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Department für Wald- und Boden-  
wissenschaften

# Sustainable Utilization of Forest Biomass

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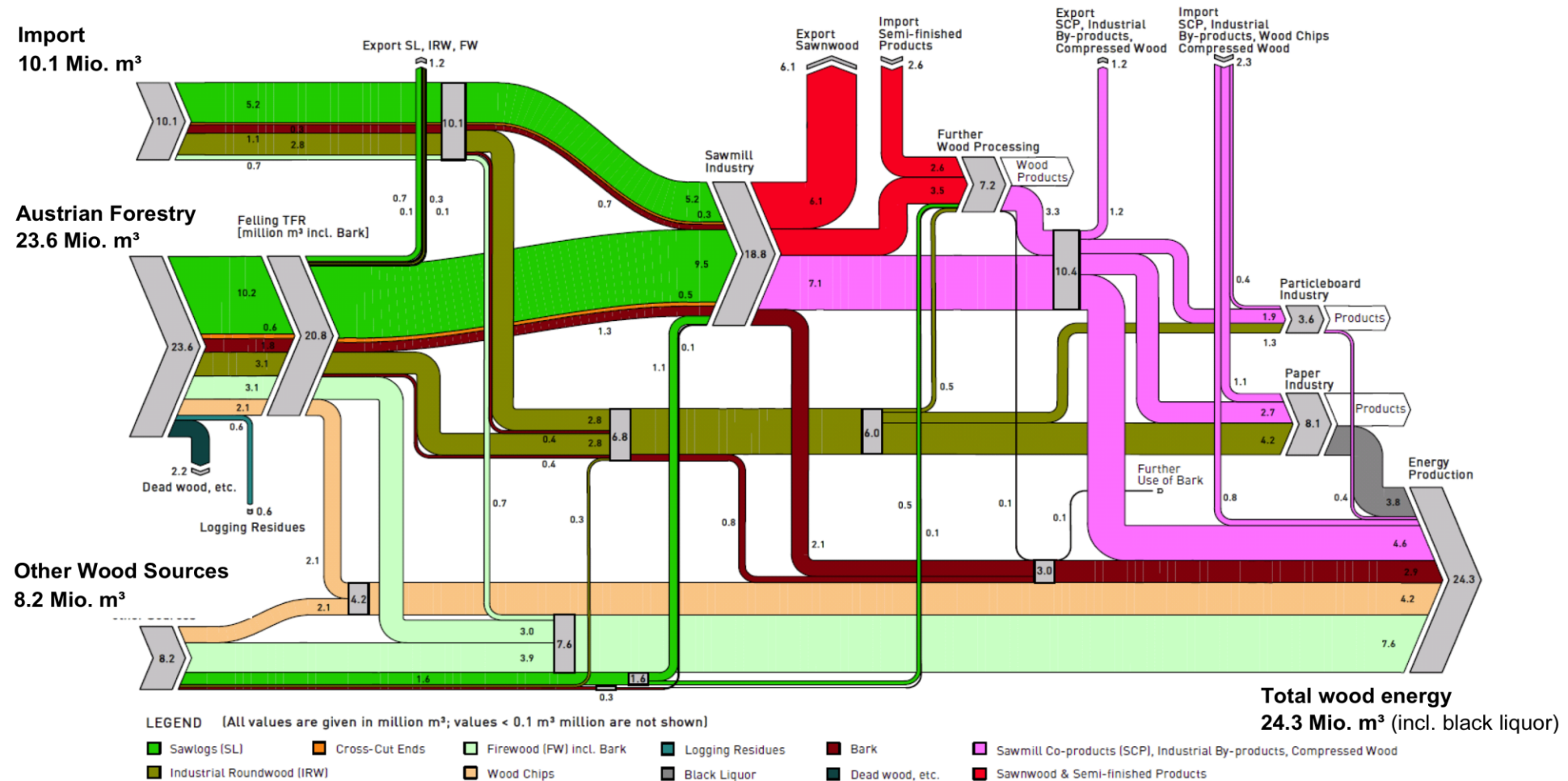
# Content



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- **Trends in forest biomass utilization in Austria**
- **Forest ecosystem and its function**
- **The effects of forest biomass extraction and utilisation**
  - **Acidification**
  - **Loss of organic carbon**
  - **Soil compaction and erosion**
  - **Other effects**
- **What you have to care for?**
- **Wood ash and compensatory fertilization**

Wood based biomass for energy is to a high percentage supplied as by-products of the sawmill, pulp and paper industry (bark, sawdust, black liquor)



## WOOD PRODUCTS and their Utilization in Austria

# Forest Biomass for Domestic Energy

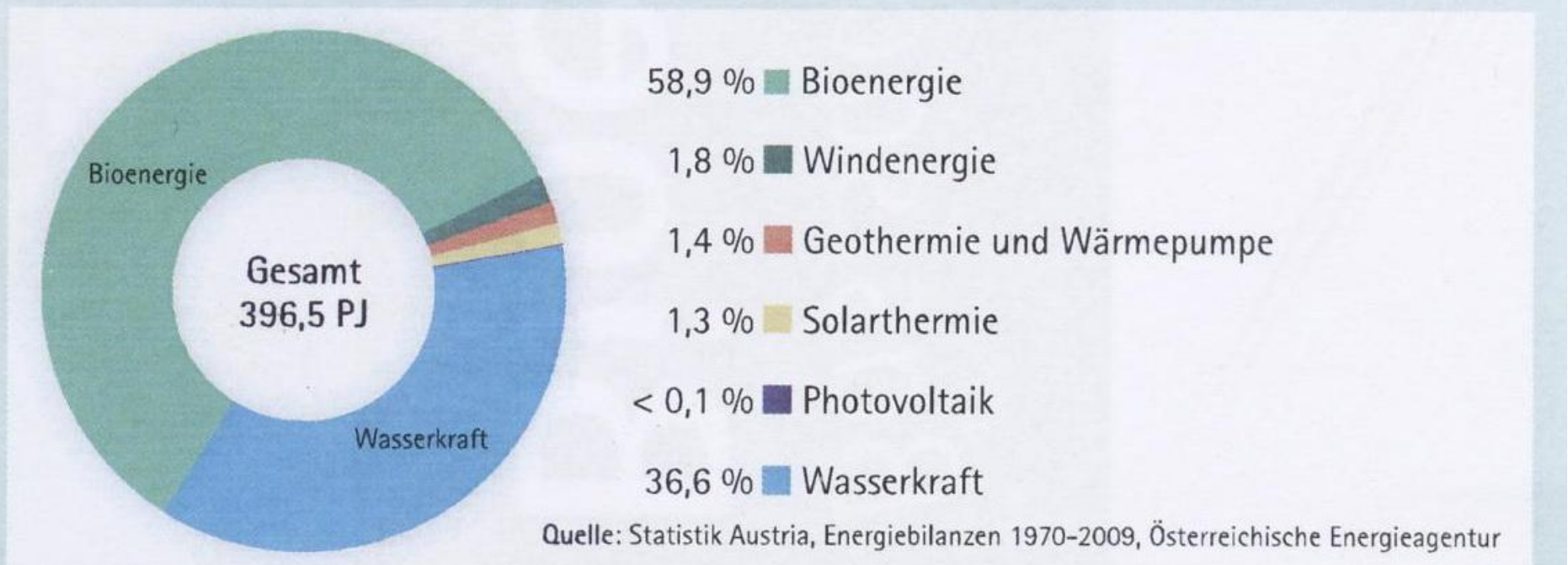


Total domestic energy consumption in 2009: 1354 PJ  
Nearly 60% of the renewables is energy from biomass



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## Bruttoinlandsverbrauch erneuerbare Energieträger 2009







