

# SHORT-TERM EFFECTS OF WHOLE-TREE HARVESTING ON UNDERSTORY PLANT SPECIES DIVERSITY AND COVER IN TWO NORWAY SPRUCE SITES IN SOUTHERN NORWAY

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Photo: Ingvald Røsberg

Harvesting forest residues, i.e. harvesting all plant parts except stumps (whole-tree harvesting; **WTH**) instead of leaving tree crowns, branches, leaves and needles in the forest (stem-only harvesting; **SOH**), may increase the use of forest products for bioenergy production substantially.

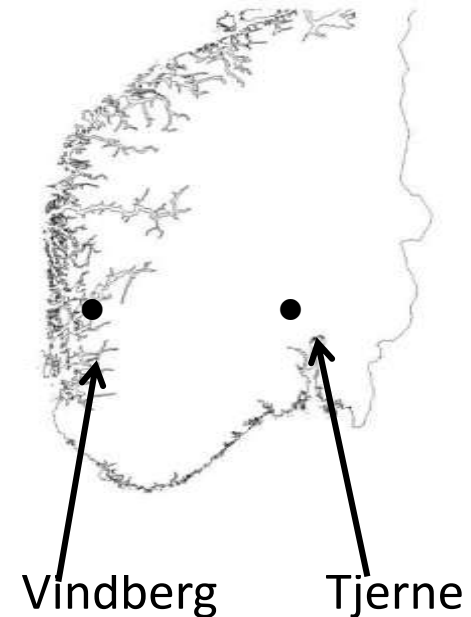
However, harvesting of forest residues may have several environmental consequences, including biodiversity loss and changes in species composition in forest ground vegetation, which in turn also may affect soil properties.

The main aims were to investigate and compare possible effects of WTH vs. SOH at two Norwegian sites, differing in climate and topography, on:

- plant biodiversity
- cover of different species groups
- species composition (not presented here)
- single species abundances (not presented here)
- ground vegetation biomass (not presented here)
- relationships to soil chemistry (not presented here)

We established two integrated field experiments in semi-natural Norway spruce (*Picea abies*) forests at sites with contrasting climate and topography, to compare the effects of SOH and WTH on soils, ground vegetation and regeneration.

The same measurements were made at both sites



Mean annual precipitation(mm)	1550	585
Mean annual temperature(°C)	4.3	3.2
Slope (°)	23	9
Harvesting	Jan 2011	Mar 2009
Slash removal	Oct 2011	Sept 2009





<- Forest at Tjerne before logging (photo: Kjersti Holt Hanssen)

Vindberg after logging ->



# METHODS

## – Treatment plots:

Tjerne: 6 for each treatment, paired plots, 20 x 20 m<sup>2</sup>, 5 m buffer

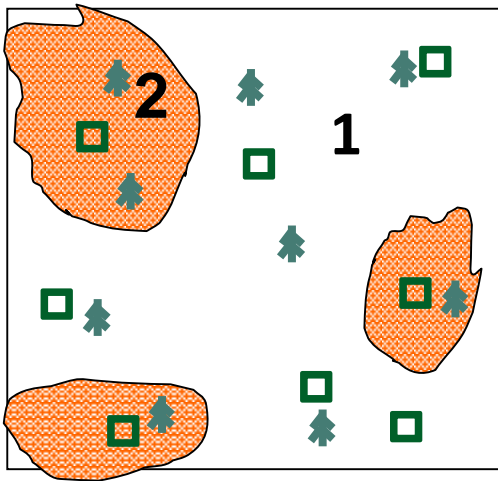
Vindberg: 5 for each treatment, paired plots, 12 x 12 m<sup>2</sup>, 4 m buffer

