**Are the Regulatory Framework and Industry Practices in Land Development in the GTA Facilitating the Spread of an Invasive Introduced Ant *Myrmica Rubra* (European Fire Ant)?**

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## Acknowledgement

It has been a long journey to get to this point and a still longer journey ahead that I look forward to enjoying in the company of my friends, family and colleagues who have made it all possible and those who I have yet to meet. I am eternally grateful to my supervisor - Gail Fraser, advisor - Felipe Montoya-Greenheck and my mentor in entomology - Laurence Packer. Special thanks to my colleagues in the Packer Bee Lab and FES faculty. Thank you to those countless individuals who offered advice, assistance and inspiration for my research. Last but not least I am blessed with my husband - Devon Calder, and my father - Rahman Ali, both making sure I ate, bathed and slept somewhat consistently in the last two years.



## Abstract

Invasive Introduced Species (IIS) are characterized by their ability to colonize, reproduce, and spread in disturbed areas and inhospitable conditions. The environmental effects that are commonly produced during construction activity create those specific conditions, as well as, environmental effects that may affect the survivorship and fitness level of native species. Additionally, development processes generate and spread large quantities of soil within a wide reaching geographic range, as well as, move landscaping, building materials, and human traffic all of which potentially carry and spread IIS. In this paper we will demonstrate that the regulatory environment addressing Invasive Species, Soil Management, and Land Development in Ontario provides an inadequate framework for preventing a wide-scale infestation of the introduced invasive ant in Canada *Myrmica Rubra* (European Fire Ant) which is known to be transferred through soil movement.


## Foreword

The major paper synthesizes the area of concentration or explores one or more of its components in depth. The major paper is expected to contribute to a student's knowledge and may also make a contribution to knowledge in general. This Paper is also submitted in fulfillment of knowledge and skills necessary to meet program requirements of the Canadian Institute of Planners and Ontario Professional Planners Institute for Candidate membership. My Plan of Study centres on IIS; specifically, the Biology, Vectors, and Management Approaches, and how planning can be used to mitigate Invasive Species, through Local Planning and Policy Implementation. My research paper addresses these components.

# Introduction

Invasive introduced species are characterized by their ability to colonize, reproduce, and spread in disturbed areas and inhospitable conditions. The environmental effects that are commonly produced during construction activity create those specific conditions, as well as, environmental effects that may affect the survivorship and fitness level of native species. Additionally, development processes generate and spread large quantities of soil within a wide reaching geographic range, as well as, move landscaping, building materials and human traffic; all of which potentially carry and spread invasive species. In this paper I demonstrate that the regulatory environment addressing Invasive Species, Soil Management, and Land Development in Ontario provides an inadequate framework for preventing a wide-scale infestation of the introduced invasive ant in Canada *Myrmica Rubra* (European Fire Ant) which is known to be transferred through soil movement.

The first component of the paper will discuss the Methods used to develop the study. In the second component I will provide a review of *M. Rubra* and it's characteristics concerning geographic range, habitat, nesting, life cycle, competition, as well as, known vectors, management, social and ecological impacts. The second component of the paper discusses the Regulatory environments - Soil Management and Land Development - as they relate to *M. Rubra*. The third component of the paper provides an analysis illuminating critical areas of dysfunction and opportunities for intervention.

# Methods

In this study I set out to answer the question of how development processes, through practice, planning and policy, are facilitating the establishment and/or spread of invasive species, with a specific focus on *M. rubra*. The study is limited to the Greater Toronto Area (Ontario, Canada), although having wide reaching applications for other regions. I reviewed peer-reviewed journals, newspaper articles and public record archives in Canada (a few outside of Canada) concerning *M. rubra*. I reviewed industry texts, public record archives and limited available peer-reviewed journals on the subject of land development and soil management in Ontario (a few from the US). I also analyzed policy documents concerning land development, soil management and invasive species at the Federal, Provincial and Municipal level and in this regard include cases outside of Ontario. I had hoped to supplement the literature component with field sampling for *M. rubra,* however access to development sites was not gained in the timeframe.

# Review of *Myrmica Rubra*

## Invasive Introduced Species

Invasive introduced species (IIS) are characterized by their ability to colonize, reproduce and spread in disturbed areas and inhospitable conditions. In their respective habitats they can be generalist type species with the ability to adapt to diverse environments for the purposes of nesting, foraging and reproduction, thereby able to occupy a cryptic role. However, they are also able to displace native species (whom did not co-evolve defences) through competitively superior characteristics, such as numerical dominance, reproductive rates, chemical defence, physical aggression, speed of recruitment and allelopathy. IIS may have the advantage of being unburdened from predator and pathogen pressure of co-evolved native species. They may also facilitate the establishment and spread of other introduced and co-evolved species with which they shared a mutualist relationship in the native range. (Simberloff 2013)

## Invasive Introduced Ants

Rabitsch (2011) describes several traits of introduced invasive ants which may in part explain their success (co-incidentally all present in *M. rubra)*; however cautions against adopting generalizations and instead encourages case by case assessment given that different species of ant have their own unique life histories and circumstances upon introduction. One, the ability to build small ephermal nests that can be quickly assembled and abandoned, small body size, as well as, a preference for disturbed habitat can aid in translocation. Two, dietary flexibility, intranidal mating, polygyny, high queen fertility and rapid brood production are ideal for establishment. Three, colony formation through budding, unicoloniality, polydymous nest structure, and superior competitive abilities encourage spread. Four, former traits as well as predation facilitate dominance through community level impacts.

In Canada, there is evidence of a number of introduced ants (other than *M. rubra)* which are known as invasive (Higgins 2014b); i.e. tropical stinging ant (Hypoponera punctatissima), Argentine ant (Linepithema humile), little fire ant (Wasmannia auropunctata), impressive fire ant (Myrmica specioides); as well as, pavement ant (Tetramorium sp.) (Higgins 2014a).

### *Myrmica Rubra*

Research has been conducted extensively on *M. rubra* in Europe where it has been known for quite some time to be widely distributed and abundant, however, adjusted to co-habitation with other ants and presenting no negative impacts to the ecological environment. On the other hand, this species has only recently gained awareness and been studied in the North American context (earlier in the US than Canada).

To date there are few publications on this species as an urban invasive. The limited references refer mostly to colony locations (e.g. Wetterer and Radchenko 2011, Lund et al. 2009). Research associated with the University of Maine has focused on mainly rural areas (e.g. Groden 2005, Evans et al. 2010) and mainly laboratory settings, as opposed to urban environments where human-ant interactions occur. However, some authors suggest *M. rubra* behaviour (e.g. invasiveness) may be different in an urban or anthropogenic setting compared to a rural environment (Wheeler 1908, p. 339, Horton 2011).

## Distribution

The European Fire Ant *Myrmica rubra* (Linnaeus 1758) can be found in Europe from Western Ireland and Portugal to Eastern Siberia, Southern Italy, and Northern Scandinavia; spanning a latitude of 39'N - 70'N (Seifert 1988). Related populations are also found in the United States, as well as Canada in south-central regions from east to west coasts spanning a latitude of 41'30N - 47.36'N (Wetterer & Radchencko 2011), leading authors to believe that *M. rubra* has not reached its potential northern range limit in North America yet. Colonization by *M. rubra* through eastern coastal areas of the U.S. is well documented (Wheeler 1908; Weber 1947; Creighton, 1950; Groden et al, 2005; Wetterer & Radchenko, 2011; Higgins, n.d.). The ant is now present in the provinces of QU (1957), ON (Meaford – 1975, Toronto - 2003), NS (1998), NB/PEI (2008), and NL/BC (2010). Despite the relatively recent documentation of *M. rubra* populations across Canada, studies indicate they have been established at least decades earlier evidenced by the colony size or distribution, as well as, anecdotal evidence (Rudmik 2010, Horton 2011, Hicks 2014).

## Origin

The geographical origin of *M. rubra* is uncertain; many flora and fauna only recently discovered in North America but long known in Europe are thought to be introduced from Europe. Lappanen (2011) and Hicks (2014) identified *M. rubra* in Europe and North America as belonging to three common haplogroups, thought to have survived the Pleistocene using multiple refugia located in Mediterranean peninsulas and further east in southern Siberia, later meeting at secondary contact zones in Germany (Lappanen 2011) and the Alps (Lappanen 2013). Recent studies provide evidence of more areas of refugia than originally estimated; for example, indicating that the Great Lakes region acted as a secondary contact area likely recolonized by migrants from western North America and from refugia near the perimeter of the ice margin, accommodated by a migration passage from the Rocky Mountains to the Great Lakes region south of the Cordelliera icesheet (Peirson 2013: Fernald, 1925; Marie-Victorin, 1938; Marquis & Voss, 1981). Species spread in North America from there and over time may have become extripated from the secondary contact area and recolonization routes, a pattern congruent with findings from widespread and northern-temperate and boreal plant and animal taxa in North America (e.g. Pierson 2013: Dobes et al., 2004; McLachlan et al., 2005; Beatty & Provan, 2010, 2011; van Els et al., 2012).

## Nesting/Foraging

*M. rubra* nests in the upper layer of soils, in a singular central structure or multiple singular structures connected via tunnels, and present in densities up to 6 nests/$m^2$ (Horton 2011). Nesting habitat is variable with a propensity for soil under stone, leaf litter, decayed wood and in moist, semi-shaded soil with herbaceous plant roots (see Native - Cammaerts & Cammaerts 2014, Bolton & Collingwood 1975, Groden et al 2005, Lappannen 2011, Fokhul et al 2007, Elmes 1975, 1981; see Introduced - Groden et al 2005, Horton 2011, Hicks 2012). Nesting habitat differs between rural and urban areas, although this may be attributed less to preference and more to habitat availability; i.e. manicured lawns making up the predominant landscape in urban areas (see rural - Groden et al 2005; see urban - Horton 2011).

Colonies can be polygynous or monogynous, forming large colonies of about 1000 workers), including 5-39 or more queens according to the size of the nest (Horton 2011). *M. rubra* is generally monogynous in the native range, but polygynous in the introduced range; a phenomenon which could be explained in part by the difference in mating patterns (Bolton & Collingwood 1975, Hicks 2012, Groden 2005). Horton (2011) found that most colonies in the urban environment have overwintering nests in protected soil and in summer they expand the territory with satellite nests in more exposed locations (ground flora).

