NATIVE PLANT GROWTH AND EFFECTS OF COMPOST TEA AT THE GREAT BARRINGTON HOUSATONIC RIVER WALK, 2006-2009

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INTRODUCTION

Industrialization in the United States has degraded and altered riparian habitats perhaps more than any other type of ecosystem. While the U.S. Clean Water Act and, in Massachusetts, the Wetlands Protection Act, have greatly improved water quality in Massachusetts' waterways, restoring riverbanks is critical to the recovery of riverine ecosystems. The science of restoring riparian habitat is rapidly developing as municipalities take on riverbank projects across the country, from Portland, Oregon, to Chicago, Illinois, to Massachusetts. Key to these efforts is monitoring their effectiveness and sharing the results, so that other riverbank organizations can adapt their strategies accordingly. At the Great Barrington Housatonic River Walk (Great Barrington, Mass.), we designed a native plant monitoring program to help direct our efforts as well as other potential projects along the Housatonic and adjacent watersheds.

The Great Barrington Housatonic River Walk is nestled between downtown Great Barrington and the Housatonic River in western Massachusetts. It follows the west bank of the Housatonic for roughly half a mile. This riverbank was once a dumping ground for municipal waste, and the Housatonic as a whole has been degraded by decades of dumping of PCBs (polychlorinated biphenyls), dioxins, and municipal and industrial wastewater. It has also played host to myriad invasive species, most notably Japanese knotweed (*Polygonum cuspidatum*), garlic mustard (*Alliaria petiolata*), and bittersweet (*Celastris orbiculatus*).

The River Walk area supports not only a neighborhood of Great Barrington and community of Berkshire residents, but it also provides habitat for various riparian species of plants and animals. It connects larger tracts of habitat that lie just upstream and downstream, illustrating the importance of urbanized areas that link sections of the Housatonic and contribute to its ecological functions. River Walk lies within Estimated and Priority Habitats as designated by the Massachusetts Natural Heritage and Endangered Species Program (NHESP). It also links two BioMap Core Habitats along the Housatonic (NHESP 2001). River Walk is within a Living Waters Critical Supporting Watershed and nearly adjacent to Living Waters Core Habitat (NHESP 2003). In Massachusetts, natural communities associated with rivers and streams are host to 90 rare species (Barbour et al. 1998).

Since 1988, over 2,000 people (volunteers and staff) have worked to reclaim this small but vital section of river bank, removing trash and debris (over 350 tons), eradicating invasive species, planting an array of native species (trees, shrubs, forbs, and grasses), and amending soils with feather meal, compost, and compost tea. Because River Walk's soils are severely degraded, as is the water quality in the Housatonic, and because our goal is to re-create a healthy rhizosphere, we do not use chemical pesticides or fertilizers at River Walk.

After nearly 20 years of successful reclamation work at River Walk, we knew anecdotally what native plant species were thriving and which areas were problematic for establishing native plants, but we were in need of quantifiable results with which to develop new planting strategies. Our compost tea applications appeared to be improving plant growth, but controlled experiments were necessary to draw conclusions and make management decisions regarding the use of compost tea. While the use of compost tea is increasing worldwide, few peer-reviewed, controlled studies have been conducted to measure the effects (NOSB 2004, Jones and Hinsinger 2008).

Therefore, we designed a monitoring and compost tea experiment at River Walk. We:

1) measured and monitored plant growth, to learn which plants might be able to spread on their own.

2) tested the effects of compost tea on our plantings, to learn whether tea treatment improved growth rates.

We created 22 quadrats (0.5m by 0.5 m) at 5 sites along the River Walk. We worked with 4 native species (*Agrimony gryposepala*, *Helianthus decapetalus*, *Lindera benzoin*, *Viburnum acerifolium*), planting one of each in each quadrat.

We found… which increased most, effects of tea.

METHODS

In the spring of 2006, we created the first 8 quadrats at the Rain Garden (RG) site (Figure 1). We used this site as a pilot study, to develop our methods for monitoring plant growth. In 2007, we created the other 14 quadrats at 4 additional sites (Norway Slope (NS), Church Parking Lot (CPL), Stanley Overlook (SO), and Searles School (SS)). Figure 1 shows locations of these sites along the River. Site selection was limited to the small areas that had not already been planted with native species. The 5 study sites represent the variability in River Walk's soils, slopes, and cover types, and they span the length of the River Walk.

