The Effects of Deer on the Regeneration and Carbon Dynamics of the Lehigh Forest

Sarah Stankus, Erin Kelly, Hannah Yahraus, Prof. Ben Felzer
Earth and Environmental Sciences, Lehigh University, Bethlehem, PA

Abstract

Deer are a major stress on Lehigh’s forests. They are eating the saplings of common tree species like oak, resulting in a lack of their regeneration and allowing the growth of invasive grasses and shrubs. The Lehigh forest is currently thought to be a carbon sink, but may become a carbon source in the future due to these stresses. We surveyed a plot in the Lehigh forest and made visual observations at pre-established deer exclosures within the Lehigh forest, the Wildlands conservancy, and the Trexler Nature Preserve to determine the forest’s sensitivity to deer herbivory. These long-term experiment data show that deer only influence plant growth where there are gaps in the canopy. We concluded that the Trexler Nature Preserve exclosures would be the best for future studies because they are the oldest, are relatively large, and contain experiments on invasive species and deer. Additionally, we collected data in our plot to better understand the Lehigh forest’s current carbon dynamics. This included using the joint quartile method to determine tree density and species distribution, measuring diameter at breast height of trees to determine biomass, measuring Leaf Area Index using the LI-2200 and hemispheric camera to scale from half to canopy level, measuring Leaf Onset Ignition and Carbon-Hydrogen-Nitrogen analysis on soil samples to determine carbon and nitrogen storage, measuring soil respiration with the Li-6180, and measuring photosynthesis and leaf respiration with the LI-6400XT.

We hypothesize that deer herbivory is reducing or recovering the carbon sink in the Lehigh forest by reducing regeneration of new canopy tree species. Because we had limited time, this project serves as a preliminary study to determine the best location and methods for future work, and will be used as a baseline for future proposals and research to determine the role of deer on Leigh forest’s species composition and carbon dynamics.

Objectives and Goals

Our objectives and goals were to:

- Conduct a survey of the Lehigh forest
- Assess the effectiveness of deer exclosures within the Lehigh forest and in the surrounding area
- Determine the carbon dynamics of the forest and if it is a source or a sink

Site

We chose a 30x30m site in Lehigh’s secondary forest to take measurements. The spot was chosen just beyond the Experimental Forest and the Arboretum located near the South Mountain Park and Frisbee Golf Course. It is dominated by oak and hickory trees, making it a good representation of regional forests.

Other Sites in the Lehigh Area

To get a better sense of how larger deer exclosures work, we visited other sites in the Lehigh Valley that have established large deer exclosures. These sites all have aspects that make them good candidates for further study, but they all also have a few key differences:

- Wildlands (Figure 2a): Wildlands is the most problematic; the tree species are different than those at Lehigh, and no control plot has been established. Although it does demonstrate the importance of gaps, as we are able to see more growth in areas with gaps in the canopy that let in light. Along with the removal of deer, the gaps allow native species to outcompete invaders.
- Trexler Nature Preserve (Figure 2b): This site has five different large plots established in 2010, which makes it old enough for the treatment to show results. There are also factorial experiments exploring the effects of both invasives and deer. However, all treatments are kept in with the same fence, without replication. The leaves in the upper canopy of the control plot are also all absent, an anomaly that could allow the data. It is also located across from the Lehigh Valley Zoo’s elk and bison exhibit, which could affect deer activity. Out of the three sites, this is likely the best for future study because of the inclusion of invasives as well as different tree species.
- Morton Wildlife Sanctuary (Figure 2c): This site has relatively healthy forest regrowth and contains three plots with different light levels. However, the deer population is reduced due to hunting in the area, and the dominant tree species differ from those seen in Lehigh forest.

Conclusions

The Lehigh forest contains few young trees growing with lots of invasives. Deer exclosures can be beneficial if there are gaps in the canopy allowing light in, otherwise new saplings cannot grow well. We can conclude deer exclosures need to be established where gaps exist, and require several years in order to show results. The Trexler Nature Preserve exclosures are the most ideal for future studies because of their tree species composition and exploration of both effects of deer and invasives.