Foraging distance has been measured as 3 to 5.5 metres from nest (Hicks 2014). *M. rubra* also has an microgynous iniquiline social parasite (Emles 1973, Elmes 1976, Vepsalainen 2009) hypothesized to be in the process of incipient advanced sympatric speciation (Leppannen et al 2015).

## Life Cycle

In contrast to the native range, there is evidence of male swarming but only one observation of a queen in flight (Higgins 2014b). In the introduced range *M. rubra* demonstrate intranidal mating (within nest, or outside nest followed by re-entry) and colonization by budding (Hicks 2012), although single queens may (but rarely do) found colonies themselves (Collingwood 1958)., There are several generations during the yearly life cycle. The first generation (rapid brood) is composed of sterile workers who take care of the queen and brood. During the summer two further broods may be laid down with a final brood produced in late Summer/early Fall. This brood overwinters as larvae in diapause (slow brood). Triggered by short day photoperiods it's ready to pupate in spring, producing workers, males and queens (Horton 2011; Hicks 2012: Kipyatkov 2001, 2005). It may be important to consider for *M.* rubra that some insects are influenced by climate change to increase brood frequency (e.g. Mountain Pine Beetle - Safranyik et al 2006) creating exponentially larger infestations and subsequent impacts. It may also be important to consider that should *M rubra* in the introduced range develop mating flight response (Hicks 2014), the dispersal range will also increase dramatically.

## Competition

There are clear differences in competitive tendencies comparing native and introduced populations (Garnas et al 2014). *M.* rubra demonstrates high abilities in displacing competitors, as well as, speed, accuracy and quantity of worker recruitment to resources (Garnas et al 2014). Workers forage on horizontal and vertical surfaces, prey on insects and other small invertebrates, attend aphids (root and aerial) and other Hemiptera from which they collect honeydew, as well as, collect and disperse seeds that contain elaiosomes (Naumann & HIggins 2015, Prior et al 2015). *M. rubra* can distinguish filled shapes but not hollow forms and use all available olfactory and visual elements for navigating (which can be conditioned over time) (Cammaerts & Cammaerts 2014). They likely utilize a navigational system of path integration operating within an egocentric system of coordinates and including an external (celestial) compass reference is the most significant mechanism. (Wehner et al 1997).

Genetically similar hydrocarbon cuticular chemical signatures enabling kin recognition may reduce *intraspecific territoriality* (Holldobler & Wilson 1990). Although intra-competition does occur increasing with distance among sites (Garnas et al. 2007) and neighbouring colonies may fight among themselves on disturbance, colonies will also combine to destroy an introduced nest of another species (Collingwood 1958). Colonies are able to co-exist at extremely high densities but there is probably effects on competitive hierarchies (Garnas et al 2014). The number of hypogaeic or cryptic ant species able to persist in proximity to an *M. rubra* infestation is unknown, however it is quite common for different species of ants to co-exist by occupying different substrate for nesting and foraging, diurnal timing of activities and/or specialization of defenses or different food resources (Garnas et al 2014: Holway 2002, Ward 1987, Horton 2011).

## Enemies

In its native range *M. rubra* is infected by several species of entomopathogenic fungi, some of which are regularly found infecting the ant in its introduced range in Maine (increasing transmission rates due to increasing populations in that region) except for one species (*Ophiocordyceps myrmicarum)* which was exclusively found in North America (Simmons et al 2015). Dr. E. Groden (University of Maine) recently collaborated on an article outlining work related to new fungal pathogens (Evans et. al. 2010) and their effect on *M. rubra, however,* the impact and dynamics still remain unknown. In fact, *M. rubra* has developed diverse and adaptive responses to sanitary risks in terms of grooming, larval care, worker interaction, and corpse (midden) disposal (Diez et al 2015) which may limit the possibilities of fungal pathogen as a control measure.

## Impacts

Articles in the public domain report homeowner experience, such as, inability to use the yard for play, pets, gardening and laundry; as well as, the inefficacy of pesticide or other management attempts (Groden 2005, Horton 2011). Robinson et al. (2013) estimated that the economic cost of *M. rubra* in British Columbia could reach $100 million/year if the ant spreads across their potential range in the province.

In a study by Prior et al (2015) *M. rubra* has been shown to promote higher recruitment of a co-introduced invasive plant (providing elaiosomes - a lipid-rich food resource) which dominates over native plants due to interaction of traits. *M. rubra* moved more seeds, more quickly, over a wider range between multiple nest sites of colony, with a greater (if any) colony satiation point, depositing further away from adult plant. The invasive plant benefited from dispersal away from adult plants, producing many small seeds over longer season, fast and competitive growth. Compared to the native ant, the invasive ant increased recruitment of the invasive plant by a factor of 8.2 and flowering by a factor of 1.7. Given the success of the invasive plant in conjunction with *M. rubra* resource benefits that can increase colony growth/reproduction, feedback cycles are likely. These effects could have long-term consequences for population dynamics, providing evidence for invasional meltdown (or mutualist facilitation).

Unlike other introduced invasive ants (e.g. *Linepithema humile* and *Solenopsis invicta*), *M. rubra* is an important seed disperser in its native range, therefore, may have co-adapted partnerships with native myrmecochores (plants that rely on ants to disperse seeds). Several plant species that *M. rubra* disperses in its native range have also been introduced to North America, which will perhaps drive non-native mutualisms outcompeting native myrmecochores and native seed-dispersing ants. (Prior et al 2015)

Although populations of *M. rubra* in North America are still fragmented, their tendency towards high population densities, multi-queen and multi- nest colonies, and aggressive nature, suggest that this species could have similar ecological effects to other invasive ants (e.g. L. humile and S. invicta) which monopolize entire habitat patches. Where *M. rubra* is present, studies have shown a decrease in both abundance and diversity of arthropods including those likely to be competitors or prey (Naumann and Higgins 2015, Hicks 2014, Horton 2011). It is hypothesized that *M. rubra* will displace all but a few native ant species where established (Holway and Case 2001), as demonstrated in many studies (Porter and Savignano 1990, Cole et al. 1992, Human and Gordon 1999), though there is some evidence the native community may recover over time (Morrison 2002).

At high populations there is concern that *M.rubra* may be interfering with the successful nesting of some birds but the outcome is uncertain (Higgins 2013, Rudmik 2011). They are also implicated in swarming activities of birds near airport facilities leading to bird fatality and infrastructure damage, due to foraging on high density *M. rubra* populations in the vicinity (Higgins 2014a).

## Vectors

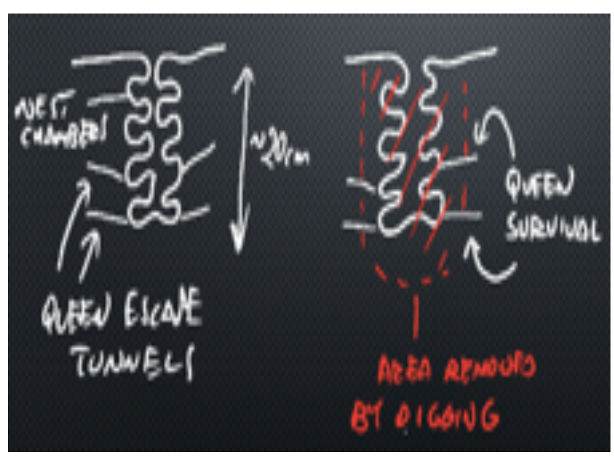
North American populations have not been observed to produce flying females (Hicks 2012), so introductions are suspected to occur via the transport of garden products or soil (e.g. nursery stock is suggested as the most common method by Groden et al (2005)), and spread through colony budding over ground (Naumann and Higgins 2015). In a study by Horton (2011), movement of budding colonies across grass and and open flat surfaces was observed, as well as, a limitation to crossing an area wider than a single driveway or car lane. Patterns of infestation supported a grid like rather than radial movement with sometimes two uninfested block separation indicating anthropogenic introduction (e.g. neighbours sharing plant materials). There appears to be some barriers that inhibit natural movement (spread): coniferous forests, roads and streams (Groden 2005); in Maine more than a 10km proximity from the coast (Groden et al 2005); In Newfoundland populations were limited to one side of town, or areas adjacent to a pond/stream (Hicks 2014).

It is important to remember that in the case of soil disturbance and movement, only one fertilized queen needs to survive in order to re-establish the colony.

## Management

Successful vectors of introduction of non-native species will vary depending on frequency of propagule pressure, suitability of introduced habitat and characteristics of the introduced population (Catford et al 2009). Movement between Canada and other countries is generally highly regulated but movement within less so. There is a prevalence of websites, fact sheets, and policies which serve as Guidance rather than regulation. Exotic species trade in horticulture and aquaculture industries is still mostly unregulated, leading to inadvertent introductions where people share or dispose of infected product primarily because few people are aware of these hazards (Horton 2011).

From an eradication/control perspective there has been innovative research conducted but as yet effectiveness from experimenting with these approaches has not been achieved (Higgins 2012); i.e. entomopathogenic fungi (Eleanor Groden, University of Maine), decapitating flies (Stanford Porter, University of Florida), microsporidia (Maynard Milks), and boric acid (Higgins, n.d.). Higgins (2014b) conceptualized the operation of the colony in response to an attack, illustrating escape chambers which the queen, larvae, and limited workers would occupy until it was safe to re-enter the main chamber and rebuild the nest (see illustration in text).



Evidence of public record of *M. rubra* infestation is far lower than actual incidents. As mentioned in Patten (2010) there is a fear of disclosing an *M. rubra* infestation for fear of decreased property resale value. Many publications espouse the economic and health costs, as well as, lack of means to eradicate and potential for spread. Considering an effective treatment or eradication is unavailable, homeowners, neighbourhoods and municipalities may be inclined to withhold or suppress information about the occurrence of infestation is my personal view. This may explain what I observed as an absence of publications overall but a frenzy of media activity at the onset of infestation in every province for a limited time (while presumably the problem continues unabated or worsened). An interesting topic of research amy be exploring the correlation between seasonal housing market trends and *M. rubra* infestation patterns.

# Ontario's Regulatory Environment

*M. rubra,* despite being documented in most provinces across Canada, has received conflicted reception for institutional cross-regional solutions which are in fact necessary for any feasible mitigative or preventative measures as demonstrated in our investigation of the characteristics of this species in the previous section. Keller et al (2011) summarize some of the key challenges to operationalizing an institutional response, all juxtaposed with the need for early and rapid response to prevent expansion of IIS. They argue that planning and policy response at a government level is complex when considering environmental issues that have an inherent degree of uncertainty; i.e. the potential for spread, the degree of ecological and social impacts, and the ability to mitigate those impacts. In the sections below we will investigate three regulatory frameworks in Ontario  and their potential to address *M. rubra* - Invasive Species, Soil Management and Land Development.