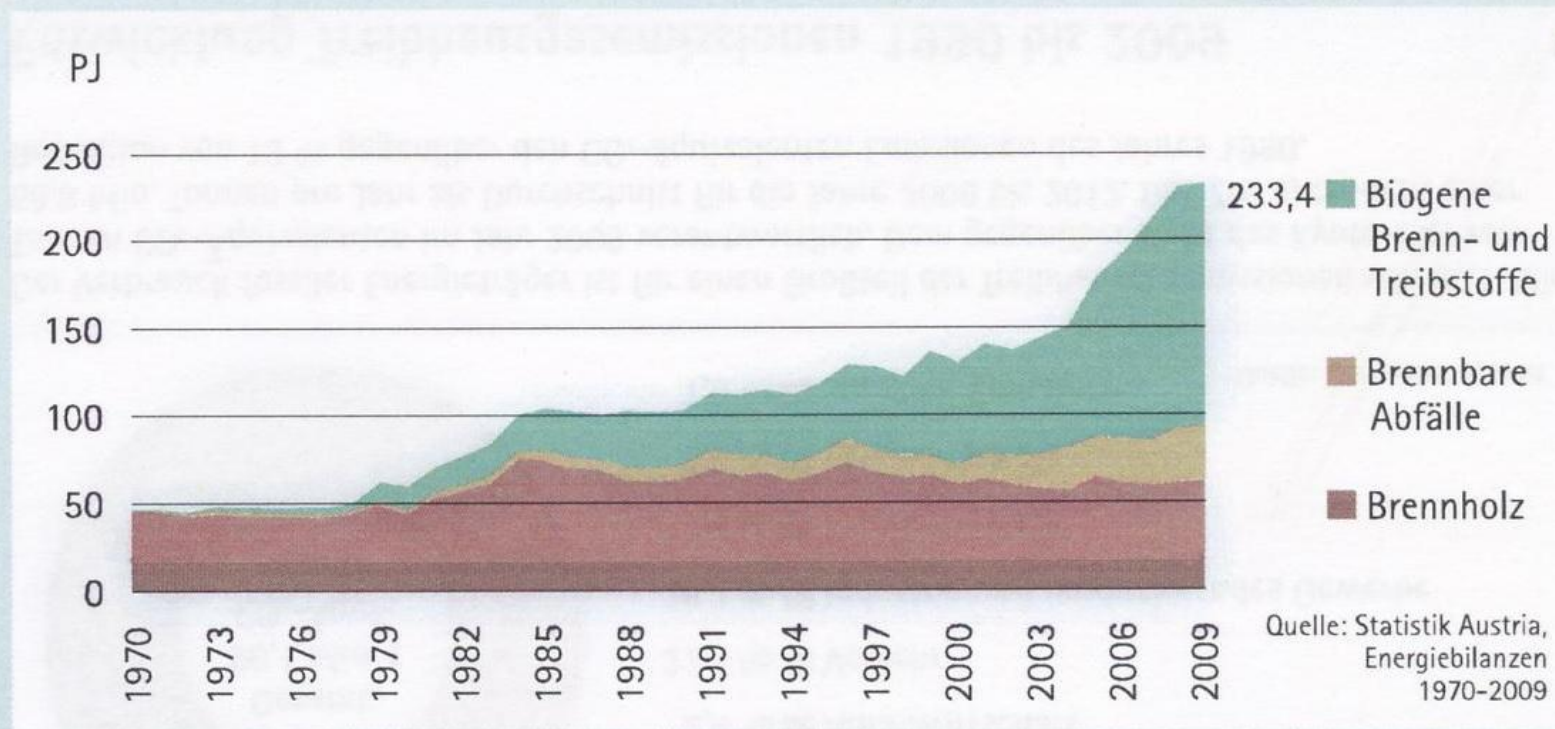
# Forest Biomass for Domestic Energy

While the temporal trend for fire wood stays fairly constant, biofuels&pellets as well as garbage incineration are on the rise



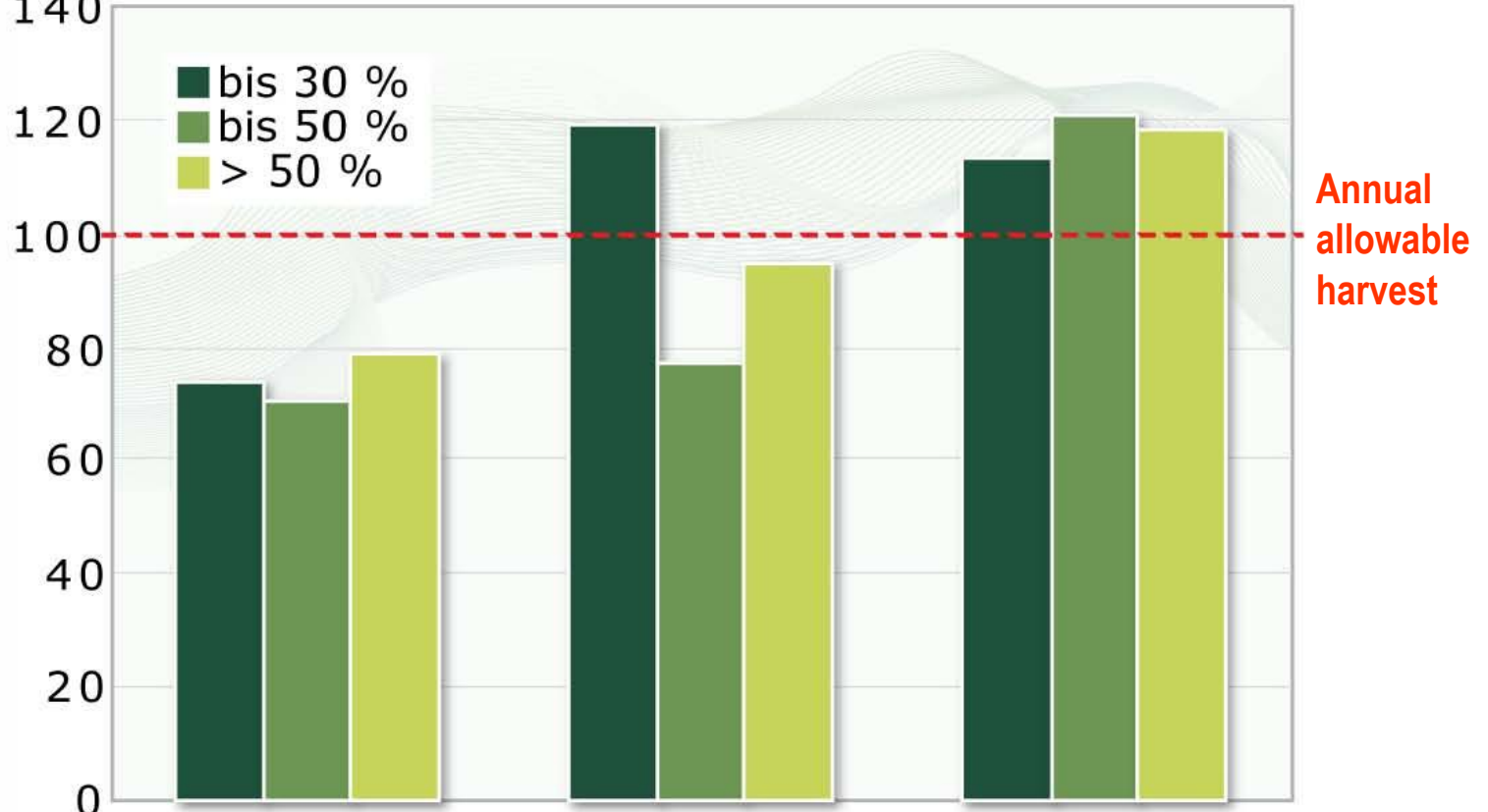
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## Entwicklung Bruttoinlandsverbrauch Bioenergie 1970 bis 2009



