Interreg

EUROPEAN UNION

Danube Transnational Programme

CAMARO-D

# Transnational best management practice (BMP) catalogue - FORESTRY

# D. T 1.2.3

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# 1 Introduction

Catalogue of Best Management Practices was created as a result of Interreg Danube Transnational Program project CAMARO-D, dealing with flood control, water quality and related questions of land management in Danube catchment.

Catalogue is presented in the form of four issues/handbooks, according to focus area in land management. The focus areas are:

- Agriculture – arable land;
- Agriculture – grass management;
- Forestry;
- Spatial Planning.

Prior the catalogue creation the BMP transnational synthesis had been worked out by CAMARO-D project in close cooperation of all project partners. The synthesis was the first catalogue input offering comparison of BMP use in Danube countries.

Then four international expert teams in above listed focus areas worked out final selection and qualified description of measures to be included in the BMP catalogue.

The catalogue therefore neither collects and assesses all practices, applied within water and landscape management in partner´s countries, nor lists practices most often recently applied within individual Danube countries.

It summarizes most effective practices applied and practices rarely (or even not yet) applied, but which application is highly desirable in several Camaro-D countries. The authors are aware that there exists number of other practices that can be effectively applied within individual countries.

The list will never be complete, but catalogue tries to collect the most effective and most often implemented practices to share knowledge and experiences within Danube countries.

All four issues of BMP catalogue have standardized structure for better orientation and includes indicative criteria as frequency of recent implementation within individual countries, effectiveness and cost demand of general support from state, EU or other legislation.



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According to the title the catalogue deals with Management Practices, but it describes also Technical Measures. Practice or Measure are understood generally as any activity, leading to improvement of water management within target area of Danube catchment.

Hopefully our target group consists of decision makers, land managers, stakeholders, and local authorities interested in Danube region landscape improvement.

## 1.1 List of Best Management Practices

- **Establishment of stable, site-adapted forest ecosystems**
- **Avoiding areas without canopy cover**
- **Improving structural diversity and stability parameters of forest ecosystems**
- **Small-scale silvicultural regeneration techniques**
- **Adequate timber harvesting techniques**
- **Identification and protection of virgin forests**
- **Manage forest-ecologically sustainable wild ungulate densities**
- **Soil conservation liming**
- **Prohibition of chemical fertilizers and pesticides within DWPZ**
- **Forest fire prevention**
- **Limitation of forest roads**
- **Forest roads with proper drainage**
- **Construction of retention pools**
- **Wetlands restoration, deconstruction of drainages**
- **Buffer strips along streams, dolines or sinkholes**
- **Establishing of field shrubs**



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# 2 Best Management Practices – catalogue

## 2.1 Establishment of stable, site-adapted forest ecosystems

| **Type of practice/measure** | | |
|---|---|---|
| Technical | Management | Other - specify |
| | **X** | |

| **Description of practice/measure** |
|---|
| Stable forest ecosystems with different layers minimize large-scale risks such as insect calamities and storm damages, and are more robust against climate change. The practice includes the establishment of mixed forests according to the natural forest community (site-adapted) and of high structural diversity which entails permanent ground cover and therefore minimizes runoff. The tree species diversity and mixture has to be adapted to the natural forest community in order to guarantee the highest degree of stability and resilience. On soils with lower permeability, deep rooting species and layered younger stands should be used to increase transpiration and interception. |

| **Intended goals of practice/measure** |
|---|
| The goal of the measure is to minimize risks concerning calamities. Stable site-adapted mixed forests with vertical and horizontal layers decrease rapidly moving and intensive runoff at the surface. Natural regeneration in particular has positive impacts on reducing runoff. |



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| Characteristics of practice/measure |
|---|
| A forest ecosystem's stability and resilience are crucial for drinking water protection and flood mitigation/prevention. Therefore, a site-adapted tree species mixture in forest stands becomes a central focus of silviculture.<br><br>During the process of forest reconstruction, when monotonous forests are changed to become mixed forests, a continuous vegetation cover should be guaranteed. Small scale structures can be created by prearranging the regeneration of shade-tolerant tree species, by initializing natural site-adapted regeneration, and by selective structural thinning. |

| Effectiveness in operation | |
|---|---|
| The positive effects of stable forest ecosystems (achieved through structured and site-adapted mixed forests) on flood and erosion risks result mainly from the permanent forest cover. In managed mixed forests, the regeneration and harvesting periods overlap, whereby the runoff is also kept to a minimum in forest development periods. The different rooting depths of mixed forests increase water retention capacity. At the same time, the soil water is used more efficiently, resulting in higher infiltration rates. Mixed and structured forests use nutrients more efficiently due to higher diversity which reduces the nutrient load in the runoff. | |
| **On soil conservation** | ** |
| **On flood control** | ** |
| **On water quality conservation** | ** |

| Costs |
|---|
| The practice may result in lower income, e.g. due to a reduced proportion of spruce or other |



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| | |
|---|---|
| conifer species and a more difficult market for broadleaved species.<br>A cost benefit is the reduced risks coming from calamities. | |
| **Investment costs** | * |
| **Operational costs** | * |
| **Economic losses of owners/users** | * |

| **Potential problems/conflicts** | |
|---|---|
| Conflicts due to lower incomes from timber sales could arise. | |
| **Rate** | * |

| **Required or supported by EU policy ?** |
|---|
| There is no EU wide forest policy. This is the competence of the member states. The EU Forestry Strategy (2013) states that "protection efforts should aim to maintain, enhance and restore forest ecosystems' resilience and multi-functionality as a core part of the EU's green infrastructure […]", but the above-described measure is not explicitly mentioned.<br>Some forest areas are being protected in the context of NATURA 2000 which may lead to stable forest ecosystems.<br>The second pillar of the CAP (Common Agricultural Policy), the EU Rural Development Policy, includes "sustainable management of forests" and "Ecosystems related to agriculture and forestry". The money from the CAP goes into national and regional programs that describe more detailed measures such as the recovery, improvement and protection of ecosystems. This is valid for all best management practices in the land use |



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category forestry.

