ANNEX 1

Pilot action cluster 1 report: C City of Vienna (1.1) and Waidhofen an der Ybbs (PA1.2)

Mountain Forest and Grassland sites

SET-UP OF PILOT-SPECIFIC MANAGEMENT PRACTICES

D.T2.1.2 Transnational case review of best management practices in pilot actions

Interreg CENTRAL EUROPE
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PROLINE-CE

BEST MANAGEMENT PRACTICES REPORT IN PILOT ACTION

"PILOT ACTION CLUSTER 1: CITY OF VIENNA AND WAIDHOFEN AN DER YBBS"

FORESTS AND GRASSLANDS IN MOUNTAINS

VERSION 1

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1. Introduction

In this report, best management practices are presented on the level of Pilot Action Cluster 1 (Forestry and Grassland in Mountain Areas). The related Pilot Actions are: (1) Pilot Action City of Vienna – Water Protection Zone of the City of Vienna **[PAC1.1]** (Grassland and Forestry) and (2) Pilot Action Waidhofen an der Ybbs **[PAC1.2]** (Forestry). The report is dealing with potential conflicts of interest between land use management and water protection.

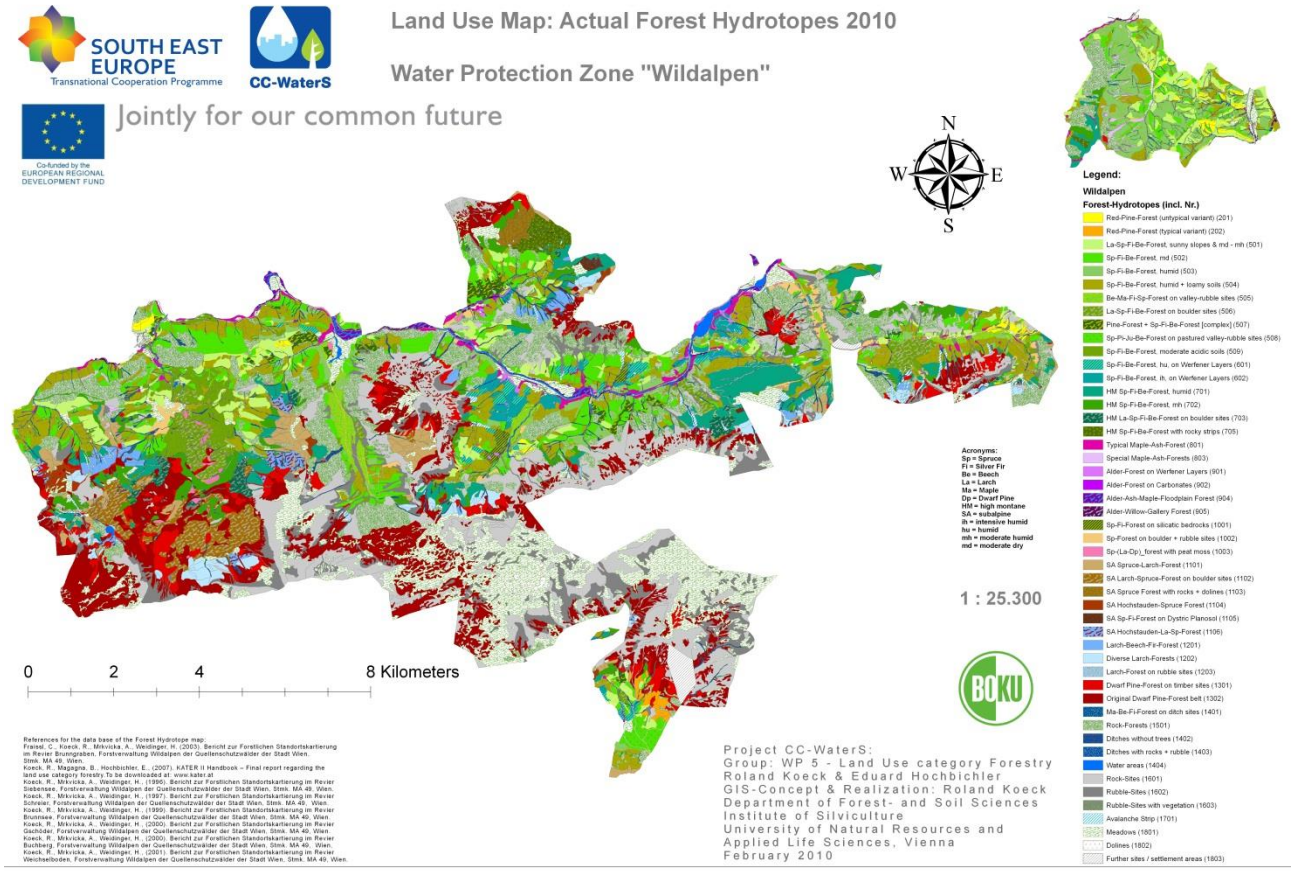
The aim of this report is to provide the review of best practices regarding different types of land use (agriculture, grassland, forestry) respectively vegetation cover (wetland), aiming at water protection and mitigating floods in the Pilot Action.

For reaching this aim, first of all human activities have to be identified, which are posing risk to water quality and quantity, flooding and consecutive to water management. Finally, a review of best management practices in the Pilot Action is presented.

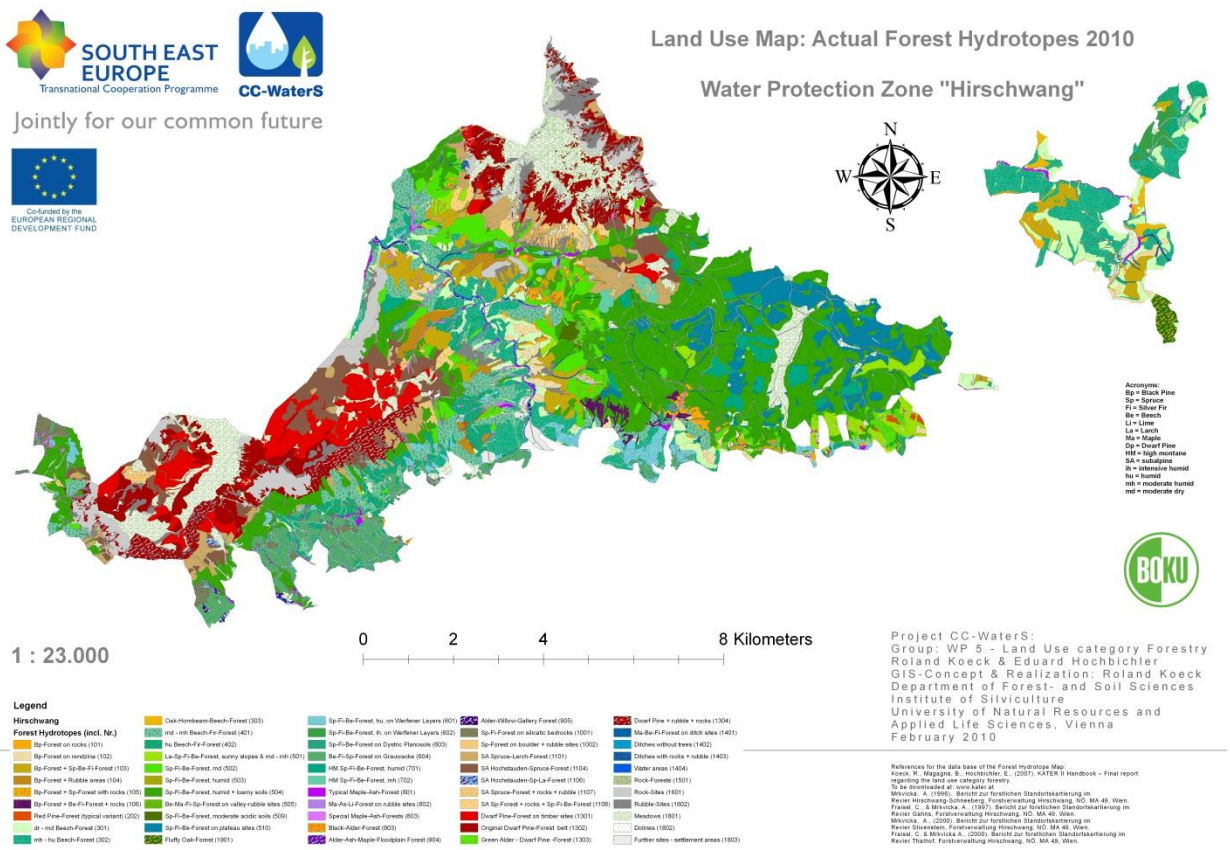
2. Land use, drinking water and flood protection in the Pilot Action

2.1. Land use

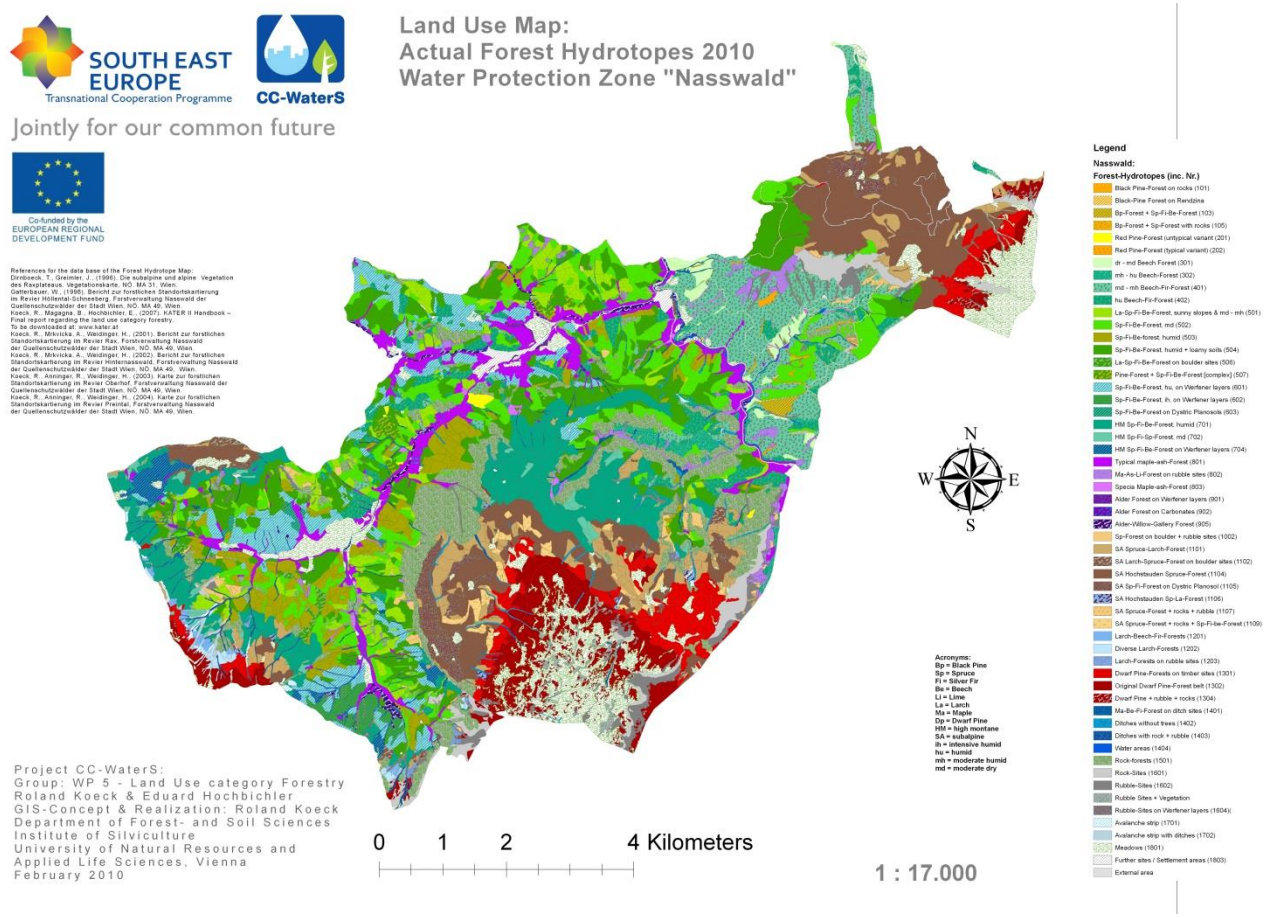
Within the Pilot Action City of Vienna (PAC1.1) the more accurate Forest Hydrotope Model (FoHyM) was used to display the land-use types within the drinking water protection zone (DWPZ) (see Pictures 1, 2 and 3). The land-use types are displayed in detail, and also the subalpine and alpine grassland types are visible. As the more accurate FoHyM exists for the PAC1.1, the usage is obligatory.



Picture 1: Forest Hydrotope Map of the Pilot Action City of Vienna, Forest District Wildalpen (Koeck and Hochbichler 2010).



