Tracing the Spread of Invsive Pests Through Remote Sensing in the Hudson Valley

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Abstract

In the last couple of years, the vegetation in the Hudson Valley has declined greatly. The source of this decline can be credited to the introduction of invasive species in North-Eastern America. We wanted to trace and examine the spread of Hemlock Wooly Adelgid (HWA) and Emerald Ash Borer (EAB) in the Hudson Valley. HWA is an exotic sap-sucking insect introduced in the Eastern United States during the 1950s. In their native habitat - Japan, they pose no significant threat. However, due to a lack of predators in America, they have spread significantly. HWA feeds on the base of the needles of Hemlock trees, resulting in reduced needle growth, reduced vigor, and gradual death of the Hemlock tree. Following a similar time frame for its effects is the EAB. They are jewel beetles native to Northeastern Asia. It has an average life span of 1 and a half years and is more active during the warmer months. There is a lack of distinct patterns for mating, adult emergence, and egg-laying for EAB. This invasive has been present in New York for decades and been feeding on Ash trees. Within 3-4 years of their presence in an Ash tree, it dies. The trick to reducing the effects of EAB is to implement prevention methods at the right time, in its various life cycles. We collected our data through Remote Sensing. Electromagnetic waves from the Sun and satellites are reflected into the atmosphere. Satellite sensors pick up this reflected electromagnetic wave and detect the different wavelengths and puts them into bands. The bands were collected from GloVis and compiled in TerrSet. The Composite tool was later used to eliminate small cloud covers and make large clouds visible. Our primary concern was the health of the vegetation. We specifically looked at the vegetation or NDVIs for all the years. For further insight into the health of the vegetation, the NDVIs were subtracted from the following year to spot any decline or improvement. Compared to EAB, HWA caused significant decline. Our observation from the Overlays portrays the decline to cover all of the Hudson Valley whereas EAB produces a seesaw effect. There were substantially fewer areas of decline and most areas improved within a year or two. The effect of EAB seems to be almost non-existent in the Hudson Valley.

Introduction

Over the years, the health of the natural vegetation in the Hudson Valley has undergone a significant decline. The decline is a result of the spread of the invasives. We looked at two invasive pests - Hemlock Wooly Adelgid (HWA) and Emerald Ash Borer (EAB) closely for our research.

HWA is an exotic sap-sucking pest from Japan. It was introduced in the Eastern United States during the 1950s. They are most active from March-November. Today, HWA extends from Georgia to Maine. HWA feeds on the sap at the base of the needles leading to reduced needle growth, reduced vigor, and gradual death. They extract Photosynthate from xylem cells which prevent Hemlock trees from being able to transport water to the rest of their bodies. HWA can be seen as tiny white wooly mosses and once it attaches itself to a Hemlock tree, it never leaves the spot (Birt et al, 94). In its native habitat, it posses no grave threat due to predation however, in their non-native habitat, they cause damage on a large scale. The effects of HWA on Hemlock trees can easily go undetected as the damage takes 4-10 years to surface (Birt et al, 95). This leads to a phenomenon known as Hemlock decline. Imidacloprid and Dinotefuran are the two most effective fertilizers to reduce the spread of Hemlock Wooly Adelgid. Moreover, introducing Silver Fly to infected areas has produced better results than most other predators. Further prevention methods are being researched (Royle and R.G, 217)

Equally as effective in what they do is the Emerald Ash Borer. True to its name, it feeds on Ash trees. It is native to North-eastern Asia and is a jewel-beetle. (Palmer, 2018) EAB has an average life-span of 1 and a half years in the Northern United States however; differs in the South due to different weather conditions. They are generally more active in the warmer months and go in hibernation mode during the winters. There is a lack of distinct patterns for adult emergence, mating, and egg-laying. Some EAB develops into an adult before winter, whereas some remain a larva and mature after the winter. Most prevention methods have remained unsuccessful. However, we have more data on EAB than HWA thus giving us a better chance of combating the effects of Emerald Ash Borer (Palmer, 2018). The trick to eradicating the spread of EAB is not just releasing their natural predators to the infected areas but the timing of it. As the life-cycle of EABs differ from region to region, we must first have a good understanding of the area infected and release predators accordingly (Clarke and Mysha, 2020) .

