

Influence of different tree-harvesting intensities on forest soil carbon stocks in boreal and northern temperate forest ecosystems

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Introduction

Effective forest governance measures are crucial to ensure sustainable management of forests, but so far there has been little specific focus in boreal and northern temperate forests on governance measures in relation to harvesting effects on soil organic carbon (SOC) stocks. We reviewed the findings in the scientific literature concerning the effects of harvesting of different intensities on SOC stocks and fluxes in boreal and northern temperate forest ecosystems to evaluate the evidence for significant SOC losses following biomass removal, discussing how the scientific findings could be incorporated in guidelines and other governance measures.

The scientific basis

Experimental results indicate increasing SOC loss with increasing harvest intensity or increasing soil disturbance at some sites but little or no effect at other sites (Fig. 1), and there is no basis for firm generalisations. Although differences in the results may to some extent be due to differences in the experimental setup, a likely site specific vulnerability to SOC loss is implied that needs to be characterized and understood.

Limited availability of long-term experimental data currently precludes firm conclusions about the long-term impact of intensified forest harvesting on SOC stocks in boreal and northern temperate forest ecosystems, suggesting a need for continuation of existing long-term experiments.

Although experimental results show variable effects of harvesting on SOC, models generally predict losses of SOC, though less in the long term. The reasons for the discrepancy between field studies and modelling results are unclear. Understanding of the SOC balance implemented in the models may be lacking some inputs or processes important for SOC accumulation; however, the difficulties involved in determining small differences in SOC stocks in the field, where there is large spatial variability, may also play a role.

Even where there are clear negative effects of harvesting on SOC stocks, it is important to note that this may be mitigated or indeed completely outweighed by improved tree growth in the next rotation. At the same time, it is important to evaluate the net effects of biomass production at the expense of SOC accumulation in relation to the potential for long-term storage of C.

Governance

Although many countries have produced national recommendations and guidelines for biomass extraction to encourage this taking place in agreement with the principles of sustainable forest management, there has been little specific focus so far on SOC stocks. Regarding certification systems, harvesting effects on SOC have until recently not often been explicitly included in Programme for the Endorsement of Forest Certification (PEFC) or Forest Stewardship Council (FSC) certification systems, although some mainly newer standards do include requirements focussing on the forests' contribution to the C cycle.

Although there is great site-to-site variation, science-based and operationally practical management guidelines might be developed with the help of expert judgement (Fig. 2). Comparison of different countries' guidelines may help to identify broad areas of agreement that should be included, while leaving details to be worked out nationally or even at a more local level. This would increase local empowerment, and also emphasises the importance of training of forest managers.

It is vital that governance measures are accepted by stakeholders. 'Soft' governance measures, e.g. management guidelines and certification systems, may often be more adaptable to changes and local conditions, and more inclusive of stakeholder inputs, than legislation, and thus more easily accepted.

Discussion

Current governance measures may state that SOC stocks are to be protected during forest operations, but often little or no direct guidance is given as to how this is to be achieved. Partly this is due to the diverging results from various experiments, which is connected to the complexity of the processes involved, the difficulties associated with measuring the changes, and the number of factors that affect the SOC stock. Effects are species-, soil-, site- and practice-specific. Both well-designed new experiments and continuation of existing long-term experiments are therefore very important. Until more knowledge is available, the gap of uncertainty between the scientific results and the need for practically useable management guidelines and clear indicators can only be bridged by expert opinion given to authorities and certification bodies.

