Survival of Meadow Species in the Face of Tree Encroachment: A Functional Trait Approach

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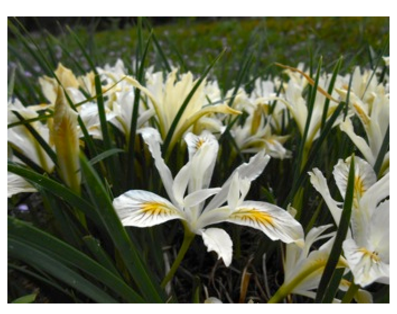
Introduction

Encroachment of grasslands by woody plants is occurring throughout the western US and more broadly around the world (Briggs et al. 2005). In parts of the Oregon Cascade and Coast Ranges, conifer encroachment has reduced the extent of montane meadows by 50% in the last 50 years (Dailey 2007, Takaoka & Swanson 2008, Zald 2009). Meadows provide critical habitat and forage for wildlife, support distinctive plant and insect communities, and serve as botanical points of interest. Thus, loss to conifer encroachment is a growing management concern. At Bunchgrass Ridge, the site of a long-term meadow restoration experiment, meadow species show varying tolerance of encroachment: some decline rapidly, whereas others persist for decades to well over a century after tree establishment (**Fig. 1**; Haugo & Halpern 2007). Plant functional traits are often used to explain ecological processes. My research explores whether variation in the functional traits of meadow species can explain variation in their survival.