## – In each treatment plot: **1 m<sup>2</sup> randomly placed vegetation sub-plots:**

8 in each WTH and 6 in each SOH plot

## – % **cover** recorded for **all species present in each sub-plot**

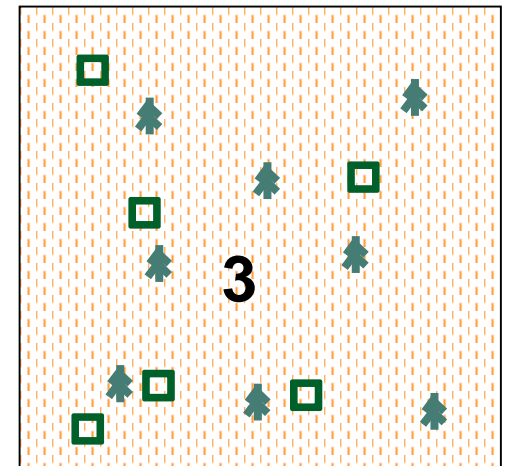
## – Sub-plots analysed before logging, reanalysed after logging



Whole-tree harvesting, **WTH: 1: “No” slash**  
(branches and tops); **2: Slash pile (removed)**

After logging:

- Slash at WTH plots left in **piles for 6-8 months**, then removed.
- Some vegetation sub-plots **covered with slash piles**
- Stumps not harvested



3: Stem-only harvesting,  
**SOH: Slash ± evenly spread**

# Statistical analyses

Non-parametric tests: Kruskal-Wallis tests and two-sided Kolmogorov-Smirnov tests to test differences between and within years from 2008-2014

- **species numbers** in species groups
- **cover** of vegetation **layers** and cover of single **species**

Data subsets each year:

- **WTH wop**; WTH plots without slash piles
- **WTH wp**; WTH plots covered with slash piles for 6-8 months
- **SOH** plots

