D45 THE FIRST AUSTRIAN INDICATION MAP OF PROTECTIVE FORESTS SHOWING THEIR OBJECT-PROTECTIVE FUNCTION CARTOGRAPHICALLY

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ABSTRACT

Previously available geoinformation on protective forests in Austria did not provide explicit mapped information on forests with a direct object-protective function. Their mapping concepts did not distinguish between direct object-protective, indirect object-protective and site-protective functions of forests, which make sense in terms of forest policy and management. Object-protective forests cannot be mapped without modelling the potential natural hazard runouts and back-tracking of potential object impacts. The now evaluated "Indication map of protective forests in Austria" presents for the first time the potential protective forest scenery in the entire federal territory based on a consistent concept, uniform criteria and methods implemented by spatial modelling as well as through the contribution of local practical expertise.

BACKGROUND AND STARTING POINT

Please note the conceptual differentiation between the protective function and the protective effect of a forest according to Brang et al. (2001), Perzl and Huber (2014) and Perzl et al. (2021), which is assumed in the following. A protective forest (protection forest) is a forest with one or more protective functions and meets the definition according to the valid forestry regulations.

Although the object-protective forest was introduced in Austria in 2002 as a statutory category to define the obligations and cost bearing of forest owners, there has been no publicly available information on the locations of these forests. The available geoinformation on protective forests, such as the Austrian Forest Development Plan (WEP), did not provide explicit mapped information on forests with a protective function against natural hazards for settlement areas and infrastructures (assets, objects), as the mapping concepts did not differentiate between object- and site-protective functions. Furthermore, the purposeful differentiation between a direct and an indirect object-protective function, as laid down in the Forest Act 1975, was not considered. It became increasingly apparent that object-protective forests cannot be mapped without modelling the potential natural hazard runouts and back-tracking of potential object hits. This resulted in the need for a new concept of categorisation and representation of the forest with protective function based on spatial modelling with respect to existing and new regulations and information tools such as the WEP. Maintaining and improving the protective effects of forests require spatially explicit information on the location of protective forests based on an expedient categorisation of protection objectives. As a part of the "Action Programme Protective Forests" (BMLRT 2020), the Federal Ministry of Agriculture, Forestry, Regions and Water Management commissioned the protective function mapping of forests (PROFUNmap). The task of PROFUNmap (Perzl et al., 2019) was to compile an "Indication map of protective forests in Austria" (IMPFA) based on a consistent concept and existing geoinformation.

METHODS: DEFINITION OF CATEGORIES OF PROTECTIVE FUNCTIONS AND MAP COMPILATION TECHNIQUE

The IMPFA is the result of these main steps: 1) definition of appropriate categories of the protective functions and preparation of first maps by GIS-modelling, 2) evaluation and adaption of the selected map proposal by regional authorities, and 3) topological post-editing and final inspection of the adapted map.

By analysing the scientific literature, the legal basis and the available geodata – the latter showing the practical approaches independent of formal-theoretical directives, three main categories of the protective function of the forest against natural and cultural hazards were elaborated: 1) the direct object-protective function, 2) the indirect object-protective function, and 3) the site-protective function of forest. This classification differs in detail from other concepts such as Schönenberger (1998), Motta and Haudemand (2000) and Kleemayr et al. (2021); however, it is not new and can be found – not explicitly – in the Austrian Forest Act 1975.

The direct object-protective function of forests refers to the capacity and task of forests (of land use and forest management) to protect settlements and infrastructures from impact by natural or cultural hazards on these sites in case of clearly assignable damage potentials at the slope level. In terms of Alpine natural hazards, that applies to snow avalanches, rockfall and (hillside) spontaneous landslides. If, for example, a landslide may occur due to heavy rainfall on a slope prone to slope failure above a residence, and the debris flow could also reach that house, an appropriate forest should be there. The protective potential of forests (Brang et al., 2001) refers to this residential building and establishes a direct object-protective function of the forest management.

The indirect object-protective function of forests refers to hazards and mechanisms of forest effects where there is no immediate temporal and/or direct spatial relationship between the potential for damage to a specific asset to be protected and the areas on which the hazard is initiated and transmitted to the asset. A slope susceptible to landsliding establishes an indirect protective function of forest, e.g., if the debris flow initiated by a slope failure will be first deposited in a torrent but might cause damage in the settlement area on the alluvial fan in case of a torrential debris flood. The hazard and damage potential of this landslide and the debris flood is not addicted to one site, one forest and a certain asset but to conditions in the entire torrential catchment. The same hazard type may require different forest conditions and measures in case of direct or indirect object-protective functions. The most important Alpine hazards with an indirect object-protective function are floods and debris floods.

