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The protection against floods becomes effective in the Beskydy Mts. using forest hydrology

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Great spruce plantations reforested in the north-ost region of the recently Czech Republic at the end of 19th century were often endangered by wind, snow, insect pests, especially by polluted air. The environment is in this area since 1954 intensively controlled, examined and cared for and this task has not been finished yet. Research in the forest hydrology has shown that the process from rains to outflows (floods) remains open and dynamic for all time with complicated relationships to many components. The research measured in the Beskydy Mts. has not shown substantial hydrological changes in the forests caused only by human activities. Floods outflowing from the Beskydy Mts. get great kinetic energy, erose forest soil, create gullies with sediment transport, endanger cultural landscape such as roads, railways, houses and industry. The torrent control has undertaken since 1906 many biological and technical remedial works in this area. At present we have to evaluate all effects of this control and to organize protection against damaging by water streams, however, first of all using near-natural technologies.

Keywords: forested watersheds, forest hydrology, headwaters, torrent control, dangerous floods, near-natural control methods

Introduction

Protection against accelerated soil erosion and flood damage by torrent control with sills on streambeds, restocking of woods and shrubs on devastated slopes in small watersheds was urgent because of specific demands of human being. But this system has to be most efficient now long-termed for protection before catastrophes by water streams power. The static character of control works in the dynamic environment showed occasionally weaknesses asking for prompt solution before human objects would be destroyed. Different solutions are practised in countries impacted by this problem. But the common needs make us now carry out improving operational remedies in a more natural way and integrate them into this system affecting the local environment beneficially. Contributions concerning this matter were published also in Bulletins of Interpraevent, f.e. (Üblagger 1988, 1992). The main principles were presented recently especially by Heumader (2004). I present here short information concerning this matter from the hilly area called the Beskydy Mts.

Natural characteristics of described area

The **Moravian-Silesian Beskydy Mts**. belong to the external Carpathian range with 18°00´–18°30´east geogr. long. from Gr. and 49°30´north. lat. in the hilly region. Giessbäche from this area flow into the river Oder and Baltic Sea. The average yearly temperatures fluctuate between 2.3–7.8 °C, yearly sums of precipitations 756–1781 mm, on average 1150 mm. The lenght of vegetation period is 95–157 days with 921–1 542 hours of sunshine. The climate is mild cold. The parent rock are resistant sandstone and minder resistant slate covered by clay–earth or brown forest soil with approximate thickness ≤1 m. The mountains lie between 350–1324 metres o.s.l. with average slope 30–50%. Till 1989 they were not protected against concentrated immissions blown predominantly from the Ostrava industrial agglomeration only 20–50 km far from here.

This area (909 km²) has 75% **forest cover** percentage with wood species composition 76.5% conifers (73.6% spruce) and 23.5% broadleaves (19.6% beech). Their middle age is 63 years, the average standing volume is 317 $m^3.ha^{-1}$, the average stand density 0.89, the merchantable timber increment is 8.3 $m^3.ha^{-1}$, yearly mountain logging 6.45 $m^3.ha^{-1}$. The standing volume is mild growing now. 1540 km of forest roads have already been built and other 314 km should be further build in this area. The roaming is 24.5 $m^3.ha^{-1}$.

The waters flows away by around 1500 km **torrents** from which only 10% of lenght were controlled during the last 100year long period of time.

Measurements of discharges, outflow peaks with sediment transport

For the preparation of torrent control it was and is important to measure and evaluate the hydrologic regime in headwaters, especially **outflow waves** precisely. All rains and discharges were measured thoroughly in two small (2 km²) experimental watersheds there since November 1953. The yearly average discharges fluctuated between 11.4–45.6 $l.s^{-1}.km^2$. Melting of snow was rarely at the end of February, as a rule in March and April, selten at the beginning of May. Maximum discharge after melting was registrated at the end of April 2006 with q_{max} = 485 $l.s^{-1}.km^2$. During the last fifty years formation of dangerous floods do not threaten in spring. But this is not valid below the area on valley plans, where the floods follow other principles.

