Forest Ecology and Management 358 (2015) 165–173

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Review and synthesis

Ecological risks posed by emerald ash borer to riparian forest habitats: A review and problem formulation with management implications

David Nisbet [a,1], David Kreutzweiser [b], Paul Sibley [a,*], Taylor Scarr [c]

[a] School of Environmental Sciences, University of Guelph, 50 Stone Rd E, Guelph, ON N1G 2W1, Canada
[b] Canadian Forest Service, Natural Resources Canada, 1219 Queen St. East, Sault Ste. Marie, ON P6A 2E5, Canada
[c] Ontario Ministry of Natural Resources and Forestry, 64 Church St., Sault Ste. Marie, ON P6A 3H3, Canada

ARTICLE INFO

Article history:
Received 5 June 2015
Received in revised form 25 August 2015
Accepted 26 August 2015
Available online 14 September 2015

Keywords:
Emerald ash borer
Invasive insect impacts
Riparian forests
Ecosystem function and susceptibility
Management options

ABSTRACT

The exotic, invasive forest insect pest, emerald ash borer (EAB), is rapidly spreading throughout eastern North America and killing almost all ash trees in its path. The loss of ash from forest habitats could trigger a cascade of ecological effects on habitat quality and the biological communities associated with it. Riparian forest habitats serve critical and often unique functions because they can exert a disproportionate influence on the productivity of riparian soils and adjacent aquatic ecosystems, and can provide important residual habitats in human-influenced landscapes. When ash trees are present in riparian forests, the rapid loss of ash from EAB infestations could put those unique riparian forest functions at risk. The first step in assessing risks and predicting outcomes of threats to an ecosystem is to formulate predictions from existing knowledge. We briefly review the literature on riparian forest ecosystem function and the impacts of other insect pest species on riparian structure and functional processes, with an emphasis on the risks to nutrient subsidies from riparian forests to adjacent waters. We then present a problem formulation that predicts impacts of the loss of ash on riparian forests. We provide a theoretical bases for predicting that most adverse ecosystem effects will arise from reductions in high-quality leaf litter inputs as nutrient subsidies to consumer communities and from the large canopy openings as a result of the rapid loss of ash in riparian forests. Management guidelines to address these potential effects are suggested, but we recognize that actual, empirical studies to measure and assess the ecological impacts of EAB-induced loss of ash from riparian forests would greatly improve risk predictions and management responses.

© 2015 Elsevier B.V. All rights reserved.

Contents

* Corresponding author.
E-mail address: psibley@uoguelph.ca (P. Sibley).
[1] Present address: Invasive Species Centre, 1219 Queen St. East, Sault Ste. Marie, ON P6A 2E5, Canada.

http://dx.doi.org/10.1016/j.foreco.2015.08.030
0378-1127/© 2015 Elsevier B.V. All rights reserved.

1. Introduction

Invasive species have a long history of environmental impacts in North America and around the world, facilitated by human activities such as international trade. These introductions have resulted in fragmentation and destruction of habitat, changes in trophic structures, and impacts on critical ecosystem services (McNeely et al., 2001; Millennium Ecosystem Assessment, 2005; Moore, 2005). Recently introduced into North America, the emerald ash borer (EAB; *Agrilus planipennis* Fairmaire) is an invasive wood-boring Buprestid beetle that kills all species of North American ash that it encounters (*Fraxinus* spp.) (Poland and McCullough, 2006). Between its discovery in 2002 near Detroit, Michigan and surveys of 2015, the EAB has spread to 24 states in the USA and two provinces in Canada, and continues to disperse in all directions (USDA-APHIS/CFIA, 2013; www.emeraldashborer.info).

EAB has the potential to cause significant economic, social and ecological impacts in Canada. Of these, ecological impacts may be the most difficult to predict. Six species of ash are native to Canada, and of those, green ash (*Fraxinus pennsylvanica*) and black ash (*F. nigra*) are common and often prominent in poorly-drained, wet, and riparian soils (MacFarlane and Meyer, 2005; Poland and McCullough, 2006). Over the next decade, the rapid spread of EAB through North America will kill most of these ash trees (Burr and McCullough, 2014). Early indications from recent studies in post-infestation areas of southeastern Canada are that regenerating ash trees are unlikely to reach maturity and to persist as canopy trees in the face of continuing pressure from EAB populations (Aubin et al., 2015). This rapid and sustained loss of a common canopy species has the potential to result in cascading ecological effects on both the terrestrial and aquatic ecosystems linked by riparian areas. Although the direct effects of EAB on ash trees are conspicuous (dead ash are obvious), few studies have investigated potential indirect (e.g., changes in habitat) ecosystem-level effects. Others have suggested that there is potential for EAB impacts on riparian systems, and that the spatial magnitude and temporality of the effects are difficult to predict (Cappaert, 2005; Poland and McCullough, 2006; Gandhi and Herms, 2010). Poland and McCullough (2006) suggested that the loss of green and black ash, common in riparian corridors and poorly drained sites, could produce the most significant ecological impacts. Crocker et al. (2006) suggested that the impacts of ash loss on riparian ecosystems could outweigh the impacts of such losses on all other types of forest ecosystems.