We have decided to look at the spread of these invasives through the lens of Remote Sensing to see their effects on a larger scale. Remote Sensing is the process of obtaining information through the usage of satellites. There are two types of Remote Sensing; active and passive Remote Sensing. In passive Remote Sensing, the solar radiation from the sun hits the surface of the Earth and reflects the radiation into space. Different objects reflect different wavelengths. The sensors in the Satellite put the information gathered in the form of a picture, giving us data. This is the same case for direct Remote Sensing but in place of the Sun, the satellite sends electromagnetic waves directly. Yeah, very high tech!

The purpose of our project is to trace the spread of EAB and HWA over the Hudson Valley and to provide an informative picture of their effects. We hope to provide environmentalists with all the required information to make their jobs easier. This data can help them come up with better prevention methods. Furthermore, they will now know areas to target instead of using parts of their resources to find possible locations themselves. This helps with the better allocation of resources and effective time-management.

Materials and Methods

For this experiment, we collected all our images from GloVis using Landsat 8. The images underwent a renaming process to make them usable for TerrSet. In TerrSet all the images were converted into Raster data. To view a better representation of what the image was showing us, we compiled all the images from the 5 years and used the composite tool. The composite tool was used to eliminate any cloud cover invisible in the initial images but also to bring the massive cloud cover in our notice. For the next step, we used the VegeIndex tool on our composites. The VegeIndex tool was used to detect vegetation which will be used in our final step. In our final step, the VegeIndex of all the years were compared with the VegeIndex from their following year. To compare the vegetations and see their decline, we used the Overlay tool. A higher negative value in the images represents an improvement whereas the higher positive value represents a decline. In the figures, the reddish-orange areas portray a decline in the vegetation.

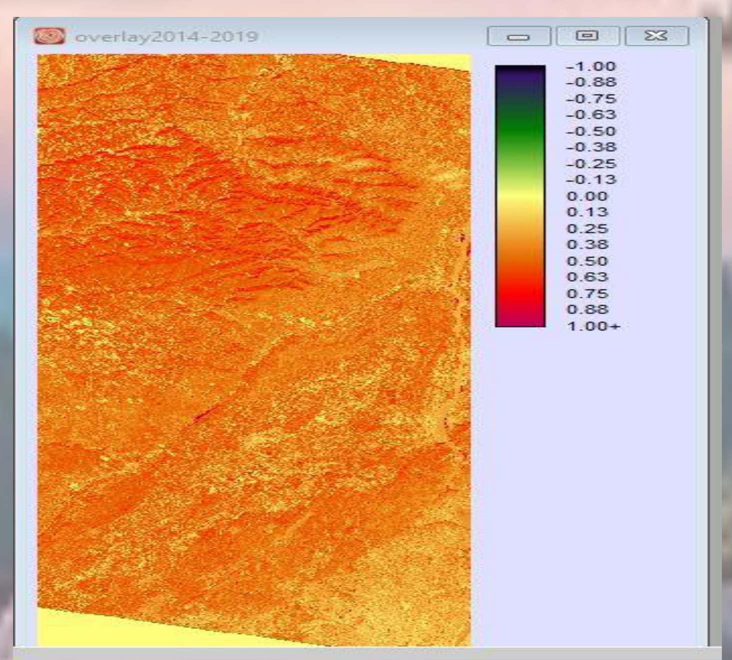
Materials

- TerrSet
- GloVis
- ArcMap online
- imapinvasives

Figure 1.

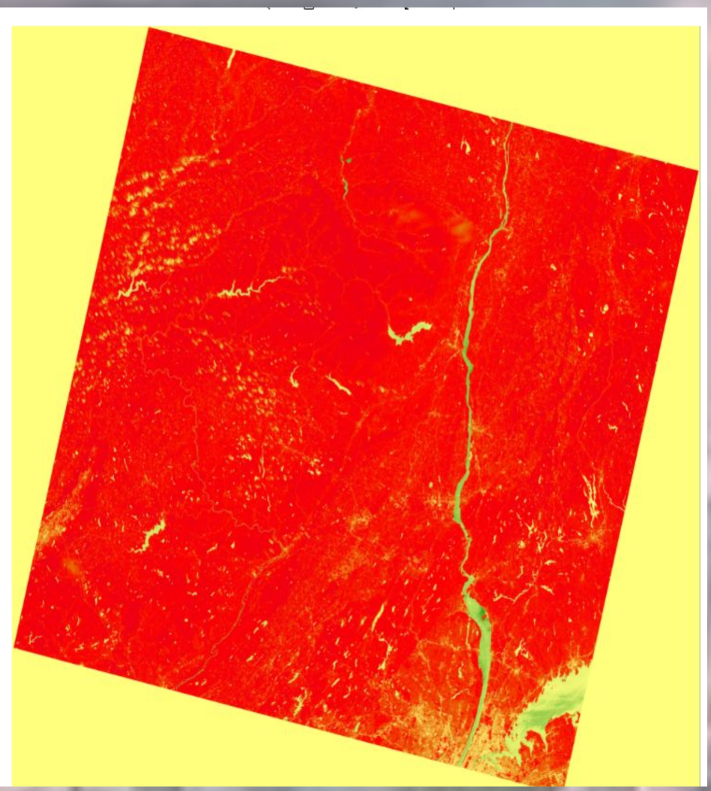
Hemlock Wooly Adelgid infestation on an Eastern Hemlock tree

