

## **Interdependence between mountain forests and freshwater provision**

The relationship between forests and the water cycle is scientifically well known although many relationships and factors have not yet found a precise quantification and definition in a certain and widespread way.

This relationship is expressed, on a different level according to a multiplicity of parameters and in conditions of different spatio-temporal scales, on the hydrological balance of a basin as well as on the quality of the waters that pass through a forest system.

The mechanisms of this last process are mainly to be found in the origin of waters, generally meteoric and therefore not subject to direct pollution phenomena deriving from human activities, in the characteristics of forest stands, but above all in the filtering capacity of forest ecosystems, due to the percolation of water in soils that have specific chemical-physical characteristics, but above all biological.

Geology plays also an important role, allowing or preventing infiltration, percolation through deep strata and underground flowing of water, even at long distance (karst).

The ability of forest ecosystems to "treat" the percolating waters that then go to load the strata that originate sources is therefore an opportunity that should not only be better studied and investigated, but above all enhanced.

In fact, it is possible to rely on a biological purification system which, at reduced costs, makes it possible to restore quality standards to treated waters, which can be considered as potable or, in any case, of high biological value.

Most of the sources of drinking water in our countries come from sources or layers that are enriched under the cover of forests.

Identifying such situations, correctly planning the degree and area of protection areas of quality waters, promoting and supporting good forest management and agricultural practices are the right forms of investment in favor of a resource whose importance is essential and vital, but also in favor of a model of organic production that, in hand, is also cheaper.

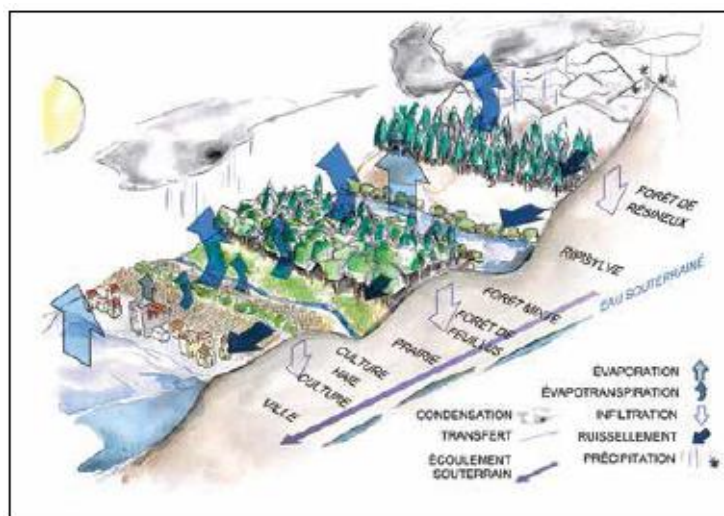
These guidelines are present in the Sustainable Management Principles and Criteria of the Interministerial Conference on the Protection of Forests in Europe (MCPFE 2007) which in the Second Resolution "Forests and Water" declares the need for better forest management to protect and make water available for potable produced by forest ecosystems.

The Mountain Alpine Protocol itself of the Alpine Convention provides in art. 8 the commitment to adopt measures that effectively ensure the protection of water resources.

## 1. The role of the forest in the protection of water resources

In the complex water cycle forests play an essential role:

- Forest cover reduces the hydrogeological and erosion risk: the tree cover favors the infiltration of the water into the soil, reducing its outflow and increasing the stability of the soil through its root system;
- Forests influence the quantity and quality of the percolation water: the rate of evapotranspiration determines the quantity of water accumulated, the root development and the humus filter the water holding back the harmful substances (buffer effect), the canopy of the trees retain many pollutants weather



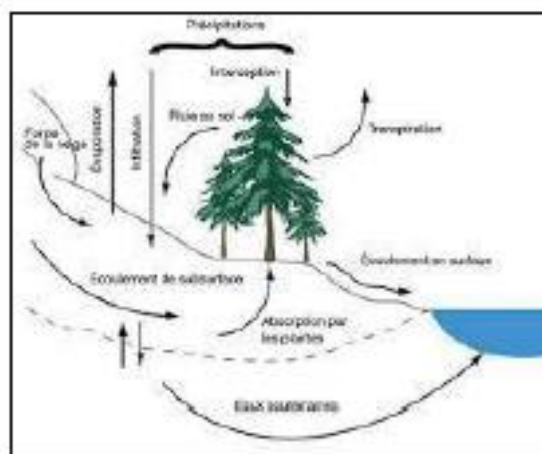
**Fig. 1** - Water cycle in the territory

In particular, in relation to aquifers, the major studies confirm that:

- The infiltration is greater in forest soils than in other soils: the soils under the forest have a greater depth and an efficient porosity, due to biological activity and root developments. Moreover, forest soils and organic layers, acting like a sponge, allow a higher storage capacity, even if dependent on the type of soil: the first ten cm of forest soil are able to hold up to 50 l. of rain / sqm (OFEV, 2005); under a hectare of forest are produced every year 2-3.000 cubic meters of ground water (UFAPP, 2005; ForetSuisse, 2016);
- The forest is the best cover for the watersheds: the forest ecosystems are permanent, and the land cover is stable; in general, they are not affected by significant phenomena of direct pollution; the concentrations of nitrates and pesticides are lower than in soils with other types of cover, the biological activity of the forest soil guarantees an important buffer effect;
- The quality of water depends on the type of forest: in coniferous woods (acid environments and humus of the "moder" type) higher quantities of nitrates are washed away than in broad-leaved woods, because the conifers tend to take ammonia nitrogen rather than in the form of nitrate.

Also, the form of rooting is important. For example, silver fir, beech and sycamore have a deeper root systems than the spruce, so they explore a larger volume of soil and are able to bind more nitrates; the organic layers of the deciduous forests is more easily degradable than that of the coniferous woods: the humus of the "mull" type which results in it plays an important filtering action, allows to store the nitrogen in a more stable form and the superficial soil acidifies less due to the mobilization of basic substances in the deeper layers of the soil;

- The infiltration is greater under mixer stands of broad-leaved than coniferous forests;
- The water storage capacity of forest soils does not only depend on the soil itself, but also on the amount of humus in the soil. Therefore, it is important to manage forests in a way that protects and raises the soil humus. This includes measures as avoiding clearcuts, permanent vegetation cover of the soil and leaving at least a certain amount of wooden debris within the forests;
- The highest water storage capacity, even more than in the average forest soil, is found in peat soils. Peatlands, as well as riparian wetlands, are integral parts of natural, water storing forests, but most of the peat and forest wetland areas in the Alps have been lost over the last 200 years. Therefore, specific efforts should be made to conserve and protect the last remaining forest peatlands and wetlands.



**Fig. 2** - Water cycle and vegetation

In summary there seems to be a clear link between the forest and the quality of the water produced by a basin, a more variable relationship between the forest and the amount of water available and a variable relationship between the forest and the constancy of the outflow.

Furthermore:

- The forest is considered the best cover to protect the drinking water withdrawal areas;
- The age and composition of the forest, the type of soil and the management significantly influence the quality of the water;
- In the deciduous and mixed forests the nitrogen cycle is well balanced and there is less loss of nitrogen. These ecosystems can absorb high amounts of nitrogen.
- Forest ecosystems that have a high presence of nitrogen, such as coniferous forests, are much more sensitive and consequently forest management must be adopted;
- Natural disturbances or extensive cuts have a modest impact on the quality of groundwater, except for turbidity phenomena in relation to the logging methods.

## 2. The situation in the Alpine regions

### The regulatory context

In all the countries of the Convention there are similar regulations that define specific protection zones of the catchment basins of drinking water, like a portion of the territory surrounding the water collection in which restrictions and limitations on the use are imposed for the protection of water.

Three protection zones are thus provided:

- Immediate Protection Area of the water collection: of modest dimensions around the collection, normally for a range of radius not less than 10 m.

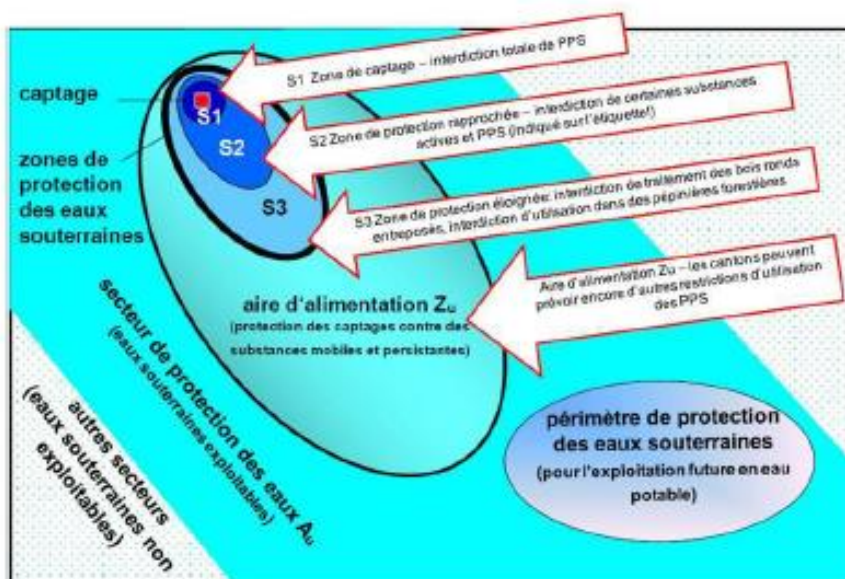
In this area there is absolute protection, with the prohibition of any activity that is not inherent to the use, maintenance and conservation of the collection;

- Zone of Close Protection or Respect: its dimension and its geometry varies according to the aquifer system, includes the area of absolute protection and is delimited in relation to the local situation of vulnerability and risk of the resource, according to the geometric criterion or the hydrogeological one; in any case, it has a radius of no less than 100 m (in Italy this value is 200 m.), with the center at the point of collection, and it hydro-geologically extends upstream of the intake structure. In Switzerland the percolation duration calculated in 10 days is also considered;

- Extended Protection Perimeter: it does not have a mandatory character; its surface corresponds to the feeding and recharge groundwater area and to the source supply basin.

In Switzerland, this area is defined as a protection area to allow adequate time and space to intervene in the event of imminent danger.