At Rain Garden (RG), we cleared the site by pulling plants by hand and by tilling the soil mechanically. At the other sites, we cleared existing vegetation by hand only. After clearing, we measured the quadrats (0.5m by 0.5m) and their 0.5m boundaries and marked these lines with stakes and flagging tape (Figure 2). The 0.5m boundary around each quadrat ensured that every quadrat was 0.5m far from the edge of the site or from an adjacent quadrat (Figure 2). We applied pine bark mulch to all quadrats and their boundaries.

We chose four test species that represented a diversity of physiology and growth strategies, that were available locally, and that we had not already planted extensively at River Walk. Once the sites were created, we planted one start of each species (*A. gryposepala*, *H. decapetalus*, *L. benzoin*, *V. acerifolium*) in each corner of each quadrat. Corners were selected randomly (by picking a number out of a hat) for each plant. The *A. gryposepala* and *H. decapetalus* were propagated from seeds collected in Berkshire County, by Marconica, Inc. (Glendale, Mass.). The *L. benzoin* and *V. acerifolium* were propagated from seed collected in Franklin County by Sudbury Nurseries West (Gill, Mass.).

In April 2008, we added predator exclusion fencing around each site (3 ft high plastic mesh "deer fence") because we had seen some evidence of predation in 2007. In the spring of 2009, we added dividers between quadrat boundaries, to ensure that rhizomes from spreading test plants did not enter other quadrats. We used pieces of roofing slate (lined-up and overlapping), driven into the ground approximately 2 inches. Before 2009, none of our test plants had spread into other quadrats or their boundaries.

We randomly selected half of the quadrats at each site to be treated with compost tea. The remaining quadrats were our controls, and they were watered when treatment plots were treated (equal volumes of water and tea). Table 1 shows the schedule of tea and water applications. We amended the soils with feather meal and granular humates to aid the growth and diversity of fungi in the soils (see Cupo 2009). All quadrats were amended with equal volumes of meal and humates (Table 1).

We collected growth data every June and every September (Table 1), as well within a week after planting the starts (August 2006 for RG; May 2007 for all other sites). In 2006 and 2007, we took the following measurements on all plants (Figure 3a):

1. stem length (measured for every stem)
2. total number of leaves
3. number of side branches
4. number of leaves on side branches only and on mainstem only
5. number of flowers, buds, or seed heads (or indication of seed production, such as peduncles)

In addition, we measured the distance from the apical meristem to the last terminal bud scar on the 2 woody species (*V. acerifolium* and *L. benzoin*).

As the plants grew and spread rhizomes, we adjusted our data points to fit within our time and budgetary constraints (Figure 3b). In 2009 for *A. gryposepala* and in 2008 for *H. decapetalus*, we did not measure every stem. In 2009 for *H. decapetalus*, we did not measure stems or count the numbers of leaves or flowers/buds/seeds. They had spread so dramatically that we only collected them for biomass measurements.

Every September or October (2006-2009), we collected the herbaceous species (*H. decapetalus* and *A. gryposepala*) from the base up, then dried them in a greenhouse (at Bard College at Simon's Rock), then weighed them (Table 1). In September of 2009, because it was the end of our last growing season, we collected the roots of the *A. gryposepala*, dried them, and weighed them. In June and September of every year, we collected all weeds, including their roots, inside all quadrats (Table 1). They were also dried and weighed.

We analyzed our data using Microsoft Office Excel 2003. Our statistical analyses included only plants that survived through the end of the last growing season (September 2009), however, we summarized the plants that died over the course of the study, by species, by year, and by study site (Table 2).

