Reduced Diversity and Relative Abundance of Terrestrial Snails in a Red Pine Plantation Compared with a Surrounding Northern Red Oak – Large-toothed Aspen Woods

Paul M. Catling[1, 2] and Brenda Kostiuk[1]

[1]170 Sanford Ave., Ottawa, Ontario K2C 0E9 Canada
[2]Corresponding author: catlingpm@gmail.com

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A Red Pine (*Pinus resinosa* Aiton) plantation and adjacent Northern Red Oak (*Quercus rubra* L.) – Large-toothed Aspen (*Populus grandidentata* Michx.) woods, both of which developed from a savannah scrub beginning approximately 60 years ago, were compared with regard to terrestrial snail diversity and abundance. The comparison involved a 30-minute search of ten 1-m^2 quadrats at ten sites in each habitat. In the Northern Red Oak – Large-toothed Aspen woodland, 13 species and 661 individuals were recorded, whereas, in the Red Pine plantation, six species and 24 individuals were recorded. In the Northern Red Oak – Large-toothed Aspen woodland, the most characteristic and abundant species was *Novisuccinea ovalis* (Say, 1817), which was present in 74 of the 100 quadrats and was represented by 460 individuals. In the pine plantation, the most common species was *Zonitoides arboreus* (Say, 1816), which was present in 16 quadrats and was represented by 17 individuals. This species was the second most common in the Northern Red Oak – Large-toothed Aspen woodland where 70 individuals were found in 34 quadrats. In both habitats, *Z. arboreus* was associated with downed wood. Other species occurring in more than 15% of quadrats in the Northern Red Oak – Large-toothed Aspen woodland were *Strobilops labyrinthicus* (Say, 1817), *Glyphyalinia indentata* (Say, 1823), and *Euchemotrema fraternum* (Say, 1824). Although a lower number and diversity of terrestrial snails in the conifer plantation was expected, the contrast was greater than anticipated. The estimated abundance of 46 000 *N. ovalis* per hectare suggests the potential importance of these medium-sized snails in the relatively dry Northern Red Oak – Large-toothed Aspen ecosystem.

Key Words: Terrestrial snails; land snails; *Novisuccinea ovalis*; *Zonitoides arboreus*; savannah; oak woodland; pine plantation; diversity; abundance; Constance Bay; Ontario

Introduction

At Constance Bay, Ontario, an open scrubby savannah of unusual composition (Catling and Brunton 2010; Catling *et al.* 2010) and with rare species followed two different succession paths. Some of it became a dry Northern Red Oak (*Quercus rubra* L.) – Large-toothed Aspen (*Populus grandidentata* Michx.) woodland (Figure 1a), a natural succession favoured in the case of fire suppression. The other path has been the unnatural conversion of the savannah to Red Pine (*Pinus resinosa* Aiton) plantation (Figure 1b), beginning with extensive planting of that species in the 1950s (Catling and Brunton 2010; Catling and Kostiuk 2010; Catling *et al.* 2010). The negative impact of pine plantations on biodiversity in native habitats has been studied in Canada for some groups of organisms, such as vascular plants and grasshoppers (Catling and Kostiuk 2010, 2015). Experimental removal of planted pine trees and pine needle litter at Constance Bay has successfully restored a portion of the savannah (Catling and Kostiuk 2010). Such restorations should be based on data concerning benefits to flora and fauna (Catling and Kostiuk 2010; Spitale 2011; Catling 2013).

The objective here was to determine the impact of plantation on terrestrial snails, by exploring the difference in snail assemblages in the two succession types after about 60 years. An added benefit is a contribution to better understanding of snail ecology and, particularly, the importance of snails in relatively dry ecosystems.

