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How severe does bark beetle outbreak affect ecosystem services ??

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Nationalpark Bayerischer Wald

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Changes following bark beetle attack and forest dieback

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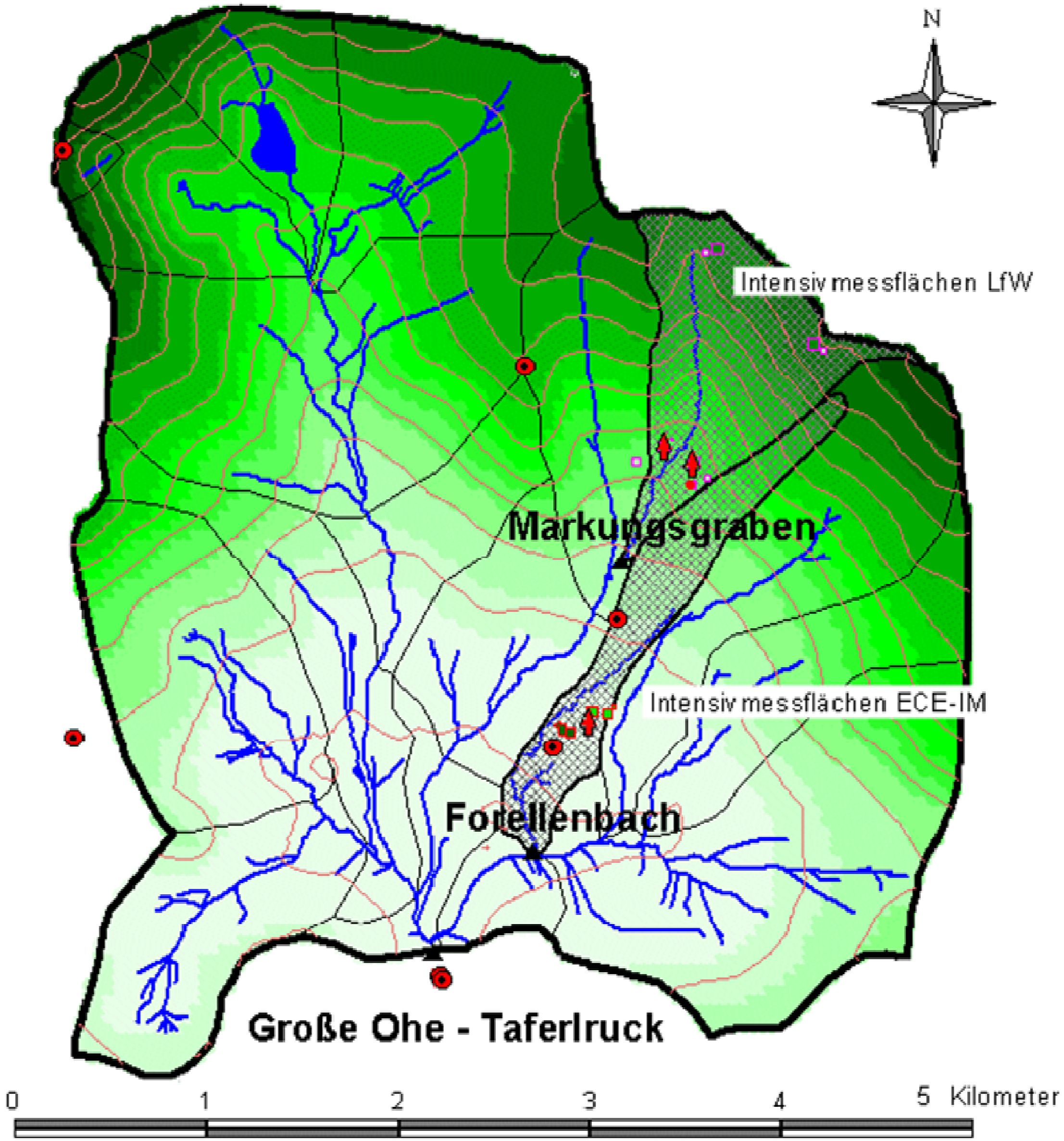
Sites and Methods



Markungsgraben

Monitoring on Air Pollution Effects on Groundwater Quality

Bavarian Environment Agency, NPA
(1989, 1.1 km²)

Forellenbach

UN/ECE ICP Integrated Monitoring on Air Pollution and Climate Change Effects on Ecosystems