Land use and forest management on sites with a site-protective function primarily aim maintaining and improving soil conditions and thus soil functions. The site-protective function as defined by the Austrian Forest Act 1975 (and, e.g., the Bavarian Forest Act 2005) can be considered as a part of the indirect object-protective function (Starsich and Perzl, 2022). Soil protection by forest is indirectly object protection. Perzl (2023) refers to this rocky area near Scharnitz/Tyrol for example, which established after a forest fire in 1949 (Heel, 2015) (Fig. 1). Insufficient site protection by forest can be followed by humus and soil loss, increased surface runoff and, subsequently, increased channel runoff (floods), debris and snow mobilisation, processes that endanger human estates. Every forest with a site-protective function also has an indirect object-protective function since soil protection is a prerequisite for indirect-object protective effects of the forest. However, not every forest with a direct object-protective function can be assigned a high importance of the site protective function.

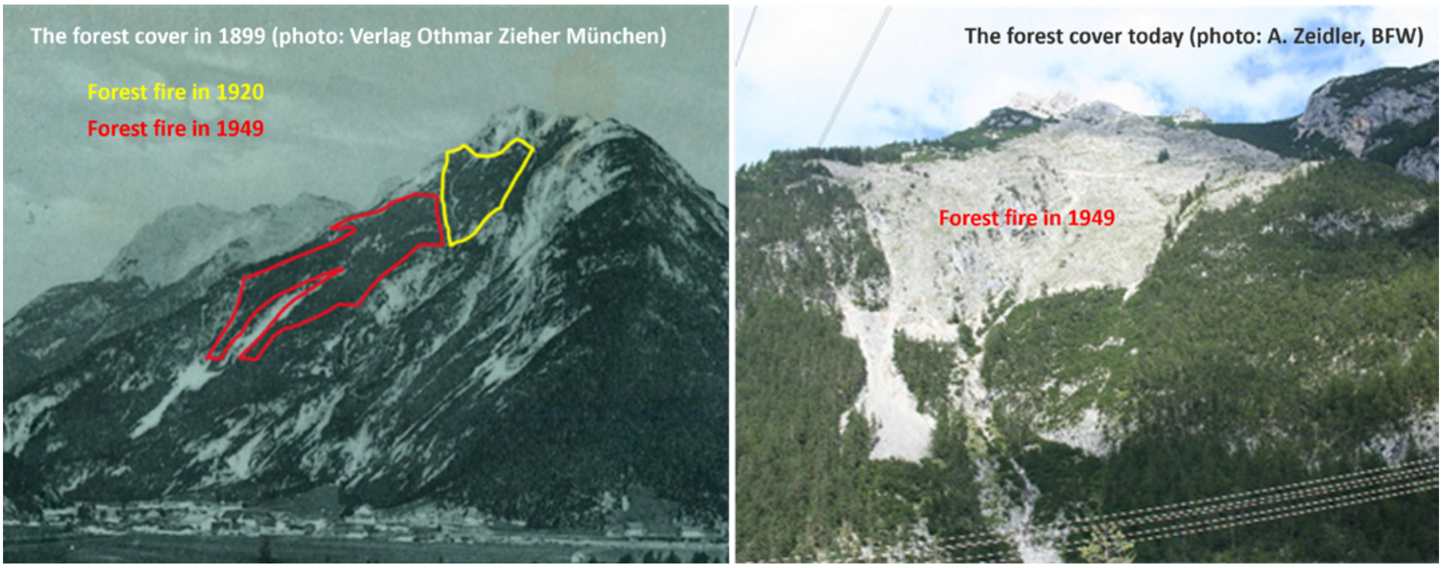

Figure 1: A rocky area caused by soil erosion after a forest fire in 1949 which interrupted the site-(soil-)protective effect of the forest.

Forest sites with a site-protective function in the sense of a pure soil-protective function and with an indirect object-protective function crossing over fluently. The challenge of a purposeful definition and spatial modelling to separate site- and indirect object-protective functions is to identify criteria for conditions where forest vegetation has no significant potential effect on the hazard and the protection of human assets. We could not find clear and currently implementable concepts, criteria, and threshold for that in scientific sources. As with protection targets (Perzl and Teich, 2021), the legal regulations and administrative directives are low informative and not coherent about this. However, for the direct object-protective function of forests, there are clear criteria and proven modelling concepts as well as geodata with operational spatial resolution created according to them.