Our data show that the Lehigh forest is currently a carbon sink. We calculated an NPE of 425.31 gC/m²/yr, indicating that the forest is currently taking in more carbon than it releases. However, we can see that many of the trees that contribute to this high NEP are older trees, and with little new tree growth, the Lehigh forest could become a carbon source in the future. While our hypothesis that the deer are reducing or reversing the carbon sink in the Lehigh forest has not yet occurred, we can see the beginnings of this taking place. It is important that we continue to study the effects of deer on the Lehigh forest to take future action to create a healthier forest and avoid it becoming a carbon source.

Possible Sources of Error:

- We excluded some standing and fallen dead trees from our survey, and photosynthesis and respiration rates, we may also have overlooked the size of the pupal population.
- The obtained two different dilution values with the two different instruments. We do not know the cause of this difference.

Table 3: Carbon Fluxes (GPP, NPP, and NEP)

<table>
<thead>
<tr>
<th>Site</th>
<th>GPP (gC/m²/yr)</th>
<th>NPP (gC/m²/yr)</th>
<th>NEP (gC/m²/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lehigh Forest</td>
<td>867.25</td>
<td>867.25</td>
<td>867.25</td>
</tr>
<tr>
<td>Wildlands</td>
<td>1100.91</td>
<td>1100.91</td>
<td>1100.91</td>
</tr>
<tr>
<td>Trexler</td>
<td>78.93</td>
<td>78.93</td>
<td>78.93</td>
</tr>
<tr>
<td>South Mountain</td>
<td>350.68</td>
<td>350.68</td>
<td>350.68</td>
</tr>
</tbody>
</table>

Table 4: Soil Carbon (LOI)

<table>
<thead>
<tr>
<th>Site</th>
<th>Depth (cm)</th>
<th>0-10 cm</th>
<th>10-20 cm</th>
<th>20-40 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lehigh</td>
<td>84.77</td>
<td>84.77</td>
<td>84.77</td>
<td>84.77</td>
</tr>
<tr>
<td>Wildlands</td>
<td>84.77</td>
<td>84.77</td>
<td>84.77</td>
<td>84.77</td>
</tr>
<tr>
<td>Trexler</td>
<td>84.77</td>
<td>84.77</td>
<td>84.77</td>
<td>84.77</td>
</tr>
<tr>
<td>South Mountain</td>
<td>84.77</td>
<td>84.77</td>
<td>84.77</td>
<td>84.77</td>
</tr>
</tbody>
</table>

References

Dunn, A. W., C. Hull, and M. Vitt (2006), Post-fire forest structure and above-ground biomass of a northern hardwood forest, Forest Ecology and Management 220(3), 629.856 |
Felzer, B. D. (2007), The effects of deer on the regeneration and carbon dynamics of the Lehigh forest, Earth and Environmental Sciences, Lehigh University, Bethlehem, PA
Kim, B. C., and J. H. Kim (2008), The effects of deer on the regeneration and carbon dynamics of the Lehigh forest, Earth and Environmental Sciences, Lehigh University, Bethlehem, PA
Pearson, T. R. H., S. L. Brown, and R. A. Birdsey (2007), Measurement guidelines for the sequestration of forest carbon, Earth and Environmental Sciences, Lehigh University, Bethlehem, PA
South Mountain from Wildlands Conservancy, http://www.wildlandspa.org/south-mountain-preserve/
Summer research 2017, Google (2017), Summer research 2017.

Figure 2a: Wildlands is the most problematic; the tree species are different than those at Lehigh, and no control plot has been established. Although it does demonstrate the importance of gaps, as we are able to see more growth in areas with gaps in the canopy that let in light. Along with the removal of deer, the gaps allow native species to outcompete invaders.
Figure 2b: This site has five different large plots established in 2010, which makes it old enough for the treatment to show results. There are also factorial experiments exploring the effects of both invasives and deer. However, all treatments are kept in with the same fence, without replication. The leaves in the upper canopy of the control plot are also all absent, an anomaly that could allow the data. It is also located across from the Lehigh Valley Zoo’s elk and bison exhibit, which could affect deer activity. Out of the three sites, this is likely the best for future study because of the inclusion of invasives as well as different tree species.
Figure 2c: This site has relatively healthy forest regrowth and contains three plots with different light levels. However, the deer population is reduced due to hunting in the area, and the dominant tree species differ from those seen in Lehigh forest.