PROLINE-CE

WORKPACKAGE T2, ACTIVITY T2.2

IMPLEMENTATION OF BEST PRACTICES FOR WATER PROTECTION IN PILOT ACTIONS

D.T2.2.3 PILOT ACTION CLUSTER REPORT

PILOT ACTION CLUSTER 1

Mountain Forests and Grasslands

Lead Institution	PP1/LP - PP2 - PP3
Contributor/s	See next page
Lead Author/s	Roland Koeck
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Contributors, name and surname	Institution
Roland Koeck	PP3, LP/PP1 - University of Natural Resources and Life Sciences, Department of Forest- and Soil Sciences, Institute of Silviculture
Elisabeth Gerhardt	LP/PP1 - Federal Research and Training Centre for Forests, Natural Hazards and Landscape
Markus Hochleitner	PP3 - Municipality of the city of Waidhofen/Ybbs, Water Works
Gerhard Kuschnig	PP2 – Vienna Water
Harald Kromp	PP2 – Vienna Water
Markus Werderitsch	PP2 – Vienna Water
Christian Reszler	JR-AquaConSol
Eduard Hochbichler	PP3, LP/PP1 - University of Natural Resources and Life Sciences, Department of Forest- and Soil Sciences, Institute of Silviculture
Daniel Bittner	PP12 - Technical University, Munich
Gabriele Chiogna	PP12 - Technical University, Munich

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1. Introduction

In this report best management practices (hereinafter: BMPs) examined in Pilot Actions (hereinafter: PA) are presented on the level of Pilot Action Clusters.

Pilot actions and pilot sites respectively were classified into three clusters (Table 1) concerning the geographic specification and natural site characteristics (aquifer type) and main land use:

Pilot Action Cluster 1: Mountain forest and grassland sites,

Pilot Action Cluster 2: Plain agriculture/ grassland/ wetland sites and

Pilot Action Cluster 3: Special sites (riparian strips).

In this report following issues in PAs from PAC1 are presented:

- an overview of conducted activities in PA;
- selected GAPs and BMPs in PAs with solutions/recommendations for adaptation of existing land use and flood management and improved policy guidelines;

Table 1: Pilot Actions and Pilot Sites respectively, classified into three clusters according to land uses and geographic scope.

PILOT ACTION CLUSTER 1 (PAC1) Mountain forest and grassland sites	PILOT ACTION CLUSTER 2 (PAC2) Plain agriculture/ grassland/ wetland sites	PILOT ACTION CLUSTER 3 (PAC3) Special sites (riparian strips)
PA1.1 Catchment area of the Vienna Water Supply, Zeller Staritzen and Central Hochschwab, AT1 Drinking water source: Karst aquifer	**PA2.1 Well field Dravlje valley in Ljubljana, SI** Drinking water source: Porous aquifer	**PA3.1 Po river basin, IT** Drinking water source: Bank filtration
PA1.2 Catchment area of Waidhofen/Ybbs, AT2 Drinking water source: Fractured karst aquifer	**PA2.2 Water reservoir Kozłowa Góra, PL** Drinking water source: Surface water	**PA3.2 Along Danube Bend, HU2** Drinking water source: Bank filtration
	PA2.3 Tisza catchment area, HU1 Drinking water source: Surface water	
	P2.4 Groundwater protection in karst area, HR **2.4.1 - South Dalmatia: Prud, Klokun and Mandina spring** **2.4.2- Imotsko polje springs)** Drinking water source: Karst aquifer	
	PA2.5 Neufahrn bei Freising, GER Drinking water source: Porous aquifer	

1.1. Pilot Action Cluster 1: Mountain forest and grassland sites

In mountain forests and grassland sites best management practices for land use and drinking water management differ from those in plain sites. Therefore, this was selected as separate Pilot Action Cluster. In mountainous areas drinking water sources are mainly originated from groundwater (fractured and karst aquifers).

Within the Pilot Action Cluster 1 (PAC1) two Pilot Actions from Austria were assigned:

- PA1.1: Catchment area of Vienna Water Supply, Zeller Staritzen and Central Hochschwab
- PA1.2: Catchment area of Waidhofen/Ybbs

Description of natural characteristics of Pilot Site is presented in *D.T.1.4 Descriptive documentation of pilot actions and related issues*. In continuation the main Pilot Action characteristics are presented in Table 2.

The objectives of the Pilot Actions in Cluster 1 Mountain forest and grassland sites are displayed in Table 2. In both cases the protection of the drinking source water is central focus of all project activities, and both PA also use modelling as tool for achieving this task.

The implementation of Best Management Practices is dedicated to alpine pasture areas (PA1.1, Fig. 2) and to forest management activities (PA1.2, Fig. 1).

Table 2: Objectives of the Pilot Actions in Pilot Action Cluster 1 (PAC1), Mountain forest and grassland sites.

Catchment area of the Vienna Water Supply	Catchment area of Waidhofen/Ybbs
Geographic focus	
The catchment area of the Vienna Water Supply (pilot action 1.1 = PA1.1) is characterized by steep karstic mountain ranges with forest ecosystems, alpine pastures and rock areas. Focus of the broad study is the "Zeller Staritzen and Central Hochschwab area" (*Figure 2*). Alpine pastures and hydrological modelling are analysed there. → karstic mountains → alpine pastures → drinking water sources	The pilot action 1.2 (PA1.2) is situated in the Drinking Water Protection Area (DWPA) of Waidhofen/Ybbs (*Figure 1*), which is characterized by karstic mountains with steep slopes, where still semi-natural forest stands grow in a mosaic-mix with artificial conifer plantations. Forestry and hydrological modelling are analysed there. → karstic mountains → forest ecosystems → drinking water sources
Thematic focus	
The main objective is improved protection of drinking water resources through an integrated land use management approach, focusing on alpine pasture practices in mountainous areas (mountain grasslands) within the drinking water protection area of Vienna Water. Source water protection will be facilitated through the implementation of Best Management Practices (BMP's) for alpine pastures, specifically designed for the DWPA of Vienna Water. Hydrological Modelling will clarify the role of surface runoff and infiltration within the DWPA. → alpine pastures (mountain grasslands) → modelling of infiltration and surface runoff → drinking water protection	Thematic focus is on forest management in a steep karstic alpine terrain with the overall purpose of drinking water protection. The karstic spring water with actual high quality should be protected so that the supply can be sustainably guaranteed on the present qualitative level. Source water protection will be facilitated through the implementation of Best Management Practices (BMP's) for forestry, specifically designed for the DWPA of Waidhofen/Ybbs. Hydrological Modelling will enlarge the protection focus in the thematic field of dolomite stone quarries. → forestry – silviculture → modelling of the hydrological impacts of dolomite quarries → drinking water protection