From the available geoinformation, five geodata sets were identified and selected, which allowed a representation of the forest according to the above classification concept:

1. The modelling of the direct object-protective function areas for rockfall from the project GRAVIMOD I (Perzl and Huber, 2014; Huber et al., 2015).
2. The direct object-protective function areas for avalanches from the follow-up DAKUMO (Huber et al., 2017).
3. The direct object-protective function areas for spontaneous (shallow) landslides from GRAVIMOD II (Perzl et al., 2021b).
4. The so-called S3 protective function areas of the digital WEP Austria (BMLRT, 2021b). The term "S3" refers to areas with a high importance of site (soil) protection by forest vegetation to avoid soil erosion.
5. The BFW forest use land layer (Bauerhansl, 2020).

The GRAVIMOD-DAKUMO data show the direct object-protective function of forests. The forest function mapping according to the WEP guideline does not differentiate between areas with object- and site-protective functions with a high importance of forest effects. However, the union with the polygons with direct object-protective functions results in areas with indirect object-protective and/or site-protective functions. The lack of a scientific and administrative convention to separate them is reflected in the WEP mapping. The gullies of torrents, e.g., are designated as areas with protective functions of forests in the WEP, without distinguishing between areas relevant for object and site protection, since it is often not possible to separate them. Therefore, we had to designate indirect object-protective and site-protective functions (forests) as one category.

After reclassifications to implement new WEP regulations, we performed a geometric union of the polygons converted from filtered GRAVI-MOD-DAKUMO raster data as well as from the WEP with the polygons of the BFW forest layer to obtain the forest use area classified by the protective functions. Such "intersections" are by no means trivial, and the difficulties should not be underestimated when using geodata that have not been created in one processing but by several organisations using different methods and resolutions. These intersections had to be performed stepwise with topological corrections and edge integrations as well as dissolution of attributes, the latter to avoid too much fragmentation. Thereafter, the map proposal was checked for plausibility and adapted by the responsible regional forest and torrent and avalanche control services (WLV).

DISCUSSION OF RESULTS, FIELDS OF APPLICATION, AND CURRENT USAGE

The IMPFA (BMLRT, 2021a) is the first digital representation of forests in Austria considering the direct object-protective function.

The map classifies the Austrian forest use area to three categories of the protective function (Fig. 2): 1) forest with (direct) object-protective function, 2) forest with (indirect) object and/or site-protective function, and 3) forest without (primary) protective function.

