CC-WARE

Workpackage 4

Act. 4.2

Qualitative Description of the Ecosystem Service 'Source Water Protection' -

Forest Ecosystems on Mountains and in Flatlands

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Qualitative
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Content

CC-WARE – Workpackage 4

Act. 4.2 Qualitative Description of the Ecosystem Service (ES) 'Source Water Protection' - Forest Ecosystems, Homogeneous Areas "Mountains" and "Flatlands"

1 Introduction

The final Ecosystem Service (ES) analyzed in the CC-WARE project is "Supply of pure drinking water in appropriate quantity". In this paper, all relevant ecosystem functions of forests, which contribute to this final ES are described in a qualitative way. It has to be emphasized that there may be derived various other ecosystem services from the forests in the pertained drinking water protected areas (DWPA), but those are not addressed in the CC-WARE project. Hence the relevant processes for the sustainable provision of the final ES will be described on the level of forest ecosystem functions. All these functions contribute to the provision of the final ES "Supply of pure drinking water in appropriate quantity".

The idea behind is the description of the 'water protection functionality' of forest ecosystems (WPF), which make the provision of the final ES possible, in a comprehensive way, so that Management Options (MO) and Best Practices (BP) for improving the WPF can be related to those. This will help so that all involved stakeholders, like water suppliers, forest owners, governmental and non-governmental organization units as well as the general public can understand the major principles of source water protection and the possibilities to improve the final ES.

There will be provided an additional stratification into homogeneous areas in order to line out the ES functionality for different ecological boundary conditions. The different homogeneous areas are (1) Mountainous Forest Ecosystems, (2) Floodplain Forest Ecosystems and (3) Flatland Forest Ecosystems. These homogeneous areas will not be further stratified, as the description of the crucial functional differences for the provision of the main ES can be achieved by these three categories.

Final ES and the Water Protection Functionality of Forests

For the provision of the Final ES, the forest ecosystems have to be in an adequate condition. The water protection functionality of the forest ecosystem (WPF) summarizes all the crucial forest functions which contribute to the provision of the ***final ES "Supply of pure drinking water in appropriate quantity"***.

All the following descriptions are detailed for the homogeneous areas 'Mountains' and "Flatlands" within SEE. Wetland Forest Ecosystems will be described in an additional paper.

Drinking water protected areas (DWPA) are essentially watersheds which are related to drinking water supply facilities. Those can be springs, groundwater bodies or dams which provide source water for drinking water supply. Hence DWPA can be of wide spatial extension.

2 The Water Protection Functionality (WPF) of Forest Ecosystems - Main functions of forest ecosystems for the provision of the final ES

For providing the final Ecosystem Service (ES) "Supply of pure drinking water in appropriate quantity", forest ecosystems can be analyzed regarding their main functions supporting this ES. The most crucial forest functions which are important for the provision of the final ES are explained in this chapter. First an overview of those is provided.

Overview of the forest functions which are crucial for the provision of the final ES:

+ **Optimal Infiltration Conditions for Precipitation Water (1)**

    (Good infiltration conditions for precipitation water into the soil matrix)

+ **Water Storage and Retention (2)**

    (Storage of precipitation water in the interception storage and soil storage)

+ **Snow Storage Capacity (3)**

    (Storage of snow in structured and mixed forest stands)

+ **Stabilization of the Soil- and Humus Formations (4)**

    (The dense root network of the forests stabilizes and the forest cover provides shadowing for the soil and humus layers. Forest trees also feed the humus cycle)

+ **Prevention or Mitigation of Erosion Processes (5)**

    (Prevention or mitigation of rock fall, landslides or avalanches by a dense and stable forest cover)

+ **Filtration of the Precipitation Water (6)**

    (The forest soils and humus layers together with the forest vegetation provide a natural filter for various substances which infiltrate via the precipitation water)

In the following chapter, a detailed description of the Forest Functions for the provision of the final ES will be given. This is the central part of the qualitative description of the main ES within the homogeneous areas ‘Mountains’ and ‘Flatlands’.