# Nutzungsprozente nach Hangneigung

Harvest percentage by ownership and slope angle



Annual allowable harvest

**Kleinwald bis 200 ha**  
**Smallholder**

**Betriebe > 200 ha**  
**Forest enterprise**

**ÖBf AG**  
**Federal forests**

# Forest Biomass Utilization



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- **Analyzing the current situation: How do increase the biomass supply?**
  - **A) timber reserves only in smallholder forests**
  - **B) or in less accessible forest sites**
  - **C) slash and logging residue become attractive**
  - **D) short rotation energy forests**
- **ad A) problem to mobilize these resources**
- **ad B) harvesting costly**
- **Ad C + D) impacts upon soils & forest ecosystems need special consideration see the following!**



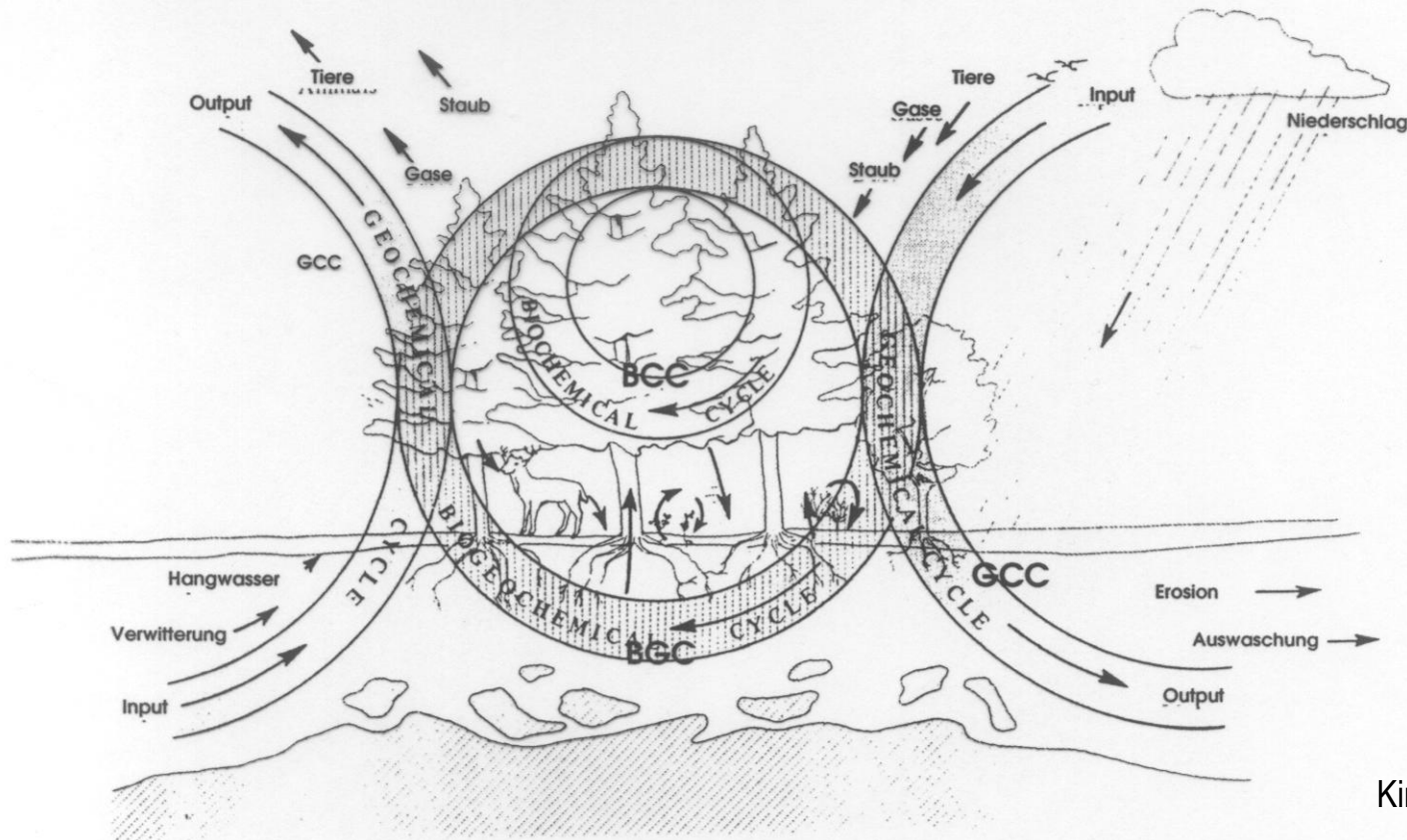
# Forest ecosystem and its function

Characteristics: open, cycling, self regulating



## Cycles in the forest ecosystem

Kreisläufe im Waldökosystem



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Kimmins, 1987

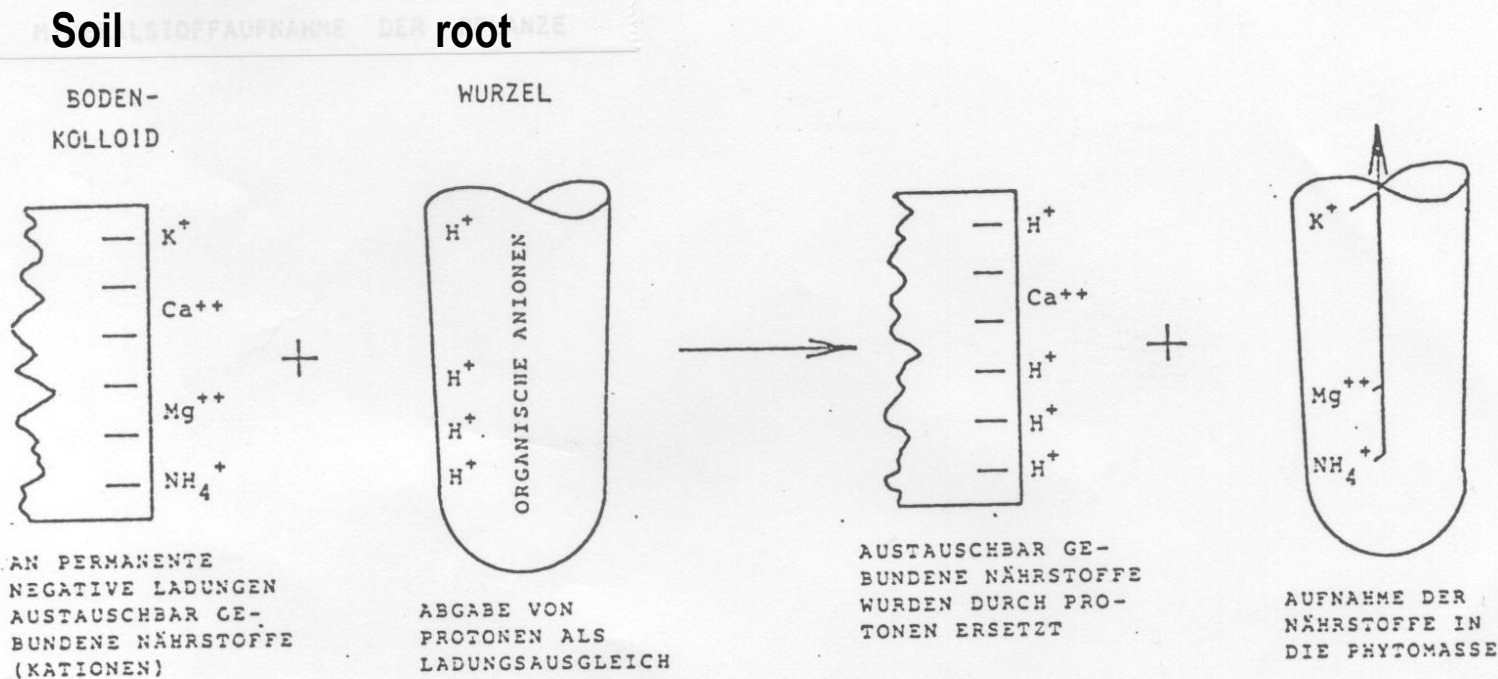
# Forest ecosystem and its function



when forest trees are taking up nutrients and when they grow, then they are acidifying the forest soil