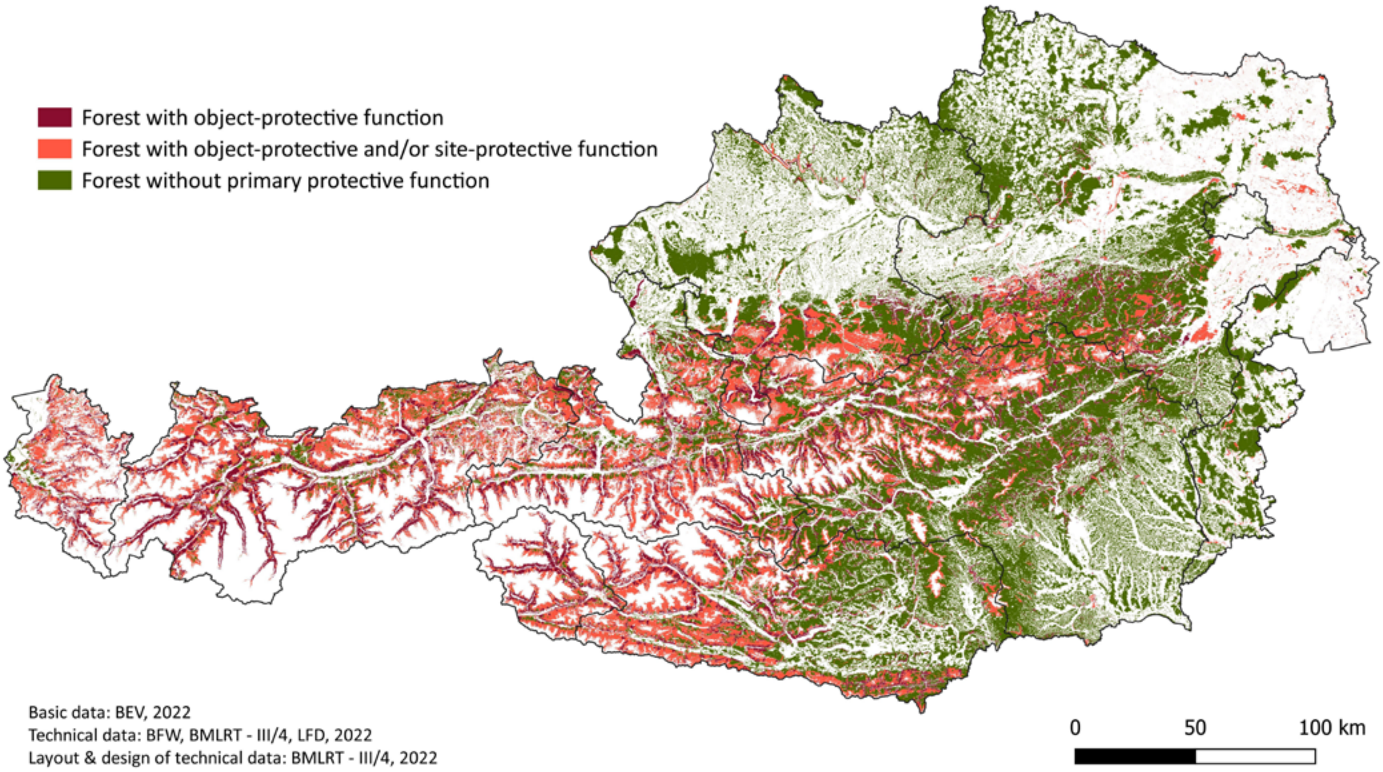

Figure 2: The nationwide representation of the forest with a protective function in three categories.

The designated forest area with direct object-protective function and a share of about 16% (Fig.3) indicates the protection of assets as primary target of forest management. On areas with object- and/or site-protective function (26%), the forest condition may be important for protection of assets against hydrological hazards and/or soil protection. The map does not consider cultural hazards. The map visualises the protective function and not the protective effect of the forest, which depends on the current forest conditions.

Categories of forest	Hectares	Percent
• with (direct) object-protective function	614,852	15.61
• with (indirect) object-protective and/or site-protective function	1,030,710	26.17
sum (intermediate total of forests with protective function)	**1,645,562**	**41.78**
• without primary protective function	2,293,146	58.22
total forest use area > 1 ha	**3,938,708**	**100.00**

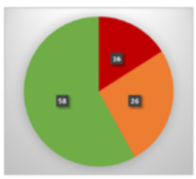

Figure 3: Area statistic of protective forests in Austria based on the BFW forest use layer 2018, main categories.

The IMPFA informs forest owners and the beneficiaries of forest services about locations of forests with protective functions. Hence, the map strengthens legal certainty, but does not represent an official notification. It supports the a-priori orientation of forest management towards protection against natural hazards, the planning and prioritisation of interventions and forest monitoring. The map has already been used for planning actions of ecosystem-based disaster risk reduction due to an operational scale, for the identification of exclusions of nature reserves, and is the basis for strategic investments and state subsidies in protective forests management (Starsich and Perzl, 2021).

Especially in view of climate change consequences, the map is an instrument to point out hot spots and to push for appropriate risk management. As an example, the windstorm in October 2018 can be noted. Hundreds of thousands of cubic metres of timber were destroyed over a large area in East Tyrol and Carinthia. As a further consequence, the bark beetle is currently active and deforests whole mountainsides. The protective effect of forest is no longer given on these slopes. Therefore, it is important to prioritise the implementation of protective measures based on hazard risk and to know the areas with object-protective functions of forests. Costly constructive measures had to be implemented to reduce hazard risk and to reforest the area. Based on the indication map, studies on the area protected by forest and the economic value of this ecosystem service (Sinabell et al., submitted) are ongoing.

CONCLUSIONS

Despite of model uncertainties, hazard modelling can generate and communicate relevant information for forest management much better than mapping without such support. Barriers are non-coordinated geodata infrastructures and the low coherence of the legal-administrative directives. However, the modelling process may support the identification of opportunities to improve the geodata and address specific issues of protective forest management.

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