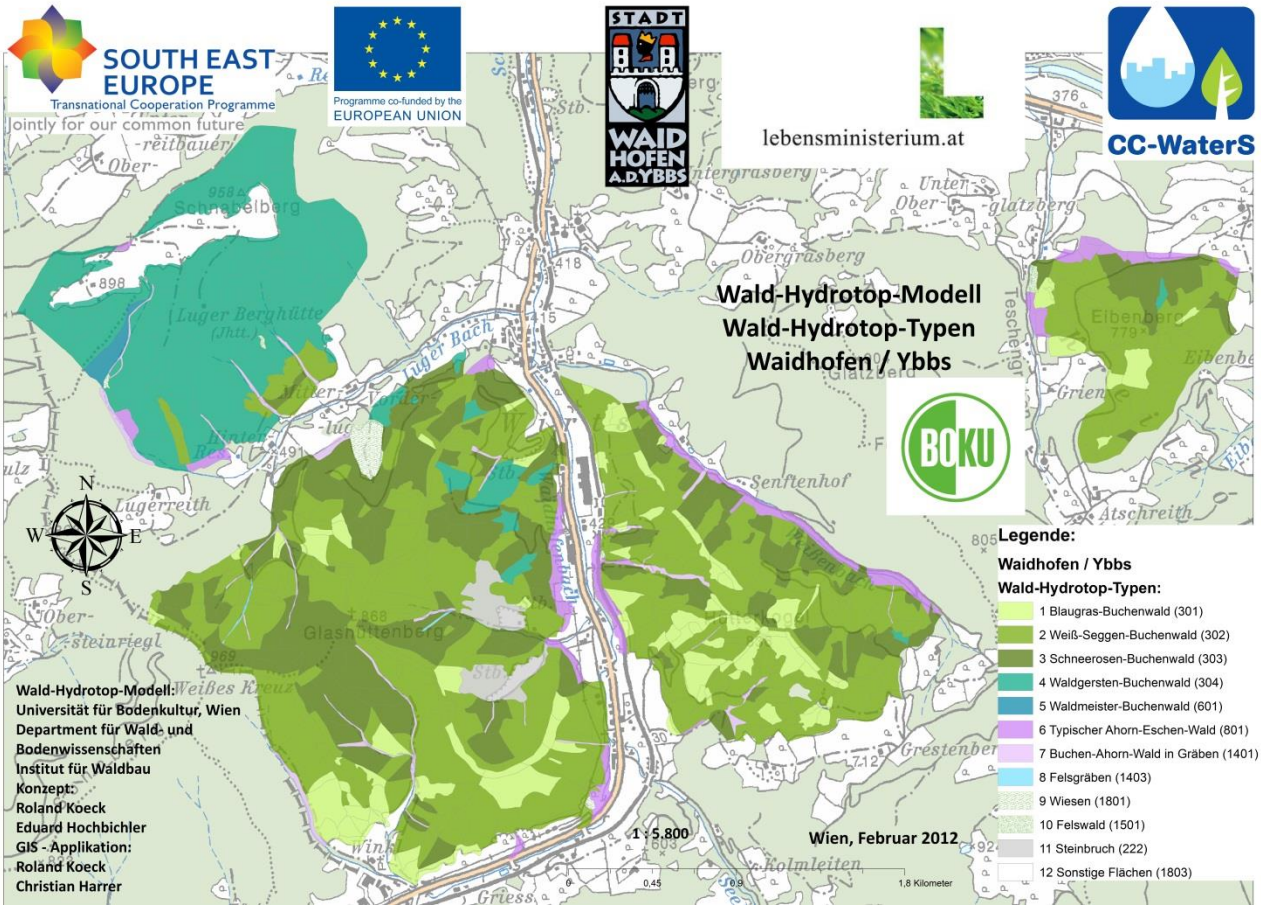
Picture 2: Forest Hydrotope Map of the Pilot Action City of Vienna, Forest District Hirschwang (Koeck and Hochbichler 2010).



Picture 3: Forest Hydrotope Map of the Pilot Action City of Vienna, Forest District Nasswald (Koeck and Hochbichler 2010).

Due to the fact that Corine Land Cover (CLC 2012) does not cover essential land use types within Pilot Action Waidhofen/Ybbs (PAC1.2), the forest hydrotope map again is displayed as alternative. Actually the small-scale resolution needed for PAC1.2 is not given through CLC 2012. The stone quarries situated within PAC1.2 are not displayed through the CLC 2012 data, but can be spatially related through the forest hydrotope map of PAC1.2 (Picture 4, grey colour, Koeck and Hochbichler 2012).

Hence all land use types given in PAC1.2 can be spatially related. The most important land-use category within the water protection zone (WPZ in PAC1.2 is encompassing 1086 ha) is forestry (86 %), followed by grassland cultivation (agriculture). The stone quarries situated within PAC1.2 are actually still in operation. One out of the two quarries has to be adapted due to a legal decree, which prescribes the creation of a 45° angle of the remaining stone-wall. This means that at this specific stone-quarry again extraction of stone material will take place, by the way forming a threat for the water resources.



Picture 4: Forest Hydrotope Map of the Pilot Action Waidhofen/Ybbs (Koeck and Hochbichler 2012).

The land use types within PAC1.1 and PAC1.2 are:

A:	Forestry	(Broadleaved Forests and Mixed Forests in PAC1.2, in PAC1.1 additionally coniferous forests)
B:	Grassland areas	(Agricultural grassland cultivation [PAC1.2] and in PAC1.1 additionally subalpine pastures)
C:	Urban Areas	(Continuous and discontinuous urban fabric, only in PAC1.2)
D:	Industry	(Industrial facilities, only in PAC1.2)
E:	Traffic Facilities	(Roads [PAC1.1 and PAC1.2] and Railways [PAC1.2])
F:	Stone Quarries and Gravel Pits	(two active ones, two other abandoned – in PAC1.2, Gravel Pits in PAC1.1)
G:	Tourism	(alpine huts, only in PAC1.1)

A: Forestry (PAC1.1 and PAC1.2)

Forestry exerts several pressures to drinking water quality. Within the PAC1.1 clear-cuts are forbidden. Through the application of **clear-cuts** by some forest owners within the PAC1.2 the mineralization processes within the soils are exaggerated. This process can potentially provoke the intrusion of soil substances into the aquifers, where they transform into pollutants of drinking water. Also erosion processes can be caused by clear-cutting, again forming a threat for water quality. All threats for water quality are also existent for flood prevention.

Elevated wild ungulate densities (red deer, roe deer, chamois, etc.) endanger the natural regeneration process of the forest ecosystems through browsing damages, by the way provoking potential erosion processes and causing the extinction of several tree species. A hindered natural regeneration process can destabilize the forest ecosystems and subsequently form a threat for water quality and also for water quantity, if surface runoff should be increased. The time-span until the negative consequences of browsing damages are visible at the level of water quality can last relatively long, but at this very moment the system behaviour would become impossible to control and any recovery of the ecosystem service drinking water protection would last very long time. Hence a forest-ecological balanced wild ungulate density has to be implemented immediately, for both drinking water protection (quality and quantity) and prevention of floods. In PAC1.1 on some areas the density of the ungulate species is already adapted towards a forest ecologically sustainable level. Despite that fact the wild ungulate densities have to be reduced within various areas of PAC1.1. Within the PAC1.2 the wild ungulate densities have to be reduced, as the whole area is affected by browsing damages.

Forest road construction and operation is another potential threat for water quality. This threat is always given during operation times of forest roads, as accidents with trucks or cars can happen within the WPZ. During the construction phase of the forest road, the threat of contamination of the aquifer is even higher. The highest danger is given if the forest road is crossing geological faults. A threat for water quantity is given through the drainage effect of forest roads, which especially is given within dolomite bedrock areas, as the natural lateral flow is concentrated within gullies and can lead to surface flow or to erosion processes. Again drinking water protection and flood prevention are both concerned. Forest road construction and operation is an essential challenge for drinking water protection within both PAC1.1 and PAC1.2.

Drinking water protection and flood prevention

The described pressures are relevant for both drinking water protection and flood prevention. All adaptations of land-use activities which are good for drinking water protection are also useful for flood prevention. One example is the avoidance of clear-cuts, which influences both drinking water protection and flood prevention in a positive way.

B: Grassland areas (PAC1.1 and PAC1.2)

Since centuries the water supply areas of Vienna (PAC1.1) are used as pastures mainly for cattle breeding. The problem for the water supply is microbial contamination due to manure. Through ponors and sinkhole the contaminants infiltrate into the aquifer.

This problem can be solved by regulating the pasture and applying different technical measures. Within PAC1.1 the situation is related to subalpine pasture areas, where also cow-dung and liquid manure exert pressure on water quality.

Within PAC1.2 the situation is clear. The pressures resulting from land-use activity grassland are caused by the application of liquid manure and manure and from grazing cattle. One spring is situated within the potential influence zone of the grassland area on Mount Schnabelberg.

The grassland activities impact above all water quality, in contrast water quantity and flood prevention are not affected.

C: Urban areas

Pressures resulting from urban areas can be identified in the field of potential contaminations caused by leaking sewage pipes or mineral oil contaminations stemming from heating systems or cars/trucks. Urban areas are relevant within PAC1.2.

The urban area activities impact above all water quality, in contrast water quantity and flood prevention are not affected.

D: Industry

Industrial facilities are situated within the WPZ of Waidhofen/Ybbs. Potential pressures resulting from them could be caused by leaking sewage pipes, mineral oil contaminations stemming from heating systems or cars/trucks or by the leakages of chemicals used in the production processes.

The industrial activities impact above all water quality, water quantity and flood prevention are not affected that much.

Within PAC1.1 there do not exist industrial facilities.

E: Traffic facilities

The traffic facilities situated within the WPZ of the City of Vienna are roads. The traffic facilities situated within the WPZ Waidhofen/Ybbs are roads and railways. The potential pressures caused by roads are contamination with mineral oil products (gasoline, oil products, etc.) and leakages of hazardous substances transported on the roads in case of accidents.

The potential pressures caused through the railway operation are leakages of hazardous substances transported on the railways in case of accidents, contamination with mineral oil products like diesel fuel, mineral oil and the impact of herbicides used for the railway maintenance. The use of herbicides was reduced by 75 % in the last years. This was possible through the implementation of automatic systems, which are able to recognize vegetation on the rail tracks and spray the pesticide only on those areas.

The traffic facilities impact above all water quality, in contrast water quantity and flood prevention are not affected that much.

F: Stone Quarries and Gravel Pits

The potential impacts of active stone quarries on the aquifers are resulting from the applied detonations, from the trucks which can cause oil-spills and from further applied chemicals like e.g. explosive materials. Also the handling of waste and waster waters may cause problems. Due to a new Austrian law the already abandoned stone quarries have to be shaped, stones are again mined, and the area of the stone quarries has to be extended for achieving the defined angle of the rock-faces. This causes an extension of the area where water infiltration into the aquifer does not occur in such quantity and quality like e.g. in the case of undisturbed soil layers. Rock areas facilitate surface runoff, what is not desired within DWPZ. Also filtration functionality of forest soils is not given in the case of stone quarries, as the soil layer was extracted there.

Stone quarries impact water quality, water quantity and flood prevention, as surface flow is increased through the bare rocks and are found within PAC1.2.

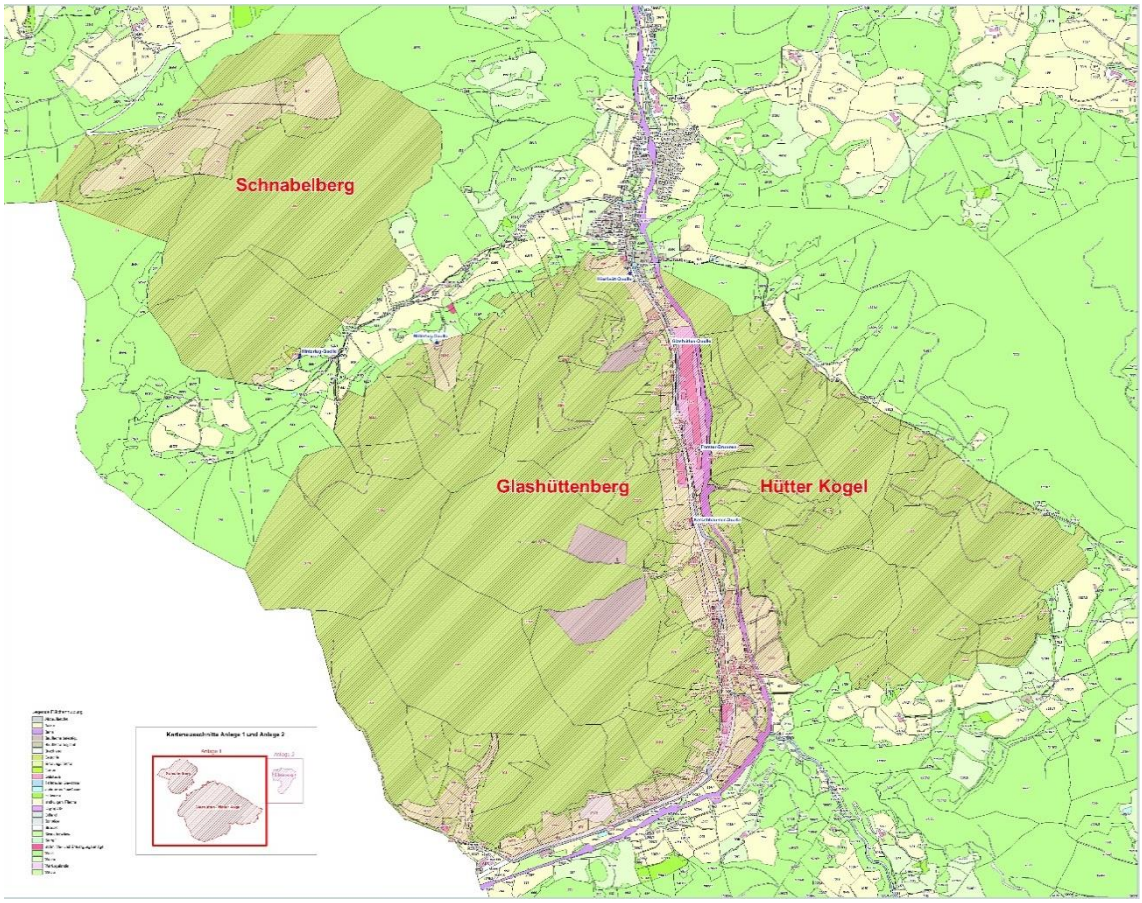
Gravel pits comprise also the danger of contamination with mineral oil products used in the trucks and excavators. But the danger linked to explosive materials is not given in this case. Gravel Pits are found within PAC1.1.

G: Tourism

Within PAC1.1 there is just soft tourism. Especially hiking and climbing are practiced. Problems arise mainly with the disposal of waste, waste-water and faeces.

To solve those problems scientific based investigations are indispensable. A thorough knowledge about the system and the processes in the system is essential. With scientific based arguments negotiations with other stakeholders and authorities can be started.

2.2. Drinking water protection



Picture 5: Water protection zone Waidhofen/Ybbs: Schnabelberg, Glashüttenberg and Hütter Kogel; Eibenberg is not displayed in this map (see Pic. 4).