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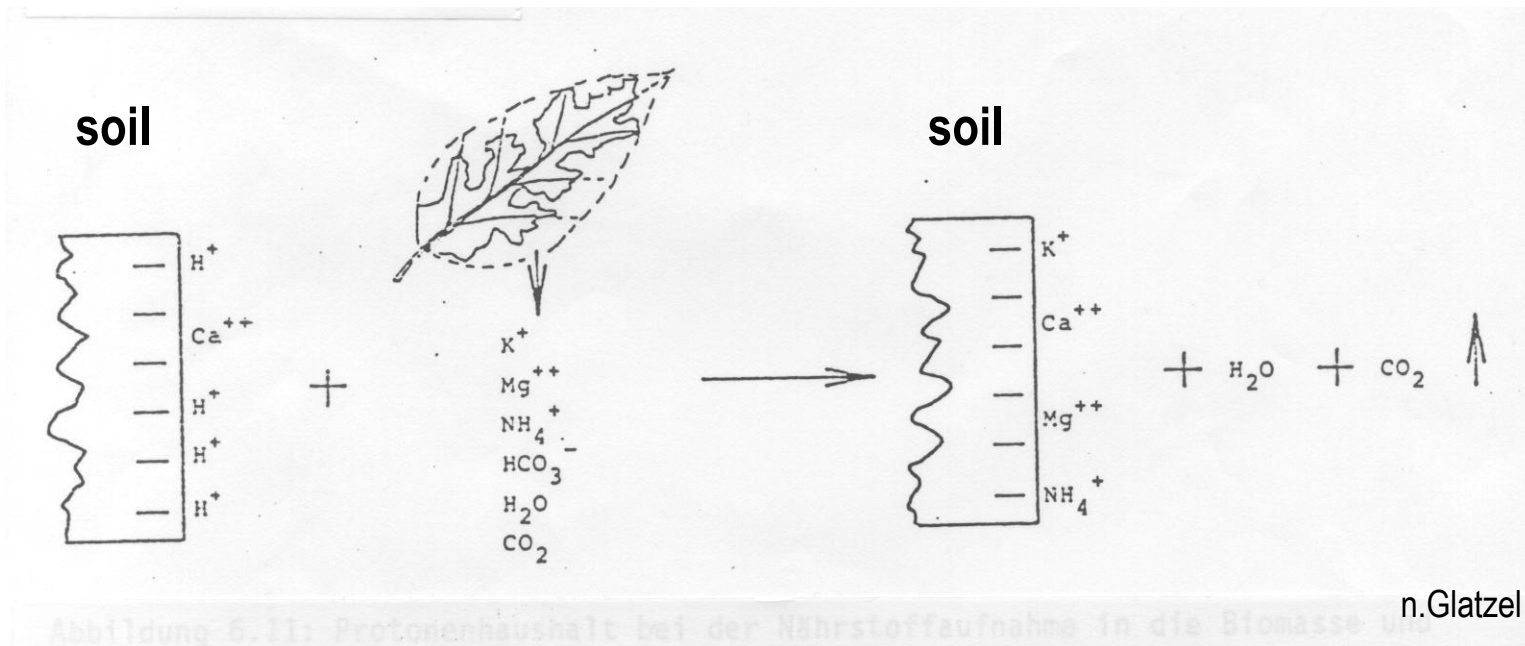
n.Glatzel 1990



n.Marschner, 1995

# Forest ecosystem and its function

when the biomass is dying off and decomposes, then acidification may be buffered at the same rate as base ions are set free to the soil solution and exchanged to the soil colloids



# Forest ecosystem and its function

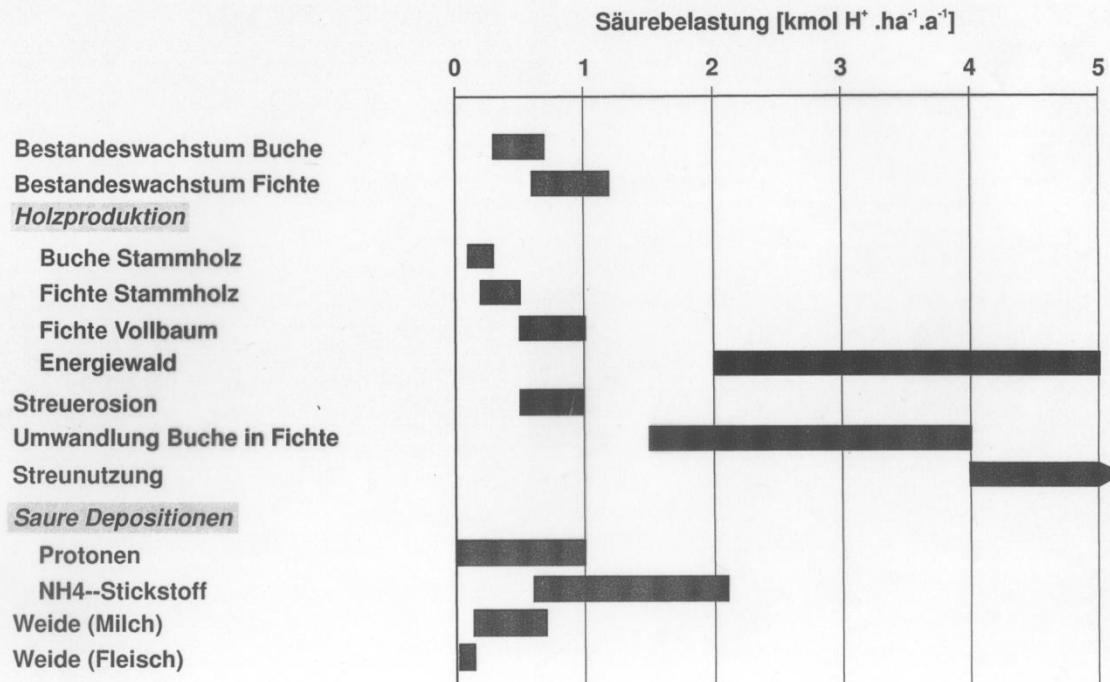


Therefore all extractions which are interrupting or retarding the cycles in the forest ecosystem are leading to acidification or depletion of nutrient stores in the mineral soil



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Säurebelastung des Mineralbodens von Wäldern