The description of the relevance of each forest function for the different homogeneous areas is displayed in tables. The different categories for the relevance are ‘very high’, ‘high’, ‘medium’, ‘low’, and ‘very low’. These qualitative estimations of the forest functions provide an overview for the homogeneous areas, but with emphasis on the category ‘Mountains’ and ‘Flatlands’.

Additionally there are displayed the ‘Water Protection Functionality’ (WPF) – Abstracts, where the essential facts of the WPF are described in a brief and concise way.

2.1 Optimal Infiltration Conditions for Precipitation Water

In drinking water protected areas (DWPA) it is of crucial importance, that the precipitation water infiltrates into the soil matrix. Forest soils, which are covered by adequately stocked and stable forest stands, provide good infiltration conditions for precipitation water, what fosters water storage in soils and also the creation of deep percolation or lateral flow. This is a desired situation in DWPA, as the precipitation water hence can pass the soil matrix and will be transformed by the soil compartments.

The forest function for enhancing the infiltration of precipitation water can be explained with the formation of typical forest soils, which provide high macro-pore content. The macro-pores in forest soils are created by the roots of both trees and soil vegetation and also by the activities of the soil fauna. For forest soils infiltration rates between 6 mm and 206 mm/hour were reported (Harden and Scruggs 2003). As extreme values, infiltration rates of up to 650 mm/hour were measured in European forests (Eichhorn 1993). In the case of karstic soil formations with forest cover, the infiltration of 100 mm/hour during a strong-precipitation-event simulation was shown. During this experiment did not occur any surface flow (Markart et al. 2011). All these exemplars highlight the capacity of forest soils for efficient infiltration of precipitation water.

In summer the shadowing of the forest soils given by dense forest cover provides lower soil temperatures in the upper soil horizons in comparison to open grassland or bare areas (Koeck 2008; Kang et al. 2000). This reduces the tendency for the creation of water-repellent upper soils (hydrophobia of the upper soils) and hence supports better infiltration conditions.

In winter the shadowing effect of forest cover provides higher soil temperatures in comparison to open areas. In case of shrub vegetation, the forest cover may also provide a consistent snow cover during the whole winter season, while on grassland areas the snow might be blown off in case of strong winds. This can support the infiltration of snow melt water during spring time (Koeck 2008).

The relevance of the WPF Optimal Infiltration Conditions for Precipitation Water is given on the level 'very high' within all homogeneous areas (Tab. 1).

WPF-Abstract:

It can be summarized that the specific conditions of forest soils together with the shadowing effect of forest cover provide optimal infiltration conditions for both precipitation and snow melt water, the first and crucial facet of the water protection functionality (WPF) of forests in all homogeneous areas, with a very special significance for forest ecosystems in mountains, what is due to the related mitigation or prevention of surface flow.

Table 1: Relevance of the WPF 'Infiltration of Precipitation Water' in the different homogeneous areas

WPF	**Mountainous FE**	Floodplain FE	**Flatland FE**
Infiltration of Precipitation Water	**Very High**	Very High	**Very High**

WPF…Water Protection Functionality; FE…Forest Ecosystems

2.2 Water Storage and Retention

Forests have the capacity of water storage. Where water storage takes place are the *interception storage* of the trees and the *soil storage*. The *interception storage* of forest stands is dependent on the tree species and growth conditions of a forest site and varies within European forests according to Baumgartner and Liebscher (1990) between 0.2 mm and 7.6 mm. Interception storage takes place on the trunks, branches, leaves and needles of the trees (Cantu-Silva and Okumura 1996; Carlyle-Moses et al. 2004; Savenije 2004). The intercepted precipitation water can evaporate and hence does not reach the forest soil.

The second place of water storage in forests is the forest soil, whose capacity is significantly huger than of the interception storage. The storage capacity of the forest soils is dependent on geology, ecto-humus layers, soil type, soil depth, soil compartments, soil structure etc. If the precipitation water or snow melt water infiltrates into the forest soil, it enters the soil storage and remains there, until it moves downward via deep percolation or upward to plant roots for transpiration. The soil storage is an important buffer for balancing the spring or brook discharge.