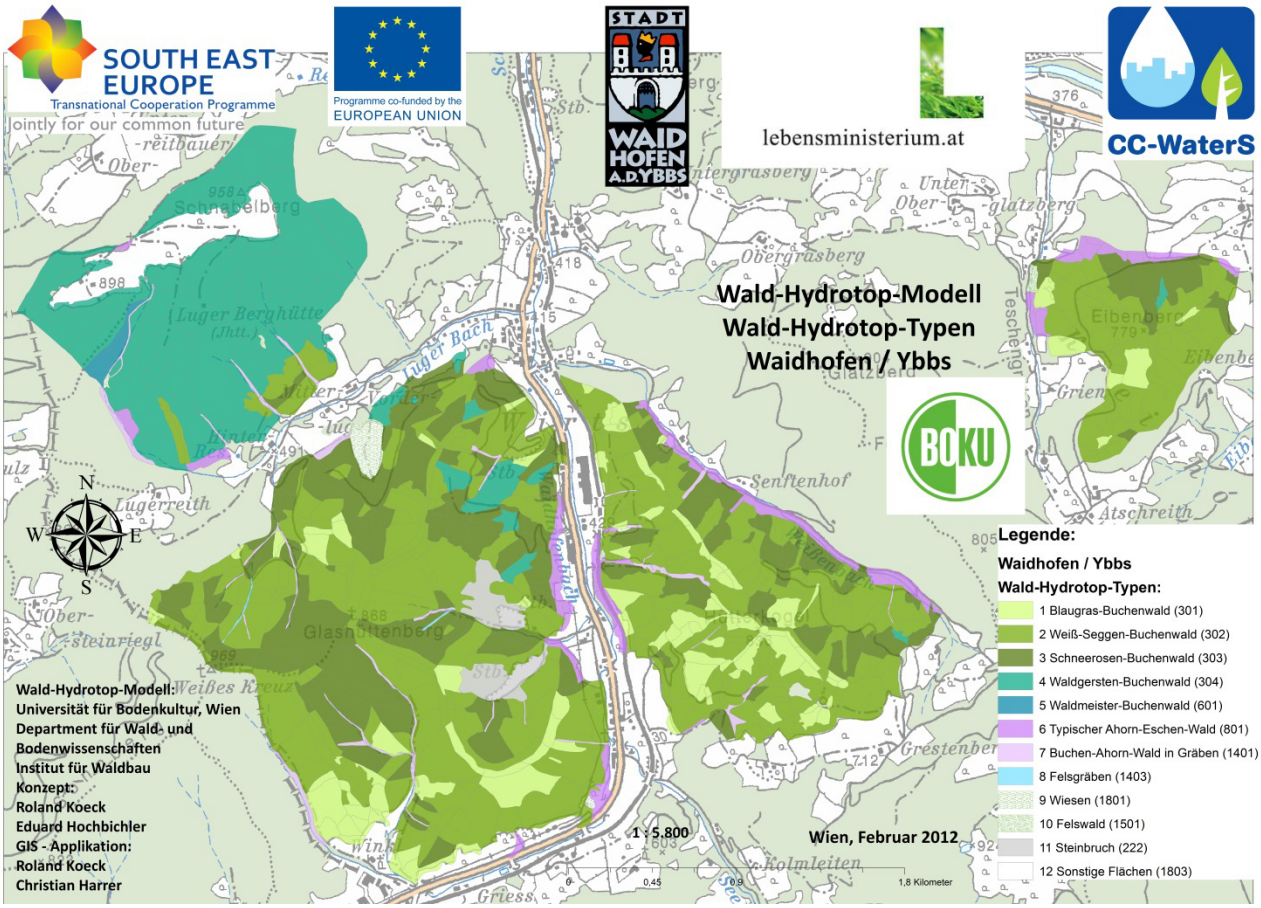

Figure 1: PA1.2, Forest Hydrotope Map of the Pilot Action Waidhofen/Ybbs (Koeck and Hochbichler 2012).