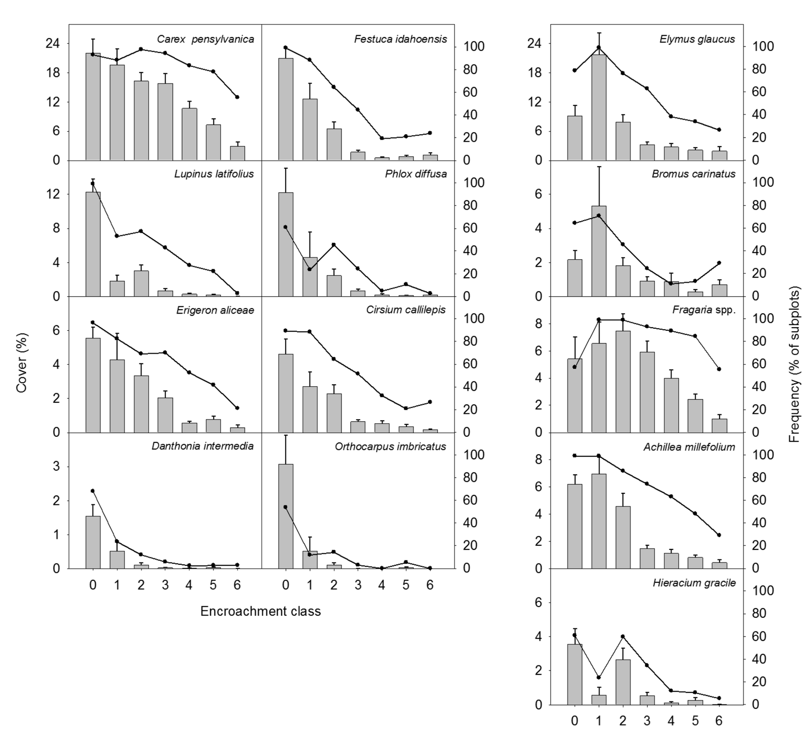


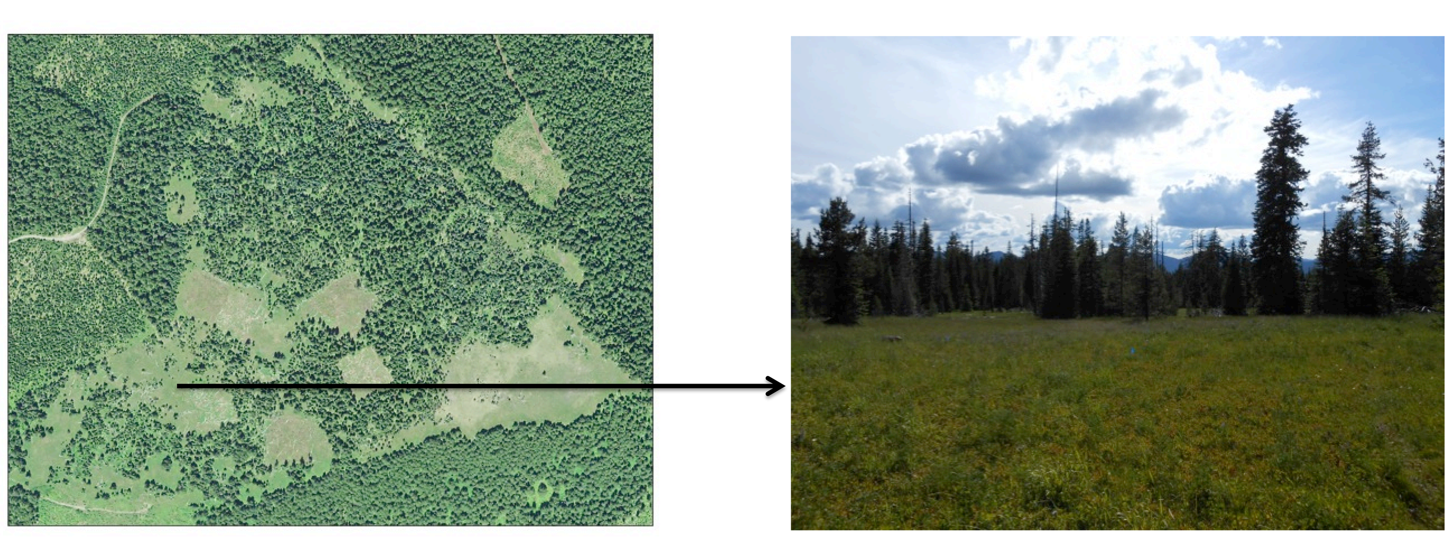
Fig. 1. Changes in species frequency (lines) and cover (bars) with encroachment. Class 0 = open meadow, 1-5 = younger forest (<90 yr), 6 = older forest (>140 yr) (from Haugo & Halpern 2007).

Hypothesis

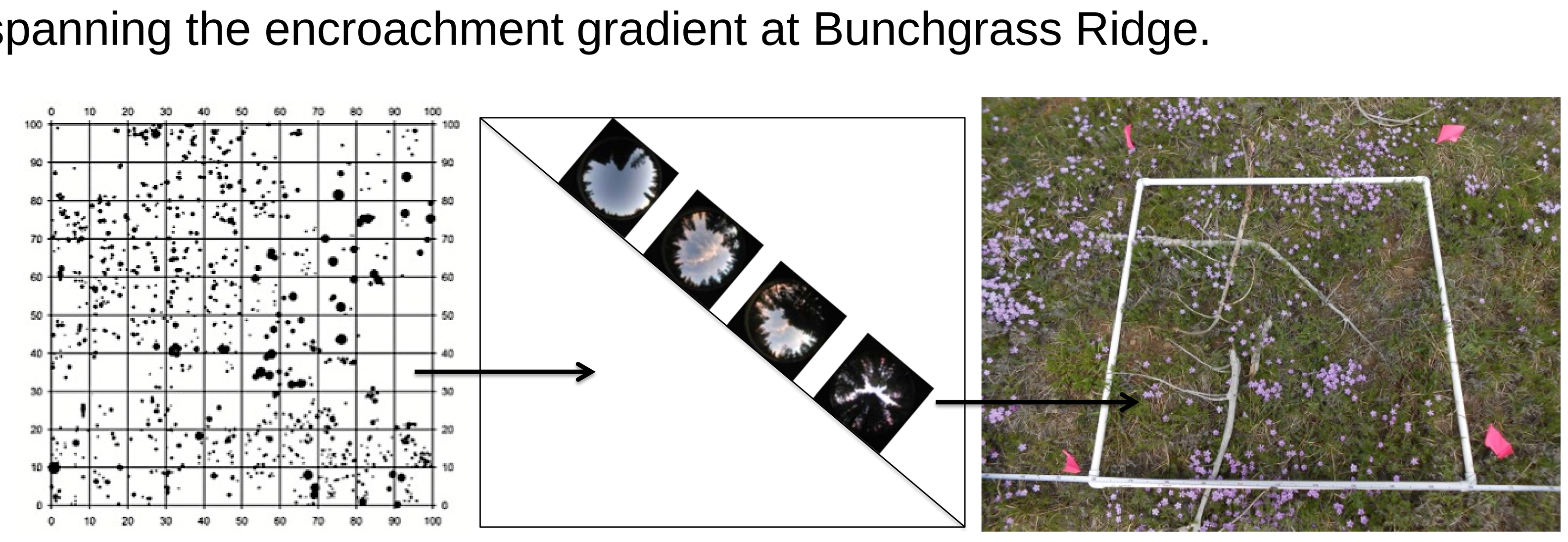
Species' sensitivity to encroachment will correlate inversely with ability to adjust allocation to resource-acquiring structures. Species that are less sensitive to encroachment (declining levels of light) are better able to adjust specific leaf area (SLA) and allocation of biomass to above-ground structures (vs. root systems).