## Framework for Invasive Species

### Provincial and Federal Agencies

The main policies addressing Invasive Species at the Federal and Provincial levels are the Invasive Species Plan (2012) and Invasive Species Act under review (2014). An outline of other Federal and Provincial agencies with existing or potential oversight in Invasive Species management can be found in Appendix A.

Following shortly on the heels of the Invasive Species Plan of Ontario (July 2012), plans were in the works by 2013 for an Invasive Species Act for Ontario (Act), a Bill introduced into Parliament on February 26, 2014. This legislation if passed will be the first stand-alone legislation in Canada of its kind. The Act provides a framework for the classification, detection, regulation and response measures (eradication and control) for invasive species, defined in the Act as those that threaten Ontario's natural environment (and some control over unknown or suspected IIS as well).

The Plan places the Ministry of Natural Resources (MNR) as lead in collaboration with partners: Ministry of Agriculture, Food and Rural Affairs (OMAFRA), Ministry of the Environment (MOE), and Ministry of Transportation (MTO). Roles and responsibilities of provincial agencies are discussed in the Plan, delegating OMAFRA to invasive agricultural species; while, MNR's Biodiversity branch will clarify roles and responsibilities within MNR and across other agencies. It does appear that MNR will hold lead for forest, OMAFRA for agriculture, and other ministries delegated to non-agriculture and non-forest. The Plan will coordinate with Canada's Invasive Species Strategy, led by Environment Canada (EC) and coordinating partners: CFIA, Parks Canada, NRCAN-CFS, DFO, AAFC, CBSA. Key partners include: Invading Species Awareness Program (OFAH); OIPC, Municipalities, Conservation Authorities, Universities and Biodiversity Education and Awareness Network.

While this Act would be an ideal tool to implement a national coordinated response plan to *M. rubra*, there are several impediments. One, upon reviewing the Guideline and Act, it is apparent that the species intended for target will be those affecting commercial fishing, forestry products and perhaps agriculture. Two, the policy is structured for implementation that appoints jurisdiction according to resource base, however, *M. rubra* has the ability to occupy most habitats across all jurisdictions

Considering the ubiquity of *M. rubra* it is unclear as to which agency purview it could potentially fall under. At the Federal level the Canadian Food Inspection Agency (CFIA) and National Resource Council (NRC) may have too narrow of a purview; the former food related, and the latter resource based. Perhaps appropriate agencies would be Environment Canada, which regulates the Species at Risk Act (SARA), or Health Canada, regulating hazardous pests to human health. Ultimately, due to the characteristics of IIS an interagency platform would be the most appropriate regulatory oversight.

The Ontario Soil Management Guideline (2014) is the purview of MOE. While not a regulation it does provide guidance to land developers on best management practices for soils and MOE reserves the right to "take appropriate action" if soil movement causes adverse effects, with a specific reference to introducing invasive plant or animal species (including citation of *M. rubra) (Saxe 2013)*. The Guidelines are discussed at length in the next Section of the paper.

## Municipalities

**Ontario**

In regards to policy and regulation in Ontario, public accountability has been limited. Action has not been mobilized although *M. rubra* is increasingly being recognized as a problem: Toronto has enacted a by-law assigning management responsibility to property owners (City of Toronto, n.d.); Markham (City of Markham n.d.) and Brampton (City of Brampton n.d.) have *M. rubra* advisories on their web sites; and the Town of Richmond Hill implemented a "European Fire Ant Management Plan" in 2006 (Newmarket Era 2008). Municipalities see the issue as cross-boundary, therefore, not their responsibility; while provincial and federal governments view it as a private property issue (McKnight 2012). While management response flounders, infestation continues to spread, as evidenced by the Richmond Hill case. By 2010, the invasion that originally occurred in the Doncrest Valley area spread into the Rouge River system, with reports emerging from Oak Ridges Moraine area, as well as, Vaughn, Markham, and Pickering (Newmarket Era 2010). In March 2013, *M. rubra* observations in the Don Watershed prompted the TRCA to host a community presentation by Dr. Higgins (BC entomologist) (TRCA & Evergreen n.d.).

The Greater Golden Horseshoe Invasive Species Working Group includes staff from the municipal and regional jurisdictions of Toronto, Mississauga, Brampton, Oakville, Markham, Peel, Halton and York, along with the Ministry of the Environment and the Toronto and Region, and Credit Valley Conservation (CVC ) Authorities. CVC is the lead on this group but they are no longer active. Clearly there is institutional experience and capacity available to coordinate on this issue and reinstating this inter-agency group may provide useful direction for *M. rubra*.

**Nova Scotia**

In regards to policy and regulation in Nova Scotia it's generally left to the provinces to monitor and there is no coordinated plan at the national level, but it is unclear whether either level is statutorily responsible or in fact whether the province is conducting monitoring (Dooley 2008). The federal mandate is not implicated because *M. rubra* is not viewed as a risk to forestry or food crop, considered a 'nuisance' rather than a 'pest' (despite that there is evidence of plants, animals and human health, directly or indirectly impacted). Halifax Regional Municipality (HRM) issued resident warnings and updates on infested localities (CBC 2006) and assigned responsibility to their parks division for management of municipally owned parkland only, but specifically instructed residents that they are responsible for their own property. Neighbourhood meetings / community information sessions were being coordinated (Shimo 2008, Canadian Press 2009, CBC Jun 22 2009). Reports indicate that spread continues and field calls to pesticide companies are on the rise (CBC Jun 22 2009).

Informally, public institutions are taking on responsibility. Clean Nova Scotia (an ENGO) appears to have acted in a role of monitoring and mapping *M. rubra* for the City of Halifax, fielding resident phone calls and issuing community advisories (Dooley 2008). Academic researcher, Susan Horton, master of science student at St. Mary's University (in collaboration with University of Maine) was conducting sampling for nest mapping and field experiments for habitat preference in the City of Halifax. The curator for the Museum of Natural History also acted as a de facto source of expertise for *M. rubra*.

**New Brunswick**

There is one brief reference to information on *M. rubra* management provided by a biologist of the University of New Brunswick (CBC Apr 26 2011).

**British Columbia**

Management of *M. rubra* in British Columbia has been largely coordinated by local entomologist Dr. Higgins (Thompson River University), who is the authority in Canada. He indicated sample processing was done by his lab but later was taken on by the Plant Diagnostic Lab of the Ministry of Agriculture (Abbotsford) which seems to indicate some degree of provincial responsibility at the time (CBC Aug 31 2012).

BC now has several invasive fire ant populations: tropical stinging ant (Hypoponera punctatissima), Argentine ant (Linepithema humile), little fire ant (Wasmannia auropunctata), impressive fire ant (Myrmica specioides); as well as, pavement ant (Tetramorium sp.) (Higgins 2014a).

There is indication of enhanced provincial involvement through the formation of a BC InterMinistry Invasive Species Working Group, which has produced valuable reports available to the public. There are two NGOs involved, the Invasive Species Council of BC (ISCBC) and of Metro Vancouver. The landscaping industry (represented by BC Landscape and Nursery Association) is being targeted as a source vector, although they disagree with that denouncement. The ISCBC also is collaborating with the Real Estate Foundation of BC, who is providing funding to establish a 'fire ant advisory council', investigating municipality strategies for dealing with legality and liability.

# Framework for Soil Management

In this section I discuss how Ontario's soil management policy framework creates an environment that facilitates poor regulation, large-scale and wide-ranging movement of potentially contaminated soils within and outside of urbanizing areas.

## Historical Development of Main Policies

How soil is managed is clearly important in mitigating the spread of *M. rubra,* as we know that only a single fertilized queen ant needs to survive disturbance in order to build a colony. There is today a multitude of legislation applicable to soil and sediment management, but three in particular have guided the development of quality criteria in Ontario (Edwards 2010). Unfortunately, these regulations (developed in parallel) have generated conflicting or confusing direction, creating challenges to compliance due to limited liability protection, ambiguity in defining soil class (i.e. soil/inert fill/waste), lack of direction in handling different soil classes, outdated criteria rationale, and impracticality respecting the actual circumstances of mass redevelopment and public projects in urban areas. Below I discuss: (1) the Great Lakes Water Quality Agreement, 1987 (GLWQA); (2) Reg. 347; and (3) the brownfields provisions in the Environmental Protection Act (EPA).

Soil management policies have evolved in response to concerns about soil, air and water contamination and waste management. In the 1970s there were no soil management policies beyond accepted industry practice. (ESEM 2014). Increasing amounts of soil and sediment were being excavated or dredged, and deposited without appropriate regard for the health of lands and waters, people, animals or ecosystems. Over the years quality criteria have been developed and expanded beyond phytotoxicity to include carcinogenicity, lethality, bioaccumulation, dermal exposure, vapour migration, and groundwater leachate; and beyond plant receptors to include other types of receptors, such as children, workers, adults, benthic organisms, mammals, birds, fish and grazing animals. (Edwards 2010)

#### ENVIRONMENTAL PROTECTION ACT - ONTARIO REGULATION 153/04, RECORD OF SITE CONDITION

The first EPA (1971) consolidated two statutes: the Air Pollution Control Act, 1967, and the Waste Management Act, 1970. The EPA (1971) and amendments (1985) provided a number of functions: prohibiting the release of contaminants creating adverse effects; empowering MOE to issue control, stop, repair and preventative measures; requiring expedited clean-up of spills and entitlement for compensation from damages. (Fishlock 2010)

In the 1980s Ontario started to develop policies not just to prohibit contamination events but also for clean-up of contaminated sites. The first published standards were released in *Guidelines for the Decommissioning and Cleanup of Sites in Ontario (*MOE 1989), which primarily focused on metal or inorganic substances. The *Interim Guideline for the*

*Assessment and Management of Petroleum Contaminated Sites in Ontario (1993)*, focused on hydrocarbon substances. However, criteria for identifying site contamination was at that time still mainly prescribed by private industry practice. (Fishlock 2010)

In mid-1990s Ontario developed a number of versions of the Guideline for Use at Contaminated Sites in Ontario, however it lacked 'regulatory teeth'. The guidelines in addition to listing soil and groundwater criteria thresholds, also provided guidance on pre-remediation site assessment. (Fishlock 2010).