Study Area

The study area included lands in and near (within 1 km) the Constance and Buckham's Bay Community Centre (45.49944°N, 76.09325°W). The plantation was a pure stand of Red Pine without understory vascular plants but sometimes with a carpet of bryophytes. The Northern Red Oak – Large-toothed Aspen area included old, spreading Northern Red Oaks, as well as young oaks and young aspens; occasional dying Jack Pine (*Pinus banksiana* Lambert); persisting depauperate shrubs from an earlier period of more open conditions, including Early Lowbush Blueberry (*Vaccinium angustifolium* Aiton), Susquehana Sand Cherry (*Prunus susquehanae* Willdenow), Sweet-fern (*Comptonia peregrina* (L.) J. M. Coulter), Black Huckleberry (*Gaylussacia baccata* (Wangeheim) K. Koch), and Poison Ivy (*Toxicodendron radicans* (L.) Kuntz); herbs including Bracken Fern (*Pteridium aquilinum* (L.) K. Kuhn); and graminoids such as Canada Bluegrass (*Poa compressa* L.), Kentucky Bluegrass (*Poa pratensis* L.), and Dry-spike Sedge (*Carex siccata* Dewey).

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FIGURE 1. Constance Bay study area. a. Northern Red Oak (*Quercus rubra*) – Large-toothed Aspen (*Populus grandidentata*) woods. b. Approximately 60-year-old Red Pine (*Pinus resinosa*) plantation. Both habitats were scrub savannah approximately 60 years ago. Photos: P. M. Catling.

Methods

Data Collection

Species of terrestrial snails and their numbers (both dead and alive) were recorded in ten 1-m^2 quadrats at 5-m intervals in 20 transects of which ten were in Red Pine plantation and ten were in Northern Red Oak – Large-toothed Aspen woodland. Each quadrat was searched for 30 minutes. No minor adjustments were made to include woody debris or other potentially important microhabitat, but it was occasionally necessary to avoid trees. Usually, little was found after the first 20 minutes of searching; thus, 30 minutes was considered a sufficient amount of search time. Only visual hand-searching was carried out. All leaf litter and the upper 2 mm of hard soil was searched. The survey was conducted during mild, 5–15°C, clear weather in September 2014 before leaf fall. Transects were laid out in such a way as to avoid habitat edges and each other by at least 20 m. They were parallel and 50 m in length. The approximate areas of available habitat within which the survey took place were 10.28 ha for the Northern Red Oak – Large-toothed Aspen woodland and 10.54 ha for the Red Pine plantation.

Identification

Specimens were collected for identification and vouchers identified by the authors were donated to the Canadian Museum of Nature with the assistance of curator Dr. Jean-Marc Gagnon. Living snails were placed in 70% alcohol and, subsequently, dried for storage. Both living snails and empty shells were included in the study and were identified on the basis of shell characteristics using Pilsbry (1939, 1940, 1946, 1948), Burch (1962), and Grimm *et al.* (2010) as well as some recent monographs (e.g., Nekola and Coles 2010) and updates (e.g., Badra 2008; Forsyth and Oldham 2014; Nekola *et al.* 2015). The names of snails used here are taken from Grimm *et al.* (2010) despite some limitations of that work (Nekola 2010a).

Results

Manually searching a defined area, for a prescribed period has been considered an efficient method for estimating diversity and relative abundance of millipedes (Mesibov *et al.* 1995) and should work well for snails provided small species are not overlooked and they are not deep in the soil. Because many micro-snails were recorded and few living snails were found in the upper 2 mm of harder soil, we think that the method was satisfactory for our purposes.

The identification of *Novisuccinea ovalis* (Say, 1817) is appropriate according to the way in which this group of snails is currently defined, although some authors have stressed the taxonomic difficulty of this group (Grimm *et al*. 2010). Other succineids, such as *Catinella vermeta* (Say, 1829), *Oxyloma retusum* (I. Lea, 1834), and *Succinea putris* (L., 1758), occur in this part of Ontario, but these are relatively distinctive genera of wetlands, shores, and disturbed habitats and differ in size, colour, and/or aperture shape.

The specimens of *Helicodiscus* had relatively broad whorls and a relatively deep umbilicus suggesting *H. parallelus* (Say, 1817) rather than *H. shimeki* Hubricht 1962. *Strobilops* shells clearly had five or six basal and parietal folds and, in a few shells where this could not be reliably evaluated, the spires were convex; thus, all were identified as *Strobilops labyrinthicus* (Say, 1817).

