Identification of runoff generation processes – Impact of different forest types on soil-water interrelations

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INTRODUCTION

One main goal of actual scientific research is the development of sustainable forestry management strategies concerning soil and water resources in silvicultural used areas. Unfortunately, information on soil-water-interrelations in soils under different forest stands and of different site properties is lacking. Hence, numerous sprinkling experiments were carried out in four forested catchments (funded by the INTERREG IVB project ForeStClim) on plot scale and hillside segments (here two catchments are presented). With this, different dominant runoff processes (DRP) of soil water at different forest stands as well as on varying substrates and parent materials were determined.

STUDY AREA / METHODS / EXPERIMENTAL SETUP

Fig.1: Topographic map of the ForeStClim test sites

Fig.2: Frankelbach catchment with test plots

Fig.3: Holzbach catchment with test plots

Table 1: Catchment and plot specific characteristics and applied methods

	Frankelbach	Holzbach
Location	Germany, Rhineland-Palatinate	Germany, Rhineland-Palatinate
Geographic area	Saar-Nahe Bergland	Hunsrück, Hoch- and Idarwald
Parent material	Permian Rotliegend	Devonian Quarzite, Permian Rotliegend
Soil types	Cambisols, stagnic Cambisols, Colluvisols	Cambisols, stagnic Cambisols, Podzols
Land usage	1/3 Forest, 2/3 Agriculture	100% Forest
	Experimental plots	
	FRA-1 Afforestation, 1 year, haplic Cambisol (silty loam)	**HOL-1** Mature beech stand, stagnic Cambisol (loam)
	FRA-2 Afforestation, 30 years, stagnic Cambisol (loam)	**HOL-2** Mature beech stand, haplic Cambisol (stagnic characteristics)
	FRA-3 Est. deciduous forest, haplic Cambisol (loam)	**HOL-3** Mature beech stand, mid slope, haplic Cambisol (silty loam)
	FRA-4 Est. Douglas fir stand, haplic Cambisol (sandy silt)	**HOL-4** Mature spruce stand, haplic Cambisol (sandy loam)
	FRA-5 Est. spruce stand, haplic Cambisol (silty loam)	**HOL-5** Mature spruce stand, haplic Cambisol (silt)
	FRA-6 Arable land, stagnic Cambisol (loamy clay)	
	Methods and Number of Samples (n)	
Soil mapping	Pürckhauer auger	Pürckhauer auger
	Soil pits with pedological description (10n)	Soil pits with pedological description (6n)
Soil sampling	100 cm³ cylinders (210n, 6n per soil horizon)	100 cm³ cylinders (144n, 6n per soil horizon)
Infiltration	Experiments with double-ring infiltrometer (36n)	Experiments with double-ring infiltrometer (24n)
Sprinkling	Experiments: 6n Plot scale, 120 mm during 3 days	Experiments: 5n Plot scale, 120 mm during 3 days