The most relevant EU policy for this practice is the EU Biodiversity Strategy 2020 which explicitly fosters biodiversity within forest ecosystems. Related targets of this strategy are e.g. the support of the forest-biodiversity through the forest owners or the integration of biodiversity measures into forest management plans.

| **Required or supported by country specific policy ?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | yes | yes | | | | |

| **Applied in the country ?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| Select level: *, **, *** | | | | * | ** | | | | |



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Photo: T. Weidner

## 2.2 Avoiding areas without forest canopy cover

| Type of practice/measure | | |
|---|---|---|
| Technical | Management | Other - specify |
| **X** | **X** | |

| Description of practice/measure |
|---|
| Avoiding areas without canopy cover by *avoiding clear-cuts* and large-scale forest die-back (e.g. due to wind-throw, bark beetle or forest fires) is the most important facet of this measure. The application of the clear-cut technique may endanger the quality of the water and also creates erosive dynamics. All these effects are contradictory to integral drinking source water protection. The avoidance of clear-cuts prevents the above mentioned negative effects. Huge clear-cuts have to be avoided, as alternative small-scale gap-cuts, single-tree-felling or the group selection system can be applied. Also the regular shelter wood cut system should be avoided, as it would involve a clear cut phase as a result of its final cut. Without applying the clear-cut technique the continuous cover forest management system can be established. |



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*Continuous Cover Forest Systems (CCF)* ensure a sustained provision of the forest functions for drinking water protection. For Drinking water protected areas (DWPZ) CCF are the most appropriate alternative to a clear-cut based forest system. 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.

*Defined canopy cover percentage of forest stands:* The crown cover percentage of forest stands has to range between 70 % and 90 % in the foothill and montane zones 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. This is a basic requirement for the establishment of CCF.

*Limitation of the percentage of timber extraction:* 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 and hence helps to sustain stability of the forest stands. It has to be applied together with the margins for crown cover percentage (*Defined canopy cover percentage of forest stands)* and also has to integrate the logging frequency.

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

*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.

If despite the application of this measure-bundle areas without canopy cover should occur, e.g. caused by wind-throw events, bark beetle infestations, forest fires or clear cuts, the *re-establishment of the forest cover* should take place as fast as possible. Part of this practice are also the *Rehabilitation and re-cultivation of damaged forest terrains* and *Afforestation of degraded land.*



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| **Intended goals of practice/measure** |
|---|
| The intended purpose of the measure is the sustainable and continuous provision of forest cover within DWPZ. This ensures the water protection functionality of the forest ecosystems in terms of provisioning ecosystem services (ES) (drinking water protection) and in terms of regulating ES (flood prevention). |

| **Characteristics of practice/measure** |
|---|
| This practice is characterized by the application of a bundle of individual measures which ensure together the provision of forest canopy cover over space and time. |

| **Effectiveness in operation** | |
|---|---|
| The measure bundle is highly effective and can be regarded as the crucial BMP within DWPZ. | |
| **On soil conservation** | *** |
| **On flood control** | *** |
| **On water quality conservation** | *** |

| **Costs** | |
|---|---|
| The costs for this measure could be huge if e.g. large wind-throw areas have to be afforested. | |
| **Investment costs** | *** |
| **Operational costs** | ** |
| **Economic losses of** | ** |



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| owners/users | |
|---|---|

| Potential problems/conflicts | |
|---|---|
| Conflicts could arise if forest owners want to continue with the application of the clear-cut technique, which actually is the case in many forest areas. Problems could also arise in protected areas where it is necessary to ask how to prevent or manage bark beetle infestations. | |
| **Rate** | *** |

| Required or supported by EU policy ? |
|---|
| No. |

| Required or supported by country specific policy ? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | yes | yes | | | | |

| Applied in the country? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Select level: *, **, *** | | | | *** | | | | | |

## 2.3 Improving structural diversity and stability-parameters of forest ecosystems

| **Type of practice/measure** | | |
|---|---|---|
| Technical | Management | Other - specify |
| **X** | **X** | |

| **Description of practice/measure** |
|---|
| Only stable forest ecosystems can provide the ecosystem services water provision (drinking water protection) and water regulation (flood prevention). Hence it becomes mandatory for forest-spatial-planning as part of general spatial planning concepts to improve the stability and resilience of forest ecosystems, especially within the context of drinking water protection and flood prevention. To achieve this purpose all possibilities to improve forest ecosystem stability and resilience have to be taken into account.<br><br>+ *Improving the structural diversity of forest stands* encompasses the creation or preservation of vertical and horizontal structure. The establishment of continuous cover forests (CCF) requires structured forest stands, where the structural diversity is created by tree species diversity, uneven-aged trees and multi-layered stands. This leads to the intended structural diversity. One possibility to achieve this target is the application of structural thinning operations. Also the application of small-scale regeneration methods (gap-cuts or group selection cuts) supports the creation of structured forest stands.<br><br>+ *The protection of the gene-pool of autochthonous tree species* is another possibility to increase stability. Those tree species have already survived past climate changes within the specific forest regions and hence form a treasure for creating or preserving stable forest ecosystems, especially if natural regeneration methods are applied within watersheds. |



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+ *Keeping huge, old and stable tree individuals in the forest stands*: This also supports stability. Old and huge tree individuals can provide stability for the whole forest stand via quasi-mechanical stabilisation 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. Hence those stable and old trees have to be seen as integral facet of forest stand stability and their protection becomes vital for the sustainable provision of the intended ecosystem services water provision (drinking water protection) and water regulation (flood prevention).

+ *Fostering stable and vital tree individuals*: In the course of fostering stable and vital tree individuals within forest stands it is important, that the most stable and/or vital tree individuals have to remain within the forest stands, no matter which timber quality the tree should promise. On the other hand, tree individuals with low stability and vitality should be removed, if reductions of the forest stand volume are intended. This deviates explicitly from classical timber forest management.

+ *Adequate deadwood content within forest ecosystems* supports the natural diversity which is a basic condition for stability. If all micro- and meso-fauna relying on dead-wood is present within forest ecosystems, stability is increasing. Also the possibility to host owls has to be mentioned within the context of standing deadwood. Owls can contribute substantially to forest stability as their prey are in many cases mice species, which on the other hand can demolish the natural regeneration dynamics of forests if occurring in high densities.

## Intended goals of practice/measure

The intended goal of the measure is to improve or preserve forest ecosystem stability and resilience. This is the only way to guarantee a sustainable provision of the demanded ecosystem services water provision (drinking water protection) and water regulation (flood prevention).

## Characteristics of practice/measure

The measure is an integrative application of silvicultural operations and general management approaches which promote stability and resilience of forest ecosystems. It encompasses both silvicultural techniques and conservation strategies for reaching the intended purpose.