The nature of ecological impacts that could result from invasive insects like EAB was described conceptually by Gandhi and Herms (2010) as potentially including: changes to forest structure and function, altered canopy gaps, reduced coarse woody debris, altered biogeochemical cycling, and changes in ecological interactions among organisms (both aquatic and terrestrial). They suggest that populations of native species that have specialized interactions with the threatened host, such as terrestrial arthropod species with a high level of association with ash, might also be at risk. While potential impacts may be intuitive, it is important that these impacts are assessed and quantified with empirical data to support the theories. When developing management plans to deal with an EAB infestation, pest and resource managers will require science-based evidence that predicts outcomes of the threats to the ecosystem. This is known as 'risk-based decision making', and is an integral part of Canada's National Forest Pest Strategy (NFPS; http://www.nrcan.gc.ca/forests/insects-diseases/13409).

The first step in predicting outcomes of threats to an ecosystem is to formulate predictions from existing knowledge. We briefly review the literature on riparian forest ecosystem function and the potential for the loss of foundation riparian tree species to impact those functional processes. We then develop a problem formulation specific to EAB in riparian forest habitats, and propose a number of management options that could direct interventions to mitigate EAB impacts on riparian forests.

2. Review of potential EAB-influenced ecological impacts to riparian areas

2.1. What is a riparian forest and why do they matter?

Riparian areas constitute the interface or transition zone between terrestrial and aquatic ecosystems. Also known as shorelines or ecotones, these land/water transitional areas can exert a disproportionate influence over the productivity of aquatic ecosystems (Naiman et al., 2005). Using the flow of energy and materials as a basis, Ilhardt et al. (2000) extend the definition of riparian areas to include the groundwater, canopy, floodplain, and the terrestrial ecosystem along watercourses. Treed riparian areas (riparian forests) have particular influences on this land/water transitional zone and adjacent water bodies (Verry et al., 2000; Sibley and Gordon, 2010). Riparian forests regulate the flow of energy and materials to forest floors and adjacent water bodies (Ewel et al., 2001; Naiman et al., 2005); filter nutrients and sediments in runoff (Risser, 1995; Weller et al., 1998; Hickey and Doran, 2004); provide canopy to filter out UV radiation and maintain cool water temperatures (Moore, 2005); deliver nutrient subsidies to receiving waters in support of aquatic food webs (Wallace et al., 1997; Richardson et al., 2010); and riparian-derived woody debris can form critical structural elements of stream beds (Bilby and Likens, 1980; Webster et al., 1994).

2.2. How will the loss of riparian ash trees impact soils and nitrogen cycling?

Leaf litter from trees is a major source of the terrestrial input of elements such as nitrogen (N) to riparian forest soils and adjacent water bodies (Attiwill and Adams, 1993; Aber et al., 1998). Nitrogen also enters the adjacent aquatic ecosystems through surface/subsurface water runoff carrying nutrients from riparian soils (Fisher and Likens, 1973; Kreutzweiser et al., 2008). Overstory canopy composition significantly influences the chemical characteristics of forest soils, which therefore influences available soil nutrients and the resulting dissolved organic material entering adjacent water bodies (Augusto et al., 2002; Lovett et al., 2004). Therefore, in ash-dominated riparian forest areas, the loss of ash leaf litter may have a direct bearing on nitrogen inputs to the soils and water, either through less N uptake from the soil by the ash trees, less usable N input through the loss of ash leaf litter, or a redistribution of N in the ecosystem (Lovett et al., 2002). This would be exacerbated in situations where the N concentrations in leaf litter of the species that replace ash in the forest canopy were substantially different. This has important ecological implications because N is a major limiting resource in most terrestrial environments, and often controls net primary productivity (NPP) (Fisher et al., 2010). Natural or anthropogenic disturbances that increase (fertilization) or reduce (loss of vegetative biomass) soil N can have significant direct effects on N cycling and many potential indirect, bottom-up effects on the structure and function of receiving ecosystems by altering the total amount of energy that enters the system and can be made available to higher trophic levels (Aber, 1992; Attiwill and Adams, 1993; Reich et al., 1997). Riparian forests are efficient at N retention, with significantly higher levels of plant production and N uptake than grassland buffers for example (Hefting et al., 2005). When a large proportion of

Download English Version:

https://daneshyari.com/en/article/86085

Download Persian Version:

https://daneshyari.com/article/86085

Daneshyari.com