As part of the soil storage, the capacity of ecto-humus layers can sum up to four-times the dry-weight of the ecto-humus substances (Hager and Holzmann 1997) and plays hence an important role in case of the presence of ecto-humus layers (not all soil types possess them). Especially within karstic catchment areas, ecto-humus layers are of outstanding significance and often the only place within the soil matrix, where water and nutrient storage can take place (Koeck 2008). The dynamic stability of the humus formations hence plays an important role within the context of source water protection.

The mineral soil layers can store water up to 50 % of their volume, the measure is called volumetric soil moisture content (cm^3/cm^3 - Ø) and the significance of this storage becomes apparent together with the high infiltration capacity of forest soils (see 2.1). If water infiltrates an intact forest soil, it can potentially be stored in the soil water storage. The variance of the soil water storage (SWS) is given over space (different soil types, depths, etc. and different forest sites) and over time (the actuation of seasons with varying actual evapotranspiration, precipitation events and dry-spells).

Water stored in forest soils is transferred to either tree roots for transpiration or to deep percolation, by the way contributing to groundwater recharge or spring discharge. It is a way of water retention at the site and hence contributes significantly to drinking water supply (Tab. 2).

It has to be mentioned that within SEE there exist geographical areas, where annual precipitation is so low that within watersheds also grassland may be selected as appropriate vegetation cover due to its lower transpiration demand, but this would only be a potentially valid solution in flatland areas. The spacing between forest land and grassland areas in such flatland DWPA has to be decided by the local authorities.

WPF-Abstract:

The storage capacity of the trees (interception storage) and of the forest soils contributes to the water retention functionality and is hence of significance for drinking water protection purposes. The storage capacity of soils is bigger than that of trees (interception).

Table 2: Relevance of the WPF 'Water Storage and Retention' in the different homogeneous areas

WPF	**Mountainous FE**	Floodplain FE	**Flatland FE**
Water Storage and Retention	**Very High**	Very High	**Very High**

WPF…Water Protection Functionality; FE…Forest Ecosystems

2.3 Snow Storage Capacity

A specific form of water storage is given in the case of the snow storage capacity of forest stands. This only can take place if the climatic conditions of a forest region provide snow cover during the winter season, which is guaranteed within the SEE space in case of all higher elevated mountainous areas, but for flatlands or valleys only in cold winters with enough snowfall. Forests in snow-rich areas have the capacity to store snow far into spring. If the forest stands are adequately structured, snow can be trapped by the rough forest canopy and with the shadowing effect of the tree cover the snow cover can be conserved longer in comparison to open areas. The extended snow ablation period contributes to a more balanced spring-discharge or groundwater-recharge and is in general an important factor for those, as it takes place in a time-period, when no water demand for transpiration (dormant season of the plant cover) and only low evaporation rates (low air temperatures) are given.

Coniferous trees can intercept more snow than broadleaved trees, which was confirmed by Pomeroy et al. (1998) and Marsh (1999) and what is due to the higher leaf area index of conifers in winter. This is also the reason, why coniferous trees provide, in contrast to broadleaved trees, a good shadowing effect during spring time. A dense stocked forest can extend the snow ablation period up to three weeks in comparison to open areas (Link and Marks 1999).

Also forest structure is of importance for snow storage. Small gaps within forest stands provide the snow trapping effect also during strong wind periods, while on huge clear-cut areas or on grassland the snow is blown-off (Mayer et al. 1997).

Especially within the subalpine forest belt the snow storage capacity of forest communities can be very high. This can be explained with the high elevation of these sites (cooler annual mean temperature) and the proximity to higher elevated grasslands, where the snow is blown off during strong winds. The blown-off snow can be trapped and accumulated within the small gaps of naturally structured subalpine coniferous forest communities, as these forest stands provide a relatively high roughness index. The shadowing effect of the surrounding conifer tree clusters can provide an extension of the snow ablation period until far into late spring at these subalpine forest sites (Koeck 2008).