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| Effectiveness in operation | |
|---|---|
| The implementation of the measure is very effective as it encompasses all facets for facilitation of forest ecosystem stability and resilience. The combination of silvicultural operations and general management approaches yields a highly efficient performance with positive effects on soil conservation, flood control and drinking water protection. | |
| **On soil conservation** | *** |
| **On flood control** | *** |
| **On water quality conservation** | *** |

| Costs | |
|---|---|
| The costs of this measure result above all from increased demand for silvicultural operations and from some minor losses of old and huge tree individuals that are left alive within the forest stands. | |
| **Investment costs** | * |
| **Operational costs** | ** |
| **Economic losses of owners/users** | * |

| Potential problems/conflicts |
|---|
| Potential conflicts through the application of this measure arise from the deviation from classical forestry which focuses on timber yield. Hence foresters will resist against the application of this practice as they want to continue with their business-as-usual way of silviculture and forest management. If the forest area is owned by the water supplier, the implementation becomes easier. In other cases Payments for Ecosystem Services (PES) as |



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| | |
|---|---|
| transfer payment for the application of the practice could be a solution. | |
| **Rate** | ** |

| **Required or supported by EU policy?** |
|---|
| No. |

| **Required or supported by country specific policy?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | yes | | | | | |

| **Applied in the country?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| Select level: *, **, *** | | | | ** | | | | | |



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## 2.4 Small-scale silvicultural regeneration techniques

| **Type of practice/measure** | | |
|---|---|---|
| Technical | Management | Other - specify |
| **X** | **X** | |

| **Description of practice/measure** |
|---|
| The applied silvicultural 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. |

| **Intended goals of practice/measure** |
|---|
| The selected silvicultural regeneration techniques in case of managed forest areas have to be implemented on small-scale areas. This has the purpose to ensure both the stability of the remaining forest stands and the provision of enough light for the establishment of the regeneration dynamics. Small-scale silvicultural regeneration techniques are the suitable alternative to the clear-cut system. The mobilisation of soil- and humus substances remains on a rather low level which contributes to the sustainable protection of source water quality. |

| **Characteristics of practice/measure** |
|---|
| All three regeneration techniques (the group selection system, the single-tree selection system or the small-gap cut system) follow the principle of natural regeneration of all tree species. This system requires the presence of all necessary tree species within the mature forest stands, where regeneration dynamics have to be induced. Should some tree species be missing, afforestation measures have to be included. For an overall success the wild ungulate |



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| |
|---|
| stocks have to be maintained on a forest ecologically sustainable level. |

| **Effectiveness in operation** | |
|---|---|
| The measure in operation secures the continuous regeneration dynamics of the forest ecosystems and can be rated as highly effective for sustaining the provision of the forest ecosystem services. This can only be achieved if there do not exist any hindrances for the regeneration dynamics of the forests, like e.g. high wild ungulate stocks. | |
| **On soil conservation** | *** |
| **On flood control** | *** |
| **On water quality conservation** | *** |

| **Costs** | |
|---|---|
| The costs of this measure are low, as the facilitated natural regeneration process of forest ecosystems takes place naturally and therefore does not cause any costs. Also the timber which can be yielded in the course of the measures is a positive economic contribution. The only difference is that the amount of timber yield is not as high as in case of clear-cut applications. In total, the costs may be lower than the conventional practices, because water security is influenced in a positive way, and drinking water is the most valuable good coming from forest ecosystems, especially ones in DWPZs. Very high costs could arise through clear cuts, if e.g. a spring cannot supply the water mains anymore because of diminished water quality. | |
| **Investment costs** | * |
| **Operational costs** | * |
| **Economic losses of owners/users** | ** |



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| **Potential problems/conflicts** | |
|---|---|
| Potential conflicts could arise with forest owners who only want to apply the clear-cut technique. This challenge has to be resolved with persuasive efforts, the application of transfer payments (PES) or by law. | |
| **Rate** | *** |

| **Required or supported by EU policy ?** |
|---|
| Yes. |

| **Required or supported by country specific policy ?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | yes | | | | | |

| **Applied in the country ?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| Select level: *, **, *** | | | | ** | | | | | |



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## 2.5 Adequate timber harvesting techniques

| Type of practice/measure | | |
|---|---|---|
| Technical | Management | Other - specify |
| **X** | | |

| Description of practice/measure |
|---|
| It is impossible to completely avoid soil damage while logging. To minimize erosion and surface runoff, only clearly defined roads and skid trails should be used on forest soils. Soil-conserving techniques should be preferred, such as skyline cranes, manual wood processing, horses, and others. To limit runoff to short stretches, cross drainages should be installed on the skid trails and roads. |

| Intended goals of practice/measure |
|---|
| The goal is to minimize the impact of forestry machinery on soil erosion and surface runoff, and to avoid the leaking of oil and fuel into the water bodies. |

| Characteristics of practice/measure |
|---|
| In general the timber should be prepared with chainsaws and transported by skyline cranes, and only if necessary, timber should be harvested with tractor-skidders. However, as this is unrealistic, alternatives must be found. One alternative is using defined skid trails and roads that are used over and over again during harvesting periods. That way, the impact is limited to those trails and roads. Harvesting should be carried out extensively with unused stretches in between. The skyline-crane method should be state of the art in DWPZs. |



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When planning a network of skid trails, the length and slope of the trails should be considered in order to maximize harvesting effectiveness. The slope should be as smooth as possible to minimize runoff speed. Cross drainages should be installed on the skid trails for road runoff to infiltrate at regular intervals instead of accumulating causing erosion and more intensive flood events.

The depth of the machine tracks can be reduced by using broad and low-pressure tires. Harvesting should be suspended when the soil is too moist.

Regeneration of machine tracks can be accelerated after harvesting through planting, but soil compaction on these sites will remain for a long time.

| **Effectiveness in operation** | |
|---|---|
| Runoff is much higher in wheel tracks than on normal forest soil because of soil compaction. Over longer distances, the runoff accumulates and increases the erosion potential. Compaction also leads to a lower rooting density and higher water saturation in the soil which result in reduced infiltration. Therefore, applying soil-conserving harvesting techniques, especially the application of skyline cranes and horses, is very effective regarding flood prevention and drinking water protection.<br>Alternative harvesting techniques may also reduce the risk of oil and fuel leaking from heavy machinery and improve surface water quality by reduced erosion and runoff. | |
| **On soil conservation** | *** |
| **On flood control** | ** |
| **On water quality conservation** | ** |

| **Costs** |
|---|



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Additional costs usually apply when alternative machinery, e.g. skyline cranes, is necessary. The risk for reducing the value of the wood is also larger due to damages that would not occur with conventional harvesters. Alternative harvesting practices may also require more personnel and therefore higher staff costs, e.g. when using chainsaws. This would also lead to a higher risk for accidents for forest workers.