Figure 2.



Overlay of Hemlock Wooly Adelgid spread from 2014-2019.

Figure 3.

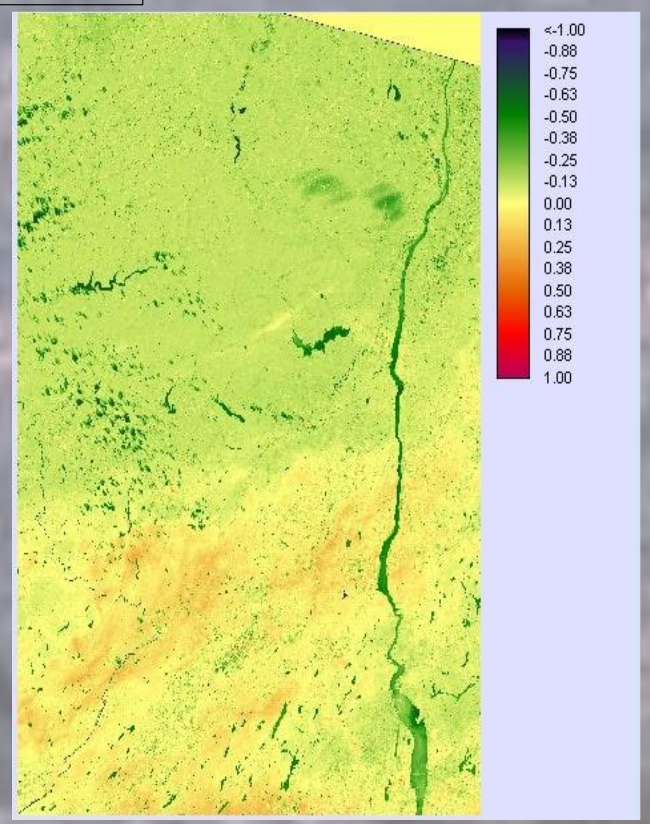


NDVI of the Hudson Valley in the year 2014

