction of this species into different regions has its origin in human-assisted transportation, in some cases quite intentional.

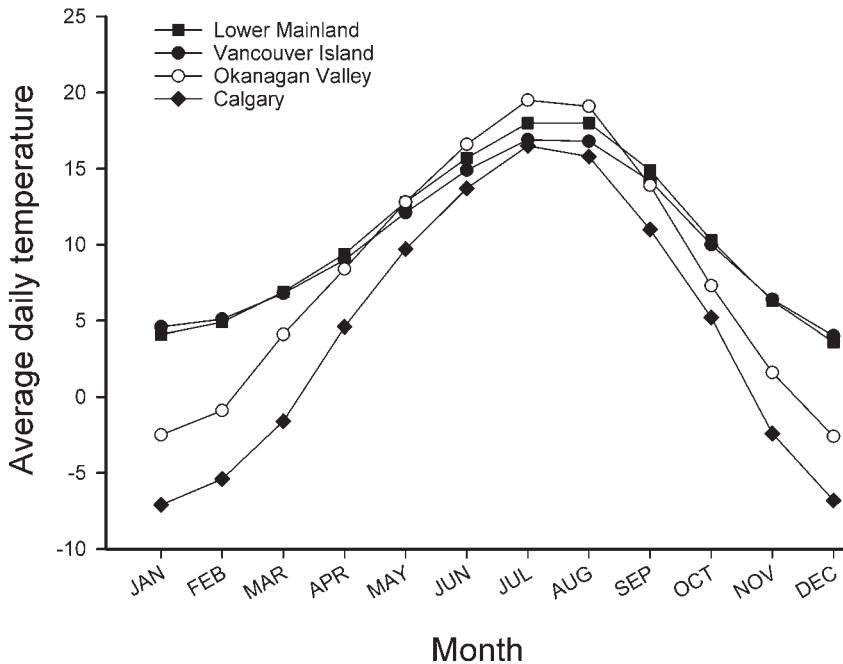
This chapter provides an overview of the establishment of eastern grey squirrels in western Canada, principally west of the continental divide and in the province of British Columbia (BC). Even within these political borders, the animal has been introduced on at least three separate occasions (the first being intentional), with the most recent occurring within the past decade. In all of these cases, the establishment of the animals took place in anthropogenic habitat, although subsequent spread into natural or semi-natural habitat is now occurring in at least two locations. BC contains a diverse array of ecosystems, and thus provides an interesting (if unwanted) opportunity to study where, and how, the animal may tolerate conditions outside of the urban environment.

A surprising lack of research, much less managerial intervention, typifies the grey squirrel introductions in BC, unlike that currently seen in western Europe. Thus, in this chapter I will not be able to draw heavily from the peer-reviewed literature, rather having to rely to a large degree on unpublished work and personal communications. Still, the goal of this chapter is to provide an overview of the grey squirrel introductions and the implications of such (realized, suspected, and predicted) in a more detailed fashion, adding in where possible information collected by myself and others in recent years. My intention is to add to the growing awareness of this species' capacity to invade a wide range of ecosystems and geographical regions, especially in the absence of pro-active or immediate managerial response.

Western Canada - repeated introductions of the eastern grey squirrel.

The appearance of the eastern grey squirrel (*Sciurus carolinensis*) in western Canada took place via an intentional release of a small number of animals into Stanley Park in the early 1900s (see Steel et al. 1985, Gonzales 2000 and Nagorsen 2005). Stanley Park is a reasonably large ($\geq 4 \text{ km}^2$) municipal park within the sprawling city of Vancouver. It protects a remnant of the original west coast forest ecosystem, a mixture of conifer and deciduous trees and intensively cultivated parkland. The fact that the park is situated on a peninsula effectively 'blockaded' by the urban environment of Vancouver likely hampered the spread of the animals for over half a century. But, as detailed by Nagorsen (2005), during the latter part of the 1900s the animal began appearing in other areas of coastal British Columbia (BC), a region referred to in BC as the 'Lower Mainland'. This region has a relatively mild climate by Canadian standards, with winter temperatures rarely approaching freezing (Figure 1).

Figure 1. Comparison of average daily temperatures ($^{\circ}\text{C}$), by month, for the four principle sites of grey squirrel introductions in western Canada. Data are 30-year norms (1981-2010) for the airport weather stations at Vancouver (Lower Mainland), Victoria (Vancouver Island), Kelowna (Okanagan Valley) and Calgary. Source: Environment Canada (http://climate.weather.gc.ca/climate_normals).