A few taxa identified with "*cf*." were listed that way because of either inadequate material or complexity of the group. The *Euconulus* are treated as *fulvus* on the basis of relatively weak spiral striae on the base of the shell, but this and other characteristics were found to be difficult to evaluate. Because they are few and only found in the red oak woods, the lack of a positive identification does not affect the comparison. The specimens of *Pupilla muscorum* (L., 1758) had shallow sutures unlike the recently described *P. hudsonianum* Nekola and Coles, 2015 (Nekola *et al*. 2015). The shells of *Columella* were immature.

In the Northern Red Oak – Large-toothed Aspen woodland, 13 species and 661 individuals were recorded, whereas in the Red Pine plantation both the number of species (six) and relative abundance (24 individuals) were much lower (Table 1). There was much variation among the quadrats: 85 contained no snails, whereas 36 snails including six species were found in the quadrat that contained the most snails.

The most abundant species in the Northern Red Oak – Large-toothed Aspen woodland was the succineid snail *N. ovalis* (Figure 2, family Succineidae), which was present in 74 of the 100 quadrats and was represented by 460 individuals. We estimated that there were 46 000 of these snails per ha. The most common species in the Red Pine plantation was *Zonitoides arboreus* (Say, 1816), which was present in 16 quadrats and represented by 17 individuals. This species was the second most common in the Northern Red Oak – Large-toothed Aspen woodland where 70 individuals were found in 34 quadrats. In both habitats *Z. arboreus* was in or on rotting wood. Other species occurring in more than 15% of quadrats in the Northern Red Oak – Large-toothed Aspen woodland were *Strobilops labyrinthicus, Glyphyalinia indentata* (Say, 1823), and *Euchemotrema fraternum* (Say, 1824) (Table 1).

Discussion

What was a single scrub savannah habitat approximately 60 years ago diverged into two habitats: a planted conifer plantation and dry deciduous woodland. Ten examples of the conifer plantation differed from ten examples of the deciduous woodland in having less diversity and smaller numbers of terrestrial snails. The data suggest that the diversity and numbers of snails will decline when a savannah or dry deciduous woodland transforms into a conifer plantation. However, the snail fauna can likely be re-established by restoration of the

TABLE 1. Occurrence and numbers of land snails found in 100 1-m^2 quadrats in a Northern Red Oak (*Quercus rubra*) – Large-toothed Aspen (*Populus grandidentata*) woods and a Red Pine (*Pinus resinosa*) plantation at Constance Bay, Ontario.

Species	Northern Red Oak – Large-toothed Aspen woods		Red Pine plantation	
	No. quadrats	No. individuals	No. quadrats	No. individuals
Oval Ambersnail, *Novisuccinea ovalis* (Say, 1817)	74	460	2	2
Quick Gloss, *Zonitoides arboreus* (Say, 1816)	34	70	16	17
Maze Pinecone, *Strobilops labyrinthicus* (Say, 1817)	18	33	1	1
Carved Glyph, *Glyphyalinia indentata* (Say, 1823)	17	22	0	0
Upland Pillsnail, *Euchemotrema fraternum* (Say, 1824)	15	22	0	0
Whitelip, *Neohelix albolabris* (Say, 1817)	7	8	0	0
Immature Polygyridae	7	7	1	1
Compound Coil, *Helicodiscus parallelus* (Say, 1817)	6	6	0	0
Trumpet Vallonia, *Vallonia parvula* Sterki, 1893	4	4	0	0
Angular Disc, *Discus catskillensis* (Pilsbry, 1896)	3	23	0	0
Brown Hive, *Euconulus fulvus* (Müller, 1774)	2	2	2	2
Widespread Column, *Pupilla cf. muscorum* (L., 1758)*	2	2	0	0
Bottleneck Snaggletooth, *Gastrocopta contracta* (Say, 1822)	1	1	0	0
Comb Snaggletooth, *Gastrocopta pentodon* (Say, 1822)	1	1	0	0
Grovesnail, *Cepaea nemoralis* (L., 1758)*	0	0	1	1
Toothless Column, *Columella cf. edentula* (Draparnaud, 1805)	0	0	1	1
Total		661		25

*Introduced.