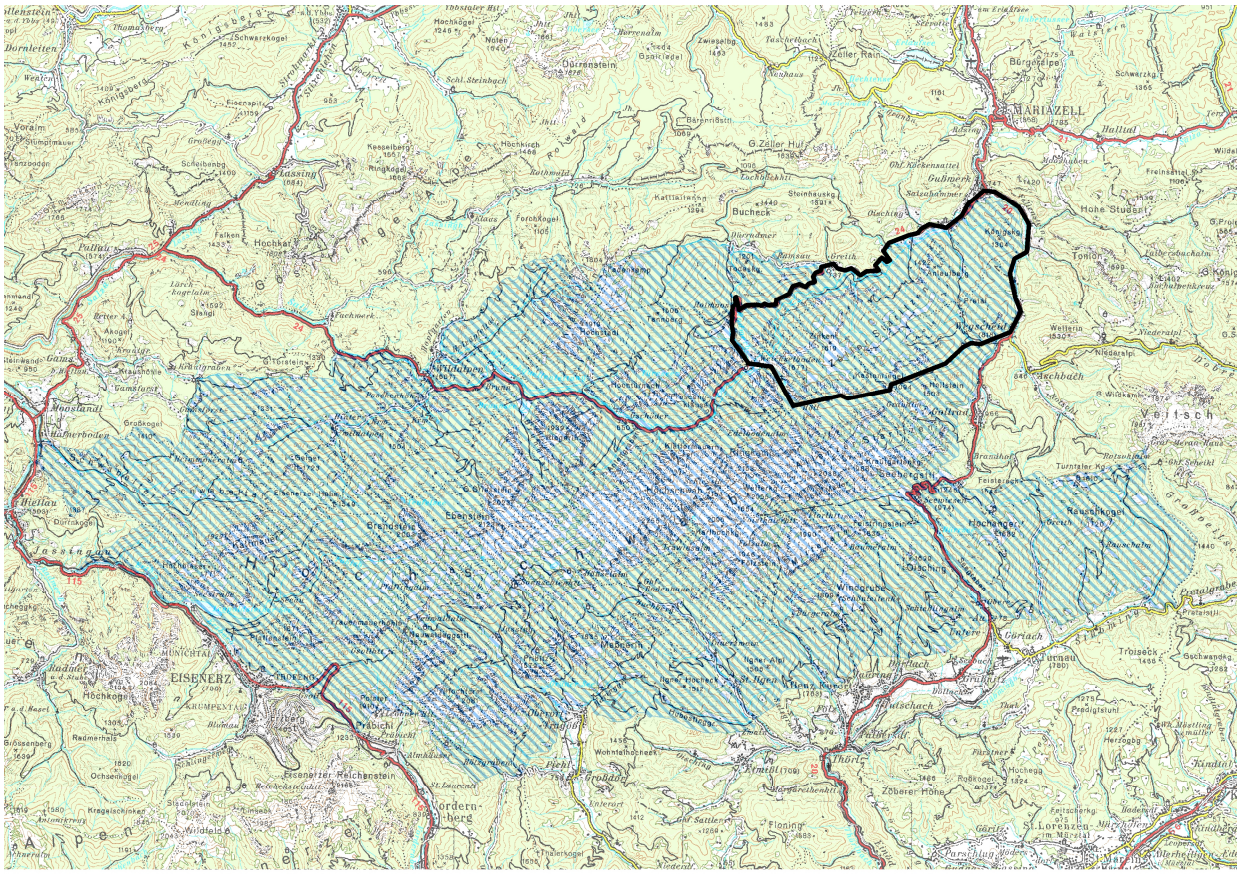

Figure 2: Water Protection Zone of Central Hochschwab area (shaded) with Zeller Staritzen (surrounded black), the whole extension of PA1.1.

2. Testing of BMPs in Pilot Action

2.1. Objectives of Pilot Actions in Cluster 1

Best management practices (hereinafter BMPs) for drinking water protection and management derived from T1 were reviewed and relevant BMPs were selected for each particular pilot action. Implementation status of BMPs was verified in Pilot Actions (T2). In case of lacks identified, possibilities of improvement and implementation were also assessed. Drinking water protection and management and best practices are strategically implemented in the pilot actions, in order to achieve a function-oriented land-use based spatial management for water protection at the operational level. Measures and actions were analysed and proposed concerning mitigation of extremes and achieving a sustainable drinking water level. PROLINE-CE pilot actions reflect the broad range of possible conflicts regarding drinking water protection, such as: forest ecosystem service function; land-use planning conflicts; flooding issues; impact of climate change and land-use changes; demonstration of effectiveness of measures including ecosystem services and economic efficiency.

Review of main land use conflicts and BMPs on Pilot Action level has already been done in Pilot Action BMPs reports, which were a basis for *D.T2.1.2 Transnational case review of best management practices in pilot actions*.

2.2. BMPs of the Pilot Actions

In the following chapter the BMP's considered in PA1.2 for solving identified GAPs are described and analysed. The BMP's represent the management actions which were considered to solve the problems given through the existing GAPs.

2.2.1. BMP group - forest management and dolomite quarry modelling, PA1.2

▪ Identified GAP provoking action	
GAP short name	**Continued application of the clear-cut technique**
GAP short description	Within PA1.2 there still can be identified the intent of forest owners to apply the clear-cut technique, which endangers water supply security as this silvicultural technique can impact water quality significantly.
▪ Best Management Practice / Management Action	
Name of BMP	**Avoidance of the clear-cut technique (BP MF1)**
Type of land use regarded	Forestry

Location	Inner water protection zone (e.g. extended protection zone of Hinterlug-spring) in PA1.2 and all other locations within PA1.2 where the clear-cut technique is intended to be applied.	
BMP description	Avoidance of the clear-cut technique (CCT) at all locations of the PA. This involves the application of the BMP-alternatives, above all the overall strategy to apply continuous cover forestry systems (BP MF2) and all related BMP's, strategies and measures. The BMP is part of the overall *guideline for silviculture within the already decreed water protection zone (WPZ)* of Waidhofen/Ybbs. The guideline passed the municipal council of the city, which forms the basic condition to implement PES (payments for ecosystem services provision) for forest owners within the WPZ. Several knowledge transfer meetings and persuasive efforts were necessary to convince the members of the municipal council from the urgency of an integral drinking source water protection strategy, which is given with the "guideline".	
Advantages of this BMP in PA	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. In PA1.2 it would open an era of consistent drinking water protection strategies, where the protection of the water resource moves into the centre of interests.	
Challenges of this BMP in PA	Resistance of the respective forest owner(s), who wants to continue with the classical clear-cut technique and resistance of the district forest authority which is responsible for the authorisation of such forest management measures. The district forest authority would have to change the business-as-usual attitude and conform to the Federal Forest Act. There was set up a meeting between the respective forest owner, the regional forest authority, representatives of the municipality of Waidhofen/Ybbs and of the water works, scientists and representatives of the Federal Ministry of Sustainability and Tourism to discuss the issue of clear-cut application within the extended protection zone of Hinterlug spring. The meeting will have to solve the issue and avoid the clear-cut application. There were set up several preparation meetings in the course of which the issue was planned and strategic stakeholder interactions, including persuasive efforts, were implemented. Those yielded already first insights of involved persons.	
Relevance	Water protection functionality	The BP MF1 is highly relevant for the water protection functionality (WPF) of the forest ecosystems. Through clear-cuts WPF is eradicated for several years (7-10 years or even more), and this within the extended protection zone of the second largest spring in PA Waidhofen/Ybbs.

	Cost of the measure	PES (payments for ecosystem services) provision, dependant on the amount assigned to the forest owner through the municipality. Medium cost level is expectable.
	Duration of implementation	Long term
	Time interval of sustainability	Continuous
Limitations	The most important limiting factor is the business-as-usual attitude of forestry players in Austria, who want to continue with the application of the forestry practice detrimental for water protection and flood prevention.	
Implementation of the BMP in PA	The implementation of the BP MF1 "Avoidance of the clear-cut technique" will be facilitated through PES schemes and talks with forest owners. Actually, some of the forest owners within PA1.2 already conform to this BMP. The others will have to be motivated (stakeholder involvement). Through the resolution of the "guideline" through the municipal council the implementation of the BMP will be facilitated.	
Comments	The resolution of the "guideline" through the municipal council can be regarded as milestone towards the implementation of integral drinking source water protection. The "guideline" is based on the BMPs defined in the course of PROLINE-CE.	
References / sources	Current process of land-use activities within PA1.2, communicated through PP3.	

