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| CENTRAL WASHINGTON UNIVERSITY |
| Thesis |
| Effects of the Western Spruce Budworm on Nitrogen cycling in Central Washington |
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**Introduction**

The natural process of defoliation is an important part of ecosystem health and function. Defoliators act as a negative feedback loop for forests when they are too thick by reducing them down to healthy population levels.() These insects also have the potential to help return soil systems back to healthy levels through consumption and excretion in the form of frass. Although defoliators can have these positive effects, trends towards WHAT are being seen. This can be attributed to the rate at which insect outbreaks are occurring as well as outbreak severity—which has increased dramatically over the last century (Senf et al. 2016).

Since the 1930s, the West has experienced intense fire suppression. This has led to major ecological changes, including thicker forests with increased canopy cover (Keane et al, 2002). High frequency, low intensity wildfires that formerly maintained an open forest stand occur less often, leading to increased incidence of forest insect pests. Historic fire regimes used to maintain insect pests via two avenues. First, frequent low intensity fires increased distance between trees making it challenging for insects to disperse. This decreased the rate at which (SPECIFIC INSECT) damaged the forest. Secondly, fires killed pests directly. A multi-decadal history of fire suppression, coupled with summer drought stress due to climate change, has generated conditions that encourage sustained insect outbreaks and disease in the forest (Keane et al, 2002). SUMMARY SENTENCE PERHAPS

A major defoliator of the coniferous forests of Central Washington, as well as North America in general (Senf et al. 2016), is the Western Spruce Budworm (WSB) (*Choristoneura occidentalis)*—a native lepidopteran that ranges from Southern British Columbia to Arizona and New Mexico (Fellin and Dewey, 1982). These insects emerge during budburst around mid-May to feed on the new growth of short needle conifers, specifically Douglas fir (*Pseudotsuga menziesii*) and Grand fir (*Abies grandis*). They are known to feed on a handful of other species as well (Fellin and Dewey, 1982), until late June or early July. They then pupate and emerge as adults, taking flight around mid to late July for oviposition. Larvae then emerge the following year in mid-May to repeat their life cycle. In a more natural fire regime that maintained an open forest structure, WSB outbreaks would occur about once every decade. In recent years, thicker forests from fire suppression and increased drought stress from climate change has created conditions that encourage more frequent and further spreading WSB outbreaks (Willis et al, 2008; Lovett et al, 2006). This shift in forest structure and herbivore behavior has the potential to change forest ecosystem dynamics with implications for forest-stream connectivity. Furthermore, the cold weather that would have normally killed off pests in the past is occurring less often,. This allows these pests to stay out longer, causing more damage to plants more often than they otherwise would (Griffin and Turner, 2012). It has also been suggested that pest outbreaks can lead to increased fires due to the dead and dying trees they leave behind (Schlesinger et al, 2015), but new research has shownthat this may not be the case, and in fact may have the opposite effect. These insects are defoliators as opposed to wood burrowers and therefore potentially have a different effects on ecosystem dynamics.

This study examined some of the possible ecological effects of sustained WSB herbivory—including the rate of decomposition of mixed conifer needles to see whether or not that rate is increasing in areas highly impacted by WSB meaning that more nutrients would be added to the system. Under non WSB conditions, leaf litter would fall to the forest floor and be broken down by microbes over time, gradually releasing nutrients into the soil. Areas highly impacted by WSB havethe potential to lead to increased nutrient availability in soils due to the large amounts of frass that these defoliators excrete that then falls to the forest floor. Once rainfall occurs, the leaching of frass frees up those nutrients, making them available for the forest system to use. From there, if nitrogen amounts are decreasing (net mineralization) then it can be inferred that nitrogen is taking the form of ammonium (NH4+) and is be taken up by plants and bacterial immobilization. If Nitrogen levels are increasing (net nitrification) then it can be inferred that it is taking the form of nitrate (NO3-) that can then be exported to streams (Lewis and Likens, 2006). Defoliation by WSB also has the potential to increase microbial activity via the changing of an ecosystem’s chemistry through allowing more light and rainfall to reach the forest floor, in turn leading to a quicker break down in litter (Chapman et al, 2013). Pests, mixed with the current drought in the region are likely to alter the areas nutrient cycles on the forest floor as well as in soils (Schlesinger et al, 2015).

This study is important for multiple reasons. Any time an ecosystem experiences a major disturbance, there is an overall change in balance, leading to implications for both wildlife and for human concerns. It has been shown that in fish, removing even one key species in the food web can greatly alter an ecosystem's health (Taylor et al, 2006). If the WSB are altering the nitrogen and phosphorous cycles in soils, it is important to know how the process happens. Looking at total phosphorus, net nitrification/net mineralization, canopy damage, and decomposition rates will help to offer explanations as to the nature of the cycle change. This can show where there might be potential problems and may help lead to suggestions as to how we might be able to manage this pest outbreak. As outbreaks occur, there is a shift in biomass. Through knowing the degree of shift, we can then look at overall litter quality to provide more explanations of the effects of these pests (Genung et al, 2013).

Little research has been done on the Western Spruce Budworm. Griffin and Turner (2012) did an extensive field study on *Dendroctonus pseudotsugae* (Douglas fir beetle) and *Dendroctonus ponderosae* (Mountain pine beetle) and found that herbivorous insect outbreaks cause noticeable changes to soil nitrogen cycling (2012). Current research on herbaceous insect outbreaks that occur is exploring organisms that do damage to crops. It is unknown as to whether any of the trees I will be looking at have any natural defense mechanisms towards these herbivores like some other conifers do. It is also unknown as to whether or not we can help induce a defense in my study organisms—as was attempted in the Norway Spruce (*Picea abies* ) (Zhao et al, 2011). There is also no evidence that the new growth of conifers is occurring earlier or that it is lasting for longer in our region as it is in many flowering plants on the East Coast (Miller-Rushing and Primack, 2008).

To summarize, this study is important to local soil ecosystem dynamics. By looking at the rate of decomposition, it is possible to see if the rate of conifer leaf breakdown is influenced by herbivory and microbial activity Leading to the addition of supplemental nutrients to the soil. We can measure whether those soil nutrients are being taken up by plants or are accumulating with potential to enter the stream due to runoff to monitor changes in stream chemistry and the community food web. From that information we can look at whether those changes are significant and whether we should be concerned with the WSB outbreaks.

This project was part of an overarching research grant and is intended to help provide more data on WSB activity and their effect on PNW ecosystems. The main question of the grant being addressed was; are the WSB affecting aquatic food webs in local streams. To help answer that question, I looked at two smaller questions that led back to that main focus. The first question that was investigated was; are WSB changing that rate of decomposition of conifer litter on the forest floor in the grant’s study site. My project will be testing against the null hypothesis that there is no change to see whether WSB are affecting the rate of decomposition. A second question will also be looked at to support the data gathered on the rate of decomposition. The second question is; are the WSB changing net nitrification in the soils of the areas being investigated. This will also be tested against the null hypothesis of no change.

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