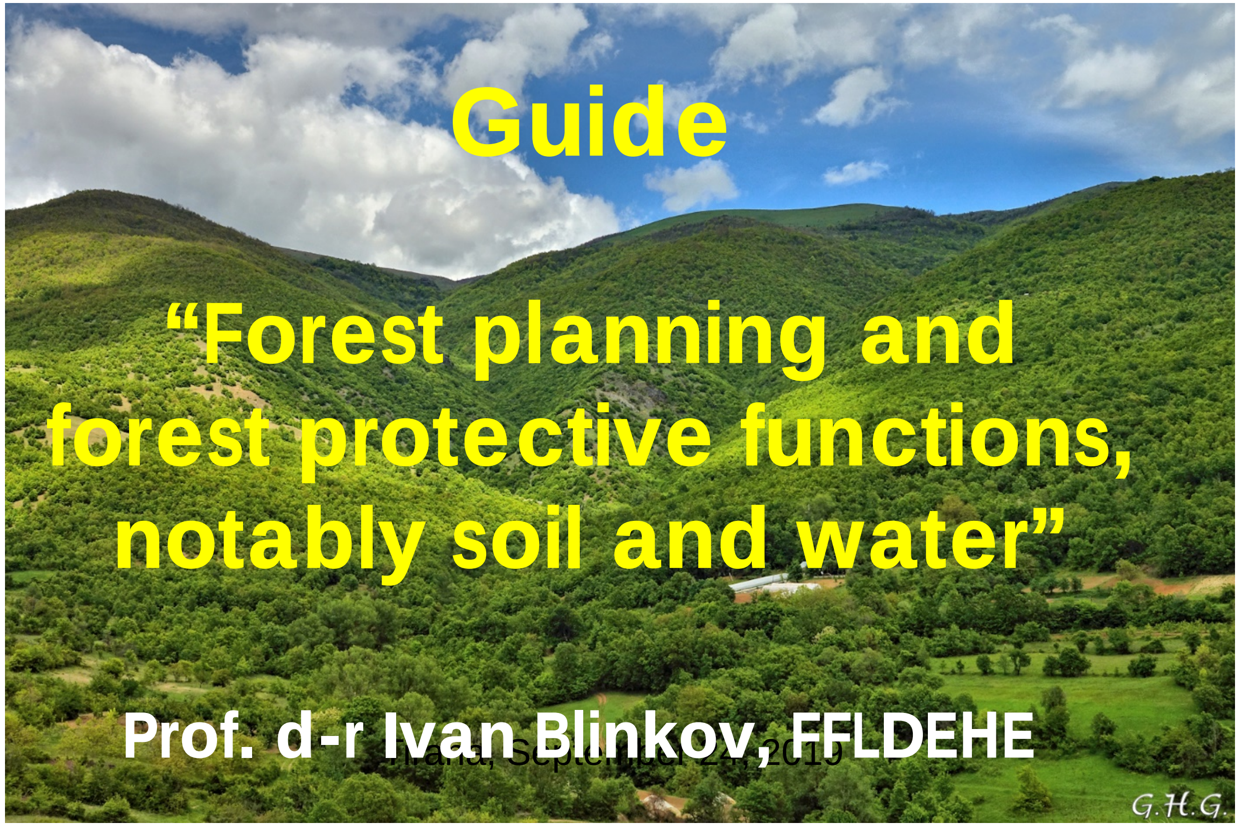
Generating momentum on water and forests in the Balkans project

GeMBalkans
Generating momentum on water and forest management



Guide

“Forest planning and forest protective functions, notably soil and water”

Prof. d-r Ivan Blinkov, FFLDEHE

Tirana, September 24, 2019

G.H.G.

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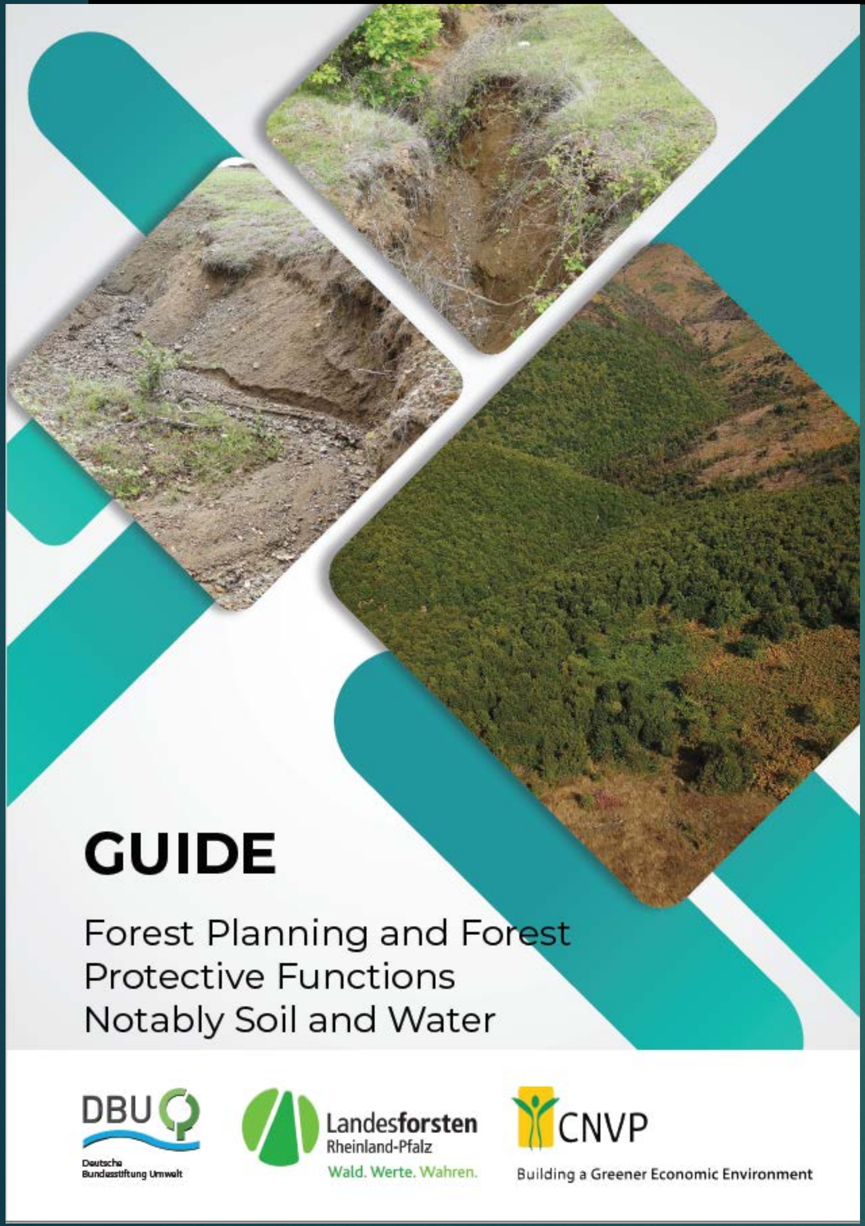

Contents

Water movement in forest ecosystems

- In forest ecosystems this complex process is directly influenced by various factors.
- Part of the water that reaches the soil surface is infiltrated into it, and part run on the surface.