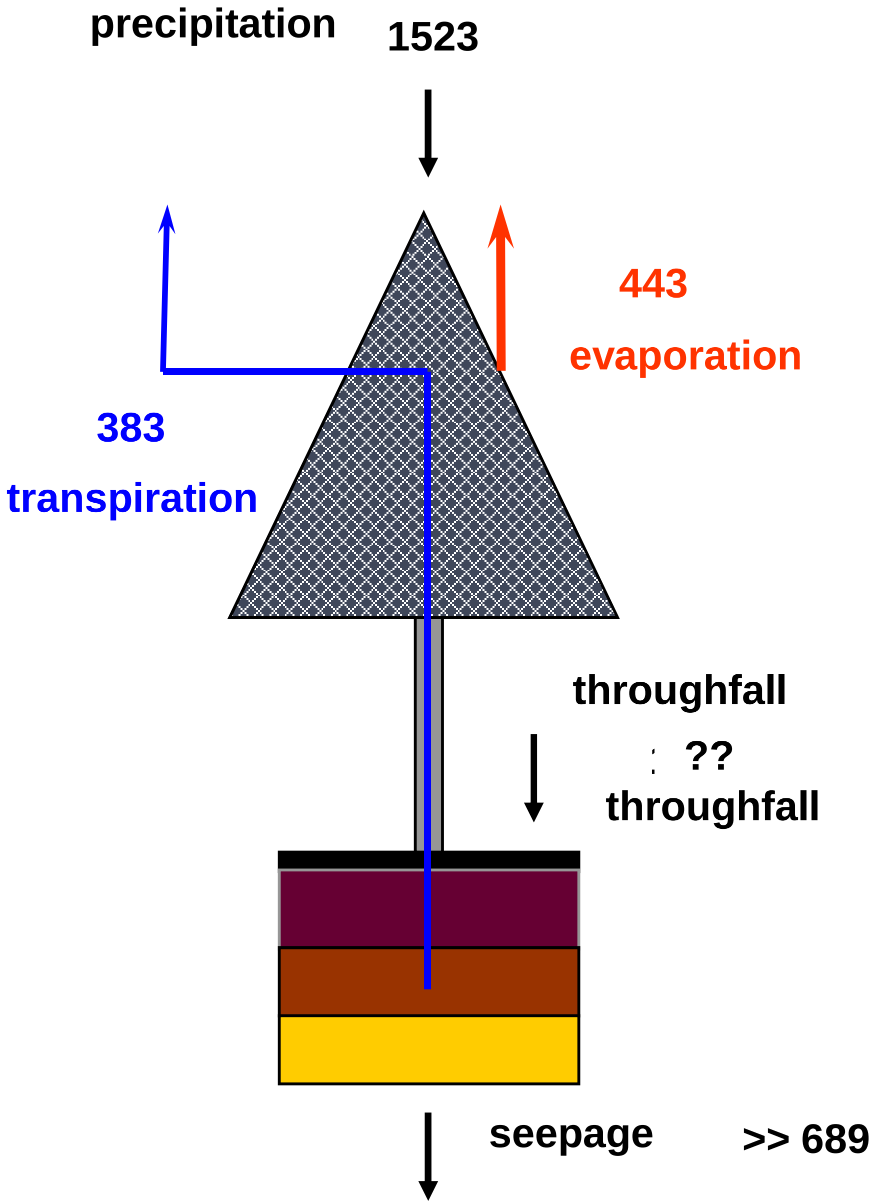
Federal Environment Agency, NPA
(1990, 0.7 km²)

Große Ohe

Monitoring on Changes in Water Cycling during Transition from managed to natural Forest

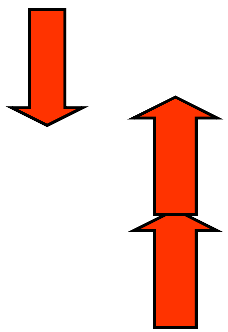
research cooperation, NPA
(1978, 19.1 km²)

Hydrological processes and balances



Water cycle (mm/a) of a low elevation spruce plot (810 m a.s.l, Ø 1992-1995)

After the dieback:

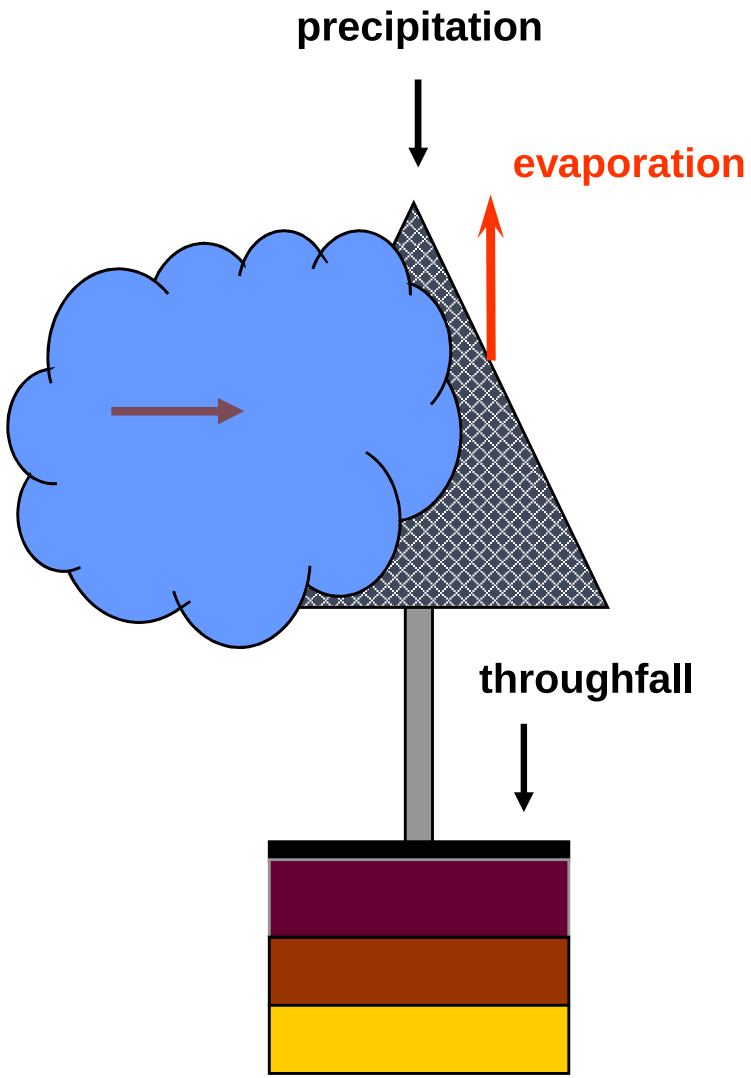


evapotranspiration

„stand precipitation“

seepage

Hydrological processes and balances



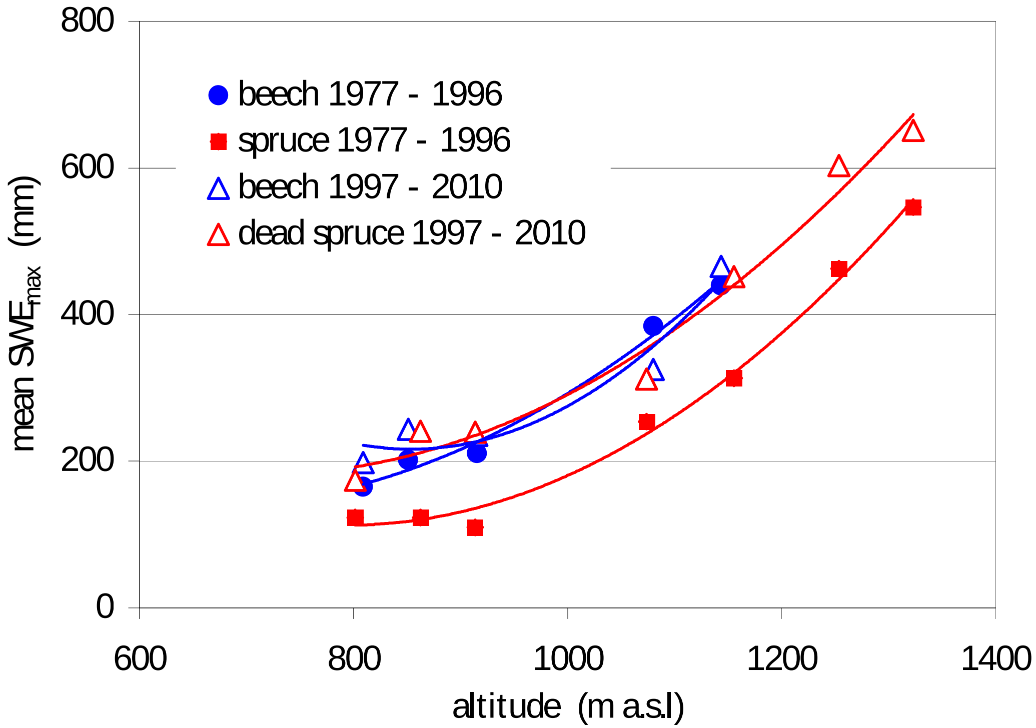
Water cycle (mm/a) of high elevation spruce plots (> 1200 m a.s.l)

cloudwater (C) = throughfall (TF)
- precipitation (P)
+ evaporation (E)

local		TF - P	E	C
1991-1996:	810 m a.s.l.	-443	443	
1999-2001:	800 m a.s.l.	-292	292	
2006-2009:	785 m a.s.l.	-529	529	
1992:	1300 m a.s.l.	-180		120
1989:	1215 m a.s.l.	-142	300	158
1988:	1203 m a.s.l	+ 87		387

Hydrological processes and balances

Snow cover dynamics (aboveground water store)



Until 1996 average maxima of water stores in snow cover had been higher under beech than under spruce at comparable altitude.

Since 1997 mature spruce stands on measuring sites are dead.
Mean maxima of snow water equivalents are now equal to those under beech.

The changes in vegetation cover influence snow cover dynamics (build-up, melting) and probably alter runoff dynamics in spring.

Hydrological processes and balances

Trend analysis of annual statistics of daily discharge (mm/day)

		exceeedance	Große Ohe (1992-2010)	Forellenbach (1992-2010)	Markungsgraben (1992-2008)
year	low flow	95%			0.04
		90%			0.04
		50%			
		10%	0.16		
	high flow	5%	0.21		
winter	low flow	95%			0.05
		90%			0.04
		50%			
		10%	0.26		0.39
	high flow	5%	0.28	0.23	0.47
summer	low flow	95%	0.02		**0.05**
		90%	0.02		**0.05**
		50%	0.04	0.04	0.06
		10%			
	high flow	5%			

High flow discharges (10% - 5% exceedance) has been increasing in all streams ($p < 0.05$), but only in winter.
There‘s no increase in flood peak

Mean flow discharges (50%) has been increasing in all streams ($p < 0.01$), but only in summer.

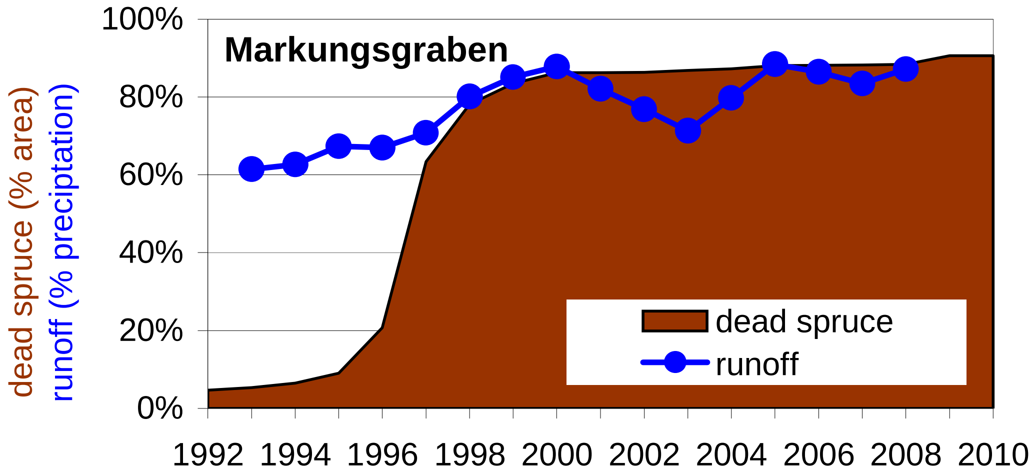
Low flow discharges (95% - 90% exceedance) has been increasing during summer in Große Ohe and most distinctive in Markungsgraben ($p < 0.001$).