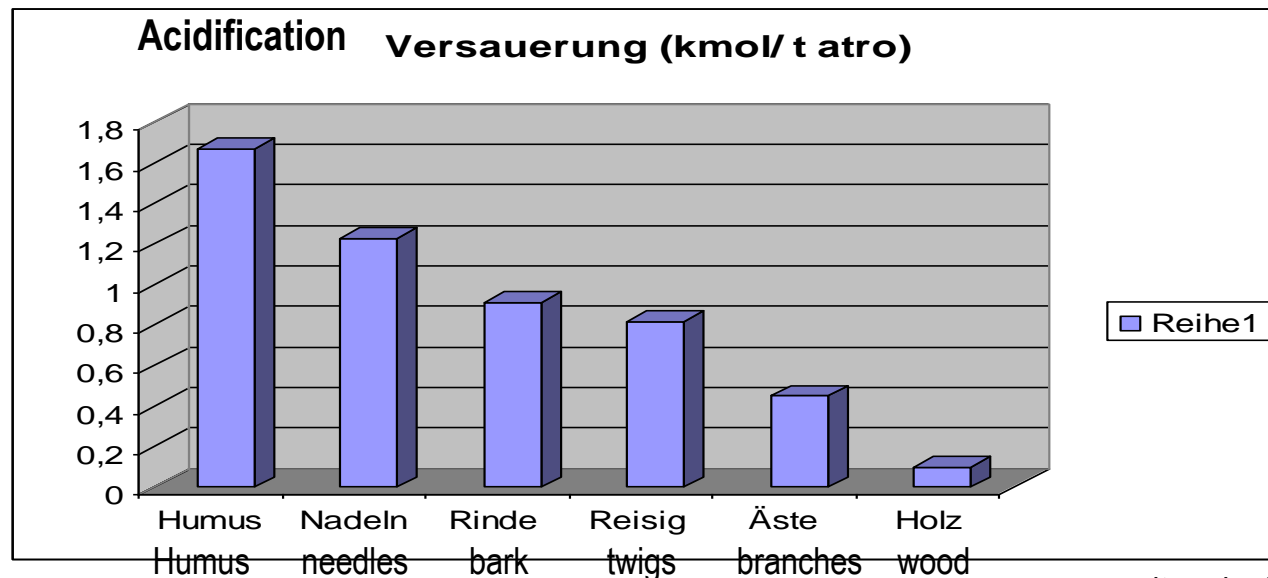


# Effects of biomass utilisation



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**Naturally all biomass utilisation results in acidification and depletion of forest soils → BUT the effect is not the same for all biomass fractions !**



altered after Englisch , 1976

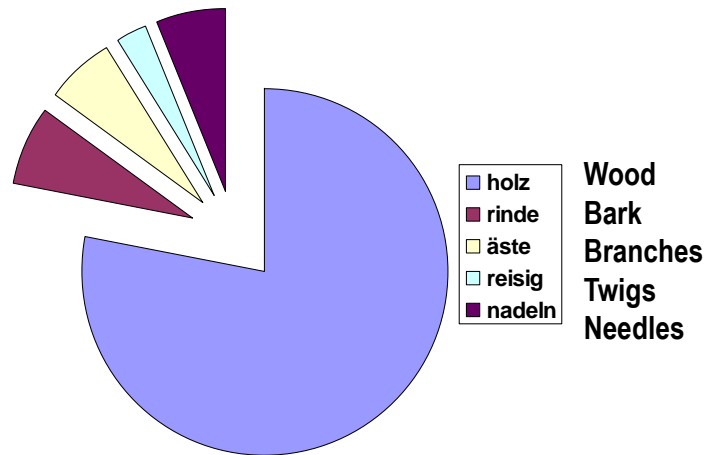
# Comparison of biomass fractions and their relative contribution to the acidification



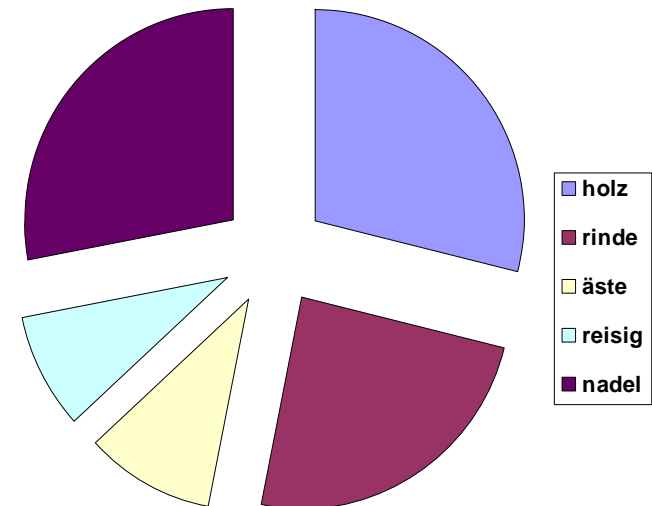
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## Norway spruce yield class 9 (m<sup>3</sup>/yr.ha)

Biomass fraction  
Biomassenfraktionen



contribution to acidification  
Anteile an der Versauerung



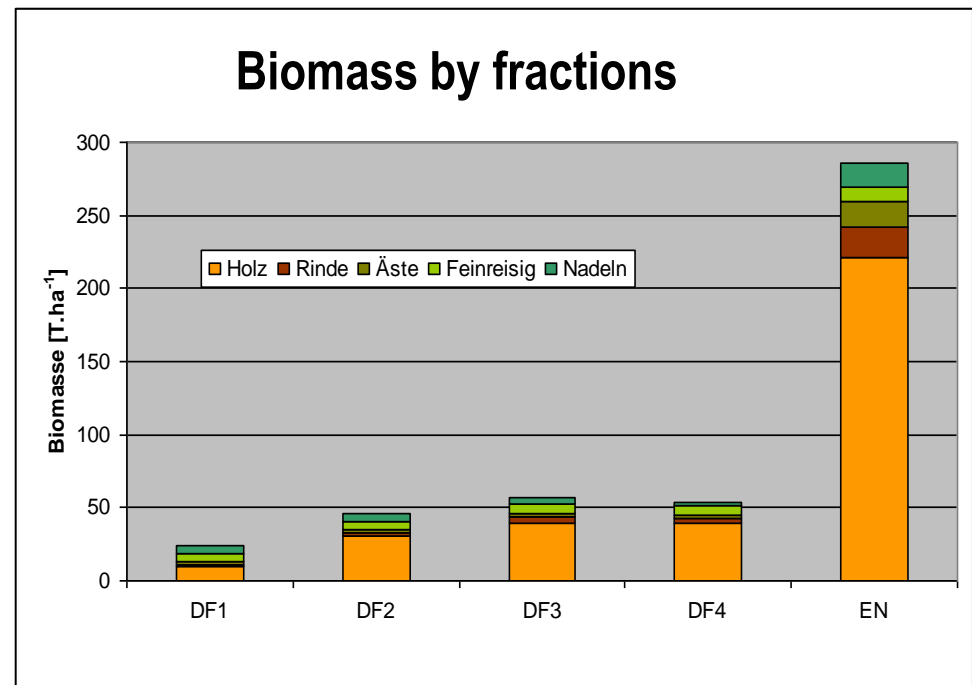


# Effects of biomass utilisation



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During the rotation period the proportion of nutrient rich biomass fractions (e.g. leaves, needles..) is changing. The younger a forest stand is the higher is the proportion of needles, bark and fine twigs within the total amount of biomass which may be utilized and therefore in such stands nutrient removal and acidification are higher.