  Part of the infiltrated water penetrates deeper into the soil , and part of it run subsoil.

- The rest of the soil that deeply penetrates the soil feeds underground releases and causes underground swells.

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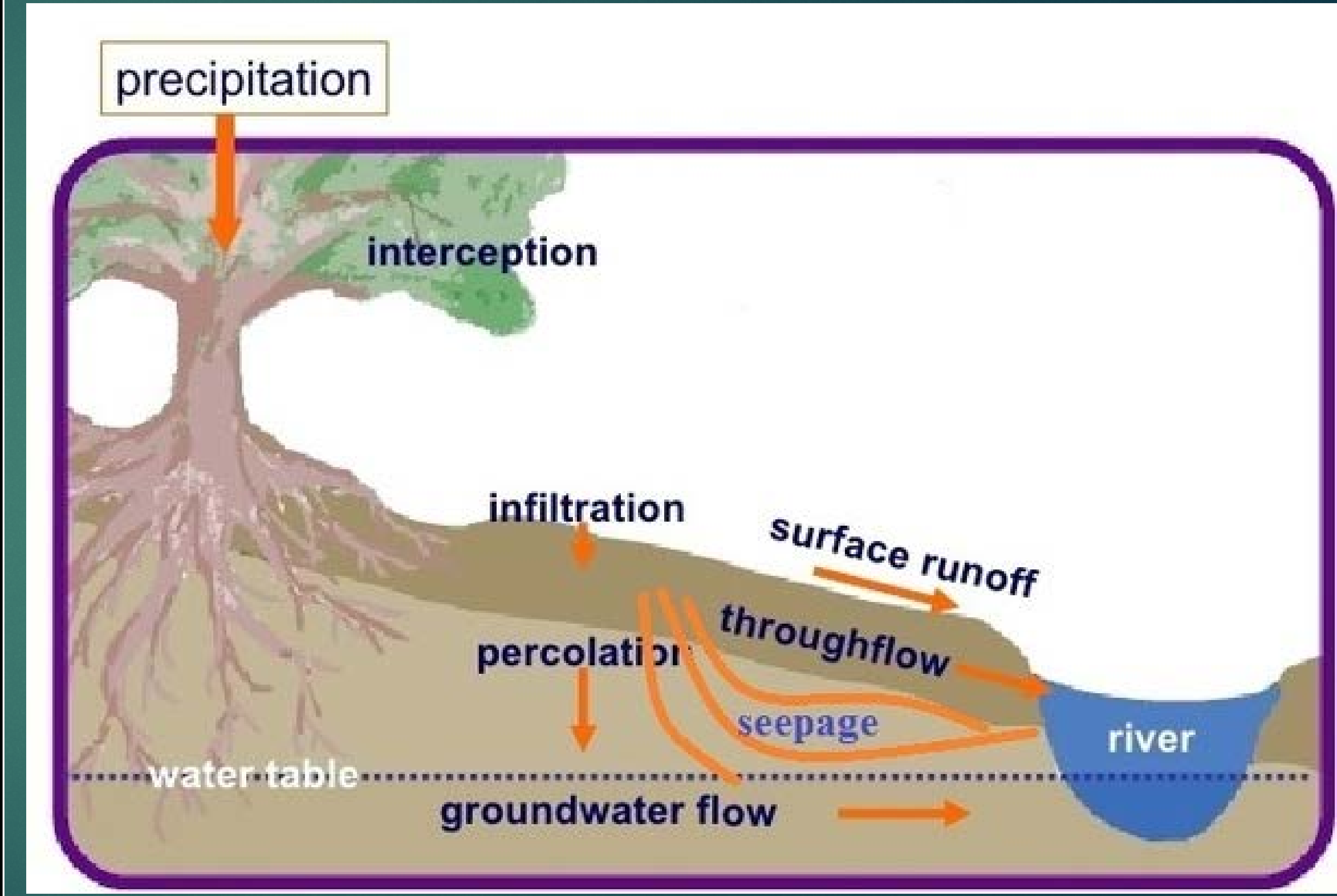


WATER BALANCE EQUATION

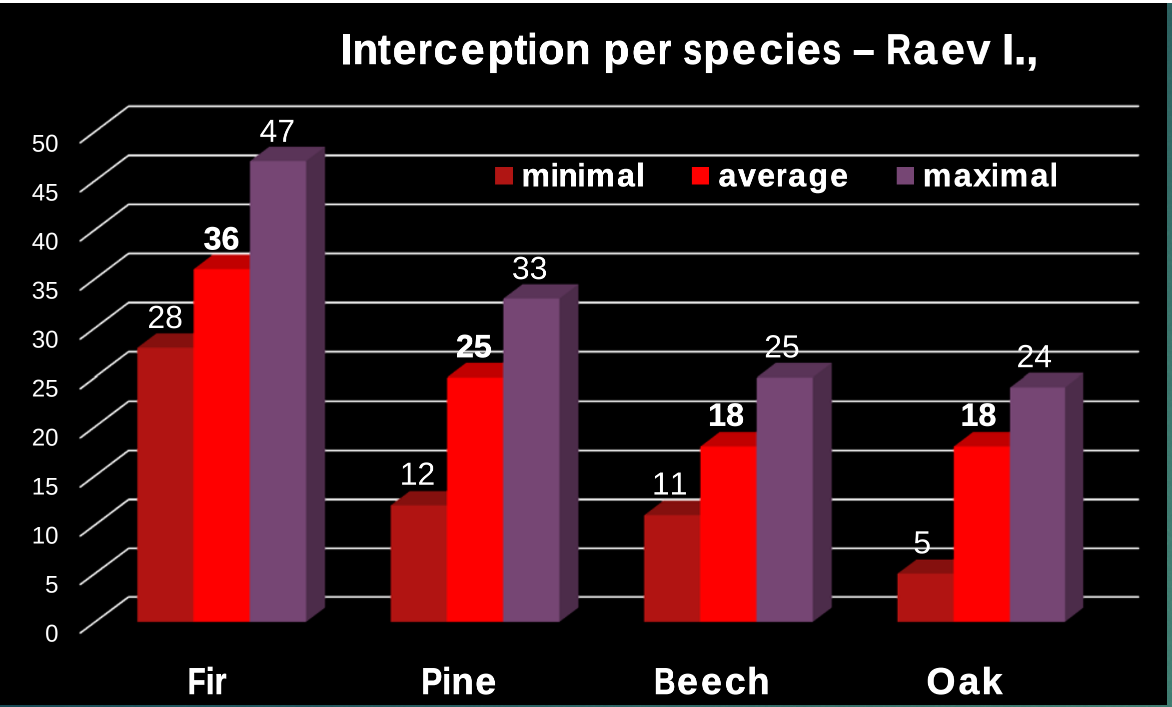
- $P = E + W + F$ (mm)