The Snow Storage Capacity of forest ecosystems has very high relevance in mountainous forest ecosystems, as lots of precipitation comes as snow there. It has medium relevance for the other homogeneous areas, as snow cover due to the low elevation does not play such an important role there (Tab. 3).

WPF-Abstract:

The snow accumulation and storage capacity of forests plays an important role for the enhancement and temporal extension of groundwater recharge or spring discharge. It can be influenced and controlled by tree species distribution and forest structural parameters. The snow storage capacity of forest ecosystems is of very high importance in mountainous forest ecosystems, while it is of only medium importance within flatland or wetland forest ecosystems.

Table 3: Relevance of the WPF 'Snow Storage Capacity' in the different homogeneous areas

WPF	**Mountainous FE**	Floodplain FE	Flatland FE
Snow Storage Capacity	**Very High**	Medium	Medium

WPF…Water Protection Functionality; FE…Forest Ecosystems

2.4 Stabilization of the Soil- and Humus Formations

For providing optimal infiltration conditions for precipitation water (see 2.1) and good water storage functionality (see 2.2) over space and time, the forest soils together with their humus formations have to be stable. Forest vegetation has the capacity to stabilize the forest soil- and humus layers. The stabilization is given through various processes inherent to forest succession and to established forest cover.

In contrast open areas without vegetation or with only a low percentage of vegetation cover produce in case of strong precipitation events surface runoff, which can cause erosion of soil and humus substances and also can form a threat in terms of flood events. Surface runoff water can contain high amounts of sediments and further eroded material, which make the usage of the source water as drinking water impossible (in cases without further technical treatment, of course). This process can take place in both mountainous and flatland forest ecosystems.

The stabilization of the humus dynamics is one crucial part of the WPF of forests. The ecto-humus layers on the top of the mineral soil layers rely on the continuous delivery of litter given through the needles or leaves falling down from the trees. An additional stabilization of the ecto-humus is given through the shadowing of the humus layers by the forest cover. The dense root-network of the forest trees together with the soil vegetation stabilizes the humus layers mechanically and hence keeps them at the forest sites. Especially the ecto-humus layers are characterized by high densities of fine-root network, as these layers contain the highest concentrations of nutrients for tree growth.

The ecto-humus of forest soils can store water in amounts up to 4 times of its dry-weight (Hager and Holzmann 1997 and chapter 2.2). In case of humus decomposition and mobilization processes, which take place after clear-cuts or wide-spread wind throw event, the nutrients stored within the humus would be released and turned into possible contaminants of the source water. The decomposition of the humus substances is caused by the elevated soil temperatures and the altered soil moisture conditions created after clear-cuts or large-scale forest breakdowns (Shutou and Nakane 2004).

The mineral soil layers are also stabilized by the dense root network of trees and soil vegetation. The most important aspect is the mechanical stabilization of the soil layers against the gravitational forces effective on steep slopes on mountainous forest sites. But also within flatland forest ecosystems this mechanical stabilization of the soil layers is of crucial importance for their WPF. The erosive force of water is mitigated by the dense root network of trees in a forest. Also by the way of the advancement of precipitation water infiltration (see 2.1), surface runoff is mitigated or prevented, what also supports the stabilization of the soil horizons.

WPF-Abstract:

Mineral soil- and humus formations are stabilized mechanically by forest vegetation via the dense root network of trees and soil vegetation. The humus formations are kept in stable dynamic conditions via the litter- and shadow provision of forest cover. This soil- and humus stabilization is of relevance for both mountainous and flatland forest ecosystems.

Table 4: Relevance of the WPF 'Stabilization of the soil- and humus layers' in the different the homogeneous areas

WPF	**Mountainous FE**	Floodplain FE	**Flatland FE**
Stabilization of the soil- and humus layers	**Very High**	High	**High**

WPF…Water Protection Functionality; FE…Forest Ecosystems

2.5 Prevention or Mitigation of Erosion Processes

The steep slopes of mountains are prone to erosion processes like rock-fall, land-slides or snow avalanches. These erosion processes would be true threats for human traffic routes, for settlements and for water supply facilities and also could cause contaminations of source waters. Hence these erosion processes have to be prevented or mitigated.