Costs may generally be higher in DWPZs, because of an increased use of skyline cranes and horses.

| | |
|---|---|
| **Investment costs** | ** |
| **Operational costs** | ** |
| **Economic losses of owners/users** | * |

| **Potential problems/conflicts** | |
|---|---|
| Increased workload when harvesting with alternative methods (chainsaws, skyline cranes or horses) may be a problem. | |
| **Rate** | * |

| **Required or supported by EU policy ?** |
|---|
| There is no EU legislation on soil protection or timber harvesting techniques.<br>The second pillar of the CAP, the EU Rural Development Policy, includes "sustainable management of forests". The money from the CAP goes into national and regional programs that describe more detailed measures such as special logging techniques. |



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| Required or supported by country specific policy ? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | no | yes | | | | |

| Applied in the country ? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| Select level: *, **, *** | | | | * | * | | | | |

**Photo: P. Adler**



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## 2.6 Identification and protection of virgin forests

| Type of practice/measure | | |
|---|---|---|
| Technical | Management | Other - specify |
| | **X** | |

| Description of practice/measure |
|---|
| Mostly virgin 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 have to be forest-ecologically balanced. If those criteria are fulfilled, the self-regulating force of such forest ecosystems is given on a high level. Hence forest management measures within those virgin forest ecosystems can be suspended and natural succession can take place, until an urgent need for management measures implementation should arise again (e.g. in case of large-scale bark beetle infestations, wind-throw or forest fires). Therefore the protection of virgin forest ecosystems secures a low disturbance regime, which supports important ecosystem services such as water provision (drinking water protection) and water regulation (flood prevention). |

| Intended goals of practice/measure |
|---|
| Through the protection of highly functional virgin forest ecosystems a low disturbance regime is created, which supports the protection of forest soils, drinking water protection and flood prevention. Hence, if huge areas of functional virgin forest ecosystems can be protected, the needed ecosystem services can be provided on a high level without causing potential contaminations of the aquifer through e.g. forestry machinery. |

| Characteristics of practice/measure |
|---|



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| |
|---|
| The measure is characterized by the avoidance of any active silvicultural management. |

| **Effectiveness in operation** | |
|---|---|
| The measure is highly effective, as functional forest ecosystems in terms of the ecosystem services water provision and water regulation are protected. | |
| **On soil conservation** | *** |
| **On flood control** | *** |
| **On water quality conservation** | *** |

| **Costs** | |
|---|---|
| The only costs which arise from the application of this measure are related with the loss created by the abandonment of timber yield. Hence no timber can be sold. | |
| **Investment costs** | * |
| **Operational costs** | * |
| **Economic losses of owners/users** | ** |

| **Potential problems/conflicts** |
|---|
| Problems could arise if forest owners want to sell timber from virgin forest ecosystems. This could be resolved with PES (payments for ecosystem services), where water suppliers provide transfer payments for forest owners in case of the application of this Best Practice. |



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| **Rate** | * |
|---|---|

| **Required or supported by EU policy ?** |
|---|
| No. |

| **Required or supported by country specific policy ?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | yes | | | | | |

| **Applied in the country ?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| Select level: *, **, *** | | | | * | | | | | |



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## 2.7 Manage forest-ecologically sustainable wild ungulate stocks

| **Type of practice/measure** | | |
|---|---|---|
| Technical | Management | Other - specify |
| | **X** | |

| **Description of practice/measure** |
|---|
| Regeneration dynamics are of crucial importance for forest succession. If the stocks of the wild ungulate game species are too high, forest regeneration is seriously hampered or even stopped. Reasons for this dangerous situation for forest ecosystems are the browsing, fraying and bark-stripping damages caused by wild ungulates. In order to guarantee stable forest stands, the wild ungulate stocks have to be kept on a level, which allows vital regeneration dynamics of all necessary tree species, i.e. of all tree species of a natural forest community (forest hydrotope type). |

| **Intended goals of practice/measure** |
|---|
| The establishment of vital and stable regeneration of all tree species within a forest community is the intended purpose of this measure, as it is important for sustainability, for stable and resilient forest ecosystems and for the possibility to be adaptable under climate change conditions. It is also the basic condition for the establishment of the continuous cover forest system (CCF), as the status of uneven-aged and structured forest stands can only be achieved via vital and continuous regeneration dynamics. |

| **Characteristics of practice/measure** |
|---|
| In some European regions especially the regeneration dynamics of Silver fir (*Abies alba*) and oak species (*Quercus sp.*) have to be facilitated by the creation of forest-ecologically balanced wild ungulate stocks. The regeneration process of all broadleaved tree species, fir, larch and in some cases spruce can be improved by this measure. The only chance to reach forest- |



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| |
|---|
| ecologically balanced wild ungulate stocks is the implementation of appropriate hunting activities and by the creation of close to nature forest stands. The focus of the hunting activities has to be on red dear (*Cervus elaphus*), roe dear (*Capreolus capreolus*), chamois (*Rupicapra rupicapra*) and ibex (e.g. *Capra ibex*). The activities of the hunters can be supported essentially by the presence of wild predators like e.g. wolf (*Canis lupus*) or lynx (*Lynx lynx*). |

| **Effectiveness in operation** | |
|---|---|
| | |
| **On soil conservation** | *** |
| **On flood control** | *** |
| **On water quality conservation** | *** |

| **Costs** | |
|---|---|
| The costs for the implementation of this measure consist of the operational costs for hunting activities and also investment costs for the hunter equipment. Also for the introduction of wild predators costs could arise. On the other hand costs for artificial recruitment measures are avoided as natural regeneration dynamics within the forest ecosystems are enabled. | |
| **Investment costs** | * |
| **Operational costs** | *** |
| **Economic losses of owners/users** | * |



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| Potential problems/conflicts | |
|---|---|
| There will potentially be problems and conflicts with the hunting lobby, which above all wants to secure the current situation where wild ungulate stocks are increased by human interventions in order to allow trophy-hunting activities. This conflict of interests is severe and can involve interferences from various established lobbies. Other problems could result from increasing predator populations, especially protected species such as the wolf where there are conflicts with sheep herders. The conflict between wolf populations and farmers can be solved with adapted concepts. | |
| **Rate** | *** |

| Required or supported by EU policy? |
|---|
| --- |

| Required or supported by country specific policy? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | no | | | | | |

| Applied in the country? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| Select | | | | * | | | | | |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| level:<br><br>*, **, *** | | | | | | | | | |

## 2.8 Soil conservation liming

| **Type of practice/measure** | | |
|---|---|---|
| Technical | Management | Other - specify |
| **X** | | |

| **Description of practice/measure** |
|---|
| In forest areas with acidified soils (especially on siliceous bedrocks) it may be necessary to carry out liming in order to counteract soil acidification caused by a high input of air contaminants. Acidification of forest soils is still a big problem in some areas despite the fact that depositions (acid rain) have decreased to very low levels since the 1990s in most parts of Europe. |

| **Intended goals of practice/measure** |
|---|
| Liming regenerates the soil from the effects of air pollution on acidified sites. It prevents nutrients and pollutants such as heavy metals from leaching into the groundwater. It helps the conservation and rebuilding of soil structure and therefore increases infiltration and water retention. |

| **Characteristics of practice/measure** |
|---|



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The process of liming starts after a phase of planning and approval. Generally, 2.5 – 4.5 t/ha dolomite is applied every 10 years. This is being done by helicopter or on the ground using a blowing machine. The measures must be documented to register ecological and economic impacts. By random samples of the used material on site, both nutrient compositions and whether or not the measure complies with fertilizer regulations are monitored. A buffer distance of 100m must be kept around sensitive areas (e.g. nature reserves, DWPZs).