- P – Precipitation [mm] $P = Pv + Ph + Fst$
- Pv – vertical precipitations (rain, snow, hail ...)
- Ph - horizontal precipitation (fog, drifting ...)
  Fst – leaking along the tree branches and stem)

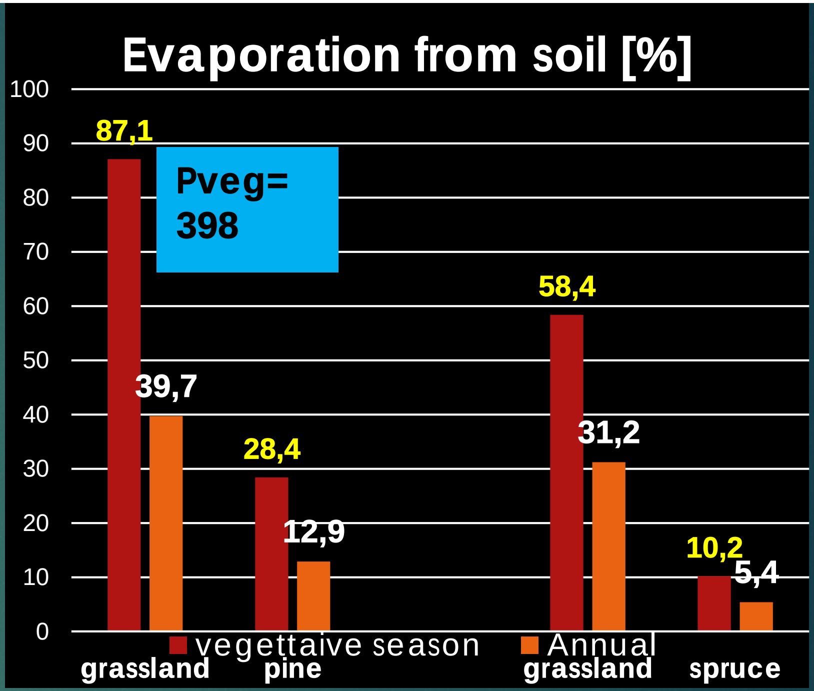
E - Summarized evaporation (mm) $E = Ei + Es + Et$
Ei - evaporation of the water retained on the crown and stems
Es - evaporation from the beginning
Et – transcription

F - general water runoff (mm) $F = Fov + Fg$
Fov - surface runoff

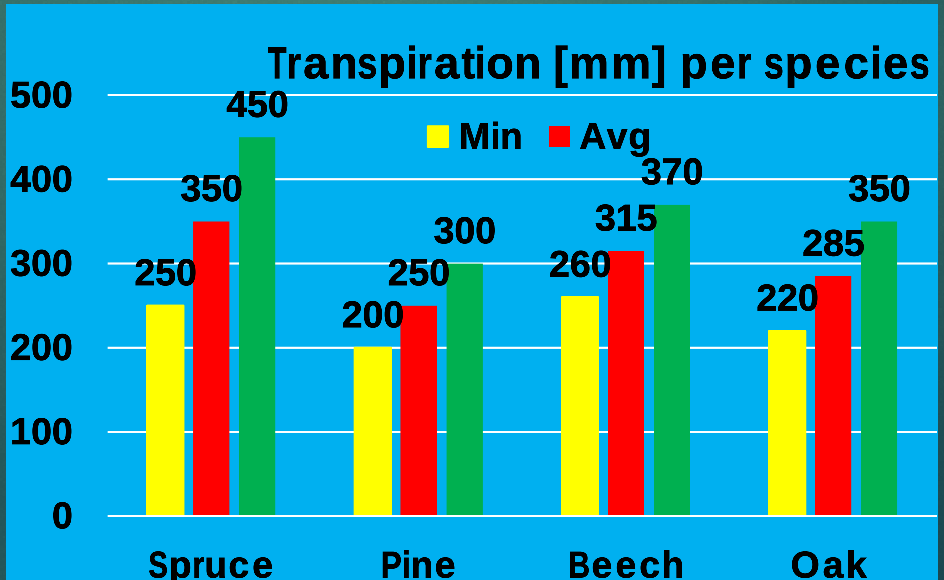
Fg - ground runoff



Interception per species – Raev I.,
minimal
average
maximal
0
5
10
15
20
25
30
35
40
45
50
28
36
47
12
25
33
11
18
25
5
18
24
Fir
Pine
Beech
Oak