The Lower Mainland landscape also is densely populated by humans which, combined with the climate, has favoured the easterly (inland) expansion of the introduced grey squirrels for at least 75 kilometres (km). However, beyond this point the abrupt rise of the Coast Mountain Range provides a dispersal barrier to the animals, with the coastal environment quickly being replaced by expansive high-elevation conifer forests, considerably fewer human settlements, and more severe seasonal weather patterns. No such barrier exists to the south of the Lower Mainland, and with the Canada-United States of America (USA) border situated nearby (see Figure 2), the range of the eastern grey squirrel in western Canada has become essentially contiguous with the population of the animals introduced along the coastal region of Washington State and Oregon.

The second major introduction of eastern grey squirrels into BC took place on Vancouver Island (Figure 1). Over 30,000 km² in area, Vancouver Island is less than 20 km distant from both the USA and the Lower Mainland of BC. Archipelagos of islands lie in the straits separating Vancouver Island from the continent, suggesting that in theory, grey squirrels may have been able to eventually reach the larger Vancouver Island by island-hopping, if not via the steady transport of motor vehicles by the large ferry fleet. Interestingly, an early attempt (≈ 1945) to establish grey squirrels in the largest municipal park in the Greater Victoria system met with failure (G. Smith, personal communication). However, an escape in the early 1960s by three captive animals led to the establishment of the current population on the southern end of the island (Nagorsen 2005). Eastern grey squirrels began appearing in city parks during the 1990s and by 2005 they were well established (G. Smith, personal communication). Whether the three founding animals were augmented by other individuals in subsequent years is not known.