Methods

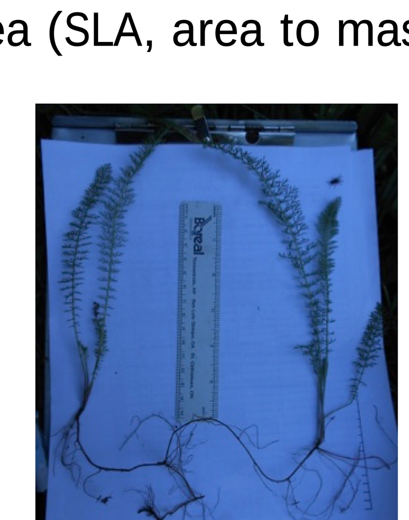
Study area. Bunchgrass Ridge is a 100-ha plateau (~1350 m elevation) straddling the boundary of the Western and High Cascades in Oregon.



Species sensitivity to light. Meadow species cover and % transmitted light (from hemispherical photos) were measured at 600 locations (10 x 10 m subplots) spanning the encroachment gradient at Bunchgrass Ridge.



Species and trait selection. From a larger set of species,13 were chosen to represent the variation in sensitivity to encroachment (Haugo & Halpern (2007). I sampled 16 individuals of each species (217 total) to ensure full representation of the encroachment gradient (open meadow to older forest). I focused on traits critical to resource acquisition (Crick & Grime 1987). I excavated, measured, and dried the components of each plant (root system, shoots, and leaves) to determine specific leaf area (SLA, area to mass ratio) and above-to-below-ground ratio (ABR).



Methods (Cont.)

Analysis. The coefficient of variation (CV) of predicted cover (from a local regression model) was used as an index of species' sensitivity to light. The slope of trait-light relationships was used as an index of trait plasticity (change in functional-trait performance) to declining light (**Fig. 2**). Using the slope and CVs of the 13 species, I examined the relationships between trait plasticity (slope of SLA or ABR) and sensitivity to light (CV of cover) (**Fig. 3**).

Preliminary results

The CV and slope proved an effective tool at illustrating species sensitivity and trait plasticity.