Over a four year process the Brownfields Act (2001) was implemented, including the finalization of O.Reg 153/04 (2004), which prescribed the process for contaminated site assessment, remediation and post-remediation management. It also created: (1) integrated soil and groundwater standards; (2) effective rules for conducting and approving site specific risk assessments; (3) mandatory requirement to file a RSC with MOE as a condition of municipal building permit associated with land use changes; and (4) liability protection under the EPA. (Fishlock 2010)

#### ENVIRONMENTAL PROTECTION ACT - ONTARIO REGULATION 347: GENERAL WASTE MANAGEMENT

O. Reg. 347 (1992) replaced O. Reg. 309 and addresses excess excavated soil and dredged sediment considered waste. The least hazardous classification is "inert fill"; meaning earth or rock fill or waste of a similar nature that contains no putrescible materials or soluble or decomposable chemical substances (O.Reg. 347 S.1). Wastes that meet the definition of "inert fill" are exempt. (Edwards 2010)

However, most soils are neither "inert fill" or "rock fill." Excess excavated soil that does not meet the definition of "inert fill" can still be deposited on land as long as it is complies with regulated contaminant criteria and obtains an approval certificate for disposal and hauling. Excess excavated soil or dredged sediment that exceeds the criterion for any regulated contaminant has to be managed according to the hazardous waste provisions in the regulation. (Edwards 2010) Non-compliance can result in charges or an order to remove the waste at significant cost to a current or previous owner, occupant or transporter. (Saxe 2013)

### Great Lakes Water Quality Agreement

The GLWQA (joint agreement concerning shared waters of Canada and USA) was amended in 1987 (updated in 2002 and 2007), to initiate the development of criteria for identifying polluted sediments, chemical and biological criteria for assessing contaminated sediment, as well as programs for disposal of polluted dredgeate. The compliance agency, International Joint Commission (IJC), identified seventeen sites in Ontario (including five with cross-border responsibility) as being "areas of concern" (AOCs), i.e., priority areas for remediation given an impairment of "beneficial uses." Impairments (such as restrictions on fish consumption, bird and animal deformities, undesirable algae and/or beach closings) were thought to be the result of contaminated sediment. (Edwards 2010)

**OTHER POLICIES FOR SOIL MANAGEMENT**

Parallel to the development of policies for soil management on land, policies were also being developed concerning excavated sediment activities impacting water resources (e.g. lakefilling, confined and unconfined fill in bodies of water). See Appendix B for an outline of the historical development of those policies.

In addition to the three major policies discussed above, other policies exist with prohibitions on the deposition of contaminated excavated soil and dredged sediment onto land or into water. See Appendix C for an outline of those policies.

## Current Political Context of Major Policies

First, many of today's environmental policies addressing soil management historically evolved in parallel however, retained differing evaluative criteria and definitions of what constitutes soil, rock, fill, inert material, and/or waste and how each of these classes of material should be managed when comparing the EPA (O.Reg. 347 and O. Reg. 134), Aggregate Resource Act, Building Code, MTO Provincial Standard Specification and the Municipal Act (Saxe 2013). For example when comparing the OPSS180 with O.Reg . 347, topsoil, natural wood, swamp material and fire debris, for example, are permitted in disposable fill by OPSS 180, but are not "inert fill" under Reg. 347. Uncrushed brick and concrete are not permitted in disposable fill, but may be "inert". To make matters worse, practice in the field often complies with neither standard. 'Clean fill' sites may accept "disposable fill", or topsoil, or neither (Saxe 2013). Furthermore O. Reg. 347 defines "inert fill" as "earth or rock fill or waste of a similar nature that contains no putrescible material or soluble or decomposable chemical substance"; however most fill does not meet this definition. As s result of prohibitive and ambiguous terminology, material that poses little risk to human or environmental health occupies valuable space in what was becoming rare locally accessible landfills. By the early 1990s, municipalities had begun to restrict or ban the disposal of excavate in their landfills. (Edwards 2010)

Second, the manner in which many policies addressing soil management have evolved - namely based on previous policy (incrementally or piece-meal) has created outdated or out of context evaluative criteria. During the 1970s, soil quality guidelines called "concentrations considered excessive" were developed for use in phytotoxicological investigations. The guidelines were replaced in 1989 with the Upper Limit of Normal (ULNs) Contaminant Guidelines. Although their primary purpose was still for use in phytotoxicological investigations, ULNs were soon adopted as clean-up criteria for contaminated sites even though they were not intended to "represent maximum desirable or allowable levels of contaminants." (Fishlock 2010)

Third, until recently soil management has not addressed the need for soil matching services or long-term large-scale stockpiling due to the high level of urban development creating high volume soil excavation; as a result, the public infrastructure costs have been enormous for large volume and long distance shipping costs to remote areas accepting fill (ESEM 2014). The social costs of excess fill movement are borne by residents in the form of taxes (e.g. costs of administration and movement of fill for infrastructure), as well as, qualitative costs of noise, congestion, air pollution, soil pollution, water table contamination, line of sight alteration, and lifestyle impacts - all potential effects of large-scale fill operations and/or 'dig and dump' practices. (CLOCA 2012)

Four, under the Municipal Act (2001), a municipality may prohibit or regulate the placing or dumping of "fill", removal of "topsoil" or alteration of the grade of the land and may require that permits be obtained. A review (RCCAO 2013) concluded that 23 of 85 municipalities reviewed implemented by-laws concerning soil quality.Fourteen of the municipalities prohibit material without reference to the EPA or O. Reg. 153/04; Eight reference the EPA, but not 153/04; one referrred to Table 1 of Soil, Ground Water and Sediment Standards adopted under O.Reg. 153/04 (Saxe 2013). With the level of inconsistency region-wide developers are challenging bylaws or taking advantage of the lack of bylaw. There is a disproportionate burden to the municipality or regional capacity of long term waste planning and expenses borne to tax payers for that infrastructure. Municipalities are more and more responding by creating by-laws which restrict accepted fill. For example, the municipality of Clarington, Ontario passed a bylaw in 2012 that restricted incoming fill to only that generated within its own boundaries (Lapointe 2012). The subject of fill use to build and expand, what proponents claim are airports and aerodromes (conventionally under federal jurisdiction), but what is arguably a lucrative business for dumping, is also being reevaluated. Most recently a court case was overturned in Burlington and an Advisory Circular released from the Federal Transportation Department seems to suggest that they are starting to acknowledge municipal authority in this matter (Luke 2014).

Five, with respect to O. Reg. 153, property owners have limited liability protection therefore enhancing the desire to avoid filing an RSC by completing inaccurate ESAs and/or removing contaminated fill and disposing at an undisclosed location (legally or illegally). Once a RSC is filed in the Environmental Site Registry, all owners (current, previous, subsequent) are protected from liability with respect to contamination that existed at the site prior to the certification date. However, there is no protection with respect to contamination that occurs after the RSC certification date; where the RSC contains false information; contamination has moved off-site; land use if more sensitive than that specified in the RSC; a person contravenes a term of an approved risk assessment or a hazardous contaminant is found on-site. (Fishlock 2010)

As a whole, the soil management policies create an environment that causes tension between private proponents and public governance — seeking cost effective ways to manage excess fill without an effective regulatory environment to handle the real problems. This has led to 'clean' soils being managed as waste and placed in landfills in short supply (Saxe 2013); illegal dumping with costs to private landowners and municipalities (Waterloo Region Soil Management Report 2013); increasingly restrictive policies of municipalities resulting in legal battles with proponents or private landowners navigating holes in environmental policies to accept unknown soils. In my opinion, developers may also be attempting to play a game of 'musical' stockpiling, shifting excess fill from one local site to another in attempt to re-use where possible while in the process creating unproductive soils (and healthy soil management is not a legal obligation in any soil policies to date). The prioritization of a healthy environment is placed against those priorities for economic development and growth when appropriate regulations are neither developed nor enforced. It is especially important to consider the interests which influence the current trajectory of policy.

# Framework for Land Development

In the previous sections I reviewed the species-specific characteristics of *M. rubra, as well as impacts, vectors and merits of management approaches. We also reviewed the political context for invasive species and soil management. This will allow us to consider how regulations and best practices effectively integrate this knowledge in the land development process.* In this section I evaluate how land development policies influencing site specific construction practice are facilitating the introduction, establishment, growth and spread of invasive species with particular reference to *M. rubra*.

## Soil Management Regulation on Construction Sites

In Ontario, municipalities, conservation authorities, and the Ministry of the Environment administer soil management on construction sites. Municipalities have legislative and regulatory mechanisms that can influence the removal of topsoil, fill placement, and grading alterations in their jurisdiction. Through site alteration by-laws under the Municipal Act, municipalities have some powers to mitigate impacts but are limited say for example where Conservation Authorities Act regulations are applicable.

Conservation Authorities (CAs) are empowered under the Conservation Authorities Act (s. 28) - "Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulations". These regulations specify regulated areas, including valley and stream corridors, Great Lakes shorelines, interconnecting channels, large inland lakes, wetlands and adjacent lands and regulated activities, including development, site grading, and temporary or permanent fill placement. CAs are limited in their purview in that they may only consider potential impacts of development activities with respect to five tests: (1) control of flooding; (2) erosion; (3) dynamic beaches; (4) pollution; and (5) the conservation of land. (TRCA 2009)

CAs have some level of influence with respect to topsoil/fill through permit review of timing and phasing of site stripping, grading and fill placement, proximity to natural features, impacts to the natural water balance, as well as restoration/site stabilization in order to avoid impacts to ecological functions, hydrologic functions and natural hazards. Coordination between CAs and municipalities is often necessary to ensure effective controls are in place to mitigate environmental impacts associated with topsoil/fill removal and placement. (TRCA 2009)

Municipalities may also have topsoil requirements through engineering, landscaping and urban design standards in association with development applications under the Planning Act, such as a plan of subdivision, consent to sever, site plan, or development permit. These requirements may be specified through agreements or conditions of approval, as well as Ontario Provincial Standards Specifications (OPSS) for public infrastructure projects. In our review of Guidelines containing Post Construction Soil Quality and Depth Standards, compliance was a condition of building or other permit approvals which provides for 'regulatory teeth' (TRCA 2009, Washington State Department 2012, City of Seattle 2009). However, there were no references to criteria for invasive species. Standards could be incorporated from existing OPPS criteria for example. In my review at least 2 standards are relevant: 1/802 Topsoil - “Imported topsoil shall not have contaminants that adversely affect plant growth.”; and 5/804 Seed and Cover.