Dangerous **floods** were registrated only in the period from 6th June to 10th September, mostly in July and not at every year. They started at q = 600 $l.s^{-1}.km^2$. Some differences exist in outflows on slopes and in torrents on the higher front range of the mountains with NW exposition – on the contrary to small watersheds at the back part of the range. Between 1954–2007 measured we **18** such floods on the front part and **12** at the back part. We registered after storming rains $q_{daily\ max}$ = 694 l $l.s^{-1}.km^2$ with the peak discharge q_{max} = 2 416 $l.s^{-1}.km^2$ (1st August 1971) at the back and $q_{daily\ max}$ = 1 093 $l.s^{-1}.km^2$ (8st August 1985) and q_{max} = 3 256 $l.s^{-1}.km^2$. (23 July 1966) on the front side of the range. After an extraordinary profuse regional rain from 5 to 9 July 1997 for 80 hours, 345.4 mm sum and q_{max} = 1 448 $l.s^{-1}.km^2$ at the back side and 489.9 mm sum with q_{max} = 2 776 $l.s^{-1}.km^2$ on the front side cause flooding which lasted only 8 days

Intensity of erosion

The measurement of erosion by water with transport of bed load and sediment has been carried out in two described experimental watersheds since 1958. It was found out that greater load has been transported only by the stream of floods, however, this does not occur fortunately very often. The sediment was washed out mainly when forest roads were built and heavy mechanized transport of wood followed. The sediment often comes from natural rill erosion. Its intensity on the front part of the mountains was threetimes greater than at the back part, however, it wasn´t very dangerous and didn´t exist long. From 1975 to 1999 concentrations of sediment in the murky water flowing into the Šance – reservoir with drinking water (Buzek 2000) were measured too. They have shown that only for 72 days of these years the daily concentration of sediment was greater than 1 mg/l of water but it wasn´t dangerous excerpt for the required quality of drinking water.

Our opinion after a long measurement and practice in the torrent control

Heavy rainfalls and dangerous discharges

It is important to measure not only **sums** but especially **intensities** of rainfalls. The greatest intensity was measured on 1st August 1971 in one small watershed called Červík in the back part with 2.2 mm/minute during 20 minutes. It fell 36.652 $m^3.s^{-1}.km^{-2}$ of stormwater on this watershed but the peak of outflow wave was only q_{max} = 2.416 $m^3.s^{-1}.km^{-2}$! This is a valid argument showing the momentary kapacity of rainwater **retention** in forests especially in forest soil. The surplus of water formed the part of this outflow curve for only 4 hours. This is very important how to do effective work for decreasing peaks of discharges: to support infiltration and storing in soils, to prevent from early concentration of water by overland flow and interflow. At that time we could see many springs of water on the bases of slopes, however, existing only for a very short period of time.

We haven´t paid sufficient attention to the water regime of forest soils till now. We see that water effects aren´t replaceable but they are limited too. Their good functions are connected not only with the abundance of organisms, but also in the water cycle. The retention space in forest soils in the Beskydy Mts. when raining is ~20–80 mm, on average 50 mm.

Kinetic energy of outflowing water

The open system was presented clearly on the poster (Weinmeister 2002): energetic model in a headwater (torrent catchment) with rarely but heavily concentrated discharges eroding gullies and torrent beds shows many physical and mechanical changes of **kinetic** energy into other kinds of energies. This is fundamental for the erosion intensity, sediment transport and protective function of torrent control. Application of this model needs to reduce moving mass, bed incline and to enlarge **roughness** of the wetted perimeter of flow profile.

We have to take always into account that 90% of the lenght of torrents in the Beskydy Mts. is kept nearly in their natural state fast without any great intact of man. But new projects of control by sills are badly critized or restricted by the regional conservation agencies of nature, which is very questionable.

It is clear that the rainfall sum >100 mm (or still smaller with greater intensity) causes flood, but fortunately this danger doesn´t come very often.

We are informed that floods didn´t only damage areas but they partly put in order beds of torrents, brooks and rivers as well. Kinetic energy of every stream has to be naturally adjusted by resistances in the flow profile to the change of a proper part in other kinds of energies.

Changing the natural landscape into cultural

Such events are opening new spaces for the development of ecosystem. However, not only water functions, but also retention with reduction of the erosion intensity by forests is limited. Ecosystem in the nature is able to resuscitate slowly but this isn´t often in harmony with human activities. We should soften these differences and not increase them. Using the system theory for solving problems is relevant because any, not every mild impulse may results into great outgrows.