Figure 5

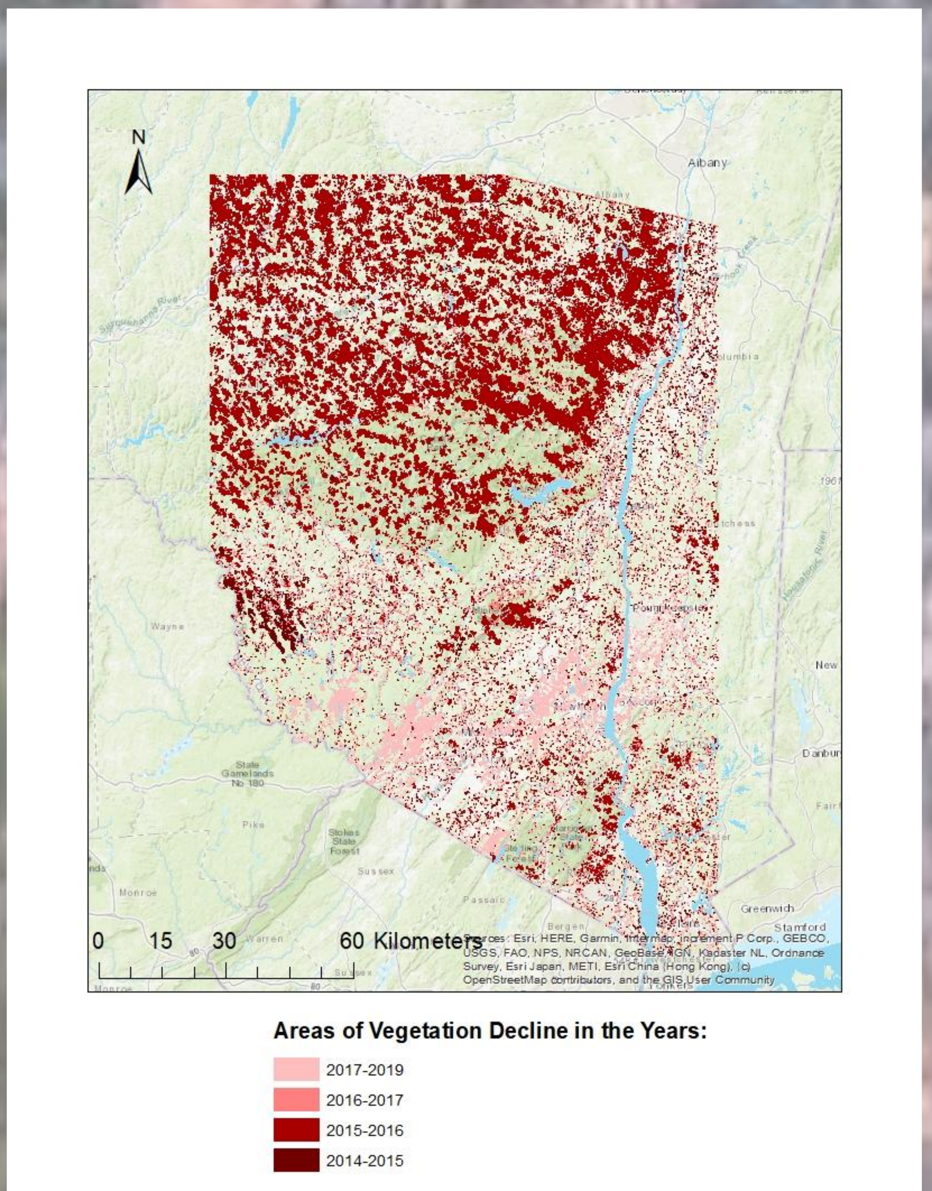
Emerald Ash Borer

Figure 4.



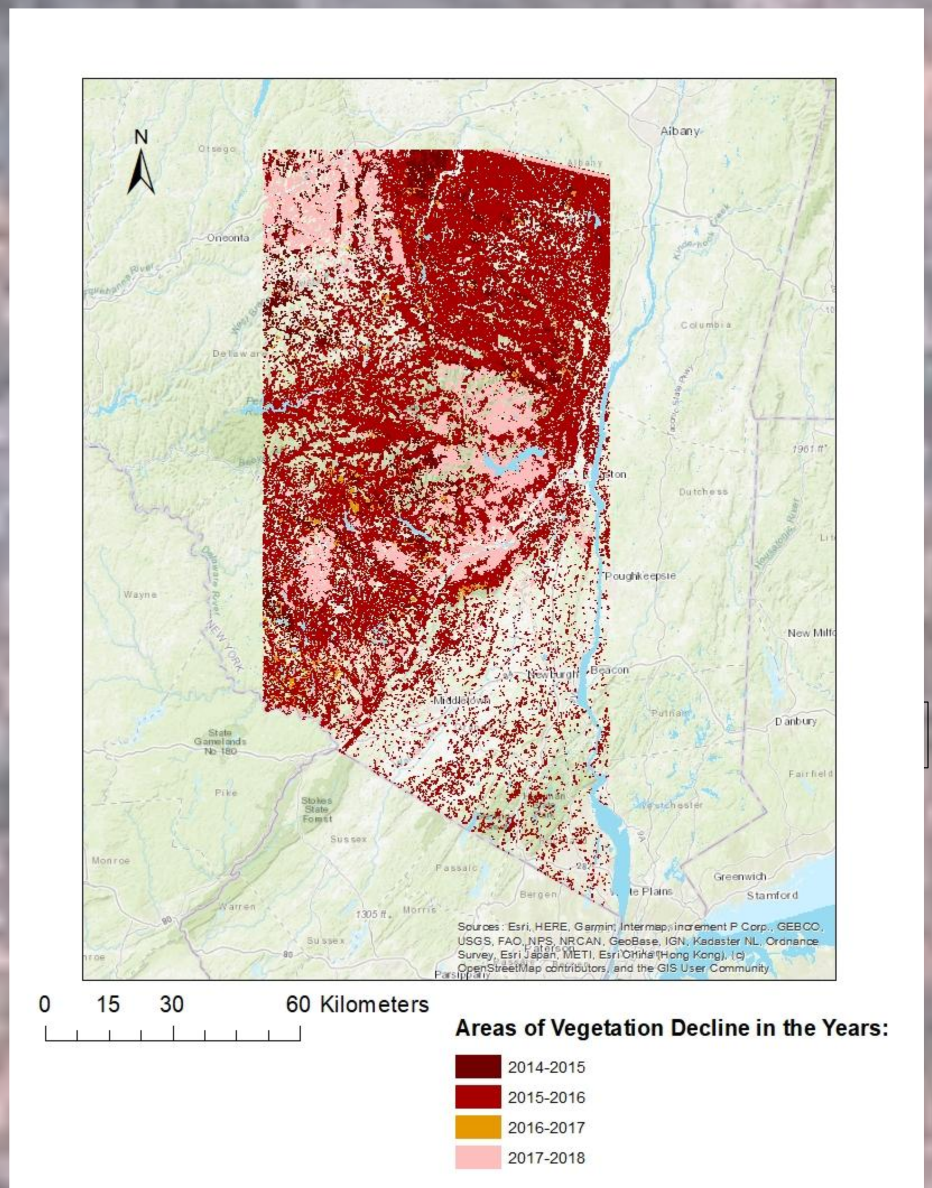
Overlay of EAB spread from the year 2018-2019