| **Effectiveness in operation** | |
|---|---|
| An increase in pH stabilizes the nutrient storage and significantly improves the living conditions for soil organisms (e.g. earthworms) which are responsible for much of the porosity and aeration of the upper soil. This increases infiltration 4- to 10-fold compared to not-limed soils. Development of water storing soil structures and an enhanced fine root growth increase water retention capacity by several l/m². The water quality can be influenced positively by reducing heavy metals and aluminum leaching to the groundwater. | |
| **On soil conservation** | *** |
| **On flood control** | ** |
| **On water quality conservation** | *** |

| **Costs** | |
|---|---|
| There are costs for the liming material and the implementation which lie at approx. 220 – 300 €/ha (in Germany). Planning costs are also very high due to a long planning period. | |
| **Investment costs** | ** |
| **Operational costs** | *** |



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| | |
|---|---|
| **Economic losses of owners/users** | - |

| **Potential problems/conflicts** | |
|---|---|
| Some environmentalists see liming as too much interference with nature.<br>An initial increase in nitrate concentrations in the water after liming can be found in some cases.<br>It is important to sample the used materials before application (mentioned above) in order to avoid any addition of unwanted elements such as heavy metals, especially in areas such as DWPZs, where such contamination would be unacceptable. | |
| **Rate** | * |

| **Required or supported by EU policy ?** |
|---|
| The second pillar of the CAP, the EU Rural Development Policy, includes "sustainable management of forests". The money from the CAP goes into national and regional programs that describe more detailed measures such as soil liming in forests. |

| **Required or supported by country specific policy ?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | yes | yes | | | | |



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| Applied in the country ? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| Select level: *, **, *** | | | | * | ** | | | | |

Photo: J. Schäffer

## 2.9 Prohibition of chemical fertilizers and pesticides within DWPZ

| Type of practice/measure | | |
|---|---|---|
| Technical | Management | Other - specify |
| **X** | **X** | |



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| Description of practice/measure |
| --- |
| The use of chemicals like fertilizers, pesticides or herbicides in forestry practices should be generally avoided (forbidden in DWPZs), as these substances form a threat to water quality. Forestry is not dependent on the use of these substances. It has to be highlighted that forestry in general does not apply chemicals in an extended way, but in some cases of course they are applied. Examples are pesticides used against insect infestations, chemicals against browsing damages, herbicides against broadleaved tree species during the establishing of conifer plantations, or fertilizers in special plantations. The potential danger of these chemicals entering the source water resources for drinking water supply is a strong argument for the prohibition of their use within DWPZ. |

| Intended goals of practice/measure |
| --- |
| Avoidance of the potential risk that chemicals could enter the aquifer and contaminate the source water for drinking water supply. |

| Characteristics of practice/measure |
| --- |
| The absence of the application of the mentioned chemicals is a crucial advantage of forested watersheds in contrast to agriculturally used ones. |

| Effectiveness in operation | |
| --- | --- |
| | |
| **On soil conservation** | * |
| **On flood control** | * |
| **On water quality conservation** | *** |



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| **Costs** | |
|---|---|
| Extra costs do not arise from this measure. In case of historic herbicide applications costs could arise for the mechanical removal of unwanted tree species. | |
| **Investment costs** | * |
| **Operational costs** | * |
| **Economic losses of owners/users** | * |

| **Potential problems/conflicts** | |
|---|---|
| In some exceptional cases conflicts could arise if forest owners want to keep their old habits of chemical application. | |
| **Rate** | * |

| **Required or supported by EU policy?** |
|---|
| --- |

| **Required or supported by country specific policy?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **yes/no** | | | | no | | | | | |

| **Applied in the country?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| Select level: *, **, *** | | | | * | | | | | |

## 2.10Forest fire prevention

| **Type of practice/measure** | | |
|---|---|---|
| Technical | Management | Other - specify |
| **X** | **X** | |

| **Description of practice/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 and are functional for flood prevention or mitigation. Climate change and other challenges threaten forests and their protection and production functionality. According to 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 infrastructural damages. This best management practice |



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| |
|---|
| is highly relevant both within the context of flood prevention and drinking water protection. |

| **Intended goals of practice/measure** |
|---|
| Reduction of the risk for forest-fire-outbreaks for whole forest areas (watersheds, DWPZ, regions). |

| **Characteristics of practice/measure** |
|---|
| Forest fire prevention measures take into account the probability of fire and include several organizational concepts and measures:<br><br>Educational actions: planning, organizing, implementing and performing control patrol actions (in times of drought and in exposed areas); mounting panels with texts on risk of fire; prohibition of forest fire or vehicle access; collaboration with local and specialized fire services; etc.<br><br>Permanent monitoring and early detection measures to end the fire before it grows.<br><br>Measures specific for silvicultural forestry activities in order to reduce the risk of fire: They refer to certain rules and precautionary strategies to be taken in the course of afforestation, care work and forest management, forest planning and forest exploitation.<br><br>Rules and measures for fire fighting. |

| **Effectiveness in operation** | |
|---|---|
| If executed in an adequate manner the forest fire prevention can be highly effective, especially if taken into account that most of the forest fires are caused by human activities. | |
| **On soil conservation** | *** |
| **On flood control** | *** |



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| | |
|---|---|
| **On water quality conservation** | *** |

| **Costs** | |
|---|---|
| Costs are potentially very high, especially for areas where fire-departments have to be established newly. Also the costs for fire-fighting hardware can be high, like e.g. for fire-fighting aircrafts which are currently only available within nations with a long history in forest fires like e.g. France or Italy. In many Danube transnational regions fire-fighting aircrafts would be an optimal investment for fighting/avoiding forest fires. Operational costs are high due to the high demand of personnel in periods with a high risk of forest fire occurrence. | |
| **Investment costs** | *** |
| **Operational costs** | *** |
| **Economic losses of owners/users** | * |

| **Potential problems/conflicts** | |
|---|---|
| Conflicts should not arise during implementation of this practice. | |
| **Rate** | * |

| **Required or supported by EU policy?** |
|---|
| No. |



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| Required or supported by country specific policy? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | yes | | | | | |

| Applied in the country? | | | | | | | | | |
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| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| Select level: *, **, *** | | | | ** | | | | | |

## 2.11 Limitation of forest roads

| Type of practice/measure | | |
|---|---|---|
| Technical | Management | Other - specify |
| **X** | | |

| Description of practice/measure |
|---|
| The amount of roads has a significant impact on water drainage and erosion. Unnecessary |



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roads should be removed and new roads should be the exception.

