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Short communication

Human pathways are barriers to beavers damaging trees and saplings in urban forests

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ABSTRACT

Urban North American beaver (*Castor canadensis*) damage of trees and saplings was compared between shore forests and forests uphill of macadam, wood chip, and raised wood board human pathways used daily in Radnor Lake State Natural Area, Nashville, TN. Also, comparisons of beaver damage were made between shore forests and forests uphill of bare earth deer paths used less than once a month by humans and the forests were on 5% and 30% slopes. Means, standard deviations, and *t*-tests ($P \leq 0.05$) were calculated for percent beaver damage, which included undamaged stems, beaver-cut stems, and beaver-cut stumps. Significant differences in beaver damage of trees and saplings were found between forests uphill of the human pathways used daily and the respective shore forests. Beaver damage of trees and saplings was not significantly different between the shore forests and forests uphill of the deer paths used less than once a month by humans for the 5% slope forest; however, the differences were significant for the 30% slope forest. Beaver damage of trees and saplings was significantly greater in the uphill of the deer paths forests than the uphill of the human pathways forests for comparable slope forests. Human scent on the pathways used daily made of macadam, wood chips, and raised wood boards was interpreted to be the barrier sensed by beavers to not cross over or under the human pathways to damage trees and saplings. This research suggests utilizing human pathways as an odor fence to spatially limit beaver damage, which provides a whole forest management alternative to individual tree protection for management of beaver damage in the urban forest.

Introduction

Urban North American beaver (*Castor canadensis*) management generally has been reactive and focused on resolving unsafe situations caused by flooding related to beavers damming water courses (Taylor et al., 2008). However, urban foresters have another reason to control beaver damage – to protect planted trees. The traditional response to beavers causing damage is trapping for relocation or harvest. Experience with white-tailed deer (*Odocoileus virginianus*) harvests in urban forests (Loeb et al., 2011) indicates removal of beavers would face stiff public opposition and any benefits are short-term due to ongoing beaver migration. Müller-Schwarze (2011, p. 195) provided three recommendations for proactive beaver management regarding trees: "protect valuable specimen trees with wire or paint with sand-containing paste"; "plant trees that beavers find unpalatable"; and "provide alternatives (food, wetlands) where beavers will do no harm." Every tree in an urban forest could be considered valuable because of planting costs or the scarcity of urban natural areas. Efforts to protect many trees in an urban forest could be affected by a negative public perception of a large number of trees painted with a sand-containing paste or covered with wire, especially in urban natural areas. Planting unpalatable native species could lead to low diversity urban forests because research from different regions indicates beavers consume a wide range of native species (Jenkins, 1979; Belovsky, 1984; Raffel et al., 2009). Native species diversity would be further limited by the commercial availability of native species. Also, studies of beaver preference for alien ornamental trees are not available to direct species selection. Finally, urban parks and natural areas are typically not large enough to host forests and wetlands devoted primarily to support beavers.

Instead of focusing on the individual trees, management of beaver damage could be oriented to a whole forest alternative based on human use of an urban forest. Urban European beavers (*Castor fiber*) cause less tree damage than rural European

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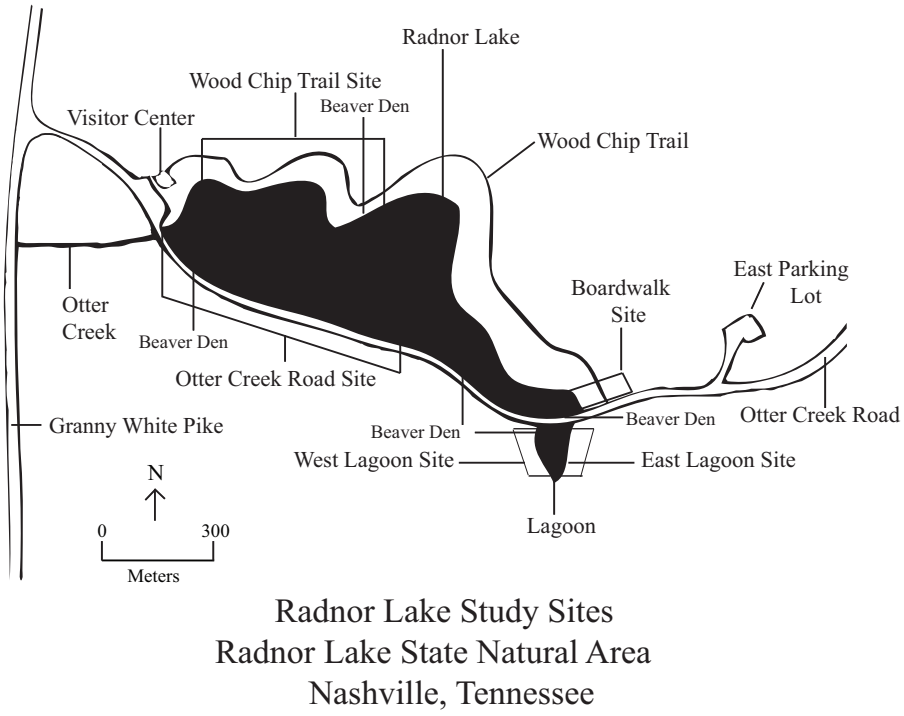