DF1 bis DF4=Thinnings; EN=Final harvest

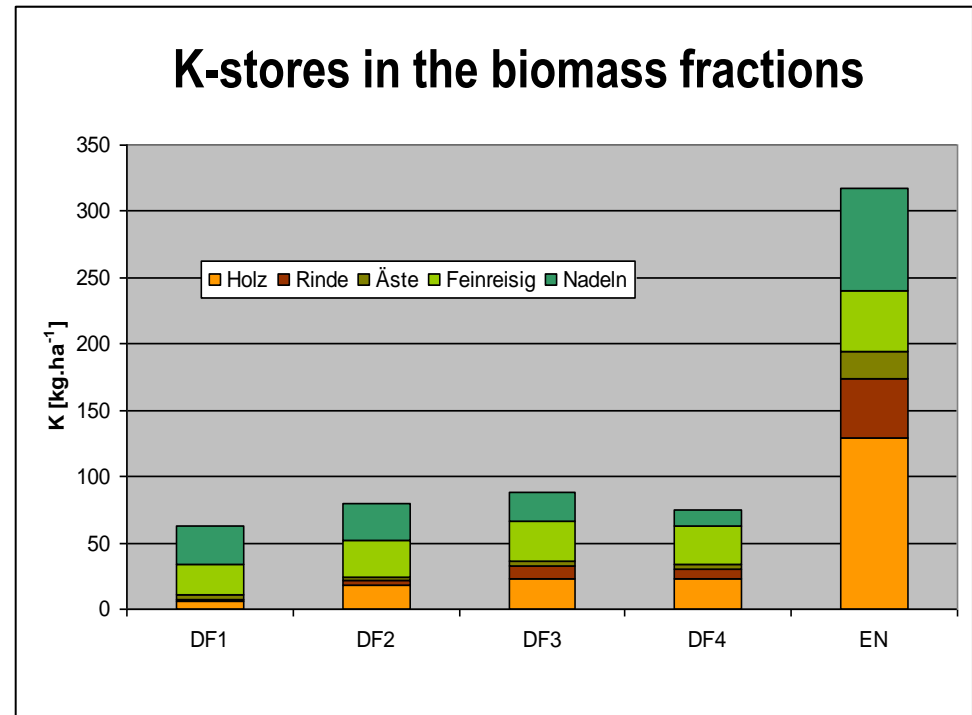
n.Englisch 1976

# Effects of biomass utilisation



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# Acidification and nutrient removal



It follows: the younger and the smaller the dimensions of biomass fractions, which are utilised the higher is the nutrient removal and on site soil acidification is. Very bad is the extraction of branches and twigs with needles or leaves.

Compare:

1 t stem wood i. bark

0.7kg N 0.2kg P 0.7kg K

2.0kg Ca 0.3kg Mg

188mol H<sup>+</sup> /t

1t twigs with needles

6.5kg N 0.9kg P 3.8kg K

6.5kg Ca 1.1kg Mg

950 mol H<sup>+</sup> /t

# Forest biomass and carbon loss



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**When forest biomass removal means an enhanced mobilisation and utilisation of forest biomass then:**

**this does not only result in more acidification**

**but also this enhancement means more Carbon is removed from the biogeochemical cycle:**

**In consequence less carbon is stored in forest soils and less humus will be in forest sites → see examples**

**and less dead wood is left standing or on the ground (habitat loss for div. fauna)**

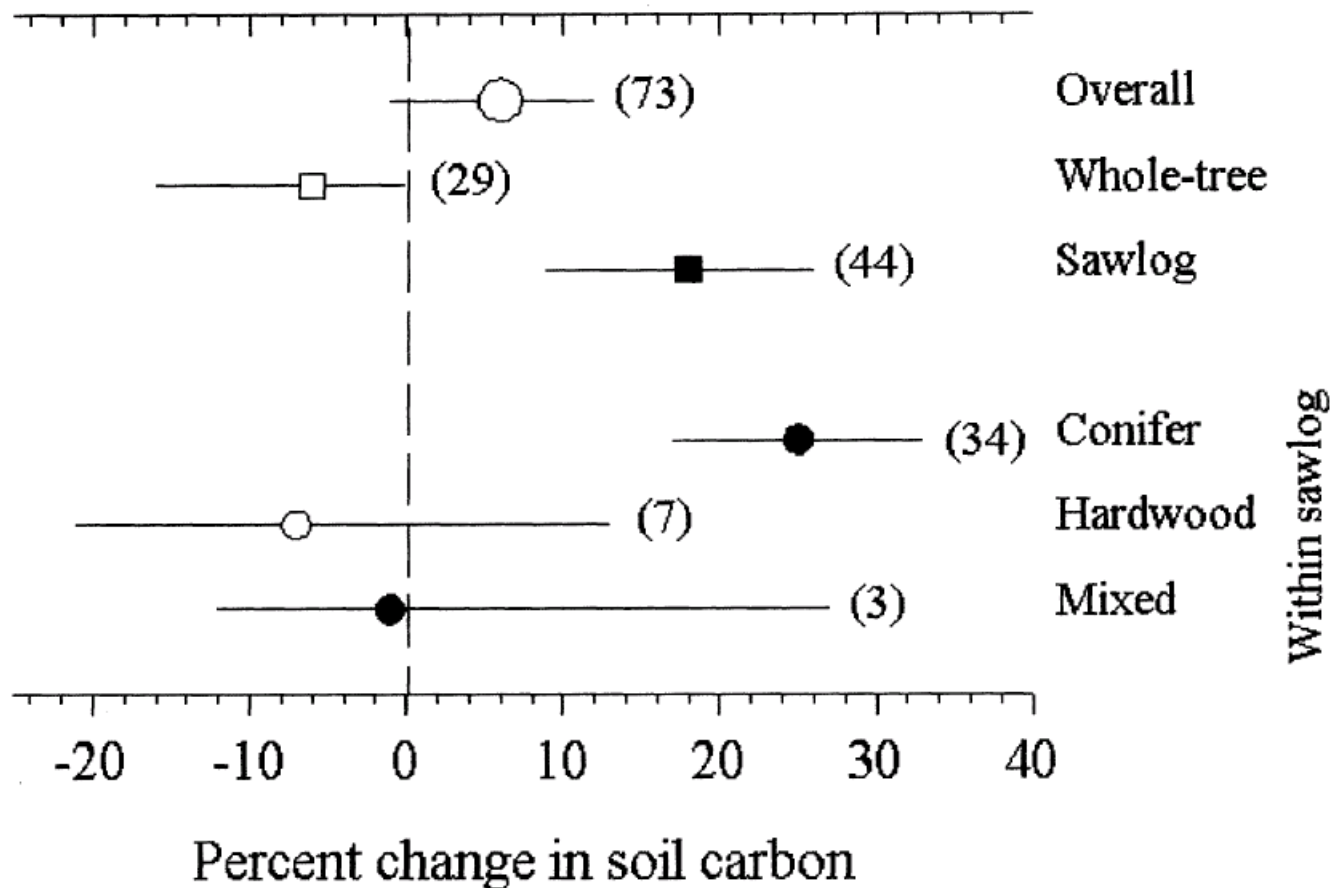


# Short term influences of final harvest intensity upon carbon stores in forest soils (Johnson & Curtis, 2001)



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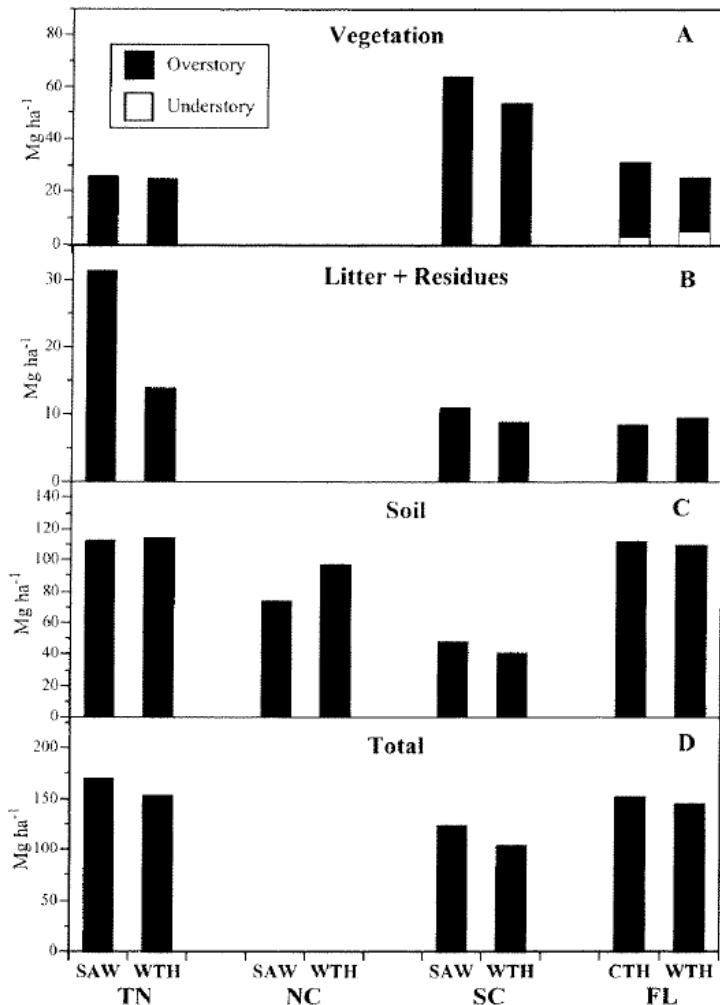
## Harvest effects on soil carbon, A horizon