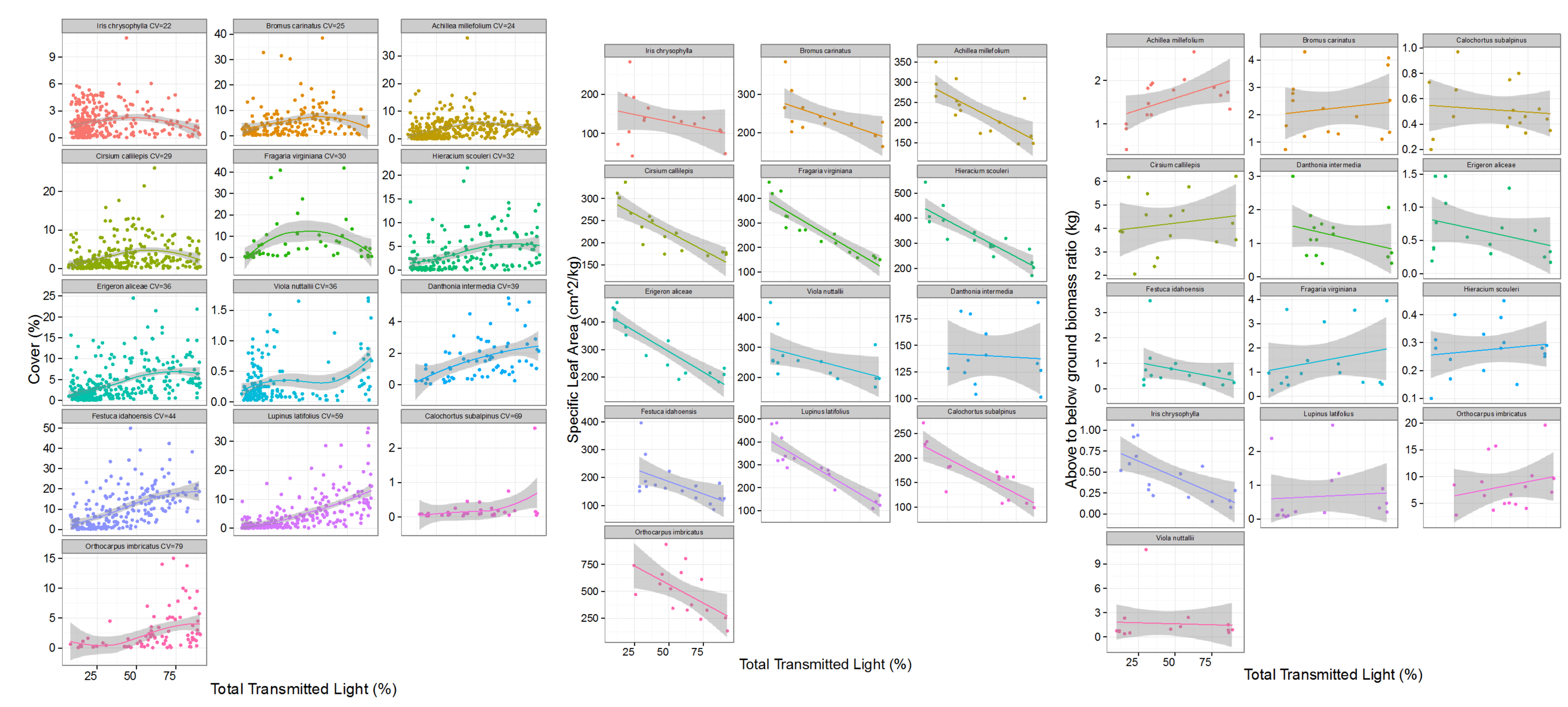


Fig. 2. Relationships between species' cover or functional-trait performance and transmitted light (%), with the corresponding CV. [**Left**] Cover (%), [**middle**] specific leaf area (SLA; cm²/kg), [**right**] above-to-below-ground ratio. Species are ordered from lower to higher sensitivity to light (lower to higher CV of cover).