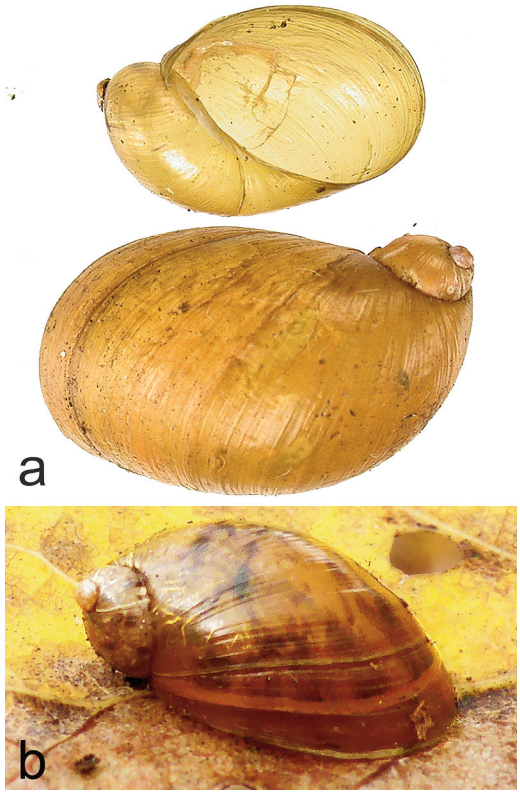

FIGURE 2. Oval Ambersnail (*Novisuccinea ovalis* (Say, 1917)), 10–15 mm in length, were common in the dry Northern Red Oak (*Quercus rubra*) – Large-toothed Aspen (*Populus grandidentata*) woods at Constance Bay with an estimated 46 000/ha. a. Shell with characteristic large aperture and few whorls. b. The animal below the transparent final whorl is blotched. Photos: P. M. Catling and B. Kostiuk.

habitat, as in the case of other flora and fauna (Catling and Kostiuk 2010), leading to a diverse assemblage possibly dominated by the Oval Ambersnail, *N. ovalis* (Figure 2).

The small number of species and relative abundance of terrestrial snails in the conifer plantation was expected on the basis of numerous reports for both conifer forests and conifer plantations (Burch 1955; Karlin 1961; Solem 1984; Bonham *et al.* 2002; Jordan and Black 2012). A characteristic thick layer of pine needle litter occurred in the conifer plantation, but there was much less leaf litter in the dry deciduous woodland and areas of litter accumulation were localized. Downed wood was present in both habitats and substrate moisture appeared to be higher in the conifer plantation. The understory was generally much more extensive in the dry deciduous woodland. Any of these, and other differences, may account for differences in snail populations. The depressed terrestrial snail fauna associated with conifers is often accounted for by the high acidity of the needle duff and lack of decaying broadleaf vegetation (Nekola 2010b).

The habitat of *N. ovalis* is often dry, and this species can survive months of desiccation (Oughton 1948: 75); this snail may occur in large numbers after rain in dry woods (Latchford 1885: 229 *sub Succinea obliqua*). It is generally reported to be most common in upland woods and rock outcrops (Nekola 2003), but Pilsbry (1948: 804) reported it from both moist and dry ground, possibly based on more than one species. Although the Constance Bay habitat of periodically very dry, rolling, and elevated Northern Red Oak – Large-toothed Aspen woodland on well-drained sandy soil may seem to be an unlikely one for snails, *N. ovalis* was not uncommon there. The calculation of 46 000 *N. ovalis* per hectare in the dry deciduous woods draws attention to the potentially significant role of this medium-sized (adult length

at this site 10–15 mm) snail dispersed throughout the ecosystem (74% of quadrats) over an area of 10.28 ha.

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