At the Regional and Local levels, municipalities have wide powers to implement policies regarding Natural Heritage protection through their Official Plans. In our review of the Official Plans operating within the Credit Valley Conservation Authority jurisdiction (14 in total), Mississauga, Brampton and Peel all referenced invasive species (two to plants; three to trees; one to tree pests and diseases; and one to invasive species generally). Mississauga and Brampton had unique policy categories for soil health/conservation. Amaranth and East Garafraxa also referenced soil impacts (assuming wider health and not just erosion). Despite the low levels of implementation, the inclusion of unique soil conservation categories and reference to invasive species is encouraging. Greater awareness of the need for coordinated policies in regards to IIS may generate higher levels of policy integration.

## Soil Management Best Practices on Construction Sites

Land use planning and development is a provincial policy led process. The Planning Act (with few exceptions, i.e. government lands and Indian Reserves) is the primary legislation governing land use planning and development in Ontario. Typically development takes places in one of three ways: block plan or draft plan of subdivision converting what is usually agricultural or otherwise vacant land into an aggregation of individual parcels for residential, commercial, institutional or other use; two, severance of lot - dividing an individual parcel into one or more lots for the purpose of usually building additional residential or commercial structures; or redevelopment of an existing parcel by demolition or adaptive reuse, creating new structures.

Each category of development will require studies/reports e.g. Block Plan, Plan Subdivision of Subdivision, Site Plan, Building Permits. An amendment to an Official Plan, Block Plan, or zoning may need approval, perhaps requiring consultation with the public, studies to demonstrate the validity of the amendment. A range of stakeholders will need to be consulted; e.g. Region, Municipality, Conservation Authority, Provincial and Federal agencies. The timeframe for the development process can take anywhere from a year to a decade or longer depending on the scale of the project, where sensitive amendments require approval or Holding Bylaws are in place. During this time land may be developed in stages and/or held vacant for extended periods of time.

The stages in the development construction process are listed below as they relate to best practices for managing IIS generally and *M. rubra* in particular:

**Vacant Land**

Vacant land represents the first opportunity for IIS to establish, spread, and alter on-site ecology in favour of further introduced invasive propagation. Sites could be left in their original condition or pre-cleared and lie vacant for years waiting for sale, planning, design, and construction. During that time what may have been reasonably healthy soil will degrade due to air and water exposure and if unmanaged can become a breeding site for IIS (transported by wind, water, passing animals, humans and vehicles). Thompson & Vig (2008) caution that site clearance should be kept to a minimum, not done in advance any longer than necessary, and especially not prior to an approved site plan. (Thompson & Sorvig 2008)

Vacant land where managed need also consider the potential for IIS colonization. Activities such as grazing, runoff, roadside mowing, pollution, changes in water table, etc. are perpetual disturbance conditions therefore attracting adaptive IIS also acting as vectors of seeds (Polster 2003). Instances of invasion by weedy plants often indicates disturbance, so correcting these problems is essential to restoring healthy plant communities, as well as, physically removing invasives if needed. (Thompson & Sorvig 2008)

In preliminary site studies vacant land is surveyed for site level identification of boundaries, grades, and features (horizontal and vertical dimensions), requiring clearance of vegetation along lines of site. However, improper 'brashing' can spread plant disease and may affect vegetation diversity (both in species and age distribution) inducing a long recovery timeframe. Vegetation removal in linear patterns along ecologically arbitrary boundaries increases disruption and opens paths for soil erosion. Minimizing removal of features, as well as, vehicle/human access impacts is essential. (Thompson & Sorvig 2008)

<u>Application</u>: *M. rubra* demonstrates an affinity for disturbed conditions, establishing readily in successional habitat that characterizes vacant sites. Their ephemeral nesting approach enables them to quickly establish new nests and their high reproductive rates facilitate large colony growth to aid in strong establishment and spread. A maintained vacant site would still require monitoring for *M. rubra* nests given practices such as mowing. While *M. rubra* has been demonstrated to avoid nesting in bare soil, pre-clearing sites would be an unwise approach because weeds and successional habitat would quickly establish regardless (even with a weed suppressant fabric).

**Site Plan Design**

The obvious way to avoid impacts to soil, vegetation and water in the land development planning process is to minimize the amount of impervious surfaces (i.e. roofs, paved surfaces). This is a central principle of Low Impact Development approaches to site design for which information can be found at length in other resources (TRCA 2012).

<u>Application</u>: Site design approaches to prevent or mitigate *M. rubra* establishment could include design methods that reduce initial impacts thereby retaining the existing native flora/fauna community, and landscape design that minimize hard substrate against soil or dense herbaceous root systems.

**Construction Site Staging**

Planning out the design and coordination of construction activities from the onset provides an opportunity to minimize disruption and maximize protection of ecosystem features and function. A site inventory derived from a site walk with involved parties can identify all areas to remain undisturbed and later communicated in all drawings. As soon as the protected areas are located in the field, they must be fenced. Even outside fenced protection zones, the whole site needs protection from some common construction activities. This protection is best accomplished by designating areas for certain uses; e.g. chemical mixing and disposal; on-site parking; fires; cutting and drilling materials; stockpiling of supplies. Another approach to site staging is to incorporate site-protecting construction methods in the criteria for conceptual site design from the onset, especially in areas with high-quality vegetation. (Thompson & Sorvig 2008)

Application: A well-staged construction site will minimize disturbance regimes to soil, hydrology and native flora, as well as, maximize the retention and healthy function of areas not being touched; the less disturbed areas the less prime habitat available to *M rubra* and the more resilient the native community against encroachment. Clearly delineated access and transportation routes, as well as, cleaning stations will be a good defence against potential 'hitchhiking' of *M. rubra* given their small size and resilience. An organized site also facilitates the opportunity to more carefully and consistently monitor areas for any changes in vegetation, soil structure, and ant community which may reflect the presence of *M rubra.*

**Clearing, Grubbing, Stripping**

The initial stage of land clearing creates conditions where invasive species can quickly establish. Earthwork machines easily transfer invasives between sites (Hostetler 2010) which necessitates use of staging areas for cleaning (Polster 2003). Invasive plants adapted to disturbance spread into areas denuded of native vegetation. Without monitoring and removal of invasives during construction, natural areas can be compromised. Conventional plant removal or "grubbing" (using heavy equipment or saws to remove at stem or surface level) may not be effective on vigorous invasive species. Many species form runners underground from a small piece of root left in the soil, leave large seed banks in the soil, or multiply widely from just a few seeds. Eradicating invasives may call for unconventional treatments and require attention to site-specific soil nutrients and plant-specific metabolism. (TRCA 2012)

Polster & Landry (1993) suggest to maintain healthy vegetation cover as a preventative measure, in particular forests with closed canopies (IIS mostly don't persist in successional advancement) and advance the successional state of the vegetative community where possible.

Application: In this stage, the treatments for Vacant Land and Site Plan Staging are also relevant. Plant-ant species dynamics will also be important, given the mutualisms between co-evolved introduced invasive and *M. rubra*. Potentially existing seed banks may favour myrmecochory by *M. rubra* and facilitate their successful establishment or vice-versa. At this stage of development disturbance of nests will reveal nest locations and provides an ideal time for coordinated nest removal.

**Topsoil/Duff Stockpiling**

Topsoil comprises a few inches in which 70–100 % of all root activity occurs. Topsoil is composed of billions of organisms interacting with organic materials and mineral components. (Thompson & Sorvig 2008) The best way to preserve topsoil is to not disturb it, which is unavoidable in construction. Soil compaction can result from a single intense force (e.g. construction equipment removing topsoil) or cumulative persistent force (e.g. foot traffic). Water, air, and roots may not be able to penetrate compacted soil, reducing or destroying capacity to sustain vegetation (metrics). The susceptibility of soils is partly dependent on soil type which is why an analysis is useful at the onset.

Stockpiling has been demonstrated to cause negative effects to soil health, such as microbial biomass, BD, water holding capacity, and viable seed populations (Wick et al 2009). Wick et al (2009) conducted a study on soil property impacts from storage and movement of topsoil stockpiles, revealing that revegetation of topsoil (with two translocations over a three year period) resulted in stable or improved soil characteristics (e.g. surface aggregation, aggregate organic carbon, organic carbon, and microbial recovery) except that with increased movement (i.e. second translocation ) micro aggregates decreased while free silt and clay increased (creating long-term structural change despite rehabilitation). Although there is potential for remediation to rehabilitate degraded urban soil studies regarding carbon loss (Chen 2013) and hydraulic conductivity (Chen 2014) illustrate that the protection of soils at the early stage of urban development is critical in order to prevent significant soil structure damage.

Prior to construction, topsoil should be removed from proposed built areas, transportation routes and staging areas. Common but ineffective practice is to place in large multiple storey height mounds unprotected. Covering with breathable material or planting with a quick-growing ground crop slows drying, keeps down dust, excludes windblown weed seeds, and avoids sedimentation and erosion.

Stockpiling longer than a month can be detrimental to the health of microorganisms, therefore phased development is encouraged enabling stripping and stockpiling for small areas and durations at a time. Reducing the depth of piled soil to less than six feet for sandy and four feet for clay soils is recommended. An innovative method to preserve topsoil and a healthy "seed bank" is to treat it like sod by removing the topsoil in the form of sheets of intact soil and plants. (Thompson & Sorvig 2008)

<u>Application</u>: Although several mechanisms are suggested (such as weed suppressant material and cover crop) to prevent degradation of soil health and establishment of invasive weeds, *M. rubra* is known to nest in all of those substrates. Where *M. rubra* is present, stockpiled topsoil can act as a central vector for spread to the rest of the site, therefore regular inspection/testing is critical. The preservation of healthy soil during stockpiling is critical to the future capacity to support functional communities of native

vegetation, or alternatively suitable habitat for M. rubra establishment. Therefore, the approach to topsoil management may require multiple techniques addressing different objectives.