During initial regeneration phase evapotranspiration on dead spruce stands is reduced compared to vital stands, enabling higher rates of groundwater recharge and thus higher low flow during summer.

Changes in high flow during winter only are probably related to changes in snow cover dynamics.

Hydrological processes and balances

Vegetation cover changes and catchment water balances

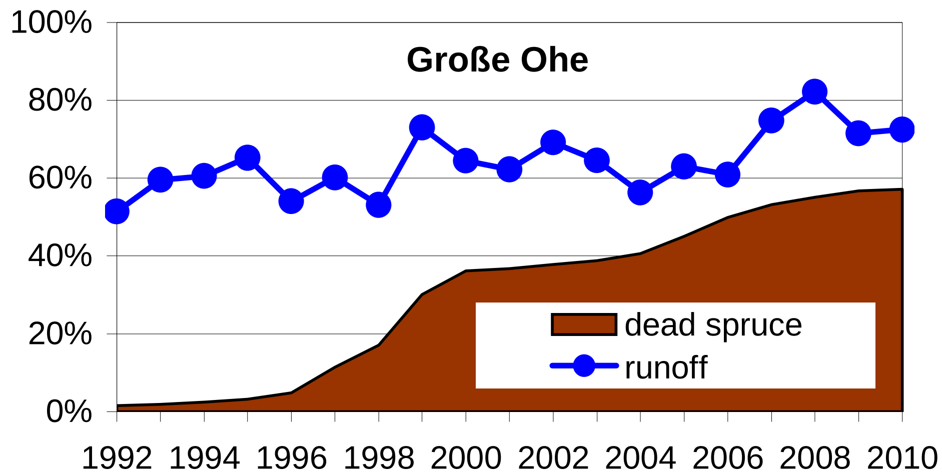


Killled spruce stands increased in the high elevation **Markungsgraben** catchment from < 10% (1995) to > 60% (1997) and to > 80% (1998).

evapotranspiration decreased
and
catchment runoff increased

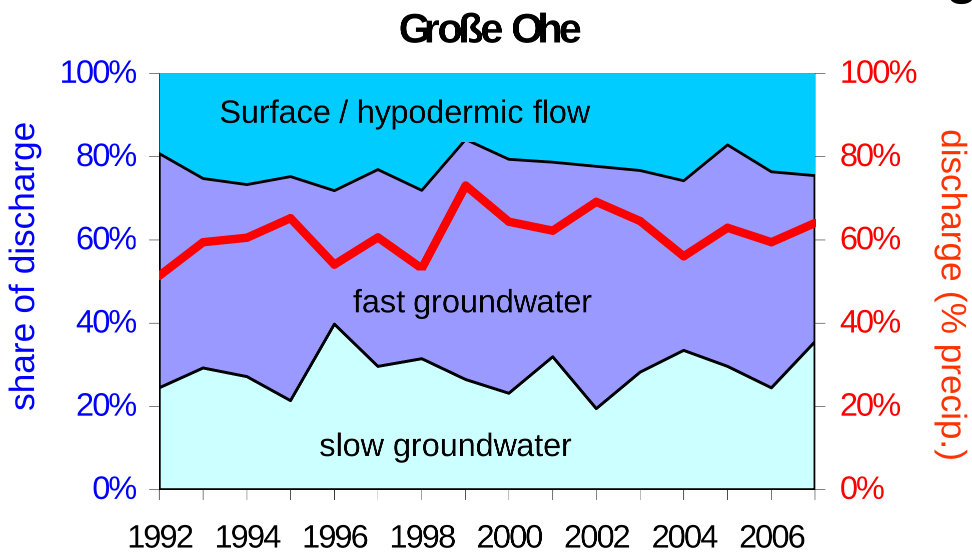
In the superordinate **Große Ohe** catchment dieback of spruce stands and hydrological effects proceeded more slowly.

The onset of runoff reaction (> 25% area) was equal to the other catchments, but size and duration were small and damped, illustrating scale effects.