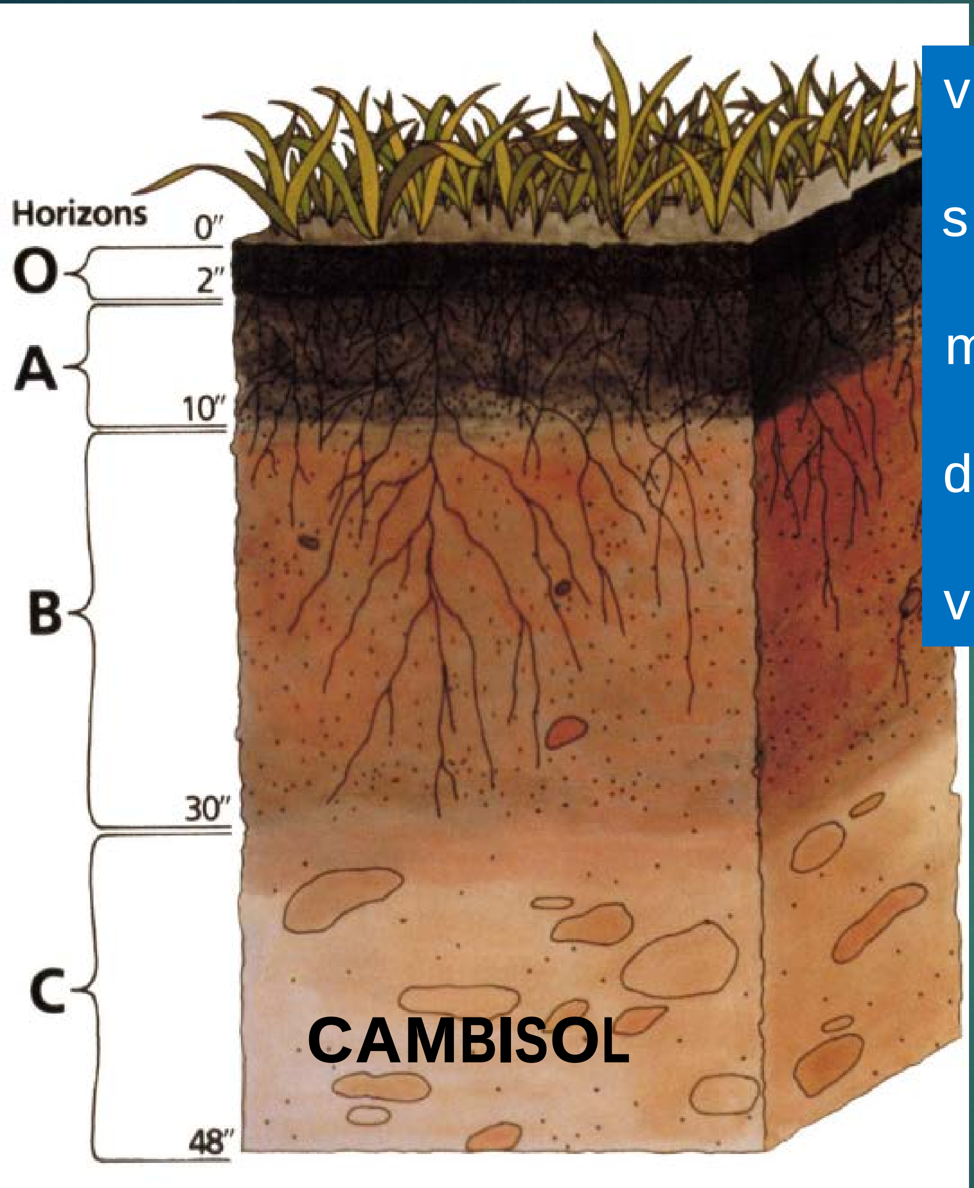


Evaporation from soil [%]
0
10
20
30
40
50
60
70
80
90
100
Pveg=
398
87,1
39,7
28,4
12,9
58,4
31,2
10,2
5,4
vegettaive season
Annual
grassland
pine
grassland
spruce



Transpiration [mm] per species
Min
Avg
0
100
200
300
400
500
250
350
450
200
250
300
260
315
370
220
285
350
Spruce
Pine
Beech
Oak

SOILS - “sponge effect”



very shallow (less than 25 cm),

shallow (25 cm-50 cm),

moderately deep (50 cm-90 cm),

deep (90cm-150 cm) and

very deep (more than 150 cm)

Permeability of Soil and Water Storage capacity

Ranker

15

Major factors influencing the rate of infiltration

- Soil Factors

The size of the micropores and the infiltration into the soil depend on

- (1) soil texture,
- (2) the degree of aggregation between the individual particles, and
- (3) the arrangement of the particles and aggregates.

In general, larger pore sizes and greater continuity of the pores result in higher infiltration rates.

Major factors influencing the rate of infiltration

- Vegetation
  - Vegetation can greatly reduce surface sealing.
  - In general, vegetative and surface conditions have more influence on infiltration rates than soil texture and structure.
  - The protective cover may be grass, other close-growing vegetation, plant residue, and mulch.
  - If the protection of a vegetative cover is lost, surface sealing may occur with drops in infiltration rates similar to those in Figure 5.2.
  - Figure 5.3 illustrates typical infiltration depth curves for a given soil with different surface and vegetative conditions.
  - Infiltration is higher for grass or mulched areas where the soil surface is protected than that for bare soil conditions.
  - Other soils may have higher or lower depths of infiltration.

In forest hydrology, the term RETENTION is defined as part of the process of general circular movement of water in nature, which consists of:

- interception (Ei), - transpiration (Et), - evaporation (Es) and
- infiltration (It).