To examine growth rates, we plotted the increase in number of stems of herbaceous plants and number of leaves of woody plants, graphing control and treated plants separately. We performed several one-tail t-tests in Excel, assuming equal variances. We tested for significant differences between control and treatment quadrats using the following parameters:

1. mean biomass of herbaceous plants (*H. decapetalus* and *A. gryposepala* were analyzed separately)
2. mean biomass of *A. gryposepala* roots
3. mean number of stems of herbaceous plants (*H. decapetalus* and *A. gryposepala* were analyzed separately)
4. mean number of leaves of woody plants (*L. benzoin* and *V. acerifolium* were analyzed separately)
5. mean length between apical meristem and last terminal bud scar on woody plants (*L. benzoin* and *V. acerifolium* were analyzed separately)

RESULTS

In the 5 study sites combined, all species showed positive growth overall, and the rate at which plants died dropped drastically after the first season (Table2). However, in NS, where Norway maple trees dominated the canopy and rhizosphere, only *L. benzoin* survived, in all 4 quadrats. *L. benzoin* also had the highest overall success rate, with a loss of only 3 plants (14%) (Table 2). *V. acerifolium* had the lowest overall success rate, with a loss of 14 plants (64%) (Table 2). Thirteen of those died within their first growing season. The plants that died were similarly divided among control and treatment quadrats (Figure 4).

Herbaceous plants – No significant differences were found between herbaceous plants in control and tea-treated quadrats at River Walk. The mean biomass (dry weight of 2009 plants) of *H. decapetalus* was lower in control quadrats, but not significantly. Mean control biomass was 578.4g (N=5), and mean treatment biomass was 842.6g (N=6; P=0.2).

Using 2009 data, we compared mean biomass (dry weight) of *A. gryposepala* in control and treatment quadrats and found no significant difference. The mean for control quadrats was 12.9g (N=9), and for treated quadrats, it was 15.5g (N=7; P=0.4). Further, there was no significant difference in mean dry root biomass. *A. gryposepala* roots in control quadrats weighed an average of 9.2g (N=9), and those in tea-treated quadrats weighed an average of 11.2g (N=7; P=0.3).

We plotted the increase in numbers of stems of herbaceous plants (*H. decapetalus* and *A. gryposepala)* in control and treatment quadrats (Figures 5 and 6). In both cases, tea treated plants grew at a similar rate to control plants, and this similarity was reinforced by an examination of mean numbers of stems per quadrat. For *A. gryposepala,* the control mean (2.9 stems per quadrat, N=59) was not significantly different from the treatment mean (2.7 stems per quadrat, N=47) (P=0.4). *H. decapetalus* sample sizes were much larger due to their rapid spread of rhizomes and new stems. The control mean (41.3 stems per quadrat, N=38) was not significantly different from the treatment mean (46.7 stems per quadrat, N=38) (P=0.4).

Woody plants – We examined the growth rates of woody plants in control and treatment quadrats by graphing numbers of leaves over time. *L. benzoin* showed similar growth rates in control and treatment quadrats (Figure 7), whereas *V. acerifolium* grew less in quadrats treated with compost tea (Figure 8). Similarly, the mean numbers of leaves in control and treatment quadrats were not significantly different for *L. benzoin* (control mean=74.7; treatment mean=70.2, P=0.4). But for *V. acerifolium*, the mean number of leaves in treated quadrats was significantly lower than that in control quadrats (control mean=31.8, N=30; treatment mean=14.8, N=30; P<0.01). In all of our analyses, this was the only significant difference detected between control and treated plants.

Despite the significant difference in numbers of leaves, V. acerifolium plants were not significantly different in their length of new growth (the distance from the apical meristem to the most recent terminal bud scar), as measured in September of 2009 (mean control=26.7cm; mean treatment=25.7cm; P=0.5). However, the sample sizes were low (2 control plants and 3 treated plants). L. benzoin measurements of new growth from the apical meristem also were not significantly different between tea-treated and control plants (control mean=42.0cm, N=8; treatment mean=47.2cm, N=9; P=0.4).

Weeds – There was no significant difference between weed biomass (dry weight) in control and tea-treated quadrats. The mean biomass per control quadrat was 8.8g (N=51), while the treatment mean was 7.4g (N=50) (P=0.3).

DISCUSSION

River Walk managers are seeking plants that might be self-sustaining and self-propagating at this site. Such plants could provide a low-maintenance ground cover that can reduce soil erosion and slow the invasion of non-native species. Our results for *L. benzoin* and *H. decapetalus* indicate that these are 2 viable species for future efforts at River Walk. *H. decapetalus* spread so rapidly that we were forced to scale down our data collection for that species. H. decapetalus increased from 22 original stems to 2,185 at all sites combined.