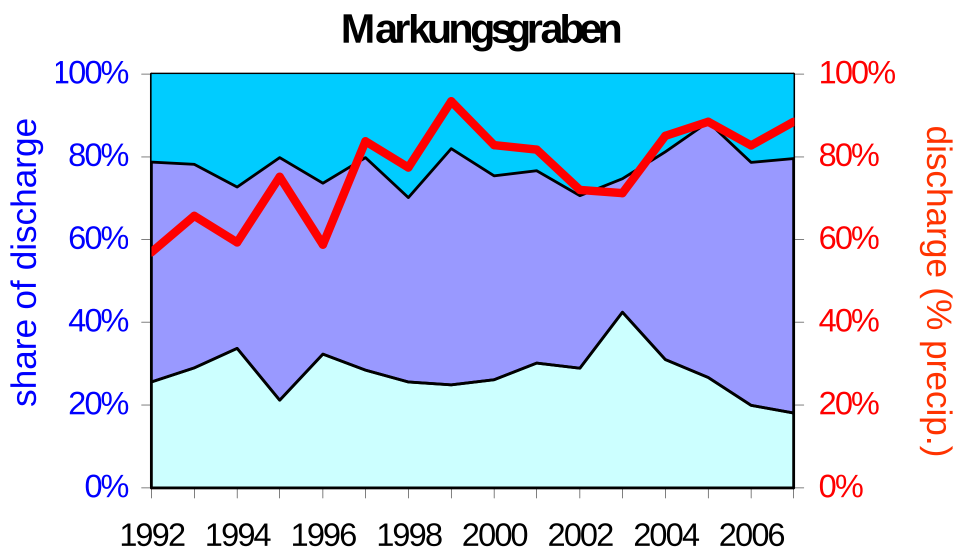
Hydrological processes and balances

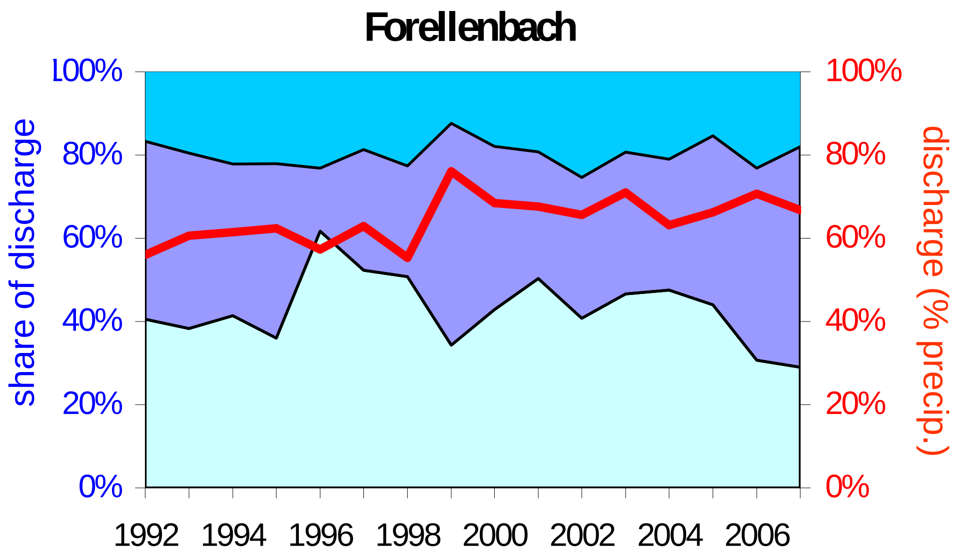
runoff generation



Annual discharge has been increased due to changes in vegetation cover,
but contributions of different runoff generation processes remained the same:

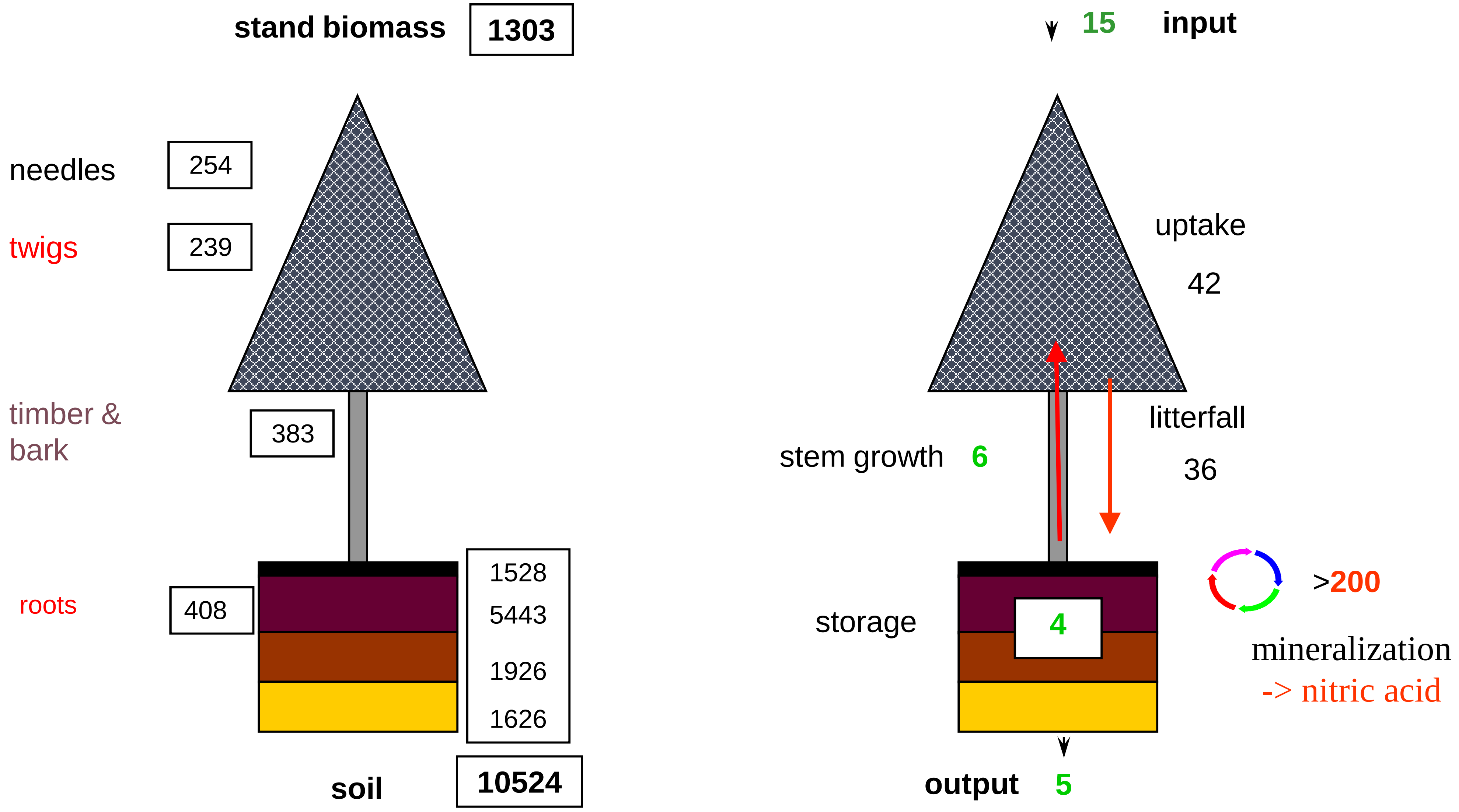
surface and hypodermic flow 20%, groundwater flow 80% with catchment specific contributions of the slow and fast component.





