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Integrative Alpine wildlife and habitat management for the next generation

Wildlife Management within the EUSALP perimeter

Alpbionet2030 – Work Package 2
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1 Introduction

Good practice documentation for target groups

This report aims to document the different frameworks of hunting management in the six EUSALP countries: Austria, Germany, France, Italy, Slovenia, and Switzerland.

Further, the effects of hunting on ungulates are examined with reflection on their suspected influence on ecological connectivity.

Not all aspects of wildlife management were covered in this report, as that would go beyond the scope and means. The topic of wildlife damages is especially complex, and the approaches to prevent it are varied and partially contradictory, as they depend on the initial perspective of the forestry and wildlife management objectives. Furthermore, most aspects highlighted and discussed in this report generally concern (hunted) ungulate species.

Given the diversity and range of habitat requirements, historical background, and variability of fauna and flora (and humans) within such a large perimeter, presenting a holistic view is difficult. Some of the statements in this report may sound a bit presumptuous, but they are only intended to reflect on and question the way wildlife management is performed.

Most of the information found in this book is extracted from the books “European Ungulates and their Management in the 21th century (Apollonio, Andersen *et al.* 2010), and the subsequently published book “Ungulate management in Europe: Problems and practices” (Putman *et al.* 2011), and the concise and guiding paper of Apollonio *et al.* (2017) “Challenges and science-based implications for modern management and conservation of European ungulate populations.”

2 Excursion

This chapter is a short excursion for the uninitiated reader to give an overview of the topic of ecological connectivity and its importance for migration and dispersal behavior of wildlife.

2.1 Migration and Dispersal

Differentiation between dispersal and migration:

Dispersal, the movement by adolescent animals away from their natal site, is a crucial process for elements of metapopulation dynamics: (i) subpopulation genetic diversification, (i) re-colonization of sites where a subpopulation has become extinct, (iii) establishment of new subpopulations in unoccupied habitat patches. It is an instrument to reduce inbreeding, which can be harmful and endanger subpopulations and reduce intraspecific competition (e.g., with resident adult individuals for food resources, resting sites, or mating partners). Dispersal might be impaired by landscape resistance, a given degree to which barriers impede dispersal or movements in general across a landscape, such as highways, cultivated and anthropogenically used areas, or simple gaps in otherwise suitable habitat patches (Yahner 2012).

Migration, in the context of ungulate biology/ecology, is the seasonal movement of groups or members of groups to more favourable habitats. These migrations occur many times over the animals' lives. When an animal migrates, it may exploit different feeding opportunities in a favorable climate, which also may include less pressure for food shortages and predation risks (Goodenough *et al.* 2010). However, migration can be risky, as it involves an increased chance of predation or being hit, injured, or killed in a vehicle collision while crossing human transport infrastructure. Nonetheless, three general benefits arise from migration: (i) an increased chance of reproduction, (ii) reduced competition, and (iii) reduced predation risk (e.g., for red deer moving to an area with less hunting pressure). Thus, a reproductive benefit may be accrued by breeding in an area with longer days and high food abundance, e.g., summer and winter resting sites of red deer providing different schemes of food availability and climatic advantages (Yahner 2012).

2.2 Connectivity

A measure: “Connectivity is a measure that describes spatially continuity and connectedness of an environmental matrix” (Forman 1995).

A function/process: “Connectivity relates to the ability of species and ecological resources and processes to move through landscapes” (Lindenmayer *et al.* 2008).

Landscape connectivity is the degree to which the landscape facilitates or hinders the movement of species among different patches that are suitable as potential habitats. It is a combined product of structural and functional connectivity (Tischendorf and Fahrig 2000). Connectivity within an environmental matrix enables the movement of species between different suitable habitat patches in a fragmented, cultural landscape with its supporting infrastructure, and it also ensures the functioning of the ecological system within a given landscape (Kettunen *et al.* 2007).

Given its complex nature, connectivity remains one of the most challenging areas of wildlife conservation. Consequently, a better understanding of which factors influence connectivity is urgently needed in the context of imminent effects of climate change on species composition and shifts in species distribution ranges. Furthermore, areas that will be rendered unsuitable due to change in temperature or resource availability caused by climatic alterations and those transfigured and fragmented by human modification of natural landscapes into cultivated landscape must be identified. Another unsolved issue is the appropriate scale for addressing fragmented and altered landscapes with various connectivity concepts (Kettunen *et al.* 2007).

Functional connectivity is the most essential form of connectivity, as physical, structural connections between patches do not necessarily provide functional relationships between patches. Nor do gaps in the habitat connectivity indicate functional separation. To face the threats posed by habitat fragmentation, ecological connectivity amongst habitat patches and subpopulations across the landscape for widely migrating species such as red deer, is generally recognized as an important and fundamental aspect of wildlife conservation (Kettunen *et al.* 2007).

Ecological connectivity is established and maintained by the identification of existing habitat that is of high connectivity importance for a particular species(-composition) irrespective of their direct importance for biodiversity. E.g., anthropogenic structures such as parks, abandoned railway tracks, canals, and rivers in urban areas may host very few resident species and in general low biodiversity or habitats of importance but may provide necessary migration, dispersal or foraging corridors for species (Yahner 2012).

(Potential) Movement of wildlife between patches can only be assessed by analysis of respective movement data and the application of habitat modeling of landscapes and habitat patches in terms of permeability and feasibility.

2.3 Corridors and ecological connectivity features

Corridors of ecological connectivity are defined by their linear and continuous structure (rivers with their banks; extended forest connecting suitable patchy habitat fragments without being intersected by more extensive transport infrastructure hampering dispersal and migration) or their function as stepping stones (such as ponds or small forested patches), both of which are vital for the migration, dispersal and genetic exchange of wild species. They aim to maintain vital functional ecological connections between different core or stepping stone habitats. These are often physical and may reach from narrow linear corridors (such as watercourses or hedgerows/tree rows) to broad landscape corridors. They also consist of functionally connected corridors of habitat patches that act as stepping stones in the wider landscape (habitat matrix).

Corridors, for example, allow some forested species to move between two isolated woodlots, provided the corridor is also wooded and of sufficient width. The higher the vegetative similarities among corridors and the two connected habitats, the more likely the corridor is to be used by wildlife. Furthermore, a dissimilar matrix in which a corridor and the connected habitats are impeded may not be as crucial as the quality of a distant habitat. Merely looking at the width and character of a corridor is often inadequate for certain species, whose behavior is affected by humans or human activities. Populations may not always be contiguous or connected by corridors. In fact, small populations may go extinct locally and be recolonized by individuals that disperse from neighboring populations (Yahner 2012).

However, as the majority of forests in the EU are managed for forestry targets, the amount of undisturbed forested patches, where red deer, for example, can find undisturbed resting sites, especially during winter, have significantly decreased. Therefore, specific management practices securing the protection, maintenance and availability of these undisturbed areas are essential. Alternatively, areas in forested and open land ecosystems need to be (re-) established to guarantee and protect resting sites, migratory routes and habitat for the dispersal and favorable conservation status of the species within landscapes.

Apart from red deer, there are other species in the Alpine landscape, whose existence and distribution requires stable and homogenous ecological conditions and whose survival is therefore particularly threatened by increased anthropogenic disturbances (e.g., for chamois, tourism in Alpine pastures forest management practices). A characteristic of these species is a high ability to maintain stable populations within the established ranges they inhabit but low capabilities in colonizing new areas. The maintenance of these species, therefore, requires special management measures, guaranteeing the availability of habitats and a sufficient long-term protection scheme for them (Kettunen *et al.* 2007).

2.4 Habitat fragmentation

Habitat fragmentation is the breaking up of extensive landscape features into disjunct, isolated, or semi-isolated patches because of changes in land-use. Fragmentation has, amongst other factors, two main harmful components for biota: the creation of smaller, more isolated, remaining "fragmented" habitat patches and the loss of total habitat area (Meffe and Carroll 1997). Fragmentation on a landscape-scale involves both habitat loss and the breaking apart of habitat with an increased "edge effect" in the particular habitat patches (Fahrig 2003).

In Europe, fragmentation plays an essential role in disturbances of ungulate habitat, with many potential and historically relevant undisturbed primary red deer habitat areas subject to ongoing development and conversion into the anthropogenically used cultivated landscape and divided habitat patches driven by land-use changes. Consequently, nowadays, many of Europe's primary wildlife habitats, at least at lower altitudes, are highly fragmented and at risk of further fragmentation especially in developing countries in the east of Europe.

However, they still contain significant contiguous wildlife habitats consisting of undisturbed primary forests and park-like open landscapes. Fragmentation ostensibly leads to habitat loss and degradation and constrains movement of far migrating species (e.g., foraging, mating, dispersal, and migration to summer and winter resting sites). Smaller habitat patches, which are dominated by edge effects, greatly affected by disturbance and other external influences, are proving suboptimal especially for species that require large habitat based on far-reaching movement and migration patterns. Subsequently, with only smaller and disconnected habitat patches available, population and range size are declining (e.g., caused by increased mortality due to vehicle collisions while migrating). Small habitat patches prove to be insufficient for species with large habitat requirements or may only be able to support small population sizes susceptible to extinction as a result of chance events.

Changes in diversity, abundance, and composition of species due to fragmentation may have cascading impacts on the habitat structure and ecosystem functions and subsequently the direct provision of ecosystem services. Nowadays, the value of ecosystem services has become widely recognized, and these services also form a cornerstone of the current EU biodiversity policy. Continued habitat fragmentation, exacerbated by the impacts of climate change, can result in socio-economic impacts, e.g. due to the cost of lost or failing ecosystem services (e.g., water purification/retention, flood/erosion prevention, and retention) (Kettunen and Brink 2006).

Fragmentation is a threat to the ongoing efforts and achievements of many of the EU's nature conservation objectives, including a halting of biodiversity loss by 2010, proposed by Kettunen *et al.* (2007). It also impairs the effectiveness of the Habitats and Birds directive, in particular, the implementation of a coherent network of protected areas (the Natura 2000 network) and, subsequently, the wider maintenance and restoration of a Favourable Conservation Status (FCS) of habitats and species. Broader implications also apply regarding the maintenance of ecosystem functions and the provision of ecosystem services and their socio-economic benefits.

3 Hunting in Europe

Hunting is one of the oldest uses of natural resources dating back to the roots of humanity. Animals provided sustenance, clothes from hides and pelts, and hunting also played a social role for our ancestors. Most of the tools, methods, and motivations for hunting have changed over the centuries; some have stayed the same. A lot has happened since the time of prehistoric hunters, from hunting as a sports activity of the medieval nobility to the modern-day hunter using off-road vehicles, high precision rifles, and wildlife camera traps. Nevertheless, and perhaps because of the adaptation to modern times, hunting still plays an important role in our cultural landscapes.

More and more stakeholders have joined the “traditional” band of land-users, including agriculture, forestry, and hunting. Agriculture and forestry exert growing demands on the cultural landscapes in which they operate. Tourism and recreational activities in nature have also increased immensely over the last centuries. Human activities and land usage have a high conflict potential with the animal residents of these landscapes, whose populations can often stretch across regions and countries and do not adhere to administrative borders. In every country within the EUSALP perimeter, there is a common understanding that hunting is an essential element in managing wildlife in order to lessen or to avoid conflicts due to the over-abundance of certain wildlife species. Hunting is, therefore, generally seen as a tool in wildlife management, but the hunters themselves have their own definitions and ideas of what hunting is and what their responsibilities include, if any.

The organization of hunting activities is handled differently in each ESUALP country, as it is a product of historical, political, and social developments. Some systems are more similar than others. The foundation of all hunting activities is primarily legislature, which defines the framework in which hunters can act. These laws and regulations determine the hunting system, hunting seasons, hunting practices, hunters’ training requirements, permissible firearms, and ammunition, and other subjects. In turn, the national hunting legislations themselves are, of course, deeply influenced by the various traditions and the history of hunting in the countries. The feudal systems, land use, and land allocation practices shaped Europe’s countries, and these effects are still present today.

4 Hunting systems

The definition of a “hunting system” is not clear-cut. The term is generally used to differentiate the German coined “Revier” / district-based hunting system (present in Austria, Germany, Slovenia and nine cantons of Switzerland), from the “Patent” / license-based hunting system (present in 16 Swiss cantons) (see Table 1 and Figure 1).

One important aspect to understand and define wildlife management systems within the EUSALP perimeter is the legal status of wildlife, where, in some countries, wild animals belong to the people/state (*res communis*/*communitatis* - SI, IT), and, in others, they belong to “no one” (*res nullius* - AT, DE, CH, FR). This distinction can be important in terms of the extent to which government bodies can control and influence the management of wildlife or management/hunting practices. Where wildlife is *res communis*, the state can decide, without reference to the actual landowner, to use a license-based system and lease management districts to individuals or hunting groups (Putman 2011).

“Revier” / district-based hunting system		**“Patent” / license-based hunting system**
Hunting is organized on a **district** level -> Hunters **lease** the hunting district from the appropriate agent/authority (landowner, commune, etc.)	**Organization/ Structure**	Hunting is organized on a “**large management area”** level (e.g. a whole Swiss canton) –> hunters are **not directly associated with the properties**/landowner
Hunters are transferred the legal **rights and duties** concerning hunting -> **Habitat management**, gamekeeping and other duties fulfilled **by hunter**	**Rights and duties**	Hunters are mostly not transferred any legal rights or duties -> **Habitat management** and other duties fulfilled **by professional game wardens, wildlife biologists**, etc.
Hunters/hunting associations have to (partially) pay for wildlife damages / **are liable for compensation** of damages	**Wildlife damages**	Damage compensation is mostly paid by a **proportion of** the **license fee** or the membership fee of a hunting association
Hunters receive a **quota** (number of animals) allocated by hunting authority **on a district level** or propose these themselves	**Quota allocation**	Hunters buy species **tags/licenses** (per animal); **Individual** hunters get a **quota** allocated for a certain number of animals to shoot
Long hunting **seasons** (many months)	**Hunting season**	**Short** hunting **seasons** (a few weeks)
Wildlife management **can be complicated/ineffective**, as **changes are difficult to introduce** (administrative **authority** often has **low assertiveness**)	**Authority**	Wildlife management **can be very effective**, as **changes can be introduced relatively easily** (administrative **authority has** a lot of **power**)

Table 1 – Simplified comparison of the properties of the district- and license-based hunting systems

In countries such as Switzerland and Slovenia, regulations and administration are usually managed at a national level (canton level in Switzerland) (Adamic and Jerina 2010; Imesch-Bebie *et al.* 2010); whereas, in countries like Austria, Germany, and Italy, wildlife management is also delegated (to state and especially) to regional authorities. Monitoring wildlife populations or restrictions on species to be hunted can be implemented more quickly if the state is in control of hunting bag allocation. As the state has control over the allocation of hunting areas, access for hunters can be restricted more easily (Putman 2011). Where the right to hunt is bound to the property, a restriction in hunting access would mean encroachment on the property law, and with this, a devaluation of the property or hunting lease. France circumvents this predicament by creating a regulatory structure under the broad provision of the Environmental Code (Pillai, A. & Turner, A. 2017).

