Review of “Biogeochemical cycles and biodiversity as key drivers of ecosystem services provided by soils” by Smith et al.

General comments:

The objective of this paper is to describe the current understanding of biogeochemical cycles and biodiversity in soil and relate them to the provisioning, regulating, supporting and cultural ecosystem services which they underpin. Thus the paper is timely, relevant and should be of interest to readers of SOIL. The manuscript is well written, contains a good overview of biogeochemical cycles and biodiversity and integrates this information to various ecosystem services. The most important aspects of biogeochemical cycles and biodiversity are pretty well described and discussed. There are some very important and valuable discussions in the manuscript. For example, Section 5 contains a very good synthesis and integration of data about how soils serve as a genetic resource; the discussion on linking new biodiversity measures to specific soil functions (Page 19) is particularly noteworthy.

There are however a few shortcomings that make the coverage of topics uneven, but these could be overcome by revising the manuscript. There are many good things in the manuscript but for the purpose of providing constructive criticism I will provide some examples below that the authors might want to consider revising to improve the manuscript.

Very little information about cultural ecosystem services is discussed in any detail in the manuscript. It seems that the authors have included this so as to fully cover all the dimensions of ecosystem services. But the impact of biogeochemical cycles and biodiversity on cultural services is listed on the tables but this topic is not fleshed out in the discussion. It therefore may be best for the authors simply to admit that this will not be covered in detail; alternatively they should either revise the objectives statement or provide more information and discussion about this aspect of ecosystem services.

The discussion about relating biogeochemical cycles and soil biodiversity to the provisioning, regulating, and supporting ecosystem services is not balanced with regards to the cycling of water. This is because there is little or no discussion (section 7.2 ff) about how specific management actions affect the water cycle. For example, soil tillage/residue management, application of organic amendments and diversification of crop production systems all affect the soil water cycle and its impact on provisioning, regulating and supporting ecosystem services but these are not described or discussed. This should be described and discussed in more detail so as to provide a holistic assessment of biogeochemical cycles and ecosystem services.

There is little exploration or discussion about how the water cycle affects soil biota (biodiversity) because the latter play such a pivotal role in ecosystem services. Soil biota are mentioned only briefly on page 18, and then only in the context of the bypass of water where biota are located. It seems that it would be worthwhile to include some discussion about the interaction between water cycling and soil biota is warranted. For example, in order to provide a holistic perspective on this interaction it might be useful to provide some information about the effect of water potential on the structure, growth and activity of the soil microbial community. (A good source of data/information on this topic is: Water Potential Relations in Soil Microbiology, 1985 [published by the Soil Science Society of America]).

A primary conclusion of the paper is that a significant challenge for researchers is to effectively share the knowledge about the potential of soils to deliver ecosystem services with soil managers and policy makers. A sentence or two describing specific examples of how researchers could raise awareness of this issue would be helpful information for the reader interested in doing just that.

Specific comments:

Note: the following page numbers and lines refer to pdf version of the manuscript

Page 5, Line 15-17. "an increase in soil C storage, could reduce atmospheric CO2 concentrations….. All three reservoirs are in constant exchange but have various turnover times,…."

Page 7, Line 9: "C input is not quantitatively or qualitatively homogeneous"

P. 7, L. 13: What does "processed" mean? It will help the reader if you can be more specific.

P. 8, L. 23-27. This is redundant information because it repeats the statements in P. 6. L. 14-16.

P.8, L. 8. "A decrease in soil C storage…"

P. 8, L. 33. Environmental conditions (temperature, precipitation) also control soil C storage. This is described later but it may be good to include a mention of these factors here.

P. 9, L. 2-3. Higher levels of plant residue inputs support higher SOC stocks **up to a point**. This is an important point because the relationship (higher plant residue inputs = higher SOC) does not continue indefinitely because it has been shown that crop yields tend to level off at some upper level of SOC. For an example see Figure 4 and text in Zvomuya, F., Janzen, H.H., Larney, F.J., Olson, B.M., 2008. A long-term field bioassay of soil quality indicators in a semiarid environment. Soil Science Society of America Journal 72, 683-692.

For a more detailed description of this feedback between plant inputs and SOC stocks see page 40 in Govers et al. 2013 (http://www.stapgef.org/managing-soil-organic-carbon-for-global-benefits/)

P. 10, L. 9-10. That glomalin plays an active role in aggregate formation and SOC stocks is stated as a fact. However there is considerable controversy about the detection, quantification and role this protein plays in processes related to soil organic matter.

P. 23, L. 5. "use of cover crops during traditional bare fallow periods helps to increase C returns…"

P. 23, L. 21-22. I don't think that biochar is a "technology", per se. Applying it to soil is part of a strategy to increase C sequestration and thus achieve negative C emissions.

P25, L. 10. "…most efficiently"

Figure 3 is too small to clearly see and identify what regions contain high/low levels of applied N and P and excess N and P.