Photos of plots below: Ingvald Røsberg, Jørn-Frode Nordbakken and Tonje Økland



# WTH between piles at Tjerne; same sub-plot 2008-2014



Left:  
2008



Right:  
2010



Left:  
2012



Right  
2014



# WTH with piles at Tjerne; same sub-plot 2008-2014



Left:  
2008



Right:  
2010



Left:  
2012



Right  
2014



# SOH at Tjerne; same sub-plot 2008-2014



Left:  
2008



Right:  
2010



Left:  
2012



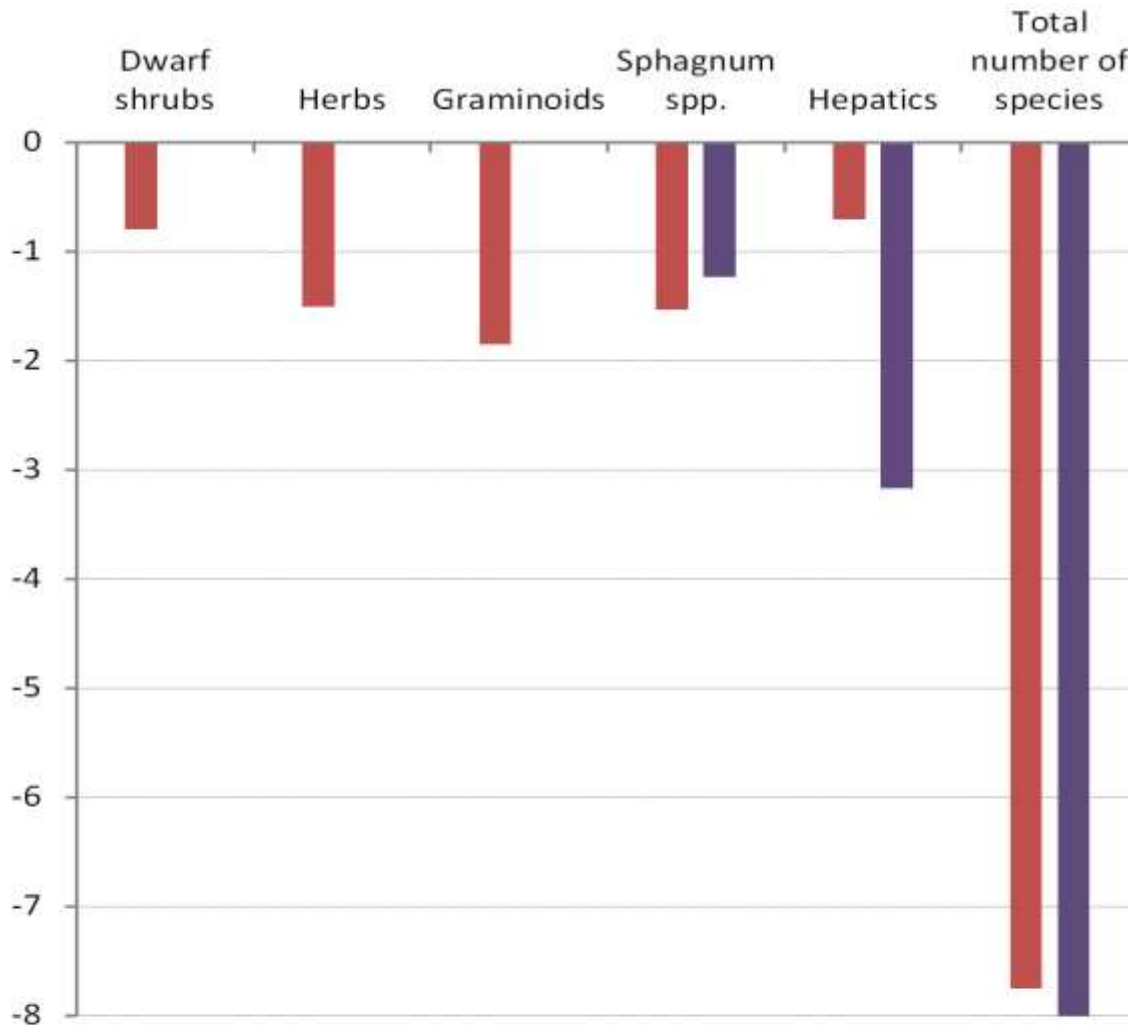
Right:  
2014

# SOME RESULTS

Number of species in different species groups at Tjerne and Vindberg, before (2008 and 2010, resp.) and after (2010 and 2012, resp.) harvesting.

	Tjerne			Vindberg		
	Pre-harvest	Post-harvest	Total	Pre-harvest	Post-harvest	Total
<b>Woody species</b>	4	8	8	4	3	4
<b>Dwarf shrubs</b>	2	2	2	4	4	4
<b>Herbs</b>	14	17	19	13	16	17
<b>Pteridophytes</b>	6	5	8	8	6	8
<b>Graminoids</b>	12	12	14	11	16	16
<b>All vascular plants</b>	38	44	51	40	45	49
<b>Mosses</b>	19	19	21	20	22	23
<b><i>Sphagnum spp.</i></b>	3	4	4	6	6	6
<b>Hepatics</b>	10	9	11	24	18	26
<b>Lichens</b>	1	1	2	2	0	2
<b>All bryophytes</b>	32	32	36	50	46	55
<b>All species</b>	71	77	89	92	91	106