When using the “district- vs. license-based system”-generalization to define hunting systems, France and Italy have an “in-between” system. In France, even though the hunting right belongs to the property, and, thus, the owner has the right to allow or forbid hunting, the quota (how many animals may be shot) is allocated through animal tags issued to the individual hunter or hunting group. The allocation of these species licenses or tags is generally used in license-based hunting systems. In most departments (10 departments), membership in an accredited communal hunting association (*Association Communale de Chasse Agréée – ACCA*; see Figure 2 and Figure 3), which manages hunting on a regional level in communes, is mandatory. Here every landowner is automatically a member in such an ACCA, and the hunters can use the whole district for hunting. The right to hunt is transferred to the ACCA (Maillard *et al.* 2010).

In Italy, hunting in the provinces of the eastern Alps is mainly managed in municipal reserves. In the provinces of the western and central Alps, hunting areas are organized in General Hunting Districts (*Ambitio Territoriale di Caccia* – ATC) and Alpine districts (*Comparto Alpino* – CA) (see Figure 4). The hunting districts can be further subdivided into ungulate hunting districts. Hunters need to apply for a license allocating him/her a specific number of animals (Apollonio, Ciuti *et al.* 2010).

Another important aspect is the legal agent to whom the hunting right belongs. This agent can be the state, which regulates who is permitted to hunt wildlife (CH, SI), or private persons, who, in general, lease a hunting area. In the district-based systems of Germany and Austria, only properties that are over 0.75/1.15 km^2 (DE/AT – differences can apply per state/province and some regions) permit the owner to have its private hunting area (if he/she has a hunting license or the area can/needs to be leased to a hunter). Otherwise, the areas are pooled to collective/municipality hunting grounds with over 0.15/5 km^2 (DE/AT), which are then leased to hunters. Here the hunter, as a leaseholder, gets the hunting rights and obligations transferred and has a more direct association with the property owner (Reimoser and Reimoser 2010; Wotschikowsky 2010).

A third wildlife management concept exists, most prominently represented in the Swiss canton of Geneva, where “hobby” hunting is forbidden, and state-appointed game wardens execute wildlife management culls. Here, the main objective is efficient wildlife management. This type of hunting management is also often present in nature protection areas, for example in many national parks, where hunting is generally forbidden except for population control purposes. In this situation, hunting, or better termed “culling”, is executed by professional hunters employed by the park administration. Slovenia also has 11 State Wildlife Reserves, where such a state-managed hunting system is implemented (see Figure 5).

In most countries, hunting associations play an integral role, functioning as a unit for organizational purposes and as an interest group for hunters at the administrative/political level. The German hunting legislation, for example, recognizes hunting associations as nature conservation bodies with quasi-legal status (Pillai, A. & Turner, A. 2017). In Austria, hunting associations have a definite legal character, and membership for hunters is mandatory (eight out of nine provinces). Mandatory membership in a hunting association is also a requirement in most of the French departments, and different associations are present on three levels of administration (national/regional/departmental). In Slovenia, the local hunting club or “hunters’ family” forms the basis of a management unit. The Italian government recognizes seven hunting associations under the hunting law n°157 (to which a series of unrecognized local associations is added).

The Federation of Associations for Hunting and Conservation of the EU (FACE) represents hunters on a European level. It is an international, non-profit, non-governmental organization and is comprised of 36 national hunting associations. FACE has been a member of the World Conservation Union (IUCN) since 1987. (https://www.face.eu)

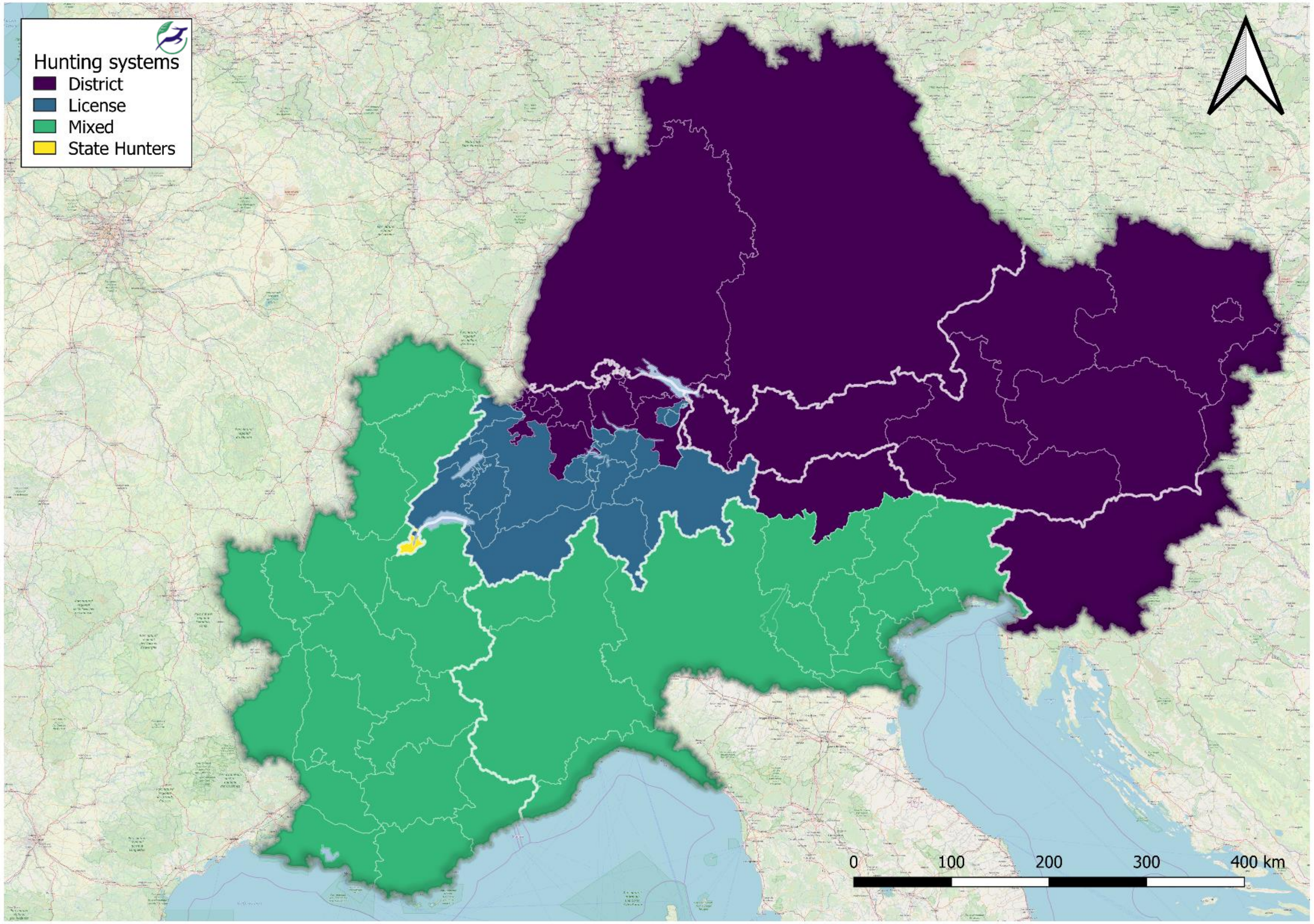

Figure 1 – Hunting systems in the EUSALP perimeter; Data by EuroGeographics, and OpenStreetMaps

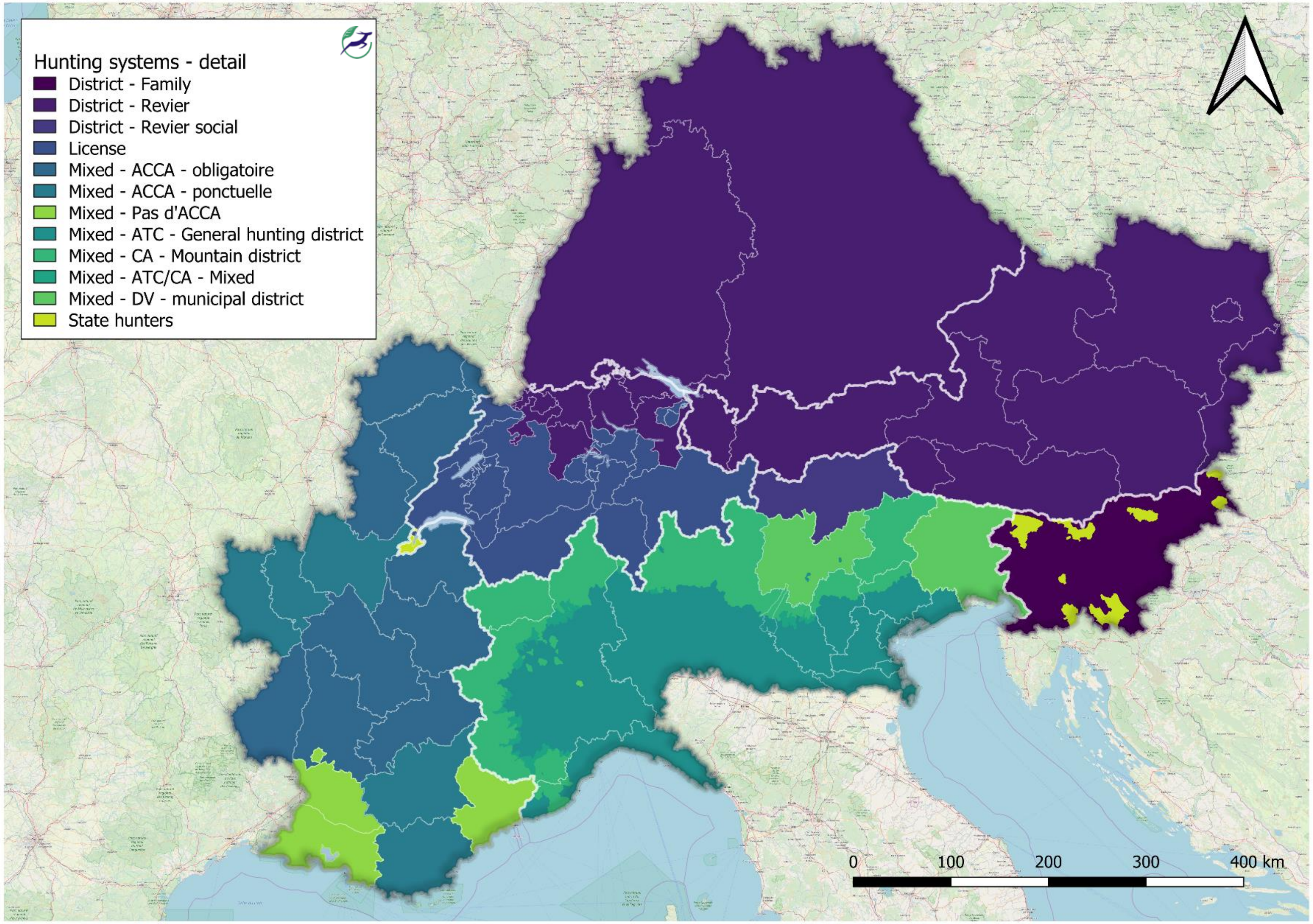

Figure 2 – Hunting systems detail in the EUSALP perimeter; Data by EuroGeographics, and OpenStreetMaps

