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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 2- General comments:

The paper describes the influence of water availability on growth and several morphological characteristics of forests, in the Cascade Mountains, Oregon. The impact of changing water availability on forest communities is a highly topical research subject due to the potential for additive climate forcing arising from elevated tree mortality in response to changing hydrological regimes. This paper makes a useful contribution to the subject by conducting a rigorous assessment of some tree morphological and growth traits within and between three species over a severe gradient of water avail-

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ability and over a period of nearly 50 years. The paper is nicely written and presents a good standard of research. The conclusions of the study are consistent with existing research but the combination of spatial and temporal measures of water availability, together with the good range of tree morphological data and adequate statistical analysis, provide convincing evidence of the linkage of carbon cycling with water availability. The only issue I identified with this ms, like Ref 1, is the lack of acknowledgment regarding the potential weakness of the correlative nature of the study. However, the response of the authors to the criticism made by Ref 1 adequately addresses this criticism. Otherwise, a very interesting and well written study; only a few minor points outlined below.

Response to general comments:

We would like to thank Anonymous Referee 2 for reviewing our manuscript, noting the value of its contribution, and highlighting places that could benefit from additional attention. We agree that inclusion of a section regarding potential weaknesses and limitations of the study strengthens the manuscript. The revised manuscript includes the technical corrections noted by the referee and addresses the specific comment concerning xylem water potentials.

Referee 2- Specific comments:

I would suggest altering the paragraph starting on P. 14510, line 20, in which ' $\Delta\Psi$ ' is used to describe  $\Psi$  xylem/plant. It is not change in  $\Psi$  that causes hydraulic failure, but absolute  $\Psi$ . Therefore, lines 3, 8 and 10 on P. 14511 are not technically accurate. On the other hand, it is correctly referred to as  $\Delta\Psi$  in lines 13 P.14511, and line 13 P. 14531: the total difference in  $\Psi$  between soil and roots (which leads to lower absolute  $\Psi$  in the canopy, for a given  $\Psi$  soil).

Response to specific comments:

The reviewer raises a very important point with regard to hydraulic failure and resulting

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physiological stress being related to absolute xylem water potential ( $\Psi$ ), rather than the gradient in  $\Psi$  from soil to plant ( $\Delta\Psi$ ). We've rephrased several sentences to refer to absolute xylem  $\Psi$  rather than  $\Delta\Psi$ . The introductory paragraph now reads: "... Plants have adaptations to maintain xylem water potentials ( $\Psi$ ) within physiologically operable ranges so as to prevent runaway cavitation of the water column and subsequent hydraulic and photosynthetic impairment (Pockman et al., 1995; Sperry and Tyree, 1988) caused by low soil  $\Psi$  and high atmospheric vapor pressure deficit (VPD; Whitehead et al., 1984). The xylem  $\Psi$  required for substantial hydraulic impairment [e.g. 50% loss of hydraulic conductance (P50)] varies both within (Domec et al., 2009) and among species (Anderegg, 2015; Choat et al., 2012; Willson et al., 2008), depending in part on the mechanical strength of the xylem conduits, which tends to increase with wood density (Chave et al., 2009; Hacke et al., 2001; Jacobsen et al., 2007). When conditions are dry, some plants reduce stomatal conductance to help maintain xylem  $\Psi$  within an operable range, yet this simultaneously reduces carbon assimilation and can lead to carbon starvation and mortality if sustained (McDowell, 2011). Plants can also manage xylem  $\Psi$  by shedding leaves or, more gradually, by increasing investment in sapwood (Maherali and DeLucia, 2001; Mencuccini and Grace, 1995), either of which lowers the leaf:sapwood area ratio (LA:SA). Holding other factors constant, taller trees experience lower (i.e. more negative) xylem  $\Psi$  at the top of the canopy due to increased gravitational pull and cumulative path-length resistance (Koch et al., 2004; Whitehead et al., 1984), which is potentially a key factor limiting maximum tree height in a given environment (Koch et al., 2004; Ryan and Yoder, 1997) and can predispose taller trees to drought-induced mortality (McDowell and Allen, 2015). Adaptations that enable plants to endure harsh abiotic stress (e.g. drought) often come at a competitive cost in more productive environments due to lower rates of resource acquisition and processing (Grime, 2001; Grime, 1974; Reich, 2014)."

Referee 2- Technical corrections: 1. Legend of Table 1: 'Climate variable(s)'

Response: Fixed

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2. Legend of Table S6, line 68: 'the(n)'

Response: Fixed

3. P. 14514, line 3. GTOS protocol should be referenced

Response: Fixed

4. P. 14522, line 19. 'considerably'

Response: Changed from "achieved considerably higher" to "reached higher."

5. P. 14522, line 19. Referred to '(Fig. 2d-f)' but the individual panels are not labelled in the actual figure.

Response: Fixed

6. P. 14524, line 25. 'photosynthesis - respiration'

Response: Fixed

7. P. 14526, line 25. 'variance'

Response: Fixed

8. P. 14530, line 20. 'increases' in P50

Response: Fixed

9. P. 14531, line 27, 29. 'tension' does not describe leaf water potential, which includes hydrostatic pressure, osmotic potential and matric potential and, therefore, these lines should be changed to 'potential'

Response: Good point. Fixed.

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