## Intended goals of practice/measure

The overall goal is to have good infiltration in forests which means a large percentage of unsealed surfaces. A network of forest roads is necessary for harvesting. The more efficient it is designed, the fewer roads are needed. The goal is to have as few forest roads as possible to minimize erosion and runoff. Especially in DWPZ, forest roads should be as scarce as possible, and the construction of new ones should be avoided.

## Characteristics of practice/measure

Extremely runoff intensive roads should be removed if possible. These are all roads with a slope of >10% (>3% for clayey or silty substrates) that do not have cross drainages. Deeply cut in roads should be filled, rarely used ones greened. Steep embankments should be flattened to reduce erosion. Concrete roads should be replaced by more permeable roads in some cases, and unnecessary roads should be removed.

## Effectiveness in operation

Unsealed surfaces and the disruption of linear structures improve infiltration and decrease height and speed of runoff peaks. A decrease in road surface area by 50% may reduce the part of the rain that ends up as surface runoff by 40-50%. This reduction is lower in case of heavy rain, especially for less permeable soils where this reduction is 10% at the most. Vegetation growing on the road reduces surface runoff by up to 50%, especially when it is without gaps.

This practice leads to a better infiltration and filtering through a larger area of intact forest soil instead of roads, thereby also improving water quality.



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| | |
|---|---|
| **On soil conservation** | ** |
| **On flood control** | *** |
| **On water quality conservation** | * |

| **Costs** | |
|---|---|
| Costs are related to the deposition of road material and longer transport routes due to fewer roads. Also, where concrete is replaced by a more permeable road cover, costs emerge from constructing a base layer and drainages. | |
| **Investment costs** | ** |
| **Operational costs** | * |
| **Economic losses of owners/users** | * |

| **Potential problems/conflicts** | |
|---|---|
| Longer transport routes for timber may provoke conflicts with forest owners.<br>Higher maintenance costs for waterbound road covers. | |
| **Rate** | * |

| **Required or supported by EU policy ?** |
|---|
| The second pillar of the CAP, the EU Rural Development Policy, includes “sustainable |



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| |
|---|
| management of forests". The money from the CAP goes into national and regional programs that describe more detailed measures such as investments for forest roads. |

| **Required or supported by country specific policy ?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | yes | yes | | | | |

| **Applied in the country ?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
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| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| Select level: *, **, *** | | | | * | ** | | | | |



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Photo: H. Hettinger

## 2.12 Forest roads with proper drainage

| Type of practice/measure | | |
|---|---|---|
| Technical | Management | Other - specify |
| **X** | **X** | |

| Description of practice/measure |
|---|
| Roads cause water to flow off to the sides and to accumulate there in narrow gutters. Frequent cross drainages on the roads carry water from the road surface to the sides to infiltrate everywhere along the road instead of being channeled to the receiving water. |

| Intended goals of practice/measure |
|---|



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The goal is to decrease flood risk and erosion by letting road runoff flow off the road in regular intervals. This leads to the water infiltrating locally and increases the time the runoff needs to flow to the receiving water, thereby reducing flow peaks.

| **Characteristics of practice/measure** |
|---|
| Water from runoff-intensive roads should be diverted into the forest stand at as short as possible intervals along the road. Runoff-intensive roads in lowland with cross slopes to both sides, and runoff intensive roads in mountainous regions with cross slopes towards the valley (up to 5%) should be treated. On roads with steep longitudinal slopes, a cross drainage should be installed at least every 50 m. Road-accompanying ditches should be avoided. In case this is not possible, the ditches should be greened to decrease water velocity. To return the ditch water to the forest stand, infiltration ditches should be installed. |

| **Effectiveness in operation** | |
|---|---|
| When the water accumulating on roads flows into the forest stand at regular intervals and infiltrates into the soil there, the runoff from forests can be prevented almost completely. The flow distance to a stream increases, flood peaks are buffered and delayed. Normal rainfall can infiltrate almost completely, but the effect is limited for heavy rain events on waterlogged soils. | |
| **On soil conservation** | ** |
| **On flood control** | *** |
| **On water quality conservation** | * |



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| Costs | |
|---|---|
| Initial costs are caused by the installation of cross drainages which cost money to maintain. A decrease in costs is obtained in fewer damages from erosion on the road. | |
| **Investment costs** | ** |
| **Operational costs** | * |
| **Economic losses of owners/users** | - |

| Potential problems/conflicts | |
|---|---|
| Management conflicts could arise from the need of regular maintenance of the cross drainages which costs money. | |
| **Rate** | * |

| Required or supported by EU policy ? |
|---|
| The second pillar of the CAP, the EU Rural Development Policy, includes “sustainable management of forests”. The money from the CAP goes into national and regional programs that describe more detailed measures such as investments for forest roads. |

| Required or supported by country specific policy ? |
|---|
| |



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| Country | AT | BG | HR | CZ | D | HU | RO | RS | SLO |
|---|---|---|---|---|---|---|---|---|---|
| **yes/no** | | | | yes | yes | | | | |

| **Applied in the country ?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| Select level: *, **, *** | | | | ** | ** | | | | |

**Photo: C. Sucker**



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## 2.13 Construction of retention pools

| Type of practice/measure | | |
|---|---|---|
| Technical | Management | Other - specify |
| **X** | | |

| Description of practice/measure |
|---|
| Naturally occurring and artificial surface depressions can be used as temporary water retention basins that are filled with water during heavy rain events and fall dry during drought periods. Water is held back during heavy precipitation events, buffering floods. This is a small-scale measure and has no connection to constructing large objects such as water reservoirs. |

| Intended goals of practice/measure |
|---|
| The goals are to buffer floods by increasing the travel time that the runoff needs to reach the receiving water, and by increasing infiltration at the retention pools. |

| Characteristics of practice/measure |
|---|
| Natural depressions, abandoned fish ponds or the depressions next to roads acting as dams should be used as retention pools, and constructing new ones should only be done when there is no other option. The retention pools should be connected to existing, non-regulated drainage trenches or cross drainages on roads.<br>The desired size of a retention pool is not large and ranges between a few cubic meters to |



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| |
|---|
| several thousand cubic meters. |

| **Effectiveness in operation** | |
|---|---|
| Surface water originating from rainfall is caught in retention pools which act as buffer storages to delay runoff. Also, some of the water in retention pools may evaporate or infiltrate. The effectiveness of a retention pool can be described as the ratio of its volume (in liters) to its catchment area (in square meters). An effect on flood peaks can be expected above a specific volume of 3 mm (3000 $m^2/km^2$). A similar effect can be produced with smaller pools installed in a cascade-like fashion. Water quality is affected positively by lower sediment loads in the runoff and by a decrease in flood peaks. | |
| **On soil conservation** | ** |
| **On flood control** | *** |
| **On water quality conservation** | * |

| **Costs** | |
|---|---|
| Construction costs may be low when retention pools are installed during road restorations and in connection to existing depressions and structures. Maintenance costs arise from removing sedimentation in the pools. | |
| **Investment costs** | ** |
| **Operational costs** | * |
| **Economic losses of owners/users** | * |