**Earthworks Operations**

Earthworks involve cutting, grading, backfill and compaction. These activities use heavy equipment, creating compaction and changes to site topography. Topsoil if replaced on top of subsoil that has been compacted by construction equipment, vehicle traffic/ parking or temporary storage of construction materials may inhibits penetration by the roots of plants and infiltration of precipitation. These conditions produce unhealthy trees and plants that are short-lived, disease prone or require excessive irrigation, fertilizers and pesticides to maintain. (TRCA 2009)

Attention to staging areas, consideration of construction machinery, and the use of tillage and amendment can all be incorporated to mitigate compaction. Use of smaller and lighter equipment, perhaps incorporating balloon tires and tracks are designed to decrease per-square-inch ground pressure, lessening soil compaction, erosion and vegetation loss. Performance based grading can allow steeper slopes requiring less horizontal distance that might require greater natural features be removed. Implementing post-construction soil standards for depth, density, composition and/or pH can also place onus of responsibility on the developer and demonstrate a clear mandate for soil conservation. (TRCA 2009)

Application: In this stage, the treatments for Vacant Land, Site Plan Staging and Topsoil Stockpiling are also relevant. Earthworks equipment offer a prime opportunity to transfer *M. rubra* through soil residue and tire treads, therefore establishment of staging areas for cleaning and delineated transportation/access routes are essential. Earthworks machines are moving mass amounts of soil, both subsoils and topsoils. Perhaps testing the soils prior to moving them would be useful.

**TOPSOIL RESTORATION & REAPPLICATION**

Soil properties need to be known in evaluating soil fertility levels in the context of what native vegetation it can sustain; i.e. mineral, chemical, structure, seeds, microbes, fungi, interactions with environment including regional climate, air deposits, as well as and how long interaction has been occurring. The goal of restored soil should be chemistry and fertility comparable to healthy regional soils and sustaining native flora/fauna. Therefore, properties of the amendment (e.g. imported soil or compost) are critical to determining their appropriate use; i.e. composition of organic matter should reflect the materials typical of the target vegetation community, and therefore, reflect the typical nutrient release, process and rates of decomposition. Soil development in nature can take centuries, but some composts and compost teas produce results as quickly as chemical methods and more lasting. The merits of subsoiling and deep tilling is variable. (Thompson & Sorvig 2008)

In general, some practices to consider for healthy topsoils as advocated by Thompson & Sorvig (2008) are: (1) Amend viable soil and avoid removing or bringing in topsoil where possible; (2) Use soil analysis services to understand site soil including chemical, microbes and soil organisms; (3) Amend soils to match healthy regional soil types rather than an arbitrary goal; (4) Use regional plant species to avoid widespread soil amendment and irrigation; (5) Stockpile topsoil from construction areas on-site, reusing as soon as possible; (6) Add amendments such as compost, restorative plants, local soil and erosion control materials; (7) Promote the use of biosolids (within limits noted above) to turn waste into a resource. (Thompson & Sorvig 2008)

<u>Application</u>: This stage of development replaces topsoil on areas that have been disturbed, either with existing or imported soils. Since there is no legislated requirement for reporting of biological contaminants (as there are for chemical contaminants) a Record of Site Condition or other certification is not useful for our purposes, however, testing for *M. rubra* is recommended (as well as for seedbanks which might reveal invasive introduced plant seed).

**Landscaping & Management**

Poor quality seed will likely generate development of weeds. Management techniques are most effective where infestations are immediately addressed and when the type, timing and duration of treatment is known, feasible to complete and tailored to species specific physiology. Repeated herbicide may continue disturbance and establishment of IIS; judicious single treatment may control difficult infestations; appropriate mowing and natural disturbance regimes (e.g. low intensity fire) can be effective; soil banks may not re-establish if conditions prevent (i.e. disturbance, vegetation gaps, etc). (Polster 2003)

<u>Application</u>: This stage of development involves bringing in landscaping materials and equipment. As we are aware, one of *M. rubra's* known vectors is transfer through contaminated nursery stock. Dealing with reputable known suppliers would be good step, as well as, testing nursery stock, imported soils, imported soil amendments, or recently installed landscaping for *M. rubra* so that early infestations can be identified and eradicated. Contract documents could also be prepared with standards for performance of soils and landscaping, which commonly have thresholds and consequences for seeds containing weeds; this approach could reasonably extend to invasive introduced insects such as *M. rubra*.

# Discussion

In this paper, I illuminate an absence of coordination around Invasive Species and Soil Management in the development industry, despite that there are many areas of *M. rubra* infestation around the GTA (acknowledged by respective municipalities through online advisories). There is a threat of unmanaged *M. rubra* populations being uncontrollable (e.g. Metro Vancouver Region, Town of Richmond Hill), and experts (e.g. Dr. Higgins, Metro Vancouver Region) have spoken out about soil movement as a main vector (Higgins 2014a). On the other hand, the development of IIS guidelines into legislation and the publishing of the Ontario Soil Management Guide for Best Practices (2014) offers encouragement.

Policy development generally occurs in marginal increments over time, and there is a long and convoluted history of soil management regulation tracing back to the 1970s, which has traditionally focused on chemical contamination (Fishlock 2010). Widespread IIS, although management issues have existed since the early 1900s, are experiencing a new dimension due to urbanization, globalization of trade and mobility, and population growth. Therefore, responses to IIS generally are experiencing a period of uncertainty and 'trial-by-fire'.

There is evidence that: (a) the development industry is generating huge investment dollars in the GTA; (b) the abundance of excavated soils is on the rise and the quality of that soil is in decline; (c) the development industry advocates strongly for less procedural inhibition of their autonomy, and costs of time and finances; (d) the Residential and Civil Construction Alliance of Ontario (RCCAO) has been a critical stakeholder in the development of soil management guidelines; and (e) interests other than industry (e.g. citizens groups, ENGOs, municipal, and conservation authorities) are experiencing negative impacts and have been advocating for greater oversight of the development industry and soil movement. In addition to ongoing infill and new development, large excavation projects currently operating in the GTA are starting to generate significant soil surplus, which will require disposal; i.e. TTC subway and LRT will produce 87,500 and 40,750 dump truck loads, respectively (Kuitenbrouwaer, P. 2013). Some of the soil may be headed to "secure landfills" as far north as Dufferin, west to Simcoe, and east to Port Hope (ibid).

The Residential and Civil Construction Alliance of Ontario is an alliance of key industry stakeholders derived from the residential and civil construction industry. The RCCAO was created to address the major challenges currently affecting the construction industry. Their mandate is to work together with governments and industry experts to offer realistic solutions to problems in the areas of infrastructure development, growth planning, regulatory reform, labour shortage, skills training, health and safety and technical standards.

RCCAO has been working with government and industry stakeholders over the years to encourage beneficial use of 'clean' excess construction soil (or 'fill') and reduce unsustainable 'dig and dump'. When O. Reg 153/04 (large commercial brownfield sites) changes in 2009 generated confusion and negative impacts regarding movement and handling of 'clean' excess construction soils (esp. from small municipal, residential, and commercial projects), a joint industry and government steering committee was developed by RCCAO (April 2012) to develop a Best Management Practices (BMP) for excess construction soil management in Ontario.

The BMP was developed in consultation with MOE, and is intended to complement the MOE Soil Management – A guide for Best Management Practices (2014). It draws heavily from the joint government/industry voluntary Code of Practice approach in the UK (CL:AIRE (Contaminated Lands: Applications in Real Environments). Stakeholders that participated in the RCCAO Excess Construction Soils Best Management Practices Steering Committee are representative of the construction industry.

Another key player occupying a strong organized advocacy role is the Ontario Soil Regulation Task Force. This organization is a coalition of citizens groups and other interested parties seeking solutions to the problems of excess construction soil. They provide many resources on their website, including case studies, mapping of hazardous sites, and links to other organizations, for example: Managing Large Scale Fill Symposium 2013 (Kawartha Conservation Authority); Citizens Against Fill Dumping; Lake Ridge Citizens for Clean Water (longstanding documentation and advocacy for fill issues) (Ontario Soils Regulation Task Force nd).

The Central Lake Ontario Conservation Authority (CLOCA) has also done considerable research on this sector and produced a great report that highlights the critical issues and complex situation (CLOCA 2012). As explained in this report, the commercial infill opportunities in the GTA represent significant profit generation. The scope and scale of development has been increasing in response, and without a place to move fill it is being transferred further than the watershed of origin, often by brokered companies, resulting in a "convoluted chain of custody". Conservation Authorities (CAs) conventionally could control the lifecycle of projects within their watershed, however, in this case it may fall outside their regulatory scope. As well, in dealing with non-compliance issues, the CAs face increasing costs. Costs of administration, as well as, movement of fill for infrastructure are all being passed on to the municipalities and the tax payers. Qualitative costs of noise, congestion, air pollution, and lifestyle impacts are all part and parcel of large-scale fill operations.

As a result new and creative tools are emerging to meet the demand for excess fill sites; e.g. model soil use by-law, pre-approved disposal sites, municipal fill strategies, and memorandums of understanding (whereby exclusive rights are provided to a develop in exchange for municipal benefits like terraforming/landscaping for recreational facilities, or fees) (ESEM 2014). Saxe (2013) suggests planning for excess soil/materials should be incorporated into municipal and regional official plans, so that development activities themselves are synchronized with the infrastructure and programs to effectively manage this.

More sustainable models for excavated soil/sediment/materials include: brokering of direct transfers (i.e. soil matching); banking of excess soil and materials; cluster projects (matching soil requirements and centrally locating a project specific treatment facility); soil/materials recycling and management facilities (e.g. soil washing, thermal desorption, biopiling, chemical methods, solidification/stabilization, composting); exploring synergies with other infrastructure facilities (e.g. excess snow storage/ disposal). Soils can potentially be reused for structural or general fill, aggregate materials or admixtures/products. One of the key issues is that the materials are not used on site because they lack the structural integrity or function required for the purpose; e.g. backfilling. However, technologies such as fibre or concrete reinforcing are feasible, as well as, mechanical means of breaking down aggregate to useful sizes. Use for terraforming, contouring, grading is also encouraged. Another key issue is financial feasibility as all these options are still costly to develop; public- private partnerships could be utilized. Some of these ideas are currently practiced at a small scale or as pilot projects, but clearly have not resulted in widespread long-term solutions. (Waterloo Region 2013)

From an economic standpoint more sustainable excess soil management can be challenging. Capital and operation costs of soil management/recycling facilities must be balanced with income generation. Although there is projected to be significant soil generated over upcoming years, there is still uncertain soil supply timing, volume, or proximity, as well as, competition from other Regions and Municipalities (Waterloo Region 2013). The viability of successfully remediated soils for ecosystem services post-development is also uncertain in light of perpetually increasing scientific knowledge pertaining to degraded soils.