■ Post harvesting: Differences WTH without piles and WTH with piles

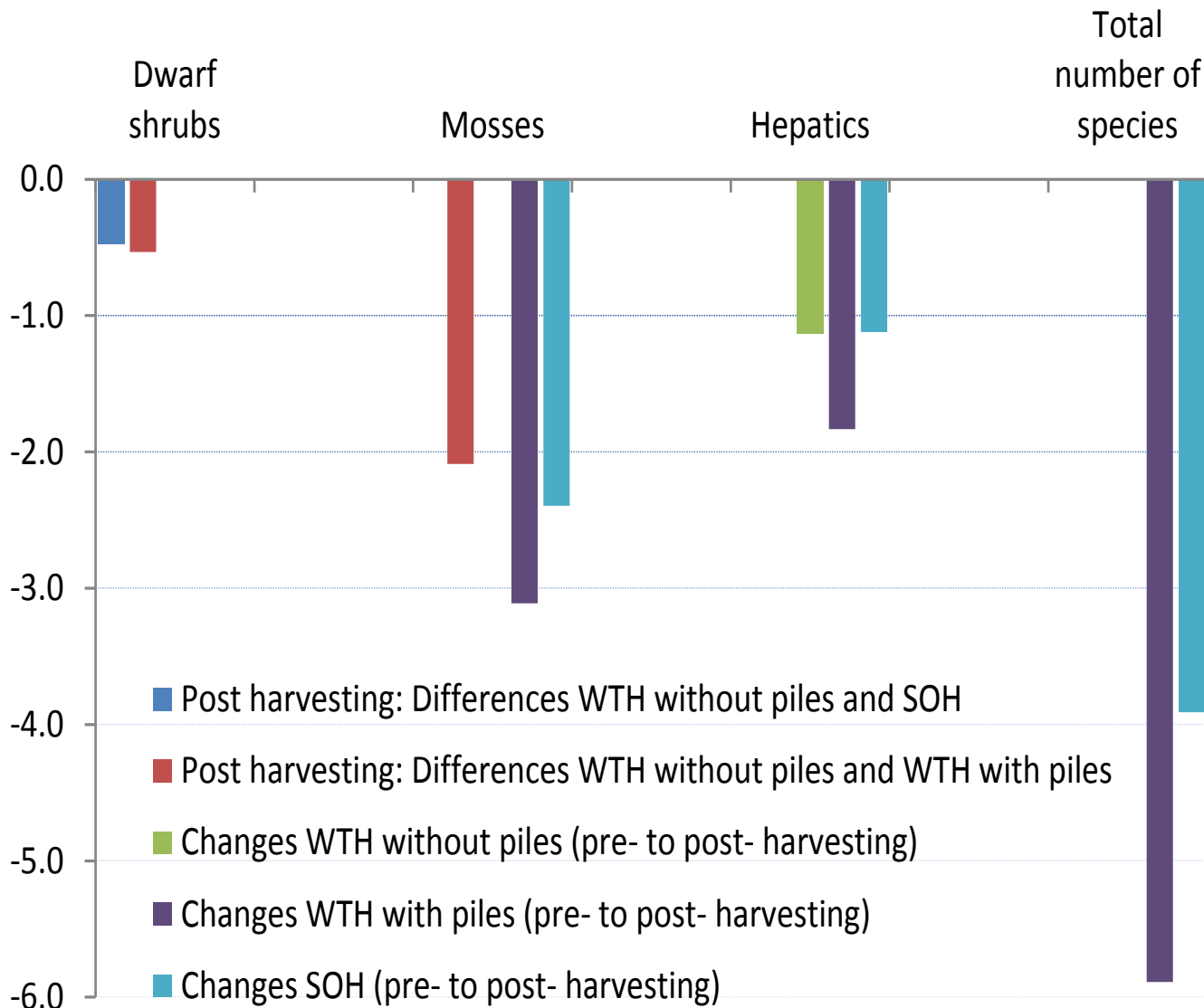
■ Changes pre- to post-harvesting: WTH with piles

Significant differences (Kruskal-Wallis tests):