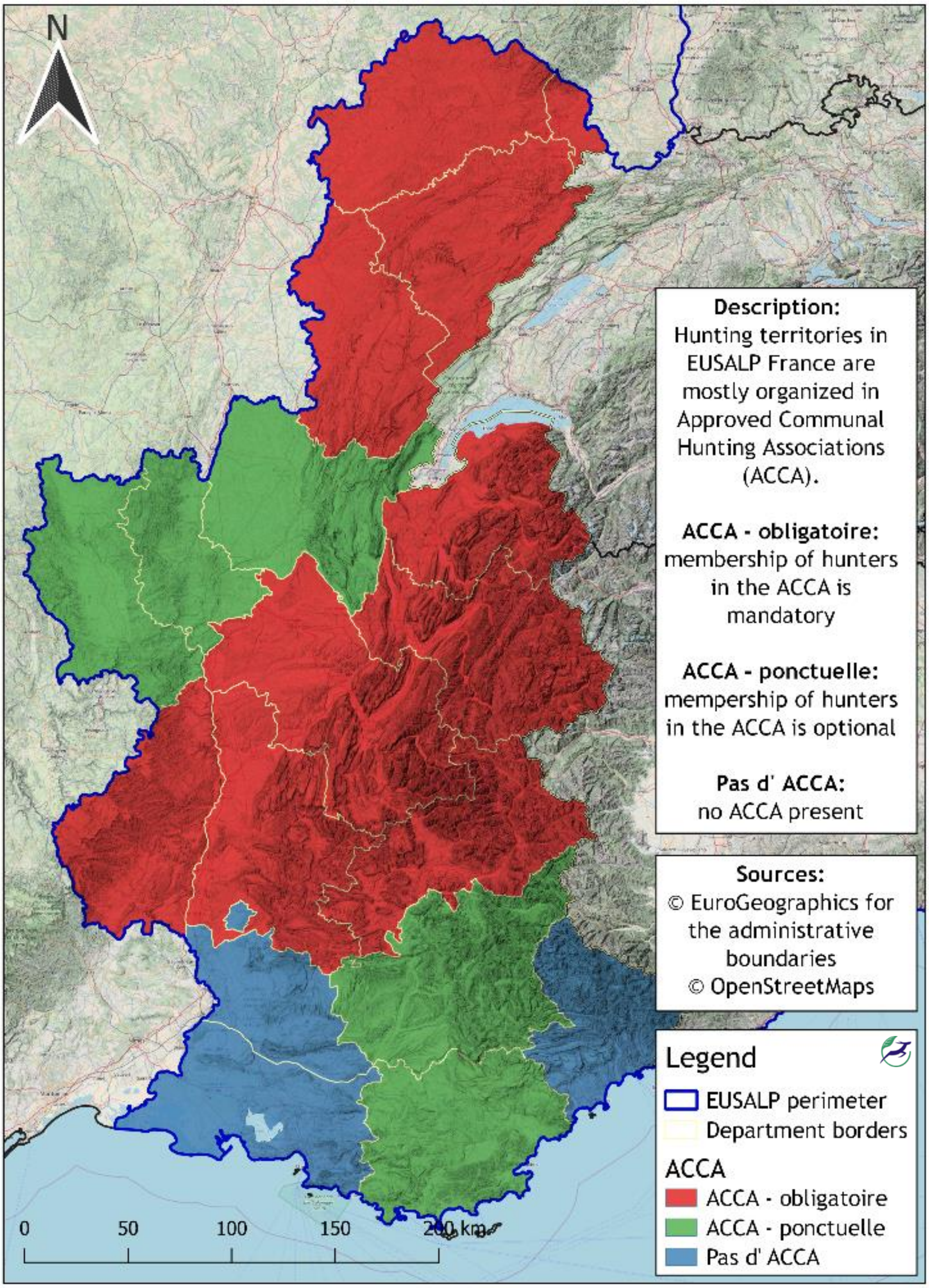

Figure 3 - Approved Communal Hunting Associations (ACCA) in France. Mandatory membership in ACCA in red, membership partially required in green, no ACCA present in blue. Map produced by FIWI/Vetmeduni Vienna based on data from EuroGeographics and OpenStreetMap

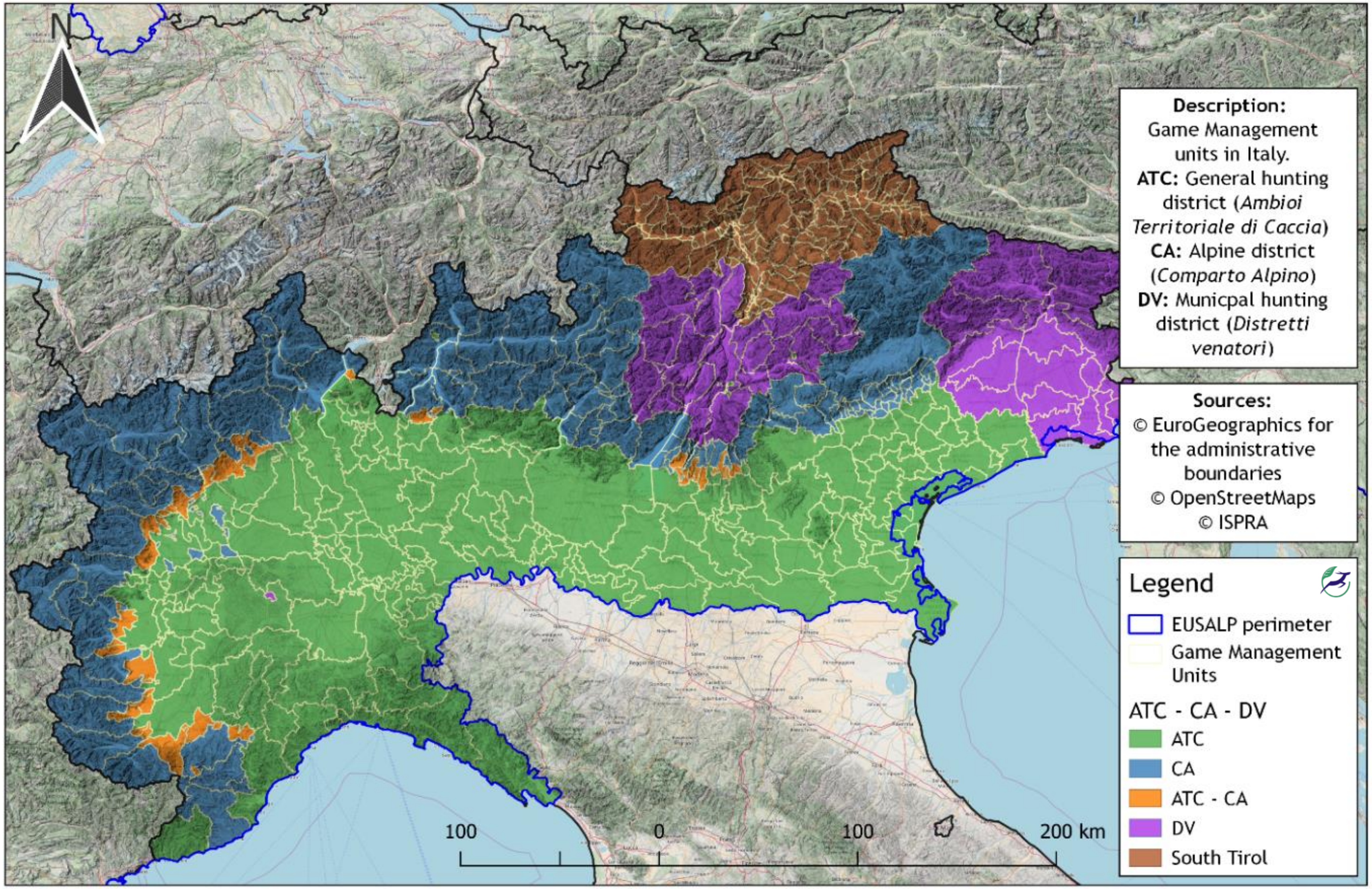

Figure 4 - Hunting management units in Italy. Map produced by FIWI/Vetmeduni Vienna based on data from ISPRA, EuroGeographics, and OpenStreetMaps

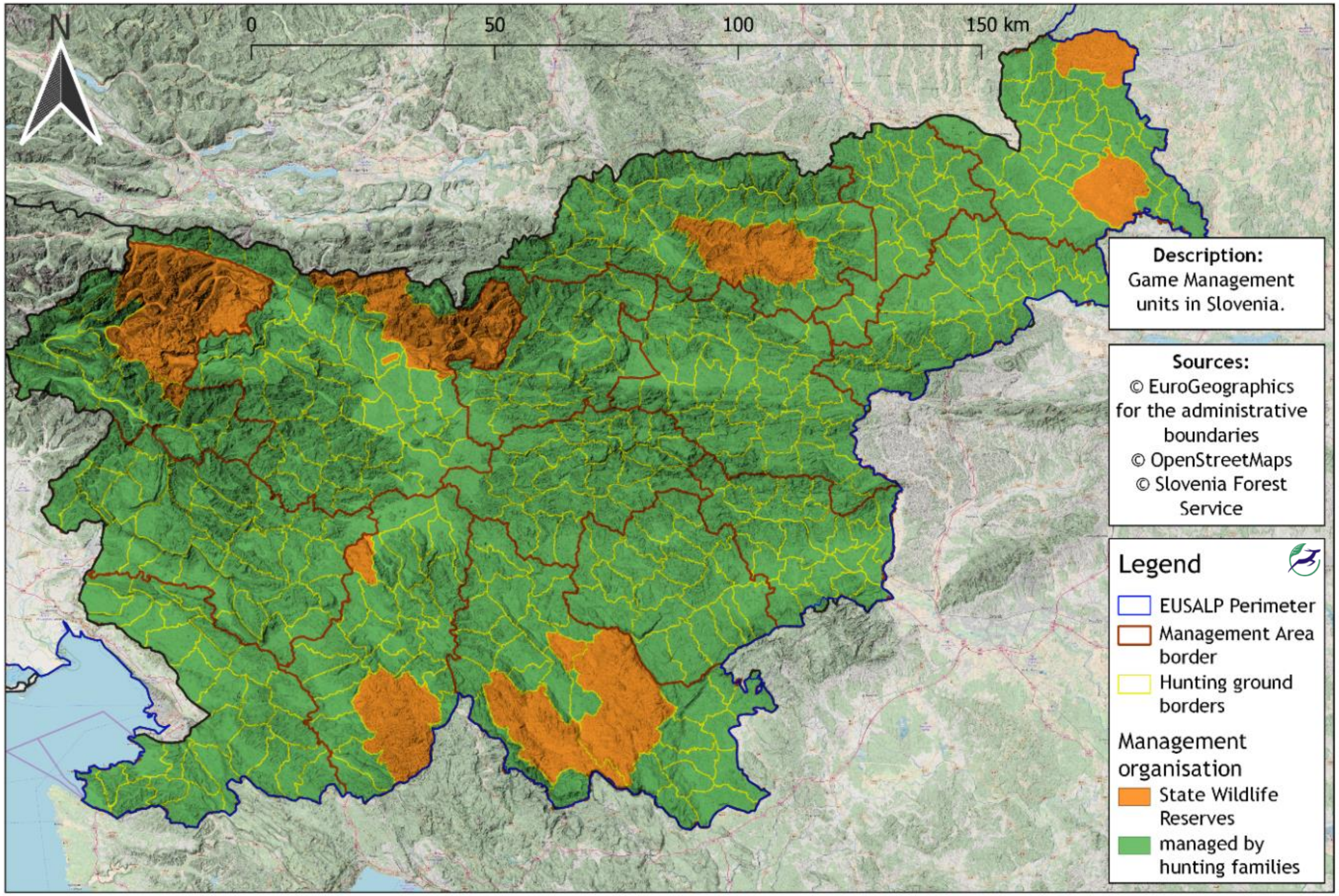

Figure 5 – Hunting management units in Slovenia. Division in Management Areas (dark red) lines, a subdivision in State Wildlife Reserves (orange), and areas managed by hunting families (green). The yellow lines show the hunting unit borders based on data by Slovenian Forest service, EuroGeographics, and OpenStreetMaps

5 Hunting licenses

Every country in the EUSALP has established hunting licenses to control the number of hunters and to ensure the hunters meet at least a set of minimum requirements, which are the knowledge of and compliance with safety regulations and the handling of firearms.

This hunters' education ranges from easy tests to more difficult ones, such as the German hunting exam, which requires a minimum of 120 hours (50/50% theory/practice) and includes a written and oral exam and practical shooting demonstration with different firearm types (rifle, shotgun, handgun) on different sets of targets (roe deer, wild boar, fox, hare, pigeon) in different shooting positions (prone, standing, sitting).

In most countries, hunting license applicants must be at least 18 years old. Younger aspirants often can apply, when parents and administration approve (down to 15 years old in France). On the other hand, some cantons in Switzerland have a minimum age of 20+ years.

The lowest common denominators for topics in the hunting exams are:

- Knowledge about game biology, ecology, and identification of game animals
- Knowledge about hunting regulations and legislature
- Knowledge about firearms and ammunition law, handling and safety
- Practical examination of firearms handling and safety

Other topics which might be additionally tested in some countries:

- Dog keeping, dog breeds, training and use of hunting dogs, dog diseases
- Hunting management, gamekeeping (German: *Hege*)
- Hunting language and traditions
- Wildlife disease detection and handling, field dressing, and processing of game meat, hygiene regulations
- Terminologies of forestry and agriculture
- First Aid for hunting-related accidents

Hunting license courses cost an average of around 600 – 1500 Euros but be as much as a few thousand for crash courses.

The hunting permits and species tags (species license; license/permit to kill a certain number of animals) cost from a few hundred Euros up to ~14.000 Euros for a "Jagdpatent" for foreigners in Grisons, Switzerland. Additionally, hunting license renewals, government fees, and hunting insurance need to be considered as yearly costs for hunting.

6 Hunting management plans

In most of the countries, harvest plans need to be fixed for a one to 10-year period for all ungulate species (except wild boar), separated by sex and age class. These plans apply for the respective management unit (e.g., "district level" in Germany, Austria, and parts of Switzerland) to the "canton level" in license-based parts of Switzerland, department in France. In Austria, France, Germany, and Switzerland, hunting grounds or hunting management units are often organized in broader management units to manage ungulate species on a population level, particularly concerning red deer management. These management units are sometimes organized over administrative borders, e.g., in Switzerland, where some cantons have transboundary management units for red deer.

Hunting seasons are generally set on a national level as a framework and are then set on a lower, but still relatively high administrative level (large area extent), such as the level of state/province/canton/region. Only in Slovenia does the national hunting season apply to the whole country.

Austria/Germany: Annual harvest plans (minimum/maximum; sex and age class) by the property owner/hunter for all ungulate species (except wild boar). Option: define minimum cull in relation to observed damages/impact. For better efficiency, hunting grounds are often organized in collective management units (CMU), where all involved landowners issue the harvest plan as one. Estimates of population size, composition, and the status of the forest vegetation must serve as a basis for the preparation of the harvest plan, which then has to be signed by the regional authority. Hunting seasons are set on the province-level (only species mentioned in hunting law) and can be modified by district administrations to adapt to local requirements.