A stable and dense forest cover provides the best protection against these erosive forces. This highlights the prior significance of stable forest ecosystems in steep mountainous terrain all over the world. The protection functionality of the forests against erosive processes gains additional relevance, if the related area is used as watershed for drinking source water supply.

The erosive force related to rock-fall occurs in areas, where rock-sites are prevalent. If those are interlinked with forest areas, rock-fall processes can be mitigated by the forest stands. The rock-fall processes may be triggered by earth-quakes, freeze-thawing processes from autumn until spring periods, strong wind-storms with related wind-throw of trees, migrating wild ungulates, etc. Most of these triggers cannot be prevented. In some cases a dense and stable forest cover can prevent or mitigate the harmful impact of rock-fall to human infrastructure. Within this context it has to be highlighted, that the impacts of some strong rock-fall events cannot be prevented by any high-stability forest cover, as their gravitational force is too high, like e.g. rock-falls which encompass huge parts of a mountain or huge rocks with high weight.

The denser the forests below rock-areas are the higher is their mitigation potential for rock-fall prevention, what can be explained by the higher probability for stones to be trapped by a tree. In addition to the amount of trees per hectare, also the stability of the individual trees is of crucial importance. Within this context the h/d relation or any further stability indicators are of significance. Only strong and stable trees can act as trap for falling rocks.

Land-slides can involve both mineral and organic soil substances and bedrock material. They mostly occur in combination with strong precipitation events, sometimes also in combination with snow ablation processes. High erosive sites in case of strong precipitation events can produce land-slide events despite a given stable forest cover, like e.g. the recent events at Gschliefgraben (Austria, province Upper Austria) or at La Villa in Alta Badia (Italy, province Alto Adige) have shown. At such sites, no human infrastructure constructions should be established.

Another situation is given, if forest sites are eroded during strong precipitation events after previously being clear-cut or wind-thrown. Those instances are mostly related to specific bedrock conditions which show a high erosive potential. In these cases the land-slides could have been prevented by keeping a continuous forest cover.

Especially gully sites, ditches and avalanche sites can be prone to land-slide erosion processes. On those forest sites, there occurs a natural concentration of water flow during strong precipitation events. All these potentially forested sites should be covered by the most stable, achievable forest stands which additionally should exhibit an adequate tree species diversity and distribution.

Avalanches occur in mountainous areas on steep slopes, where a dense forest cover is lacking and snow is accumulated. Normally those actually given sites are indicated by a specific forest vegetation dynamics and structures (low growing height of trees up to maximal 5 m, indicating species, destroyed single trees, etc.). On those sites avalanches can occur frequently (in past and in future), the process only might be stopped if the forest cover should establish a critical threshold regarding density and dimensions (dbh – diameter above breast height and growth height).

Actually also normal forested sites could become avalanche sites, if they are steep enough and were clear-cut or wind-thrown. In these cases a reforestation could become difficult or even impossible, if the avalanches should destroy the regenerating trees frequently. This situation has to be avoided by a sustainable provision of a protective and continuous forest cover.

The erosion of soil- and humus substances processes caused by clear-cuts, huge wind-throw areas or intensive timber cutting volumes (= clear cut conditions, CLC), also endanger source water quality. The nutrients stored within the tree roots are released after CLC were established, and those stored within the organic soil- and humus substances are mobilized by mineralization processes and hence also released. The leaching of these substances can result in a contamination of the source waters. On the other side, the forest sites decline due to nutrient leaching and respiration.

All those erosion processes can harm source water quality by increasing turbidity, matter concentration or sedimentation processes and hence have to be prevented or mitigated within drinking water protected areas. A stable and continuously provided forest cover protects efficiently from those erosion processes by either preventing or mitigating them.