# Midterm effects of different intensity utilisations



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C-Stores in forest ecosystems 15 years after final harvest (Johnson et al., 2002)

SAW...Sawtimber  
WTH...whole tree harvest  
CTH...canopy whole tree

TN: Mixed hardwoods  
SC: *Pinus taeda*  
NC: Mixed hardwoods  
FL: *Pinus elliottii*



# Forest biomass and carbon loss



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**The examples given above are still a bit inconclusive and heterogenous:**

**Because of the large spatio- temporal variability of carbon contents in forest soils**

**But if less carbon is left with the logging debris in the forest over longer terms there will be lower carbon stores in the forest soils**

**Consequently: there will be lower humus content;**

**1g Humus = 3-5g more water storage (Trienet; 1999)**

# Soil compaction and erosion



If heavy forest machinery is travelling to the tree and the tree is not transported to machines then pore space is lost and soil is compacted the water infiltration rate decreases Surface runoff and erosion (soil loss) is increasing

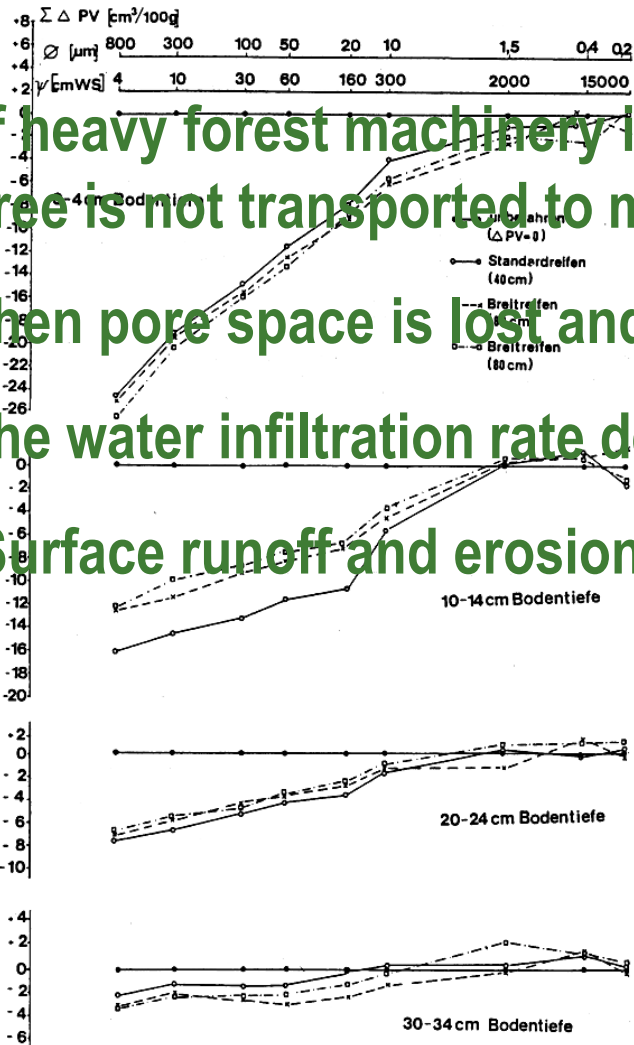


Abb. 1: Summenkurven der Abnahme des Porenvolumens nach Befahrung in Abhängigkeit von der Kapillarspannung der Poren bzw. der Porenäquivalentdurchmesser

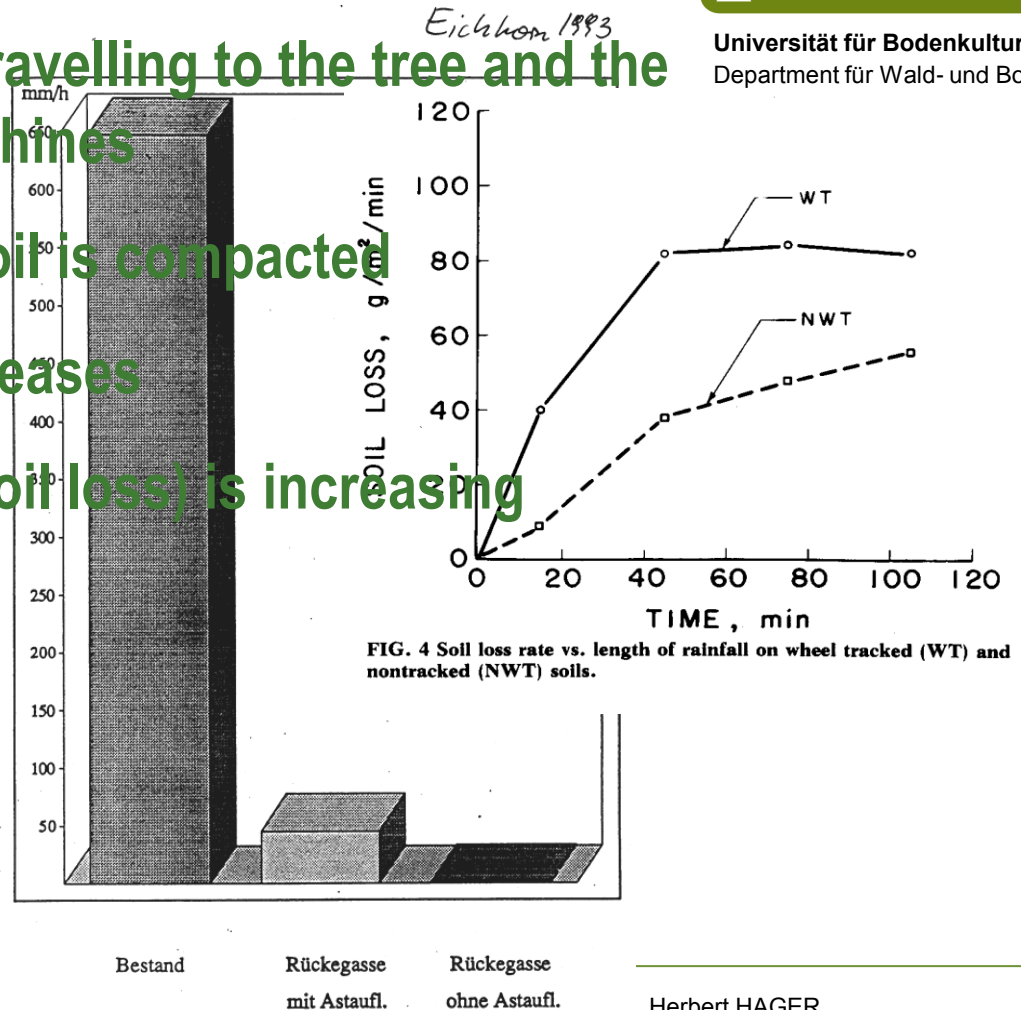


Abb. 15: Infiltrationsraten am Mondseeberg in mm/h

# Other effects



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**If logging debris and dead wood is removed**