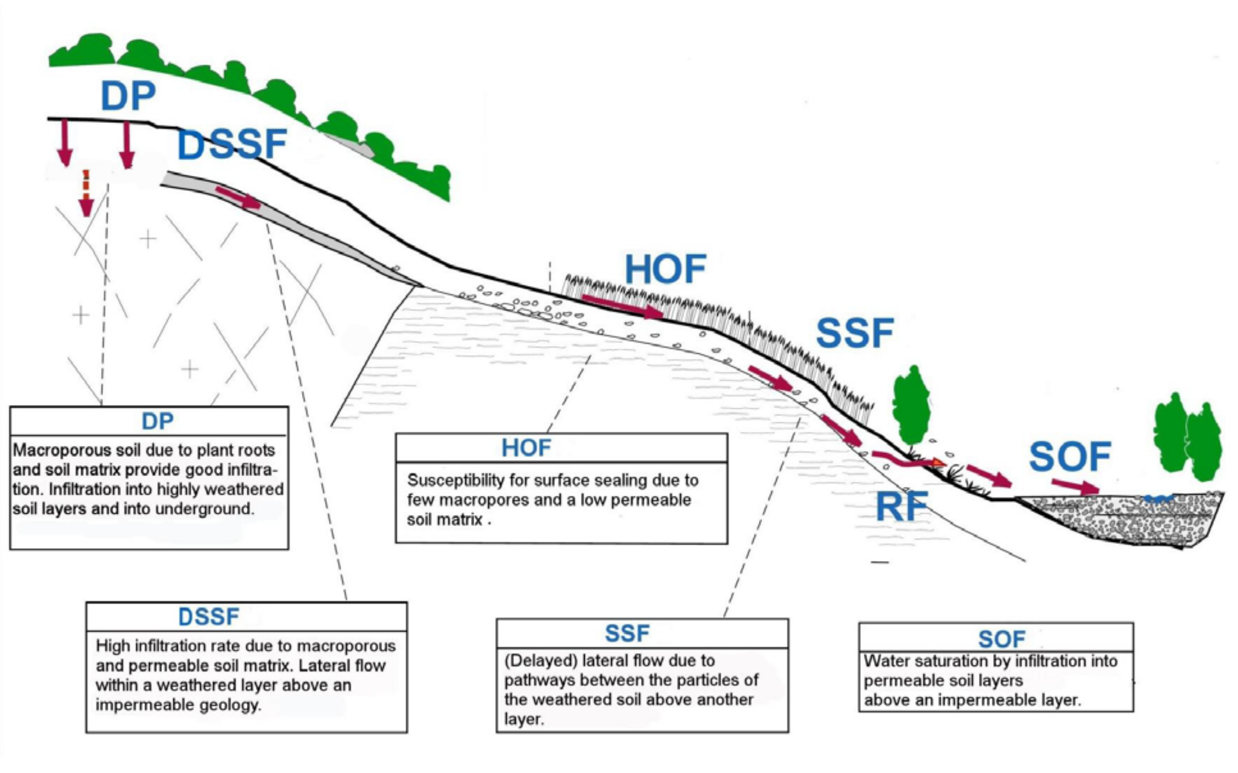
Runoff in forest ecosystems is a very important component of water balance.

A mathematical representation of the runoff is the runoff coeficicnet expressed through introduced and so on. swelling coefficient - η.

Runoff coefficient represents the relationship between and swollen (Pe) and total (P) precipitations.

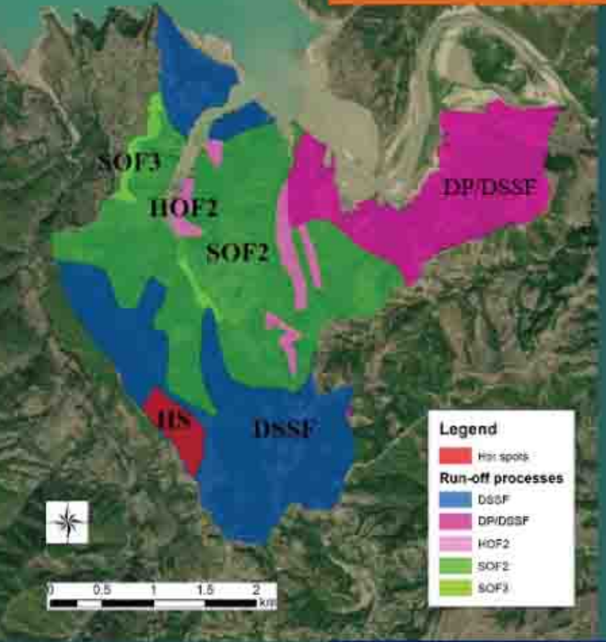
$$\eta = \frac{Pe}{P}$$

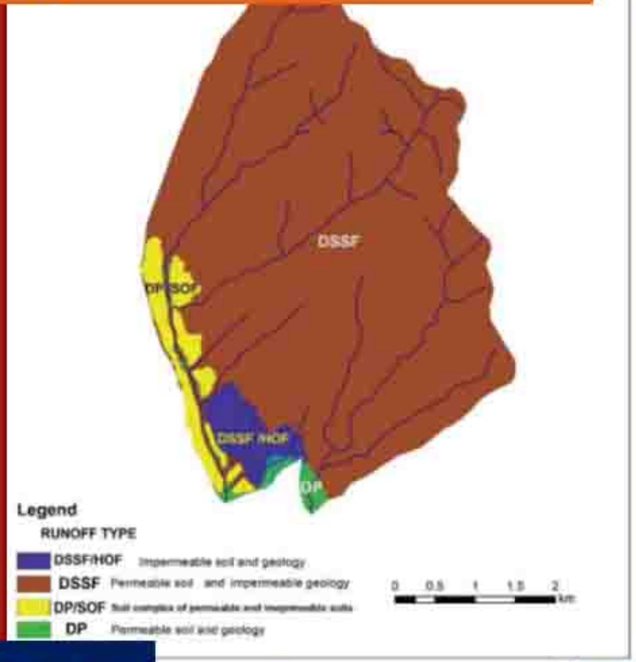
Theoretically, coeff. of runoff (η) may range from 0-1, (0-100%), but for a natural watershed generally the catchment ranges from 0.10 to 0.75.



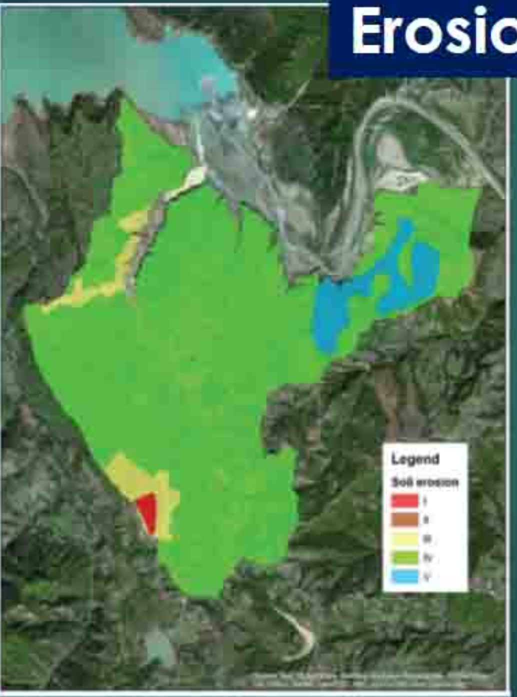
Origin: Federal Institute of Technology, 2001 modified