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| Potential problems/conflicts | |
|---|---|
| Retention pools may transform into wetlands over time which is a positive side effect. Unfortunately, wetlands will eventually lose their initial purpose of being a retention pool and have a much smaller effect on flood control, and removing them is prohibited by law.<br>Conflicts could arise when forest owners are not willed to construct retention pools. | |
| **Rate** | * |

| Required or supported by EU policy ? |
|---|
| The EU floods directive states that adequate and coordinated measures to reduce flood risk should be taken by the EU member states. |

| Required or supported by country specific policy ? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | yes | yes | | | | |

| Applied in the country ? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Select level: *, **, *** | | | | ** | * | | | | |

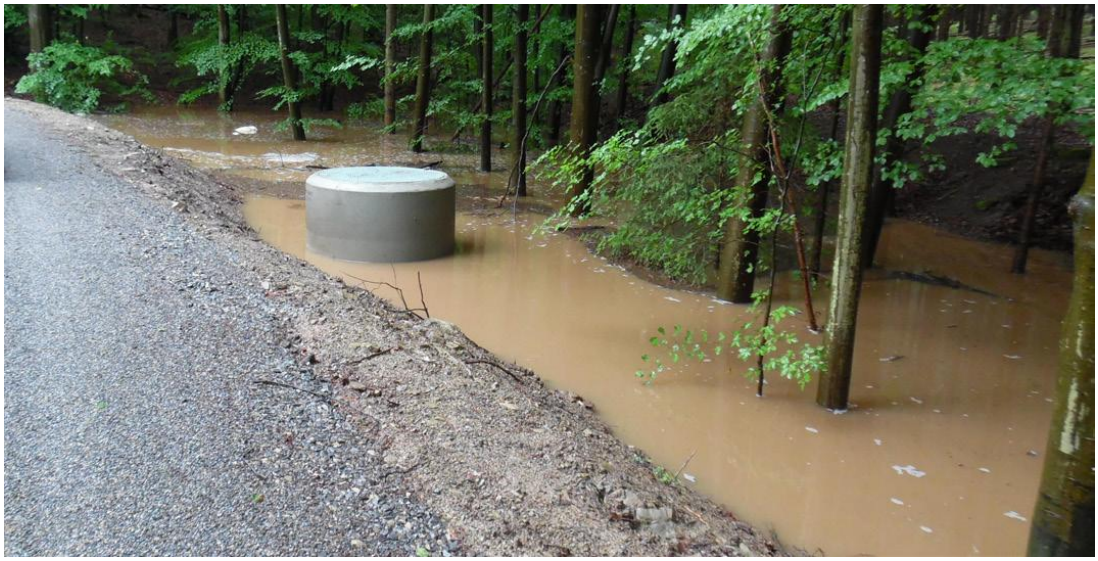

Photo: M. Schnickl/ A. Assmann

## 2.14Wetlands restoration, deconstruction of drainages

| **Type of practice/measure** | | |
|---|---|---|
| Technical | Management | Other - specify |
| **X** | | |

| **Description of practice/measure** |
|---|
| Reactivating former wetlands can increase water retention long-term and dampen flood events. The deconstruction of ditches and drainage systems directly affects flood events by |



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increasing the retention capacity of the land and reducing flood travel time to streams.

| **Intended goals of practice/measure** |
|---|
| Wetlands retain water which increases flood travel time to the receiving water, thereby reducing flood peaks. They are also good sediment and contaminant filters, and therefore have positive effects on water quality. |

| **Characteristics of practice/measure** |
|---|
| Before applying this measure, some planning should be done. The area has to be mapped, and the impact of a restoration must be assessed. The actual implementation starts with removing or closing off drainage systems, thereby slowing runoff. Constructing linear structures (roads and paths) should be avoided in these areas. The accumulation of linear runoff should be stopped and can, for example, be disrupted by reducing the width of linear flow channels (ditches) using wooden poles. This causes temporary water retention and slows flood waves. |

| **Effectiveness in operation** | |
|---|---|
| Closing drainages leads to a significant decrease in flow speeds. Intact wetlands decrease flood formation, especially because of an increased evaporation through peat mosses as compared to forest soils. Drained wetlands have changed soil properties and a significantly reduced water retention capacity. Restoring the soils will have a large positive effect on water retention and filtering capacities, thereby also increasing water quality. | |
| **On soil conservation** | * |
| **On flood control** | *** |



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| | |
|---|---|
| **On water quality conservation** | *** |

| **Costs** | |
|---|---|
| Planning, restoration measures and maintenance of the retention structures incur costs. | |
| **Investment costs** | *** |
| **Operational costs** | * |
| **Economic losses of owners/users** | ** |

| **Potential problems/conflicts** | |
|---|---|
| There may be different problems and conflicts resulting from the restoration of wetlands. Either, restored wetlands are taken out of cultivation completely, or there are other problems for the land users, such as timber marketing. Certain site-adapted tree species may not be in large demand by the market. Also, there are higher costs associated with cultivation on saturated soils which affects both timber harvesting and thinning operations. | |
| **Rate** | ** |

| **Required or supported by EU policy ?** |
|---|
| Wetland measures are supported and required in regard to water quality (i.e. in the EU Water Framework Directive), in regard to flood protection (i.e. EU Floods Directive) and in the context of Natura 2000. |



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| Required or supported by country specific policy ? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | yes | yes | | | | |

| Applied in the country ? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| Select level: *, **, *** | | | | * | * | | | | |

Photo: C. Sucker



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## 2.15 Buffer strips along streams, dolines or sinkholes

| Type of practice/measure | | |
|---|---|---|
| Technical | Management | Other - specify |
| **X** | **X** | |

| Description of practice/measure |
|---|
| Buffer strips along streams, dolines and sinkholes limit erosion processes and are a very effective way to prevent the entrance of various substances into the water body. Forested buffer strips along streams and lakes have to be established in order to protect the open water bodies from direct infiltration of nutrients or sediments, which can be caused by strong precipitation events, erosion processes or logging activities. Streams are sensitive sectors, also in many DWPZ's, 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 are protective against lateral erosion processes. 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. |

| Intended goals of practice/measure |
|---|
| The intended purpose of the measure is the stabilization of riparian areas in order to mitigate or avoid lateral erosion processes which could mobilise huge amounts of soil- and bedrock substances in case of flood events. This practice also exerts positive impacts on drinking source water protection. The second essential purpose is the protection of the streams from direct input of sediments or nutrient loads, which affects drinking water protection and fishery activities. |



