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# *Interactive comment on* "Ideas and perspectives: use of tree-ring width as an indicator of tree growth" *by* R. A. Hember et al.

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General comments

The manuscript focuses on the lack of proportionality between the radial increment, the basal area increment and the biomass increment of trees.

The authors report that the magnitudes of change in trees dimensions are not proportional between them. While I agree with most results and facts, I disagree with the statement that "sensitivity of primary production indirectly inferred from analysis of w or BAI is significantly underestimated". The manuscript focuses too much on the dimensional aspect of the conversion from the radial to the biomass increment, belaboring the obvious, while it misses many important sources of discrepancy between these



time series.

Specific comments

a. Lack of proportionality

That D, Dˆ2 and Dˆ2.5 have different rates of growth did not need a demonstration. Anyhow it seems hard to find examples where the diameter increment over several years is used without being transformed. The dendrochronological studies are rather based on detrended series -mostly ring width- where the level is removed and thus focus on relative changes.

b. Relative changes

The statement "significantly underestimated" seems an overstatement because, despite the lack of proportionality between the radial and the biomass increments, relative changes do nut suffer from the same discrepancy at inter-annual step. At lines 8343-16 it is written that "relative changes in w or BAI are not directly comparable with changes in AGR". This is true but the magnitude of this issue is very very small. To take a short example based on those provided in the manuscript: let be Dt the diameter at breast height at time t of 7 trees of increasing size, Dt = 1, 10, 20, 30, 40, 50, 60 cm

w is the radial growth, equal to 1 mm. Let's suppose a doubling in growth at year t, such as Dt-1 = Dt – w and Dt+1 = Dt + 2w.

The relative change in diameter growth is (Dt+1 – Dt) / (Dt – Dt-1) = 2.

The basal area at t is pi/4*Dtˆ2. Therefore the relative change of BAI can be boiled down to 4*((Dt+w)/(2*Dt-w)). Using the equation presented in the manuscript, the biomass at t is Bt = 0.18 * Dtˆ2.5. The relative change of biomass increment is obtained by computing (Bt+1 – Bt) / (Bt – Bt-1).

With these values, we obtain a relative change of biomass increment higher by 1.6e-04 at maximum to that of the diameter (table 1), for a tree with D=1 cm. For a tree with

D=30 cm, an average size for many forests, the difference between the rates of growth is 5.3e-05: really not much. Many other factors (listed below) will create much greater discrepancies between the ring-width and the biomass increment series.

About what happens on long term when using BAI, biomass increment, or forest carbon accumulation time series, a detailed analysis was already published by Babst et al. 2014a using a variety of sites and species for temperate forests.

On section 2 (Page 8343), the volume of trees is represented in a funny manner: V= l x w x h. The very rich literature on tree volume estimations is both much more specific and simple: V = dˆ2 * h * k where k is a form factor. When expressed this way, it is obvious that the radial growth is equal along l and w, unless we assume an elliptical stem section, which is not the case here. Therefore the problem is more a 2- than a 3-dimensional one. But the form factor is also clearly another important factor that can be expected to vary in time, and could have been discussed in the manuscript. Again, a vast body of literature explains how varies the form factor with tree age and how this impacts the dbh-to-biomass increment relationship.

The example of the Douglas fir is a pertinent example where the primary growth (height growth) has a known magnitude, larger than that of the secondary growth (radial growth). Indeed, one key element in converting tree-ring-based measurements into above-ground or whole-tree biomass increment estimations is the difference between the primary growth and the secondary growth. The ring-based measurements directly address the secondary growth (the radial one) and we are left to using assumptions concerning the primary growth. The simplest assumption is a proportional growth. Nevertheless, the use of allometric relationships does not suppose the implicit existence of a proportional growth, since the integration of the allocations is made through the dimensions of the trees themselves.

While the discrepancy between the radial and height growth has received little attention, it seems too simplistic to pack all the conversion issues from ring width to biomass



increment into a sole dimensional problem. Here, conversely, the many sources of discrepancy have been pointed out in the literature, and can be summed up as: - variations in biomass growth between organs or compartments (stem, branches, roots) - variations in wood density - variations in growth along the stem (axial) These are issues occurring at tree level. At stand level, generalizing from the sampled trees to the stand level comes with its own load of difficulties, which depend among others on the distribution between trees of the biomass increment, the effects of wood density that differs between species and others. The problem is, many studies have already proven that the conversion from tree-ring width to biomass was an improvement when the aim is to obtain time-series of biomass or carbon uptake, and implemented such conversions for example to compare against modeled carbon balance or eddy covariance fluxes: e.g. Rocha et al. 2006, Babst et al. 2014b, Nehrbass-Ahles et al. 2014, Peichl et al. 2010, Ramming et al. 2015.

Technical comments

Page 8342 line 20 The primary growth is very seldom named “Organ elongation”. Page 8343 line 8 and after, Annual ring width is classically referred to as Tree Ring Width (TRW), which cannot be confused with the tree’s weight w as it is the case here. The biomass increment of trees is often referred to as the Above Ground Biomass increment (AGB) since the equations for biomass conversion are more often available for the above-ground parts of the trees only, and simply B otherwise. The Absolute Growth Rate of biomass (AGR) is an unusual term and a bit confusing.

In conclusion, while the title is very catchy, the subject is in fact very partially covered, since the focus is solely on the proportionality of the rate of growth for radial, BAI or biomass increment. The manuscript does not correspond to what is claimed in the title and brings little new knowledge to the topic. The main limitation of using ring width series to produce biomass or carbon uptake series was indeed already documented in different studies based on more experimental evidences, and describing a variety of factors of stronger influence than the proportions. It is important, in my opinion, not to skip the review of the literature and to relativise the conclusions regarding the relative changes and their consequences.

References

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Table 1. Relative changes in growth in each dimension for trees with diameter from 1 to 60 cm. Estimations are based on a doubling of the radial growth rate.

| Diameter | 1 cm | 10 cm | 20 cm | 30 cm | 40 cm | 50 cm | 60 cm |
|---|---|---|---|---|---|---|---|
| D (w) | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| BAI | 2.0015 | 2.00015 | 2.000075 | 2.00005 | 2.000038 | 2.00003 | 2.000025 |
| Biomass | 2.001575 | 2.000158 | 2.000079 | 2.000053 | 2.000039 | 2.000032 | 2.000026 |

**Fig. 1.**