▪ Identified GAP provoking action	
GAP short name	**Unnaturally elevated wild ungulate densities as result of trophy-hunting activities and resulting browsing and bark-stripping damages.**
GAP short description	Within PA1.2 elevated wild ungulate densities cause browsing, fraying and bark-stripping damages, which lead to instable forest ecosystems. Those cannot provide water protection functionality any more. Hence drinking water supply security can be endangered within a medium-term perspective.
▪ Best management Practice / Management Action	
Name of BMP	**Forest Ecologically Sustainable Wild Ungulate Densities (BP MF9)**
Type of land use regarded	Forestry
Location	The whole drinking water protection zone, hence the whole area of PA1.2.
BMP description	High wild ungulate densities provoke severe browsing damages on tree seedlings and saplings, fraying damages and bark-stripping 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.*	
Advantages of this BMP in PA	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. Within PA1.2 the application of this BMP would open the path for a sustainable provision of water protection functionality of the forest ecosystems.	
Challenges of this BMP in PA	The main challenge is related to the actual practice of many forest owners within the PA, which is focusing on trophy-hunting activities and related high wild ungulate stocks. The hunters and forest owners within PA1.2 will have to conform with the regional Hunting Act of the province Lower Austria (Niederösterreich), where all necessary frame-conditions are defined.	
Relevance	Water protection functionality	The BP MF9 is highly relevant for the water protection functionality (WPF) of the forest ecosystems in PA1.2.
	Cost of the measure	Medium costs
	Duration of implementation	Long term
	Time interval of sustainability	Continuous
Limitations	Limitation within the context of BP MF9 is the missing willingness to change behaviour in the field of hunting/rearing “wild” ungulates. Related forest owners show in most of the cases inertia and want to continue their practices devastating for forest ecosystems.	
Implementation of the BMP in PA	The implementation of BP MF9 within PA1.2 can be described as truly challenging task, as it involves the change of management purposes for many forest owners. It can be regarded as success if some of the forest owners within PA1.2 show willingness for change. This could be achieved as one out of the forest players could show disposition for this fundamental change. The PES strategy could also motivate some forest owners to change their management purposes. Also, the regional Hunting Act of the province Lower Austria (Niederösterreich) has to be applied where all necessary frame-conditions are defined.	
Comments	The implementation of BP MF9 is not only within PA1.2 crucial as it is relevant for the whole Austrian forest area.	
References / sources	Current process of land-use activities within PA1.2 communicated through PP3 and further through different actors in the field of forestry in Austria.	

■ Identified GAP provoking action		
GAP short name	**Extensive construction of forest roads**	
GAP short description	Within the PA1.2 forest roads are constructed according to the aims of the forest owners; the requirements of integral drinking water protection were not taken into account until now.	
■ Best Management Practice / Management Action		
Name of BMP	**Limitation of forest roads (BP MF20)**	
Type of land use regarded	Forestry	
Location	The whole Pilot Action (PA1.2).	
BMP description	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.	
Advantages of this BMP in PA	For avoiding potential contaminations and hydrological adverse impacts caused by forest roads, the limitation of their construction within DWPZ is an indispensable need.	
Challenges of this BMP in PA	Forest owners within the PA1.2 have to be confronted with the potential negative effects of forest roads on the karst water bodies. Through information and motivation for BMP application through PES the change of the business-as-usual attitude could be achieved. Furthermore, the actual situation requires an authorization of each forest road construction project according to the Austrian Federal Water Act. This new situation is due to the fact that PA1.2 is now a legally decreed DWPZ (since June 2018). Specific legal frame-conditions are now in force for the whole PA1.2.	
Relevance	Water protection functionality (WPF)	For WPF it is of high relevance that forest roads do not occur in specific areas of the PA and that their overall proportion in DWPZ is rather low.
	Cost of the measure	Medium
	Duration of implementation	Long Term
	Time interval of sustainability	Continuous
Limitations	The BMP application is limited to forest owners who are willed to accept the change of management and also the amount of PES as motivating asset. But in the new situation with the legally decreed DWPZ (since June 2018) each forest	

	road construction project will have to be passed and authorized according to the Austrian Federal Water Act. This will make it much more difficult to construct forest roads within the DWPZ (PA1.2).
Implementation of the BMP in PA	The implementation of BMP MF20 will be dependent on the knowledge transfer process and the related negotiations with the forest owners. It is planned to provide a motivating aspect of PES for those forest areas which are kept free from forest roads. The necessary authorization of each forest road project according to the Austrian Federal Water Act will make it more difficult to construct forest roads within PA1.2.
Comments	Forest road construction is still seen as basic condition for the application of forest management in Austria. This basic condition in terms of willingness to change has to be overcome for DWPZ, especially in PA1.2.
References / sources	Current process of land-use activities within PA1.2 communicated through PP3 and further through different actors in the field of forestry in Austria. New legally decreed DWPZ in PA1.2.

▪ **Identified GAP provoking action**	
GAP short name	**Creation of conifer plantations, even within deciduous forest communities (forest hydrotopes)**
GAP short description	Plantation of Norway spruce (*Picea abies*) over all available forest sites within a region, in this case PA1.2.
▪ **Best management Practice / Management Action**	
Name of BMP	**Tree Species Diversity According to the Natural Forest Community (BP MF7)**
Type of land use regarded	Forestry
Location	The whole area of PA1.2
BMP description	Tree species diversity according to the natural forest community (to the forest hydrotope type) 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 non-natural tree species should be transformed gradually to stands dominated by native species, depending on the local experience and legislation. In PA1.2 the whole DWPZ is represented through the Forest Hydrotope Map, defining the optimal tree species set for each forest site.
Advantages of this BMP in PA	In many forest areas tree species diversity according to the natural forest community is a definite advantage, as homogeneous conifer plantations are

	partially dominating the forest sites in PA1.2. Especially in times of climate change tree species diversity becomes mandatory for achieving forest ecosystem stability. Diversity has also positive side effects, e.g. for conservation purposes. Within PA1.2 the implementation of the tree species diversity according to the Forest Hydrotope Model becomes mandatory. This will increase stability and resilience of the forest ecosystems and hence improve their water protection functionality.	
Challenges of this BMP in PA	In some cases of forest owners there can be expected resistance against tree species diversity according to the natural forest community (forest hydrotope type), if the habitual forestry practices had put a strong focus on conifer plantations or other homogeneous timber yield focused plantations. It will be part of stakeholder talks and negotiations to overcome this hindrance and to convince the forest owners from the necessity to adapt tree species diversity to the site conditions. Through the resolution of the "guideline" by the municipal council the implementation of the BMP will be facilitated, as the PES scheme will now be available.	
Relevance	Water protection functionality	The application of this BMP is of crucial importance to improve the water protection functionality of the forest ecosystems within the PA1.2, as it will provide stability and resilience for the related forests.
	Cost of the measure	Medium
	Duration of implementation	Long Term
	Time interval of sustainability	Continuous
Limitations	The potential limitation for this BMP is, if forest owners are not willed to cooperate with the municipality. Almost all forest owners within the DWPZ will be cooperative within the context of PES schemes available, but also exceptions can be expected.	
Implementation of the BMP in PA	Some forest owners within PA1.2 actually are allowing the natural regeneration of the natural tree species set. Others still are planting Norway spruce on their forest sites. Those have to be convinced from the need for tree species diversity through knowledge transfer and the application of PES schemes. This process is facilitated through the resolution of the "guideline".	
Comments	The water protection functionality of the forest ecosystems within PA1.2 depends on the creation of diverse forest stands where the natural tree species set is implemented.	
References / sources	Current process of land-use activities within PA1.2 communicated through PP3 and further through different actors in the field of forestry in Austria.	