(1) Post-harvest  
between plot types and  
 (2) changes pre- to post-  
harvest

**in species number** for  
 species groups at  
**Vindberg.**

Vertical axes: Average  
 difference/change in  
 species number per plot



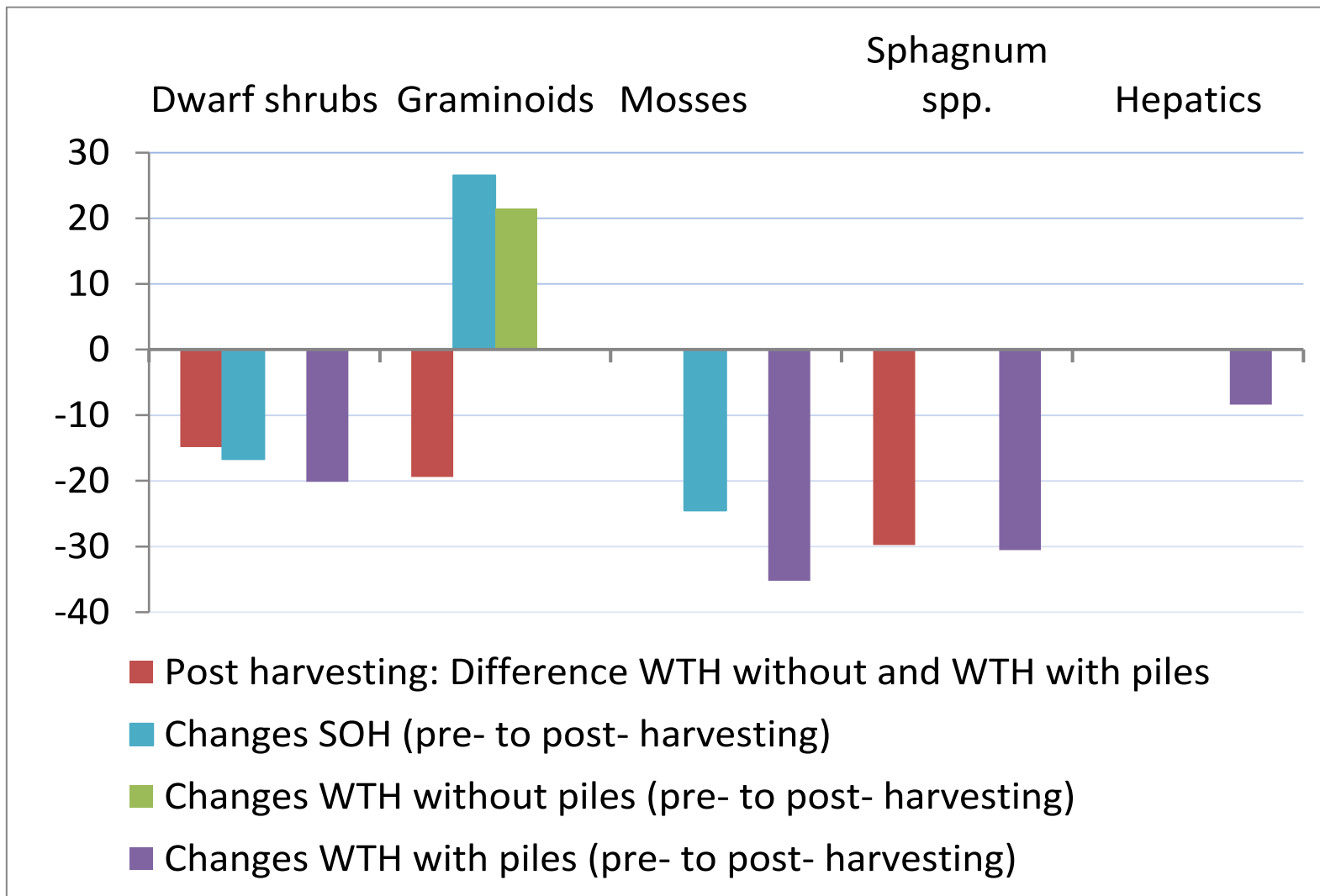
Significant differences (Kruskal-Wallis tests):