France: Each department must define regional wildlife policies and develop regional management plans for six years. The hunting management plans consist of actions concerning: hunting quotas, improving the safety of hunters and non-hunters, improving the management of target species (game releases, supplementary feeding), conservation and/or restoration of natural wildlife habitats, reaching a balance between hunting, farming and forestry interests. The FDC produces management plans on the department level in collaboration with the landowners, game managers, and hunters of the area. The plan then has to be validated by the prefect of the department. The hunting commission must fix a yearly quota per species on the department level advised by local administrations, hunters, farmers, foresters, conservationists, experts. They are fixed in relation to the economic value of forest in most areas and the population density. Each holder of the right to hunt can ask to be assigned an individual shooting plan. The department prefect has the final decision. The harvest is controlled by tags, which must be attached to the hind leg of the animal before transport. The price for the tags is defined at the national level for every species, but each FDC can additionally increase the cost for the tag for compensation of wildlife damages.

Italy: Harvest management plans are mandatory for cervids and bovids and must be prepared by the ATC, CA, or municipal reserve authorities to the level of the smallest hunting district (per species, sex and age class). The plans have to be approved by the provincial government. Every hunter applying for a license to hunt is allocated a specific number of animals from this plan. Harvest plans for wild boar are not mandatory, and, if present, the hunters get an overall number to cull. Hunting seasons are generally fixed in the national hunting law 157/92 and set to three months for wild boar (October to January) and two months for all other ungulates (can be set variably and separately; usually October to November). The actual seasons are set on a provincial or regional level. Exceptions are present in the eastern Alps, where longer hunting seasons exist. Autonomous regions and provinces can lengthen the hunting seasons over the limits set by the national law.

Slovenia: Wildlife management plans must be prepared by the District Wildlife Officers of the SFS for 10 years for each WMA. Management plans for hunting units, which include harvest quotas, habitat improvements, etc. are prepared in collaboration with the hunters' families and the SFS every year. Hunting periods are fixed in the "Law on Wildlife and Hunting" (2004), but special permissions for extended hunting seasons in areas of high damages to agricultural crops or forest stands are regularly issued by the Slovenian Ministry of Agriculture and Forestry.

Switzerland: Annual management plans have to be prepared for all huntable species, in discussion with representatives from hunting, forestry, agriculture, communities, nature conservation, and animal welfare. Minimum requirements for shooting plans: culling quotas must correspond at least to the annual growth rate of a population, a minimum of 25% must be kids/calves of yearlings, the sex ratio at least 1:1 (or female-biased). Hunting statistics are reported centrally to the BAFU.

7 Hunting seasons

As part of their hunting legislature, each respective responsible administrative level establishes their hunting seasons for each huntable wildlife species on a national or regional level. In Switzerland, for example, the Federal Office for the Environment in Bern (BAFU) sets the time frames for game species during which hunting them is prohibited. The cantons themselves have the authority to extend this protection period via regulations but not to shorten them. In Austria, the hunting seasons are solely the responsibility of the provinces (German: *Länder*), as there is no federal hunting law. The implementation of hunting seasons is an important responsibility of wildlife management agencies, as state or regional characteristics might demand different requirements adapted to wildlife population levels or wildlife damage situations.

It is worth mentioning here that hunting interest groups, of course, have a considerable influence on the setting of hunting seasons. Hunters have valuable knowledge of their areas and local peculiarities since spatial and temporal behavior of some species can be quite dynamic. On the other side, they also have a direct self-interest in the extension of hunting seasons and are represented by a strong lobby in nearly every country with representatives from diverse backgrounds but also often situated in politics and industries.

The seasons often differ greatly between bordering administrative regions, not only in the total sum of hunting days but also in the frequency of how often the hunting season alters between these regions (i.e., when hunting is allowed on one side of the border and forbidden on the other side). These differences are one of the most striking aspects varying between the hunting systems, as the hunting season lengths in license-based systems are generally only a few weeks while they last many months in district-based hunting systems. At best, the hunting seasons are set to avoid important seasonal events of the species, such as breeding seasons, birthing seasons, and resting periods during winter months. In reality, hunting seasons are often set especially to include these aggregation events of most species, as they are then the easiest to find. Depending on the management goals and hunting system type, different overlapping or separately standing hunting seasons are assigned to different age and sex classes of a species. This is mostly the case in district-based hunting systems, where an ideology of selective hunting is still strongly present. In license-based hunting systems, hunting seasons are generally considerably shorter than in district-based hunting systems (For instance red deer hunting seasons: license-based: mean 40 days, median 24 days; district-based: mean 187 days, median 213 days; see Figure 6 for comparison of hunting systems, and Figure 7 for a detailed view of hunting seasons for red deer).

Environmental factors also limit the determination of hunting seasons. Hunting during wintertime in montane/subalpine areas over 1500 m ASL can be detrimental to the ungulates residing there, when snow levels, harsh climate, and food shortage already constrain the animals. These animals are adapted to the conditions and react with physiological changes, e.g., reducing their metabolic rate and shrinking of digestive organs. Flushing them during this time can be life-threatening, as they will then unduly increase their energy consumption.

Management requirements and objectives, such as the control of overabundant species, impacts on agriculture and forestry, or the support and sustaining of recreational hunting, need to be reflected in the hunting seasons. For this, accurate information about rutting seasons, parturition, effects of hunting on locally occurring non-target species, actual time hunters spend in the field, and social traditions. Especially concerning the effects of social traditions on hunting practices: scientifically sound hunting practices should be favored (Apollonio *et al.* 2011).

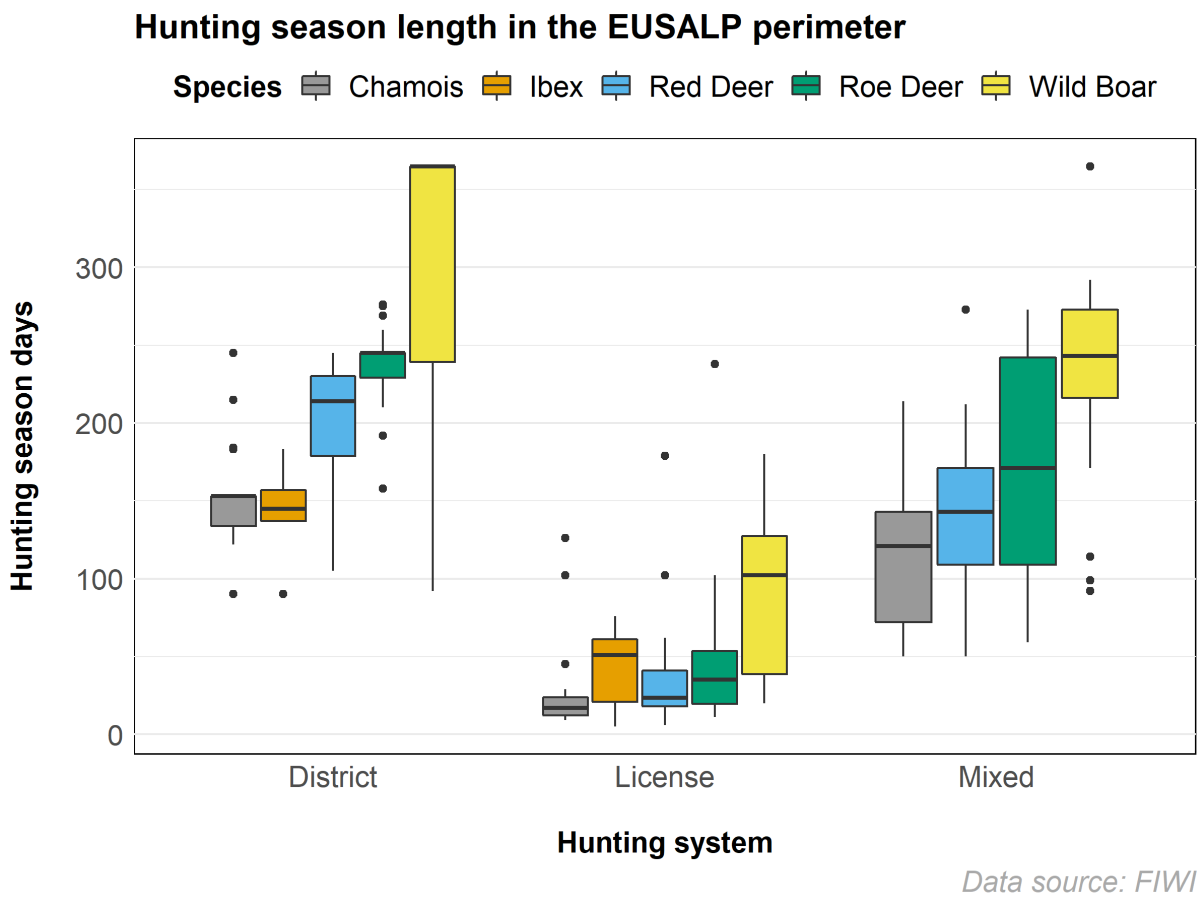

Figure 6 – Sum of hunting season days of chamois, ibex, red deer, roe deer and wild boar; grouped by hunting system

Figure 7 – Hunting seasons for red deer in the EUSALP countries/respective administrative regions

7.1 Hunting season mapping

Hunting season data were collected for all areas within the EUSALP perimeter from legal texts or webpages of the appropriate government agencies or hunting associations in the respective regions. As hunting season start and end dates vary between the regions, dates were reduced to “day of the year” to enable comparability. The regional information was intersected with the national administration layer (EuroGlobalMap).

The **hunting season** layers show for every day of the year where hunting of the respective species is allowed or not. The “No hunting season” part of the layer includes days when hunting is discontinued during the hunting season due to special regulations, e.g., where certain weekdays or official holidays prohibit hunting. The layers also show if the particular species are not explicitly mentioned in the respective hunting regulations for the region and where data on the hunting season is still missing/incomplete. As there is one layer for 365 days per year for eight species, the layers were not included in this document, but can be accessed on www.jecami.eu.

The **number of hunting days** layers show the sum of hunting days for the respective species on the level of the administrative region (see Figure 8 showing red deer as an example; the other species can be found in Appendix I).

The **hunting season differences** layers visualize on how many days no-hunting and hunting differ between bordering regions. The thickness of the line represents the number of days that differ between the regions (The sum of days where there is hunting season in one of the bordering countries and at the same days no hunting season in the other country) (see Figure 9 showing red deer as an example; the other species can be found in Appendix II).

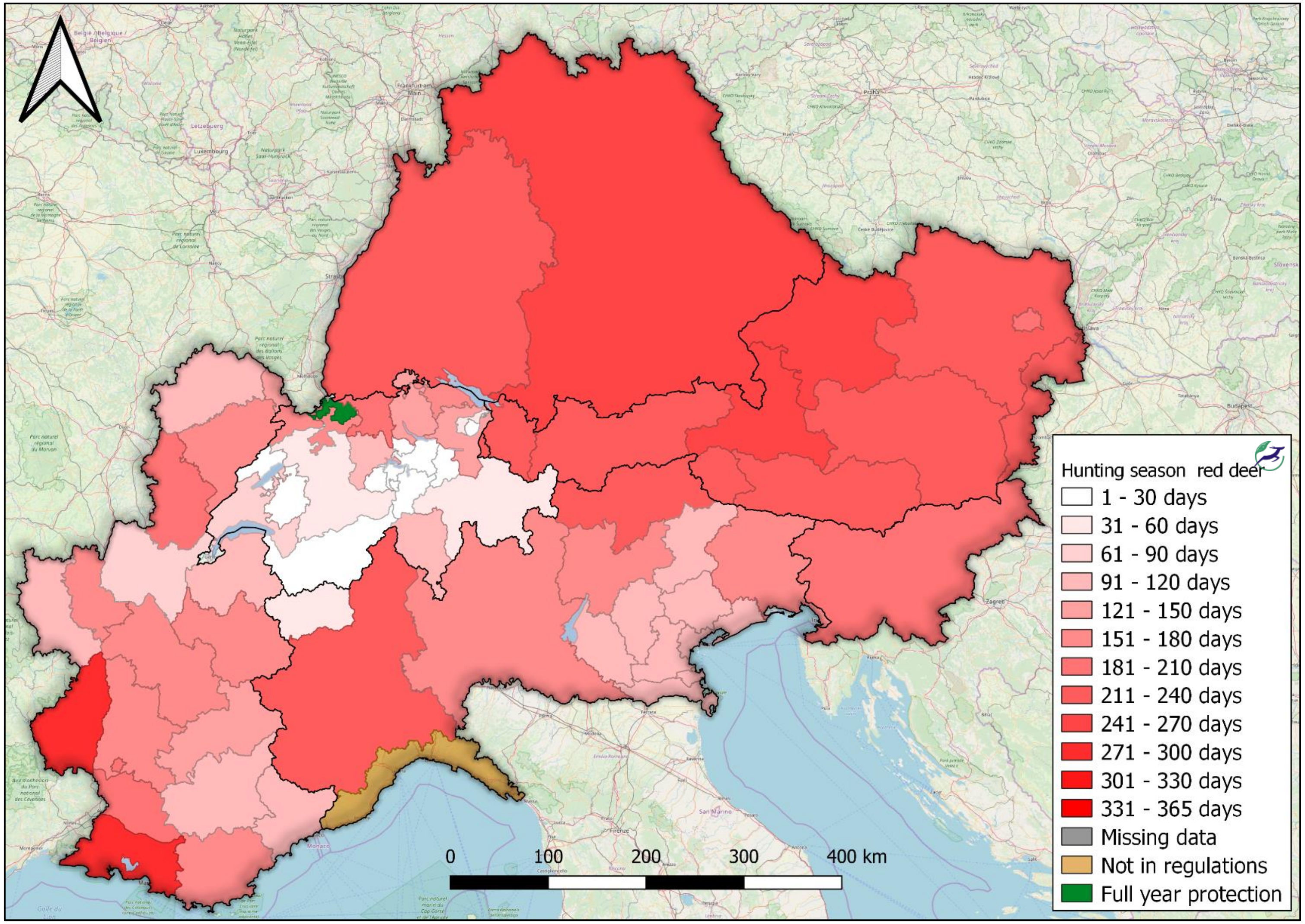

Figure 8 – Sum of hunting season days for red deer from 1 – 365 days; Missing data in grey; Species not in hunting regulations in Yellow; Region where species is under full year protection in green. Data by EuroGeographics, and OpenStreetMaps