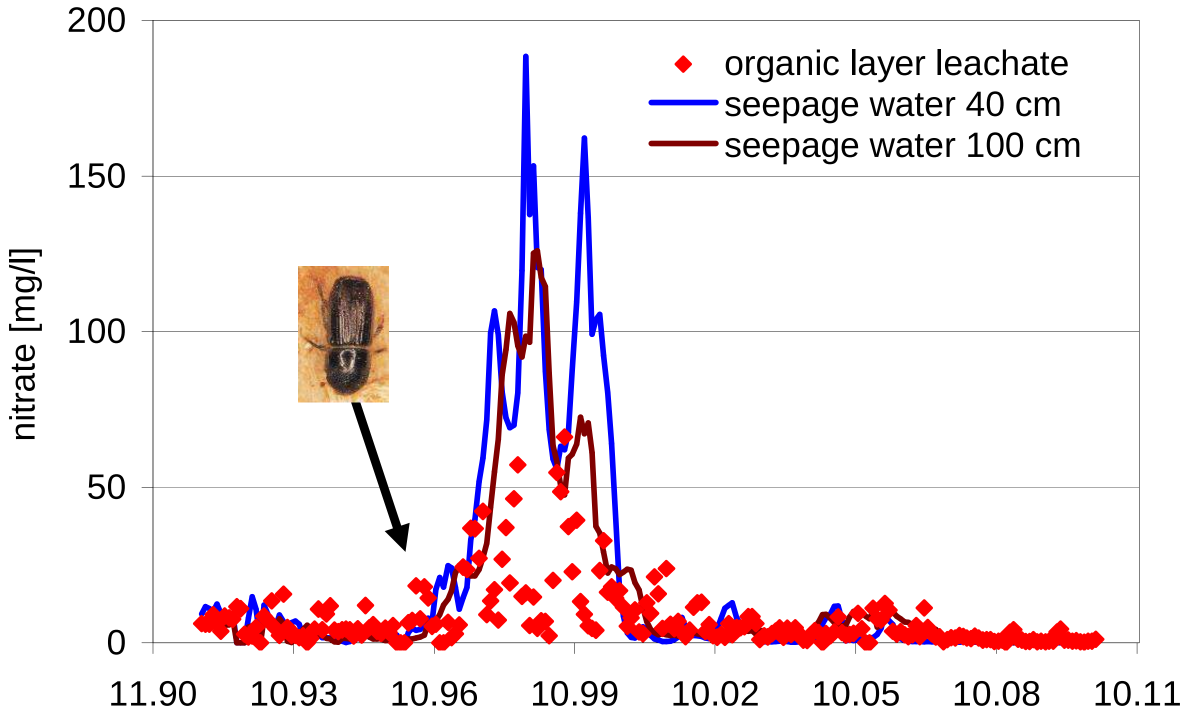
Biochemical processes and element fluxes

nitrogen pools and annual fluxes on spruce plot (kg/ha)



Biochemical processes and element fluxes

Excess mineralization



Already two months after bark beetle induced dieback in harvest 1996 nitrate concentrations began to increase in the organic layer percolate.

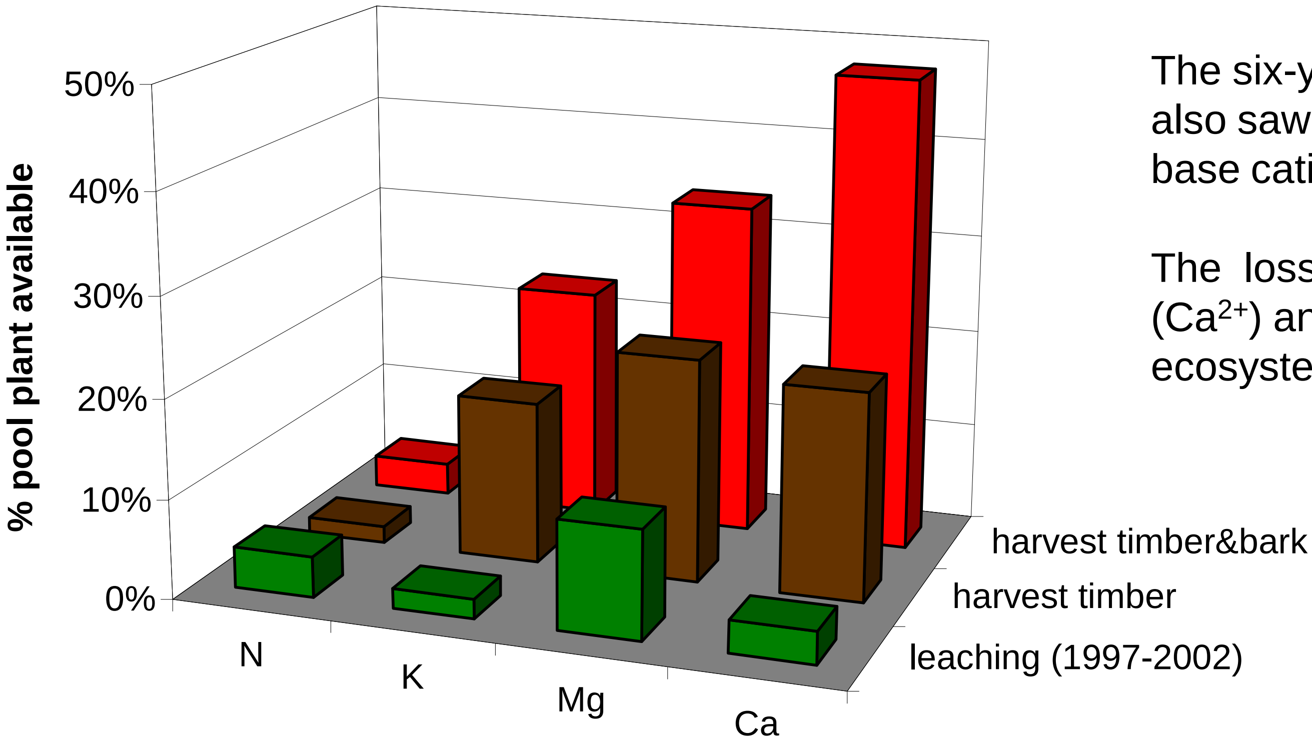
Highest concentrations occurred in mineral soil water in 40 cm (~ 200 mg/l) and 100 cm depth (125 mg/l).