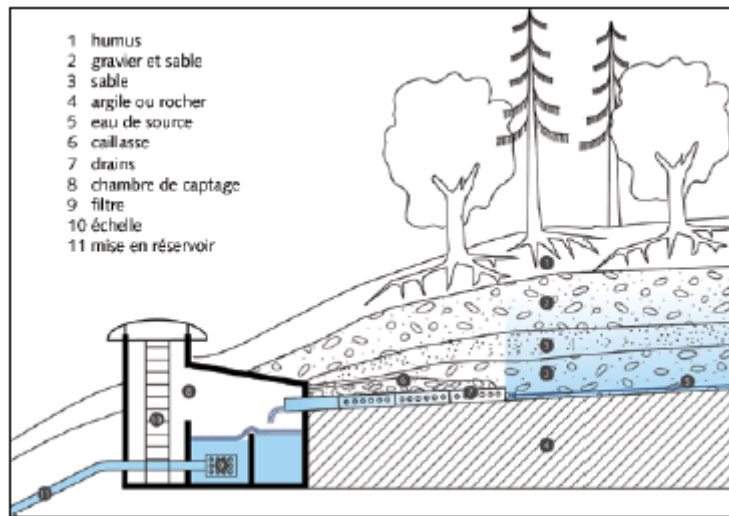
In Switzerland there is also a fourth area, the Feeding Area (Zu), which is the area where 90% of the water can be collected.



**Fig. 3** - Scheme of protection zones for drinking water collection

## Captations of drinking water in forests and protection forests

There are different ways of collecting groundwater for human consumption: in a simplified way, it is possible to distinguish between spring catches and groundwater collecting through wells.



**Fig. 4** - Source collection scheme

In this report we will consider only the sources, which are the typical forms of emergence of the water table on the surface, which are captured through the construction of works, generally consisting of a tunnel that is embedded in the rock on site which will channel the spring waters in a building in which are contained all the tanks and equipment that give rise to the aqueduct.

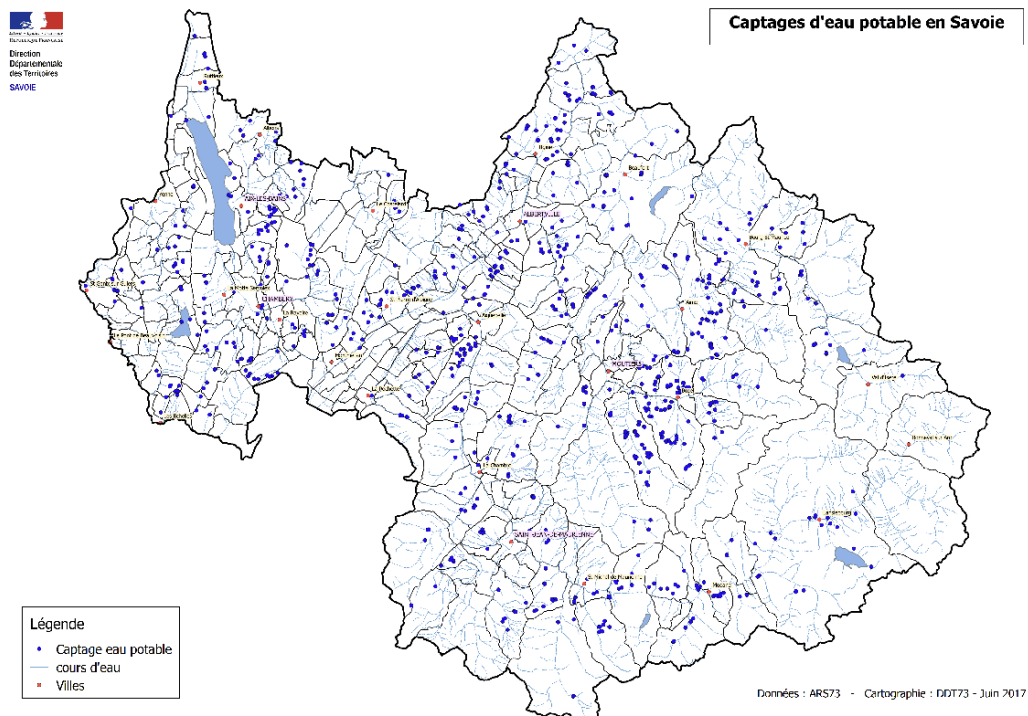
## France

The French national forest inventory records, at national level, a data of ha. 44.800 of forests with a specific statute for the protection of drinking water catchment areas ([www.inventaire-forestier.ign.fr](http://www.inventaire-forestier.ign.fr)).

However, at local level, in particular for some French Departments belonging to the Convention area, there are several more specific data:

Department	N. sources tot.	Production M mc/y	N. inhabitants supplied	Cost €/mc	Forest protection area	% forest area departments
Haute-Savoie	895	80	716.000	3,03	38.000 ha	21
Savoie	1300	50	411.000	3,47	22.700 ha	13
Isère	923	n.a.	1.197.000	3,03	49.000 ha	20
Alpes Haute-Provence	500	n.a.	162.000	2,56	44.000 ha	14
Alpes Maritime	352	135	940.000	2,56	43.000 ha	9

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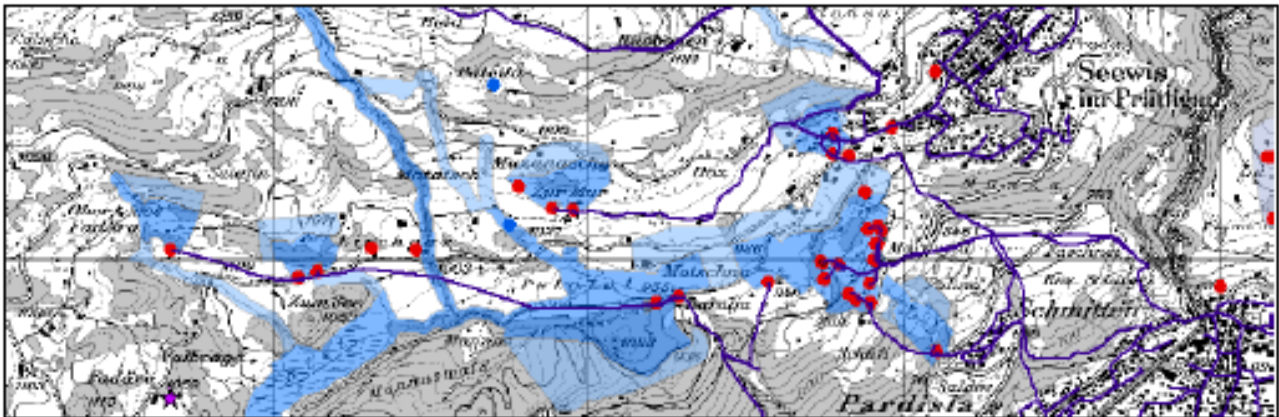
**Fig. 5** - Water Captations in the Department of Savoy (F)

## Switzerland

At national level, 42% of the groundwater protection zones are located within forest areas, which represent 27% of the total forest area and on which the specific protection rules apply ([www.bafu.admin.ch](http://www.bafu.admin.ch)).

From these sources, about 380 M m<sup>3</sup> / year are produced, which represent 41% of the entire supply of drinking water.

In Switzerland all sources and the respective catchment areas are mapped.



**Fig. 6** - Sources and catchment areas in Switzerland

Regarding the data on drinking water resources in the territory of some cantons of the Convention area, the following data are available:

<b>Cantons</b>	<b>N. sources tot.</b>	<b>Production M mc/an</b>	<b>N. inhabitants supplied</b>	<b>Cost CHF./mc</b>
Ticino	450	80	289.000	2,00
Vallese	3600	n.a.	320.000	2,00
Grigioni	370	n.a.	197.550	2,00

n.a.: not available

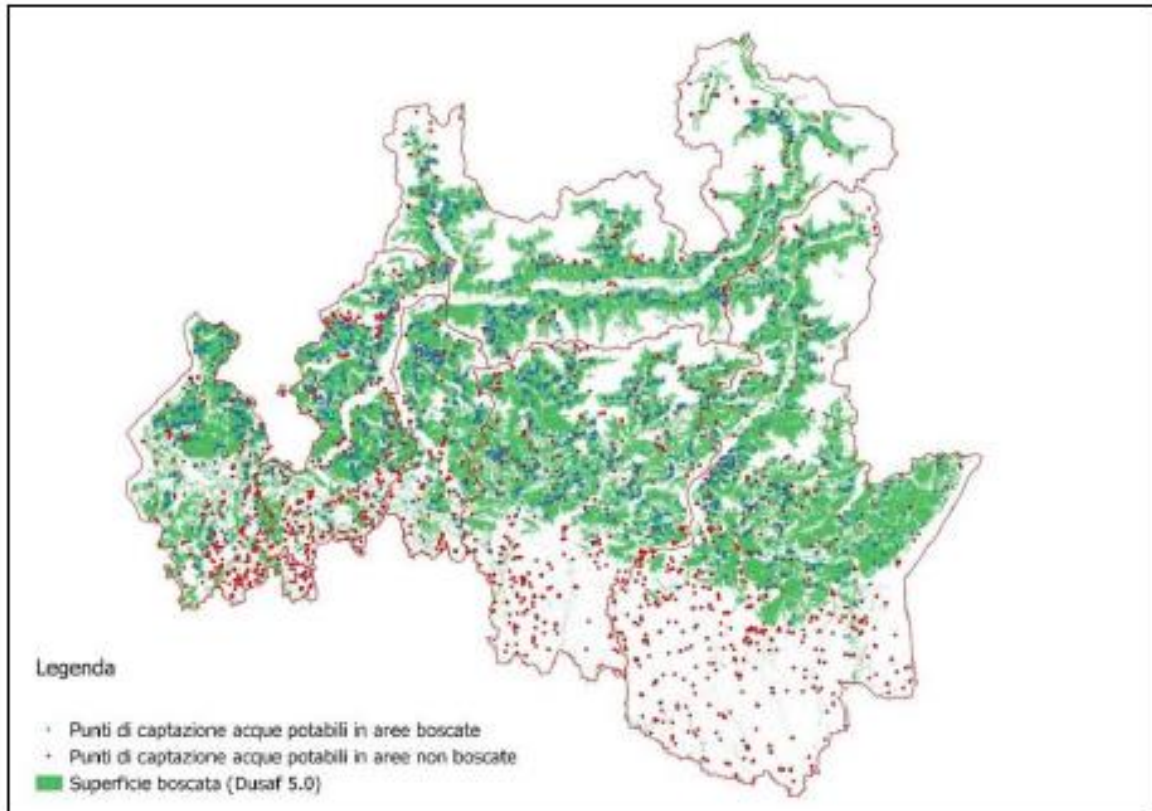




## Italy

In the Lombardy Region 2.326 springs in forests were registered in the Convention area, equal to 56% of the total sources of the provincial territories involved, with an estimated annual production of about 146 M m<sup>3</sup>/year of drinking water (Regione lombardia,2006).