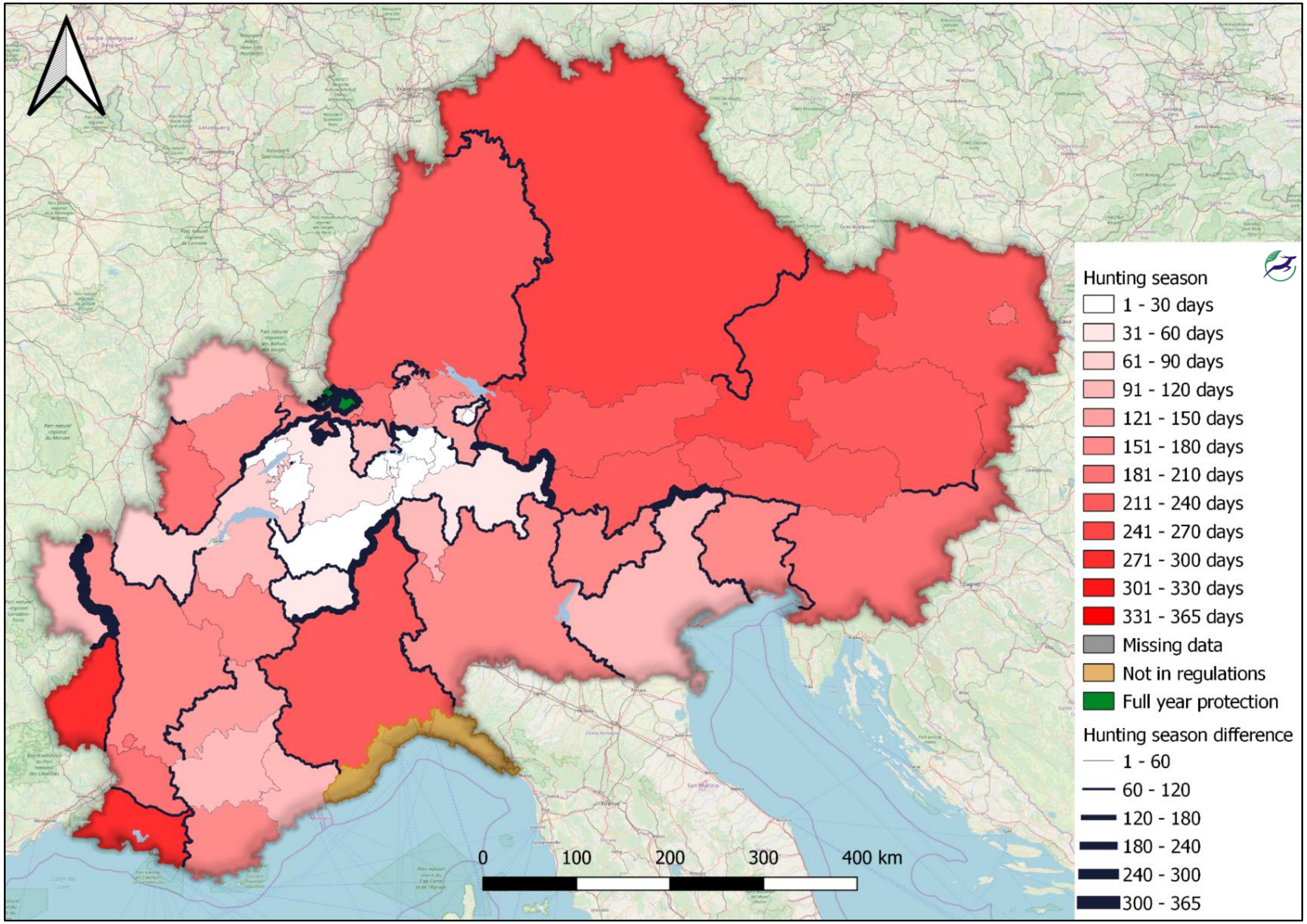

Figure 9 - Sum of hunting season days for red deer from 1 – 365 days; Missing data in grey; Species not in hunting regulations in Yellow; Region where species is under full year protection in green. Sum of days where hunting season differs between bordering regions are represented by the thickness of the black line. Data by EuroGeographics, and OpenStreetMaps

8 Monitoring

Management objectives differ between countries, and management goals are mostly related to stakeholders such as forestry, agriculture, and transportation. For most countries, the main objective of wildlife management is the prevention damage to forests and agriculture crops (Austria, Germany) by wildlife. Here, a strong focus is on the management of forests and agricultural pastures. Other countries, such as France and Switzerland, formulate their management objectives and legislative framework to support sustainable use of natural resources while also accounting for the use interests of other stakeholders (Morellet *et al.* 2011).

To ensure habitat-related species management, knowledge about the development of wildlife populations needs to be gathered as precisely as possible. The number of animals, sex and age structure, population growth rate, as well as offspring development, all constitute import information to consider in determining harvest plans and habitat measures. As counting wildlife is difficult and costly, and populations can usually only be estimated, since various causes may distort the data, indicators such as the status of natural rejuvenation, fraying, or browsing damages can be used to assess population trends. When monitoring populations, it is crucial to use the same method over an extended period of time in order to obtain comparable data. In relative terms, this makes it possible to identify developing trends. Most countries do not have scientifically based or systematic census method(s) to monitor ungulate population sizes. Generally, hunting bags of the previous years, in combination with assumptions regarding the sex ratio, population growth rate, and offspring mortality, are used to calculate population sizes.

In most cases, monitoring is undertaken to survey the extent of wildlife damages. Some countries employ a nationwide monitoring program of browsing and debarking intensities in forests to determine areas with high population levels of red deer, roe deer, and (forest) chamois. Pellet counts, track counts, and IR photography by helicopter might be used on a local level, but these are not the norm.

As the ungulate populations in Europe are under no extinction threat from over-hunting, the extent to how intensively these species need to be monitored appears to be debatable. However, to meet management objectives that exceed the minimum requirement of a simple population trend analysis, a set of different census methods should be combined and applied over several years. The indicators then need to be reviewed and tested to determine whether defined goals were achieved. The variety of habitats utilized by ungulates prevents the use of a single census to monitor populations uniformly. Furthermore, the use of any method is limited by the amount of effort that is affordable in terms of costs and personnel. There are some census methods available (see Table 2 and Table 3), and a detailed description for this comprehensive list can be found among others in “The census and management of populations of ungulates in Europe” by Morellet *et al.* (2011) in “Ungulate management in Europe: Problems and practices” (Putman *et al.* 2011).

Census method/techniques	Advantages	Drawbacks
Faecal accumulation rate	– low disturbance on population	– no measure of accuracy and variable precision

Census method/techniques	Advantages	Drawbacks
	– adapted in all habitat types	– no measure of detection probability
		– requires estimation of the defecation rate
		– risk of confusion between species
		– low cost-effectiveness
		– the method assumes a stable relationship between the amount of dung present and the number of animals
Faecal standing crop	– low disturbance of population	– no measure of accuracy and variable precision
	– adapted in all habitat types	– no measure of detection probability
		– requires estimation of the defecation rate
		– risk of confusion between species
		– low cost-effectiveness
		– the method assumes a stable relationship between the amount of dung present and the number of animals
		– requires estimation of the decay rate (variable between habitat and meteorological condition)
Snow track counts	– low disturbance of population	– no measure of accuracy and variable precision
	– adapted in all habitat types during periods of snowfall	– no measure of detection probability
		– requires sufficient snow conditions or soft ground
		– easily applied method – risk of confusion between species – depending on method, requires an estimation of animal daily travel distance – low cost-effectiveness
Cohort analysis		– to calculate the population size in any past year, data need to cover a period extending beyond the lifespan of animals born in that year; this requirement is problematic in large ungulates because of their long lifespan
		– variations in age structure from harvested animals are notoriously difficult to interpret, and can provide very misleading results without independent data on birth and mortality rates
Vocalisation of animals		– no measure of accuracy and variable precision

Census method/techniques	Advantages	Drawbacks
		– risk of double counting but also:
		– risk of underestimation with increasing density
Hunter/gamekeeper observations	– cost effective	– no measure of accuracy and precision
		– shown to severely underestimate number of animals
Strip transect/line transect from airplane or helicopter	– large areas observed	– no measure of accuracy and variable precision
	– little disturbance on population	– no measure of detection probability for strip transect
	– cost-effective	– risk of underestimation in closed habitat
Capture–mark–recapture from air	– large areas observed	– no measure of accuracy and variable precision
	– improvement of accuracy	– risk of large underestimation
	– a measure of detection probability	– requires marked animals well distributed at the scale of the study of interest
		– low cost-effectiveness
		– high disturbance on population during marking
		– not suitable in closed habitat
Capture–mark–recapture from ground	– best method to estimate population size in terms of accuracy and precision	– low cost-effectiveness
	– a measure of detection probability	– high disturbance on population during marking (and eventually during remarking if there is no re-sighting)
	– possibility to estimate some parameters of the population dynamic	
	– well adapted in all habitats	
Counts in open areas/artificial feeding places	– often cost effective	– no measure of accuracy and precision
Vantage point counts		– sampling error may be large
		– greatly affected by vegetation type
Drive counts		– increasing rate of underestimation with increasing population density
		– sampling error affected by beater skill and numbers

Table 2 – Census methods used by wildlife managers in Europe with the purpose to attain absolute and relative ungulate densities (Reprinted from Morellet et al. (2011), "The census and management of populations of ungulates in Europe", p.113-115)

Census methods	Advantages	Drawbacks
Track counts on bare ground		– can only be used for estimating presence or absence of animals
Observation of marks		– can only be used for estimating presence or absence of animals
Wildlife triangle scheme		– unknown accuracy and precision during winter
Spotlighting		– the assumption of full detectability seems unrealistic
Line transect counts	– can catch trends of animal variation over time on a specific study area	– the irrelevance of the absolute value (preventing comparison between different sites)
	– low cost-effectiveness	– the absolute necessity to respect standardized protocols
Deer observation monitoring	– well suited for solitary animals	– not well suited for herd species
	– active involvement of hunters	

Table 3 – Census methods used by wildlife managers in Europe to attain relative densities of ungulates (Reprinted from Morellet et al. (2011), "The census and management of populations of ungulates in Europe", p.116)

9 Species distribution mapping

One of the objectives of the project was to collect data regarding and assess the distribution of five ungulate species (Chamois (*Rupicapra rupicapra*), Ibex (Capra ibex), Roe Deer (*Capreolus capreolus*), Red Deer (*Cervus elaphus*), Wild boar (*Sus scrofa*)), and two species of the Tetraoninae subfamily (Black grouse (*Lyrurus tetrix*), Capercaillie (*Tetrao urogallus*)) and the European hare (*Lepus europaeus*).

Species distribution data were collected from appropriate state agencies and (hunting) organizations. As there is no consistent methodology nor legal requirement in the different countries on how species distribution is mapped, the available distribution data differed greatly. Some regions provided distribution data (e.g. France), some provided habitat distribution data (e.g. South Tyrol), and in some regions data on the species distribution was not available or was not collected (see Table 4). Geodata on species distribution for hare, black grouse and capercaillie were nearly never provided or if they were it was with very low resolution. Most authorities are reluctant to share spatial information about capercaillie and black grouse distribution out of fear that this information could be used to harass and disturb the animals at the localities. The distribution for these species was not mapped further.

The complete list of datasets used for the distribution layers of the different species is provided in Appendix III. As some datasets overlapped, the applied dataset was indicated in the column "Country / Region applied" as country/region code or as "<<" when the original extent of the dataset was used.

Species absence was derived from layers of urban areas for the countries and some species, elevation data was used to exclude areas where distribution is unlikely (conservative assessment). If used, the elevation parameter can also be found in Appendix III.

The respective layers were imported into a PostgreSQL database and processed using the spatial extension PostGIS.

The distribution data was patched together from different sources: (fine to coarse)

1. Distribution data
2. Species habitat data
3. Hunting bag data (quality differs)
4. IUCN distribution data (intersected with NUTS community data)

When distribution or habitat data were not available, an approximate distribution derived from hunting bag data (years 2008 – 2018, depending on availability) was used by intersecting hunting bag data with the NUTS community layer. When no other data were available, either an intersect of the NUTS community layer with the IUCN red deer distribution layer was used, or, in case the IUCN distribution layer overlapped the NUTS layer, the NUTS community layer was used as-is. The layers were simplified to 10m, validated, dissolved and intersected with the National Administrations layer (EuroGlobalMap). Occurring Spatial gaps occurring due to varying scales and spatial precision of the input layers were manually cleaned in (QGIS Development Team 2019). The distribution layer was then clipped with settlement data, where the distribution of the species can be ruled out with relative certainty.