■ Identified GAP provoking action		
GAP short name	**Cutting of old, huge and vital tree individuals**	
GAP short description	Huge, old and vital tree individuals in most of the cases are cut for timber yield as those trees provide a considerable amount of biomass for any given purpose.	
■ Best management Practice / Management Action		
Name of BMP	**Foster old, huge and vital tree individuals (BP MF11)**	
Type of land use regarded	Forestry	
Location	The whole area of PA1.2.	
BMP description	Old, huge and vital tree individuals carry excellent genetic information. They can supply younger and smaller tree individuals with nutrients via their common mycorrhizal network. Thereby they provide a substantial contribution to forest stand stability. Hence, they have to be selected and protected, so that they can provide their services as long as possible. Especially within PA1.2 the application of this BMP could contribute significantly to improved forest ecosystem stability.	
Advantages of this BMP in PA	The genetic information provided by old, huge and vital tree individuals has a high value for the sustainability of forest ecosystems. 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. In PA1.2 stability and resilience of the forest ecosystems could be improved through the implementation of this BMP.	
Challenges of this BMP in PA	Forest owners in general cut old and huge tree individuals for timber sale. Within PA1.2 forest owners will have to be informed about the advantages of this BMP and also will have to be motivated to implement it through the application of the PES scheme. Now the basic condition for the implementation of PES, the “guideline”, was passing through the municipal council.	
Relevance	Water protection functionality	The application of this BMP is of crucial importance within PA1.2, as it will increase stability and resilience for the related forest ecosystems.
	Cost of the measure	Medium
	Duration of implementation	Long Term
	Time interval of sustainability	Continuous
Limitations	The potential limitation for this BMP is again given, if forest owners are not	

	willed to cooperate.
Implementation of the BMP in PA	The implementation of this BMP will need motivation, knowledge transfer, and training for the related stakeholders. Protection of those tree individuals requires specific silvicultural knowledge. This process is again facilitated through the resolution of the "guideline", as it will allow the implementation of the PES scheme.
Comments	---
References / sources	Current process of land-use activities within PA1.2 communicated through PP3 and further through different actors in the field of forestry in Austria. Koeck, R., Hochbichler, E. (2012). Das Wald-Hydrotop-Modell als WSMS-Werkzeug im Quellenschongebiet der Stadt Waidhofen/Ybbs. Report in the course of the CC-WaterS project: https://www.bmnt.gv.at - search for: "ccwaters"

▪ **Identified GAP provoking action**	
GAP short name	**Dolomite quarries are causing a decrease in groundwater recharge**
GAP short description	The pilot area, in particular the recharge area of the Kerschbaum spring, suffers from increasing spaces used for dolomite mining.
▪ **Best management Practice / Management Action**	
Name of BMP	**Continuous monitoring of relevant, hydrological data and hydrological modelling**
Type of land use regarded	Forestry
Location	The whole area of PA1.2.
BMP description	The impact of dolomite mining on the quality and quantity of the Kerschbaum spring can be assessed by a continuous monitoring of the spring discharge and the electrical conductivity, as a sum parameter of individual ions. As the quarry areas are considered being compacted without remarkable amounts of infiltration, surface runoff drains the quarries into the Waidhofenbach. Monitoring of electrical conductivity in the Waidhofenbach and the Kerschbaum spring helps evaluating the impact of mining on the spring water quality. Moreover, using hydrological modelling to continuously evaluate the changes of spring discharge due to extending of quarry areas in the pilot area helps to support future decision-making.
Advantages of this BMP in PA	The continuous monitoring is a cheap but powerful measure. It is a sustainable way to assess any changes occurring in the pilot area. A continuous validation of the existing hydrologic model further supports the prediction of available water resources considering further land use changes.
Challenges of this BMP in PA	A challenge of the presented BMP is to analyse the monitored data and to apply the hydrologic model. Still, this is a task typically pursued by experts

	(hydrologists). To overcome this issue, water managers should be trained to assess hydrological data and to run a hydrologic model.	
Relevance	Water protection functionality	The application of this BMP is of crucial importance within PA1.2, as it will support to ensure the future water supply with high quality freshwater.
	Cost of the measure	Low
	Duration of implementation	Short
	Time interval of sustainability	Continuous
Limitations	The potential limitation for this BMP is given by the introduced challenges, which is that the hydrological tasks are typically performed by hydrologists.	
Implementation of the BMP in PA	The implementation of this BMP was done during the project period of PROLINE-CE.	
Comments	---	
References / sources	Bittner, D., Sheikhy, T., Kohl, B., Disse, M., Chiogna, G. (2018): Modeling the hydrological impact of land use change in a dolomite-dominated karst system in: Journal of Hydrology, 267-279; DOI://doi.org/10.1016/j.jhydrol.2018.10.017.	

2.2.2. BMP group - alpine pasture management and surface flow modelling, PA1.1

■ **Identified GAP provoking action**		
GAP short name	**Infiltration and surface flow affecting spring quality are not known**	
GAP short description	Occurrence of surface runoff and corresponding erosion processes can lead to input of solutes/contaminants into a karst system that may affect spring quality. The longer the flow paths the more likely erosion and solute input into the system occur. A spatially distributed hydrological model is needed to identify surface runoff patterns at different hydrological conditions, e.g., during summer storms, in a catchment.	
■ **Best management Practice / Management Action**		
Name of BMP	**Surface flow - spring dynamic modelling in the area of Zeller Staritzen with the hydrological model KAMPUS**	
Type of land use regarded	General – the hazards. Pressures and impacts of various land use activities can be assessed.	
Location	Zeller Staritzen and central Hochschwab	
BMP description	Applying a rainfall/run-off model based on observed and defined processes as well as measured and mapped parameters the spatial patterns of surface run-off and infiltration will be determined. The results are used for optimizing land use management and formulating water safety plans in a risk-based procedure by comparing the patterns with potential contamination loads, e.g. from cattle grazing.	
Advantages of this BMP in PA	Infiltration and surface run-off are important to assess the vulnerability of the groundwater.	
Challenges of this BMP in PA	Implementation of different parameters in the model.	
Relevance	Water protection functionality	high
	Cost of the measure	Ãpp. €150.000,-
	Duration of implementation	til 2019/04
	Time interval of sustainability	Basic information for catchment management; sustainability not limited
Limitations	Can the simulations reproduce the observed spring dynamics?	
Implementation of the BMP in PA	Implementation is in progress.	
Comments		
References / sources	Report: modelling Hochschwab – spatial patterns of surface run-off	