- (1) Post-harvest between plot types and
- (2) changes pre- to post-harvest

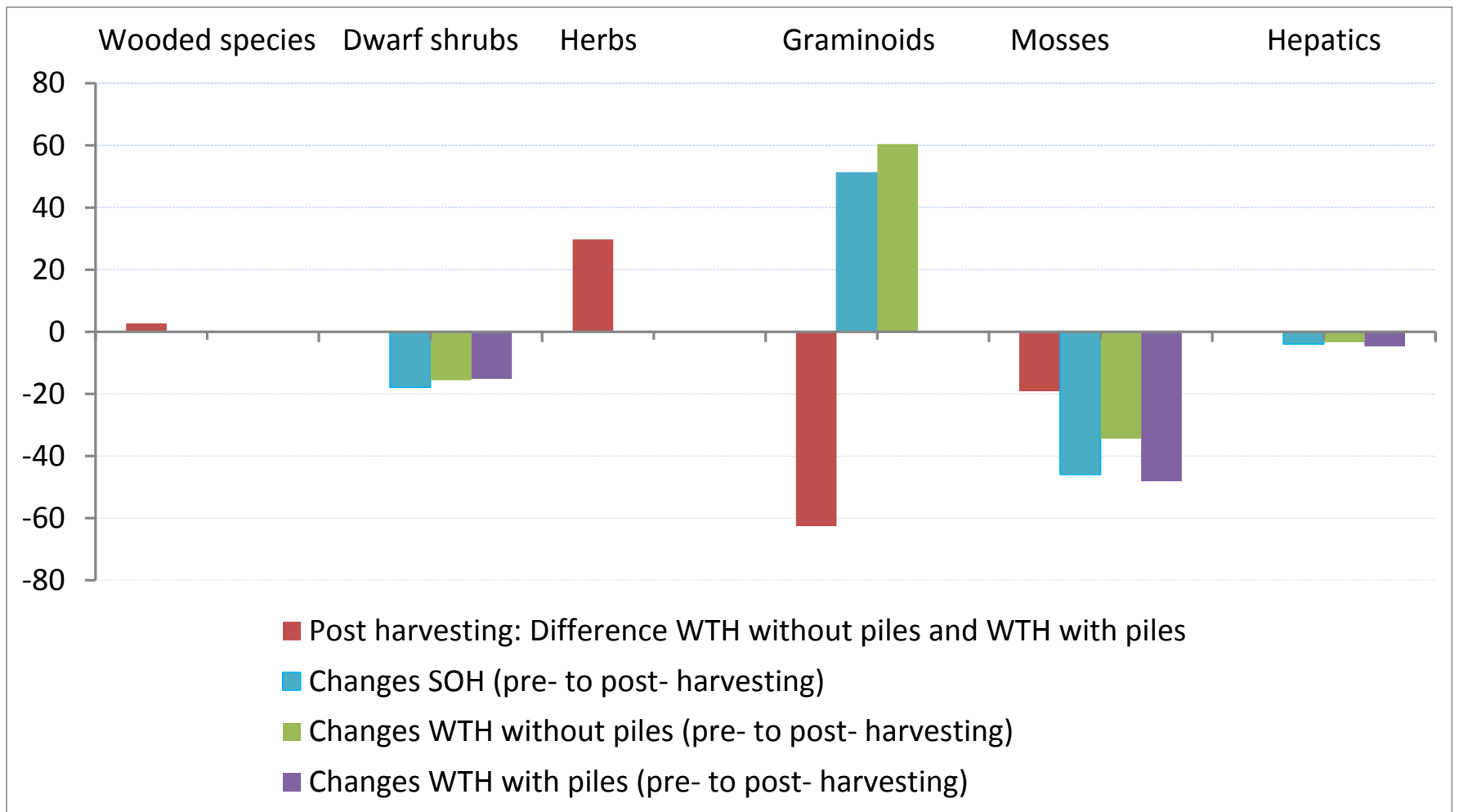
**in species number for species groups at Tjerne.**

Vertical axes: Average difference/change in species number per plot





Significant differences (Kolmogorov-Smirnov tests) between plot types post-harvest and changes pre- to post-harvest in (summarized) **cover for species groups** at **Vindberg**. Vertical axes: Average difference/change in % cover per plot



Significant differences ((Kolmogorov-Smirnov tests) between plot types post-harvest and changes pre- to post- harvest in (summarized) **cover for species groups** at **Tjerne**. Vertical axes: Average difference/change in % cover per plot



# PRELIMINARY CONCLUSIONS

- Plant biodiversity was considerably and significantly reduced for several species groups at both WTH and SOH plots at Tjerne, but only at WTH plots with piles at Vindberg.
- Bryophytes in particular were strongly reduced, and most on WTH plots with piles.
- Cover of several species groups was also reduced, while cover of graminoids increased at WTH plots without piles and at SOH plots
- Differences between the two harvesting methods at both sites were mainly due to the residue piles assembled during whole-tree harvesting and the physical damage made during the harvesting of residues in these piles.
- The presence of the residue piles had a clear negative impact on both species numbers and cover.
- Pile residue harvesting on unfrozen and snow-free soil caused more damage to the forest floor in the steep terrain at Vindberg compared to Tjerne
- Can the vegetation return to its pre-harvest state, even after many decades?

THANK YOU FOR YOUR ATTENTION



Reference :

Økland, T., Nordbakken, J.-F., Lange, H., Røsberg, I., & Clarke, N. Short-term effects of whole-tree harvesting on understory plant species diversity and cover in two Norway spruce sites in southern Norway. *Scandinavian Journal of Forest Research*: in press.