Lithologic Controls on Watershed Morphology in the Central Oregon Coast Range: Towards Extrapolation of Tyee-Based Models to Other Bedrock Types

Stephen B. Taylor, Earth and Physical Sciences Department, Western Oregon University, Monmouth, Oregon 97361; taylors@wou.edu

Studies in the Oregon Coast Range have yielded numerous contributions to the understanding of mountain river systems. Published research topics include sediment budget analysis, sediment transport models, debris flow dynamics, hillslope hydrology, landslide risk modelling, effects of punctuated sediment supply, landscape evolution, and tectonic controls on bedrock erosion rates. While this rich body of work has significantly improved our geomorphic understanding of mountain river systems, most studies have been limited to landscapes underlain by bedrock of the Eocene Tyee Formation. Few studies have been conducted in portions of the Oregon Coast Range underlain by other lithostratigraphic units. Work in other bedrock domains is needed to assess the applicability of existing models to other Coast Range landscapes. This study involves comparative morphometric analysis of HUC 6th field watersheds, using Tyee-based landscapes as a benchmark for comparison with other bedrock types in the central Oregon Coast Range.

The Luckiamute River watershed drains 815 km^2 along the east flank of the Coast Range in west-central Oregon. Bedrock map units are grouped into four lithospatial domains, these include the Siletz River Volcanics Domain (south), the Tyee Domain (west-southwest), the Yamhill-Intrusive Domain (north-northwest), and the Spencer-Valley Fill Domain (east). The Siletz River Domain comprises 19% of the watershed and is mainly seafloor basalt. The Tyee Domain (29% of total area) is underlain by arkosic sandstone lithofacies with local mafic intrusives. The Yamhill-Intrusive Domain occupies 23% of the watershed and is characterized by outcrop of marine siltstone and mafic intrusives. The Spencer-Valley Fill Domain (29%) is underlain by a patchwork of marine sandstones and Quaternary alluvium. Hillslope landforms and colluvial processes dominate the Siletz River, Tyee, and Yamhill domains, whereas fluvial landforms and alluvial processes are characteristic of the Spencer Domain.

Fourth-order subbasins (n = 5-6, avg. Ad = 16 km^2) were selected from each bedrock domain for subsequent terrain analysis of USGS 10-meter DEMs. Averaged quantitative parameters for the Spencer, Siletz, Yamhill, and Tyee domains include, respectively: **(1)** hypsometric integral (0.30, 0.40, 0.48, 0.29), **(2)** basin ruggedness (0.2, 1.2, 1.1, 1.6), **(3)** total drainage density (1.4, 2.3, 2.0, 2.4 km^{-1}), **(4)** Shreve magnitude (14, 49, 31, 55), **(5)** first-order stream density (0.7, 1.2, 1.0, 1.2 km^{-1}), **(6)** channel gradients (0.04, 0.13, 0.18, 0.14), **(7)** stream power index (69, 1909, 2534, 1133), **(8)** hillslope gradients (3.2, 12.7, 11.9, and 14.5 degrees), and **(9)** hillslope profile curvature (0.004, 0.008, 0.007, 0.011 m/deg). The Tyee Domain is more finely dissected by low-order stream channels and associated with more rugged hillslopes compared to the other three domains. Results of the slope analyses are consistent with debris-flow hazard models released by the Oregon Department of Forestry, suggesting that hillslopes in the Tyee Domain are most prone to slope failure (percent of domain area in hazard zone: Tyee = 38.1, Siletz = 30.2, Yamhill = 24.6, and Valley Fill = 0.7). Morphometric analysis of higher-order valley widths at 500 m increments shows that trunk drainage across the Tyee Domain covers a much wider swath of valley floor (avg. W_v = 274 m) compared to a similar-sized drainage area in the Yamhill Domain (avg. W_v = 109 m). Stream power parameters suggest that while Tyee drainages are more energetic than the Spencer system, they are less potentially less effective at sediment transport than the other upland domains. These data suggest that bedrock lithology exerts a strong control on hillslope morphology, style of hillslope process, and sediment-transport efficiency in headwater portions of the Luckiamute.

The interplay between hillslope transport mechanisms, delivery rates, and channel hydraulics control the volume of sediment exported or stored within a mountainous watershed. The comparatively steep, debris-flow-prone slopes and wide valley bottoms in the Tyee Domain indicate a potential for hillslope transport rates to be greater than the ability of the channel system to export sediment. Analytical results presented herein provide a preliminary dataset upon which to build a field-based sediment-storage budget for the Luckiamute watershed. The working hypothesis is that the Tyee Domain has a significantly greater volume of valley-bottom sediment in storage compared to the other upland domains (Siletz, Yamhill). The model implies that spatial variation of bedrock lithology is a primary factor controlling slope gradients, hillslope delivery rates, and the resulting sediment-transport efficiency of the channel system. The rich body of work from other Tyee-based landscapes in the Oregon Coast Range will serve as the platform from which to extend future research in the Luckiamute to other bedrock domains.