Figure 6.



Vegetation decline in the Hudson Valley over the years due to the spread of EAB

Figure 7.



Vegetation decline in the Hudson Valley over the years due to the spread of HWA

Discussion

Our research on the spread of Emerald Ash Borer (EAB) and Hemlock Wooly Adelgid (HWA) produced striking differences in results. HWA appears to have a substantial spread in the Lower Hudson Valley in comparison to EAB.

The Overlays of HWA from 2014-2015 and 2015-2016 showed a decline in the vegetation at the Upper Hudson Valley and the Lower Hudson Valley respectively. However, the Overlays of 2016-2017 and 2017-2018 portrayed an improvement. This improvement was unexpected, however, it may have been caused by natural vegetation changes such as climate, temperature, and thickness of the soil. Yet, the Overlay from 2018-2019 provides a whole new story. The year 2018-2019 resulted in the most decline, covering most of the Hudson Valley. This result would most likely be due to the phenology of HWA. Once they start feeding on a Hemlock tree, the tree will slowly start to have damaged needle and less endurance. It takes 4-10 years before there is permanent damage to the vegetation. HWA most likely infested the Hemlock trees in the Hudson Valley years earlier but it only took effect during our chosen time frame. After only a few areas of damage spotted during our observation of the first two Overlays for HWA, we see a substantial amount of damage observed during the later years.

On the other hand, while we looked at the spread of EAB it produced unimaginable results. Contrary to HWA, EAB showed no significant spread. The areas of decline are very minimal. To make our observations of EAB even more interesting, we saw the areas of decline surprisingly improve in the following years. It is hard to trace a year that had more decline than the rest. The improvements occur during the same time as the improvements with the HWA. This is also due to weather conditions. Overall, the results of the Overlays of EAB follow a seesaw effect. Unlike Hemlock trees; Ash trees do not cluster in large areas. This could explain why the damage was never as severe as HWA. Furthermore, EAB has been around far longer than HWA and the damage may have been done already. This might have caused TerrSet not to pick up any decline in vegetation.

Just as with any research we possibly had errors in our project. Most of our data has been hard to find. We encountered numerous technical difficulties that likely resulted in not having the best data set. We did not have data for EAB during the year 2018 and much of the data held clouds. Furthermore, there was a severe lack of ground-truthing in our project due to the recent pandemic. Due to our inability to ground-truth, we were not able to differentiate between natural vegetation changes. Many of the areas of decline may have been a result of weather conditions during the year. Moreover, there may have been other invasive pests in the area. Therefore, our conclusions are inferences. However, we matched the hotspots of EAB and HWA from imapinvasives with areas of decline from our data. We were able to find that the hotspots and our data align very well. Therefore, we are confident in our data for the most part.

Following the possible errors in our research, there are things we will like to improve. Our data was taken in a 5-year time-interval from 2014-2015. This data set is small compared to the time needed for EAB and HWA to affect the vegetation. We would choose a broader time-frame to have a better understanding of how the invasives spread. We combated numerous technical difficulties and our computers crashed frequently due to the sheer size of the data. Access to faster and better technology would make the data more accessible. We were unable to verify our data through ground-truthing due to the pandemic. If given more time, we would implement ground-truthing in our research. This will provide us with more accurate data.

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Literature/References

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