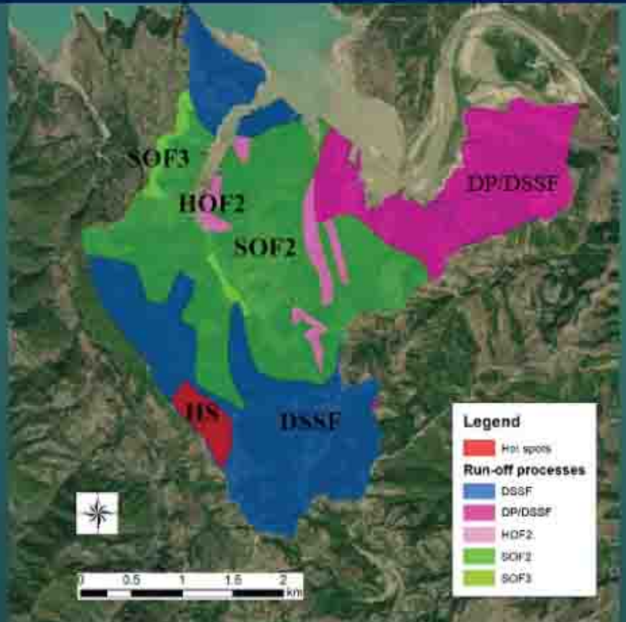
Runoff types and Discharge accelerating linear structures