Fig. 1. Sketch map of Radnor Lake area with the locations of the Otter Creek Road, Boardwalk, Wood Chip Trail, East Lagoon, and West Lagoon sites and beaver dens noted, Radnor Lake State Natural Area, Nashville, TN.

beavers; however, people rarely observe urban beavers causing damage (Czyżowski et al., 2009). The presence of people, like other predators, is detected through the beaver's olfactory sense (Engelhart and Müller-Schwarze, 1995; Rosell and Czech, 2000). Although predator scents reduce beaver damage activities, repeated application of the scent is needed to maintain effectiveness (Severud et al., 2011). In contrast to most rural forests, urban forests have a large number of people using pathways daily and thusly the scent of people is applied to the pathways many times each day. Conceptually, people walking on urban forest pathways are re-scenting an odor fence each day. A second difference is people commonly walk on bare earth surfaces, such as deer paths, in rural forests while pathways in landscaped and natural urban forests are varied in regard to surface including macadam, wood chips, and wood boards. Considering the presence of human scent, human pathways used daily could be barriers to beaver damage of trees in the urban forests uphill of the pathways. This possibility can be investigated in two research questions: (1) Are human pathways used daily, specifically a road paved with macadam, a raised wood boardwalk, and a wood chip covered trail, barriers to beaver damage uphill of the pathways in urban forests? (2) Are bare earth deer paths used by humans less than once a month barriers to beaver damage of trees uphill of the deer paths in urban forests?

Methods

Study area

Radnor Lake State Natural Area was selected for the research because urban forest management is regulated by the Tennessee State Natural Areas Preservation Act, which includes a prohibition of off-pathway activities that is strictly enforced. Radnor Lake State Natural Area is located in Nashville, TN (36°04′ N, 86°48′ W) and encompasses approximately 473 ha. The artificial Radnor Lake including the lagoon is 34 ha but the lagoon is separated from the lake by Otter Creek Road (Fig. 1). Leashed pets are allowed only on Otter Creek Road and service dogs were not permitted on the other pathways until 2013. North American beavers were first observed in Radnor Lake in 2000. There were 6 dens on the shores of Radnor Lake (Fig. 1) but one located on Otter Creek Road was lost to a landslide caused by torrential rains in May 1–2, 2010 (Loeb and King, 2011). Plant nomenclature follows Gleason and Cronquist (1991). Mammal nomenclature follows Kays and Wilson (2009).

Forest measurements were performed in 2011, 2012, and 2013 at four sites (Fig. 1). Three human pathways used daily were sampled for the first research question: Otter Creek Road (7.5 m wide macadam surface); Boardwalk (1.5 m wide wood surface raised 1 m above a forested wetland); and Wood Chip Trail (1.5 m wide wood chip surface). Although no census of visitor use of the three human pathways has been performed, repeated field observations over three years indicate typically more than 100 visitors a day use each of the three pathways. Visitors are allowed to run only on Otter Creek Road. The fourth site, deer paths (10 cm wide bare earth surface), was divided into East Lagoon and West Lagoon to serve as a control and to answer the second research question. Visitors are not allowed in deer paths but a park ranger walks near the Lagoon less frequently than once a month. West Lagoon and Otter Creek Road forests are on a 30% slope while East Lagoon, Boardwalk, and Wood Chip Trail forests are on a 5% slope.

Sampling

The area between Radnor Lake and Otter Creek Road is narrow; therefore, sampling was performed with 5 m wide × 20 m long plots. The plots were placed along the shores of the Lagoon and Radnor Lake and along the uphill side of the deer paths in East Lagoon and West Lagoon, Wood Chip Trail, Otter Creek Road, and Boardwalk in continuous lines except as noted below. Because Wood Chip Trail was the only location with forest between the shore and deer paths or human pathways, additional plots were measured downhill of the Wood Chip Trail when the distance from the shore to