L. benzoin did not spread (which was not expected from a shrub in 3 years time), but its survival rate was highest of all species tested, and it was only species to survive at the NS site. This is an important result for River Walk managers because Norway maples have been an impediment to native plant success. Several other species of native plants have been planted in the understory and failed, until now. More *L. benzoin* plants could be planted on this steep slope, where their root masses would prevent some soil erosion.

Our compost tea results provide important direction for River Walk and other projects involving compost tea and improvement of the health of the rhizosphere. Several authors express the need for controlled studies on the use of compost tea (NOSB 2004, Sooby et al. 2007, Jones and Hinsinger 2008), and we at River Walk have provided much-needed results. There is a need for such studies if we are to develop ways to avoid chemical fertilizers and pesticides. This is especially important in an area where we are trying to create a functioning, self-sustaining rhizosphere where the soils are severely degraded.

Our results indicate that compost tea application at River Walk does not enhance growth of our 4 test species any more than water application does. In fact, in the case of *V. acerifolium*, compost tea may hinder growth. However, our *V. acerifolium* samples are our smallest of the 4 species, making it difficult to draw fast conclusions. In addition, *V. acerifolium* died at equal rates in control versus treated quadrats (7 out of 14 lost plants were from treated quadrats).

Further testing of the effects of compost tea, at River Walk or elsewhere, would improve our understanding of its effects or lack of positive impact. Examination of soil microbes in control and tea-treated areas may provide insights into the effects of compost tea that plant monitoring cannot provide (see Sooby et al. 2007). In addition, further examination of root systems that have been treated with compost tea may be warranted. Because the plants we planted and tested were valuable to River Walk, we only examined one species' roots (*A. gryposepala*), and only in 2009. An analysis of the effects of sunlight (open canopy) on the growth of native plants, relative to the effects of compost tea and water, would also further our ability to establish native plants at River Walk.

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Tables and Figures

Table 1. Schedule of data collection and tea application at River Walk's test sites, 2006-2009. See Figure 3 for specific measurements taken. Weeds and herbaceous plants were collected for measuring dry weights (biomass). When compost tea was applied to treatment quadrats, an equal volume of water was applied to control quadrats.

Site	No. of quadrats (no. individuals at planting)	Date planted	Growth measurements taken	Weed collection	Herbaceous plant collection	Compost tea application[1]
Rain Garden (RG)	8 (32)	9 Aug. 06	9 Aug. 06 20 Sept. 06 20-23 Jun. 07 12-18 Sept. 07 25-28 June 08 18 Sept. 08 15-23 June 09 23-26 Sept. 09	27 Sept.-4 Oct. 06 25 Jun. 07 21 Sept. 07 18 June 08 11 Sept. 08 8 June 09 16 Sept. 09	4 Oct. 06 28 Oct. 07 18 Sept. 08 25 Sept. 09	6 June 07 20 June 07 18 July 07 8 August 07 19 Sept. 07 17 Oct. 07 30 July 09 2 Nov. 09 2 Dec. 09
Searles School (SS)	2 (8)	16 May 07	17 May 07 20-23 Jun. 07 12-18 Sept. 07 25-28 June 08 18 Sept. 08 15-23 June 09 23-26 Sept. 09	9 Jul. 07 21 Sept. 07 18 June 08 11 Sept. 08 8 June 09 16 Sept. 09	28 Oct. 07 18 Sept. 08 25 Sept. 09	
Stanley Overlook (SO)	4 (16)	16 May 07	17 May 07 20-23 Jun. 07 12-18 Sept. 07 25-28 June 08 18 Sept. 08 15-23 June 09 23-26 Sept. 09	25 Jun. 07 21 Sept. 07 18 June 08 11 Sept. 08 8 June 09 16 Sept. 09	28 Oct. 07 18 Sept. 08 25 Sept. 09	
Church Parking Lot (CPL)	4 (16)	16 May 07	17 May 07 20-23 Jun. 07 12-18 Sept. 07 25-28 June 08 18 Sept. 08 15-23 June 09 23-26 Sept. 09	25 Jun. 07 21 Sept. 07 18 June 08 11 Sept. 08 8 June 09 16 Sept. 09	28 Oct. 07 18 Sept. 08 25 Sept. 09	
Norway Slope (NS)	4 (16)	16 May 07	17 May 07 20-23 Jun. 07 12-18 Sept. 07 25-28 June 08 18 Sept. 08 15-23 June 09 23-26 Sept. 09	25 Jun. 07 21 Sept. 07 18 June 08 11 Sept. 08 8 June 09 16 Sept. 09	28 Oct. 07 18 Sept. 08 25 Sept. 09	