In mountainous areas all erosive forces are prevalent, hence the relevance of this WPF is very high, in floodplain or flatland areas only the soil- and humus erosion function is of high relevance, hence its relevance was assessed as high there (Tab. 5).

WPF-Abstract:

Stable, adequately mixed and stocked forest stands provide protection from or mitigation of the erosive processes like rock-fall, land-slides, avalanches or soil erosion. This capability of forests contributes to the water protection functionality (WPF) of forests in mountains and can be regarded as crucial forest function in terms of source water protection.

Table 5: Relevance of the WPF 'Prevention or Mitigation of Erosion Processes' in the different homogeneous areas

WPF	**Mountainous FE**	Floodplain FE	Flatland FE
Prevention or Mitigation of Erosion Processes	**Very High**	High	High

WPF…Water Protection Functionality; FE…Forest Ecosystems

2.6 Filtration of the Precipitation Water

A various number of different inorganic and organic substances can be transported to our forest soils via wet (precipitation) or dry deposition. These substances have a variable degree of contamination-potential for our source waters and may either be leached and transported to the related aquifers, or they may be adsorbed to soil- and humus components.

The soil- and humus layers in forest ecosystems have the capacity to filtrate precipitation water, if the water flows through the soil matrix. It also has to be mentioned that via the sometimes occurring preferential flow in forest soils, pollutants may bypass soil areas where the adsorption of contaminants can occur (Keesstra et al. 2012). Preferential flow pathways may either be increased trough soil and humus erosion or minimized by adequate silvicultural treatments, however, they never can be excluded totally. This situation highlights the fact, that in some soil types a part of the infiltrating water will pass the soil matrix, so pollutants can be adsorbed there. Other parts may bypass the soil matrix via preferential flow paths hence the solved pollutants can directly leach to the aquifer. In karstic environments with significant ecto-humus layers, preferential flow may be increased during extreme dry spells via the formation of crevices in the humus layers.

Nitrate (NO_3^-) and ammonium (NH_4^+) have to be mentioned among the most prevalent ions occurring as potential contaminants. Nitrate concentrations within drinking source water are globally of crucial relevance, as they occur wide-spread and hence form the most widespread threat for water quality. Nitrate can be absorbed by plant roots, especially by deciduous tree species, as it is an essential plant nutrient.

Forest soils in the past were limited in nitrate content and did not reach nitrate saturation. Actually various forest soils in Europe show nitrate saturation (Aber et al. 1989), caused by intensive nitrate immissions via air pollution, caused by our industrialized civilization.

Further reports were communicated within the context of soil humus layers in forests, which are capable for adsorbing the radioactive isotope cesium and hence prevented this toxic radioactive fallout from nuclear facilities from percolating into the aquifers.

WPF-Abstract:

Forest soil- and humus layers have the capacity for filtrating potential contaminants from the precipitation water. This functionality is related to the adsorption of those substances to soil and humus compartments. One part of the precipitation water may always leach directly to the aquifers via preferential flow paths.

Table 6: Relevance of the WPF ‘Filtration of the Precipitation Water’ in the different homogeneous areas

WPF	**Mountainous FE**	Floodplain FE	Flatland FE
Filtration of the Precipitation Water	**Very High**	Very High	Very High

WPF…Water Protection Functionality; FE…Forest Ecosystems

3 Drinking Water Protection through Forest Ecosystems

Forest Ecosystems can provide capacious drinking water protection functionality (WPF), if they are fulfilling specific basic criteria. WPF of forest ecosystems assures the sustainable provision of the final Ecosystem Service (ES) "Supply of pure drinking water in appropriate quantity".

In order to fulfill the before mentioned most crucial forest functions for source water protection, the forest ecosystems and forest stands in DWPA have to be in adequate condition. Here some of the most important features of forests within DWPA are highlighted.

Requirements for Forests within DWPA, Specific Basic Criteria (SBC):

+ The forest cover has to be given continuously over space and time. This fact allows only small openings of the forest cover (like e.g. small gaps) for the establishment of natural regeneration. Timber yield is possible if it conforms to this requirement.