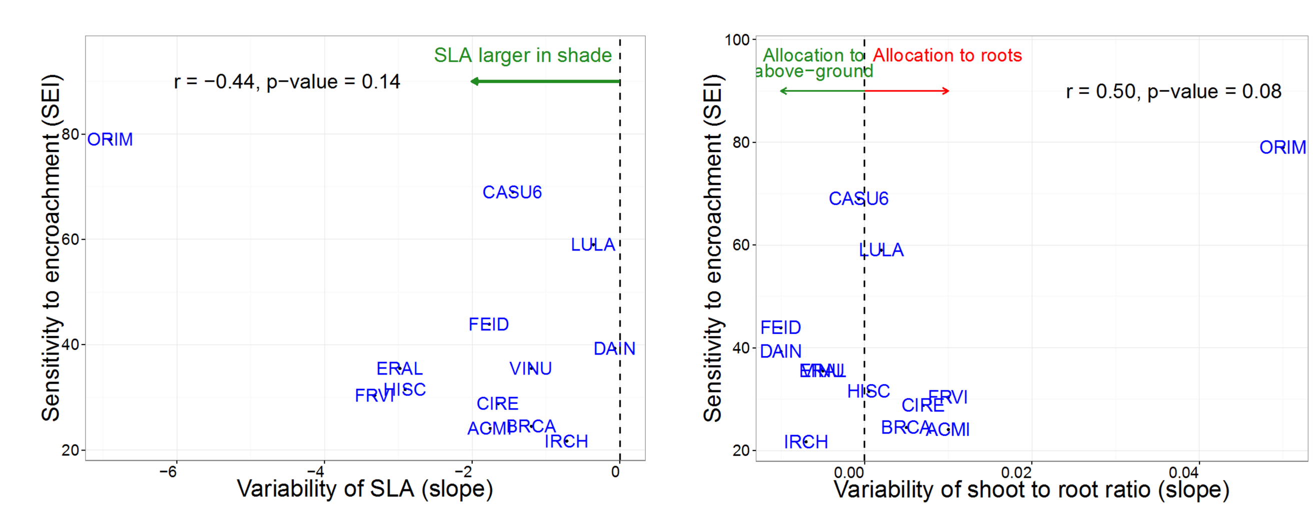


Fig. 3. Relationships between trait plasticity and sensitivity to light for SLA [**left**] and ABR [**right**]. Sensitivity explains 1% and 38% of the variation in plasticity for SLA and ABR.

Conclusions

There is evidence that species that are more plastic in their above to below ground biomass ratio are less sensitive to decreasing light levels. However, there is no evidence that plasticity of species SLA is related to species sensitivity. The relationship of leaf area to light (one component of SLA) offers a different perspective on leaf trait plasticity (**Fig. 4**). Species that are more sensitive to changes in light tend to have a positive leaf area-light relationship, i.e. they develop smaller leaves as light declines. Future analyses will integrate multiple traits of species and their distributions with respect to changing levels of light.