[1] One liter of tea was applied on all dates, except 6 June 07, when 1.5 liters were applied. One-half cup of feather meal was also applied on 8 Aug. 07 and 31 Oct 07. Granular humates (1/2 cup) were added on 2 Dec. 09.

Table 2. Plant loss by year and by site at Great Barrington Housatonic River Walk. Twenty-two plants of each species were originally planted, so percentages are calculated from totals of: 22 plants per species; 88 plants per year; 16 plants at NS; 16 at CPL; 16 at SO; 32 at RG; 8 at SS.

	Number dead by year			**Number dead by study site**					
species	**2007**	**2008**	**2009**	**NS**	**CPL**	**SO**	**RG**	**SS**	**Total (%)**
A gryposepala	0	4	1	3	0	0	2	0	**5 (23)**
H. decapetalus	7	1	0	4	2	2	0	0	**8 (36)**
L. benzoin	1	2	0	0	0	0	3	0	**3 (14)**
V. acerifolium	13	0	1	4	3	0	7	0	**14 (64)**
TOTAL (%)	21 (24)	7 (8)	2 (2)	11 (69)	5 (31)	2 (13)	12 (38)	0 (0)	**30 (34)**

Figure 1. Aerial photograph of Great Barrington Housatonic River Walk (Mass.), showing locations of study sites. The study sites, and number of quadrats per site, were: 1) Norway Slope, 4; 2) Church Parking Lot, 4; 3) Stanley Overlook, 4; 4) Rain Garden, 8; Searles School, 2.

Figure 2. Photograph of one quadrat at the Stanley site, Great Barrington Housatonic River Walk. Stakes and flagging tape indicate the quadrat itself, while the slate dividers (lower corners) and mesh excluder fence (upper corners) mark the outer boundaries of that quadrat. Photo was taken in September 2009, at the end of the study, and after the *H. decapetalus* had been collected for biomass measurement. *A. gryposepala* (left) and *L. benzoin* (right) are visible in this photo.

Figure 3a. Field form used at the beginning of the study (2006-2008) at River Walk.

Quadrat no: ________ **Date:** ______________________ **Site:** ____________________________________

Recorder(s):

Apical meristem (y/n)	species	Stem length (cm)	No. leaves total	No. leaves mainstem	No. side branches	No. flowers	No. buds	No. seeds	No. peduncl es	Dist. to last term. bud scar (cm)	Comments (note any damage)

Figure 3b. Field form used at the end of the study (2009) at River Walk, when data points were adjusted according to each species.

Quadrat no: ________ **Date:** ______________________ **Site:** ____________________________________
Recorder(s):

species	Stem length (cm)	Apical meristem? (y/n)	No. leaves total	No. leaves mainstem	No. side branches	No. flowers	No. buds	No. seeds	No. peduncl es	Dist. to last term. bud scar (cm)	Comments (note any damage)
linben											
vibace											

species	No. stems	Apical meristem? (y/n)	No. leaves total	No. leaves mainstem	No. side branches	No. flowers	No. buds	No. seeds	No. peduncl es	Comments (note any damage)
agrgry										

species	No. stems	Comments (note any damage)
heldec		

Figure 4. Plant loss by year in control and treatment quadrats at River Walk.