The type of woods is mainly deciduous (59%), followed by coniferous (23%) and mixed (18%) woods.



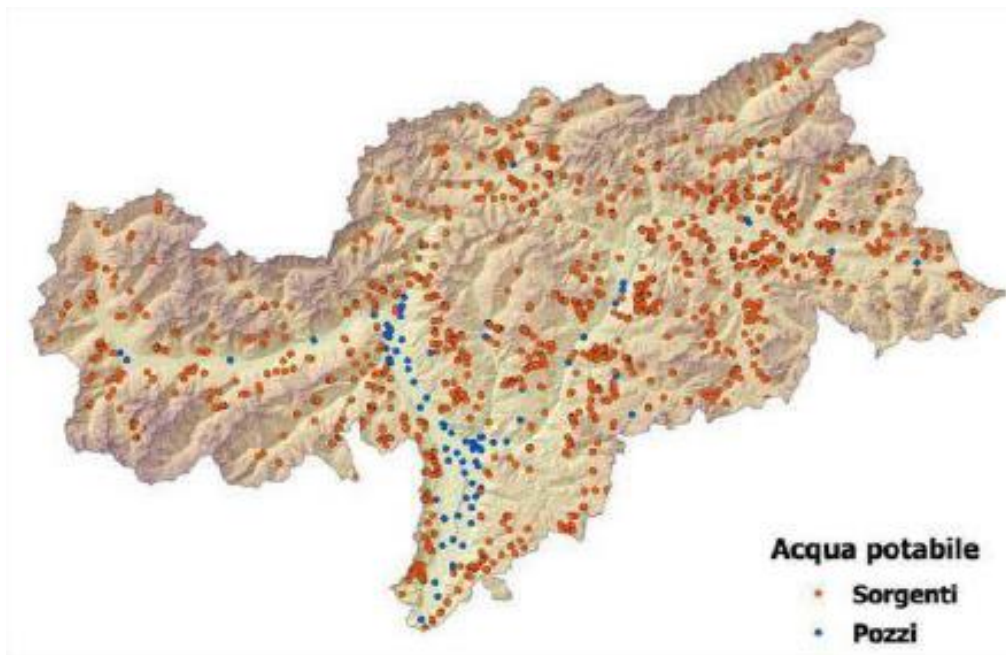
**Fig. 8** - Classification of the points of collection of drinking water located in wooded areas - Lombardy

Since there is no value of the forest protection surfaces, it can be estimated the extension by applying the geometric formula of the areas of respect (minimum 200m upstream of the source with an amplitude of 90° - De Maio, 2013) thus reaching ha 14.608, equal to 2,3% of the forests alpine Lombardy.

In the Lombardy mountain provinces 12,269 river basins are present; among these 1,869 basins contain at least one point for drinking water (around 15%). Although some catchment points are not located directly in wooded areas, the catchment area of which it is almost always largely consists of forest stands. The contribution given by forests is therefore also relevant for those sources located outside wooded areas.

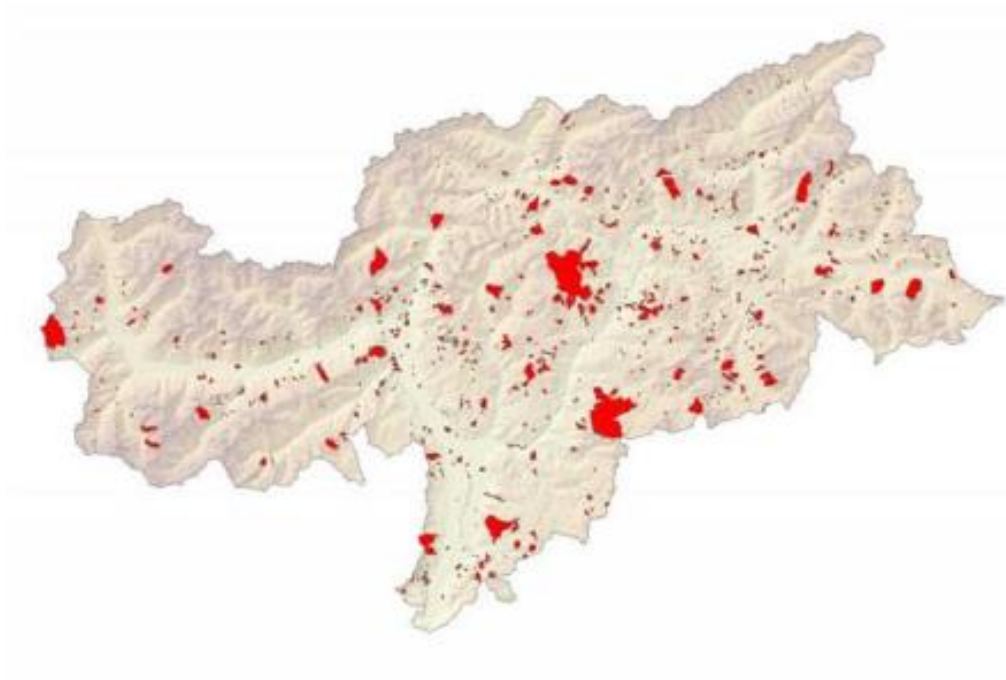
In the Province of Trento there are about 1.600 springs captured in forest areas, equal to 80% of the provincial total. The forest area present in all the Hydrogeological Protection Areas, therefore in the recharge areas of the springs, is equal to ha. 50.144, equivalent to 13.31% of the provincial forests (PAT, 2016).

The Province of Bolzano has about 2,000 springs collected for public use, which provide drinking water for 58% of the provincial needs (30 M mc / ha) and about 3775 sources for private use, which supply 4% of the total demand (Provincia Bolzano, 2017).



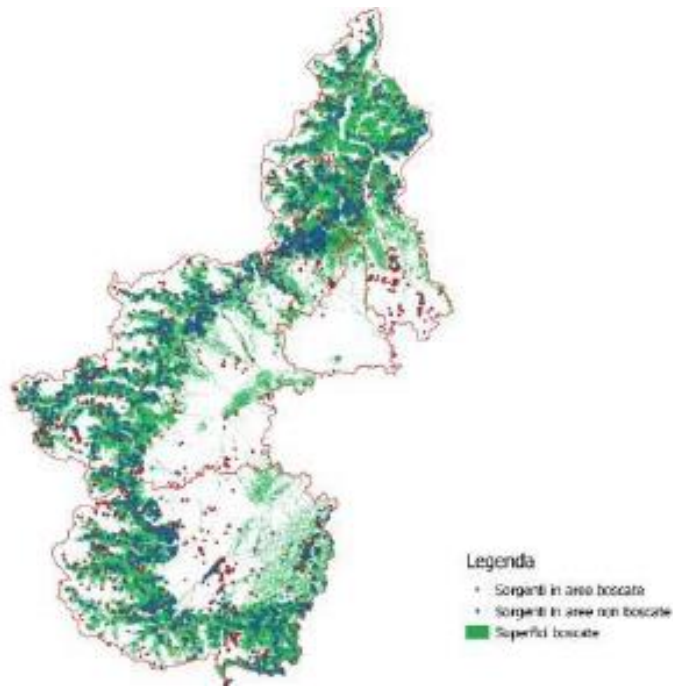
**Figura 9** - Captation of drinking water in the Province of Bolzano

The protection area is quantified in 1,000 square kilometers, equal to 14% of the provincial territory



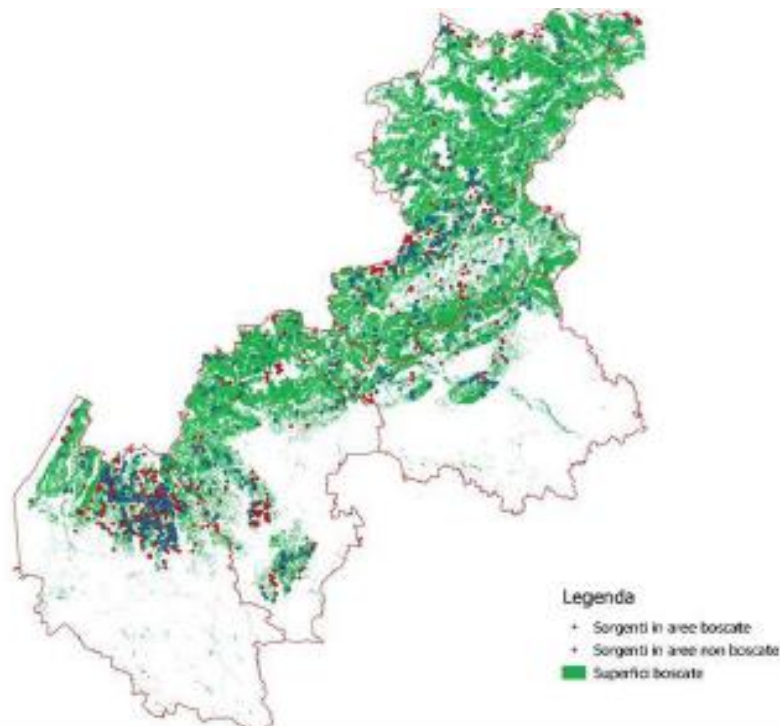
**Figura 10** - Protection surfaces in the Province of Bolzano

In the Piedmont Region 4128 springs are registered in wooded areas, equal to 73% of the total, within the province of interest of the Convention, with a production of 125 M mc / ha (Regione piemonte,2003).



**Fig. 11** - Identification of sources in wooded areas in Piedmont

According to data from the Sources Land Registry, in the Veneto Region 1256 springs collected for public use have been surveyed, of which 699, equal to 56%, in wooded areas.