Alternatively, an approach to addressing *M. rubra* colonization could focus on species-specific Management Plans. Maine, USA has been at the forefront of *M. rubra* research (see Groden 2005). Similar work related to *Solenopsis invicta* ‘red imported fire ant’ (Queensland Australia), termites (Guelph, ON), and tree bark beetles (Mountain Pine Beetle, Emerald Ash Borer, Long Horned Asian beetle) may also have useful insights for *M. rubra*. But the most innovative work in the Canadian experience with invasive ants is being conducted in British Columbia. The BC Inter-Ministry Invasive Species Working Group (IMISWG) was created in 2012, bringing together stakeholders from all levels of government. In two subsequent workshops, priorities were set for field research and planning actions, including: mapping infestations; inventorying research; facilitating inter-agency collaboration; education and public awareness campaigns; backgrounders publication; research on best practices, impacts, and enabling local government legislation (Inter-Ministry Invasive Species Working Group 2013).

As demonstrated in this study, Ontario currently has the capacity for addressing invasive species in the land development process through Post-Construction Specifications imposed as conditions for development approvals. Official Plans can also integrate authority regarding soil health conservation and invasive species through the their Natural Heritage Policies, which we are starting to see occur in some municipalities.

# Conclusion

Research revealing how development activities interact with the ecological community (which in turn has social implications) is important at this time of intense urbanization in South Central Ontario (and beyond). Not only are sites of development immediately impacted, but unprecedented volumes of soil are moved around the urban vicinity and into rural regions, including environmentally sensitive areas. The present planning and policy mechanisms do not legislatively require any evaluation of the biotic component of soils, which may contain insects, fungus, pathogens, microbes, seed banks, and rhizome segments; an issue only recently gaining attention in the Excess Soil Management guidelines (MOE 2013), where mitigative measures are encouraged for IIS (specifically mentioning *M. rubra*).

Human mediated processes (e.g. climate change, global transportation systems, and patterns of development that create fragmentation and disturbance) drive colonization by IIS in greater frequency, intensity, and distance (Hulme 2009). The planning and policy response to *M. rubra* has evolved in Ontario in a manner that has contributed to introduction, spread, and impacts to human and ecological communities. The Ontario Invasive Species Act (MNR 2013) and Ontario Guidelines for Best Practices in Excess Soil Management (MOE 2013) were only recently implemented, and a Bill for the Ontario Invasive Species Act (MNR 2014) was just introduced into Parliament on February 26 (open for comment until April 14).

Historically *M. rubra* infestation has received conflicted reception for institutional cross-regional solutions which are in fact necessary for any feasible mitigative or preventative measures. The potential for IIS spread, the degree of biological and social impacts, and the ability to mitigate those impacts is uncertain. Subsequently, a management response at a government level is complex (Keller et al 2011): (1) resources and political will are not generally operationalized until a crisis point; (2) 'lag time' between establishment, spread, and manifestation of impacts results in surpassed critical thresholds whereby management results can be ineffective; (3) management approaches require inter-jurisdictional coordination, where those relationships take time to build; (4) required trade-offs are disincentives to economic and trade interests, therefore, require political navigation; (5) a high level of unpredictability exists in determining whether an IIS will become invasive, and therefore, whether or what point to invest in management; and (6) implementation of IIS initiatives needs legislative support, which is often ineffective or interminable. All of this juxtaposed with the need for early and rapid response to prevent growth and expansion of IIS.

The complex arrangement of developer, planner, and landowner with respect to role in conserving biodiversity during the development process is problematic: the conceptualization of brown fields (and soil by inference) as 'waste' with little value for biological diversity or ecological function; two, the legislative requirement and/or tools for ecological evaluation are not available, improperly performed, or inaccurately reflect correlations for conservation value (i.e. that were developed in rural areas and do not equate in urban habitat); and the prioritization or formalizing of knowledge that is 'expert' rather than 'local', undermining the ability of studies to access other forms of knowledge.

Because development as it pertains to excavation of soils takes place predominantly in urbanized areas, knowledge about the ecology of urban soils is needed (at present limited). Mechanisms of invasion are not entirely understood; i.e. propagule pressure, abiotic factors of environment, and biotic characteristics of species (Catford 2009). Researchers have begun to synthesize divergent theories, highlighting transdisciplinary work, and engaging new frameworks (e.g. situating IIS in novel peri-urban ecosystems) (Catford 2009, Blackburn 2011, Pysek and Richardson 2010, Cadenasso & Pickett 2013). Ideas of population and community structure dynamics are being challenged and reconceptualized in relation to human mediated processes that create different patterns of colonization in species including IIS (Lessard 2012, Hulme 2009, Jeshcke 2005/2012, Meyerson 2007, Atwood 2009).

While a reasonable body of research exists on the subject of ants generally (Holldobler 1990, Andersen 1997), invasive ants (Holway 2002, Kenis 2009, Wolfgang 2011, McGlynn 1999, Morrison & Porter et al 2004, Rabitsch 2011), and *M. rubra* specifically (Groden 2005, Garnas 2004, McPhee 2012, Wetterer & Radchenko 2011, Higgins 2014a, Horton 2011, Hicks 2012, Hicks 2014), the most important research to understanding the behaviour and invasion dynamics of *M. rubra* in North America is taking place as we speak predominantly in Maine and Florida, USA, as well as, Nova Scotia and British Columbia, Canada. Rob Higgins suggests that innovation is needed in management approaches, and knowledge is required of species physiology, distribution, and drivers. Since an effective control for *M. rubra* does not exist, there is at least the possibility of control and mitigation with early detection, rapid response, and cooperation (Robinson et al 2013). It is important to emphasize that *M. rubra* once established, expands relatively slowly, given reproduction through budding and patchy habitat (Higgins 2013). However, just a single fertilized queen can start a colony.

There is presently no empirical research (although supported in the literature) regarding soil movement as a vector for the spread of invasive ants, although it is a known vector for the spread of IIS. Lindroth (1957) clearly outlines the mechanism by which ballast soil transferred IIS from Europe to North America. Groden et al (2005) suggest anthropogenic movement of soil (i.e. contaminated nursery stock) the most common method of introduction of invasive ants to new regions. Higgins (2014a) outlines a number of occurrences where *M. rubra* could potentially be transferred through soil (e.g. nursery operation, conservation restoration, and disposal). Hicks (2014) conducted a study that identified putative sources for *M. rubra* colonization in different areas of Newfoundland mainly attributed to soil transfer from ballast or nursery stock. Wetterer & Radchenko (2011) suggest that through this pathway *M. rubra* could spread through the USA and Canada, coast to coast. Field studies investigating this question are needed to test this hypothesis.

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# Appendices

# APPENDIX A: FEDERAL AND PROVINCIAL REGULATORY AGENCIES

**Canadian Border Services Agency (CBSA)**

CSBA is a federal enforcement agency responsible for border enforcement, immigration enforcement and customs service. The Agency is responsible for providing integrated border services that support national security and public safety priorities and facilitate the free flow of persons and goods, including animals and plants. Mainly acts under the Customs Act, but there are many others.The CBSA administers more than 90 acts, regulations and international agreements, many on behalf of other federal departments and agencies, the provinces and the territories.

Key Role in IIS: inspect and enforcement with regards to illegal import/export of regulated IIS.

**Canadian Food Inspection Agency (CFIA)**

The CFIA is a regulatory agency that consolidates the delivery of all federal food safety, animal health, and plant health regulatory programs. CFIA reports to the Minister of Health Canada (but does not fall under that agency's jurisdiction). CFIA mainly uses the Food and Drugs Act.

Key Role in IIS: The CFIA is also involved in work to protect the natural environment from invasive animal and plant diseases and plant pests (where deemed a threat to those plants/animals of food source important).

**Pest Management Regulatory Agency (PMRA)**

PMRA is a regulatory agency under Health Canada responsible for pest management regulation. PMRA works with all levels of government in Canada, as well as, organizations outside Canada (e.g. US EPA, NAFTA technical working group, and OECD); a partnership which informs policy development.

Key Role in IIS: Regulation of control and use of pesticide on IIS, which include exceptions (prescribed) to agriculture, forestry, and threat to natural ecosystems.

**Natural Resources Canada (NRCan)**

NRCan seeks to enhance the responsible development and use of Canada's natural resources and the competitiveness of Canada's natural resources products. We are an established leader in science and technology in the fields of energy, forests, and minerals and metals and use our expertise in earth sciences to build and maintain an up-to-date knowledge base of our landmass.

Key Role in IIS: Contribution mainly thorugh the CFS. Under the CFS, The Great Lakes Forestry Centre (GLFC) is one of five research centres within the CFS, which includes forest pests as one of their research priorities (Sault Ste. Marie, ON).

- Canadian Forest Service **(CFS)** is a science based policy organization that operates under Natural Resources Canada. The vision is: "An innovative, globally competitive forest sector—rooted in sustainable forests—creating prosperity for Canadians." CFS presumably operates mainly under the Forestry Act.

**Environment Canada (EC)**

Environment Canada has purview over a wide range of policies and management activities; e.g. Water governance (IRIA, Water Act); Environmental Protects (CEPA, Fisheries (DFO), AEPA); Biodiversity (SARA, MBCA, WAPPRIITA, CWA); Sustainable Development (FSDA, CEAA); etc.

# APPENDIX A: FEDERAL AND PROVINCIAL REGULATORY AGENCIES

Canadian Border Services Agency (CBSA)

- Canadian Wildlife Service (CWS) core area of responsibility is the protection and management of migratory birds and their nationally important habitats. Other areas of responsibility include species at risk, research on nationally important wildlife issues, control of international and interprovincial trade in endangered species and the negotiation and domestic implementation of international wildlife related treaties and agreements. CWS is responsible for Canada's National Wildlife Areas and Migratory Birds Sanctuaries which are federally protected areas.

- The Canadian Environmental Assessment agency (CEAA) is an arms-length federal body that reports to EC, whose mandate is to reduce environmental impacts of development projects. Management for invasive species is something that can be incorporated in EIIS

- Parks Canada is responsible for the management of national parks and conservation areas, as such is involved in IIS management. Parks Canada also employs Park Wardens; at the provincial level of Parks Ontario, PWs are being given Inspection authority under the proposed ON Invasive Species Bill/Act.