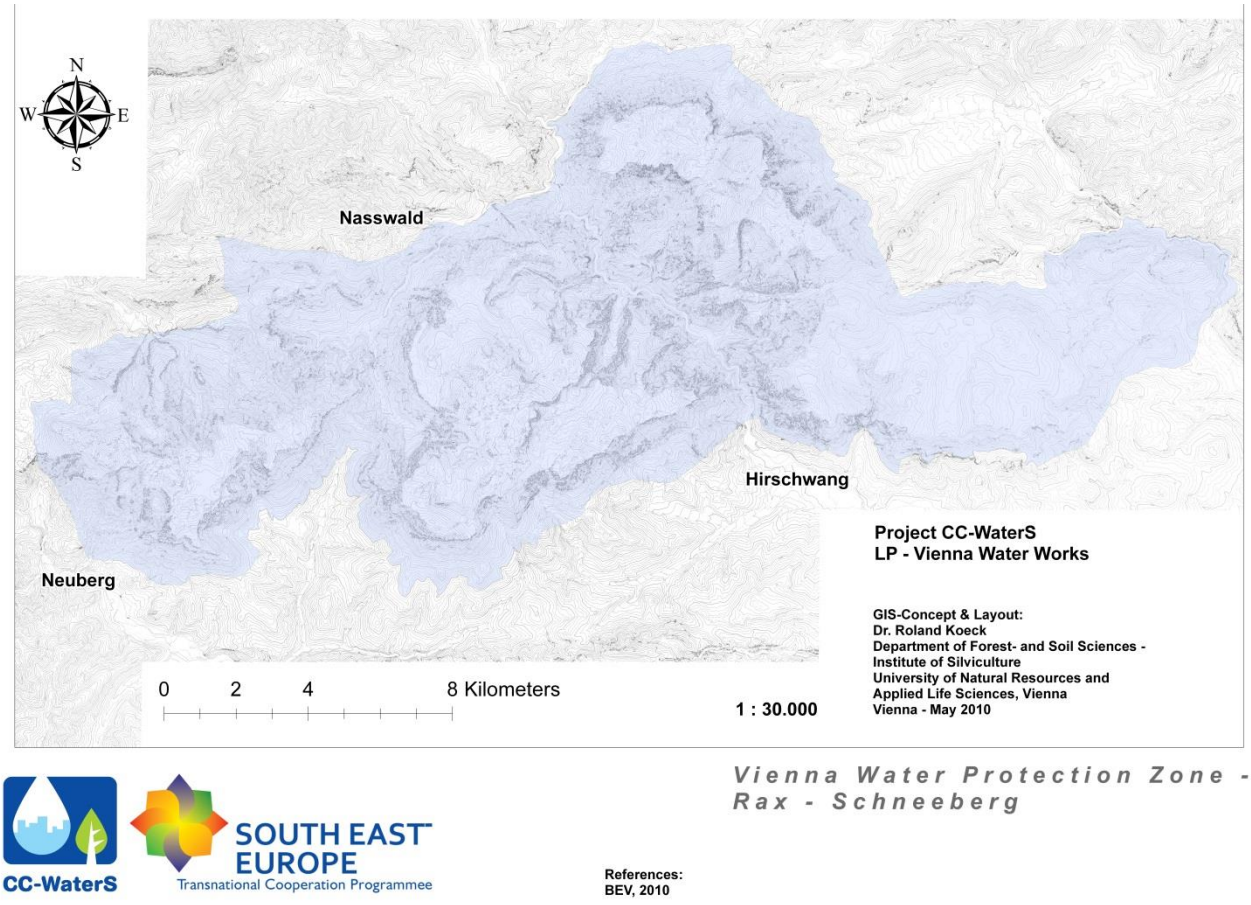
Table 1: Water Protection Zone of Waidhofen/Ybbs.

Category of protection	Area (ha)
Water Protection Zone	1086
Protection Zone I	1
Protection Zone II	18

The Pilot Action Waidhofen/Ybbs (PAC1.2) encompasses the water protection zone (WPZ) of the city. The whole WPZ covers 1086 ha. There exists the water protection zone I with 1 ha and the water protection zone II with 18 ha (table 1). Most of the area (86 %) is forested.

The small extension of PAC1.2 explains why the CLC 2012 data, which are not corrected, are not precise enough to display the different land cover types. Due to this situation the land use types within PAC1.2 are displayed by the forest hydrotope map and described in written form.

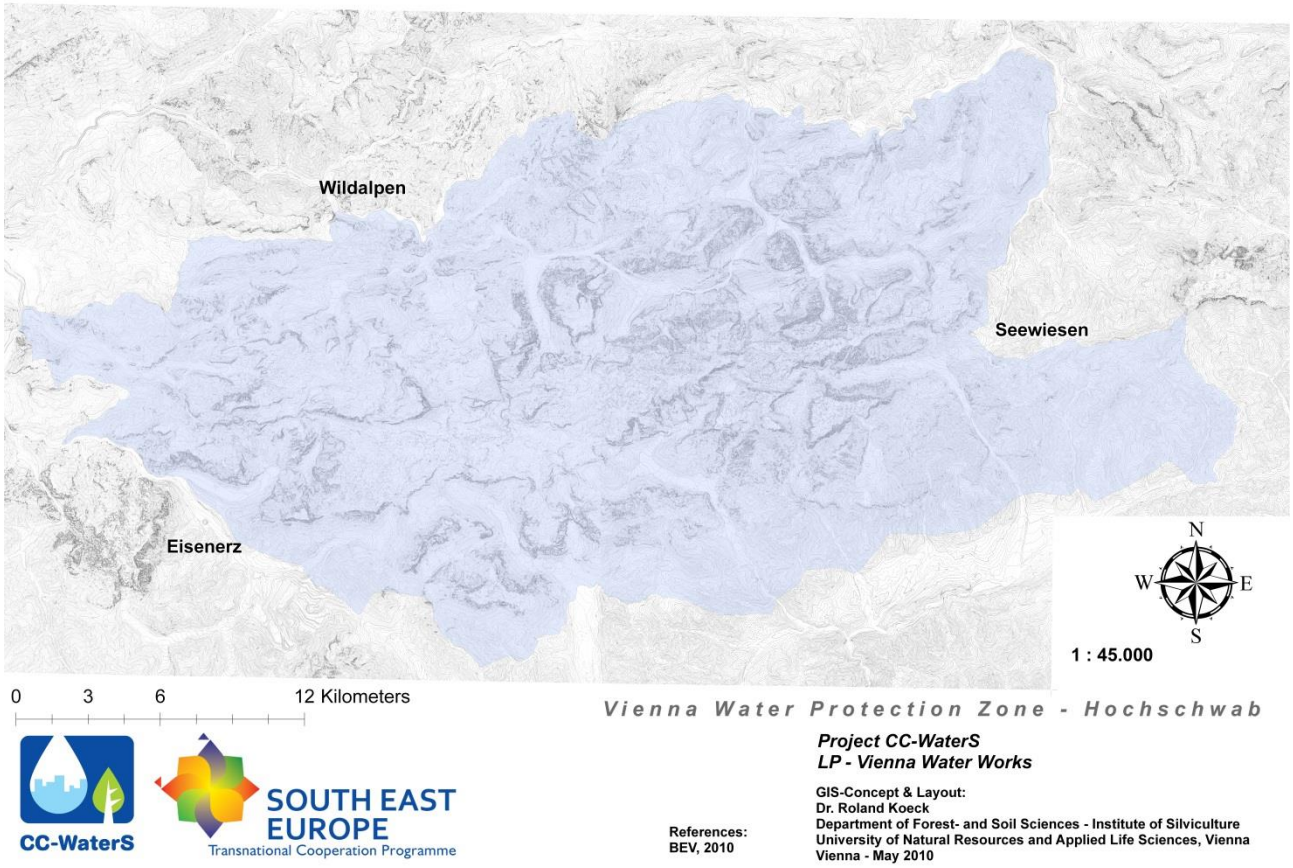
The Pilot Action City of Vienna (PAC1.1) covers the whole drinking water protection zone (DWPZ) of Mount Hochschwab, Rax, Schneeberg and Schneealm. The area is a legally decreed water sanctuary and covers 943 km^2.



Picture 6: Vienna Water protection Zone, Rax – Schneeberg – Schneealm (Koeck 2010).

Table 2: Water Protection Zone of Vienna.

Category of protection	Area (km^2)
Water Sanctuary Zone	943
Owned by the City of Vienna	330



Picture 7: Vienna Water Protection Zone, Hochschwab (Koeck 2010).

The City of Vienna owns 330 km^2 of the whole water sanctuary zone (German: Quellenschongebiet, Pic. 6, 7, 8)), which encompasses 943 km^2 (Table 2). The whole area is dominated by forests, which cover 63.9 % of the DWPZ. Subalpine pastures can be found on 7.5 % of the area, also dwarf pine communities (*Pinus mugo*) cover 8.9 % of the territory (Table 3).

Table 3: Land Cover Types within the PAC1.1 (water protection zone of the city of Vienna).

Land Cover Types	
Forests (63.9 %)	Subalpine Pastures (7.5 %)
Rock Areas (15.6 %)	Grasslands in valleys (2.5 %)
Dwarf Pine (8.9 %)	Artificial Surfaces (1.5 %)
Water Bodies (0.1 %)	

Picture 8: Schematic map of Vienna water supply.

3. Best Management Practices

3.1 Forest

BP MF1 Avoidance of the clear-cut technique

Description of the measure

The clear-cut technique (CCT) as silvicultural measure for timber yield and subsequent artificial recruitment techniques does not conform to water protection requirements, as it can cause contaminations of the aquifer or streams with nutrients and solid matter mobilized from plant, humus and soil compartments. Additionally CCT creates top-soil drought conditions, what causes water repellency of the soil and humus layers. Water repellency of the top soils increases surface runoff processes and hence is in contradiction to flood mitigation and also decreases groundwater recharge.

Measure advantages

Avoidance of CCT opens the path for a consistent water protection strategy. It assures the avoidance of the most threatening processes caused by forestry in terms of drinking water protection and flood prevention.

Challenges

The resistance of foresters towards the avoidance of CCT may be very strong, as CCT can be regarded as the most important silvicultural system applied in timber-yield forestry in Austria. It will need a lot of knowledge transfer strategies to convince foresters in Austria about this step.

PAC1.1-situation

Within the PAC1.1 the clear-cut technique is forbidden since 1985.

PAC1.2-situation

Within the PAC1.2 the clear-cut technique is still applied by some forest owners. It will be part of the stakeholder-processes to change this situation.

BP MF2 Establishment of a Continuous Cover Forest System

Description of the measure

Continuous Cover Forest System (CCF) ensures a sustained provision of the forest functions for drinking water protection and flood prevention. The forest stands of CCF are multi-layered, uneven-aged and built up by the potential tree species diversity of the specific forest site. Forest management activities have to be applied on small spatial scales hence supporting a low disturbance regime. CCF forms an excellent basis for drinking water protection and flood prevention.

Measure advantages

CCF as true alternative to the clear cut technique provides the basis for a consistent strategy in forestry with the overall purpose of drinking water protection and/or flood prevention. It ensures the water protection functionality of forest ecosystems over space and time.

Challenges

In Austria the application of CCF requires in most of the cases specific training, as the majority of foresters are used to apply the clear cut technique. PROLINE_CE can provide such trainings as first step in the course of the stakeholder workshops.

PAC1.1-situation

Within the PAC1.1 the CCF is applied since the last decade. Hence it will need several decades until the whole forest area can be described as CCF. Despite this fact the aim of silviculture is the establishment of CCF.

PAC1.2-situation

Within the PAC1.2 the CCF is still far from being applied. Most of the forests actually are treated via the classical age-class-system, comprising clear-cuts and artificial regeneration.

BP MF3 Defined Crown Cover Percentage of Forest Stands

Description of the measure

The actual given crown cover percentage of forest stands has to range between 70 % and 90 % in colline to mountain areas and between 60 % and 80 % in subalpine areas. This guarantees a high degree of stability towards disturbances like wind storms and additionally provides enough space and light for a continuous regeneration process. Mobilization processes in soil and humus layers are kept on a low level and it can be regarded as basic requirement for the establishment of CCF and for the sustained provision of the water protection functionality of forest ecosystems.

Measure advantages

The defined crown cover percentage for forest stands provides a clear frame for forestry in DWPZ. It is a very important BP and helps to secure the water protection functionality of forest ecosystems (together with other BP's).

Challenges

As timber production was and is the overall purpose for most of the Austrian forest regions, this BP can create discussions among foresters, as it requires a fundamental change in silvicultural concept and measure application.

PAC1.1-situation

In the course of silvicultural measures this BP is not applied. Communication efforts with the foresters could be a solution for this situation.

PAC1.2-situation

Within the PAC1.2 the implementation of this BP requires communication efforts with the forest owners. The incentives may be motivating enough to establish it.

BP MF4 Limitation of the Percentage of Timber Extraction

Description of the measure

The limitation of the percentage of timber extraction with 10-25 % of the forest stand volume during each silvicultural measure guarantees a low disturbance regime in forested DWPA. It helps to sustain stability of the forest stands and has to be applied together with the margins for crown cover percentage (BP MF3). The cutting frequency has also to be integrated.

Measure advantages

The limitation of the percentage of timber extraction has the great advantage that together with the application of BP MF 3 the sustained stability and resiliency of the forest stands and forest ecosystems can be facilitated. This is a basic condition for the protection of drinking water resources and from floods.

Challenges

Again the habitual management procedures in Austrian forestry will be an obstacle for the application of this BP, as it requires from the foresters a fundamental shift of timber yield patterns. Drinking water protection as overall purpose is still rather new and unknown for most of the foresters in Austria.

PAC1.1-situation

In the course of silvicultural measures this BP is also not applied. Communication efforts with regard to actual management procedures of the foresters could be a solution for this situation.

PAC1.2-situation

Some farmers within PAC1.2 act on small-scale level in terms of silvicultural operations, but most of the forest owners act like classical Austrian foresters hence the implementation of BP MF4 will require communication efforts.

BP MF5 Continuous Regeneration Dynamics

Description of the measure

Forest stands in DWPZ have to host a continuous regeneration phase on minimum 10-20 % of their spatial extension. This ensures the highest degree of resilience, as in case of disturbances the water protection functionality of the forest can be restored the fastest way. Continuous regeneration is a basis condition for CCF, as it provides the basis for uneven-aged forest stands. In case of natural forest stands it also ensures the natural regeneration of autochthonous genetic material, which is of crucial importance for stability and resilience, especially under climate change.