**Fig. 12** – Identification of sources in forest areas in Veneto

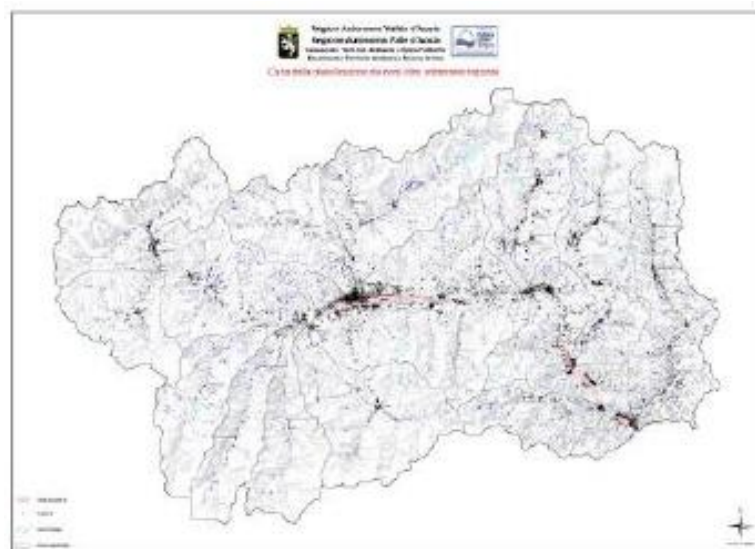
In Friuli Venezia Giulia Region, according to data from the Regional Water Protection Plan (Regione Friuli V.G., 2018), 1,186 springs are registered, mainly in the mountain area, with a production of around 315 M m<sup>3</sup>/Y.

According to the mountain sources Registry of the DISGAM of the University of Trieste (2004), there are 2,400 springs, of which 600 are collected for public aqueducts.



**Fig. 13** - Identification of sources in Friuli V. G.

In Valle D'Aosta the sources surveyed amounted to 1,700, of which 55 ° captured for civic aqueducts, with a production of 21.9 M m<sup>3</sup> / year (Valle d'Aosta, 2007).



**Fig. 14** - Identification of sources in Valle d'Aosta

In summary, the data are summarized as follows:

<b>Regions</b>	<b>N. Sources</b>	<b>Production M mc/a</b>	<b>Cost € mc/a (4)</b>	<b>Drinking water forest protection area (ha)</b>	<b>% regional forest area</b>
Valle d'Aosta	1.700	22	1,36	5.338 (2)	5,4
Piemonte	4.128 (1)	125	1,68-2,31	12.962 (2)	1,4
Lombardia	2.326 (1)	146	1,25-1,96	7.304 (2)	2,3
Veneto	699 (1)	271 (3)	1,52-3,40	2.195 (2)	0,6
Provincia Trento	1.533 (1)	48 (3)	0,77	50.144	13,31
Provincia BZ	5.775	32	1,19	24.178 (2)	7,2
Friuli.V.G.	1.186	315	1,36-1,90	3.724 (2)	1,4
Liguria	426 (5)	4 (5)	1,10	1.338 (2)	1,1
<b>TOTAL</b>	<b>17.773</b>	<b>963</b>	<b>0,77-3,40</b>	<b>107.183</b>	<b>3,4</b>

(1) Sources in wooded area

(2) Forest protection area calculated with the geometric method of the areas of respect

(3) Estimated data based on the average flow rates of the sources

(4) Data from "13 ° Survey by the Observatory prices and rates" of Cittadinanzattiva

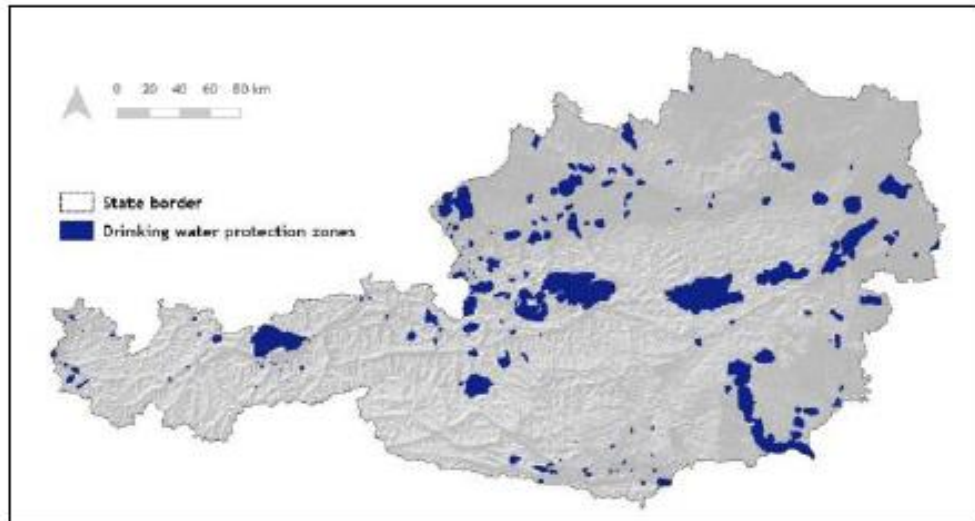
(5) Data of the Municipalities of the territory of the Convention in the Province of Imperia

## Austria

At national level, 39.39% of the surface of the drinking water protection areas is occupied by forests which, as a whole, represent ha 226,185, equal to 5.66% of the entire Austrian forest area.

55.34% of these protection forests consist of conifer formations.

The protection areas cover around 7% of the Austrian territory.



**Fig. 15** – Drinking water protection zones (DWPZ) in Austria.



**Fig. 16** - Water Protection Zones in Austria, displayed with Corine land cover data (CLC 2012)

From these sources, about 380 M m<sup>3</sup> / year are produced, which represent 41% of the entire supply of drinking water.

The case of the city of Vienna is interesting: from 1873 drinking water comes from the basins located in the Northern Limestone Alps of Lower Austria-Styria, with about 380,000 cubic meters per day.

The watersheds, ranging from about 450 m to s.l. up to 2200 m a.s.l., concern about 100.000 ha and are also used for the water supply of Graz - the second largest city in Austria - and numerous local communities.

In total over 2 million people are supplied with drinking water from this area.

Vienna thus finds itself in the unique situation of covering almost all its demand for drinking water from mountain springs; only a small part is obtained by means of underground water collection.



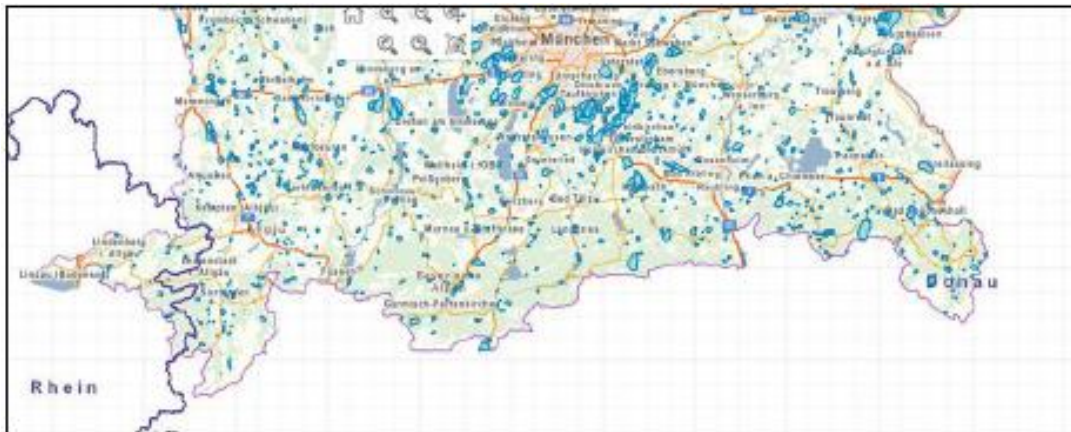
**Fig. 17** - Drinking water production areas in the city of Vienna

In the Federal District of Styria, the city of Vienna created the "SpringWater Museum Wildalpen", with the aim of informing and making.

## Germany

In the Lander Baden Wurttemberg and Bavaria, the production of drinking water from springs, generally located in the Alpine area, is equal to 110 M mc and 135 M mc respectively (Ludwig, 2016), corresponding to 13% and 15% of total production of the Landers.

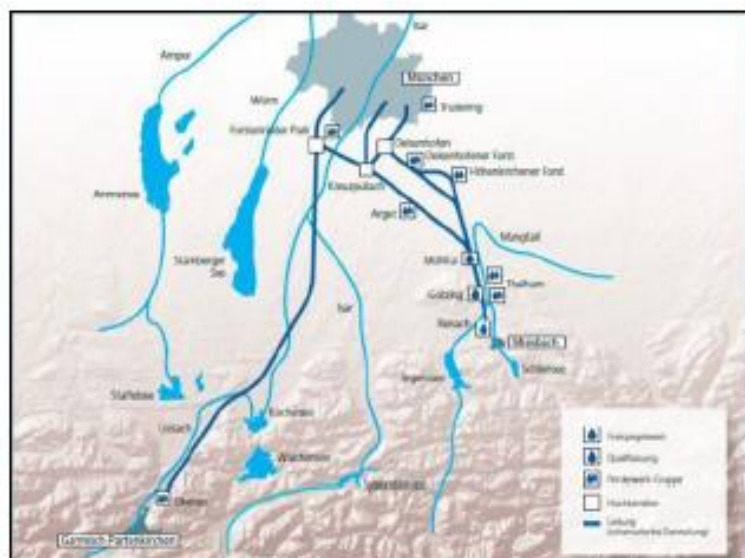
The cost of drinking water is on a national basis between € 1.40 and €. 2.60 ([https://www.bundeskartellamt.de/SharedDocs/Meldung/EN/Pressemitteilungen/2016/30\\_06\\_2016\\_Wassbericcht.html](https://www.bundeskartellamt.de/SharedDocs/Meldung/EN/Pressemitteilungen/2016/30_06_2016_Wassbericcht.html)).



**Fig. 18** - Drinking water protection zones in Bavaria and in the alpine region (Umweltatlas Bayern)

The case of the city of Monaco is interesting: drinking water, which supplies around 1.4 million inhabitants, comes directly from the Bavarian Alpine Highlands and in particular from the Mangfalltal valley, with a covered feed basin of over 1,800 hectares of forests providing a balanced hydrological regime.