■ Identified GAP provoking action		
GAP short name	**Erosion processes around water troughs for cattle due to open soils without vegetation cover, as well as washing out faeces.**	
GAP short description	Erosion take place where water troughs for cattle are placed in concentrated manner. Cattle is frequently trampling the soils around the troughs, hence destroying the vegetation cover there. Erosion dynamics and concentrated amounts of faeces are the result of this situation.	
■ Best management Practice / Management Action		
Name of BMP	**Placing of water troughs for cattle more frequently, avoiding concentrations of cattle / Concrete basements for the troughs and their surroundings**	
Type of land use regarded	Subalpine and alpine pastures (mountain grasslands)	
Location	Zeller Staritzen and Central Hochschwab	
BMP description	Water troughs are an important tool for the subalpine and alpine pastures within karstic mountains, as water has to be provided there for grazing livestock (cattle). In order to avoid the creation of erosion dynamics and concentrations of faeces, more troughs should be provided and distributed strategically over the whole alpine pasture. This should ensure enough drinking water for the cattle, bring the cattle close to envisaged areas of the pastures and avoid erosion dynamics. The addition of concrete plates (concrete basements) for the troughs, also helps to avoid erosion dynamics.	
Advantages of this BMP in PA	Avoiding erosion dynamics within the context of alpine pastures is essential for drinking water supply security. Hence it is of interest to implement an alpine pasture strategy. Part of such a strategy is the spacing of the water troughs for cattle and also the construction of concrete basements in cases where this is possible. The avoidance of erosion and of concentrated cattle faeces around those troughs is the main advantage of this BMP.	
Challenges of this BMP in PA	Challenging is that the construction of concrete basements for the troughs is not easy at many locations of the alpine pastures. Another challenge is the lack of water within the karstic environment of the alpine pastures in PA1.1. Hence the sites where water troughs for cattle can be placed are naturally limited.	
Relevance	Water protection functionality	High
	Cost of the measure	Low-Medium
	Duration of implementation	Continuous
	Time interval of sustainability	Immediate until the time-span of the duration of implementation
Limitations	Water troughs for cattle can only be placed on sites where water is available.	

Implementation of the BMP in PA	The implementation of this BMP has been fulfilled for the major part of PA1.1, in some cases the implementation is on the way.
Comments	Water for cattle is an essential question within karstic alpine pasture areas. The lack of water in the higher elevations of these mountain ranges creates the need to solve the question of water provision. Within this decision-space also the issues of drinking water supply security have to be integrated. Hence a strategical spacing of the water troughs becomes a mandatory BMP.
References / sources	Gregory Egger 2018

▪ Identified GAP provoking action		
GAP short name	**Grazing of cattle in or close to dolines and sinkholes**	
GAP short description	As dolines and sinkholes have direct connection to the karst aquifer, grazing of cattle within or close to those karstic features constitutes a high risk for source water contamination.	
▪ Best management Practice / Management Action		
Name of BMP	**Fencing of dolines and sinkholes in order to keep cattle in distance from those karstic features**	
Type of land use regarded	Subalpine and alpine pastures (mountain grassland)	
Location	Zeller Staritzen and central Hochschwab	
BMP description	At all active pastures within the Hochschwab massif the karstic features dolines and sinkholes are fenced out in order to minimize the risk of source water contamination with faeces stemming from cattle or other grazing livestock. The fences have to be kept in functional condition and hence have to be checked through the mountain pasture staff.	
Advantages of this BMP in PA	The protection of the karstic aquifers from direct infiltration and percolation of faeces stemming from grazing livestock (above all cattle) is central part of the drinking water supply security strategy.	
Challenges of this BMP in PA	One challenge is that in case of strong precipitation events faeces of grazing livestock may be washed into dolines and sinkholes, despite the fact that the animals are fenced out from those features. This challenge can be faced through construction of derivation dams.	
Relevance	Water protection functionality	High
	Cost of the measure	Low
	Duration of implementation	Continuous
	Time interval of sustainability	Immediate until the time-span of the duration of implementation
Limitations	Only well-known karstic features can be fenced out from grazing livestock. If	

	there should exist unknown karstic features, the BMP cannot be applied.
Implementation of the BMP in PA	The implementation of this BMP has been fulfilled for the major part of PA1.1, in some cases the implementation is on the way.
Comments	Despite the fact that alpine and subalpine pastures are in contradiction to drinking water supply security, the implementation of this BMP helps to reduce the risk of contamination of the source waters. The existence of subalpine and alpine pastures is related to old servitude rights. Hence the BMP has to be highlighted as significant measure for water suppliers.
References / sources	Gregory Egger 2018

▪ Identified GAP provoking action		
GAP short name	**Unwanted grazing patterns of cattle**	
GAP short description	Most of the alpine pasture areas within PA1.1 do not have a strategic grazing management system at the moment. Overgrazing or undergrazing are the unwanted result of this situation. Potential erosion dynamics or degradation oft he pasture quality can be caused through this situation.	
▪ Best management Practice / Management Action		
Name of BMP	**Grazing management for cattle on alpine pastures**	
Type of land use regarded	Subalpine and alpine pastures (mountain grassland)	
Location	Zeller Staritzen and central Hochschwab	
BMP description	Most of the alpine pasture areas within PA1.1 do not have a strategic grazing management system at the moment. Its implementation can be regarded as major land use management adaptation. Grazing management requires strategic planning, the placing of fences and the punctual change of the grazing cattle from one to the next fenced part of the alpine pasture.	
Advantages of this BMP in PA	This BMP provides the advantage that the alpine pasture area is used efficiently. Erosion processes can be diminished or avoided but also the degradation of the pasture quality through under-grazing is avoided.	
Challenges of this BMP in PA	The challenge of this BMP is the necessity of a strategic planning process which requires detailed knowledge about the pasture quality on the alpine pasture and the consequent implementation through the strategic placing and spacing of fences.	
Relevance	Water protection functionality	High
	Cost of the measure	Low
	Duration of implementation	Continuous
	Time interval of sustainability	Immediate until the time-span of the duration of implementation

Limitations	The BMP cannot be applied if the alpine pasture staff is not willed to learn and improve the management procedures.
Implementation of the BMP in PA	The implementation of this BMP should be fulfilled for the whole area of PA1.1. At the moment the implementation is nowhere on the way.
Comments	---
References / sources	Gregory Egger 2018

3. Activities in the Pilot Actions

The main activities carried out in the PROLINE-CE Project for the PAs are summarized in Table 3.