Fig. 4: Sprinkling setup in forest

Fig. 5: Soil pit with collector plates

Figure 6: Hortonian Overland Flow

RESULTS

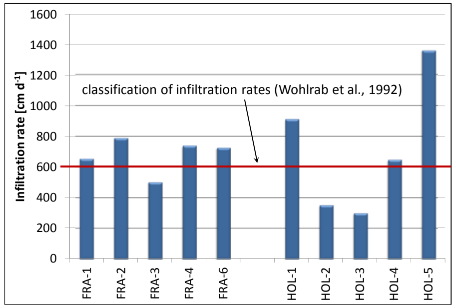


Fig. 7: Averaged infiltration rates at the Frankelbach and Holzbach catchment

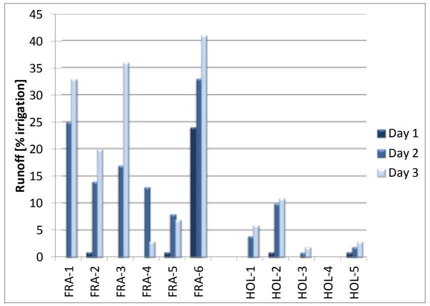


Fig. 8: Daily runoff coefficients at the Frankelbach and Holzbach test sites

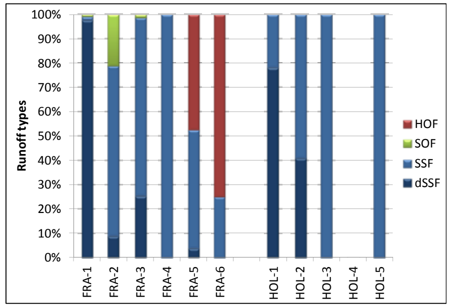


Fig. 9: Runoff types during sprinkling experiments at the Frankelbach and Holzbach test sites

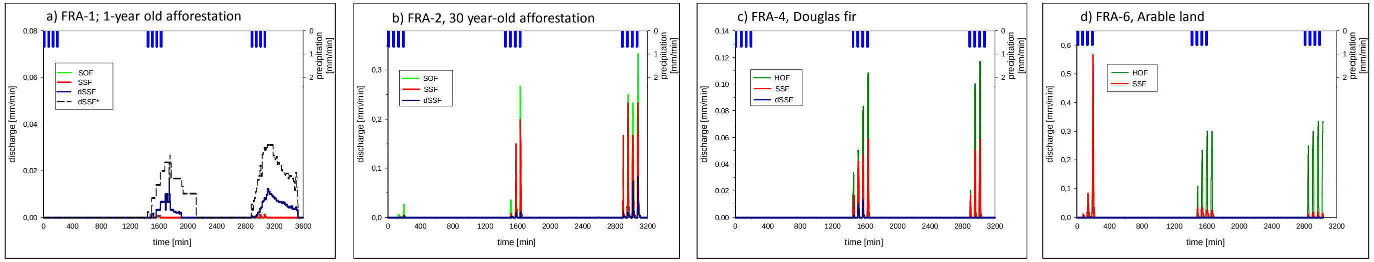
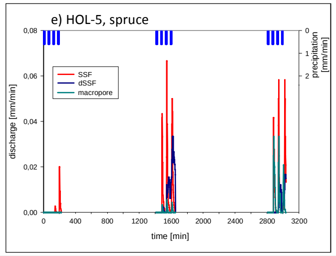


Fig. 10 a-e: Runoff behaviour during sprinkling experiment



- The infiltration rates of the investigated forest stands were high to very high according to Wohlrab et al. (1992).
- Sprinkling experiments are suitable to identify the different runoff processes on soil areas of different land use.
- Runoff processes and generation at selected afforestations are comparable with arable land (FRA-2 & FRA-6).
- An afforestation of marginal earning sites is not a warranty for an enhancement of soil physical properties (FRA-2).
- An amelioration (e. g. deep loosening) preceding site afforestation is advisable to improve the physical soil conditions.
- Extensive dehydration leading to water-repellency (hydrophobicity) can cause Hortonian Overland Flow (HOF) even in forests.
- A scrutiny of the prevailing soil conditions is very important regarding a sustainable forest increase and flood protection measures.

CONCLUSIONS

- Runoff generation mainly depend on the specific site and soil properties. The physical soil conditions are one of the crucial factors for mitigating fast runoff.
- The results show that oftentimes specific site and soil characteristics have a greater influence on runoff generation than different forest types.
- Nevertheless, afforestation of former agriculturally used areas (especially marginal earning sites) is advisable.
- Regarding flood protection and sustainable silvicultural management it is important to implement these results within further forestal planning (expert knowledge).

REFERENCES

- Wohlrab, B., Ernsberger, H., Meuser, A., Sokollek, V. 1992. Landschaftswasserhaushalt. Wasserkreislauf und Gewässer im ländlichen Raum. Veränderungen durch Bodennutzung, Wasserbau und Kulturtechnik. Hamburg und Berlin: Verlag Paul Parey, 352.

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