The forest is managed by the Municipal Forest Administration (Städtische Forstverwaltung) on behalf of the municipal water supply company (Stadtwerke München, SWM) and is also certified in accordance with the Forest Stewardship Council (FSC). In the basin, since 1992, a process of conversion towards organic farming has been promoted throughout the river basin

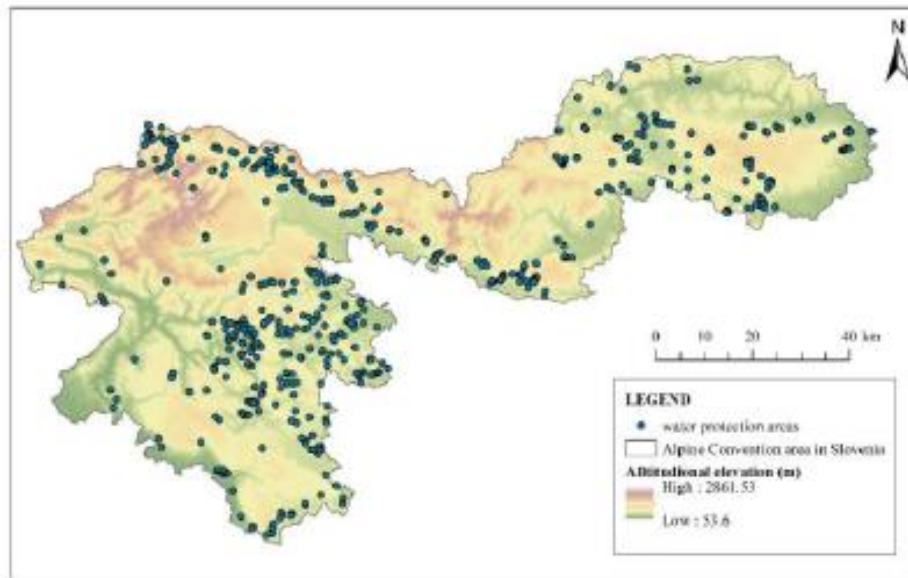


**Fig. 19** - Production areas for drinking water in the city of Munich

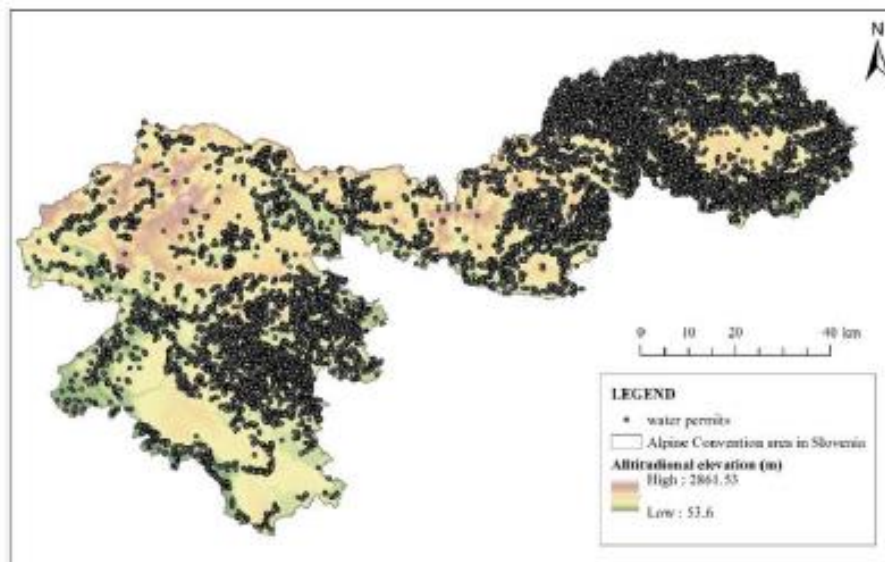


## Slovenia

In 2016 members of the Slovenian National Assembly adopted a proposal to enshrine the right to drinking water to the Constitution of the Republic of Slovenia by 64 votes in favor to none against. For this constitutional act to be adopted, two-thirds of constitutional majority in the National Assembly, i.e. at least 60 votes, were required. This makes Slovenia the second EU Member State, beside Slovakia, to protect the right to drinking water at the highest level.

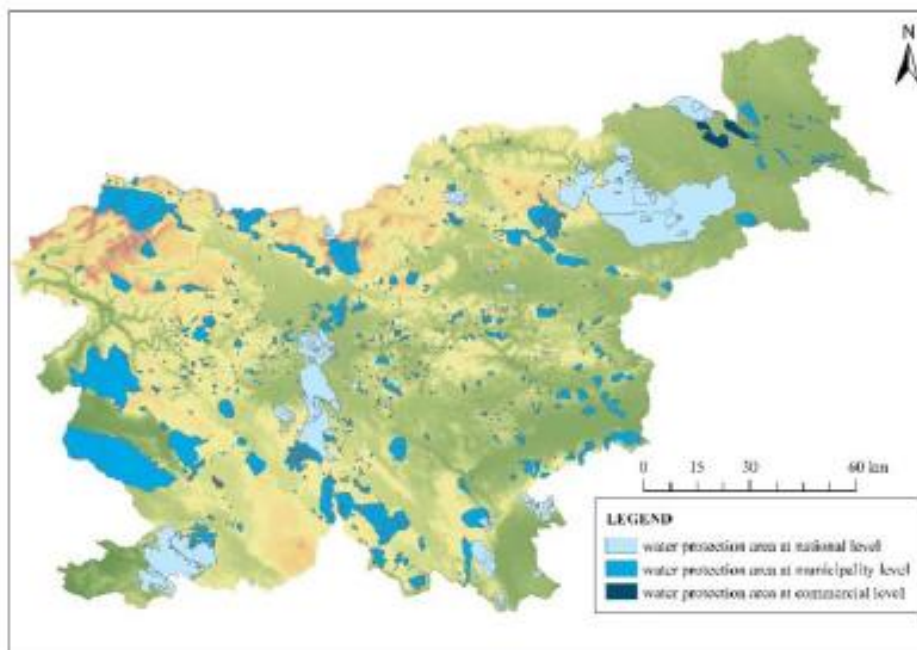


**Fig. 20** - Distribution of water protection areas for water supply managed by Public services (also covers spare water supplies). Source: ARSO, 2013



**Fig. 21** - Distribution of water permits for own drinking water supply. Source: ARSO, 2013

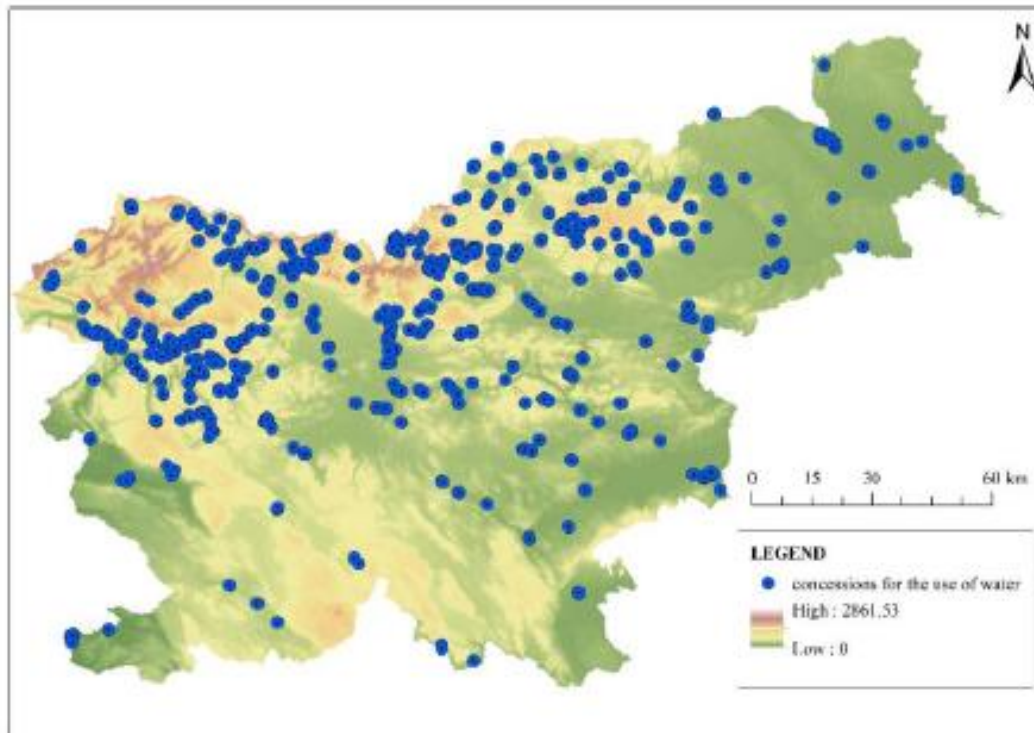
The Figure 21 shows that the highest density of issued water permits for own drinking water supply in Alpine Convention perimeter in Slovenia is located in the Koroška region (southeastern part of the area) and in the Škofjeloško hribovje in the Gorenjska region (Škofjeloško hribovje).