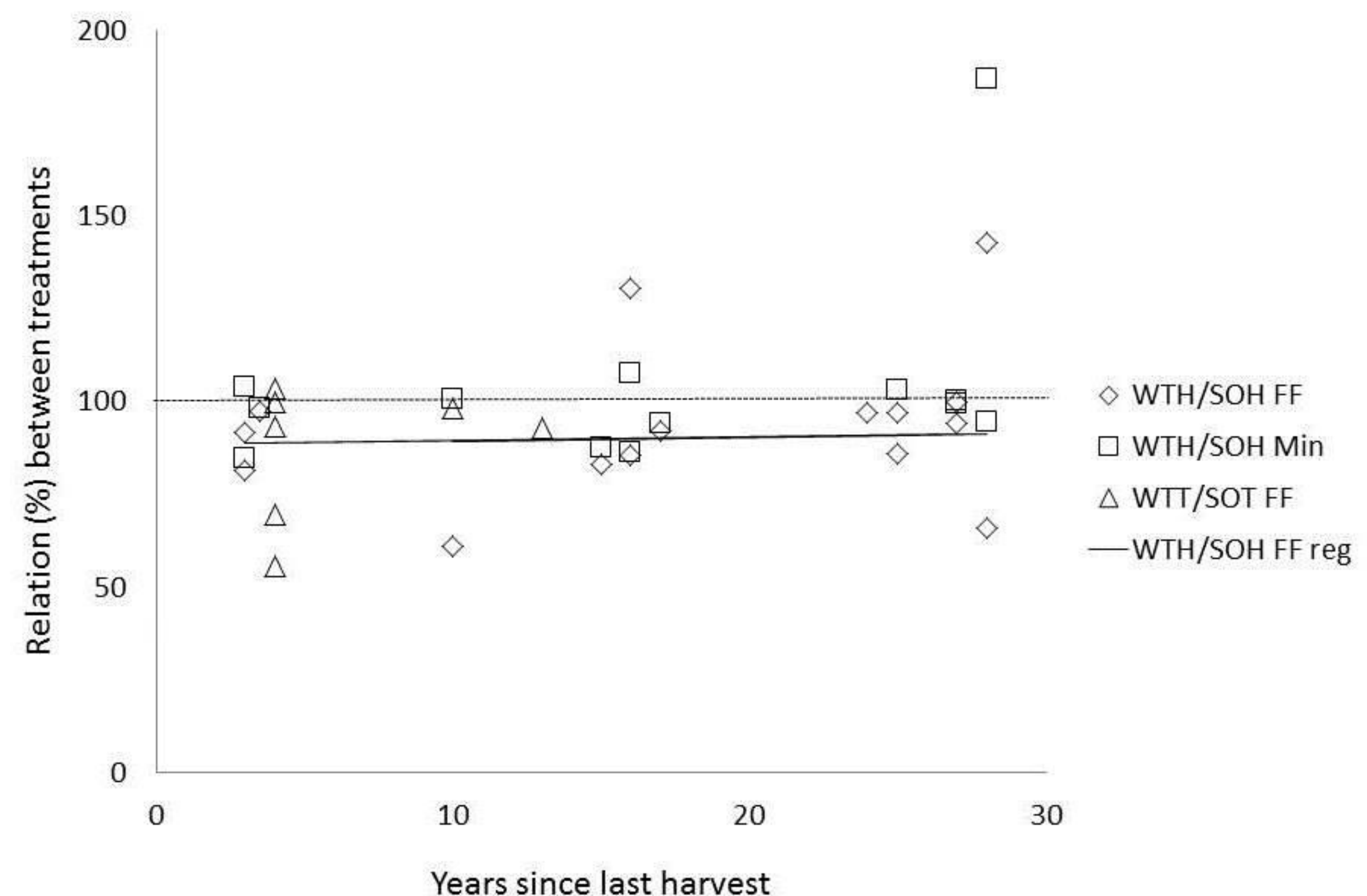


Figure 1: Effects of harvest intensity expressed by the relative change in % of SOC with whole tree harvesting or thinning relative to stem only harvesting or thinning (SOH=stem-only harvesting, SOT=stem-only thinning, WTH=whole-tree harvesting, WTT=whole-tree thinning) in the forest floor (FF) and upper mineral soil (Min), based on field studies. Dashed line = 100%. Solid line (WTH/SOH FF reg) is a linear regression for WTH/SOH in the forest floor, omitting one outlying study. From Clarke et al. (2015).