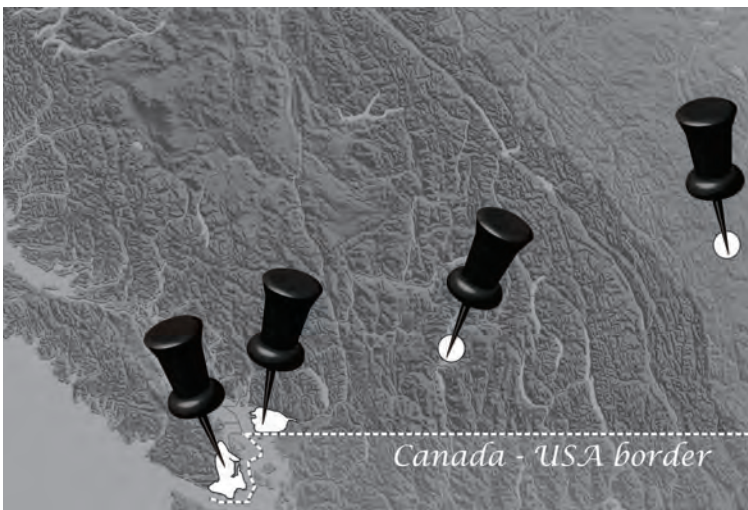


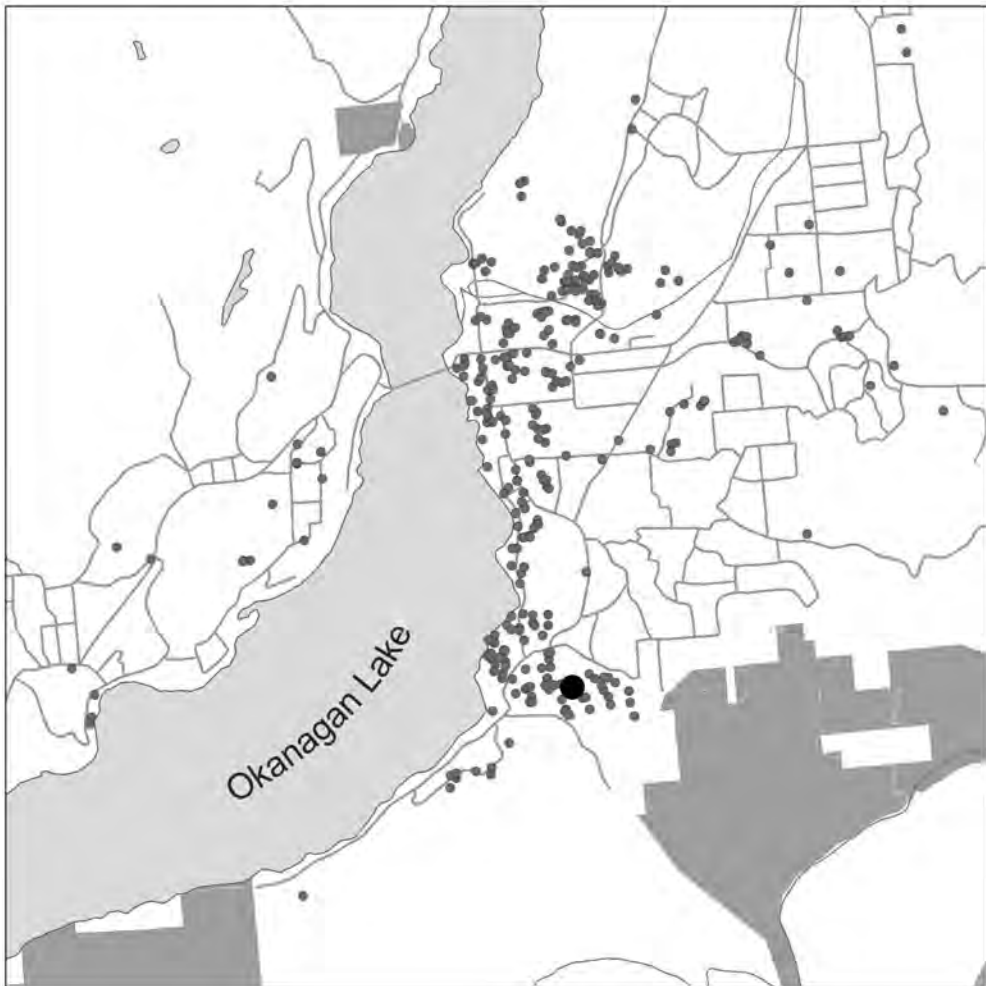
Figure 2. Principal locations of eastern grey squirrel (*Sciurus carolinensis*) introductions in western Canada. From left to right: southern Vancouver Island (including the City of Victoria), the 'Lower Mainland' region of British Columbia (including the City of Vancouver), the Okanagan Valley (principally the City of Kelowna) and the City of Calgary, Alberta.

Like the Lower Mainland of BC, much of Vancouver Island experiences a mild climate (Figure 1) that favours lower-elevation forests with a substantial broadleaf tree component. Although initially a confined population, grey squirrels have spread along the eastern (mainland-facing) coast of Vancouver Island. Once again, predominant conifer forests at higher elevations or harsher climate zones may have prevented the animals from further spread, but the intentional transport and release of animals has likely negated any such effect and hastened the spread of the animals (Nagorsen 2005). The relocation of trapped, nuisance animals by homeowners or even professional pest-control agencies has been suggested as a likely mechanism of spread for the grey squirrels (Fraser, personal communication). A detailed spatial analysis of the dispersal of grey squirrels across Vancouver and the Lower Mainland also concluded that the distribution of the animal at the time of the study was best explained by a combination of unassisted and human-assisted dispersal (Gonzales 2000). Newer restrictions, penalties and education efforts have been brought in by the BC government to discourage these practices (Sigg, personal communication). Indeed, grey squirrels are now known to populate a number of the smaller islands that lay immediately off the coast of Vancouver Island, having arrived there through either intentional or accidental transport via ferries (Hanke, personal communication) or private boats (Fraser, personal communication). Interestingly, on at least two of these islands (Newcastle and Sidney) the populations of the animals have been removed through action by the provincial parks authority (Fraser, personal communication).

The third and most recent distinct establishment of grey squirrels in BC occurred within the interior of the province, at a considerable distance from the potential source population on the Lower Mainland. The City of Kelowna, within the centre of the Okanagan Valley, appears to be the epicentre of this recent introduction, although reliable reports of grey squirrels also have been made from neighbouring cities of Vernon and Kamloops. Kelowna is approximately 300 km distant from the Lower Mainland, and the mountainous intervening topography of BC strongly suggests the founding animals in this population were transported by humans. Communications from members of the public and government agencies indicate grey squirrel sightings were becoming more common by 2009, although the appearance of the animals in backyards occurred as early as 2004 (Harborne, personal communication) By 2009, the animals were routinely sighted within a handful of 'greenbelts' within the city, and by 2012 the animals were more established and had moved across a large lake into the neighbouring municipality of West Kelowna, likely via a motorway bridge (Figure 3). Still, only a modest number of sightings (n=27) of the animals were reported by having the species incorporated into the 2012 Christmas Bird Count for Kelowna and neighbouring cities (this is an annual mid-winter survey for birds conducted through volunteer effort, under the auspices of the Audubon Society). All of these sightings came from within the City of Kelowna. I had this procedure repeated during the Christmas Bird Count in 2015, yielding a count

of 22 grey squirrels in Kelowna, and zero animals in the neighbouring cities within the Okanagan Valley. This suggests a substantial expansion or increase in the density of the animals may not have occurred, but too many uncontrolled variables in the survey method make such a conclusion very tentative.