Species	Distribution	Distribution grid	Habitat	Hunting bag	IUCN data
Chamois	France, Haute-Savoie(FR), Liechtenstein	Italy	Tyrol(AT), Haute-Savoie(FR)	Slovenia	Austria, Germany, Switzerland
Ibex	Switzerland, France, Haute-Savoie(FR), South-Tyrol(IT), Liechtenstein	Italy	Tyrol(AT)	Slovenia	Austria, Switzerland, Germany
Red deer	France, Liechtenstein	Italy	Tyrol, Germany, South-Tyrol(IT)	Austria, Switzerland, Slovenia	
Roe deer	Liechtenstein	Italy	South-Tyrol(IT)	Austria, Slovenia, Switzerland, Baden-Wuerttemberg(DE)	Bavaria(DE), France
Wild boar	Italy			Austria, Switzerland, Slovenia	Germany, France

Table 4 – Species distribution data types received from agencies/associations for the respective region. IUCN geodata was used in case the requested data was not made available or is generally not collected by the respective agencies

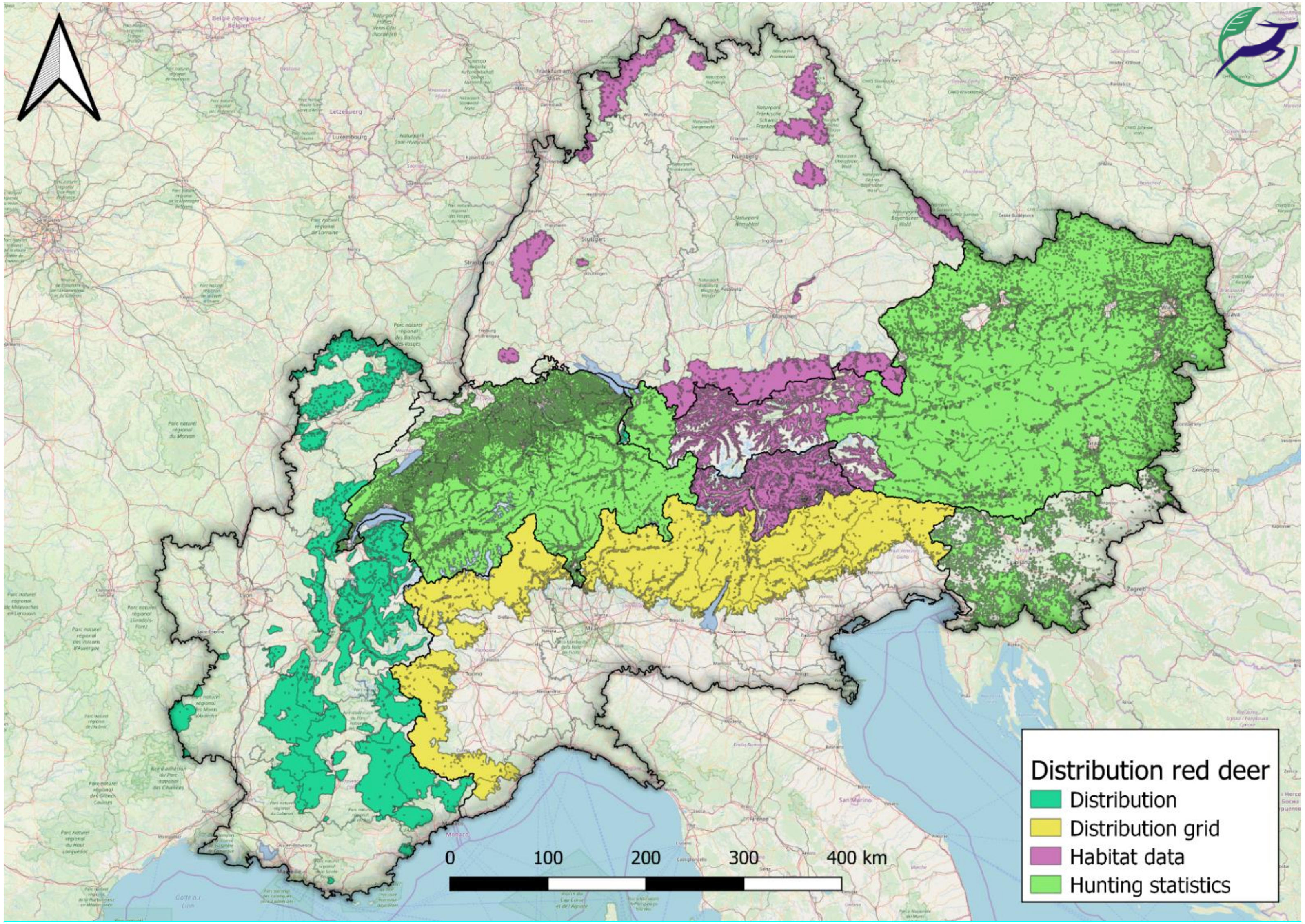

Figure 10 – Distribution data received from the respective wildlife agencies and hunting associations. For data sources see Appendix III

10 Effects of hunting activities on wildlife behavior

Hunting and other hunting-related activities can directly influence spatial and temporal behavior, physiology, and energy use of ungulates. Some hunting practices can exert considerably more stress on wild animals than others. Especially when hunting with dogs or during chases, stress is not only exerted on the hunted animals but also other individuals (Grignolio *et al.* 2011). In a study on the effects of hunting on wild boar, Thurfjell *et al.* (2013) reported that different hunting methods/types had different effects on wild boar movement, with hunting activities targeting other species (pheasants, ducks) influencing wild boar habitat use and flight distance on the day of the hunt and also on the following day.

The use of off-road vehicles, such as SUVs, quads and snowmobiles, has not only increased the range hunters can utilize but also introduced an element of additional disruption of habitats. Additionally, modern firearms extend the effective shooting range and modern hunting accessories enable the hunter to extend the shooting time beyond dawn and dusk (even though often forbidden). As ungulate populations and the pressure of forestry objectives increase, new areas are continually accessed for hunting (Pfefferle 2012).

The (in)visibility of most ungulates in our landscapes is a direct result of the extent of the pressure exerted on the animals by humans. Roe deer and red deer have become shier and more reclusive through hunting and related activities (Sandfort 2016). Bold behavior of animals is being punished in the context of hunting, as increased movement rates (explorative behavior) and use of open areas lead to being shot. These behavioral traits can be attributed to personality traits (being bold vs. being shy) or adaptation to predictable human activity (or both).

Thurfjell *et al.* (2017) reported behavioral plasticity in female red deer providing evidence that the underlying processes were additive (a sign of a learned behavior). Females older than 9-10 years became almost un-huntable due to adaptations to hunting pressure. The animals also showed different adaptation behavior to either rifle or to bowhunters, which further affirmed their results. In another study, surviving male red deer of the previous hunting season shifted their habitat-use to areas with denser vegetation (Lone *et al.* 2015). The increase in human activity and the presence of hunting dogs and other cues during this time might have triggered these behavioral changes.

These adaptations appear to be reversible (at least to a certain extent). Pfefferle (2012), a professional hunter from Oberallgäu, Bavaria, Germany, demonstrated in his hunting area that changes in hunting regimes can cause game animals to become visible again, where previously they could only be seen almost solely during dawn or dusk, potentially increasing the efficiency of hunting measures.

10.1 Hunting during breeding and juvenile dependency

Apollonio *et al.* (2011) summarized some of the impacts of hunting on species reproductive behavior: Hunting during the rutting period may disrupt reproductive aggregations of some ungulates, which can lead to conception failures, increase the chance of mating by inferior males, and alter the synchronization of births. The latter can have direct effects on overwinter mortality in younglings, but also may affect migration behavior in animals that migrate in groups by delaying migration onsets.

Disruptions during mating, e.g., the removal of a leading male, can also lead to females forgoing mating for the season and temporary/long-term abandonment of a traditional breeding place. Loss of knowledge of these places would mean a reduction in mating opportunities. Short-term consequences of disruptions by hunters could be changes in the day/night cycle. The breeding activity could be pushed into night-time or dawn/dusk. As time windows are a critical component in polygynous species (estrus period of only 36-48 hours), missing the cycle will prevent reproduction.

Hunting females during offspring dependency is generally forbidden in all countries within the EUSALP perimeter. Some exceptions apply, where hunters are obliged to shoot the young before the female, in order to be allowed to shoot the female. However, this is problematic when the hunter does not know that the young is a dependent juvenile if the mother does not accompany it. This is often the case after birth, where the mothers of almost all species may not accompany their newborns; this is all the more true for species such as fallow deer or roe deer, whose young are not "followers" but "hunters". In these cases, the culling of adult females can lead to the orphaning of dependent offspring (Apollonio *et al.* 2011).

10.2 Effects of hunting on wildlife genetics

The effect of wildlife harvesting/hunting by humans and the evolutionary consequences on phenotypic traits are general concerns for wildlife managers. The strong bias of selective hunting might lead to undesirable effects causing a decline in trophy traits (Harris *et al.* 2002; Allendorf *et al.* 2008; Allendorf and Hard 2009; Mysterud and Bischof 2010). The evidence for the effects of hunting on the genetics of game species is still circumstantial. Multiple factors affect harvest selectivity. Spatial isolation and small population sizes can lead to inbreeding depressions (Zachos *et al.* 2007; Reiner and Willems 2019). The potential genetic consequences of hunting include alteration of population structure, loss of genetic variation, and evolution resulting from selective hunting practices (Harris *et al.* 2002; Allendorf *et al.* 2008; Allendorf and Hard 2009). The extent to which these effects are present, however, is being debated, and therefore, managers should consider keeping population structures close to “natural” (higher utilization of immature individuals) (Mysterud 2011).

An important aspect to consider: Contrary to breeding of cattle in agricultural/farm environments, selection by hunters often removes the most desirable animal from the gene pool.

The effect of selective hunting might depend on various factors:

1) Hunter preferences

2) Opportunities to be selective via

- management regulations (quotas; economic costs, etc.)
- hunting methods (stalking vs. drives, etc.)
- animal trait variation (strength of hunter cues, appearance)
- animal behavior
- animal abundance

▪ population structure (sex ratio and age structure)
▪ habitat openness

(Taken from Mysterud (2011))

In most German federal states, the distribution of red deer is only permitted in officially defined areas (see Figure 11). Outside these areas, the shooting of red deer is mostly mandatory. This situation is, of course, not a direct effect of hunting per se but a result of the German forestry policies of the 1950s. The argument here is the preventive avoidance of game damage. In Bavaria, 14% of the land area is allocated to red deer; in Baden-Württemberg, it is only 4% (https://www.rothirsch.org//). In Austria, one-quarter of the Styrian province area is determined as “red deer-free zones”. In Carinthia (AT), areas in which intensive agriculture is practiced are designated as such.

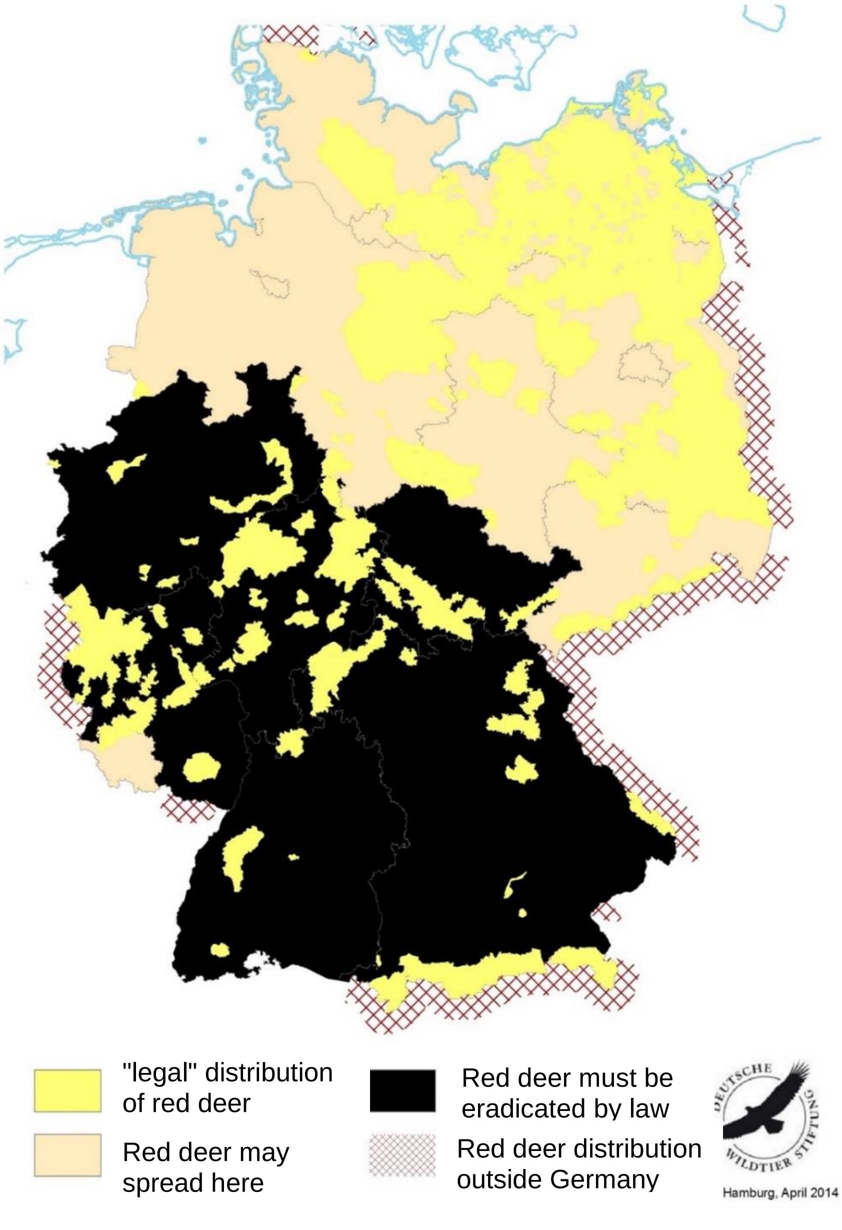

Figure 11 – Red deer exclusion zones in Germany. In yellow, areas where red deer are “allowed” to exist; in black, areas where red deer has to be eradicated; in cream, areas where red deer are allowed to spread; in red checking, areas where red deer occurs outside the border area

10.3 Supplementary/Diversionary feeding

Supplementary feeding is a highly discussed topic amongst the parties involved in wildlife/hunting management, as the intentions and respective outcomes vary substantially. Publicly, supplementary feeding is often seen as a method to bind desired game animals to an area and prevent them from migrating to areas of other hunters, or as a way for hunters to artificially increase population densities of the target species.

While elements of this might be true in some instances, artificial feeding is mostly performed to mitigate the effects existing barriers in the landscape have on wildlife populations, such as the resulting disruption in seasonal migration possibilities and to prevent damages to forest or agricultural structures by the target species (Völk *et al.* 2003).

However, the definition of "damage" is subjective and should not be applied too eagerly when evaluating the influence ungulates have on the vegetation. Wildlife impact/influence should only be identified as "damages" when it has extreme consequences for management objectives or other human interests. Natural or managed communities may benefit from browsing, grazing, trampling or rooting by wildlife but may also potentially suffer damage from them. The decline in population density due to increased hunting in response to perceived damages could have even more adverse effects (Reimoser and Putman 2011).