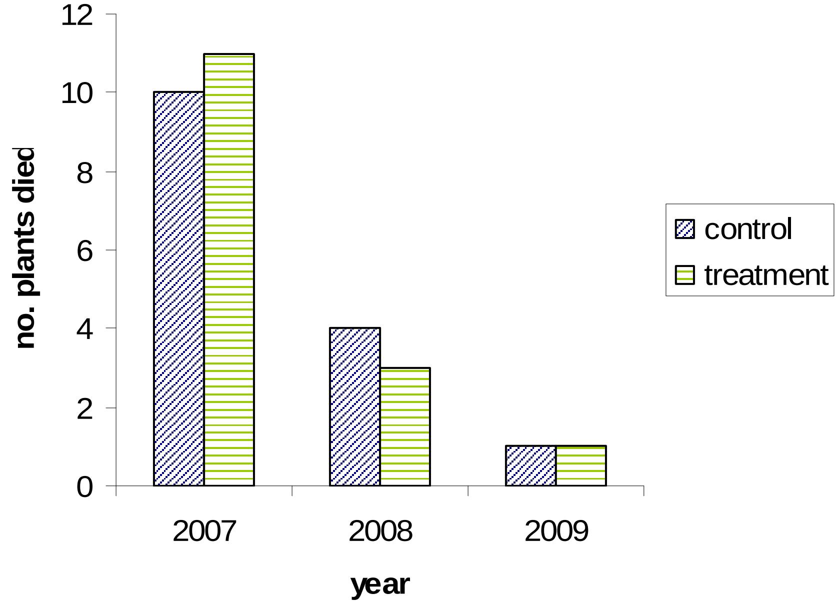


Figure 5. Growth of *A. gryposepala* at River Walk, represented by average number of stems per quadrat by season.

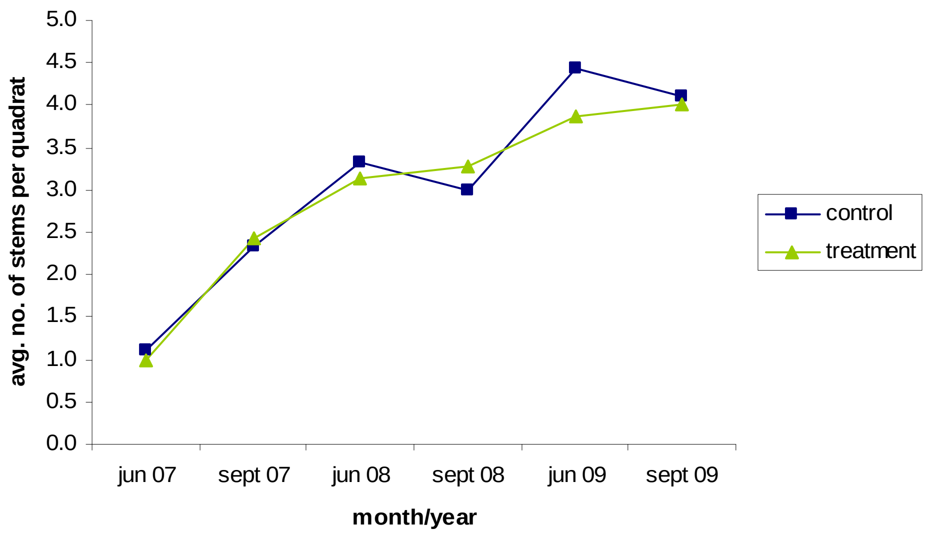


Figure 6. Growth of *H. decapetalus* at River Walk, represented by average number of stems per quadrat by season. Note that stems were not counted in June 2009, steepening the end of the growth curve.

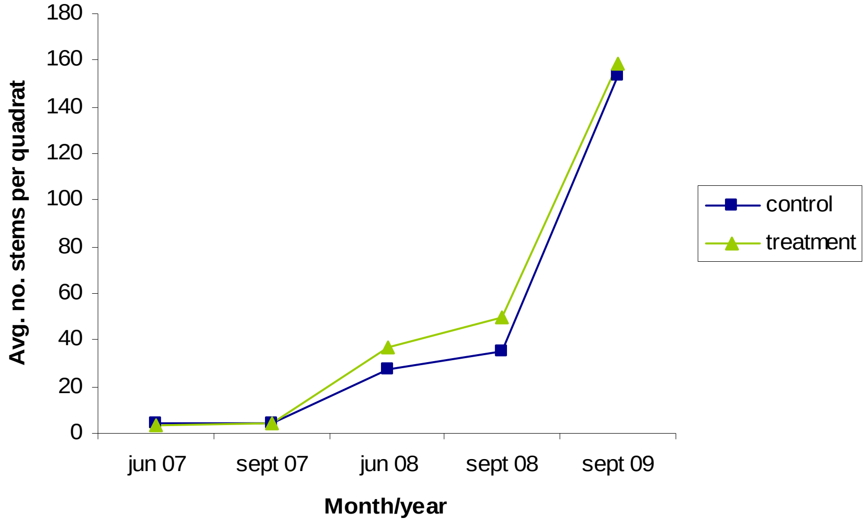


Figure 7. Growth of *L. benzoin* at River Walk, represented by average number of leaves per quadrat by season.