The acid produced during nitrification was partly buffered by the release of aluminum ions in the soil.

Consumption of acidity has been occurring in the aquifer by mineral weathering, releasing base cations Concentrations of aluminum ions in groundwater has not been increased.

Biochemical processes and element fluxes

Base cation issues



The six-year-period of excess mineralization also saw an increase in losses of nutritional base cations via seepage.

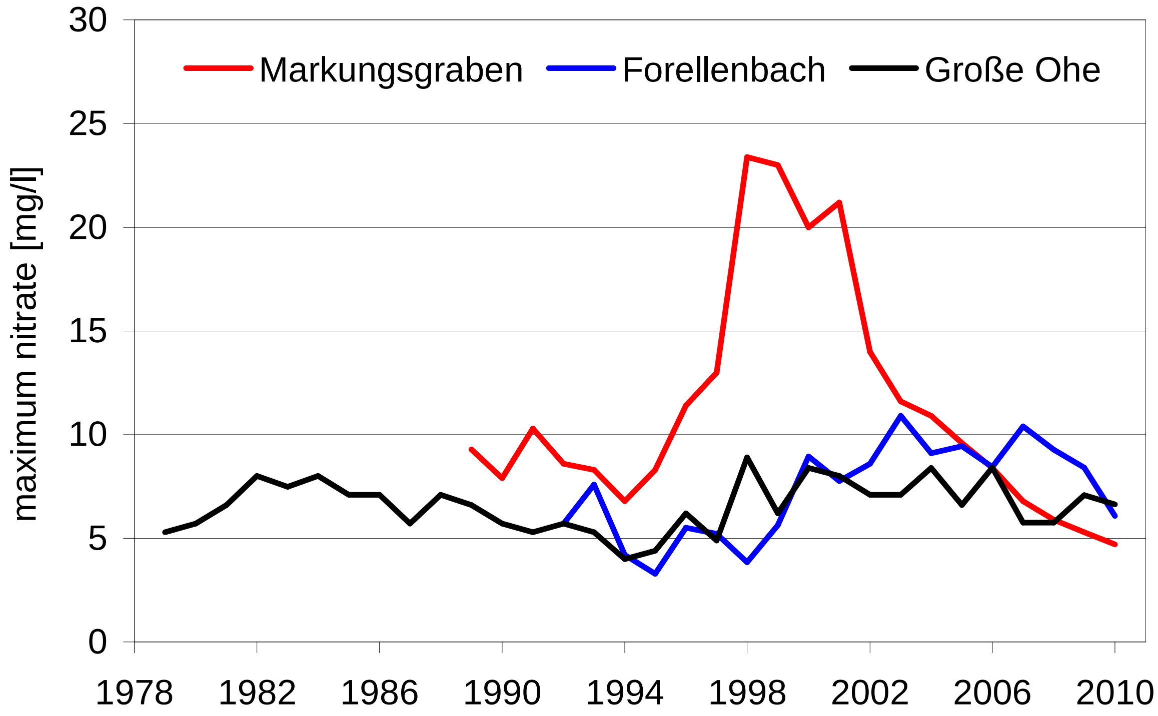
The losses accounted for 2% (K^+), 3% (Ca^{2+}) and 11% (Mg^{2+}) of plant available ecosystem pools.

The dieback induced losses of base cations were much less than the export via biomass harvest.

This holds true for the harvest of timber only, which is considered to be sustainable use.

Biochemical processes and element fluxes

Following the nitrate signal through the catchments



Nitrate in fast flowing groundwater reached only 10% of maximum soil water concentrations, slow flowing groundwater only 5%.

Seepage water from vital forest stands (mixing effect), the spatiotemporal distribution of killed stands and the short duration of excess nitrification result in very diluted concentrations in groundwater and finally in streamwater.

Markungsgraben exhibited comparatively high nitrate concentrations for some years.

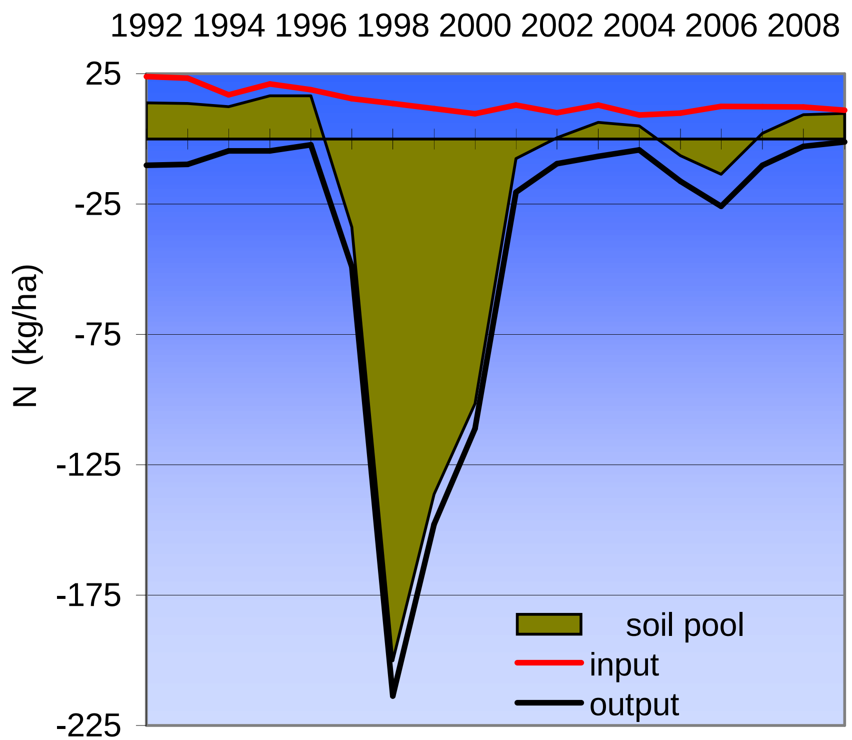
Forellenbach and Große Ohe reached maximum concentrations from 7 to 10 mg/l (~1980s)