Table 3: Summary of activities in the Pilot Actions in Pilot Action Cluster 1 (PAC1), Mountain forest and grassland sites.

Catchment area of the Vienna Water - PA1.1	Catchment area of Waidhofen/Ybbs - PA1.2
Activities in PA	
In PROLINE-CE, Vienna Water aims to enlarge an already developed model for surface run-off, erosion and infiltration dynamics. We suppose that all addressed dynamics exert considerable pressures on the karstic groundwater resources. Vienna Water also combines this model with other outputs and results (snow model, climate model and measuring stations) from former – also partly EU-funded – projects. The validation of this model will be tested by model outputs compared to hydrological measurements at springs during high precipitation events. The main pilot activities are situated in the area of "Zeller Staritzen and Central Hochschwab". In the field of alpine pastures (mountain grasslands) Vienna Water aims to communicate and implement Best Management Practices which support drinking water supply security. The most crucial BMP's in the field of alpine pastures were elaborated and defined as guidelines for the farmer's staff working in the mountainous areas. In the course of information transfer meetings and workshops with farmers, alpine pasture related authorities and water works staff, the thematic field of BMP on alpine pastures was	Within the DWPA it is necessary to convince the private and federal forest owners about the requirements of drinking water protection in relation to forestry. This is necessary as the overall purpose of drinking water protection in the field of forestry is new for the private and federal forest owners. Hence also the Best Practice Catalogue is new or unknown for them and as a result of this situation the activities focus on knowledge transfer to forest owners in the course of individual round table discussions about the requirements of drinking water protection within forested DWPA. Incentive payments (payments for ecosystem services) from the water supplier should motivate the stakeholders to apply Best Practices. The Best Practice catalogue of the project was written in short comprehensible style and translated into German language in order to be a potential tool for the stakeholders. The implementation of BMP's in PA1.2 Waidhofen/Ybbs was strategically planned through the elaboration of the "**G**uideline for securing the **W**ater **P**rotection functionality of the forest ecosystems within the DWPZ" (GWP) which

opened and discussed. The information transfer activities can be regarded as crucial for the thematic field and persuasive efforts are integrated in order to ensure application of the BMP's.	defines all relevant BMP's for the watershed. As the implementation process in forest management needs time, GWP sets the foundation for a sustainable BMP application. GWP was resolved through the city council of Waidhofen/Ybbs and has now normative character. As part of the testing/demonstrating character of the PA, stakeholders will be invited to visit specific sites of the DWPA where results of already fulfilled or outstanding management activities will be showcased and discussed.

Within PA1.1 Vienna Water the BMP's regarding surface runoff, erosion and infiltration modelling was tested in the course of the modelling process. The model is already in the process of calibration and the results will be available at the end of the project period. The implementation of the BMP's in the field of alpine pastures was initialized through stakeholder involvement (knowledge transfer and persuasive efforts) (Tab.3).

Within PA1.2 Waidhofen/Ybbs the BMP's regarding forest management within the water protection zone were tested in course of previous scientific works and applications in other forested water protection zones. Hence their applicability is proved. The application of the BMP's was also tested within the PA1.2, some of the practices were analysed regarding their actual status of implementation.

The implementation of BMP's in PA1.2 Waidhofen/Ybbs was strategically planned through the elaboration of the "Guideline for securing the Water Protection functionality of the forest ecosystems within the DWPZ" (GWP) which defines all relevant BMP's for the watershed. The fact that the GWP was resolved through the city council can be regarded as milestone, now it has normative character (Tab. 3).

The implementation of the BMP "Continuous monitoring of relevant, hydrological data and hydrological modelling" was already done through the instrumentation of springs and water courses. The analysis of the data and its interpretation will be a continuous task. Hydrological modelling was also part of the works.

3.1. Solutions for case specific adaptation of best management practices

Here is summarized an analysis of examined/tested best management practices and related foreseeable solutions and recommendations for adaptation of existing land use and flood/drought management practices and improved policy guidelines in the particular PA of Pilot Action Cluster 1. The overall purpose of all mentioned management adaptations is the sustainable protection of the drinking water resources.

All remaining issues to be solved are also mentioned and the needs for action identified in each PA as consequence of remaining gaps between the revised/tested BMP and actual management practices are mentioned (Tab. 4).

Table 4: Overview about the GAPs and related BMPs within PAC1 - Mountain forest and grassland sites.

Actual management practice (GAP)		**GAP group 1** **Forest management:** 1-Continued application of the clear-cut technique 2-Elevated wild ungulate densities 3-Extensive construction of forest roads 4-Creation of conifer plantations 5-Cutting of old, huge and vital tree individuals **Modelling:** 6-Dolomite quarries are causing a decrease in groundwater recharge	**GAP group 2** **Pasture management:** 1- Erosion processes around water troughs for cattle due to open soils without vegetation cover, as well as washing out faeces 2-Grazing of cattle in or close to dolines and sinkholes 3-Unwanted grazing patterns of cattle **Modelling:** 4- Infiltration and surface flow affecting spring quality are not known
Proposed BMP		**Forests** **BMP1-Avoidance of clear-cuts**	**Forests** **BMP2-Forest Ecologically Sustainable Wild Ungulate Densities**
Proposed solutions and recommendations	Adaptation of existing land use management practices	As alternative small gap-cuts can be applied for the creation of forest stand regeneration dynamics.	Hunting should follow the purpose of balancing the wild ungulate densities.
	Adaptation of existing flood/drought management practices	The BMP is also relevant for flood/drought management practices.	The BMP is also relevant for flood/drought management practices.
	Adaptation of policy guidelines	The avoidance of the clear-cut technique should be implemented in an Austrian federal guideline for forested DWPZ.	The execution of the regional province-based laws for hunting should be the central agenda of federal and province policy in Austria.

Remaining issues to be solved		---	---
Proposed BMP		**Forests BMP3-Limitation of forest roads**	**Forests BMP4- Tree Species Diversity According to the Natural Forest Community**
Proposed solutions and recommendations	Adaptation of existing land use management practices	Instead of forest roads, skyline-cranes should be used for timber-yield within DWPZ.	Fitting tree species according to the forest hydrotope type (FoHyM) should be planted and the natural regeneration process should be successful for all-natural tree species of a given forest site.
	Adaptation of existing flood/drought management practices	This measure is also in line with flood mitigation concepts.	This measure is also in line with climate change adaptation strategies and supports the overall forest ecosystem stability. It enhances the protection functionality of the forest ecosystems, also for flood/drought issues.
	Adaptation of policy guidelines	Forest roads should not be enhanced anymore within DWPZ instead they should be limited by law at such locations.	The Austrian Federal Forest Act should support the establishment of forest stands which are in line with the natural forest community.
Remaining issues to be solved		---	---
Proposed BMP		**Forests BMP5-Foster old, huge and vital tree individuals**	**Modelling PA1.2 BMP6-Hydrological water balance modelling**
Proposed solutions and recommendations	Adaptation of existing land use management practices	To strengthen forest stand stability through keeping old huge and stable tree individuals on-site would improve the overall water protection functionality of the ecosystem and also the diversity of the gene-pool.	As result of the modelling task the actual practice of dolomite mining could be impacted, as it reduces groundwater recharge.
	Adaptation of existing flood/drought management practices	This measure also supports flood mitigation.	As groundwater recharge is reduced by dolomite mining, it is also of relevance for drought management. Modelling processes clarify the role of the dolomite quarries.

