Factsheet #16

Relationships Between Above- and Belowground Plant Carbon Using Minirhizotron & LiDAR Metrics

This research was funded by the UW Precision Forestry Co-op

Introduction

The impacts of climate change on forest ecosystems have been a major research focus since the 1980s (Linder and Cramer 2002), largely because forests store a vast majority of aboveground terrestrial carbon (C) (Dixon et al. 1994) and forest C dynamics respond so heavily to enhanced levels of atmospheric carbon dioxide (CO_2) (van der Meer 2002). In the near future a change in climate could alter global CO_2 uptake and decomposition rates of forests, changing how C is stored both above- and belowground in these ecosystems. A better understanding of relationships between above- and belowground forest C dynamics is drastically needed and could provide evidence of the influences of CO_2 concentration in the atmosphere, which is known to strongly influence the global climate system (Chapin et al. 2006). Due to the uncertainty and concerns of the effects of climate change on forest ecosystems, there is a pressing need for novel approaches that efficiently and effectively refine estimates of the relationships between above- and belowground global forest carbon (C) (Hese et al. 2004; Boudreau et al. 2008).
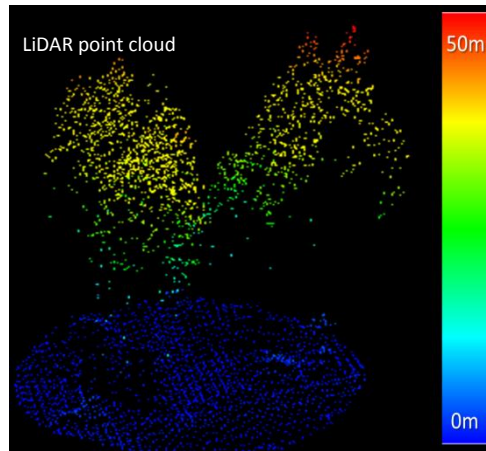
Remote sensing technologies that utilize lasers are becoming increasingly available to researchers and can quickly provide landscape level coverage of forest C stocks. However, data sets quantifying forest C using remote sensing tools, such as aerial LiDAR, inherently exclude plant C stored belowground. For instance, belowground tree C is typically estimated, not directly measured, and is usually blanketly applied a value of 25-33% of aboveground tree C (Clark et al. 2001). It is likely that widely applied value varies by ecosystem type and should be applied with caution. To refine estimates of belowground plant C further research is needed.
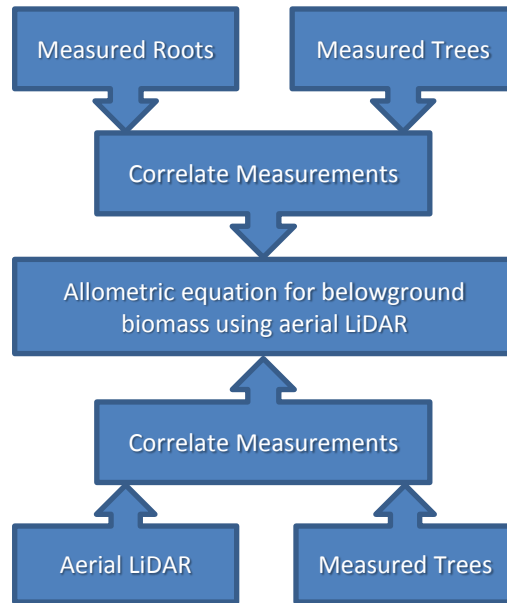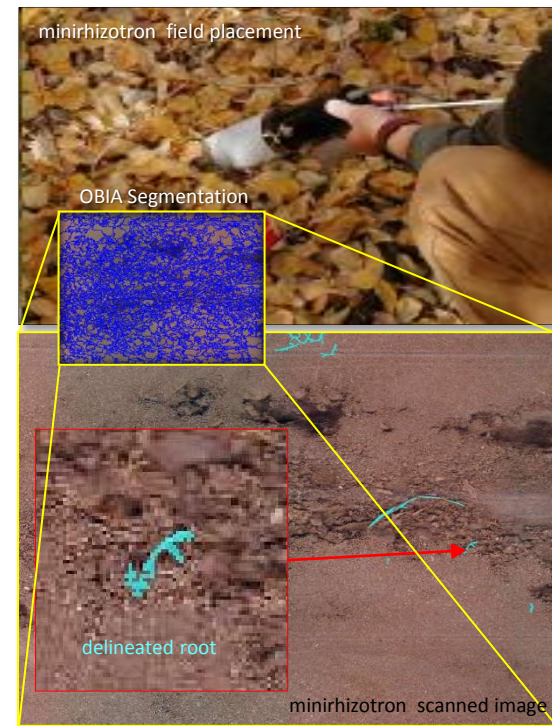

Figure 1. Schematic flowchart of project design.

The Problem

Accurate estimation of terrestrial C pools is a key focus in an age of global concern over C budgets. Balancing a C budget often requires accurate estimations of sources (inputs) and sinks (outputs) of both above– and belowground C. Aboveground tree C is rarely directly measured, but rather estimated using allometric equations. There are many allometric equations for aboveground C, but there is currently a lack of allometric equations estimating belowground C. To measure belowground C tools such as minirhizotrons are used to quantify fine root turnover, which tells you something about belowground biomass (see figure below). Potentially, with larger application of tools such as minirhizotrons more exact estimations of belowground biomass, and in turn whole tree C, would allow for better understanding of worldwide carbon flux and pools, and could allow for accurate and precise estimations of worldwide C budgets.

Figure 3. Field placement of a minirhizotron and a one time scanned image segmented using Object Based Image Analysis (OBIA) method, delineated roots are highlighted.

To delineate fine roots from an image, roots are traced sequentially using OBIA. The pixels that a root covers is converted into its biomass. Multitemporal scans allow for change analysis resulting in estimates of fine root turnover (FRT). which allows for the annual estimation of FRT, which is one element of belowground C.

Figure 2. To the left, yellow pins indicate EEON plots near The Evergreen State campus, show on top of aerial photography. Above, LiDAR point cloud of an EEON plot colored by height. Such point clouds can be collected with aerial laser scanners (ALS) and terrestrial laser scanners (TLS). We will use both ALS and TLS.

THE ISSUE:

Allometric equations between tree root biomass and aboveground biomass are in need of a comprehensive and expanded database, which represents numerous ecosystem types (Clark et al. 2001). If allometric equations are created using remote sensing tools, such as LiDAR, these may be applied across landscapes to more accurately describe whole plant carbon.

THE KEY QUESTIONS:

Is there a relationship between above- and belowground tree carbon in forests?

Citation: Kirsch, J.L., L.M. Moskal, D.M. Styers and D.G. Fischer , 2011. Relationships Between Above- and Belowground Plant Carbon Using Minirhizotron and LiDAR Metrics. Factsheet #16. Remote Sensing and Geospatial Application Laboratory, University of Washington, Seattle, WA. Digital version of the fact sheet can be downloaded at: http://dept.washington.edu/rsgal/