Figure 3. Reports of Eastern Grey Squirrels within the City of Kelowna, in south-central British Columbia in 2011-2012. The locations were submitted by members of the public in response to a media awareness and sighting-request campaign by the author. Reports were cumulative up to the time of the survey, hence the locations on this map almost certainly include non-overlapping generations of the animals, and possibly multiple sightings of the same individuals. The earliest known appearance of grey squirrels in the area is indicated by a larger black circle. Protected (natural) areas appear in dark grey.



What makes the Okanagan Valley introduction particularly interesting is that the climate in this region is considerably different from the two previously-described locations within the province (Figure 1). This region has a relatively warm and arid climate, being influenced by air flow out of the Great Basin Desert in the USA. Summer temperatures above 40°C can occur in the Okanagan, and although snowfall and sub-zero temperatures are common in winter, the extremes seen elsewhere in the mountainous and northern regions of BC are uncommon. This climate favours grasslands with cacti and other xeric plant species in the warmer valley bottoms, where (not by coincidence) the density of humans is highest. Starting at approximately 600 metre elevation, these grasslands give way to dry forests (Ponderosa Pine, *Ponderosa pinus*, and Douglas-fir, *Pseudotsuga menziesii*) that are in turn replaced by other conifer forest types at higher elevations. Aspen (*Populus tremuloides*) is the only native deciduous tree that can be found in small stands at lower elevation, although a related species, the Black Cottonwood (*Populus balsamifera*), occurs along riparian habitat.

As per most cities and towns in temperate North America, artificial watering and selective planting has allowed the establishment of a wide variety of other tree species in the Okanagan Valley, including those found in the Eastern Grey Squirrel's native habitat (e.g. maples, *Acer spp.*). The warm climate that attracts humans to this region also makes it important for agriculture in BC, being one of the few fruit- and wine-producing regions in Canada. Thus, farms (vegetables, orchards, and wine grapes) cover much of the valley outside of the major cities and towns. The extent to which grey squirrels will be able to extend their range throughout and beyond the Okanagan Valley via anthropogenic habitat is not known, much less being formally monitored. The dry, arid native forests (occupied by the North American pine squirrel, (*Tamiasciurus hudsonicus*), albeit in low densities) should prove unsuitable for grey squirrels, although at the present time this also cannot be verified.

Introduced grey squirrels appear elsewhere in western Canada, the most notable location being in Calgary, Alberta (see Figure 1). A common statement from people I surveyed in Calgary and Alberta was that grey squirrels were released intentionally in 1938 in the vicinity of the Calgary Zoo, although I could find no formal reference to this, much less a specific date of release. The animals are now widely spread within Calgary and possibly within smaller neighbouring communities (Edwards, personal communication). Aside from the occasional report of an individual animal further away, there is no suggestion that the species has been able to extend its range outside of city limits (Court, personal communication). Calgary lies in the prairie region of Canada, an area subject to continental weather patterns (Figure 2) that include extreme weather due to arctic outflows of cold air (i.e. < 30°C). Moreover, Eastern Grey Squirrels extended their range from eastern Canada into the prairie provinces of Manitoba and Saskatchewan during the first half of the 1900s, likely in response to human agriculture, windbreak plantings, and development (Woods 1980;

Naughton 2012). Artificial retreats (e.g. buildings) coupled with supplementary food sources (e.g. birdfeeders) will only serve to facilitate the persistence of populations through harsh winter weather. All told, the squirrel's presence in the Canadian prairies and the northern regions of their native habitat clearly reveals the animals can withstand conditions much harsher than those at the introduction sites in BC.

Multiple introductions in the same jurisdiction – how so?

