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Investigating organic matter in Fanno Creek, Oregon, Part 1 of 3: Estimating annual foliar biomass for a deciduous-dominant urban riparian corridor

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SUMMARY

For this study, we explored the amount, type, and distribution of foliar biomass that is deposited annually as leaf litter to Fanno Creek and its floodplain in Portland, Oregon, USA. Organic matter is a significant contributor to the decreased dissolved oxygen concentrations observed in Fanno Creek each year and leaf litter is amongst the largest sources of organic matter to the stream channel and floodplain. Using a combination of field measurements and light detection and ranging (LiDAR) point cloud data, the annual foliar biomass was estimated for 13 stream reaches along the creek. Biomass estimates were divided into two sets: (1) the annual foliage available from the entire floodplain overstory canopy, and (2) the annual foliage overhanging the stream, which likely contributes leaf litter directly to the creek each year. Based on these computations, an estimated 991 (±22%) metric tons (tonnes, t) of foliar biomass is produced annually above the floodplain, with about 136 t (±24%) of that foliage falling directly into Fanno Creek. The distribution of foliar biomass varies by reach, with between 150 and 640 t/km^2 produced along the floodplain and between 400 and 1100 t/km^2 available over the channel. Biomass estimates vary by reach based primarily on the density of tree cover, with forest-dominant reaches containing more mature deciduous trees with broader tree canopies than either wetland or urban-dominant reaches, thus supplying more organic material to the creek. By quantifying the foliar biomass along Fanno Creek we have provided a reach-scale assessment of terrestrial organic matter loading, thereby providing land managers useful information for planning future restoration efforts.

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1. Introduction

The link between terrestrial sources of organic matter and their effect on instream processes is well established (Abelho, 2001; Benfield, 1997; Meyer et al., 1998). Foliage from the surrounding canopy falls as leaf litter, enters the channel and begins to decompose, consuming oxygen from the stream. Due to the relation of allochthonous litterfall and instream organic matter, resource managers are increasingly interested in knowing the location and the amount of available canopy foliage, or foliar biomass, which supplies material to their managed streams. Thus, quantifying terrestrial biomass provides meaningful insight about potential instream organic matter and the associated water-quality issues, such as low dissolved oxygen concentrations that may propagate downstream from known source areas.

The amount of foliar biomass a tree canopy supplies varies significantly depending on the environmental setting and predominant land use. For example, successfully quantifying the amount of foliar biomass available in an urban, primarily deciduous environment can be challenging (Nowak, 1996). For years, classic forestry texts have demonstrated ways to quantify available biomass in forested areas by measuring tree canopy characteristics, such as canopy cover and canopy fuel load, through either destructive (Brown, 1978; Snell and Little, 1983) or nondestructive field-based techniques (Bunce, 1968; Scott and Reinhardt, 2005). Modern forestry practices focus more on methods that use remotely sensed data, such as light detection and ranging (LiDAR) data, to produce spatially accurate estimates of tree canopy metrics and biomass loads (Anderson et al., 2005; Erdody and Moskal, 2010; Li et al., 2008). However, these different techniques have varying success when applied to a mixed deciduous urban setting.

Paralleling forestry professionals, ecologists and biologists have also developed numerous techniques for determining foliar biomass, leaf area, litterfall rates, and leaf litter decomposition

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through either remotely sensed (Popescu et al., 2004; Zheng and Moskal, 2009) or field-based methods (Abelho, 2001; Swan and Palmer, 2004; Edmonds and Tuttle, 2010; Hladyz et al., 2010; Roberts and Bilby, 2009). Researchers utilized these techniques to determine the relation between in channel processes and above channel vegetation. These studies demonstrate a greater applicability to deciduous dominant setting, but still do not fully account for variations in land cover. Thus, we are testing whether a hybrid remotely sensed and field-based technique can successfully quantify foliar biomass production along a variable land use, primarily deciduous-dominant riparian corridor at a suitable scale for land restoration decisions to be made. With this approach we can provide land resource managers information about where leaf litter originates, the amount of the material produced, how much of the material will enter the stream in any given year, as well as provide beneficial insight into how different land uses drive biomass production.

1.1. Background

Once terrestrial organic matter, such as leaf litter, enters a stream, microbes begin to decompose and break down the material. During decomposition oxygen is consumed from the water column through the process of biochemical oxygen demand (BOD) and sediment oxygen demand (SOD). BOD and SOD are two of the main drivers of low dissolved oxygen (DO) concentrations found in streams. Low DO is considered a water-quality impairment by U.S. Environmental Protection Agency (2006) and is regulated by the ODEQ; Oregon Department of Environmental Quality (2001). To combat low DO in streams, total maximum daily loads (TMDLs), or the maximum amount of a pollutant a stream can carry while still meeting a water-quality standard, have been established by ODEQ for much of the Tualatin River basin, including Fanno Creek (Oregon Department of Environmental Quality, 2001). In the case of Fanno Creek, a TMDL has been established for total volatile suspended solids—essentially the organic matter that decomposes instream and uses DO from the water column.