Although supplementary/diversionary feeding can be an effective tool to steer habitat selection in red deer (Putman and Staines 2004; Luccarini *et al.* 2006; Arnold *et al.* 2018), the effectiveness of feeding to deter damages seems questionable (Geisser *et al.* 2004; Kubasiewicz *et al.* 2016).

Impact of ungulates on their environment:

- Changes in species composition
- Expansion of species tolerant to defoliation
- Decline/increase in species diversity
- Decline/increase in species abundance
- Changes of structure without change in diversity or abundance
- Impact depends strongly on the initial situation at the time of disturbance
- Prolonged impacts can have profound effect on ecological communities

(Reimoser and Putman 2011)

Supplementary feeding can alter animal behavior, as shown for roe deer, and should be evaluated in light of climate change, as better habitat conditions might reduce the need to feed. Roe deer home ranges are drastically reduced by supplementary feeding, as the high energy requirements in winter can be satisfied in a smaller area. This can lead to a lack of seasonal variation in home range usage, as the natural selection of feeding places by the animals is prevented (Ossi *et al.* 2017).

Moreover, as many ungulates reduce their digestive organ sizes and reduce their metabolic rate during winter when food resources are scarce, feeding can have unintended repercussions for the animals and also the habitat. Studies at FIWI on red deer have shown that fasting periods during winter delayed the doubling of metabolic intensity during spring, (using heart rate as a proxy measurement) and the concomitant dietary needs (Arnold *et al.* 2015). If the winter food shortage does not exist because intensive feeding is legally required, not only is the reduction in metabolic activity lower, but the nutritional needs also begin to increase earlier in spring - in the worst case, even before the natural vegetation begins to grow. In order to avoid damage to the forest vegetation, if feeding takes place at all, it is important to feed the animals as long as possible until enough natural forage is available.

10.4 Veterinary outlook on feeding practices

As wildlife habitats are under pressure from various anthropogenic influences, habitat loss, fragmentation, human activity, and climate change, the knowledge of the implications of all factors affecting the connectivity of wildlife populations becomes ever more critical. Knowing the spatial behavior of species becomes especially essential where wildlife diseases become more prevalent, such as a recent outbreak of African Swine Fever (ASF) in the Czech Republic (AGES 2018) or in cases where new diseases emerge, such as Chronic Wasting Disease (CWD) in Scandinavia (Benestad *et al.* 2016). These diseases can have severe impacts on affected wildlife populations but also constitute a severe risk for human livestock.

In the case of red deer, connectivity between populations can become a double-edged sword, as red deer are a major reservoir of TBC (bovine tuberculosis) and often share their habitat with cattle species. In Vorarlberg and especially Tyrol (Austria), TBC is widespread (Fink *et al.* 2015), and it represents the largest (known) TBC reservoir in the Alpine Space. Feeding practices that aggregate large numbers of animals are especially high-risk factors for the spread of infections. In the case of disease situations like this, it is vital to know the impact hunting activities have on migration behavior to adapt hunting management accordingly.

Several factors need to be understood to assess the risk of a disease spreading across a landscape, such as pathogen characteristics, transmission frequency within and between patches where susceptible host populations are present, and the frequency of dispersals. So, for example, enhancing connectivity in the Alps from Austria westwards might accelerate the spatial spread of TBC. Linked host-pathogen-landscape model development is needed to understand how landscape changes may affect wildlife location, density, and pathogen distribution (Walzer 2016). Minimizing disturbance and hunting pressure in disease-prone areas may reduce the risk of spreading the disease into other populations. On the other hand, the situation might require a drastic reduction of the population, and thus, the applied hunting methods need to be evaluated according to their effectiveness (Apollonio *et al.* 2017).

Sufficient scientific literature exists to conclude that supplementary feeding/baiting can potentially negatively impact species health. Feeding areas represent a non-natural arena for disease transmissions. Thus, managers should consider the implementation of disease surveillance of the population besides implementing other measures to limit disease transmission and spread. Usually, the intended aim of supplementary feeding is the enhancement of body condition. In theory, animals should be better able to combat diseases. The aggregation of dozens of animals in a relatively small area, however, facilitates disease transmission directly and indirectly. Other factors, such as the densities at feeding/baiting stations and the surrounding natural habitat also affect the transmission risk (Sorensen *et al.* 2014).

Major diseases whose transmission is potentially affected by supplemental feeding

Chronic Wasting Disease (CWD) – deadly to cervids

Naturally occurring transmissible spongiform encephalopathy (TSE) of native North American deer (*Odocoileus spp.*) and Rocky Mountain elk (*Cervus elaphus nelsoni*). The causative agent has been definitively identified.

Fatal neurodegenerative process:

- Changes in movement and behavior
- Progressive loss of body condition
- Sole TSE that is transmitted horizontally
- Detected in Scandinavia

(Miller *et al.* 2000; Benestad *et al.* 2016)

African Swine Fever (ASF)

Domestic and wild *Sus scrofa* are susceptible. Ticks are the only known arthropod hosts that act as reservoir and vector.

Peracute form: Sudden death with few signs

Acute form: Death within 6-13 days; often up to 100 % mortality rate in domestic swine

Subacute form: Death within 15-45 days; Lower mortality rate (30-70%)

Chronic form: Develops over 2-5 months (low mortality)

(OIE 2019)

Bovine Tuberculosis (BTB)

Chronic bacterial disease caused by *Mycobacterium bovis*. Closely related to human and avian tuberculosis (broad host range). Humans are susceptible to BTB.

Prolonged course of disease:

- Weakness, loss of appetite, weight-loss
- Fluctuating fever
- Intermittent hacking cough
- Diarrhea
- Large prominent lymph nodes
- Can be dormant
- Mortality rate varies form (10-100%)

(OIE 2013)

Giant liver fluke (*Fascioloides magna*)

The giant liver fluke was introduced from North America to European red deer by imported North American wapiti (*Cervus canadensis*). Cattle and sheep are also susceptible to the fluke.

- Complex life cycle
- Subclinical course of infection
- High infestation can lead to emaciation
- Severe liver damages can lead to death of the host
- roe deer, chamois and moufflon can be false hosts

(Novobilský *et al.* 2007; Obermayer 2016)

10.5 Effects of hunting on ecological connectivity

Migration is an important mechanism for many species in their yearly cycle. For some species, it is necessary to migrate due to seasonal resource variation in their habitat. Depending on the species, regional characteristics, and habitat, different migration behaviors are expressed. Generally, the long-distance migration of traditionally migratory species is becoming less and less viable, as our cultural landscape disturbs the migration paths with artificial barriers (Harris *et al.* 2009).

As presented in the preceding chapters, the presence of hunters can influence the spatial and temporal behavior of wildlife in various ways. Red deer under hunting pressure shifts migratory activities into the night, and further disruption of stopovers during migration might prevent or hamper migration movement entirely (Paton *et al.* 2017). As migration patterns are culturally transmitted, the removal of individuals with knowledge about these migration routes can disrupt the persistence of this behavior in the population/group (Jesmer *et al.* 2018). Hunting at wildlife passages during migration periods would, of course, have an ultimate disrupting effect on the migratory behavior of the animals.

In only a few studies was hunting reported to influence the migratory behavior of (mainly) red deer. As far as the direct influence of hunting on migration is concerned, the effect appeared to be increased migration behavior. The beginning of the hunting season can act as a "signal" for migrating red deer. Rivrud *et al.* (2016) found the onset of hunting to be an additional trigger for migration besides other cues such as snowfall, temperature, and plant phenology.

Peak migration border crossings of migratory deer also coincided with the hunting seasons in another study (Meisingset *et al.* 2017). Alternating hunting seasons between national/regional borders might provoke the movement of target species out of hunted areas into non-hunting areas and could result in a harvest loss for the affected hunting administrations.

11 Conclusions

Historically, wildlife management in Europe can basically be considered a success. There is more game than ever before. Our cultural landscapes tend to be able to accommodate unnaturally high densities of ungulates due to a fundamentally higher food supply. Border effects resulting from the mixture of forest and field are especially effective in providing good habitat conditions for many species. Additionally, many wildlife populations have been (and are still being) artificially increased by conservation and other measures. It is notable that the feeding practice, although forbidden or regulated in most countries, is too often abused, and excessive feeding is practiced.

However, contrary to the trends in wildlife populations, the number of hunters in Europe is decreasing on average (Massei et al. 2015). This poses major challenges for hunting, as growing game populations in many regions make it increasingly difficult to hunt. There are several reasons for this. Smaller and more isolated habitats, but also the increasing use of nature in many areas, lead to more contact between wildlife and humans and thus to increasing pressure on the animals. The animals react by changing their spatial and temporal habitat use. The animals become shyer, use denser habitats for cover, and often develop nocturnal activity patterns. Hunting has also played a role in influencing the age and social structures of the populations as well as their genetics.

The different factors and effects cannot be clearly separated, as they influence each other directly or indirectly. For example, the visibility of the animals in the forest or open land, as described in the previous chapters, is strongly influenced by hunting practices. A constant presence of hunters in the forest in combination with negligent hunting, e.g. establishing an association between the presence of hunters and lethal danger, creates selective pressure not only on the gender and age group composition but most likely also on the expression of personality types in the population. Bold animals are more likely to be shot than shy ones, as they are more likely to show themselves to the hunter. The personality type of the animals desired from the point of view of hunting management is removed from the gene pool, or this knowledge may be passed on from the shy animals to their offspring.

This becomes particularly clear when the wild animals reappear due to shortening the hunting periods or changing the hunting regime. There is a correlation between this behavior/change and hunting, but the underlying mechanisms have not yet been clearly elucidated. With such an intelligent species as red deer, one can certainly assume a learning effect behind the change in behavior. Personality differences may also play an important role. Old red deer cows are frequently reported to go into long-term hiding after losing their calf during the hunting season.

Reactions to hunting activities are also very variable, as not all species have the same life history, and other factors such as different environmental parameters and social structures influence personality and behavior. Animals in groups have different enemy avoidance or recognition strategies than solitary animals. Also, their flight distances differ.

11.1 So, what is the deal with the hunting systems?

The issue of hunting and its influence on other forms of land-use and wildlife is a complex subject that does not have any simple explanations or standard solutions. A precise analysis of the land-use conflicts and differing objectives in the region is necessary to formulate clear recommendations. Regarding the differences already present in animals: There are deer that migrate to lowlands before winter. In other areas, red deer migration leads into the mountains. This alone shows that a simple solution for a management concept is not easy

Although hunting systems differ in certain aspects (hunting methods, hunting laws, etc.), in practice, hunting takes place on a few hectares; the individual behavior of the hunter generally has the most substantial influence. The time a hunter has to hunt is, of course, limited by the hunting system. In addition, certain behaviors are only made possible by the respective legislation. Especially in the hunting ground hunting systems, the hunting seasons often seem to be chosen so that the hunters are able to hunt anything all year round. Especially here, it should be considered that hunting can also have a strong influence on non-target species. Suspension of roe deer hunting, combined with high hunting pressure on wild boar, will also have a significant impact on roe deer's habitat use. A permanent presence in the hunting ground, especially off the trails, does not allow roe deer adequate time and space for retreat, especially in winter. This affects the use of cover and, ultimately, also the fulfilling of hunting bag objectives.

Alternating hunting times between administrative borders can also harm hunting planning and execution. Once the animals have become accustomed to the onset of the hunting season, they can (and do) avoid the hunters by moving to unhunted areas.

Seasonal habitat changes are more likely to be furthered by hunting activities, as the start of the hunting season is more likely to be a signal for migratory movement than to restrict the animals' movement. However, hunting in stopover areas through which the animals merely pass can also affect migration behavior. That hunting in wildlife passages is taboo should be self-evident.

The repercussions of "deer-free" zones are ultimately reflected in the resulting genetic isolation of red deer populations: inbreeding depressions and genetic drift. Although this is currently not the case everywhere, it is ultimately only a matter of time as fragmentation progresses.

Deer exclusion areas can be an important tool to prevent damage in priority economic areas, such as vineyards and orchards, but should only ever provide a last resort if other methods prove inadequate. However, a bypass route for the animals must be ensured.

To address the role of hunting in the continuum of ecological connectivity:

High-resolution behavior patterns of wildlife **and** hunters are needed to answer the question of the effects of hunting on ecological connectivity:

- Comparative studies of similar regions but different observed behaviors of wildlife >> Why are the animals causing damages in one region and not in the other?
- General movement during hunting season inconclusive; Hunting activity is not uniform but varies on a small-scale level
    - Requires high resolution spatial, but also temporal data for animal activity
- Spatial information of hunters is needed
    - hunters generally try to avoid being noticed >> low impact on animals

- but when hunters **are** noticed by wildlife >> high probability of a **high** impact on the behavior, as hunters often enter the living space of the animals

- The reaction of animals to shooting events must be recorded >> long term behavior difference to “normal” behavior

11.2 Wildlife-damage

Many factors determine the susceptibility of a forest to game damage. In principle, the defining element should be considered the forest rather than the game. The condition of the forest defines the level of tolerable game influence. A forest with low susceptibility to game damage can very well be influenced by wildlife, but the compensatory capacity of the forest is so high that the influence need not be classified as damage. In forests with a high susceptibility to game damage, the influence of wildlife affects the forest management objectives, e.g., the amount of available natural regeneration that is sufficient to reach the target stand. In this case, game damage would be present if the game influences the natural regeneration to such an extent that financial damage occurs (with a potential loss of value; if cost-intensive planting measures are necessary to reach the target objective).

Practical implications

Recently, more related to agriculture, wildlife damages have shifted to forest stands in many countries, especially to protective forests. Red deer, for example, can cause damages that become problematic for forestry objectives, when protection from avalanches, landslides, and mudflows is of greatest concern. In too many regions, red deer retreat into these areas in winter times, as these are often difficult for humans to access and, thus, provide respite from human disturbances.

Rest during winter times is especially crucial for ungulate species, as their metabolism is reduced to low levels. Disruptions during this time can result in life-threatening energy loss when no appropriate food source is available. The protective forests usually do not provide enough quality food, and the deer damage the tree stands through bark stripping, thereby destabilizing the protective function of these forests.