Measure advantages

Continuous regeneration dynamics provide a basic condition for forest ecosystem stability and resiliency. Only if young trees can grow without hindrances in all forest stands and ecosystems, the system stability and also the water protection functionality are given on a high level.

Challenges

In Austria the high wild ungulate densities are the greatest threat for a continuous regeneration dynamic. Browsing damages occur wide spread and also several DWPZ are affected. To solve this issue is a true challenge, as the hunter organisations have a strong lobby and do not want to have significant changes, as those could affect their hunting habits.

PAC1.1-situation

Within the PAC1.1 area the natural regeneration process of the forest ecosystems is a declared aim. Through the reduction of the wild ungulate densities within the PAC1.1 some areas already show continuous regeneration dynamics. In some parts of the WPZ the reduction of the wild ungulates still needs some time, hence also natural regeneration is still hindered there. Those areas are declared management intervention zones.

PAC1.2-situation

Within the PAC1.2 the high wild ungulate densities exert a major hindrance for natural regeneration dynamics. Actually the continuous regeneration dynamics of the forest ecosystems within the PAC1.2 can be used as indicator for forest ecologically balanced wild ungulate densities. If natural regeneration of all tree species takes place on an optimal level, the challenge of elevated ungulate densities can be regarded as solved.

BP MF6 Foster Stability, Vitality and Resilience of the Forest Ecosystems

Description of the measure

In DWPZ stability, vitality and resilience of the forest ecosystems are the most important features. Stable forest ecosystems and forest stands can resist any given disturbance. In case of strong disturbances, resilient forest ecosystems can recover their water protection functionality

rapidly. The vitality of the tree individuals and of the whole forest ecosystem is the basic condition for stability and resilience.

Measure advantages

Stability, vitality and resilience are the most important features of forest ecosystems in DWPZ. Hence any activities to foster those are important for drinking source water protection and flood prevention. The purpose in silviculture moves from high quality timber trees towards stable and vital trees, what makes a definite difference.

Challenges

This change in silviculture requires again a renunciation from habitual procedures in forest management. The foresters have to be trained towards perceiving the most stable and vital trees and also towards a consequent implementation of fostering stable and vital tree individuals.

PAC1.1-situation

Within the PAC1.1 the improvement of stability and resilience of the forest stands is part of the internal guidelines. The implementation of it will need further training for integrating new views. Despite this fact the actual silvicultural practices already focus on the improvement of stability.

PAC1.2-situation

The focus of the stakeholder trainings will have to be put on the necessity to increase stability of the forest ecosystems. Also BP MF6 will have to be integrated into the stakeholder program.

BP MF7 Tree Species Diversity According to the Natural Forest Community

Description of the measure

Tree species diversity according to the natural forest community guarantees the highest level of stability and resilience. Tree species diversity provides a high level of adaptability, also under climate change. Forest stands created by diverse tree species can utilize a broader scope of the forest soils, if deep-rooting and shallow-rooting trees are growing together. Knowledge about spatial distribution of the natural forest communities (forest hydrotopes) is required for the operational stratification of the DWPA and adaptive forest management. Man-made plantations with not-natural tree species should be transformed gradually to stands dominated by native species, depending on the local experience and legislation.

Measure advantages

In many Austrian forests tree species diversity according to the natural forest community is a definite advantage, as homogeneous conifer plantations are actually dominating the forests. Especially in times of climate change tree species diversity becomes mandatory for achieving forest ecosystem stability. Diversity has also positive side effects, like e.g. for conservation purposes.

Challenges

In some forest areas there can be expected resistance against tree species diversity according to the natural forest community, if the habitual forestry practices had a strong focus on conifer plantations or other homogeneous timber yield focused plantations.

PAC1.1-situation

The Forest Hydrotope Model was elaborated within the PAC1.1 on behalf of the city of Vienna. It is a declared forest management goal to implement the natural tree species diversity according to the different forest hydrotope types. The process is ongoing, as on huge forest areas homogeneous conifer plantations were created.

PAC1.2-situation

Within the PAC1.2 the forest hydrotope map is available for the definition of the silvicultural targets to be fulfilled in terms of tree species diversity. The current trend to plant conifer tree species has to be reversed through persuasive efforts, which may be supported by the incentives intended for adequate forestry in terms of water protection. BP MF7 is relevant for both drinking water protection and flood prevention.

BP MF8 Improve the structural diversity of the forest stands

Description of the measure

Forest stands in DWPZ should be structured vertically and horizontally. This involves tree species diversity as well as uneven-aged and multi-layered forest stands. Structural diverse forest stands are a basic requirement for continuous cover forest systems. Stability and resilience are improved in case of structural diverse forest stands.

Measure advantages

Structural diversity in forest ecosystems provides an improvement of forest stand stability and additionally is necessary for CCF (continuous cover forest systems). Hence it has to be followed as purpose in forest management within DWPZ to achieve structural diversity.

Challenges

As most of Austrian forest stands are based on the age-class system, structural diversity is actually not very common. Most of the forest stands are even-aged and only single-layered. The change of silvicultural practices towards structural diverse forest stands will have to involve both persuasive efforts and training of the foresters.

PAC1.1-situation

Structural diversity is created through small-scale silvicultural measures. Those have to be implemented with continuity. The purpose of forestry within PAC1.1 is the creation of structural diverse forest stands. The implementation of this guideline is a true challenge hence training sessions for foresters could solve this situation.

PAC1.2-situation

Within PAC1.2 the creation of structural diversity depends on the forest owner. Some farmers already create structural diverse forest stands by implementing small-scale measures. Huger forest owners implement the clear-cut technique and create homogeneous forest stands. The implementation of structural diversity will have to be part of training programs in connection with the project-goals.

BP MF9 Forest Ecologically Sustainable Wild Ungulate Densities

Description of the measure

High wild ungulate densities provoke severe browsing damages on tree seedlings and saplings, fraying damages and bark-peeling damages. Those inhibit the natural regeneration process of whole forest ecosystems or destabilize those. Natural regeneration is the crucial process in forest ecosystems, which has to be given on an optimal level for all present tree species, especially within DWPA. This can only be guaranteed, if the wild ungulate densities are regulated to a forest ecologically sustainable level, hence providing vital regeneration of all tree species.

Measure advantages

Forest ecologically sustainable wild ungulate densities provide the huge advantage that the forest ecosystems can evolve naturally, can grow according to their natural inner dynamics. This includes a vital regeneration layer within the forest stands, encompassing all tree species of the respective natural forest community. It is the most essential precondition for providing the water protection functionality of forest ecosystems.

Challenges

In Austria the high level of wild ungulate densities is the greatest threat for a continuous regeneration dynamic. Browsing damages occur wide spread and also several DWPZ are affected. To solve this issue is a true challenge, as the hunter organisations have a strong lobby and do not want to have significant changes, as those could affect their hunting habits. To establish forest ecologically sustainable wild ungulate densities can be regarded as the main challenge in the Austrian forest sector.

PAC1.1-situation

Within PAC1.1 some areas show already forest ecologically sustainable wild ungulate densities which is indicated by the vital development of natural regeneration of all relevant tree species. But some areas still need further efforts to establish forest ecologically sustainable wild ungulate densities. Hence the situation has to be seen differentiated.

PAC1.2-situation

Within PAC1.2 high wild ungulate densities form a major threat for forest ecosystem stability. This endangers both drinking water protection- and flood prevention functionality of the forest ecosystems.

BP MF10 Protection of the Gene Pool of the Autochthonous Tree Species

Description of the measure

Autochthonous tree species have evolved since thousands of years in their specific forest regions. They carry the genetic information, which allowed them the survival of the past climate changes in those areas. They are the basis for the establishment of the natural forest communities (BP MF 7). Tree species diversity is dependent on them.

Measure advantages

Autochthonous tree species are the basic requirement for forest ecosystem stability. They carry a lot of genetic diversity and are the best in coping with the local climatic conditions. In times of climate change their value becomes priceless.

Challenges

In Austria in some regions it could already become difficult to find autochthonous tree species, especially in such where only Norway spruce (*Picea abies*) was planted, always using only the varieties with the greatest increment levels. Again persistence can be expected, if the change from high-timber-yield species towards more stable autochthonous species is envisaged.

PAC1.1-situation

As the paradigm of natural regeneration is part of the silvicultural strategy within PAC1.1, the gene pool of autochthonous tree species is still at a high level. There also exist wide spread forest areas, where the tree species composition of the natural forest community (forest hydrotope type) is still given. It is recommended to mark tree individuals which should provide their genetic material for longer periods (strong, huge and vital trees).

PAC1.2-situation

The current situation provides a good starting point for the protection of autochthonous tree species, as there still was identified a high share of those within the forest area of PAC1.2 in the course of the hydrotope mapping survey. Those individuals of each species just have to be identified and marked in order to protect their gene pool.

BP MF11 Foster old, huge and vital tree individuals

Description of the measure

Old, huge and vital tree individuals carry excellent genetic information. They can supply younger and smaller tree individuals with nutrients via their common mykorrhizal network. Thereby they provide a substantial contribution to forest stand stability. Therefore they have to be selected and protected, so that they can provide their services as long as possible.

Measure advantages

The genetic information provided by old, huge and vital tree individuals has a high value for the sustainability of the forest ecosystem. Old and huge tree individuals can provide stability for the whole forest stand (in a quasi-mechanical way) and are also important for the nutrition of young

trees (including the regeneration phase), who may receive nutrients from the old trees via the mycorrhiza-interconnected root system.

Challenges

The old, huge and vital tree individuals have to be selected for remaining in a forest stand. In recent times huge trees in Austria are in general selected for being cut. This change of behaviour has to be achieved through information and persuasive efforts.

PAC1.1-situation

The selection of old, huge and vital tree individuals with the purpose to remain in the forest stand is envisaged by some foresters. In order to implement this Best Practice more consequently, information transfer to the foresters would be an adequate solution.

PAC1.2-situation

Selection and marking of those stable and old tree individuals should be executed in order to become aware about the stability-network within the forest stands/forest ecosystems. Until now such an effort has not been undertaken within the PAC1.2, but this could be a first step towards a target-oriented silviculture, which supports both drinking water protection and flood prevention.

BP MF12 Adequate Dead-Wood Content

Description of the measure

In DWPZ, coarse dead-wood has to be present in each forest area in adequate quantity and quality. Coarse dead-wood is a habitat and an ecological niche for many organisms with relevance for forest stability, especially insects. Also owl species, which depend on standing dead-wood, can improve forest stand stability by controlling mouse populations. Lying coarse deadwood provides space for nurse-log regeneration.

Measure advantages

Deadwood is an important feature of biodiversity in forests as it improves the ecological conditions and hence is a pre-condition for the establishment of stable and vital forest ecosystems. Dead-wood keeps the forest ecosystems alive, as the multitude of organisms living in and on it can be explained as fundamental for the interdependencies within forests. The measure does not cost very much and the effect is strong. Besides, dead-wood also acts as water storage.

Challenges

To keep standing and lying dead-wood in forest stands is still a challenge for some foresters, as they have the tendency to yield each single tree. Again in some cases the change of behaviour has to be achieved through information and persuasive efforts.

PAC1.1-situation

Within the PAC1.1 the awareness regarding adequate dead-wood content in the forest stands is elaborated. The foresters created “woodpecker-trees” (standing dead-wood) and have the declared aim to leave a certain amount of dead-wood within the forest stands.

PAC1.2-situation

The dead-wood content within the forest ecosystems of PAC1.2 in most of the cases can be described as satisfactory. Hence BP MF12 is not rated with priority for implementation within PAC1.2.

BP MF13 Buffer Strips along Streams, Dolines and Sinkholes

Description of the measure

Streams are sensitive sectors in many DWPZ and hence have to be protected with highest priority. Buffer strips with dense and vital forest cover can protect the streams from direct infiltration of sediments or nutrient loads and from lateral erosion. Forest vegetation has to be stable in buffer strips and management operations have to be carried out extremely cautious. Dolines and sinkholes are karstic features and deserve the same attention like streams, buffer strips are also an adequate solution there.

Measure advantages

The protection of the stream-banks from lateral erosion processes through a vital forest cover can be regarded as the most crucial effect of buffer strips, as lateral erosion could mobilize huge amounts of soil-, gravel- and rock material, endangering both water supply facilities and human infrastructure in general. But also the protection from nutrient loads and sediments is relevant. Buffer strips along streams are one of the classical Best Practices on global scale. Additionally the shadowing effect of them on the stream is relevant for keeping the waters relatively cool.

Challenges

Actually there can be identified a trend in Austria, where Buffer Strips along streams are clear-cut. This trend has to be reversed, as the protection from lateral erosion processes is more important. The balance between driftwood prevention and preservation of the forest cover along streams has to be found, what maybe could lead to multi-dimensional discussions in some cases. The most important purpose within this context has to be the most efficient flood mitigation/prevention/protection functionality of the system Streams/Forest Ecosystems. It will have to come to a trade-off between lateral erosion prevention and drift-wood prevention. The huge threat-potential of lateral erosion processes has to be taken into account. This situation is valid for both mountain and plain (flatland) stream systems.

PAC1.1-situation

Buffer strips along streams are a vital means for erosion control within the PAC1.1. The protection and adapted management of those can still be described as challenge. Some foresters keep the adequate forest cover along streams, others have cut it totally. Hence a guideline for

the whole PAC1.1 should be elaborated in order to keep the buffer strips with vital and stable forest cover.

PAC1.2-situation

Within the PAC1.2, buffer strips along streams are also forming a vital means for erosion control and hence have to be protected from being clear-cut. This is of essential interest for both drinking water protection and flood prevention.

BP MF14 Adaptive Forest Management under Climate Change

Description of the measure

Climate change can alter the growth conditions for forest ecosystems significantly. For ensuring the provision of the ecosystem service (ES) 'drinking water protection', adaptive forest management towards climate change has to be applied. This involves a strategic procedure, where the evaluation of both climate development regarding the climate change scenarios and of forest succession has to be carried before concept-design. The concept-design of adaptive management can demand various measures like e.g. the support of the migration of certain indigenous tree species.

Measure advantages

Adaptive forest management under climate change ensures the provision of the Ecosystem Service (ES) 'Drinking Water Protection' over space and time. This is elementary for water protection issues.