**Fig. 22** - Water protection areas in Slovenia. *source: Water Directorate, Ministry of the Environment and Spatial Planning.*

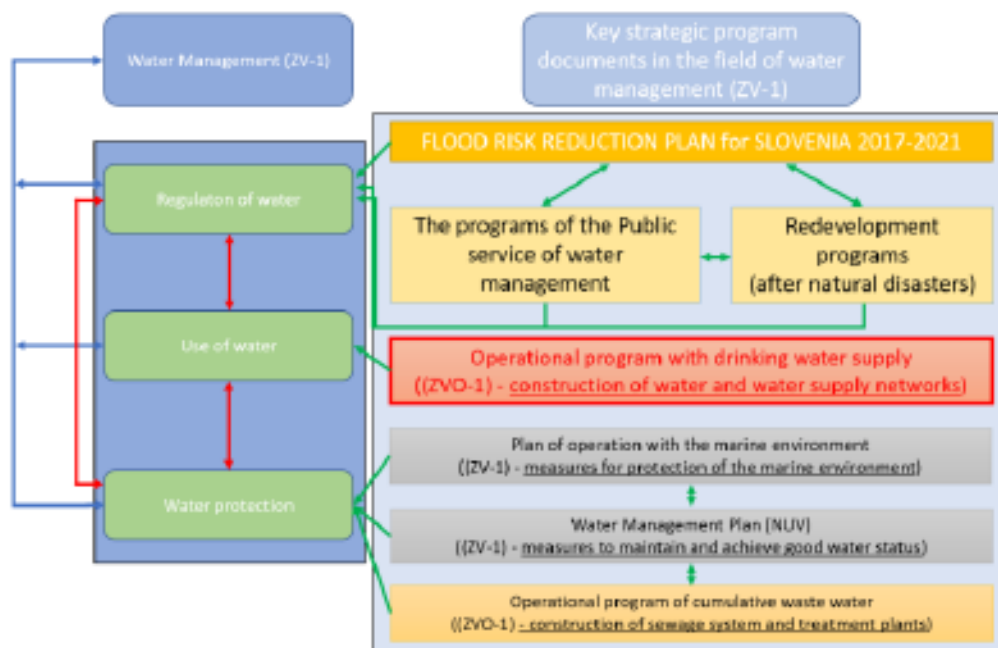
### **Slovenian Water Atlas web browser**

Slovenian Water Directorate created a completely refurbished water Atlas web browser. It is the first publicly available web browser to be installed on the state-owned computer cloud (SCC). In the renovated water Atlas is a graphical representation with the updated contents of the water cadaster and water rights. Metadata descriptions of data from the Water Directorate of the Republic of Slovenia are available on the Slovenian INSPIRE metadata system. Water Atlas web browser identifies that in the area of the Alpine Convention can be estimated about **656** water sources, of which 75% in the woods.



**Fig. 23** - Concessions for the use of water. *source: Water Directorate, Ministry of the Environment and Spatial Planning, 27.07.2018).*

**Water management in Slovenia in relation to key strategic program documents**



**Fig. 24** - Water management (regulation, use and protection of waters) in relation to strategic program documents in the field of water management (2017), Flood risk reduction plan for Slovenia 2017-2021, Ministry of the Environment and Spatial Planning, p. 262.

## Summary of data at alpine level

The summary of data at the Alpine level does not allow to have a complete data for the whole area and for all types of data.

Starting from the information reported in the paragraphs developed for each country, the general picture is represented as follows:

Country	N. of sources	Production M mc/y	Cost €. /mc	Protective forets area	% of total forest area (1)
France (1)	3.970	265 (3)	2,56-3,47	196.700	11,9
Switzerland	4.420 (4)	80 (5)	2	397.237 (6)	40 (6)
Italy (3)	17.773	963	0,77-3,40	107.183	4,3
Austria	3022 (10)	138 (11)	3,15	n.a.	n.a.
Germany	n.d.	225 (7)	1,40-2,60 (8)	1.800 (9)	0,4
Slovenia	656	n.a.	n.a.	n.a.	n.a.
<b>TOTAL</b>	<b>29.675</b>	<b>1.671</b>	<b>0,77-3,47</b>	<b>709.290</b>	<b>13,2</b>

(1) Forest area in the Convention area

(2) Data only for the departments of Haute-Savoie, Savoie, Isère, Alpes-Haute-Provence, Alpes-Maritime

(3) Data only for Departments of Haute-Savoie, Savoie, Alpes Maritime

(4) Data only for the cantons of Ticino, Valais, Graubünden

(5) Data for the Canton of Ticino only

(6) Data for all cantons

(7) Data for Land Bavaria

(8) Average data for Germany

(9) Munich protective surface data

(10) Data only for Tyrol

(11) Production data for the city of Vienna

n.a.: not available

What is possible to derive from this information?

Some ideas for observation:

- Not all countries have formal relationships and provide information dedicated to the theme of potable water protection by forest formations. Switzerland and France do so in their National Forest Inventories, but not in a homogeneous way. At the same time, the data collected by NFIs do not seem to be consistent with information that exists on a more local level, Departments in France and Cantons in Switzerland. Sometimes there are data for specific local realities, it is the case of the city of Munich that underlies large areas of production and protection in the Bavarian Alps of which there are good data, but no data were found for the entire Lander;

- Information on protective forests of drinking water often presents two non-contradictory data because they represent two different situations, but not always clearly integrated and correlated: on the one hand the value of forests that fall within the protection areas defined by law and regulations, on the other hand the value of the forests that go back to the entire feeding basins of the springs and outlets.

It is the case, for example, of the data of the French NFI which reports at the national level has. 44,000 in total, but for the individual Departments of the Alpine area there is a value of ha. 196,700;

- The definition of the drinking water sampling points is not homogeneous between the countries and also in the regional levels: in particular the distinction between sources and between groundwater collection is not always reported;
- In the same way, the location of source or outlet points in the wooded area is not always available information among the various consulted relationships;
- Also, the value of the data related to the production of drinking water in the forest context, in the context of this relationship, must be considered carefully, since the methods for collecting information have not been detected in the various documents. These figures are therefore intended as an indicative estimate.

Based on the data collected, it is possible to estimate an indicative production of approximately 2,500 M m<sup>3</sup> /year.

## Mineral water

The mineral sources are a typical production and a significant resource for the Alpine mountains, which produce important brands of high economic value.

On the whole, 169 brands are registered in the Alps as distributed by countries:

Paesi	N. producers	N. brands	Production mc/a	Value €/a	Cost €/l	Average consumption l./inab/y (7)
Francia (1)	9	9	4.026.000	1.541	0,98-7,72	136
Italia (2)	55	123	7.479.447 (a)	3.814 (b)	0,88-6,33	196
Svizzera (3)	14	22	n.a.	150	0,37-2,6	102
Germania (4)	3	4	n.a.	n.a.	0,61-2,4	144
Austria (5)	5	9	50.600 (a)	10 (b)	0.33-1,5	92
Slovenia (6)	2	2	n.a.	n.a.	n.a.	106
<b>TOTAL</b>	<b>88</b>	<b>169</b>	<b>11.505.447</b>	<b>5.505</b>	<b>0,33-7,72</b>	

(1) [http://www.boisson-sans-alcool.com/marques\\_eau-france.html](http://www.boisson-sans-alcool.com/marques_eau-france.html)

(2) Bevitalia 2017-2018, (a) data on 31 producers (b) data on 30 producers

(3) <http://eau-minerale.swiss/>

(4) [www.minerlwasser.com](http://www.minerlwasser.com)

(5) [www.forum-minerlwasser.at](http://www.forum-minerlwasser.at), (a) data on 2 producers (b) data on 1 producer

(6) [www.acqueinbottiglia.it](http://www.acqueinbottiglia.it)

(7) <https://www.efbw.org/index.php?classement=07> (2013)

n.a.: not available

The market data show that production and consumption, therefore also turnover, are continuously growing, with increases of 100% on a ten-year basis.

The available data reflect a market value of at least 4.000 M €. in Italy, 1.541 M €. In France, 150 M CH in Switzerland, for a total estimated production of the Alpine arc of at least 11.500 M cubic meters of bottled mineral water.

Italy and France, at the world and European top in the consumption of bottled water, are also due to the importance of production and the market with large quantities exported.

To give an account of the importance of Alpine mineral waters in the sector it is useful to highlight that in France the alpine sources belong to the first three groups that hold 80% of the market production ([www.boisson-sans-alcool.com](http://www.boisson-sans-alcool.com)) and in Italy they are 4 the first market groups, with 51.8% of production, owners of the main alpine mineral sources (Bevitalia 2017-2018).

Compared to the altitude of the springs, almost all located under m. 1,800, it can be considered It can be estimated that 80-90% of Alpine mineral sources are in forest contexts, even if the relative protection surfaces are not known.

This fact, in many cases, is used by brands as an element of promotion and guarantee of water produced in natural places and therefore not contaminated, produced in a sustainable way and with high quality guarantees.



**Fig. 25** - Examples of labels that recall the relationship with the world of nature and forests

The high market value could lead to the definition of territorial contracts to guarantee forms of payment of services provided by forests and / or for investments in the territory, to be eventually recovered as further *green appeal* during the marketing and promotion of the product.

This opportunity is made even more significant by comparing the different values that, on a European scale, are made by companies as concession fees for the research and exploitation of mineral springs:

Country	Concession fee € / mc
Italy	1,15
France	0,586
Germany	0,034

<http://ricerca.repubblica.it/repubblica/archivio/repubblica/2018/01/02/la-minerale-non-disseta-i-comuni27.html>

On the other hand, it may also be useful to remember that according to some studies (SSIGA 2015) the consumption of 142 liters of drinking water per person per day has the same environmental impact as the respective consumption of 0.3 liters of mineral water.

This topic could also be considered to promote, in addition to more sustainable production methods, also forms of compensation and / or return to the territory of the intense use of resources.

Water Protection areas are defined in all Alpine states: mostly as geometric or topographical borders in relation to the water sources. It is necessary to combine geological and topographical data to define actual protection areas and source feeding areas in order to effectively protect drinking water sources, that in all the Alpine area represent the most important provider of high quality and cheap drinking water. A clear and universally accepted definition of the protection and feeding source areas is the condition for the acceptance of payment methods of this essential ecosystem service.

### **3. Forest management for drinking water protection**

Forest management has a direct influence on the quality of the water that percolates into the soil below the forest cover, thus affecting the water supply.

The choice of suitable silvicultural methods and policies suitable for basin scales help to create the best conditions for the production of water from the best quality and ideal water basins.

There are various contributions produced over time:

- AAVV (2012) - Protection des eaux souterraines en foret- Guide Alpeau dans l'Arc Alpin et Jurassien. Alpeau Project, Interreg.pg.37. [www.alpeau.org](http://www.alpeau.org)
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- Bansept A., Fiqueperon J. (2014) – Protéger e valorosirer l'eau forestière. Guide pratique nationale. Programme "EAU+FOR". Pg. 164
- Forstwegebau und Holzernte im Wasserschutzgebiet (2014)- Bayerisches Landesamt für Umwelt – Merkblatt Nr. 1.2/10.  
[https://www.lfu.bayern.de/wasser/merkblattsammlung/teil1\\_grundwasserwirtschaft/doc/nr\\_1210.pdf](https://www.lfu.bayern.de/wasser/merkblattsammlung/teil1_grundwasserwirtschaft/doc/nr_1210.pdf)
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- Koeck R., Magagna B., Hochbicler E. (2007) – Best Management Practices for the drinking water protection forests. Appendix I KATER II Project. University of Natural resources and Applied Life Sciences, Vienna.p.34
- Koeck R., Hochbicler E. (2014) - Best Practices for Forest Ecosystems in Mountains and Flatlands. Appendix WP 4 CC-WARE Project, South East Europe pg. 68. [www.ccware.eu](http://www.ccware.eu)
- ONF, Volvic, CRPF d'Auvergne (-) – Guides des bonnes pratiques sylvicoles sur l'impluvium de Volvic. Life Semeau. p. 16.