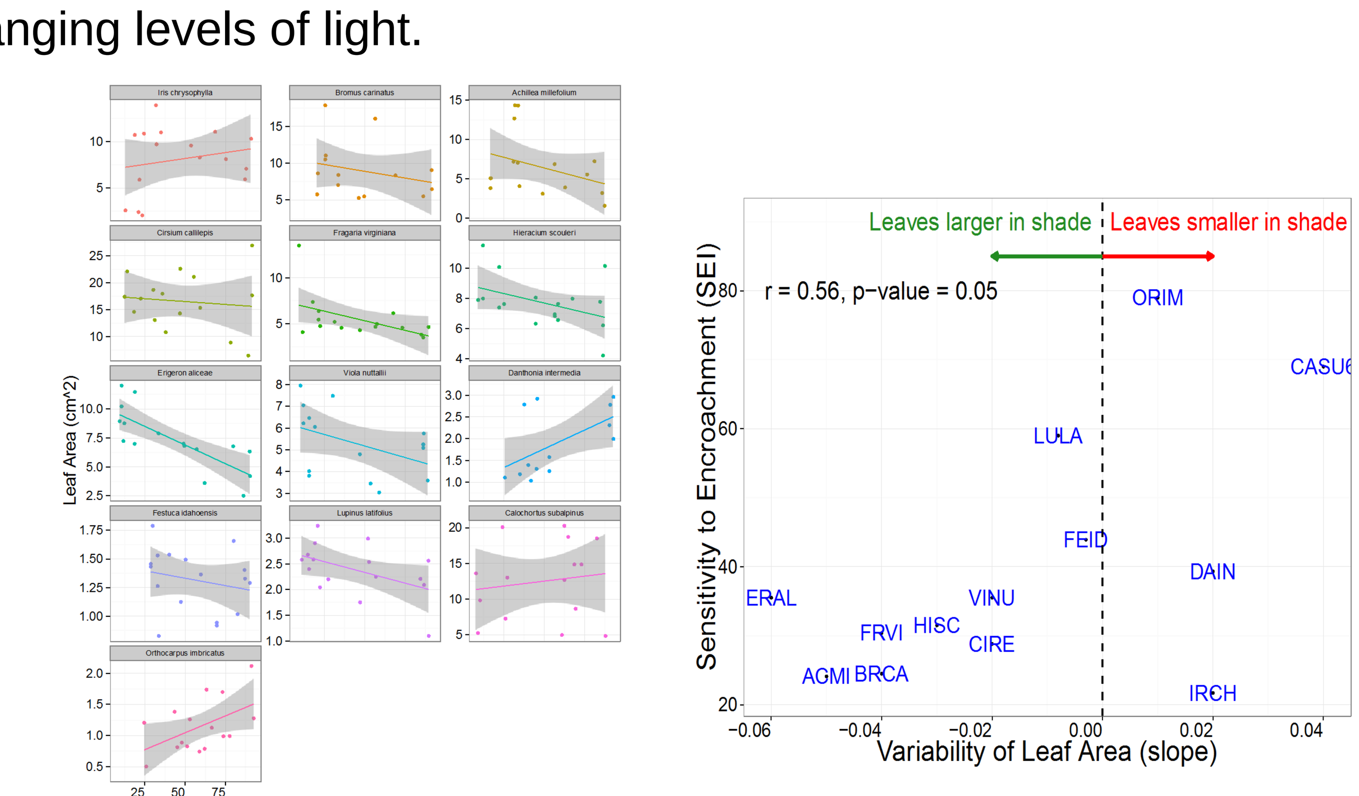


Fig. 4. [**Left**] Leaf area vs. transmitted light (%). Species are ordered from lower to higher sensitivity to light (CV of cover). [**Right**] Slope of leaf area vs. light as a function of species' sensitivity to light.

References

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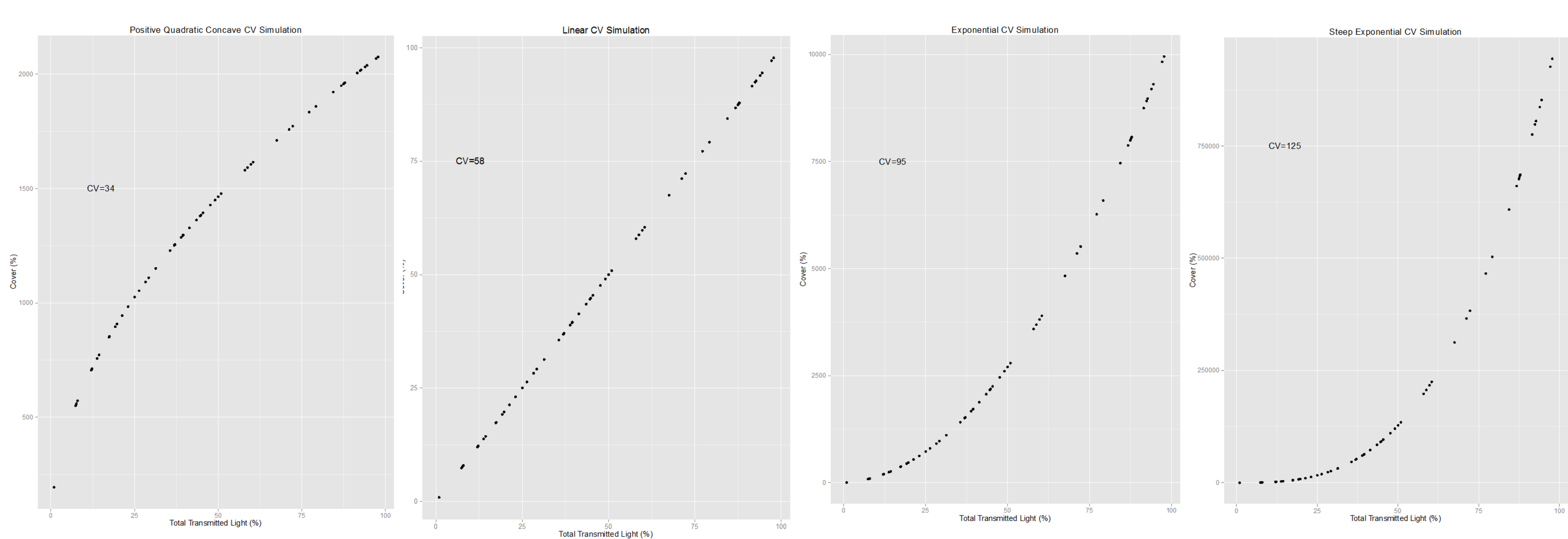
Positive Quadratic Concave CV Simulation
CV=34
Cover (%)
Total Transmitted Light (%)
Linear CV Simulation
CV=58
Total Transmitted Light (%)
Exponential CV Simulation
CV=95
Cover (%)
Total Transmitted Light (%)
Steep Exponential CV Simulation
CV=125
Cover (%)
Total Transmitted Light (%)