The intentional, planned introduction of grey squirrels into the lower mainland of BC occurred well before the implications of alien species were firmly established. Indeed, the first significant monograph on invasive species (Elton 1958) was not to appear for nearly half a century afterwards. The realization that invasive species posed significant threats was more firmly established by the time grey squirrels appeared on Vancouver Island, yet an early assessment (much less on-the-ground action) did not occur. The most recent establishment of grey squirrels in the Okanagan Valley is more difficult to defend, given the notoriety of the animal in the same province, along with its listing as one of the world's 100 most invasive species by the IUCN (Lowe et al. 2000). Further, the presence of the animals in the Okanagan also was verified relatively early, when control and/or eradication methods may have been at least entertained (see Shuttleworth et al. this volume, Chapter 24). At that time, BC was lacking a formal government strategy that enabled and funded rapid managerial responses towards invasive species. Focus on invasive species in general (as opposed to just plants) by both the provincial government and the renamed Invasive Species Council (ISC) of BC has only recently occurred, so established programmes were absent during the initial appearance of grey squirrels in the Okanagan. Although a more comprehensive strategy has now been released (Government of British Columbia 2012), dedicated funding to convert recommendations into reality has not yet materialized. Further, the more recent development of an 'Early Detection Rapid Response' plan (www.for.gov.bc.ca/hra/invasive-species/edrr.htm) outlines how the provincial government should respond to *new* invasions within the province, but does not cover invasive species well established in one part of the province that become introduced elsewhere. At the federal level, Canada has had a national strategy on invasive species for a longer period of time (Government of Canada 2004), yet funding available through the federal Invasive Alien Species Partnership Programme was terminated in 2012 and has not yet been re-established in any similar form. In Canada, wildlife is a resource falling primarily under provincial jurisdiction, and hence immediate response to invasive species, such as those envisioned by Ricciardi et al. (2011), likely will need to be spearheaded by provincial governments.

Undoubtedly another important roadblock in formal grey squirrel control is the outward appeal of the animal, a problem suggested elsewhere in this volume (see Bertolino et al. this volume, Chapter 25). Shortly before the presence of

grey squirrels in the Okanagan Valley was recognized, the City of Kelowna became embroiled by controversy over the control of a feral rabbit population. Opposition to culling led to the capture and sterilization of over 170 rabbits and the building of holding facilities (Seymour 2009) that ultimately failed to eliminate the animals. Other city councils in BC have experienced similar problems over large numbers of urban deer (Crawley 2015), and Bertolino and Genovesi (2003) outlines how opposition to a trapping programme for grey squirrels in Italy led to a suspension of field work for a critical period of time. Experiences of this nature undoubtedly make all levels of government reluctant to sanction much less fund culling or other control measures, especially without lengthy bouts of stakeholder involvement. The immediate control of species less attractive and/or clearly linked to economic or other direct impacts on humans will be more palatable (e.g. snakehead fish - Love et al., 2015). Certainly, numerous articles outlining the undesirable appearance of grey squirrels in the Okanagan appeared in various media formats, yet neither the municipal or provincial government launched any control action. The fact that introductions have tended to occur within municipal boundaries (Victoria, Kelowna, etc.) complicates the issue further. Yet another obstacle is limited public awareness that the eastern grey squirrel (despite its common name) is in fact an invasive non-native species in western Canada (Sigg, personal communication; author personal observation). This misconception may be due in part to the long history of the animal in the Lower Mainland, such that people consider the animal native to BC.

Overall, a lack of clear, demonstrable impacts by *S. carolinensis* in BC on human values and/or ecosystems may be the single most important reason that repeated introductions of the species have been tolerated. Bruemmer et al. (2000) provided a breakdown of the impacts grey squirrels had effected in Great Britain and Italy, and discussed the implications for the introduction of the species on Vancouver Island. A more detailed and updated summary of grey squirrel introductions is presented in this volume (Table 2 in Gurnell et al. this volume, Chapter 16). Although the list is lengthy, the lack of research in western Canada means analogous impacts can be neither proven or disregarded. In fact, research to date specifically investigating the impact of grey squirrels in BC has been nearly non-existent, in part because of a lack of dedicated sources of funding, but also because, realistically, projects addressing known problems almost always will be assigned higher priority than pro-active, exploratory work (Liu et al. 2011).

Are grey squirrels causing impacts in British Columbia? Bruemmer et al. (2000) forecasted two main consequences of the grey squirrel introduction to Vancouver Island, one being impacts on the Garry Oak (*Quercus garryana*) ecosystem. This ecosystem is now constrained to less than 5% of its original (and restricted) distribution in Canada (Garry Oak Ecosystems Recovery Team 2013). Although references to grey squirrels appear in Garry Oak management

documents and websites (e.g. Garry Oak Ecosystems Recovery Team 2013; Parks Canada Agency 2006), the impact of the animal is largely supposed or inferred from research done elsewhere, in other ecosystems (see Steele et al. 2005 and references therein). Fuchs et al. (2000) investigated factors affecting the emergence and early survival of Garry Oak seedlings in habitats frequented by *S. carolinensis* and another known consumer of acorns, the Steller's Jay (*Cyanocitta stelleri*). Although they were unable to identify specific predators on buried acorns, they concluded that vertebrates removed just over half of the acorns placed on the surface, and buried acorns were disturbed less. All told, 7-48% of buried acorns were removed by vertebrates, suggesting that grey squirrels have some impact on the recruitment of oak seedlings.