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| Characteristics of practice/measure |
|---|
| The preservation of forested buffer strips along streams is an essential task within DWPZ and areas prone to floods. Forest cover in buffer strips has to be stable and dense. The tree roots have to provide the filtering capacity of the buffer strips. Also tall trees should remain if they show stable, vital and strong growth. Forest management measures should only be executed for the improvement of forest stability or for the initialisation of regeneration dynamics. The buffer strip width should be ranging between 10 m and one tree length in all cases. No dead-wood or instable trees can be accepted in those belts in order to prevent drift-wood creation. Also only the natural tree species should be kept within those forested belts as conifer plantations (e.g. Norway spruce) are not adequate there. |

| Effectiveness in operation | |
|---|---|
| The measure is highly effective for flood mitigation and also for drinking source water protection, in the latter case especially if applied in case of dolines and sinkholes within karstic catchment areas. | |
| **On soil conservation** | *** |
| **On flood control** | ** |
| **On water quality conservation** | *** |

| Costs | |
|---|---|
| The costs for this practice result from silvicultural operations, which have to be carried out with utmost care for the fragile ecosystems (soils and forest cover). It has to be highlighted that inside buffer strips all mechanized operations with heavy machines have to be prohibited to avoid soil and stream bank disturbances. | |
| **Investment costs** | * |
| **Operational costs** | ** |



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| | |
|---|---|
| **Economic losses of owners/users** | * |

| **Potential problems/conflicts** | |
|---|---|
| Conflicts could arise if some stakeholders are putting their management focus only on the prevention of driftwood. Conflicts with land users also come from a loss of economically usable land to buffer strips. Land needs to be available for buffer strips, which often is agricultural land and not forest land. | |
| **Rate** | ** |

| **Required or supported by EU policy?** |
|---|
| Indirectly through the EU floods and the EU drinking water directive. |

| **Required or supported by country specific policy?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | no | no | | | | |

| **Applied in the country?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |



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| | | | | | | | | | |
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| Select level: *, **, *** | | | | * | | | | | |

## 2.16Establishing of field shrubs

| **Type of practice/measure** | | |
|---|---|---|
| Technical | Management | Other - specify |
| | **X** | |

| **Description of practice/measure** |
|---|
| Field shrubs may act as the transition zone from forest to un-forested land. Shrubs (especially root-intensive trees such as alder) planted parallel to the slope of runoff-intensive areas can slow runoff and increase water retention. |

| **Intended goals of practice/measure** |
|---|
| The goals are to decrease surface runoff and soil erosion, and to increase water retention in the transition zone between forests and agricultural land. |

| **Characteristics of practice/measure** |
|---|
| Preferable areas are fallow sites parallel to the slope in the transition zone between agriculture and forestry. Hotspots with particularly high runoff should be identified |



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| |
|---|
| beforehand, where afforestation with field shrubs has the highest mitigation effect on flood formation. The plant choices should be in favor of site-adapted tree species and ecologically stable, root-intensive plants. Tested options are rows of alder with parts of lime, ash or maple as well as rows of lime/hornbeam with parts of oak. Alder should not be used within DWPZ due to its nitrogen-fixation. |

| **Effectiveness in operation** | |
|---|---|
| Field shrubs parallel to the slope shorten runoff lines that are parallel to the dip direction. A higher surface roughness in the afforested area slows the runoff and reduces erosion. Root-intensive tree species increase infiltration rates and water retention capacity significantly. Field shrubs also have a high interception and evaporation rate, hence supporting the reduction in runoff. The percentage of the precipitation that is discharged as surface flow is 50% lower under forests than on grassland. Reduced runoff and higher infiltration also have positive effects on water quality. | |
| **On soil conservation** | *** |
| **On flood control** | *** |
| **On water quality conservation** | * |

| **Costs** | |
|---|---|
| Afforestation costs lie between 2200 €/ha and 2600 €/ha (in Germany). Additional costs are forest protection measures and potential replacement planting. In case agricultural land is used for the establishment of field shrubs, there is a reduction in income for the land user. | |
| **Investment costs** | ** |



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| | |
|---|---|
| **Operational costs** | * |
| **Economic losses of owners/users** | ** |

| **Potential problems/conflicts** | |
|---|---|
| A potential problem for farmers is a potential increase in pests such as snails and mice. | |
| **Rate** | * |

| **Required or supported by EU policy ?** |
|---|
| The second pillar of the CAP, the EU Rural Development Policy, includes "sustainable management of forests" and "Ecosystems related to agriculture and forestry". The money from the CAP goes into national and regional programs that describe more detailed measures in agriculture and forestry. |

| **Required or supported by country specific policy ?** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **Country** | **AT** | **BG** | **HR** | **CZ** | **D** | **HU** | **RO** | **RS** | **SLO** |
| **yes/no** | | | | yes | yes | | | | |

| **Applied in the country ?** |
|---|



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| Country | AT | BG | HR | CZ | D | HU | RO | RS | SLO |
|---|---|---|---|---|---|---|---|---|---|
| Select level: *, **, *** | | | | ** | ** | | | | |

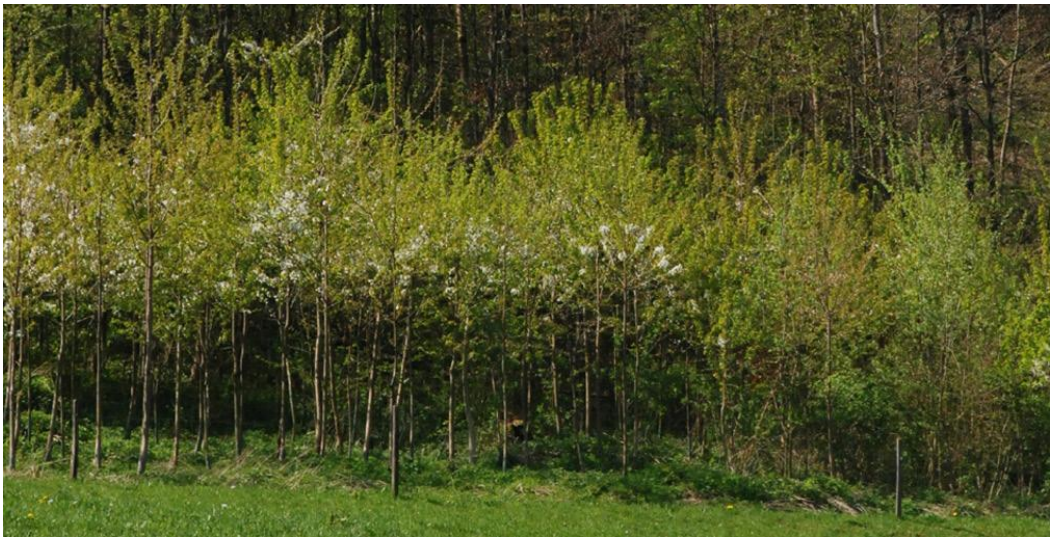

**Photo: T. Weidner**



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