

## ***Interactive comment on “Evaluating digital terrain indices for soil wetness mapping – a Swedish case study” by A. M. Ågren et al.***

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Received and published: 10 June 2014

Answer to interactive comment on “Evaluating digital terrain indices for soil wetness mapping – a Swedish case study” by A. M. Ågren, W. Lidberg, M. Strömgren, J Ogilvie and P. A. Arp.

Anonymous Referee #1 Received and published: 12 May 2014 General comments  
The manuscript evaluates several digital terrain indices for their ability to identify the location of wet forest soil areas. The evaluation was done on three areas representing different soil types. One of the studied indices, the depth-to-water index was shown to predict the mapped soil “wetness” with a reliable and consistent manner. The results of the study are new and highly valuable and applicable when mechanized forest

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harvesting, planting and soil preparation operations are planned. In many countries it is becoming unacceptable to cause soil rutting and to enhance soil erosion when carrying out forestry operations. In addition wet soils can also increase the costs of the forestry operations since forest machines get easily stuck on wet soils. The manuscript is mostly well written and can be published after minor revision taking into account the following specific and technical comments.

Thank you, below you will find our responses to your comments.

Specific comments The introduction on page 4105, lines 2-9 give an impression that rutting increases the export of Hg into watercourses. The mechanism behind that phenomenon should be briefly described.

We now write: “Forest harvesting, rut formation and site preparation create conditions favorable for a net MeHg production because of i) higher soil temperature on the sun exposed soils after clear-cut in combination with ii) fresh organic litter from the slash that provide an energy rich carbon source for sulphur reducing bacteria and iii) anaerobic conditions due to compaction of the soil following harvesting in combination with increased water levels and standing water pooling in the tracks (Eklöf et al. 2014).”

The introduction justifies nicely the practical importance of the study. What is, lacking is a short description of the existing, available wetness indices and the experiences of their use on forest soils. Now there are only references to the literature and the reader has to find out by him/herself, what is the current status of the development of these indices (page 4104, lines 19-21).

We have now inserted a new section in the introduction explaining the development of different mapping techniques, the opportunities and challenges of the new mapping techniques and how they can be used in practice.

It would also be good to mention in the introduction what are the main criteria for good wetness indices to be useful in practice.

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We now write “ Soil wetness maps intended to guide forest planning and related operational decision making need to be as reliable as possible at meter-by meter resolution across large areas.”

The method for determining the soil “wetness” in the field is described in high detail on pages 4106-4107, however, it should be made clear what was the resolution for determining the soil wetness classes on the transects lines.

We now write “The geographical positions for each soil wetness class transition along the transect lines were determined using hand-held GPS, with an accuracy of <10 m in 95% of the measurements.”

The used soil wetness classification includes wetness classes which pertain the depth to the groundwater table. It would be informative to give an explanation how that is determined.

We now write “According to the survey protocol, the depth to the groundwater was not measured but was estimated based on reading the terrain in reference to the nearest open water locations such as streams, pools and ponds.”

Page 4110, lines 3-4. What are the locations where water is estimated to be at surface?

We now write: The Cartographic depth-to-water (DTW) index refers to the least-cost depth or elevation difference (in m) to the nearest open water locations such as the DEM-derived streams, lakes, pools, ponds or shoreline where DTW is set to be 0.

Page 4111, chapter 2.4.3. It would be good to justify why a matrix with only four classes (DTW\_1 m and > 1m) was chosen for the evaluation. Was that sensitive enough to reveal the conformance of the index in real practical applications?

This is similar to the work by Arp, Murphy, Ogilvie and others. More classes can be used in principle, but we wanted to be practical in following the simplified classification protocol. In this, we followed the experience gained by forestry practitioners in Canada, where large areas have been DTW mapped (25,000,00 ha at 1 m resolution, and an

other 25,000,000 at 10 ha resolution) and have been implemented in practical forestry planning using these four classes.

Please, add in the discussion some discussion about the sensitivity of the results to the seasonal variation in soil wetness and what that means in practice. To my understanding the machine drivers should know beforehand the time when the soil is wet and vulnerable to rutting and they should avoid driving. The wetness might change day by day depending on the climatic conditions. Describe how the wetness indices described in this study sensitive to the variation in climatic conditions or changes in soil wetness e.g. after clear-cutting?

We have now expanded on this in the introduction and in the discussion. For example: “Hence, by varying the threshold for stream flow initiation, spatial and temporal variability of the stream network and adjacent wet soils can also be modelled, with setting lower and larger threshold values for wet and dry seasons, respectively. For example, a 4 ha flow-initiation threshold tends to reflect general end-of-summer flow and soil wetness. In comparison, DTW maps based on 1 m DEMs and setting 1 to 2 ha flow initiation thresholds are useful (i) for planning or locating road-stream channel crossings except for sandy landforms such as, e.g., floodplains and glacial outwash (Campbell et al. 2013), and (ii) for estimating the distribution of wet-area obligatory species (Hiltz et al. 2012; White et al. 2012). Lowering the flow-initiation threshold further to 0.5 and 0.25 ha would emulate soil wetness and soil trafficability during wet summer weather and the snowmelt season (Murphy et al., 2011). Going from flat to montane areas may also require a downward change in the flow initiation threshold from 4 ha, as a reported by Jaeger et al. (2007). In arid regions, flow initiations and related depth-to-water mapping may increase to 1000 ha or more during dry and drought seasons.”

Technical comments

The Figures should be numbered in the order they are referred to in the text.

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The figures are now numbered in the order they are referred to in the text.

Description of the calculation of the different indices are described on pages 4108-4109. It is unclear why some of the words/indices are written in italics?

The plants names in Latin are given in italics, as they should be. The copy editor has also used italics to highlight the terms for when we define a term in the text.

Page 4109, line 13. Unclear text on that line.

Yes, we have now clarified the text.

Table 1. Would it be possible to include also the number of observation points in the Table?

We now write in the Table heading: “The comparison between map data and ground truth were done on a cell by cell basis (area 1 n= 3903, area 2 n=3218 and area 3 n= 2268).”

Figure 2. Figure caption is not informative enough. Some more information is needed for the variables included in the analyses, the abbreviations are not all clear even after reading the text. We have now clarified the figure caption as follows: “Figure 2. OPLS loading plots for Area 1, 2 and 3 and their DEM-derived terrain indices regarding soil wetness prediction. Variables in black/grey text have a higher/lower influence on soil wetness prediction, respectively. Variables that cluster closely within the same neighborhood along the far sides of the X-axis are the more robust soil wetness predictors across DEM scales and landforms. For reference, the OPLS dot projection for soil wetness is also shown.” We have also clarified the text in the results section discussion this figure.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 4103, 2014.

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