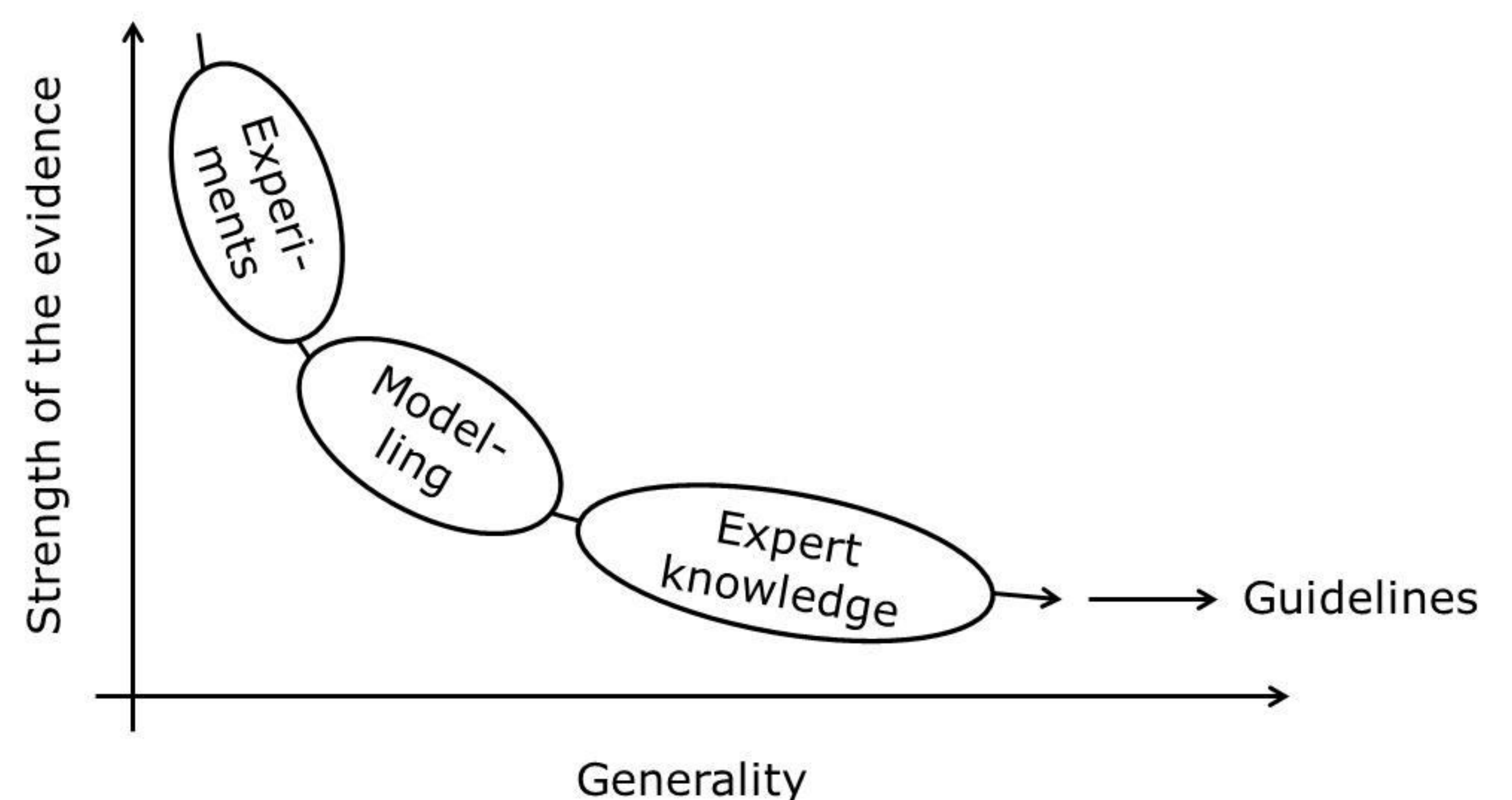


Figure 2: Conceptual model of the scientific basis for development of generalised guidelines from case studies. From Stupak et al. (2013).

References

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