Human activities have been permanently changing the natural landscape into cultural. It hasn´t been fully proved that because of these changes the floods occur more frequently and the peaks of floods are higher now but the damages of human objects are surely greater than earlier. It is true that floods do not damage all natural elements. They take nonliving and nonfunctional parts of a biosystem with and regenerate the ecoton, make the movement of organisms and plants into new areas easier, however, this takes a longer time than people wish. The relationships between rainfalls and outflows have their origin in the dynamic system. Due to entropy this system is naturally unordered and we wish to arrange it by static measures of torrent control adding external energy. Our experience has shown that the function and existence of objects are naturally limited and this is why they have to be permanently fortified with other measures against damage caused by floods, such as insurance, hazard mapping etc. We have to look through for results of control measures not only on the torrent, but also on the whole watershed making prompt right changes of the open system. Water is still in interaction with other living and nonliving elements of nature with space and time differences of matter and energy in a sphere of landscape. We need to support the restoration of the disturbed system and to support next homeostasis only by useful objects. It is better to prove and to understand intermittent component changes by the system theory than only by static calculations and objects.

Experiences with control objects made by loosen stones

Since 1906 have been controlled torrents in the Beskydy Mts. using objects from the Alps: sills with banks covered by vegetation (Willow sp., any broadleaves), pavements, stone walls, stacked stones, streamside trees and shrubs. Controlled parts of torrents were earlier finished by higher trapping check dam. These methods of protection have brought as goods as problems: they are rather expensive and not every near-natural operating. It seems to be important to seek for others as well.

At the beginning of sixties in the last century it was attractive to prove constructions built from loosen stones. In 1963 the first two stone chutes on the Stonávka – small torrent at the Beskydy Mts. – were built using the impulse of (Schauberger 1957) – Fig. 1. Only on this torrent there are 23 chutes today with their stability and functions tested by floods during 44 years most in 1997. The first chute seems to look well naturally now – Fig. 2 but all chutes were adequate separately amended to the nature by hydraulic and ecologic effects.

Having an idea from the Aara River under Thuner See in Switzerland we carried out a similarly looking experiment of 650 m lenght on the Lomná torrent in 1965. It looks nature-near even nowadays and a long time existence is doubtful.

We tried out rarely higher check dams to build by loosen stones. It seems to be that the methods using loosen stones are more near-natural but they cannot be used without limit having no experiences on all localities.

Recommendations for the headwater control on watersheds in the middle-mountain areas

We aren´t endangered by great debris flows in the Czech Republic. This is why the near-natural management of small watersheds is required there.

We have to measure more rainfalls at the range of hilly watersheds; not only their sums but also digitally intensities and register peaks of outflow waves. Theoretic hydrologic models of rain – outflow processes are only helping aids and they have to be verified by data from natural events.

We have to differentiate immediate help at the time of flood; local remedies of flood damages; prevention works on the whole watershed (we are late) by near-natural inexpensive works.

We have to solve softening of dangerous kinetic energy from the streamwater with adequate measures to the hydrologic regime which doesn´t disrupt the ecosystem.

We have to regulate sediment transport but not to stop it by high check dams in headwaters.

We have to preserve full flow capacity of headwaters (torrents) inclusive cleaning riparian (streamside) stands, to maintain the flow capacity of culverts and bridges against sailed wood, stumps or branches, etc.

It will be useful to do the detailed inventory of controlled parts of headwaters (torrents) and to evaluate objects crushed by stream with the purpose not to repeat earlier mistakes.

We call for a direction concerning the near-natural protection of small watersheds in the hilly areas being in harmony with natural-protective agencies and laws.

We are missing a separate regulation for protecting against floods by near-natural control works on headwaters (torrents).

It will be thought to amend the regional strategies for development of forests (OPRL in the Czech Republic) by data from the pedohydrology in the headwatersheds.

It will be useful to keep international contacts concerning protection against floods using near-natural control techniques, f.e. with International Research Society INTERPRAEVENT, Klagenfurt, Austria.

Fig. 1: The first stone chute in the Stonávka-torrent built in April 1963 (orig. M. Jařabáč)

Fig. 2: The same stone chute looks in 2007 near-naturally and is not damaged by water streams (orig. M. Jařabáč)

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