From studies in the native range of the grey squirrel, it is clear that that the animals can impact oak forests through acorn consumption and caching, particularly when the latter includes embryo excision to prevent germination (Steele et al. 2005). Given that embryo excision is an innate behaviour, likely refined through learning, it is highly probable that grey squirrels would be affecting Garry oak acorns in this matter (Steele, personal communication), although specific reports of such do not appear to exist. Selectivity and caching behaviour of grey squirrels in the Garry Oak ecosystem in BC needs to be examined more purposely. Impact on other species of plants associated with the Garry Oak ecosystem through stripping or seed predation (*cf.* Gurnell & Pepper 1998) is also suspected but not yet proven (Fraser, personal communication).

Bruemmer et al. (2000) also provided a rationale suggesting that grey squirrels in BC would impact the smaller native pine squirrels, (*Tamiasciurus hudsonicus*), and Douglas' squirrels (*T. douglasii*). Impact on pine and Douglas' squirrels was predicted to take place primarily through displacement, principally within hardwood/mixed forest stands and in urban settings, where the adaptive and specialized traits of the native species to conifer habitat would afford less of an advantage. The social system of the grey squirrel also allows higher-densities of the animals compared to the self-limiting territorial behaviour of *Tamiasciurus*. This same aggressive behaviour may allow *Tamiasciurus* to challenge and repel individual grey squirrels, something I have witnessed. However, I also have observed a single pine squirrel attempting to repel three grey squirrels simultaneously, likely a costly task in terms of energetics. On south-eastern Vancouver Island, there is a strong sentiment that the abundance of pine squirrels has become greatly diminished in areas where grey squirrels are numerous (Fraser, personal communication), but quantitative data do not yet exist.

In 2012, I conducted an awareness campaign in Kelowna and neighbouring regions in order to solicit sightings and observations of grey squirrels from the public. Over 400 reports were received, most simply providing locations of grey squirrel observations; however, multiple reports (> 15) cited the

disappearance of pine squirrels from neighbourhoods and properties, along with the coincidental establishment of grey squirrels. One resident observed a grey squirrel carrying a 'dead pine squirrel'; this occurred at a time (early April) when female grey squirrels would not likely be relocating their partially-grown offspring, although scavenging of a pine squirrel carcass remains another plausible explanation (also filed were six reports of pine and grey squirrels foraging side-by-side on the ground or at bird feeders). North American pine squirrels also have disappeared from parks in the Greater Victoria system (Smith, personal communication), again coinciding with the spread of grey squirrels. These observations suggest that at least on a local scale, within urban and rural environments, grey squirrels may be capable of replacing *Tamiasciurus*, although the exact mechanism has not yet been established. Whether the same can be said for more-natural areas, even those containing large amounts of deciduous forest, is less clear.

Working in the lower mainland of BC, Gonzales et al. (2008) used records of grey squirrels and two native squirrels (Douglas' squirrel, and northern flying squirrel, *Glaucomys sabrinus*) supplied from three wildlife shelters for a non-spatial analysis, and found no indication that grey squirrels were replacing the native squirrels on the scale of municipalities. Their work instead suggested that native squirrels declined with a loss or alteration of native conifer habitat, rather than the incursion of grey squirrels. However, the scale of their work also precluded analyses on factors such as the size, quality and spatial separation of habitat patches. These are likely important factors: enclaves of native squirrels within small or remnant patches of suitable habitat are likely extirpated through increasing numbers of grey squirrels over the larger landscape, a situation analogous to that seen in the United Kingdom (UK) with grey squirrels and the Eurasian red squirrel (*Sciurus vulgaris*) (Koprowski 2005). Hwang and Larivière (2006) tested for inter-specific competition by comparing Douglas' squirrels in Stanley Park (where grey squirrels exist) with those in another municipal park devoid of grey squirrels. They found no differences in density, body mass, or home range size of Douglas' squirrels in the two populations (although the latter was estimated from trapping locations rather than through telemetry); however, the proportion of breeding females was lower in Stanley Park, suggesting that although coexistence of the two species may be possible for a period of time, a slow decline in the Douglas' squirrel might occur due to lower recruitment. The fact that the Douglas' squirrels still exist on Stanley Park, the site of the original grey squirrel introduction in BC (see above) provides argument that coexistence of the two species is possible, depending on the scale of the assessment. As Hwang and Larivière pointed out, their study highlighted the need for behaviour study, and long-term demographic monitoring is needed to fully understand how the grey squirrels and the native squirrel(s) may or may not coexist.