Challenges

In Austria there actually can be identified various attempts to adapt forest ecosystems towards climate change. The most important fact in DWPZ is the use of indigenous tree species for reaching this goal, what could result in discussions in various cases, as there can be identified a tendency to use alien conifer or deciduous tree species for adaptation. This could be very dangerous as their stability in our climate is not proved. Hence the use of alien species for forestations or afforestations is not acceptable within DWPZ. Again in some cases information transfer and persuasive efforts will have to be applied.

PAC1.1-situation

The strategy to adapt the forest ecosystems to climate change were described in detail in the course of the CC-WaterS project. For each forest hydrotope type the strategy was elaborated. For the current time the establishment of the natural tree species diversity of each hydrotope type is the most crucial activity. This is the defined goal of silviculture within PAC1.1. Further adaptations can first be implemented, if the climate evolves further towards the predicted situation.

PAC1.2-situation

Some alien tree species were planted in the past. The strategy to adapt the forest ecosystems to climate change were described in detail in the course of the CC-WaterS project. For each forest hydrotope type the strategy was elaborated. For the current time the establishment of the natural tree species diversity of each hydrotope type is the most crucial activity. Further adaptations can first be implemented, if the climate evolves further towards the predicted situation.

BP MF15 Natural Forest Succession in Case of Stable Forest Ecosystems

Description of the measure

In some cases forest ecosystems already fulfil all criteria of an adequate drinking water protection forest. Tree species diversity and distribution, uneven-aged and multi-layered structure of the forests are given and stability, vitality and resilience have to be given on an optimal level. Wild ungulate densities are forest-ecologically balanced and the self-regulating force of such forest ecosystems is given on a high level. If all these criteria are fulfilled, forest management measures within those forest ecosystems can be suspended and natural succession can take place, until an urgent need for management measures implementation should arise.

Measure advantages

This measure assures a low disturbance regime for the included forest areas. This is of crucial interest for water protection. Also conservation targets can be achieved with this measure.

Challenges

It is not very common in Austria to let natural forest succession take place outside from national parks and natural forest reserves. Within DWPZ this measure could be a solution for achieving necessary goals, but again persuasive efforts will have to be applied.

PAC1.1-situation

Within the DWPZ of the City of Vienna there already exist forest conservation reserves, which are protected from ongoing management interventions due to their close-to-nature status of forest stands and their stability.

PAC1.2-situation

Within the PAC1.2 there could be identified such stable forest ecosystems in future, actually the challenges like browsing damages on most of the tree species do not allow natural forest succession on a huger area. If the frame-conditions should be given in future, this could be an appropriate tool for some remote forest areas.

BP MF16 Small-Scale Regeneration Techniques

Description of the measure

Within DWPZ the applied regeneration techniques have to be carried out on small-scale areas. This is an essential contrast to the clear-cut technique and supports forest stand stability during the mostly natural regeneration phase. The adequate techniques are e.g. group selection cuts, single tree cuts or small-scale gap cuts. There has to be given the balance between light-provision for the regeneration of the forest trees and the stability of the remaining forest stand.

Measure advantages

Small Scale regeneration techniques like single tree cutting, small gap cutting or group selection system assure a low disturbance regime within the context of forest management measures and give advantage of the natural seed regeneration. This allows and supports the overall purpose of drinking water protection. The remaining forest stands can be kept in stable conditions and the conditions for natural or artificial regeneration dynamics are created.

Challenges

Small scale regeneration techniques are in the clear-cut country Austria not very common, but in general well known. In some DWPZ they are common (City of Vienna) or have been tested (in Waidhofen/Ybbs during the project CC-WaterS). The need to apply them within DWPZ will have to encompass information transfer and persuasive efforts.

PAC1.1-situation

As the clear-cut technique is forbidden within the PAC1.1, small-scale regeneration techniques are already applied there.

PAC1.2-situation

Some farmers apply small-scale regeneration techniques within the PAC1.2. The challenge is to provide for the whole WPZ the implementation of BP MF16, what will require persuasive efforts in case of many forest owners within the PAC1.2, which still apply the clear-cut technique. Again the incentives will be an important motivator.

BP MF17 Structural Thinning Operations

Description of the measure

In order to create uneven-aged and multi-layered forest stands, structural thinning can be applied. The focus is on the improvement of forest stand stability. Stable trees remain and unstable ones are removed. The structure of the forests is improved in terms of the creation of uneven-aged and multi-layered stands with a wide diameter-distribution. The spatial distribution of the thinning measures is determined by the improvement of structure and stability within the forest stands. The structure of the forest stands should be given on a horizontal and vertical level. Also the tree species diversity according to the forest hydrotope type (natural forest community) has to be given and hence is facilitated by structural thinning.

Measure advantages

Structural thinning can create more stable forest stands by widening the diameter-distribution, by the way increasing the age-distribution and structural diversity of them. This supports forest stand stability and resiliency and facilitates the establishment of the intended continuous cover forest system (CCF).

Challenges

Structural thinning is not very well known in Austria's forestry enterprises and hence will need to be taught to foresters.

PAC1.1-situation

Structural thinning is applied within the PAC1.1 in some cases, all times depending on the expertise of the forester.

PAC1.2-situation

Structural thinning does not seem to be part of the silvicultural operations within the PAC1.2, hence it will have to be communicated as alternative.

BP MF18 Artificial Recruitment Techniques

Description of the measure

Artificial recruitment techniques become necessary in cases, if the natural regeneration dynamics do not provide adequate results in terms of tree species composition and/or of quantity of tree seedlings and saplings. It is mandatory to use autochthonous plant material in order to maintain forest stand stability in a sustainable way. Artificial recruitment may also become necessary as measure under climate change, if migrating tree species have to be supported.

Measure advantages

Artificial recruitment techniques are in some cases the only way to establish regeneration phases within forest ecosystems. Hence they are an indispensible factor for the facilitation of stable forest ecosystems. It never can be excluded that there arises the need for the application of artificial recruitment techniques. It is of crucial importance to use only indigenous tree species according to the forest hydrotope type (natural forest community) for planting.

Challenges

Artificial recruitment techniques are very well established in Austrian forestry hence their application should be easy. The use of indigenous tree species only will provoke in some cases discussions – these have to be lead with the purpose of transporting the cornerstones of source water protection through adaptive forest management.

PAC1.1-situation

As natural regeneration is the paradigm within PAC1.1, artificial recruitment techniques are only applied in exceptional situations. It is recommended to extend the application of artificial recruitment techniques under pending circumstances of forest stability.

PAC1.2-situation

Artificial recruitment until now was performed with conifer species like Norway spruce, European larch or Douglas fir. Except European larch, the other species do not show high adaptability within the PAC1.2. Hence the focus should be placed on the set of natural tree species defined for each forest hydrotope type.

BP MF19 Forest Fire Prevention

Description of the measure

Forest fire prevention is of vital interest for the integrity of forest ecosystems, especially if they are providing a continuous protection of drinking water supply. Climate change and other challenges threaten forests and their protection and production functionality. According climate change simulations forest fires could increase in future. For this reason it is necessary that forest management practices address principles that ensure fire prevention. Fire prevention measures require attention from all authorities, especially from those responsible for forest management. Forest fire prevention does not only protect life, environment and natural heritage, but in most cases is the most effective strategy to reduce damages.

Measure advantages

As the effects and impacts of forest fires are disastrous for the water protection functionality of forest ecosystems (both for drinking water protection and for flood prevention), forest fire prevention becomes crucial for DWPZ. Especially in countries with a high risk of forest fires this is of prior importance, but also other countries like Austria have to be aware about the threat of forest fires and should have prevention and mitigation concepts available.

Challenges

As Austria is a quite humid country, the forest fire prevention concepts are not that wide spread like e.g. in Mediterranean countries. Despite this fact the forest fire prevention concepts and strategies have to be elaborated for DWPZ.

PAC1.1-situation

It is recommended to elaborate forest fire preventions concepts and strategies for the PAC1.1 (DWPZ), as in Austria the tools for fighting forest fires should be improved.

PAC1.2-situation

It is recommended to elaborate forest fire preventions concepts and strategies for the PAC1.2 (DWPZ), as in Austria the tools for fighting forest fires should be improved.

BP MF20 Limitation of Forest Roads

Description of the measure

Forest Road construction and maintenance can cause several adverse impacts on water bodies and should hence be limited in DWPZ. The increase of surface runoff and of water storage loss is the main negative effect. Only in cases, if forest roads are necessary for the stabilization of forest areas, their construction could be considered. In those cases their construction has to meet strict environmental restrictions.

Measure advantages

For avoiding potential contaminations and hydrological adverse impacts caused by forest roads, the limitation of their construction within DWPZ is an indispensable need.

Challenges

In Austria forest roads and their construction is a cornerstone of "normal management situations". Foresters tend to construct forest roads. Hence it is very difficult to convince them about the need of abstaining from constructing them. Focused information transfer and persuasive efforts will have to be applied.

PAC1.1-situation

Also in PAC1.1 the construction of new forest roads should be limited or stopped. The potential negative impacts of forest roads on the aquifers require such a decision.

PAC1.2-situation

The limitation of forest roads has to be implemented within the PAC1.2. Forest owners have to be convinced that incentives are only possible if they confirm to abstain from further construction activities.

BP MF21 Adequate Timber Yield Techniques

Description of the measure

In DWPZ the applied timber yield techniques should prevent the disturbance of the soil- and humus layers. In the case of mountainous forest sites the application of the skyline-crane system or animal-traction systems is recommended. The tractor-skidding method should only be applied in exceptional cases and the soils must then be frozen or dry. With the cable-crane system the assortment-technique (cut to the length method) has to be applied and the whole-tree harvesting method has to be avoided. In flat areas the tractor-skidder method has to be applied in times when the soils are frozen.

Measure advantages

The application of adequate timber yield techniques has the advantage that the soil and humus layers are kept in desirable conditions, by the way providing the full level of forest ecosystem services "water protection". Also the remaining forest stand can be kept stable.

Challenges

In many cases there will be a tendency to apply the cheaper tractor-skidding method, also in steep terrain. This will have to be opposed, as within DWPZ only the water protection functionality and the ways to protect this should be followed. Again focused information transfer and persuasive efforts will have to be applied.

PAC1.1-situation

Within the PAC1.1 there can be identified a strong focus on the skyline-crane method, as the DWPZ is situated in a rather steep alpine landscape. Despite that fact the tractor-skidding method is still applied on less inclined forest sites. This should be subject of discussion, as this method should be avoided within DWPZ.

PAC1.2-situation

Incentives for the forest owners have to be restricted to the application of the skyline-crane method, animal-traction systems or hand-craft traction. The tractor-skidding method has to be avoided due to negative effects on drinking water protection and flood prevention.

BP MF22 Prohibition of the Use of Chemicals in Forestry Practices

Description of the measure

Chemicals like fertilizers, pesticides or herbicides are substances which form a threat for water quality and hence should not be present in forested DWPA. In forests their use is generally only marginal. Despite this fact their use has to be prohibited within forested DWPA. The absence of the application of those chemicals is a crucial advantage of forested watersheds in contrast to agriculturally used ones.

Measure advantages

Pesticides and other agro-chemicals form a strong threat for source water quality in agriculturally used watersheds. The absence of the application of those chemicals is a crucial advantage of forested watersheds in contrast to agriculturally used ones. Hence this measure has to be applied with ultimate consequence.

Challenges

In Austria the application of chemicals in forestry is rare, but in some cases present. Within DWPZ the use of chemicals is in general prohibited. If this should not be the case, focused information transfer and persuasive efforts will have to be applied.

PAC1.1-situation

The application of chemicals within the DWPZ of PAC1.1 is restricted, and within the forest area of the city of Vienna chemicals are totally forbidden.

PAC1.2-situation

The use of chemicals will be regulated with the decreed water protection zone. It has to be avoided strictly within the DWPZ.

BP MF23 Source Water Protection Policy and Institutional Implications

Description of the measure

In Austria, like in most of the CE partner countries substantial administrative deficits were identified in legislation within the context of the protection of DWPZ and source water quality and quantity. An integrated source water protection policy (SWPP) has to integrate all potential impact factors on water resources. The establishment of an adequate legislative and administrative frame would be a fitting outcome.

Measure advantages

Integrated source water protection policy takes all potential drivers, pressures and impacts on drinking water resources into account and defines routines for adequate response. This results in an encompassing drinking water protection and flood prevention/mitigation policy, which secures water resources.

Challenges

In Austria the PROLINE-CE output DriFlu Charta will form a step towards the elaboration and implementation of such an integrated source water protection policy.

PAC1.1-situation

For PAC1.2 the PROLINE-CE output DriFlu Charta will form a step towards the elaboration and implementation of such an integrated source water protection policy.

PAC1.2-situation

Also for PAC1.2 the PROLINE-CE output DriFlu Charta will form a step towards the elaboration and implementation of such an integrated source water protection policy.

BP MF24 Integrative Planning Strategy for Watersheds (Forest Ecosystems with drinking water protection as focus)

Description of the measure

The operative activities within watersheds (DWPZ) need a detailed planning process in order to be efficient. The water protection functionality (WPF) of the forest ecosystems has to be given over space and time. Deviations from an optimal WPF have to be detected by the screening of the current forest dynamics (monitoring). A GIS-based integrative planning strategy provides an efficient schedule for improving or maintaining the WPF of the forest ecosystems. Integration of all relevant impacts on source water protection into the planning strategy is required. The implementation of an adequate watershed classification according to the regional indicators, like e.g. vulnerability of the local ecosystems, tree species sets, etc. have to be set up for each DWPZ.

Measure advantages

The integrative planning strategy would establish a structured and operative tool for well-established management for DWPZ.

Challenges

The establishment of an integrative planning strategy in DWPZ would need the commitment of all involved stakeholders towards it. It would be a huge step for the Austrian drinking water protection sector.

PAC1.1-situation

The establishment of an integrative planning strategy for watersheds within PAC1.1 would be a huge step towards applied source water protection. Actually there exist partial aspects of it, but the integration into one encompassing strategy would be an innovation.

PAC1.2-situation

As the area of PAC1.2 is owned by various different people and organisations, such an integrative planning strategy would be a huge step towards integral drinking source water protection. It could be based on the implementation of the incentive system.