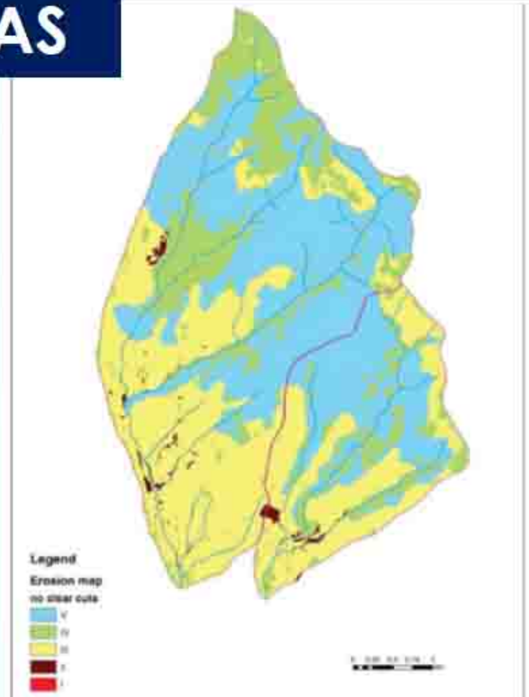


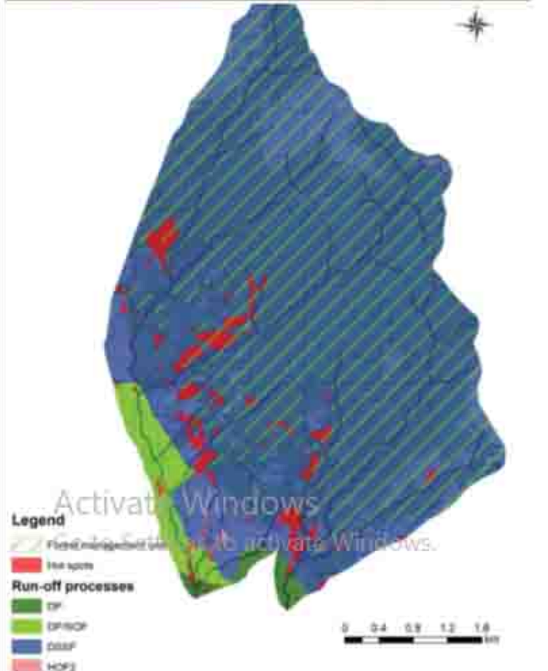


Erosion zones and HOT SPOT AREAS

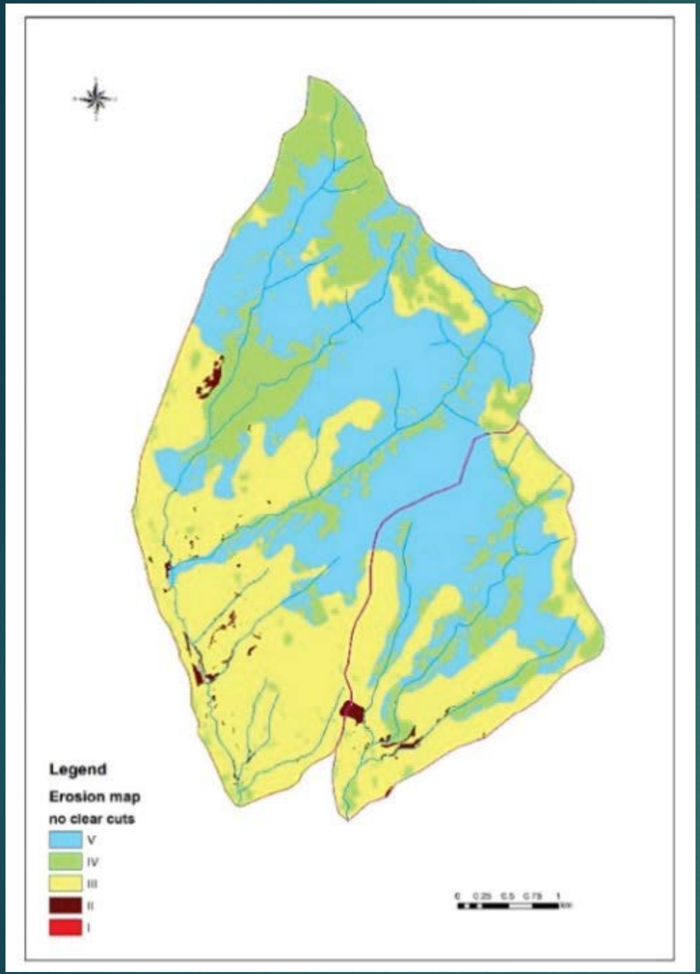




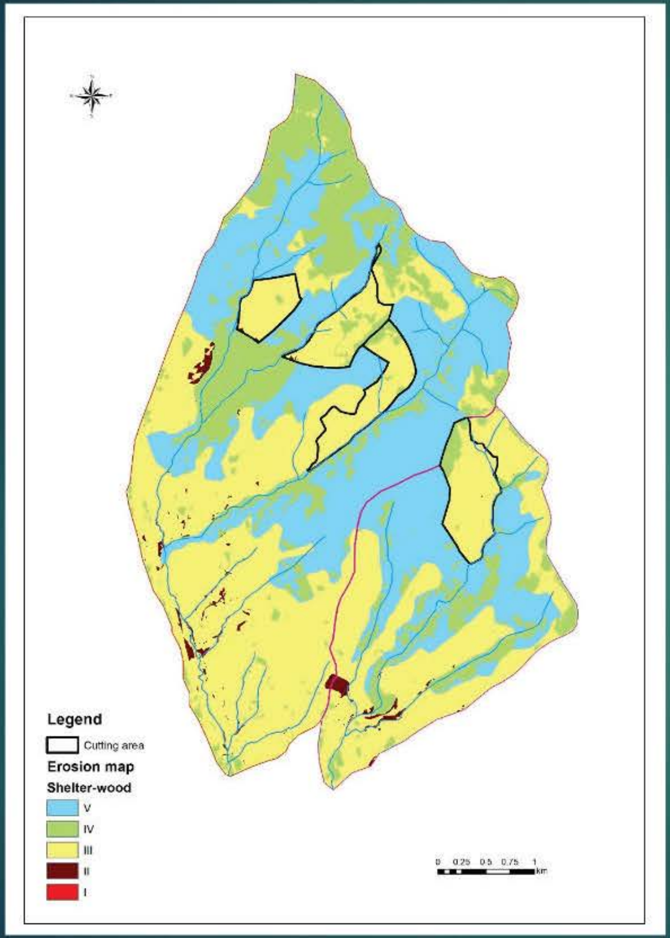




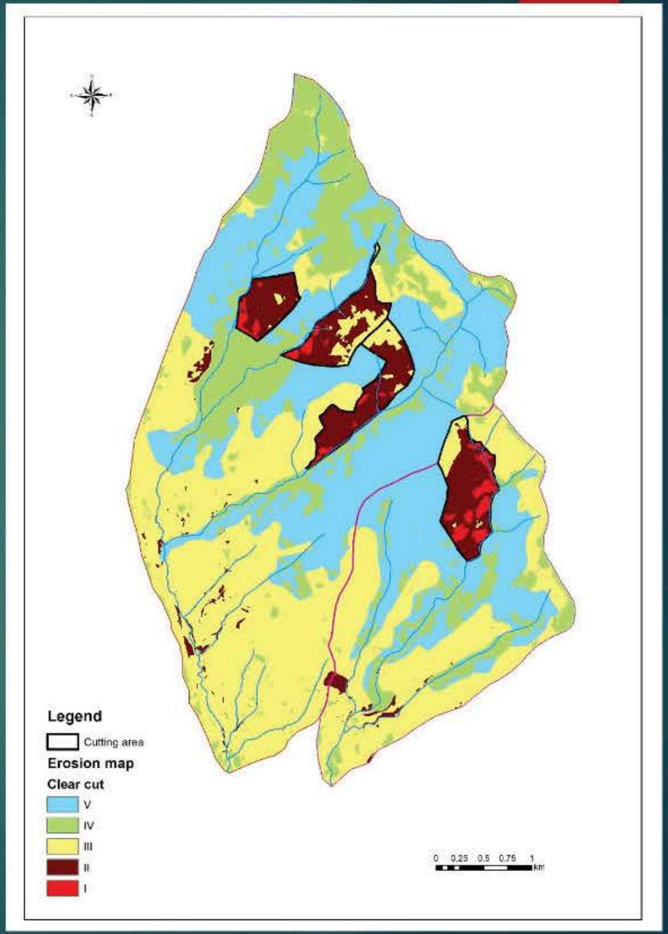
– What if scenario – Type of cut and erosion



Shelterwood cut



Clear cut



- Generally on a catchment level erosion intensity after clear cut will be increased for 16, 9%
- (Cresevska Reka) and 20.1% (Vinichka Reka). Soil loss expressed as produced sediments will
- increase for 1809 m3 (Cresevska Reka) and 931 m3 (Vinicka Reka).

Recommendations for appropriate forest activities

Some statements and recommendations by prof. Schuler G.

- 1. There is an almost unshakable opinion that forests retain so much water by Interception that flood hazards are reduced or avoided, anyway, the interception of the forest canopies ranges from a humidification capacity of 2 - 6 mm precipitation to a saturation capacity of 10 mm. Thus it is almost meaningless compared to the amount and intensity of rain of heavy rainfall events (> 40 mm/event), but through fall energy is less, especially if there is a multi-stored canopy in an intensively vertically structured forest (Peck & Mayer 1996, Salihi 1984).

- 2. The water consumption (transpiration) of the forests with approx. 4-10 mm/day empties the soil water reservoir and thus increases the absorption capacity of the soil for newly arriving precipitation water (Elling et al. 1990, Benecke 1990). Forests are particularly effective in the case of smaller, but more frequently occurring precipitation events. Anyway, the evapotranspiration of a closed grass cover (with up to 8 mm/day) is as high as that of forests (Penman 1948).

- 3. The recent soil physical conditions determine the runoff behavior of water from the forests, and thus the possibility of delaying runoff or reducing runoff peaks (Huemann et al. 2011).
- Anyway, Land use history teaches that forests often have remained on “bad” soils, i.e. shallow, poor soils with low water storage capacity or stagnant soils with natural rapid runoff. The better soils were reserved for agricultural use.

- 4. Nevertheless, soils under “old” forest are often not so heavily secondary compacted, as driving in forests was rather restricted. Therefore “old” forest soils have a well-draining pore system with a high infiltration rate, with good water conductivity and therefore with a low tendency to surface runoff and with slow interflow (Huemann et al 2011).
- Anyway, this does not apply to recently reforested former agricultural soils. The soils under afforestation after agricultural use probably take centuries to regenerate (Klaes et al. 2016); this means that these soils react just like the soils under agricultural use due to the still unfavorable soil physical conditions.

- Flood development should be minimized through the precautionary forestry management approach. Precautionary measures for water retention in forests must consider the various site conditions, meteorological events, and the present state of the soil water balance. The efficiency of retention measures varies according to precipitation events and site features (e.g. intensive or continuous rainfall on dry soils with further water storage capacity vs. saturated soils, or on sites with dominantly deep percolation vs. subsurface flow).

- On sites with deep percolation, the avoidance of clear-cutting is less important, because the undisturbed soil and parent substrate is sufficiently porous that deep percolation dominates in contrast to subsurface or overland flow.