Grey squirrels on Vancouver Island can be observed in stands of timber with a high conifer component, particularly in winter when leafless deciduous trees likely provide substantially less cover. Also, under-stories of Pacific Filbert ('hazelnut' - *Corylus cornuta*) appear to support grey squirrels (Fraser, personal communication). Matkin (unpublished) determined that released grey squirrels at one location selected conifer habitat at a greater proportion than was available, perhaps due to reduced cover in deciduous trees due to the autumnal leaf shed. At the same time, the assumption that grey squirrels will be unable to colonize strictly conifer forests is supported by data from the UK and other locations where pure conifer stands have provided important refugia for the Eurasian red squirrel. Further discussion on this appears elsewhere in this volume, including some indication that this pattern has exceptions (Halliwell et al. Chapter 23). In the Okanagan valley of BC, the grey squirrel population at present appears limited to urban and agricultural areas, but the assumption that the animals will remain confined by surrounding conifer forests and winter conditions remains unproven (see discussion above). A somewhat analogous argument has been put forth to explain the restriction of introduced grey squirrels in South Africa to anthropogenic habitat and suitable terrain (summarized by Long 2003).

Other forms of impacts by grey squirrels in BC largely remain conjecture, yet potentially quite important. In some circles, the loss of the native *Tamiasciurus* from urban and rural areas may be considered acceptable, simply due to the extensive range of these animals throughout the natural western conifer forests. However, the replacement results in higher densities of invading grey squirrels which may have a negative effect on local biodiversity, due to the increase in predatory effects on species such as song birds or other plants. Significant impacts on commercial agriculture have not yet been voiced by the farming community in BC, although localized impacts on walnut or other nut production were evident through the aforementioned survey. Some growers of hazelnuts on Vancouver Island have removed their plantations due to consistent depredations by grey squirrels (Fraser, personal communication). Recently, work in the author's lab with captive grey squirrels demonstrated the breadth of agriculture food items that will be used by grey squirrels (McAllister et al. 2016). Included in this list were many agricultural fruits and both red and wine grapes; these could be significant issues given that the Okanagan Valley in BC supports one of the two significant fruit and wine industries in Canada. Grey squirrels also have caused impacts on ornamental horticulture: the City of Victoria Parks Division has had major issues with grey squirrels excavating and removing bulbs, especially after autumn plantings. Up to 70 bulbs may be removed in one night, requiring workers to place wire over mass plantings; this is a particularly difficult and time-consuming task when the bulbs are interspersed with taller plants (Smith, personal communication). Grey squirrel foraging on tuberous ornamentals (e.g. *Begonia*) in Victoria also has been observed (Fraser, personal observation).

Disease spread has not yet been linked to the grey squirrels introduced in BC, unlike the example of squirrelpox virus (SQPV) in the UK where the Eurasian red squirrel appears more vulnerable to the infection than the carrier grey squirrel (Bruemmer et al. 2010). Twenty samples collected from grey squirrels on Vancouver Island all tested negative for SQPV antibody presence (Bruemmer, personal communication). No doubt the demonstrable plight of the Eurasian red squirrel (and other species) has aided significantly in drawing attention to the seriousness of the grey squirrel invasion in the UK and elsewhere. To date, proof of similar impact in western Canada is likely a significant roadblock (short of funding) to generating on-the-ground responses to the eastern grey squirrel.

Will the public aid in controlling grey squirrels?