3.2 Grassland

- **BP MG1 Establishment or enhancement of grassland by regeneration process**

Description of the measure

Alpine ecosystems are characterised by unfavourable climatic conditions with limiting effects on growth and bio-mass production of plants that are increasing with altitude. At an altitude of 2000 m, the number of growing days (average daily temperatures > 5°C) is reduced to 67 days. In alpine environments, vegetation has therefore a growing season of two to three months to establish. Because of the limited growing period, restoration activities at high altitudes should be carried out the first weeks after snow melt. The results of investigations on climatic site conditions indicate that large scale interventions and thus restoration with seed mixtures generally should be avoided above altitudes of 2.400 m.

Above timberline, more dense vegetation with a cover of about 80 % is recommended. Therefore, a sufficient combination of application technique and adapted seed mixture, reaching the minimum requirement of sustainable vegetation with 70 to 80 % cover within the first two vegetation periods has to be the goal behind restoration in high altitudes. Under average conditions of high altitudes the necessary minimum demand on cover can be achieved in the second vegetation period at the earliest. This requires application techniques with sufficient protection of top soil for the first two vegetation periods.

The best protection against erosion can only be reached by additional cover of the top soil with straw mulching, hay mulching, different mats, nets, three-dimensional mats etc. causing a clear decrease of superficial soil losses and water flow rate.

Measure advantages

One of the most severe problems within re-cultivation works in mountainous areas (with 30-45% slope gradient) is the increased surface run-off and soil erosion (B. Krautzer, AREC). Seeding procedures with adequate protection against erosion are important requirements for a successful revegetation. Without the adequate cover of the top soil indigenous and fast-growing species show a comparable bad erosion-behaviour within the first 4-8 weeks after seeding.

In view of an economic evaluation, the set up costs indicate that commercial seed mixtures would be much cheaper than seed mixtures including indigenous species. But when looking at the years following the set up the sites that use commercial seed mixtures have to calculate with follow up costs (reseeding and steady fertilisation). So in the long term in order to reach a sustainable restoration the use of indigenous species is meaningful not only from an ecological but also from an economic standpoint.

Challenges

Within the whole alpine area, thousands of hectares are affected every year, e.g. by ski slopes, ski lifts, tourist infrastructure, improvement of alpine pastures and roads. After intervention, those areas are re-seeded and normally used as pastures. Such areas, mainly within the sub-alpine and alpine stage, are one of the most sensible parts of the Alps. Every intervention in such alpine living spaces leads to interference that requires different technical and ecological measurements to reach the goal of a sustainable restoration of those affected areas. This can only be reached with the help of indigenous plant material. For want of indigenous vegetation, seed mixtures have to be used in most cases.

On 8 localities of the Alps, in different altitudes from 1.230 m to 2.340 m, the research project “Seed Propagation of Indigenous Species and their Use for Restoration of Eroded Areas in the Alps” (FAIR CT98-4024, short title “ALPEROS”), supported by the EC, was carried out in order to assess the possibilities to restore damaged areas using a combination of improved application techniques combined with seed mixtures of indigenous species.

To get basic information about the effects of different application techniques on superficial soil losses and water flow rate, a mobile erosion facility with three chambers was built up at the location Hochwurzen (1,830 m ASL) in order to measure erosion in dependence on different application techniques after restoration.

PAC1.1-situation

The use of autochthonous seeds for the grassland areas within PAC1.1 is not of superior relevance, as cases of erosion which could be solved by sowing grassland seeds are not very common. Despite that fact artificial seed application is applied under rare circumstances especially after removal of krummholz.

PAC1.2-situation

The use of autochthonous seeds for the grassland areas within PAC1.2 is not of superior relevance. Despite that fact the use of autochthonous seeds for the grassland in case of eroded grassland sites should be state-of-the-art.

- **BP M(P)G2 Establishment or enhancement of grassland by sowing or planting**

Description of the measure

Only autochthonous or regional seed from the natural surroundings of the respective construction project is optimally adjusted to the specific site conditions. As it usually origins from high-quality crops rich in species, it generates an especially dense, dynamic and powerful root system. The choice of the target vegetation must be based on the natural vegetation of the site to gain ecological stability and ensure a higher resistance to environmental stress and diseases and reducing therefore the maintenance demands and costs.

Measure advantages

Due to the especially dense, dynamic and powerful root system an optimal protection against soil erosion and the improvement of biodiversity can be guaranteed. Technical functions of primary importance in terms of the stabilisation properties of plants in the frame of soil and water bioengineering interventions are:

1. Covering of the ground using plant communities as protection against heavy precipitation, soil erosion by water and wind
2. Mechanical anchoring and buttressing of the soil by the roots.
3. Cohesion and stabilisation of the soil trough the aggregation of soil particles by plant roots, humus, mycorrhizae and micro-fauna as well as interlocking or anchoring of topsoil and subsoil and prevention of the washout of fine material through their retention and filtering by the network of fine roots.
4. Slowing down and diverting air and water flow. Effects in the area of the root, in particular compression through the increase in root thickness, soil loosening due to movement of the root system induced by the movement of the stem and branches and soil compaction due to the weight of the vegetation.
5. Increase in overall soil cohesion through the extraction of water by evapotranspiration
6. Positive management of the local and regional water balance trough the evaporation of soil water, retention of precipitation water, retention of soil water and balanced water infiltration.

But in areas with no or only little vegetation in gullies and other drainage channels intensive rainfall events may cause strong surface run-off causing intense erosion. That is why a dense vegetation cover is needed as associated with complementary measures to increase the roughness of the surface. A suitable coverage with vegetation such as wood, bushes and hedges can be used to regulate the water regime particular in extreme or very disturb sites like gullies, steep slopes or other erosion prone areas. The impact of these bioengineering measures can be especially important in catchments which are situated above an area of flood risk as well as a catchment belonging to hydro-dam and other constructions of water supply.

Challenges

Research on grassland farming in the alpine area exists in Austria since 1889. After successful breeding of cultivars of forage crops, a comprehensive programme for breeding of grasses and

legumes for the use in seed mixtures for permanent grassland has been started. Additionally, also a programme for the propagation of seed of alpine and subalpine ecotypes for erosion protection and landscaping has been conducted.

One result of these efforts is the launch of a special cultivar. A number of indigenous species have been selected during the last years, optimising the production and harvesting technique for successful seed production.

The slow growing rate of the alpine grasses and forbs, their subsequently low competitive capacity and their susceptibility to fungal diseases make seed production difficult in context of organic farming. Therefore, 18 subalpine and alpine grasses, legumes and herbs have been selected by means of intensive research procedures, to be propagated and used for high zone restoration.

In Austria indigenous seed mixtures for different altitudes and site conditions are available on the market.

PAC1.1-situation

In case of erosion processes on the grassland areas sowing with indigenous seed mixtures would be an appropriate tool for re-establishment of the vegetation cover.

PAC1.2-situation

In case of erosion processes on the grassland areas sowing with indigenous seed mixtures would be an appropriate tool for re-establishment of the vegetation cover.

- **BP M(P)G3 Supporting guidance for creation of low-input grassland to convert arable land at risk of erosion or flooding**

Description of the measure

The purpose of this Best Practice is to establish a new sward by sowing a low productivity grass mix containing at least four flowering species. The sward has to be established before beginning of June (in the first year) – sawing in spring or autumn. The wildflower mixture should be made up of autochthonous species. At least 15 per cent of the mixture should be herbs and the rest grasses.

Grazing animals are good at creating variety with their trampling, dunging and eating. Grazing should be at light to moderate levels to keep the sward at a range of heights and to allow some plants to flower. A way to create as diverse habitats as possible and to consider as many species as possible is „rotational grazing", which means a spatial and temporal change of grazed and un-grazed areas. Where no stock are available to graze, grassland should be cut (not before mid of August) to a height between five and ten centimetres.

Measure advantages

The benefit of this BP is the improvement of soil and water quality as well as biodiversity within arable fields which are prone to flooding and / or soil erosion. The grass area should be located within fields or areas at risk to help prevent soil erosion. For example:

7. particularly long uninterrupted slopes
8. field valleys, low corners or other areas which tend to concentrate run-off
9. light soils (with a relatively high sand or silt content) tend to be more prone to erosion particularly those with a low organic matter content
10. areas which drain directly to a watercourse will be of greater risk of transferring eroded soil to the watercourse
11. areas with flooding risk (adjacent to watercourses)

Challenges

In Austria the so-called "Austrian Agrarian Environmental Programme" ÖPUL for environmentally friendly management of agrarian land provides a funding system for certain sustainable measures:

12. Protection, restoration and conservation of biodiversity also in Natura 2000 sites, endangered or rural areas, land management with high nature value
13. Enhancement of water management incl. manure management and pesticides
14. reduction of soil erosion, enhancement of soil management
15. reduction of emissions from agriculture (through site-appropriate cultivation, reduction of fertilisation, field-related fertilisation accounting in combination with soil samples, compulsory participation at trainings)
16. promotion of carbon storage in agriculture and forestry
17. Nitrate Action Plan 2012: regulation of nitrate-fertiliser
18. Promotion of buffer strips, especially along water courses to avoid erosion and pollution through nutrients
19. Groundwater 2020 (in Upper Austria): comprehensive protection of groundwater sources and the respective funding of sustainable land use management measures

PAC1.1-situation

There cannot be found any arable land within the PAC1.1 at the moment, this situation will not be different in future, what is due to the alpine location of the DWPZ. Hence this BP is not relevant.

PAC1.2-situation

There cannot be found any arable land within the PAC1.2 at the moment. Grassland could be converted into arable land, but this management-step does not seem to be very probabilistic. In case of future conversions dialogues with the farmers will become necessary.

- **BP M(P)G4 Weed control in particular against invasive plant species**

Description of the measure

Invasive plant species are considered as one of the major threats to biodiversity. They can reduce yields from agriculture, forestry and fisheries, are known to decrease water availability and to cause land degradation. They suppress native plants that play an important role in binding soil with their roots and may thereby contribute to increased soil erosion. The main identified costs in Europe comprise eradication and control costs and damage to agriculture, forestry, commercial fisheries, infrastructure and human health. Comprehensive management measures against these invasive plant species have to be pursued continuously by all countries to minimize their expansion.

Measure advantages

Through intensive destruction of invasive species, especially plant species as they are most important concerning water resources protection and flood mitigation, native species can spread over their original range and provide again the necessary ecosystem services (e.g. minimizing soil erosion and land degradation, improvement of water quality).

Challenges

The REGULATION (EU) No 1143/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species has been implemented in national law since 1st January 2015 and is to be applied directly. A surveillance system and official controls need to be implemented as well as management of invasive alien species that are widely spread.

The prevention and control of invasive plant species in Austria is organized and managed by the nine federal provinces. Based on the nature protection laws, several institutions offer information tools and practical instructions as well as special courses and trainings (e.g. OEWAV, Mountain and Nature Protection Associations and public bodies). Numerous projects are being implemented in practice.

In Austria several guidelines, directives, regulations, action plans, management plans, Funding Programmes (Life+, Leader, Rural Development Programme 2014-2020, Framework Programmes, Environmental Programmes (e.g. ÖPUL in Austria), information campaigns and initiatives, specific regional and national projects are actually conducted. Main goal is the optimization of existing legal instruments and tools for implementation and monitoring together with voluntary measures, but clearing invasive alien species is an expensive business.

<u>Some Best practice examples in Austria:</u>

20. **Effective management in Carinthian nature parks** „Dobratsch and Weißensee“ against *Fallopia japonica* and *Impatiens glandulifera*. The priority initiative in co-operation with “ARGE Naturschutz” is relevant for the protection of biodiversity. Management plans include repressing of invasive plants, public awareness and voluntary measures (articles in newspapers, municipality newsletters, and clear directions for disposal).

21. **School initiatives (science practice) in District Liezen (Styria)** together with Mountain and Nature Rescue Service, Styrian Society of Nature Conservation, Austrian Service for Torrent and Avalanche Control, District Office, local municipalities. The annual activities include active management, monitoring, research activities, documentation, public awareness, information brochures, science in school activities (outdoor activities, matriculation projects, internships and information workshops).
22. **LIFE Nature Project "Gesäuse"** (Styria, Enns valley):
23. The **LIFE project „Flusslandschaft Enns"** (2011-2015): "Conservation strategies for forests and torrents in the region ´Gesäuse´ incl. management of invasive plant species (especially Impatiens glandulifera) forms the starting point of the renaturation of the river Enns. The management plan for invasive species was implemented at the different river sections with ongoing activities.
24. **LIFE+ Project Ausseerland** (http://www.bundesforste.at/natur-erlebnis/life-projekt-ausseerland.html); management plan for invasive plant species

PAC1.1-situation

BP not yet considered. If necessity will arise suggestions and BMP will be applied. At grassland sites there has not been identified the risk for the establishment of invasive plant species within the PAC1.1. Invasive alien species can be found along the brooks and rivers.

PAC1.2-situation

There has not been identified the risk for the establishment of invasive plant species at the grassland-sites within the PAC1.2.

- **BP M(P)G5 Reduction of nutrient inputs into water resources**

Description of the measure

Due to land use management measures within grassland/agricultural areas concerning adequate fertilisation, especially adjacent to water courses and lakes, water pollution through nutrients can be mostly prevented. Following measures should be considered: optimum timing of application, reduction of fertiliser-amount, special techniques of application, avoidance of soil compaction, and maintenance/establishment of a dense grass sward.

By means of indicator plants the specific site status can be identified (A. Bohner, AREC). Changes of site characteristics as well as wrong fertilisation and cultivation measures can be recognised at an early stage. Site specific improvement measures and the adequate demand for fertilisation can be estimated accordingly.

Measure advantages

Through suitable cultivation measures within arable and grassland areas losses of nutrients (e.g. phosphorus) to the groundwater and surface water can be reduced and the respective water quality will be improved.

Challenges

In the framework of the INTERREG IV project “Gewässer-Zukunft” (2009-2013) – “Water-future: reduction of nutrient inputs into surface waters in the cultural landscape of the Bavarian and Austrian foothills of the Alps” a sustainable improvement of the water quality of river ´Antiesen´ in Upper Austria was envisaged. To reach this target, phosphorus inputs from agricultural used areas have to be reduced. Most of the grassland soils investigated exhibit very low levels of CAL-soluble phosphorus. Arable land, cropped with cereals, maize or oil plants (rapeseed, flax), has on average higher contents of CAL-soluble phosphorus in the topsoil than grassland. In the agricultural used soils, the levels of water-soluble phosphorus in the uppermost 15 cm are sometimes very high, increasing the risk of greater phosphorus losses in surface runoff in dissolved form on slopes.