	Adaptation of policy guidelines	Enhanced awareness about old-growth trees and forests would be of importance.	The existing Austrian Law on the strategy how to shut-down stone quarries should be adaptable in exceptional cases, as the required maxim angle of 45° of the remaining rock-area causes in many cases a significant extension of the actual stone quarry areas.
Remaining issues to be solved		---	---
Proposed BMP		**Alpine Pastures** **BMP1- Placing of water troughs for cattle more frequently, avoiding concentrations of cattle / Concrete basements for the troughs and their surroundings**	**Alpine Pastures** **BMP2-Fencing of dolines and sinkholes in order to keep cattle in distance from those karstic features**
Proposed solutions and recommendations	Adaptation of existing land use management practices	The actual practices of alpine pastures within PA1.1 have to be adapted in most of the cases.	Dolines and sinkholes have to be fenced within all alpine pasture areas hence this means a consequent implementation of this BMP over the space of the water protection zone.
	Adaptation of existing flood/drought management practices	The BMP is not relevant for flood/drought management practices.	This measure does not have implications for flood mitigation or drought management.
	Adaptation of policy guidelines	Policy guidelines do not have to be adapted for this BMP.	It is recommendable that this BMP becomes part of the alpine pasture policy in Austria. It is relevant for the karstic groundwater resources of Austria.
Remaining issues to be solved		---	---
Proposed BMP		**Alpine Pastures** **BMP3- Grazing management for cattle on alpine pastures**	**Modelling - PA1.1** **BMP4- Surface flow - spring dynamic modelling for the region Zeller Staritzen**
Proposed solutions and recommendations	Adaptation of existing land use management	Most of the alpine pasture areas within PA1.1 do not have a strategic grazing management system at the moment. Its	Land use management practices do not have to be adapted.

	practices	implementation can be regarded as major land use management adaptation.	
	Adaptation of existing flood/drought management practices	This BMP is also in line with flood/drought issues as it helps to avoid erosion processes which could increase flood dynamics.	Flood/drought processes can be estimated with this modelling task.
	Adaptation of policy guidelines	The federal and provincial policy for alpine pasture areas should be adapted so that grazing management strategies are being facilitated in the future.	For this modelling procedure policy guidelines do not have to be adapted. It is a mere decision of the water supplier to apply this modelling task.
Remaining issues to be solved		---	---

4. Conclusions

Pilot Action Cluster 1 (PAC1) Mountain Forest and Grassland Sites encompasses Pilot Action 1.1 (PA1.1) Vienna Water - catchment area of Vienna Water Supply, Zeller Staritzen and Central Hochschwab and Pilot Action 1.2 (PA1.2) - catchment area of Waidhofen/Ybbs water supply. The focus of land use activities in case of PA1.1 is on alpine pastures (mountain grasslands) and in case of PA1.2 on forestry. Also, modelling was carried out in both pilot actions, focusing on surface flow and erosion processes (PA1.1) and on groundwater recharge impacts of dolomite stone quarries (PA1.2).

Existing gaps were analysed in both pilot actions and the related Best Management Practices (BMPs) as response to provide fitting solutions in terms of land-use adaptation strategies were elaborated.

PA1.1 – DWPZ Vienna Water – Zeller Staritzen and Hochschwab

In case of alpine pasture management in PA1.1 the existing gaps were identified as (1) Erosion dynamics around water troughs for cattle, (2) Grazing of cattle in or close to dolines and sinkholes and (3) Unwanted grazing patterns of cattle.

The BMPs which help solving challenges in the field of alpine pastures are (1) Placing of water troughs for cattle more frequently, avoiding concentrations of cattle / Concrete basements for the troughs and their surroundings, (2) Fencing of dolines and sinkholes in order to keep cattle in distance from those karstic features and (3) Grazing management for cattle on alpine pastures.

Stakeholders were informed about the relevance of the application of BMPs within the drinking water protection zone (DWPZ). In the course of information transfer meetings and workshops with farmers, alpine pasture related authorities and water works staff, the thematic field of BMPs on alpine pastures was opened and discussed. The information transfer activities can be regarded as crucial for the thematic field and persuasive efforts are integrated in order to ensure application of the BMP's. Alpine pasture staff shows a high level of inertia in terms of management habits.

PA1.2 – DWPZ Waidhofen/Ybbs

In the case of forestry in PA1.2 the gaps (1) Continued application of the clear-cut technique (2) Elevated wild ungulate densities, (3) Extensive construction of forest roads, (4) Creation of conifer plantations and (5) Cutting of old, huge and vital tree individuals were identified as most crucial for the specific drinking water protection zone (DWPZ). In the field of hydrological modelling (6) the impacts of dolomite quarries on spring discharge were analysed.

The BMPs for solving those challenges are given through (1) Avoidance of the clear-cut technique (2) the establishment of Forest Ecologically Sustainable Wild Ungulate Densities, (3) the Limitation of forest roads constructions in the DWPZ, (4) the establishment of Tree Species Diversity According to the Natural Forest Community and (5) strategies to Foster old, huge and

vital tree individuals. In the field of hydrological modelling, (6) continuous monitoring of relevant, hydrological data and hydrological modelling were applied.

The implementation of those most important BMPs within PA1.2 will be facilitated through the "Guideline for securing the Water Protection functionality of the forest ecosystems within the DWPZ" (GWP) which defines all relevant BMPs for the watershed. As the implementation process in forest management needs time, GWP sets the foundation for a sustainable BMP application. GWP was resolved through the city council of Waidhofen/Ybbs and has now normative character. All forest owners who comply with the GWP will receive transfer payments by hectare and year (PES – payments for the provision of ecosystem services).

The fact that GWP was resolved by the city council is due to intensive stakeholder involvement during PROLINE-CE, which encompassed meetings, presentations, discussions and persuasive efforts.

The stakeholder involvement provided in PROLINE-CE was crucial for achieving steps towards the implementation of the BMPs within the Pilot Actions.

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