Within Canada, responsibilities for wildlife fall largely to the provinces, meaning that laws and policies influencing how grey squirrels and other invasive species may be controlled must be legislated by provincial governments. In BC, grey squirrels are listed under *Section C* of the *Wildlife Act*, meaning they are exempt in some ways from standard blanket laws protecting species in the province. The animals may be trapped or hunted at any time of the year without a permit requirement. However, these approaches to grey squirrel control have their own limitations: With regards to hunting, the discharge of firearms and bows on private property is subject to municipal laws, and on the provincial level, it is illegal to discharge a firearm within 300 metres of a human dwelling. In terms of trapping, grey squirrels may be live-trapped on private property by the owner or a designate, but unfortunately, it is still legal for the captured squirrel to be released up to 10 km away, providing the release site falls on the trapper's own property or on provincial ('crown') land (in some wildlife management units on Vancouver Island, this distance was reset to one km in an effort to curtail the spread of the animal). Such relocation practices, while legal, are discouraged, and members of the public with live-trapped squirrels are encouraged to seek out humane forms of euthanasia for grey squirrels; this situation will present a conundrum to those landowners unwilling and/or untrained in rodent euthanasia, and reluctant to pay for the services of a licensed veterinarian. Parks and protected areas also are seen as appealing release sites for trapped nuisance grey squirrels (personal observation.; Fraser, personal communication).

Kill trapping of grey squirrels, as a *Section C* species, is another legal option for dealing with grey squirrels on private lands, but under the *Commercial Activities Regulation*, it is an offense to set a kill trap within 200 metres of a human dwelling. This restriction seem appropriate for larger kill traps that could potentially injure or kill pets, livestock, or even people, but it nevertheless blankets smaller, humane kill traps. In reality, these restrictions appear largely ignored by individuals determined to remove grey squirrels from their property

(personal observation). The Kania™ kill trap (www.kania.net) was invented in BC for specifically targeting squirrels, and although it is widely used elsewhere (over 30,000 units sent to the UK alone), sales continue to increase within the province (Kania, personal communication). Nonetheless, the current set of intertwined legislation and regulations within BC, if unchanged, likely will hinder any large-scale, government-sanctioned management plan for controlling grey squirrels.

Wildlife rehabilitation centres, often privately owned and operated, are another potential vector for grey squirrel releases. The permits issued to these facilities normally do not allow for the rehabilitation, much less release of, grey squirrels. Unfortunately, the Conservation Services of the government (responsible for enforcing the Wildlife Act) simply lack the capacity to monitor these situations. The end result is that rehabilitation and release of grey squirrels continues in the province (personal observation) albeit likely at reduced rates due to self-compliance by some centres in response to a wider awareness of the negative effects of the animals (Sigg, personal communication). Still, on average, 60-70 rehabilitated grey squirrels are released each year by at least one rehabilitation centre, although the animals are only released into urban areas where the species already is established (Dubois, personal communication).

Grey squirrels continue to appear in British Columbia at locations well distant from their main points of introduction. In 2008 a grey squirrel was detected in a municipal park near William's Lake, over 300 km away from both the Lower Mainland and Okanagan Valley populations (Anaka, personal communication), and very recently (2015) another individual appeared in the town of Revelstoke, approximately 150 km from the Okanagan Valley (Cooper 2015). In both cases, the animal was promptly removed. The remoteness of both of these locations from existing populations strongly suggest human-mediated transport of grey squirrels (intentional or not) will continue, and points to the importance of raising and maintaining public awareness of the seriousness of non-native species.

Conclusion

As this monograph is focused on the ecology and management of grey squirrels in Europe, this chapter ideally would provide insight and management recommendations garnered in Canada. Regrettably, such information does not exist. It is somewhat ironic, although clearly linked to history and zoogeography, that European nations demonstrate more attention to grey squirrel invasions than that seen in Canada, where the size, geographic diversity, and political structure permits an animal native to one side of the continent to become established elsewhere, still within the borders of the same country.

As described by Peacock (2009), prompt, coordinated action eradicated grey squirrels in Australia. Anderson (2005) presented another success story involving an invasive alga, that hinged on awareness and a rapid mobilization of resources (see also Adriaens et al. 2015). Unfortunately, as is more commonly the case, this sort of action has never been directed towards grey squirrels in BC, leading to yet another series of introductions. The most recent establishment of grey squirrels in BC occurred at a time when invasive species strategies finally were emerging for both BC and Canada; unfortunately, the policies, procedures, and funding needed to act quickly on invasive species, regardless of initial public perceptions, are not yet in place.

Studies to verify (or refute) the influence of grey squirrels on native ecosystems are scant in western Canada. Perhaps even more so than in Europe, these sorts of data are urgently required to galvanize future management actions. The list of impacts presented by Gurnell et al. (this volume, Chapter 16) provides a good framework for conducting research in BC and elsewhere. However, it is also clear that to prevent further invasions of the grey squirrel, and possibly the spread of existing populations, both government and non-government agencies must work to create the social license and concomitant resources needed to effect strong, swift control measures on future introductions.

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