Within the INTERREG IIIA project "Nachhaltige Landwirtschaft in der EU Regionalen Seenlandschaft" (2004-2007) – sustainable fertilisation of drained grassland areas in the EU Regio-Alpine upland lake landscape was developed. The primary aim of this study was to develop suitable measures to reduce losses of phosphorus from agricultural used soils to the groundwater and to the surface water in the catchments of Mondsee, Irrsee and Waginger-Tachinger See. In the study area grassland is a very important land-use pattern. Therefore, phosphorus losses from grassland by surface runoff are prevailing. In order to minimize these phosphorus losses the optimum timing of fertilizer application, the avoidance of soil compaction, and the maintenance or establishment of a dense grass sward without gaps are important measures. On sites very susceptible to leaching and surface runoff – especially nearby surface waters - measures such as reduction in the rate of phosphorus-fertilizer application or cessation of fertilizing and the resulting decrease in management intensity as well as – especially on drained grassland - special techniques of slurry application (for example flat injection) are further effective and sustainable measures for the protection of the groundwater and the surface water in the long-term.

PAC1.1-situation

No fertilizers are applied in PAC1.1. Already accomplished studies show that the nitrogen balance is negative due to grazing. The problems within PAC1.1 are stemming from cow-dung in the areas of the subalpine and alpine pastures.

PAC1.2-situation

Within the PAC1.2 all substances stemming from manure and liquid manure constitute a problem for source water quality hence microbes, nitrate, phosphorus and all other critical substances have to be prevented from leaching into the aquifer. The application of fertilizers should be restricted within the DWPZ so that source water quality can be maintained on a high level.

- **BP MG6 Site-appropriate extensive management of mountain pasture land**

Description of the measure

Through the abandonment of pastures or inadequate intensive management measures in mountainous areas the adequate ecosystem service “protection of surface and soil” gets lost.

Mudslides and erosion processes increase and important areas and soils are destroyed as the former vegetation and its root-system changes. After intensive fertilisation or abandonment of pastures the rooting decreases and thus the potential risk of erosion processes increases. Fallow lands of 15 up to 20 years are the most unstable areas (TASSER et al. 2004).

Within sensible sites (e.g. steep gullies, sensitive wetland areas, DWPZ) also erosion processes and soil losses can occur by trampling damages through livestock. Grazing should be accordingly limited or totally abandoned within these areas. On already destroyed sites the improvement of the sward through site-specific seeds should be conducted supplemented with adequate fertilisation. Important in this connection is the diversity of the vegetation to provide different root-lengths, so that the interlocking with the underground and the stabilisation of the topsoil get improved.

Measure advantages

Site-appropriate management of pastures cause a positive effect on water storage capacity and run-off behaviour during rainfall. The risk of dangerous torrent-flows or erosion processes throughout heavy rainfalls decreases.

Challenges

The adequate extensive management of mountain pastures is very labour-intensive, difficult and uneconomic. Therefore in some areas of Austria the danger of abandoned pastures in the mountains increases.

Nevertheless some positive examples exist.

PAC1.1-situation

No negative impacts on the water resources due to pasture abandonment have been detected. Within the **DWPZ of the City of Vienna (PAC1.1)**, cattle-grazing is regulated in a way, that dolines and sink-holes are fenced so that cattle cannot approach these highly vulnerable sites. Through these measures the critical dung of cattle is intended to be kept in distance to the areas, which have direct connection to the aquifer. In order to avoid the direct entrance of precipitation water also technical constructions were used, like e.g. dams which prevent precipitation water from directly flowing into dolines or sinkholes. The water can subsequently infiltrate slowly via the soil matrix, so that the potential contaminants are reduced (soils are acting like a filter). Additionally for avoiding erosion processes and consequently threat for source water quality by trampling damages through livestock (above all cattle), fencing of erosive sites was done for keeping livestock away from there.

PAC1.2-situation

A classical mountain-pasture area is situated at Mount Schnabelberg. Any measures to reduce the intensity of use of this pasture area would be of interest for securing water quality. The afforestation of this area would be the best solution with regard to drinking water protection.

3.3 Agriculture

Within both **PAC1.1** and **PAC1.2** currently there do not exist agricultural areas, all farmland areas can be associated with grassland or subalpine pastures.

3.4 Urban areas (settlements)

BP U1 Utmost care with mineral oil products

Description of the measure

All mineral oil products (MPR) used in settlement areas have to be handled with utmost care. It has to be avoided that MPR enter the soils and could be transferred to the aquifers. Hence all MPR have to be kept within their intended courses of application. Oil tanks and all oil lines have to be kept sealed. Oil tanks need special level of quality and containments. Oil tanks within areas endangered by flood events have to be prohibited.

Measure advantages

The measure ensures that no MPR are entering the aquifer. This is of crucial importance for drinking water security.

Challenges

The sustainable implementation of the measure needs communication with people living in the settlements within the DWPZ. They might show resistance against the implementation of the measures, but have to be convinced about the urgent dimension of integral drinking source water protection.

PAC1.1-situation

There are no urban areas within the PAC1.1.

PAC1.2-situation

The settlements within the DWPZ in PAC1.2 have certain restrictions. The usage of oil-tanks is restricted within the DWPZ. Also the intrusion into the soil in the course of new constructions or drilling boreholes for thermal pumps is restricted. Sewers are subject to approval in terms of the Water-Act. All houses except 4 are actually connected with the public sewage system, which was

set up during the years 2012-2015, applying the technical state-of-the-art. All five years the sewage system and also the seeping pits are checked for tightness.

BP U2 Avoidance of pesticide application in settlement areas

Description of the measure

Pesticide application within settlement areas in the DWPZ has to be avoided. Many products are already wide-spread in current days, like e.g. 'RoundUp' (Glyphosat) or others. People have to be informed about the threat they are creating also to them-selves if they use those products within their gardens or on their paved areas. Information about alternatives could be part of the strategy.

Measure advantages

The measure ensures that the application of pesticides is limited and avoided within the DWPZ. This contributes to the drinking water security.

Challenges

People might show resistance against the application of the measure if they are used to the application of pesticides. This creates the need of an information campaign.

PAC1.1-situation

Within the DWPZ the application of pesticides is strictly limited.

PAC1.2-situation

Within the DWPZ the application of pesticides is restricted. The application and also the storage of pesticides have to be declared and have to be approved. Until now there were not detected any pesticides or metabolites within the source water.

3.5 Industrial areas

BP I1 Avoidance of the construction of new industrial areas within the DWPZ

Description of the measure

The construction of new industrial areas within the DWPZ is avoided, instead there are provided more adequate sites for the facilities, which are not connected with aquifers used for water supply.

Measure advantages

The measure ensures that no potentially hazardous substances used within industrial facilities could enter the aquifers, simply by avoiding those activities within the DWPZ. This contributes to drinking water security.

Challenges

It might be difficult to prevent industries to settle within DWPZ, but if there exists a decreed WPZ, this restriction might be easier being implemented.

PAC1.1-situation

Within the DWPZ of PAC1.1 there do not exist industrial facilities. Also the construction of new facilities is not realistic what is due to the remote location of the DWPZ.

PAC1.2-situation

Within the DWPZ of PAC1.2 the construction of any new industrial facility will not be allowed. Actually there are two industrial plants operating within the DWPZ.

BP I2 Industrial Activities within the DWPZ carried out with utmost care

Description of the measure

Clear guidelines within the context of the use of potentially hazardous materials (PHM) make sure that those remain in the intended containments. The whole chain of PHM usage is under surveillance and the industrial use follows the technical state-of-the-art. Hence the risk that PHM enters the aquifer is minimized.

Measure advantages

The measure ensures that the risk is minimized that potentially hazardous materials (PHM) used within industrial facilities could enter the aquifers. This contributes to drinking water security.

Challenges

It might be difficult to convince the owner of such industrial facilities to apply the state-of-the-art technique, as it might be more costly than the business-as-usual.

PAC1.1-situation

Within the DWPZ of PAC1.1 there do not exist industrial facilities. Also the construction of new facilities is not realistic what is due to the remote location of the DWPZ.

PAC1.2-situation

Within the DWPZ of PAC1.2 two industrial facilities are in operation. The inspection of the two facilities showed that potentially hazardous materials (PHM) for human health and drinking water are used and stored there. But the quantities of those PHM are so little that also in case of an accident the water could be contaminated, but the threshold values never could be exceeded. For providing a high level of drinking water security the restrictions for the industry are as follows: Sewage channels have to be inspected regarding impermeability every 5 years. The construction of traffic areas, water mains, drillings or other activities which encompass the soil are subject to approval in terms of the Water Act. Also unpaved parking areas and the infiltration of surface water are forbidden. The storage and application of PHM is officially strictly restricted. Additionally the enterprises have to elaborate emergency plans how to act in case of accidents.

3.6 Stone Quarries and Gravel Pits

BP S1 Abandonment of stone quarries within DWPZ

Description of the measure

Stone quarries are abandoned within DWPZ. This is the only measure which excludes any potential danger stemming from active stone quarries. Areas which are prone to be vegetated are planted with autochthonous seeds of soil plants and trees.

Measure advantages

All potentially harming activities within stone quarries are stopped. This contributes to drinking water security.

Challenges

It might be difficult to convince the owner of stone quarries to stop the mining activities, what might be due to the profitable running of the quarry.

PAC1.1-situation

Within the DWPZ of PAC1.1 there do not exist huge stone quarries for industrial use. Only small quarries (gravel pits) for the construction of forest roads are in operation, their spatial extension is rather small.

PAC1.2-situation

Within the DWPZ of PAC1.2 two stone quarries are actually in operation, but the level of operation is already focused on the abandonment of the quarries. Two stone quarries are actually already abandoned.

BP S2 Utmost care in the course of working-processes in stone quarries

Description of the measure

Stone quarries are run with utmost care within DWPZ. All given restrictions are met. The works within the stone quarry are executed according to the technical state-of-the-art. The stone quarry is intended to be abandoned soon. The embankment has to be adapted towards a 45° angle for being re-vegetated. For being within limits also rock-faces may be present, hence the spatial demand of the adaptation can be minimized.

Measure advantages

All activities within stone quarries are carried out with utmost care for the water resources. The overall purpose of the measures is the abandonment of the quarry.

Challenges

It might be difficult to convince the owner of stone quarries to carry out the mining activities with utmost care, as this may involve higher costs.

PAC1.1-situation

Within the DWPZ of PAC1.1 there do not exist huge stone quarries for industrial use. Only small quarries (gravel pits) for the construction of forest roads are in operation, their spatial extension is rather small.

PAC1.2-situation

Yearly the stone quarries are examined by the authorities, including geological, water level and water quality investigations in groundwater and surface waters. Additionally it is examined whether the restrictions regarding waste, waste waters, storage and refuelling with gasoline and oil are met. For potential accidents it is necessary to store oil binding agents. The devices like trucks and excavators have to be checked with regard to drip losses. If the devices are not in operation they have to be parked at sealed and roofed surfaces. Between the yearly controls unexpected examinations are carried out through the water works and the authorities. A potential extension of the stone quarry was forbidden through the authorities.

3.7 Tourism

BP T1 Financial support and contributions of and to other stakeholders

Description of the measure

The installation of waste water and sewage treatment is supported, especially within the context of mountain huts within the DWPZ. The transport of waste water and sewage out of the DWPZ is being paid. Farmers are supported building stables, build drinking places for animals, fencing in vulnerable spots, etc.

Measure advantage

The financial support enables effective protection measures. Long lasting negotiations or even law suits are not necessary.

Challenges

High costs.

PAC1.1-situation

Vienna Water has already supported larger projects (stables and touristic mountain huts). For smaller operations a yearly budget is planned. The financial contribution is based on contracts which state conditions for sustainable water protection.

BP T2 Installation of compost toilets in small mountain huts

Description of the measure

Approximately 22.000 mountain huts and refuges currently exist in the Alps. Most of them are situated in extreme locations where they are hard to access. Nevertheless, they generate relevant amounts of sewage and wastewater. In order to protect the Alpine environment and to preserve drinking water resources, the wastewater generated by mountain huts and refuges must be properly treated and/or disposed to minimize adverse impacts. For adapted sanitation systems, composting toilets are a possible system component, especially in the case of water shortage.

Composting toilets can be applied as component of the sanitation system at remote objects in the alpine region. Due to the extreme climatic conditions, the degradation efficiency of the composting process for the reduction of hygienic parameters is low or does not work at all. The not continuous delivering of compost material is an additional challenge.

Vienna water has in close cooperation with the University of Live Sciences in Vienna developed the toilet design and the composting (degradation) process in order to implement sanitation systems in the DWPZ.

Measure advantages

The composted sewage and wastewater may be disposed in the protection area with (almost) no hazard to the aquifer.

Challenges

The composting period takes for years. The investment is medium price. The handling needs training.

PAC1.1-situation

After the development and testing the implementation is ongoing.

3.8 Alpine karst regions (PAC1.1, karst water research)

BP AK1 Geological mapping

Description of the measure

Geology is part of the natural system. The distribution of the different rocks is mapped, and profiles are constructed to achieve a 3-dimensonal picture of the underground. The hydrologic properties of the rocks are described.

Measure advantages

It is indispensable for assessing impacts of land use activities on water resources and for designing measures and management plans. A geological map is the basis for other investigations.

Challenges

Depending on the extent and the topographic characteristic of the catchment area geological mapping is elaborate, costly and time consuming.

PAC1.1-situation

The total catchment area of the DWPZ is geologically mapped.

PAC 1.2-situation

The total catchment area of the DWPZ is geologically mapped.

BP AK2 Investigation of the geological structure

Description of the measure

Based on the geological map the structure of the underground is mapped, described and assessed. The geological structure is characterised by faults and other geological lineaments. The hydrological properties of faults have to be studied and described (faults can be more or less permeable and drain the water in special directions).

Measure advantage

Basically structural mapping is detailing geological mapping especially for hydrological and water supply reasons. It is essential for hydrological modelling and allows for a better understanding of the processes in the aquifer.