The various studies conducted, and the various product management manuals agree that the following practices are significant:



### Forest management guidelines for drinking water protection

- Promoting mixed forests and, in general, mixed stands with high amounts of broad-leaved trees and silver fir: with the loss of the leaves in autumn, these woods allow a greater infiltration, filter less nitrogenous substances present in the atmosphere.

Moreover, generally having a deeper root system, they fix larger quantities of nitrates in the soil. Finally, the humus of broad-leaved trees is biologically more active, improving the filter effect and the buffer effect on the water.

- Providing controlled and limited extension forest cuts: in the protection zones the cuts should be according to the selection system, but also in the catchment basins of drinking water should be preferred a continuous and non-intensive treatment, aimed to establishing uneven-aged-stands.

In the mountain area this model can be configured as "shelterwood selection system" with a maximum size of 5.000 square meters (www.life-semeau.eu; Koeck, Magagna, Hochbicler, 2007).



**Fig. 26** - Mountain forest managed under the shelterwood selection system

In fact, cuts too large the risk of creating phenomena of excessive mineralization of humus and nitrate run-off, as well as risks of increased turbidity as a result of the elimination of the grassy and shrubby layers with soil denudation.

In addition, extended cuts require the construction of roads or forest tracks and the logging of the logs with soil denudation and still risk of turbidity of groundwater.

All cuts in the catchment areas of respect must be authorized and checked.

- Adopting biological lubricants for the use of machines and equipment: these products are to be preferred in the management of the drinking water protection forests, since one of the main risks for forest management is the spillage of hydrocarbons.

In the same way, the wood fuel storage and the means of recharging the equipment's must take place in protected conditions.

Ensuring the presence, in work sites, of absorbing materials to intervene in case of accidents with oil and fuel leaks.

-Adopting suitable logging methods for the sites, the characteristics of the soils and the moments of heavy rain (with the limitation of the use of heavy vehicles and machinery in the areas near the catchments), to avoid risks of compaction on the one hand and erosion other with subsequent turbidity of the waters.

-Avoiding the use of pesticide products, insecticides or fungicides, also to treat the felled timber.

This should be set up in areas outside the feed basins or on waterproof substrates.

The Interreg CE project "PROLINE-EC" has developed a "Transnational best management practice report", which accurately describes the different measures applicable in the forest environment and the relative advantages and limitations, also identifying specific practices for each practice ([www.interreg-central.eu/Content.Node/PROLINE-CE.html](http://www.interreg-central.eu/Content.Node/PROLINE-CE.html)).

An example is shown in Fig. 27.

**Table 2. Best management practice relevance - Forests**

Best management practice	Water protection functionality	Cost of the measure	Duration of implementation	Time interval of sustainability
<b>MOUNTAIN SITES</b>				
Avoidance of the clear-cut technique*	High	Low	Long Term	Long Term
Establishment of a Continuous Cover Forest System*	High	Medium	Long Term	Long Term
Defined Crown Cover Percentage of Forest Stands*	High	Medium	Long Term	Long Term
Limitation of the Percentage of Timber Extraction*	High	Medium	Long Term	Long Term
Continuous Regeneration Dynamics*	High	Low	Long Term	Long Term
Foster Stability, Vitality and Resilience of the Forest Ecosystems*	High	Low	Long Term	Long Term
Tree Species Diversity According to the Natural Forest Community*	High	High	Long Term	Long Term
Improve the structural diversity of the forest stands*	Medium	Medium	Long Term	Long Term
Forest Ecologically Sustainable Wild Ungulate Densities*	High	Medium	Long Term	Long Term
Protection of the Gene Pool of the Autochthonous Tree Species*	High	Medium	Long Term	Long Term
Foster old, huge and vital tree individuals*	High	Low	Long Term	Long Term
Establishment of an adequate deadwood management*	High	Low	Long Term	Long Term
Buffer Strips along Streams, Ditches and Sinkholes*	High	Medium	Long Term	Long Term
Adaptive Forest Management under Climate Change*	High	High - Medium	Long Term	Long Term
Natural Forest Succession in Case of Stable Forest Ecosystems*	High	Medium	Long Term	Long Term
Small-Scale Regeneration Techniques*	High	Low	Long Term	Long Term

**Fig. 27 - Good forest practice framework drawn from the "PROLINE-EC" Project Forestry guidelines**

Other operational indications are illustrated by the Alpeau Project in the report "Protection des eaux souterraines en foret- Guide Alpeau in the Arc Alpin et Jurassien" ([www.alpeau.org](http://www.alpeau.org)).

The "Orientgate" project has elaborated a Water Protection Functionality Index (WPFI), which allows to represent the contribution of a forest ecosystem to the supply of the "drinking water" ecosystem service (DWP), understood as 'supply of high quality drinking water in adequate quantities' ([http://www.orientgateproject.org/uploads/Press%20releases/results%20docs/pilot%20study%20reports/WP4\\_Pilot%20Study%201\\_Report\\_WEB.pdf](http://www.orientgateproject.org/uploads/Press%20releases/results%20docs/pilot%20study%20reports/WP4_Pilot%20Study%201_Report_WEB.pdf)).

Forest ecosystems can provide a high level of DWP if they are treated according to specific guidelines for areas protected by drinking water. This requires adaptive forest management at all levels of silvicultural interventions, as indicated in "Recommendations for Adaptive Management Concepts" (Koeck and Hochbichler 2014).

If inadequate forest management practices are applied, water protection functionality can be reduced, in some cases even destroyed.

For the evaluation of WPFI in the pilot study area of the available project, three parameters were used in a specific simulation model: (1) the silvicultural technique applied in the area, (2) the specific composition of the ground and (3) the regeneration dynamics, considered as the most important for the definition of WPFI of a forest area.

WPFI is calculated as a normalized value of the three forest parameters applied.

High water protection functionality is expected if WPFI is between 0.8 and 1.0, a very low WPFI value between 0 and 0.29 indicates that the water protection functionality of a forest is actually very low:

WPFI Value	0.8 – 1.0	0.5 – 0,79	0.3 – 0,49	0 – 0.29
WPFI Indication	high	medium	low	very low

#### General guidelines

- To integrate forest management documents (Management plans, Regulations, contracts) with specific attention to the management of forests for the protection of drinking water resources.
- To ensure correct forest management not only in protected areas of catchment areas and also throughout the feed basin, through the adoption of forest management and logging practices aimed at protecting groundwater.
- To activate modalities and moments of dialogue and comparison between forest authorities, foresters and local water management companies, to share appropriate forest management solutions.
- To promote, starting from significant experiences already underway, forms of remuneration of the function of protection of drinking water, between public entities, forest owners and water companies. In particular, the compensation for the higher costs required by the specific methods of silvicultural management should be distinguished from the remuneration of the real water supply service.
- To promote public and consumer awareness actions and activate training actions for water services managers and forest managers.
- To remember the clause for the protection forests and their proper management in the tenders of forest works assigned to the companies.

#### 4. Some considerations

##### Costs and benefits

The careful management of forests in the areas of drinking water protection is a cause of costs higher than ordinary management.

These can be referred to the need to adopt less intensive methods of cutting and logging, with limitations to the opening of forest roads, or the need to make it farther away, with lighter operational means of transport, with the suspension of working time in periods of strong rain and soils impregnated with water; or for the need to use ecological mixtures and oils for machines and tools; or for the most accurate cleaning and removal of branches and wood residues.

According to the authors, these higher costs range from € 33/ha/y at € 75-100/ha/y in France (with an incidence of € 0,04 to 0,07/mc of water) (Fiquepron J., 2012), from CHF 9/ha/y to CHF 300/ha/y in

Switzerland (Burgi A., Spjevak S., 2009), with 500-1.000 €/ha for forest improvement and increase in the presence of deciduous trees in coniferous forests.

Some studies also highlight the value of benefits derived from the presence of forests for the protection of drinking water, which do not require specific treatments.

In Switzerland, the water treatment cost of 0,20 CHF/mc is reported to water purification, which would result in a saving of 80M CHF/year on the quantity of drinking water coming from springs (UFAFP, 2005).

In France it has been estimated that the cost of withdrawing water from sources in the forests is 4 times lower than the cost of groundwater uptake and is less than 26 to 60 times the cost of pumping water from the lakes (Fiquepron J.,2012).

The non-treatment of water thus allows a savings estimated on average in €. 0.44 / mc (Fiqueperon et Picard, 2010).

## Remuneration services

Today the principle of compensation for forest management is a necessity recognized by many subjects and begins to be so also in different national regulations.

However, its modalities must be implemented through new regulations or contractual forms, which must find the sharing and participation of the parties in the explicit and formal definition of the roles managed and of the recognized goods and services.

It is possible to imagine two opportunities:

- To integrate economic compensation in the context of forest water collection procedures;
- To remunerate the services provided by forest management.

Several experiences have already been carried out in Europe, in the United States, in Australia (Pettenella, Secco, Ravanelli, 2006; Deck, 2008).

For example, in France, the protection service provided by new afforestations on agricultural land is estimated at 15 €/ha/y. In the municipality of Saint-Etienne (F), the private water management company has signed an annual agreement with ONF worth around € 30.000/year for technical management and small forest protection measures for forest springs. The Inter-communal Water Syndicate of Moises (SIEM) in France, on the lakeside of Geneve, has supported the establishment of an association of forest owners to facilitate the correct management of 150 ha of protection forests, guaranteeing compensation for higher costs and financing a flat rate of € 1.000/ha to support the transformation of forests into irregular mixed forests.