- Other water retention concepts are necessary on sites with compact sub-soils, which tend to hold moisture and produce subsurface flow, and on sites with low infiltration or field capacity. On these sites clear-cutting should be avoided because reduced evapotranspiration will tend to increase runoff (MOLTSCHANOV 1966; HIBBERT 1967; VORONKOV et al. 1976; HOFFMANN 1982; ROSEMANN 1988; BENNECKE 1992; PECK and MAYER 1996; MOESCHKE 1998; MENDEL 2000).

- A permanent forest cover composed of a structured successional mosaic of trees decreases the risk of runoff (BREDEMEIER and SCHÜLER 2004). It is therefore essential to mimic the permanent cover principle of a mosaic cycle in close-to-nature silviculture management with horizontally and vertically structured forest stands using site-adapted tree species (EDER 1997). Vertically and horizontally structured canopies, with high leaf area indices, of a multi-storied stand improve the hydro-ecological efficiency of forests by maintaining high interception and transpiration rates (MÜLLER 1996).

- In addition to the canopy effects of mixed forest stands, the roots of different tree species exploit different layers and soil depths in the soil. A rapid turn-over of fine - roots promotes the creation of soil macro and mesopores (NOGUCHI et al.1999). Thus, these processes enhance the storage and retention capacity of multi-structured forest ecosystems, while bearing in mind that in close-to-nature silviculture, the harvesting and regeneration phases are occurring simultaneously within a forest stand. Investigations of different regeneration types demonstrated that runoff can be reduced in the hydro-ecologically sensitive phases of forest development (SCHÜLER 2003).

- Advanced regeneration in multi-storied stands and rapid establishment of regeneration after harvesting maintain the forest influence. Thus the soil will be protected, even if a atastrophic storm damage.

Recommendation for sustainable forest management activities by PIlas et al., 2011

- Introduction of Close-to-nature forest management assures that with the human interference into forest ecosystem sustainability and multifunctionality will be preserved. One of basic principles of close-to-natural management is to imitate natural structures and natural regeneration patterns, for example natural disturbances (Bončina and Diaci 1998).

- **●● Use of appropriate activities for enabling quantity of drinking water**
- ○○ Forbidden clear cut area in the drainage basin of main sources
- ○○ Frequency, intensity and technique of harvesting to be adopted
- ○○ Tree species composition, crown density, cover percentage, distribution of growth classes, vertical and horizontal stand structure to be adopted to enable more quantity of drinking water

- **Use of appropriate forest activities for minimizing water pollution as follow:**

- ○○ Compulsory use of biodegradable chainsaw lubricants and oils in hydraulic. Machines in forests (Košir 2006); Storage facilities for fuel and oil should be kept away from water courses and other water bodies (Mulkey 1980). Prohibition of washing, maintenance and repair of forest mechanization in a forest (Trontelj 2006). ○○ Use of heavy machinery on erodible soils should be minimized or avoided, in the riverbed prohibited (Mulkey 1980).

- ○○ Selective thinning should be performed in narrow riparian zones of forest to remove old and unstable trees. Strip of riparian vegetation (including trees and shrubs) should be established and maintained to prevent or mitigate pesticide and other pollutants in the freshwater (Binkley and Macdonald 1994).

- **●● Use of appropriate techniques to minimize runoff**

- **○○ In areas where is defined SOF, HOF and DSSF type of runoff, sustainable forest activities must be applied.**
- ○○ Forcing **unevenaged** stands with dense canopy cover, diverse vertical structure and even distribution of growth-phases where it is possible (Frehner et al. 2005).
- ○○ Area of barelands including regeneration younger than 10 years should be less than 25% of the drainage basin (Twery and Hornbeck 2001).
- ○○ The canopy cover of all forest stands should be more than 70% in the whole drainage basin as well as in the riparian cone (Twery and Hornbeck 2001).

- **Use of appropriate activities to minimize erosion and sediment**

- ○○ Continuous presence of natural regeneration, developing under shelter of adult trees (Frehner et al. 2005).
- ○○ Landslides can be prevented with planting of tree species having deep root system to stabilize the soils as well as draining excessive water (ash, oak, maple, black alder and fir tree, dwarf pine, Austrian pine) (Frehner et al. 2005).
- ○○ Working in dry weather (in spring or summer) can significantly decrease the risk of erosion near watercourses and drinking water collectors (Nisbet 2001).
- ○○ In the event of erosion urgent preventive measures should be taken and no cutting, burning or damaging of upper soil layer at least 100 years after the event (Twery and Hornbeck 2001)

Other recommendation for North Macedonia

- **Proclaiming protective forests according to the Law on Forests, prohibit clear cut in this area and plan sustainable forest management activities:**
- ●● in the protective zones around springs for supply of drinking water
- ●● in the zones around reservoirs and lakes vulnerable to erosion and sediments
- ●● in the actual and potential erosive zones
- ●● in the riparian zone – 50 m from the highest water level of lakes and reservoirs and 50 m from the line of discharge - Q1%

- **Recommendation related to erosion and sediments**
- ●● Principles of Eco-DRR to be used in erosion and torrent control
- ●● For erosion control everywhere where is it possible to be used native materials as: rock, gravel, sand, wood, Straw, wood fibers, other or products by native materials as wattles, fascines, gabions, bags, blankets, straw rolls, mesh etc.
- ●● Taking in consideration forecasted climate changes and negative consequences, for afforestation of bareland to be used fire resistant species

Recommendation for forest roads protection

- **There are some general recommendation:**

- ●● Construction of new forest roads based on a final design, prepared according to the standards (constructive elements of road drainage)
- ●● Construction of skidding tracks and transportation roads on less steep slopes to avoid excessive ground stripping and excessive use of trenches and the length of forest routes (Mulkey 1980)
- ●● During the period of heavy and persistent rainfall, closure of forest roads can prevent formation of ruts and their flooding (Mulkey 1980).
- ●● Frequently used roads and entry points on erodible soils should be hardened with rocks, lumbers or branches (Mulkey 1980).

Generally two engineering methods are in use for exist roads as follows:

- 1. Paving the traveled road with
- gravel or similar

2. Use of drainage culverts on forest roads and water diversions (water bars) on skid trails just after logging.

Road grade (%)	GW, GP Aggregate surfacing	GM, GC	CH, CL	MH, SC, SM	SW, SP, ML
2	120	97	75	52	29
4	103	84	65	45	26
6	88	71	55	39	23
8	74	60	47	33	20
10	61	50	39	28	17
12	50	41	32	23	14
14	42	34	26	19	11

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Thank you for your attention