Instream organic matter comes from a variety of terrestrial and aquatic sources, including leaf litter, algae, organic-rich soils, bed sediments, and stormwater. Bonn and Rounds (2010) indicate that it is the terrestrial, rather than aquatic sources of organic matter, which lead to low DO conditions found in Fanno Creek and downstream in the Tualatin River. Therefore, this study was designed to explore the predominant terrestrial organic matter source by estimating available foliar biomass and computing how much of this foliage is available as litterfall to Fanno Creek and its floodplain. Measurements of other terrestrial sources of organic matter to the creek, such as bank erosion, bed-sediment transport, and stormwater are also evaluated independently in this issue (Goldman et al., 2014; Keith et al., 2014).

For the purpose of this study, foliage refers to all the leafy components of the tree canopy structure, such as leaves, flowers, needles, seeds, cones, and fruits (Benfield, 1997) that blossom and shed annually as litter. This material is comparable to the leaf litter components used for canopy fuel load estimators, such as FARSITE (Keane et al., 1998), and other canopy metric calculators (McGaughey, 2009; Rebain et al., 2011; Scott and Burgan, 2005). Foliar biomass estimates do not include dense woody materials like tree branches or trunks. Although these woody sources are a component of terrestrial biomass and play a vital role in the ecological health of a stream (Abelho, 2001), their contribution to seasonal stream BOD and SOD is small compared to the more labile leaf litter (Meyer et al., 1998) that is the focus of this study.

1.2. Study area

1.2.1. Location

Fanno Creek is an urban stream that originates in the West Hills of Portland, Oregon (Fig. 1). The watershed drains 82.4 km^2 of predominately residential land within the southwestern metropolitan area. The creek flows 27 km through a riparian corridor comprised of a series of intermittent wetlands, parks, and small forests before entering the Tualatin River in the city of Durham. The study area (Fig. 1) extends along the Fanno Creek geomorphic floodplain and is divided into 13 reaches (Table 1). A geomorphic floodplain is not a recurrence interval-type (e.g., 100-year or 500-year) flood delineation boundary, like that used by the Federal Emergency Management Agency for flood insurance, but rather represents the extent where the stream system has flowed and created landforms over the last 10,000 years (i.e., Holocene Epoch). Within the Fanno Creek floodplain (Sobieszczyk, 2011b), each reach is separated by a major roadway or bridge and is discrete in design and management. For example, the reaches in the upper section of the Fanno Creek floodplain are heavily urbanized and consist of a narrow, riparian buffer that weaves through residential neighborhoods, business areas, and a golf course. Much of the area in the middle section of Fanno Creek is designated as parks and wetlands complete with restoration projects and reintroduction of native

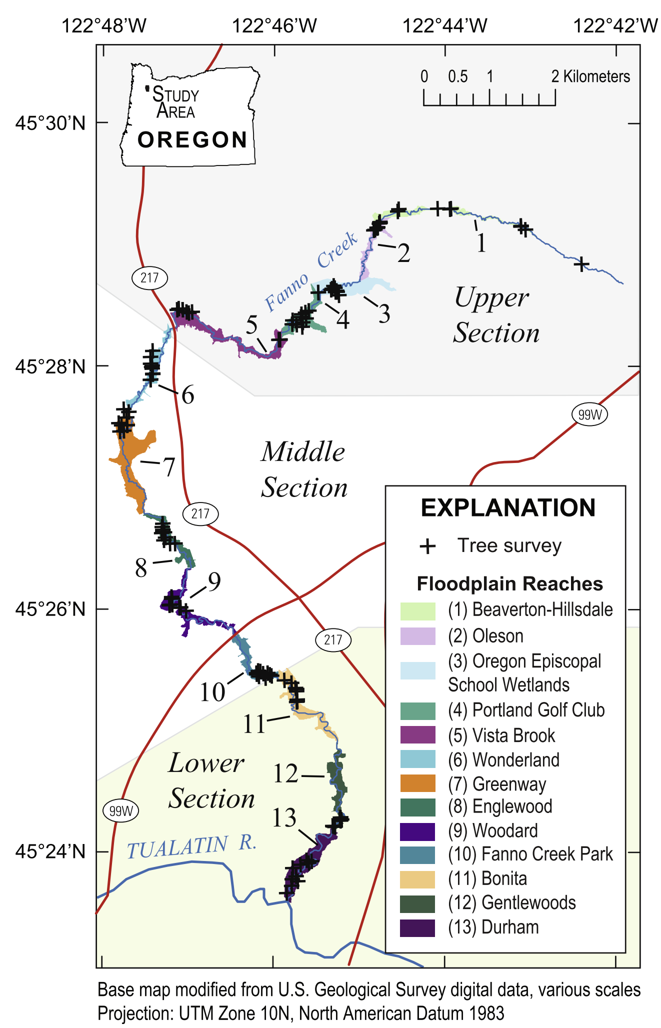

Fig. 1. Location of Fanno Creek, Oregon, including reach extents and tree inventory sites.