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Interactive comment on "Water limitations on forest carbon cycling and conifer traits along a steep climatic gradient in the Cascade Mountains, Oregon" *by* L. T. Berner and B. E. Law

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Referee 1 (Dr. Ben Bond-Lamberty)

General comments: "This manuscript describes a spatial (multiple sites across a precipitation gradient) and temporal (tree rings) analysis of how forest structure and function (morphology, chemistry, growth) relate to climate stress in the eastern Cascades, Oregon, USA. This is an interesting topic with clear relevance for a broad range of scientists, managers, and policymakers. The ms is extremely well written, with appropriate references, and generally clear. On the one hand, the larger lessons from this study are unsurprising and have been known a long time: water availability is a

strong control on forest structure and growth in the eastern Cascades. But this study's multiple lines of evidence and rigorous analysis make a substantial contribution, and the discussion does a nice job discussing potential sources of unexplained variance. This is, overall, a very strong and interesting manuscript–nice job, and congratulations. There are a few minor weak points (see short list below), and two somewhat larger ones. First, the authors need to be more explicit about the statistical packages used. In addition, it's 2015 and I really expect to see the data and code under pinning this analysis made available, either as SI or deposited in a repository. Second, for all its rigor and care, this is fundamentally a correlative and observational study, and it would be good to acknowledge the limitations of this somewhere."

Response to general comments: We appreciate the positive feedback provided by Dr. Bond-Lamberty and have worked to address the issues that were raised. In preparing the revised manuscript, we have (1) added additional information about the statistical packages used in the analysis; (2) incorporated the project dataset and code into a supplemental file; and (3) added text to the discussion noting several of the limitations associated with the study. Additionally, we addressed each of the line-specific comments.

We added a Data Availability section that reads: "In addition to providing species- and site-level summaries for each carbon cycling and trait variable, we include both the underlying datasets and code as a supplemental so as to help enable future data syntheses, increase transparency, and prevent long-term data loss. The datasets include measurements of tree stem characteristics (e.g. DBH, height, bark thickness, wood density, sapwood area), tree ring-width time series, leaf traits (e.g. carbon, nitrogen, specific leaf area, leaf longevity), and leaf area index. The leaf trait and site-level carbon cycling measurements were recently combined into a regional database with similar measurements made as part of other NASA-, DOE-, and EPA-funded projects at over 200 sites across the Pacific Northwest. The North American Carbon Program Terrestrial Ecosystem Research and Regional Analysis Pacific Northwest (NACP TERRA-

PNW) Forest Plant Traits, NPP, Biomass, and Soil Properties (1999-2014) dataset (Law and Berner, forthcoming) is being publicly archived with the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC). Furthermore, our tree ring-width measurements will be made publicly available through the NOAA International Tree Ring Data Bank (NOAA ITRDB). In addition to archiving the datasets, we provide a set of R scripts that were written for data preprocessing, analysis, and visualization. We make these datasets and code freely available for non-commercial community use. Following the AmeriFlux Fair Use Policy (http://bwc.berkeley.edu/Amflux/fairuse.htm), we request to be (1) informed of how these data are used prior to publication and (2) either acknowledged via citation as the data source or, if the dataset constitutes a significant contribution, offered participation as authors."

We also added a Limitations section to the Discussion: "We note several limitations associated with using an observational study to elicit the response of plant form and function to variation in climate, as well as with using CMI as an indicator of water availability. The observational approach makes it very challenging to separate the effect of a single environmental factor on plant form or function given that it is not possible to control the suite of environmental factors that can influence plant processes. For instance, although we focused on CMI as a dominant driver of carbon cycling and trait characteristics, there were additional differences among sites in climate (e.g. VPD, frost frequency, snow pack), soil, and disturbance history that independently, or interactively, could affect the processes of interest. Observational studies can elucidate existing spatial and temporal variation in plant response to climate or other controlling factors, yet are strengthened when coupled with experimental and modeling studies focused on the underlying mechanisms of response.

We used the CMI as an indicator of plant water availability and acknowledge that while useful, it is a rather simple index with several shortcomings. The index is easy to calculate from gridded climate data and serves as the water balance calculation underpinning the SPEI (Vicente-Serrano et al., 2010), which together have been used

to examine hydroclimatic controls over forest distribution (Hogg, 1997), productivity (Berner et al., 2013;Vicente-Serrano et al., 2013;Vicente-Serrano et al., 2014), and wildfire (Williams et al., 2014). The CMI is sensitive to changes in temperature and integrates both atmospheric inputs and withdrawals; however, it does not account for spatial variation in soil depth, soil water holding capacity, or snowpack that, along with rooting depth and architecture, further determine plant water availability. Additionally, we estimated CMI at each site using gridded PRISM climate data and an empirical equation for calculating ET0 from T, PPT, and R. Different climate datasets, or means of estimating ET0, could affect the statistical relationships that we observed, yet it is the overall tendencies, rather than the absolute statistical parameters, that we are most interested in capturing."

Specific comments:

1. Page 14508, line 15: perhaps "of fir individuals" for clarity Response: Suggestion adopted

2. P. 14509, l. 13: start new paragraph? Response: Suggestion adopted

3. P. 14510, l. 18: "species"' Response: This has been changed from species to species'.

4. P. 14513, l. 8 and p. 14515, l. 7: "publicly" Response: Fixed; thank you.

5. P. 14513, l. 19: ? fix Response: Fixed

6. P. 14514, l. 4: how was height measured? Response: We added following text: Tree H was measured using a laser rangefinder (Laser Technology Inc., Centennial, USA).

7. P. 14515, l. 27-29: necessary to state? Doesn't seem relevant Response: These lines have been removed.

8. P. 14516, l. 14: here or somewhere, give beta values used Response: We added a new table (Table 1) that includes the beta values.

9. P. 14519, l. 17: ‘stats’ is part of base R, so this isn’t very informative. What version of R? What functions, specifically? Availability of code and data? Response: We address the availability of datasets and code above, and added the following text: Power function models were fit using the nonlinear least squares (nls) function from the stats package in R (version 3.2.0).

10. Figure 4: nice plot! Very informative visualization of a lot of data Response: Thank you. The data and code used to generate the analysis and figure are now included as a supplemental.

11. Table S3 caption: give units for SA and DBH “Response: The units have been provided and the Table S3 caption reads: Table S3. Equations relating sapwood area (SA; cm2) to diameter at breast height (DBH; cm) for three conifer species in the eastern Cascade Mountains, Oregon. Equations are of the form SA = aDBH, where a is the slope of the relationship.”

Interactive comment on Biogeosciences Discuss., 12, 14507, 2015.