Excess nitrification is finished on catchment scale (Markungsgraben, Forellenbach).

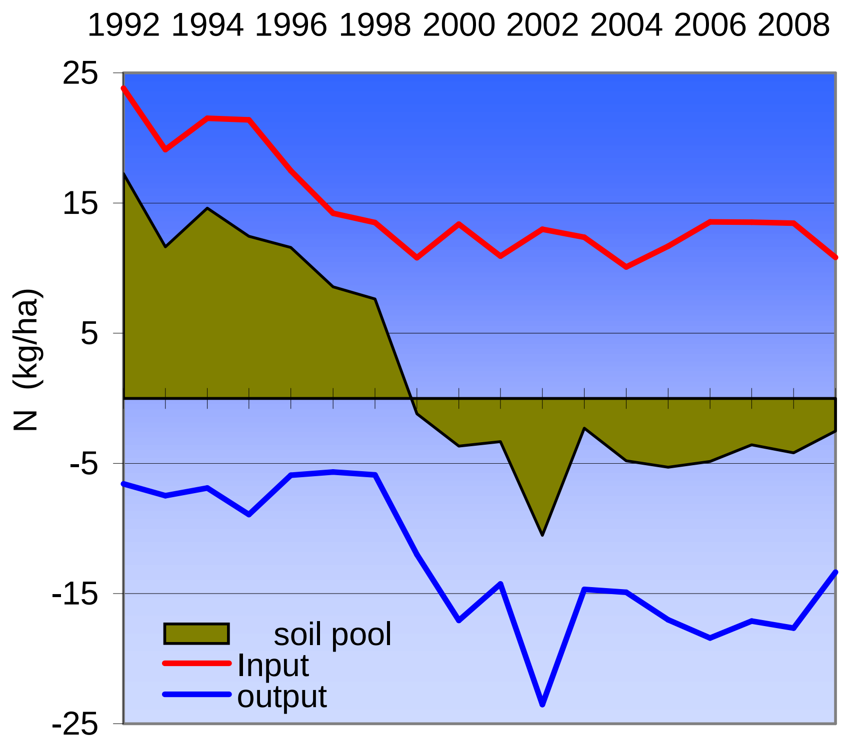
Biochemical processes and element fluxes

Nitrogen budgets

spruce plot



Forellenbach catchment



Net nitrate losses reached > 200 kg N/ha/a and ~ 500 kg N/ha during 5 years following dieback.

The system seems to balance since 2002 and quite recently to get back its sink funktion.

By 1999 the catchment has turned from net sink to net source of nitrogen.

The stream output rates are quite stable, since groundwater is the prominent source of nitrate.

Conclusions

Bark beetle outbreak and follow-up processes affect ecosystem services

- Leaf and surface area index decrease substantially, reducing roughness of vegetation cover and thus interception of airborne substances and water
- Evapotranspiration in summer half year is therefore reduced, increasing the amount of seepage water and the recharge of groundwater
- Low flow characteristics change to higher discharges in summer esp., demonstrating that the quantity of groundwater remains constant at least
- High flow characteristics change to higher discharges in winter only, but flood crest didn‘t increase
- Quality of useable water is altered (enriched in nitrate and base cations), but fulfills all requirements for human nutrition (German laws, WHO)

These effects are due to natural disturbances only, lasting for 10 – 30 years

(until young and dense tree stands will be established on catchment scale)

Why should we aggravate these outcomes by management intervention in a National Park ???

hlavní ponaučení

Kůrovcová kalamita a následné procesy ovlivňují "ekosystémové služby"

- index olistění a plochy pokryvu výrazně klesá, "hrubost" rostlinného pokryvu se snižuje a tím i intercepce vody a látek přenášených vzduchem.
- Důsledkem toho je evapotranspirace v letní polovině roku snížena, roste množství vsakující se vody, hladina podzemní vody se rychleji obnovuje
- charakter nízkých stavů vody se mění, zvláště v létě, ve prospěch vyšších průtoků, což ukazuje, že množství podzemní vody zůstává přinejmenším stále stejné
- charakter vysokých stavů vody se mění ve prospěch vyšších průtoků pouze v zimě, ale kulminační výška hladiny za povodní se nezvyšuje
- kvalita pitné vody se mění (obohacení o kationy dusíku a Ca, Mg, K), ale nadále splňuje nároky na lidskou výživu (německé zákony, WHO)

Tyto změny jsou pouze důsledkem přírodních disturbancí a trvají 10 - 30 let

(dokud se mladé a husté porosty dřevin neuchytí plošně na úrovni povodí)

Jsou tyto výsledky tak znepokojující, že je nutné hospodářsky zasáhnout v Národním parku ???