In the Volcic mineral water production region, the Danone property pays compensation to municipalities and private owners from € 300/ha/y to € 1.200/ha/y, up to a maximum of € 3.000/ha/y, for restrictions on use.

Also, in France, a study in the Nancy area has verified the willingness to pay € 50/y more for families to have "natural" water of forest origin (Fiquepron coord., 2010).

The investments of Vittel and the city of Munich to reforest agricultural land in the catchment areas are worth respectively € 0,0154 and € 0,00006 per bottle produced.

An approximate estimate of 1% /mc on the average value of drinking water (€ 2.5/m<sup>3</sup>) and 0,1% for minerals waters (€ 1/l.) could guarantee the management of water protection forests something like 62,5 M €/year for drinking water and 800 M €/year for mineral water.

It is certainly pending, given the regulatory difficulties in some cases or the operational difficulties in others, the assessment between the choice to leave the contract between the two contracting parties for the payment of the ecosystem services, or to entrust the government public the remuneration of the costs necessary for the management, recognizing the service offered a high public good value.

## Quality brands

The good quality of the water of forest origin can constitute a positive image for the forests as well as for the producers.

The aim of the quality label is to improve the value of the forest in supplying consumers with good quality water.

In particular, the brand, in addition to valorise the quality of the water supplied to the consumer, enhances the important social value of the forest, the role of the person managing it, the action of the service companies, and finally the quality and value of the territory, managed in a sustainable way.

The mark can also serve as an instrument of recognition and guarantee to attribute any overhead management costs on the tariffs.



**Fig. 28** - Examples of a Swiss brand

The quality label can also today be supported by the new and specific FSC forest certification standards, which have recently foreseen the possibility of certification of eco-system services, including those relating to the so-called "basin services" inherent, among others, the use of water for domestic use.

## Hydroforestry policies

It is recognized that technical water treatment is much more expensive than water filtered through forest ecosystems.

Therefore, it is quite reasonable therefore to support a specific good policy for the conservation of the drinking water resources provided by forests.

Not all the world of forest managers nor that of water services is fully aware of the need to adopt specific strategies and methods for the management of production of drinking water from forest areas.

It therefore appears necessary to promote better awareness at different levels and adopt appropriate ways to promote good policies:

- To integrate water and forest management in the Territorial Plans
- To identify forest areas for the protection of aquifers in forest planning;
- To promote territorial agreements or contracts between the various parties involved in forest management and water services.

An agreement was concluded in the Haute-Savoie between SIEM and an association of forest owners for the protection of catchments within the forests.

The agreement provides for the drafting of a management plan, the drafting of a tender for forest uses with the recognition of higher costs, the realization of works for forest roads.

- To orient the legislation towards a clearer and fair recognition of the value of forest management for the protection of drinking water resources.

## 5. Conclusions

The forest management exerts a considerable influence on the quantity and quality of the percolation water and consequently also on the drinking water in the catchment basins.

This is an important service in providing quality drinking water without particular treatment needs.

The natural origin of the water allows it to offer consumers the guarantee of a quality product, a theme on which today's attention is maximum.

Forest ecosystems guarantee the constant supply of good quality drinking water for populations and tourist presences.

Public institutions, forest authorities, water management services, local municipalities should be aware of the role that forest ecosystems play in guaranteeing water resources and taking shared actions for the protection of springs and good forest management of the protection areas.

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# **Good Practice Template**

## **WG Report**

# **"Interdependence between mountain forests and freshwater provision" 2018**

<b>Planning tools for the sustainable management of forests for the protection of drinking water sources Title</b>	Planning tools for the sustainable management of forests for the protection of drinking water sources
<b>Reference</b>	Activity carried out during the years 2004, completed but not activated due to the different restructuring processes of the company.
<b>Country, Region</b>	Bergamo, Lombardia, Italy
<b>Specific objective</b>	To provide the company responsible for drinking water in the city of Bergamo with the specific tools for knowledge, protection and enhancement of forest stands for the protection of springs.
<b>Localization</b>	Sub-regional territorial location
<b>Bodies involved</b>	Uniacque s.p.a as owner of the aqueducts for the City of Bergamo (formerly BAS); ERSAF as regional authority for forest services; TESAF of the University of Padua for scientific support
<b>Abstract</b>	<p>Uniacque s.p.a manages the water service for 172 municipalities in the province of Bergamo for a total of 820,000 inhabitants, using 575 units, mainly sources present in the pre-Alpine belt near the plain.</p> <p>Among these the city and the hinterland of Bergamo with about 225.000 inhabitants, that consume approximately 220 l / inhabitant / day.</p> <p>The supply to the city is guaranteed in particular by the Nossana spring, about 30 km away in Valle Seriana, at an altitude of 480 m.</p> <p>This is a karst source with an average annual flow rate of 3,000 l / s, which, according to the latest studies, has a hydrogeological basin of 80 sq. Km.</p> <p>Considering that most of the springs are in the forest context, during the early 2000s Uniacque provided, through ERSAF, a specific management plan for forests for hydroprotective purposes.</p> <p>Subsequently, only for the area of the source Nossana has started a series of studies to identify, even as a pilot case internally, modalities, critical issues and opportunities for a correct management of the territory for the protection of water.</p> <p>The collaboration between Uniacque, ERSAF and the University of Padua has therefore produced a series of studies and working documents useful for the sustainable management and enhancement of natural resources in the context of water management activities.</p>
<b>Actions, measures</b>	<p><b>a. to. "The forest and the protection of water resources in Val Nossana".</b></p> <p>In this first phase a description was made of the main elements that make up the landscape of the valley: the use of the land, the survey in the field of forest resources, the alpcultural activity, the presence of mines and the proposal to establish a park mining. Evaluations have been made on concentrated and dispersed recreation, in relation to the risks these activities entail for water resources, the role of forests in the protection of land and water resources, identifying good forest management practices for the entire hydrogeological basin . The areas managed by Uniacque have a central role in the protection of water resources due to their proximity to the source, and through the ground and the forest cover they perform a filtering action on rainwater and control surface and subsurface outflows that develop in site. On the other hand, they are not able to influence the deep runoff routes of the water, originating upstream: in this case they can only guarantee protection from possible sources of pollution, while they can not exert an improvement action on</p>

water quality. These practices concern the different aspects of the anthropic action on the forest: forestry, fire, fertilization, use of herbicides and pesticides, thinning and conversion, forest utilization, removal of branches, cimals and cutting residues, logging, construction of storage, use of oils and fuels, construction of roads and forest tracks, grazing and creation of buffer strips.

**b. Hydrological balance of the feeding basin and quality of the waters of the Nossana spring.**

Based on the analysis of available hydrometeorological data, it was assessed as a working hypothesis that the feeding basin far exceeds the one identified by the watershed: it was thus possible to estimate a real area between 60 and 70 sq. Km, compared to 24- 25 considered up to now. In the balance equation applied to the topographic basin, a U-size was introduced relative to the underground contributions of the neighboring basins equal to twice the P rainfall affecting the basin. The presence of numerous measurement limits and the lack of available data do not allow a precise definition of the real extent of the feeding basin. This fact suggests an analysis of the underground run-off routes (for example, using tracers) as possible development of the survey, in order to set up an effective water resource protection strategy based on a correct management of the use of the soil

**c. Economic estimate of the value of the forest in relation to the protection function of the water resource.**

Methods of economic estimation have been applied to the hydrogeological protection function carried out by the wooded formations. These estimates concerned both the entire hydrogeological basin and the single zone of respect, from which the values for each unit of surface area and per cubic meter of water supplied were obtained. There were two lines of assessment: that related to land use (for example the cost of construction and management of a forest or the estimate of additional costs due to the predominantly protective function of the forest and the application of good forest management practices ) and that related to drinking water (for example the market value of the water resource or the capitalization of the water production function). The values thus obtained cover a very wide range (from a minimum of 10 to a maximum of 36,500 € per ha). This remarkable variability is to be referred to the different estimation criteria that can be used in relation to the different economic aspects of the asset that are intended to be privileged. In general, it is possible to prefer in principle the estimates directly linked to the production of water as they are not influenced by other cost or benefit components such as landscape value. In particular, the costs of subrogation and treatment of polluted waters are significant, ranging between 0.1 and 80 € / mc. However, in the light of the values obtained, two important conclusions emerge: based on even the most restrictive estimates, it appears that the costs of a good management of the catchment area are widely justified; according to the precautionary principle that should guide the management of the water resource, the highest results of the estimates should also be considered. The case of negative events that influence the availability of water, as related to a low probability of occurrence, and the costs that derive from it, must be concretely taken into account by the operator.

**d. Activation of environmental certification procedures for forest resources.**

A feasibility study was carried out on the forest certification of the wooded areas managed by Uniaccque. The objective is the activation of a certification process of

	<p>good forest management in relation to the hydrological protection function. The certification of the SLIMFs pilot project (Small and Low Intensity Managed Forests), initiated by the Forest Stewardship Council International, was therefore proposed. This project is in fact aimed at two types of forest resource that were up to now excluded from the normal areas of certification: forests of small size and those where the production function is not a priority. On the basis of the FSC requirements, it emerged that no significant changes to the management criteria are necessary, confirming the validity of the silvicultural practices implemented up to now, but that some procedures, such as stakeholder consultation, and some elements need to be included ex novo to be perfected, such as the preparation of some written procedures and the methods of monitoring the source protection areas.</p>
<b>Period</b>	
<b>costs</b>	Any reference to the costs incurred if known
<b>contact</b>	<p>giovanni.ravanelli@ersaf.lombardia.it  laura.secco@unipd.it  davide.pettenella@unipd.it</p>
<b>Bibliography/ documents</b>	<p>Pettenella D., Secco L., Ravanelli G. (2006) – La stima del valore del servizio idropotabile offerto dalle risorse forestali. In: E. Basile, C. Cecchi ( a cura di). Diritto all'alimentazione, agricoltura e sviluppo. Atti del XLI Convegno di Studi Sidea. Franco Angeli, Milano, p. 682-701.</p> <p><a href="http://www.uniacque.bg.it">http://www.uniacque.bg.it</a></p>
<b>Notes</b>	<p>At the moment, while the forest management activities continue, according to the specific indications of the management plans, the certification path has not been activated due to the different changes in asset management interventions in recent years</p>
<b>Cartography</b>	