Key Role in IIS:

*Environment Canada is the lead on the Invasive Species Strategy for Canada (2004)*. EC was also the lead for the Invasive Species Partnership Program; however, funding was cut in 2012. In the IISCC, EC explains stakeholder roles in relation to Invasive Species: At the federal level, the coordination for the implementation of the IISSC is led by Environment Canada (EC), and core responsibilities for implementing the IISSC are shared among three departments and one agency: Canadian Food Inspection Agency (CFIA) for terrestrial invasive plants and agricultural pests; EC for terrestrial invasive animals and wildlife diseases; Fisheries and Oceans Canada (DFO) for aquatic invasive species; and Natural Resources Canada (NRCan) for forest pests.

**Ontario Ministry of the Environment (MOE)**

The MOE mandate is: "The Ministry of the Environment is responsible for promoting clean and safe air, land, and water to ensure healthy communities, ecological protection and sustainable development for present and future generations of Ontarians." The scope of their jurisdiction covers such issues as: water health and use (Clean Water Act, Ontario Water Resources Act Adams Mine Lake Act, Safe Drinking Water Act); water, waste, sewage, and toxic management (Municipal Water and Sewage Transfer Act, Nutrient Management Act, Waste Diversion Act, Toxics Reduction Act, Environmental Protection Act ); sustainable development (Environmental Assessment Act); and watershed health (Lake Simcoe Protection Act) . An important piece of legislation is the Environmental Bill of Rights, which gives citizens the right to participate in decision making about environmental issues, directs Ministries to consider environmental legislation in decision making, and promotes transparency and accessibility in the process through the Environmental Registry.

Key IIS Role:

# APPENDIX A: FEDERAL AND PROVINCIAL REGULATORY AGENCIES

| Canadian Border Services Agency (CBSA) |
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| • MOE oversees regulation of pesticide use through the Pesticides Act. The Environmental Protection Act (EPA) provides MOE with authority to address the discharge of a contaminant into the natural environment causing an "adverse effect". MOE may assess all activities related to soil management, including those occurring at the excavation site, during transportation or at sites where the soil is received, and may take appropriate actions within the MOE's legislative mandate (e.g. issuing orders). |
| **Ontario Ministry of Natural Resources (MNR)** |
| MNR's mandate is to "promote healthy, sustainable ecosystems and conserve …. (MNR) also manages Ontario's Crown land, promotes economic opportunities in the resource sector and enhances opportunities for outdoor recreation." Their scope of jurisdiction includes: |
| • Fish & Wildlife Management – sustainably managing Ontario's fish and wildlife resources. |
| • Land & Waters Management – leading the management of Ontario's Crown lands, water, oil, gas, salt and aggregates resources, including renewable energy projects. |
| • Forest Management – ensuring the sustainable management of Ontario's Crown forests. |
| • Ontario Parks – guiding the management of Ontario's parks and protected areas. |
| • Forest Fire, Flood and Drought Protection - protecting communities from related emergencies. |
| • Geographic Information – developing and applying to help manage natural resources. |
| Committees and branches that have special relevance to IIS: |
| • Biodiversity - Biodiversity: It's in Our Nature (2012) is a Plan that sets out the actions the government will undertake to contribute to the vision and goals outlined in Ontario's Biodiversity Strategy (2011). The plan will enable the province, together with partners, to better work toward halting biodiversity loss and advancing recovery. |
| • Species at Risk – the Endangered Species Act (2007) protects through regulation endangered species and their habitats using science-based decision-making (act conferred independent body, the Committee on the Status of Species at Risk in Ontario (COSSARO)) |
| • The critical Plant Pest Management committee provides a forum for MNR, OMAFRA, CFS, AAFC, and CFIA to discuss plant pests, including those affecting agriculture, at a strategic level. Meetings are held pursuant to a Memorandum of Understanding for the Prevention, Eradication, Control and Management of Critical Plant Pests (MNR 2011). |
| • Critical Plant Pest Management committee - a forum for OMNR, OMAFRA, CFS, Agriculture and Agri-Food Canada, and CFIA to discuss plant pests at a strategic level. Meetings are held pursuant to a Memorandum of Understanding for the Prevention, Eradication, Control and Management of Critical Plant Pests. |

# APPENDIX A: FEDERAL AND PROVINCIAL REGULATORY AGENCIES

| Canadian Border Services Agency (CBSA) |
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| • Canadian Council of Forest Ministries (CCFM) - A vehicle to work cooperatively on common forest and forestry-related issues of Canadian and international concern. The CCFM is composed of fourteen federal, provincial and territorial ministers (elected officials). Each year members of the Council assume the responsibility of the chair for the Council. The secretariat for the Council is provided by Natural Resources Canada's Canadian Forest Service. They have developed and implemented a National Forest Pest Strategy (NFPS). |
| Key Role in IIS: |
| See Invasive Species Plan/Act |
| **Conservation Authorities (TRCA, CVC, Grand)** |
| Conservation Authorities battle a number of invasive species which pose a growing threat to Ontario's economy and native biodiversity. Invasive species damage important natural ecosystems such as wetlands, forest, lakes, rivers and streams, as well as threaten agricultural practices, infrastructure, tourism, fisheries, and water quality and quantity. |
| Key Role in IIS: |
| Conservation Authorities currently address invasive species through a wide variety of means: watershed plans; habitat restoration and rehabilitation; forest management, tree and shrub planting; natural heritage strategies / invasive species strategies; water quality and quantity programs; natural lands management; community outreach and education; monitoring and reporting; technical advice. A total of 15 Conservation Authorities are members of the Ontario Invading Species Awareness Program (OFAH). |

# APPENDIX B: HISTORICAL DEVELOPMENT OF SOIL MANAGEMENT POLICIES IMPACTING WATER RESOURCES

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| Evaluating Construction Activities Impacting Water Resources (MOE 1976): Used by staff to evaluate the effects of road and bridge construction, shoreline development, dredging and other activities on water quality and to determine mitigation measures. |
| Open Water Disposal Guidelines MOE (1976): Used to determine whether or not dredged sediment and later excavated soil were suitable for disposal in open water. The guidelines remained in effect until 1992, when they were replaced by the draft (interim) *Fill Quality Guidelines for Lakefilling*. |
| In-place Pollutants Program (MOE/COA1983): Initiated to evaluate the significance of contaminants in sediments and to develop strategies to protect ecosystems. The results from this program played an important role in the development of the PSQGs (35 in total and updated in 1994 with 12 polycyclic aromatic hydrocarbon (PAH) criteria). |

# APPENDIX B: HISTORICAL DEVELOPMENT OF SOIL MANAGEMENT POLICIES IMPACTING WATER RESOURCES

Guidelines for the Protection and Management of Aquatic Sediment Quality (MOE 1993): PSQGs first published in the guideline were developed to support clean-up of AOCs under the GLWQA, as well as spills, and to ensure that deposition of fill in open water did not degrade nearby sediment.

Fill Quality Guidelines for Lakefilling in Ontario, (1992 updated in 2003): Evaluates suitability of fill for open water disposal.

*An Integrated Approach to the Evaluation and Management of Contaminated Sediments*, (MOE 1996): Included additional guidance on assessing contaminated sediment and determining management options but did not change any sediment quality criteria. For confined fill, quality criteria were established for additional contaminants and were made less stringent for some other contaminants. For unconfined fill, the quality criteria from the 1992 version of the Fill Guidelines and the 1993 and 1994 PSQGs mentioned above were adopted without change.

Soil, Ground Water and Sediment Standards for Use under Part XV.1 of the Environmental Protection Act (MOE 2004): Adopted the sediment quality criteria for unconfined fill in the 2003 Lakefilling Guidelines as the background and generic sediment standards in the 2004 document with only minor changes. Although the criteria became enforceable with the passing of O. Reg. 153/04, made under the EPA, through the Record of Site Condition, they remain guidelines under circumstances not subject to O. Reg. 153/04. MOE published updated soil and groundwater quality standards in January 2010 but did not update the sediment quality standards. The PSQGs developed in 1993 and 1994 continue to be in effect.

Canada-Ontario Agreement Contaminated Sediment Assessment Decision-making Framework (COA 2007): Developed a risk-based decision-making framework for contaminated sediment in the Great Lakes area using a rule-based, weight-of-evidence approach for assessing contaminated sediment on a site-by-site basis. Although the framework does not include sediment quality criteria, it does require that the appropriate sediment quality criteria for the jurisdiction be used. In Ontario, the relevant criteria are the PSQGs.

Guidelines for Identifying, Assessing and Managing Contaminated Sediments in Ontario: An Integrated Approach (MOE 2008): Incorporated the 2007 COA framework, which MOE decided could be applied province-wide. The guidelines replaced the 1993 Guidelines for the Protection and Management of Aquatic Sediment Quality and 1996 An Integrated Approach to the Evaluation and Management of Contaminated Sediments. The new guidelines adopted the 1992/1993/1994 sediment quality criteria without any changes.

## APPENDIX C: OTHER SOIL MANAGEMENT POLICIES

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| Ontario Provincial Specification Standards (OPSS): Outlines standard practice where a public infrastructure project (e.g. highways) is being constructed. OPSS180 provides the general specification for the Management of Excess Materials and unique definitions for Disposable Fill, Earth, Excess Material, and Waste. (http://www.raqsb.mto.gov.on.ca/techpubs/ops.nsf/fee5d2d0c518bc6c85257172004af2c6/76b09cb3de5b7a15852570c9006ae630/$FILE/OPSS%20180%20Nov11.pdf) |
| Fisheries Act Canada: Prohibits the discharge of any substance into water where it is likely to be deleterious to fish, fish habitat or to human use of fish. |
| Ontario Water Resources Act: Prohibits the discharge of any material into water or on shore that may impair the quality of the water. |
| Conservation Authorities Act: Outlines the approval and management requirements for fill in areas designated by the local Conservation Authority. |
| Clean Water Act (2006): Requires that threats to the quality of drinking water supplies be identified. Contaminated sediment is considered a "condition of past activities." Source Protection Committees may but are not required to develop policies to reduce the risk to source water of past activities. |
| Municipal Official Plans: May (according to the Planning Act) implement by-laws restricting, controlling or requiring conditions regarding the deposit of fill & site alteration. (Saxe 2013) |
| Provincial Policy Statement and Provincial Plans: I.e. Oak Ridges Moraine Conservation Plan, Niagara Escarpment Plan, Greenbelt Plan and Source Water Protection Plans. These Plans contain specific policies related to protection of ground and surface water resources, features and systems, including highly vulnerable aquifer areas, as well as natural heritage features and systems. They also contain policies on site alteration within, and adjacent to, these features and systems, including landform conservation. (MOE 2012) |