SBC Continuous Forest Cover

+ The forest cover is stable and resilient.

SBC Stability and Resiliency of the Forest Ecosystems

+ The tree species diversity corresponds to the natural forest community (NFC), the tree species distribution corresponds to the purpose of a high degree of water protection functionality.

SBC Tree Species Diversity according NFC

+ The regeneration dynamics evolve successfully and encompass all tree species of the specific natural forest community.

SBC Successful and diverse regeneration process

+ The forest stands are adaptable towards climate change (through a high degree of adequate tree species diversity).

SBC Forest stands are adaptable to climate change conditions

+ The forest stands are multi-layered and uneven aged, hence a diverse forest structure evolves.

SBC Multi-Layered and Uneven Aged Forest Stands

+ The tree species of a forest stand provide genetic diversity and are stemming from the natural gene pool of a forest site (autochthonous tree species).

SBC Gene-Pool of autochthonous tree species

+ A low disturbance regime is established (stability and resiliency towards natural disturbances and a low degree of manmade disturbances like timber yield, forest road construction, etc.).

SBC Low Disturbance Regime for Forest Ecosystems

+ The stable and resilient forest cover provides the basic conditions for the stabilization of the soil and humus layers dynamics, who act as water storage and filter for precipitation water.

SBC Stabilized soil and humus layers (By adequate forest cover)

+ The density of wild ungulate species is given on a level which allows a sustainable succession of the forest ecosystems (successful regeneration dynamics).

SBC Forest ecologically sustainable wild ungulate densities

As the water protection functionality is only given on an adequate level, if the above mentioned SBC are fulfilled, it is of crucial importance to apply “Best Management Practices (BP)” within forest ecosystems in order to achieve optimal water protection functionality (WPF) there. The catalogue of BP was elaborated for all four ecosystem types analyzed in CC-WARE and is published as both catalogue in form of a table and also as detailed description of each BP (www.ccware.eu/output documentation).

4 Conclusions

The final Ecosystem Service (ES) analyzed in the CC-WARE project is "Supply of pure drinking water in appropriate quantity". In this paper, all relevant forests functions, which contribute to this final ES are described in a qualitative way. The water protection functionality (WPF) of forest ecosystems was by this way qualitatively described according to 6 main forest functions within the context of forest hydrological questions.

For drinking water protection purposes utmost important are the forest-typical functions (1) good infiltration conditions for precipitation water, (2) storage and retention of water within the soil and interception storages, (3) snow storage capacity, (4) stabilization of the soil- and humus formations, (5) prevention or mitigation of erosion processes and (6) filtration of precipitation water. All these forest functions were described in a qualitative way therefore outlining the WPF in a comprehensive form.

The description of the forest functions highlights the need for an adequate management of forests within DWPA or within watersheds which are connected to drinking water supply infrastructure. The most important features of forest ecosystems in terms of Specific Basic Criteria (SBC), which have to be given for an optimal WPF were also described as overview. It was highlighted that the optimal WPF of forest ecosystems can only be guaranteed, if the forests are managed according to Best management Practices (BP) for DWPA.

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CC-WARE: facts and figures.

Project acronym: CC-WARE

project title Mitigating Vulnerability of Water Resources under Climate Change
project code SEE/D/0143/2.1/X

Funding Programme: South East Europe (SEE)

priority Protection and improvement of the environment
area of intervention Improve integrated water management and flood risk prevention

Project partners

18 partners from South East Europe programme area

ERDF partners*	12 (1 lead partner, 11 project partners)
IPA partners**	1
10% partner***	3
EU ASP Partners****	2
involved countries	11 (AT, BIH, BG, GR, HR, HU, IT, MD, RO, SI, SRB)

Project duration

01.12.2012 – 30.11.2014

Project budget

total budget	€ 1.826.633,20
thereof ERDF budget	€ 1.415.163,47
thereof IPA budget	€ 137.474,75

More information

about the project www.ccware.eu
about the programme www.southeast-europe.net

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*** partners financed by the Lead Partner
**** Associated strategic partners (ASP)