Challenges

The measure is elaborate

PAC1.1-situation

Just parts of the catchment area of PAC1.1 are mapped and investigated. Additional parts will be studied in course of PROLINE-CE.

BP AK3 Investigation of the karst-morphological features and properties

Description of the measure

Carbonate rocks especially limestones are prone to solution by hydro-carbon-acid which is dissolved in water. This solution forms ways of easy and rapid water infiltration and transport. To map these karst features on the surface (polje, dolines, ponors, sink-holes, …) are mapped and characterised. Secondly caves are explored and their influence on the water cycle described.

Measure advantage

Karst-morphological mapping helps to locate vulnerable zones and points

Challenges

The measure is elaborate

PAC1.1-situation

Just parts of the catchment area of PAC1.1 are mapped and investigated. Additional parts will be studied in course of PROLINE-CE

BP AK4 Mapping and investigation of soils

Description of the measure

The spatial distribution of soils is mapped. The thickness and other features of soils are described.

Measure advantage

Soils are important for filtering, buffering and retaining precipitation water. To assess the vulnerability of the system the knowledge of soils – their spatial distribution and their specific properties – is important.

Challenges

The measure is elaborate

PAC1.1-situation

The area owned by the city of Vienna is totally mapped. This concerns mainly the forested areas. Areas above the timberline are just partially mapped. In this area the distribution of the soils can be concluded from vegetation and karst-morphologic maps. Some of the soils will be mapped during inspection tours.

BP AK5 Mapping and investigation of forests (see Best management practices 3.1)

The forest hydrotope model, which was created out of the forest site mapping survey of the water protection forests of the city of Vienna, was already mentioned and explained in chapter 3.1.

BP AK6 Mapping and investigation of vegetation above the timberline

Description of the measure

The spatial distribution of plants is mapped. Their properties regarding erosion prevention and influence on the water cycle is described.

Measure advantage

The knowledge of plant cover and plant type helps to design water protection measures. Soils are important for filtering, buffering and retaining precipitation water. To assess the vulnerability of the system the knowledge of soils – their spatial distribution and their specific properties – is important.

Challenges

The measure is elaborate.

PAC1.1-situation

Except for small areas the total catchment is mapped. The rest will not be mapped.

BP AK7 Studies of Microbial situation

Description of the measure

Springs are probed and the amount of microbes is determined. The abundance of microbes is put in relation with hydrological events. Samples of faeces are collected in the catchment area and that allows for a so called microbial source tracking (MST).

Measure advantage

Origin of microbial contamination can be determined and appropriate measures can be designed

Challenges

The measure is elaborate, costly and time-consuming.

PAC1.1-situation

Relevant studies are already accomplished. Their results will be included in other projects.

BP AK8 Evaluation of pastures

Description of the measure

Pastures are mapped regarding their quality and yield. Additionally the intensity of their use is mapped.

Measure advantage

Such maps give a good impression, where cattle prefer to stay. Protection measures can be designed adequately. A further advantage is that such studies are also informative for farmers and it facilitates the discussion.

Challenges

The measure is elaborate.

PAC1.1-situation

Investigations in this realm have started and will be extended regarding the need.

BP AK9 Determination of spatial patterns of surface runoff and its influence on spring dynamics

Description of the measure

This best practice combines classical hydro-geological mapping methods and hydrological modelling for representing spatially distributed information of the interplay of infiltration and surface runoff processes in a karstic catchment. Aim is the identification of surface runoff patterns at different hydrological conditions, e.g., during summer storms. Classical hydrogeological mapping is extended by the "process-oriented" view, i.e. a detailed description of dominant runoff generation mechanisms at an area. The procedure provides two results: (a) A static "surface runoff propensity index" is provided by the mapping which contains a specification of typical flow lengths. It is a quick measure of the frequency of surface runoff occurrence. (b) Transient modelling provides dynamic surface runoff patterns at different events. Also, from the continuous simulation patterns of frequency of surface runoff occurrence are produced.

Measure advantages

In karstic catchments, occurrence of surface runoff and corresponding erosion processes can lead to input of solutes/contaminants into the system that may affect spring quality, particularly during aestival thundershowers. During these events, the generation and flow paths of surface runoff play an important role for material mobilization and transport. The main advantage of the procedure compared with traditional vulnerability mapping is the incorporation of hydrological processes in mapping ("process-oriented") and the combination with transient modelling, which allows for an illustration of dynamic surface runoff patterns. These can be analysed at different event types and different hydrological conditions whereas vulnerability maps are static. In the highly vulnerable catchments of karst springs of the Vienna drinking water supply the model is used for optimizing land management and formulating water safety plans in a risk based procedure by overlaying the surface propensity with solute loads.

Challenges

The view on hydrological processes is not common in hydrogeological mapping which traditionally regionalises lithological/soil properties from a limited number of mapping points. The challenge is to map a large number of points and polygons with less detail rather than few points with a lot of detail. Strictly applying (hydro)geological mapping principles implies that only those items are included which are possible to categorize in the field. These principles are extended by the "process-oriented" view. This provides a pre-defined mapping catalogue and enables to map a large remote region without using a regionalisation model. Cooperation between the hydrogeologist (mapping) and hydrologist (modelling) is an essential part of this method. Comprehensive discussions are particularly important for defining the mapping catalogue in a systematic, process-oriented way as well as for specifying dominant processes. On the other hand, selection of model parameters requires a high degree of hydrological understanding and modelling knowledge. This significantly reduces uncertainties introduced by the parameter upscaling procedure. Model calibration is limited in a karstic catchment, when catchment boundaries are not known. Furthermore, the generally coarse spatial rainfall distribution in high alpine areas increases uncertainties in parameter identification.

PAC1.1-situation

A pilot study has been accomplished already. In PROLINE-CE the continuation of this investigation is the central part of the thematic work.

BP AK10 Climatological and hydrological monitoring

Description of the measure

State-of-the-art climatological monitoring is performed at stations in the catchments recording parameters such as precipitation, temperature, air humidity, global radiation, as well as snow depths. At the springs discharge (water quantity) is recorded as well as other parameters such as electric conductivity, SAC254 and turbidity, which indicate water quality measures.

Measure advantages

Comprehensive monitoring is necessary for drinking water supply management and early warning (based on water quality thresholds). Archiving and documentation allows for analysing hydrological behaviour and tracing activities in the system.

Challenges

In the high alpine region station maintenance is very time consuming and expensive. Particularly precipitation data in winter are often of critical quality and need a comprehensive check or correction.

Due to the high number of spring gauges, data have to be well organised (data bases) and data screening and checking is time consuming. Building measurement infrastructure is costly.

PAC1.1-situation

The number and location of meteorological and hydrological stations was designed in cooperation with agencies and is regarded as sufficient. Also the data handling is organised and operated in cooperation with public meteorological and hydrological agencies.

BP AK11 Development of a GIS (Geographical Information System)

Description of the measure

In order to use all the information described in the previous BP examples a GIS-based tool is most appropriate to assess the information. It includes all spatial information and is connected to the measurements from the monitoring systems.

Measure advantage

Information can be used optimal, can be merged and visualized. The connection to the data from the monitoring systems allows for an integration of all information.

Challenges

The development of such a system is elaborate, costly and time consuming. Also the maintenance is challenging.

PAC1.1-situation

Vienna Water has developed such a system and it is regarded as a valuable tool and it is updated according to the progress of other operations.

BP AK12 Catchment inspection tours

Description of the measure

In regular intervals the catchment area is monitored by staff of Vienna Water, who report their observations and problems encountered. Changes in nature can be observed, described and assessed. But even more important are contacts with other stakeholders met during the tour. That enables the exchange of information and the stating of problems which are to be solved.

Measure advantage

The regular contact with other stakeholders is of great importance for both sides. Changes which cannot be measured are also described and can be evaluated.

Challenges

Own staff in the catchment area is necessary.

PAC1.1-situation

Vienna Water implemented this practice since decades and regards it as indispensable.

BP AK13 Financial support and contributions of and to other stakeholders

Description of the measure

The installation of waste water and sewage treatment is supported. The transport of waste water and sewage out of the DWPZ is being paid. Farmers are supported building stables, build drinking places for animals, fencing in vulnerable spots, etc.

Measure advantage

The financial support enables effective protection measures. Long lasting negotiations or even law suits are not necessary.

Challenges

High costs.

PAC1.1-situation

Vienna Water has already supported larger projects (stables and touristic mountain huts). For smaller operations a yearly budget is planned. The financial contribution is based on contracts which state conditions for sustainable water protection.

BP AK14 Paddock management of mountain pastures

Description of the measure

In most pastures in karstic areas there are sink holes, creeks and dolines. Those are sensible locations where potentially contaminated surface water may infiltrate into the aquifer. Paddock management allows to steer and direct farm animals away from sensible area but still allowing for sufficient grazing. The pasture can be used more efficient because the grazing is distributed optimal over the total pasture area.

Measure advantage

The infiltration of contaminated water can be minimised. The advantage for farmers is that the whole area of the pasture can be grazed. On the long run this method helps to improve the quality of animal feed and limits the spreading of weed which is not grazed by animals.

Challenges

The fencing and the maintenance of the fences is time consuming. Water places are scarce in karstic areas and watering places or drinking troughs have to be provided.

PAC1.1-situation

In the PAC1.1 paddock management is implemented step by step where appropriate.

BP AK15 fencing of sensible spots

Description of the measure

Instead of dividing a pasture in several paddocks the fencing out of sensible spots can achieve the same protection results.

Measure advantage

The infiltration of contaminated water can be minimised. Animals can go to existing watering places.

Challenges

The fencing and the maintenance of the fences is time consuming. Fencing out is often not possible since sensible spots are often drinking places for the animals.

PAC1.1-situation

It is long lasting practice in PAC1.1 and implemented when regarded as necessary.

BP AK 16 Growing of vegetation around or along sensible spots

Description of the measure

Growing of local vegetation (mostly dwarf pine in Austrian alpine areas) around or along sensible spots.

Measure advantages

The growing may happen as a natural process. For planting the effort is low. No maintenance is necessary.

Challenges

The natural growing is very slow and may take decades and cannot be influenced. Planting shows often that growing and spreading does not succeed.

PAC1.1-situation

It is long lasting practice in PCV and implemented when regarded necessary.

BP AK 17 Installation of compost toilets in small mountain huts

Description of the measure

Approximately 22.000 mountain huts and refuges currently exist in the Alps. Most of them are situated in extreme locations where they are hard to access. Nevertheless, they generate relevant amounts of sewage and wastewater. In order to protect the Alpine environment and to preserve drinking water resources, the wastewater generated by mountain huts and refuges must be properly treated and/or disposed to minimize adverse impacts. For adapted sanitation systems, composting toilets are a possible system component, especially in the case of water shortage.

Composting toilets can be applied as component of the sanitation system at remote objects in the alpine region. Due to the extreme climatic conditions, the degradation efficiency of the composting process for the reduction of hygienic parameters is low or does not work at all. The not continuous delivering of compost material is an additional challenge.

Vienna water has in close cooperation with the University of Live Sciences in Vienna developed the toilet design and the composting (degradation) process in order to implement sanitation systems in the DWPZ.

Measure advantages

The composted sewage and wastewater may be disposed in the protection area with (almost) no hazard to the aquifer.

Challenges

The composting period takes for years. The investment is medium price. The handling needs training.

PAC1.1-situation

After the development and testing the implementation is ongoing.

4. Conclusions

The drinking water protection zones (DWPZ) of the city of Vienna (PAC1.1) and the city of Waidhofen/Ybbs (PAC1.2) are forming Pilot Action Cluster 1 in the PROLINE-CE project. The main thematic focus is put on the land-use types forestry and grassland cultivation. The grassland is especially in PAC1.1 dominated by subalpine pastures.

The DWPZ encompass in the case of PAC1.1 943 km^2 and in the case of PAC1.2 1086 ha. Both are karstic alpine catchments, where forests play a dominant role. Despite that fact for this report all existing land-use types were analysed for each DWPZ.

The actual land use activities form in some cases threats for water quality, water quantity and flood prevention.

Land use category forestry is present in both PAC. There are given fundamental differences between the PAC, as in the case of the city of Vienna (PAC1.1) the overall purpose of drinking water protection for forestry is defined since decades, whereas in Waidhofen/Ybbs (PAC1.2) the overall purpose for most of the various forest owners is still maximised timber yield. Forestry actually exerts in PAC1.2 the most relevant threats, as the clear-cut technique is still applied there, which in contrast is already forbidden in PAC1.1. Elevated wild ungulate densities are present in both PAC, but in PAC1.1 in some areas of the DWPZ there is already implemented a forest ecologically sustainable wild ungulate density, which is reflected through vital and abundant regeneration of all relevant tree species for each forest hydrotope type. The different Best Practices were discussed according their implementation status within each of the two PAC. All Best Practices in the field of forestry are valid for both drinking water protection and flood prevention.

Land use category grassland cultivation is also present within both PAC. In PAC1.1 it is dominated by subalpine pastures, in PAC1.2 cultivated grassland areas are dominant. The prevention of the entrance of liquid manure, manure or cow dung into the aquifers is a declared purpose for both PAC. The status of the defined Best Practices in the field of grassland was again discussed for both PAC. Land-use category agriculture has no relevance in both PAC.

Urban areas are present within PAC1.2 and related Best Practices encompass utmost care in case of the use of mineral oil products and pesticides, as well as controlling the novel sewage systems.

Industrial areas again are only present within PAC1.2 and demand attention within the context of potentially hazardous materials. Best Practices were discussed for two already existing facilities within the DWPZ.

For PAC1.2 there were discussed Best Practices for the stone quarries situated within the DWPZ, while for PAC1.1 the existing gravel pits within the DWPZ were thematised.

Tourism infrastructure was thematised within the context of alpine huts for PAC1.1.

The karst research program of the City of Vienna was discussed as Best Practice for PAC1.1.

The implementation of the Best Practice Catalogues defined and discussed in this report is of high importance for the sustainable protection of the related drinking water resources and for flood prevention.

5. References

Koeck, R., Hochbichler, E. (2010). Forest Hydrotope Maps of the Pilot Action of the City of Vienna. Wildalpen, Nasswald and Hirschwang. CC-WaterS Output Documentation, Maps, www.ccwaters.eu.

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