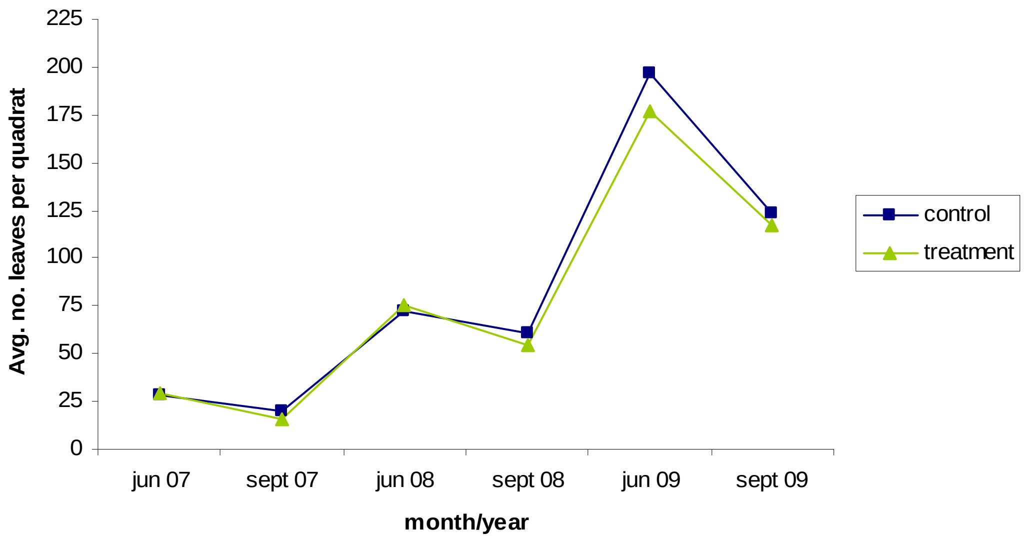
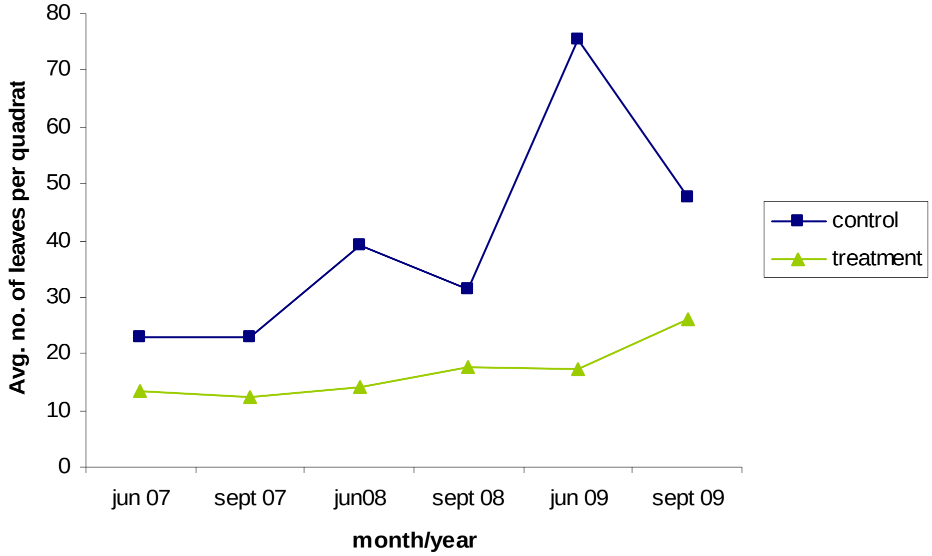


Figure 8. Growth of *V. acerifolium*, represented by average number of leaves per quadrat by season. *V. acerifolium* was the only species that was significantly (adversely) affected by compost tea.



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