**Habitat and life supporting resources for many small organisms are lost (dead wood fauna, decomposers  
→ nature conservation aspects)**

**Or the C-storage of forest ecosystems is decreased (see  
Kyoto- protocol 3.4)**

# WALDSTRUKTUR: Totholz Dead wood by regions

Ertragswald

## Regionale Unterschiede

\*) ohne Strauchflächen

Naturräume\_2

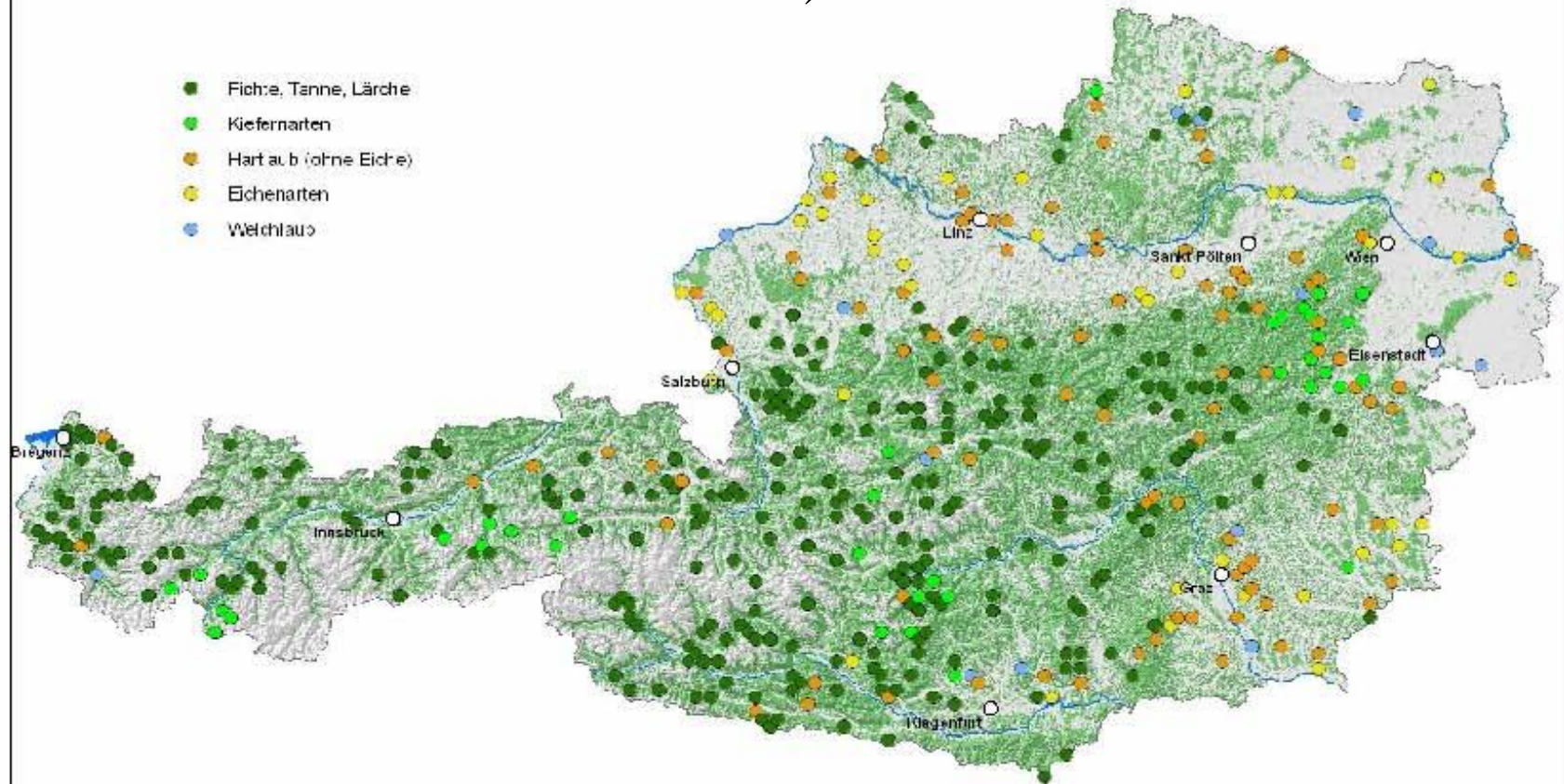
Naturaum	Steh. TH fm	Lieg. TH m <sup>3</sup>	Summe stehend+liegend	Steh. Vorrat Vfm/ha *)	AFBI wert	Waldfl. Ertrw[ha] *)
Innen-und Zwischenalpen	9,05	14,62	23,67	336	67	1104832
Mühl- und Waldviertel	4,33	3,54	7,87	344	21	362758
nördliches Alpenvorland	4,98	4,43	9,40	359	24	134172
Randalpen	9,94	14,03	23,97	333	70	1418176
sommerwarmer Osten	5,64	5,02	10,66	273	37	322397
<b>Gesamt</b>	<b>8,42</b>	<b>11,83</b>	<b>20,25</b>	<b>330</b>	<b>59</b>	<b>3342335</b>



# WALDSTRUKTUR: Lebende Starkbäume

## AUSTRIAN Forest BIODIVERSITY INDEX 4.5

Large diameter trees (<math><0.1\%</math> should be 1% of tree number )



# WHAT WE HAVE TO LOOK OUT FOR?



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**To guarantee the sustainability of the utilisation**

**The nutrient removal and acidification can be controlled to a certain extent: the earlier and the smaller the assortments, the higher the proportion of biomass rich in nutrients (needles, leaves, small twigs, bark) the higher is the removal of nutrients and soil acidification**

**Take care of the site quality, nutrient reserves and the potential of the soil to replenish nutrient by weathering of soil minerals**

**Consider site & soil properties when you plan mechanised harvesting and transport logistics**



# Wood ash recycling and compensatory fertilization



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## Wood ash functions as a strong basic and very reactive fertilizing medium

### Element content (%) of

	Wood ash	Lime		
Ca	15	31	Many nutrients are contained in wood ash in easily soluble oxidized form	
K	2.6	0.13		
Mg	1.0	5.1		
Al	1.6	0.25		
Fe	0.84	0.29		<b>Attention!</b>
P	0.53	0.06		Content of toxic substances
N	0.15	0.01		

# Wood ash recycling and compensatory Fertilization



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**Because of the above problems application of wood ash in forest sites should not be done indiscriminately and without considering site specifics and site quality**

**Otherwise there is the imminent danger of high nutrient exports with seepage water and the litter layer may be rapidly decomposed (some times this may be desirable, but not in all circumstances)**

# Wood ash recycling and compensatory fertilization



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Example Sweden: National Board of Forestry 2002:  
Recommendations for the extraction of forest fuel and  
compensation fertilization

Table 2. Spruce stand – the standard values in nutrient compensation, tonnes of dry matter (DM) in ashes per hectare and rotation

Extraction		Habitat index, compensation dosage, tonnes of DM in ashes/hectare and rotation		
		G18	G26	G34
All stemwood during rotation		1.5	2.0	2.5
Final felling	Logging residue <u>without</u> the greater part being needles *	0.7	0.8	0.9
	Logging residue <u>with</u> the greater part being needles **	1.1	1.3	1.4
Cleaning -thinning	Delayed cleaning***	0.4	0.5	0.6
	All thinning: logging residue <u>without</u> the greater part being needles ****	0.3	0.6	0.8
	All thinning: logging residue <u>with</u> the greater part being needles *****	0.6	1.0	1.3

Tree species

Habitat index

Type of operation

Amount of wood ash allowed per ha



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