Forestry and hunting, in cooperation, must ensure a site-appropriate forest composition with natural regeneration potential. The establishment of game species or population levels of these species that endanger the protective function of forests against damages to humans must be counteracted. Especially here, game reserves and/or resting areas that can help to reduce the potential for damage by game species are needed. The elaboration of such wildlife ecological planning areas must be carried out in cooperation with all stakeholders involved. Here, the participation of hunters and forest management is just as important as that of representatives of nature recreation users, nature protection, and agriculture.

“Hunting for fear” (Cromsight *et al.* 2013), the intentional display of the hunters’ presence can be used to deter animals from areas where they are not wanted. These priority hunting areas should be created where the preservation of forests with protective functions and other priority goals are of primary concern. Wildlife species generally learn to recognize predictable human hunting patterns, and this can be utilized to decrease wildlife damages to forest stand and natural rejuvenation.

Even though one might only look for hunting concerning the problem of wildlife damages, this problem is by no means a unique occurrence of district-based hunting systems because the same or similar problems also exist in license-based systems. Hunting is only a single factor in a myriad of other human activities influencing wildlife behavior.

11.3 Measures

- The basis of hunting management plans should be systematic & include scientific monitoring
- Hunting bags & habitat indicators can and should be used for orientation but should not be the sole method
- Measurement and evaluation of game damage serves as the objective of the "tolerable" population size
- No social hunts during winter (no noisy hunts); only limited hunts/work in hunting areas
- No hunting in and around wildlife passages (~300m distance)
- Employ different hunting strategies for different areas of concern:
    - Population control: Interval hunting; raised hide/driven hunts (stalking is suitable to a certain extent; can have a high potential for disturbance)
        - Leave no witnesses behind; only shoot when the accompanying animal can be shot too
        - No shots into groups
        - No shots from street/car
        - No hunting at feedings/baiting places
        - Low profile/only hunt if success is probable/low presence in (hunting ground) area
    - Focused hunting pressure on areas with high damages, natural rejuvenation, protection objectives
        - Direct hunting in forests (through thickets; loud hunting) and intensive drive hunts to deter game from the area

11.4 Sustainability

Sustainable use of ecosystem resources and services is not possible without connecting elements that bridge the human-made ecological wastelands and connect the exclaves of many wildlife species. To what extent and in what quality such corridors are made available to the animals is usually a question of money. Legal compulsion to create landscape links in new large-scale projects, especially in road construction, must be regarded as an absolute minimum obligation. As demonstrated by projects over the last 15 years on the subject of ecological connectivity, one result is this: Knowledge, tools, and guidelines have long been available at the EU level. However, there is an apparent lack of political interest or will to implement them. With the prospect of significant climate change and the inability of wildlife managers to directly influence its progression, management should focus on connectivity to reduce susceptibility of wildlife populations to the effects of climate change.

Consideration of ecological connectivity must be part of the notion of sustainable hunting and should be included in the delineation of hunting criteria. Without the consideration and integration of connectivity as a basis for healthy populations, no real sustainability is possible because the long-term perspective is missing.

As part of the Alpbionet2030 project, a multi-stakeholder cross-border wildlife management concept is being developed in the Prealpi Giulie Nature Park / Triglav National park area between the Italian and Slovenian park administrations (PNPG, TNP, and Slovenian Forest Service) to harmonize wildlife management of chamois and Alpine ibex in this region (Poljanec *et al.* 2019).

11.5 Fragmentation in the light of climate change

Addressing the fragmentation of ecosystems and landscapes has become more urgent and essential because of the predicted effects of climate change (Thomas, Cameron *et al.* 2004; Thomas, Williams *et al.* 2004; IPCC 2018). Fragmentation impacts are likely to be exacerbated by the effects of climate change (e.g., temperature, change in habitat structure and composition, resource availability) with the resilience of habitats and species populations to climate change impaired and reduced. Fragmentation limits the ability of ungulates to move to new areas that provide suitable climatic conditions (e.g., chamois in Alpine pastures and mountainous areas: with temperatures increasing, animals have to move higher for adequate climatic conditions). Thus, in combination, fragmentation and the added impacts of climate change constitute a significant threat to ungulate species inhabiting Alpine ecosystems of the EU affected and threatened by climate change. Fragmented landscapes present significant barriers to the colonization of new habitat areas with suitable climatic conditions. Therefore, measures to restore connectivity are increasingly required to allow for ecosystem and species resilience in order to enable habitat and species shifts in response to climate change (Kettunen *et al.* 2007).

A better and more concrete understanding of connectivity is urgently required given impending effects of rapid climate change on shifting species distributions and the potential of range shifts caused by blocked habitat areas that are altered by human intervention. Failure to acknowledge the dynamic nature of systems under the combined effects of climate change and landscape alteration will inevitably result in unexpected change and underachievement of intended conservation goals. Thus, accommodation for changes in successional dynamics, spatial and temporal mosaics, colonization and extinction processes, and distribution range shifts associated with climate change must be carefully considered and included in planning efforts. Understanding the cumulative impacts of these changes will be increasingly important, as climate change will affect landscapes that have already been heavily modified (Thomas, Cameron *et al.* 2004; Thomas, Williams *et al.* 2004).

Additionally, large-scale natural disturbances such as fires, floods, climate change accelerated increases in bark beetle infestations, and other harmful organisms (e.g., fungi, bacteria) can be important drivers of changes in ecosystem and landscape processes. With the experience of the last decades, we see how these events increase in frequency and intensity because of a strongly accelerated climate change (van Aalst 2006).

Since the early 2000s, the effect of climate change on species distribution ranges has been recognized, as has its ability to alter habitat structures and seasonal dynamics with its future impacts predicted to be extensive (Sala *et al*. 2000). An additional threat is presented by land-use changes and modifications for anthropogenic purposes and needs, leading to a reduction in habitat area and to fragmentation, which, as a rule, reduces connectivity between patches. Climate change alters the geographical location and availability of suitable climatic niches, resulting in shifts in species distribution ranges. In severe cases, the entire future climatic suitable niche lies outside the species present distribution range, necessitating migration for the species to survive or leading in severe cases to absence/extinction of entire resident subpopulations (Trakhtenbrot *et al.* 2005).

Species with a narrow climatic niche are likely to be most affected by ongoing climate change. These species face the most significant challenges with their present geographical range becoming climatically inappropriate. For such species, survival depends solely on rapid migration and available climatically suitable replacement habitats. Given the rapid rate of anthropogenically induced climate change, short-distance dispersal may not be sufficient to cope with a changing landscape, in terms of climate, succession, resource availability, and resource depletion. In those scenarios, significant long-distance dispersal (LDD) ability will be crucial for species survival. Similarly, because the number of dispersers in threatened species is usually low, LDD is extremely important for the realization of rapid migration (Trakhtenbrot *et al.* 2005).

12 EU Policies fostering connectivity for wildlife and their implementation

In previous Alpine Space projects, we have already reported extensively on the EU policy landscape regarding ecological connectivity (Svadlenak-Gomez *et al.* 2014). We found that a wide range of policy instruments (conventions, directives, strategies, policies) exist globally and in the European Union that directly or indirectly make provision for biodiversity conservation and for the associated goal of maintaining ecological connectivity and preserving ecosystem services. The review found problems, however, in the status of implementation of existing policies, partly because many of the policies are mere recommendations and are not binding, and partly because, despite potential sanctions from the European Union, member states often lag in implementing policies. Even instruments that have legally binding requirements are not consistently implemented and contain non-binding elements. The goals of key sectors (environment, agriculture, forestry, hunting and fishing, energy, transport, construction, tourism and spatial/land-use planning) sometimes conflict, and, even where synergies could exist, there is not necessarily consistent coordination, and the integration of biodiversity targets into other (non-environmental) sectors is insufficient or overlooked. Wildlife management continues to be one of the most significant challenges globally and also in the Alpine region. It is made difficult by human-induced wildlife habitat loss, often resulting from a lack of proper land use planning. On the one hand, wildlife species populations face a steady decline, and on the other hand conflicting encounters between humans and wildlife lead to loss of life (e.g., traffic accidents), damage of property (e.g., predation of farm animals or beehives) and retaliation where people are killing endangered species (e.g., poisoning of raptors).

For this report, we also reviewed more recent EU documents covering the implementation of the EU´s Green Infrastructure strategy, which is the policy instrument that most directly targets wildlife corridors and ecological connectivity (European Commission 2011; European Environment Agency 2011). Developing green infrastructure is a key step towards achieving the EU 2020 Biodiversity Strategy. The Strategy's target 2 necessitates that, by 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems' (European Commission 2011). The EU strategy on adaptation to climate change also recognizes ecosystem-based solutions and green infrastructure as relevant approaches to addressing climate change.

Thus in 2013, the European Commission adopted an EU-wide strategy promoting investments in green infrastructure to restore the health of ecosystems, ensure that natural areas remain connected together, and allow species to thrive across their entire natural habitat. The Strategy also aims for the development of a Trans-European Network for Green Infrastructure in Europe, much like existing networks for transport, energy, and ICT. The backbone of the green infrastructure network is the Natura 2000 network of sites.

In 2019, the European Commission published a review of progress on the implementation of the EU green infrastructure strategy. The Nature Directives alone are insufficient to halt the loss of biodiversity, and so the connectivity of Natura 2000 areas through the deployment of green infrastructure projects is meant to help in this. The conservation of existing biodiversity-rich ecosystems and the restoration of degraded ecosystems inside and outside the Natura 2000 network would both be useful types of green infrastructure measures. The Habitats Directive requires member states to set priorities for conservation and restoration and regional or national levels (Prioritized Action Frameworks), and these frameworks now may include information on wider green infrastructure measures.

At the time of reporting, Germany was the only EU country within the Alpine region to publish such a Restoration Prioritization Framework. Some restoration activity is taking place in other countries as well in response to other relevant EU legislation (e.g., the Water Framework Directive) (European Commission 2019). However, except for Germany´s national Green Infrastructure concept, no member state has yet adopted a strategy dedicated explicitly to green infrastructure. The concept is often implicit in national biodiversity strategies, however.

The EU report states that more could be done to highlight the multiple benefits that green infrastructure has for climate change mitigation and adaptation, not only directly through carbon sequestration by green areas, but also because, at least in urban settings, green infrastructure has energy-demand reduction effects by providing natural cooling and insulation of buildings. Similarly, the report points out the linkages between disaster risk reduction and ecosystem-based approaches such as green infrastructure, as well as the positive impact on human health (European Commission 2019).

The European Commission also points out the possibilities of using the environmental instruments of the Common Agricultural Policy (CAP) to enhance green infrastructure and thereby contribute to biodiversity conservation and ecological connectivity. Agriculture covers almost half the land surface area of the European Union, and it shapes the environment in which it operates, including essential wildlife habitats. It is well established that certain agricultural practices, such as mowing only at specific times of the year, leaving field margins with native plants and flowers, or planting trees in strategic locations, have beneficial effects for the provision of wildlife habitat – and thereby on the enhancement of permeable ecosystems. Such practices can benefit the hunting sector as well. One example is the documented problem of the decline of brown hares in agricultural landscapes, which has to do with an inferior habitat caused by intensive monocultures and the use of pesticides combined with a loss of nutritious wild plants (Klansek 2015). The European Commission´s Communication on the Future of Food and Farming acknowledges that the CAP needs to lead the transition towards a more sustainable agricultural system. It also contains recommendations that would potentially strengthen green infrastructure (European Commission 2017).

Concerning the crucial subject of transport infrastructure, which causes the fragmentation of habitats and leads to many wildlife deaths, the EU reports that good practice examples are still too isolated (European Commission 2019). Some implementation progress has been made, although at an insufficient level. Greater efforts are required to enhance biodiversity by using green infrastructure along with transport infrastructure. In Austria, for example, there are a number of regulations that are intended to protect wildlife from vehicle collisions and to create connections between habitats, such as the Guideline on Wildlife Protection (RVS 3.01) and instructions to ASFINAG by the Ministry of Infrastructure (BMVIT 2006). The ASFINAG, a parastatal company that is responsible for planning, constructing and managing all highways, and which also owns 53 square km of forest, has a biodiversity management program and is building green bridges along highways. This is being done in accordance with an implementation concept by the WWF “Strategic Planning for habitat networks in Austria – prioritizing retrofitting proposals for green bridges along highways” (Strategische Planung für die Lebensraumvernetzung in Österreich – Prioritätensetzung für Nachrüstungsvorschläge für Grünbrücken über Autobahnen und Schnellstraßen) (Proschek 2005)– according to this, 20 such green bridges are to be realized by 2027 to secure habitat networks for wide-ranging wildlife species in the long term. In addition, the ASFINAG is now committed to mowing vegetation along highways in accordance with flowering times, and in 2015 they voluntarily stopped using the pesticide Glyphosate.

Some provisions for ecological connectivity are made in the EU macro-regional strategy for the Alpine Region (EUSALP), which adopted a joint ministerial declaration on Alpine green infrastructure in October 2017. Similarly, EU urban policy has produced an Urban Agenda on sustainable use of land and nature-based solutions, and a partnership was launched in 2017 for funding the testing of innovative solutions in cities. The European Green Capital and Green Leaf awards now include green infrastructure as an award criterion, and Horizon 2020 is providing funding for research into nature-based solutions in urban areas (European Commission 2019). This could be an opportunity for some of the Alpine cities as well.

The EU actually has some funding (loans) available for green infrastructure initiatives: The Natural Capital Financing Facility (NCFF) is an instrument that supports biodiversity and climate adaptation projects (European Investment Bank 2019). A few loans have been provided that are expected to provide green infrastructure and benefits from nature. None of the projects currently listed as financed or under appraisal are in the Alpine region. Co-funding is also available through Horizon 2020 and BiodivERsA, and LIFE. Proportionally, LIFE is the biggest contributor to green infrastructure implementation (1,248 million EUR from 2014-2020) (Trinomics B.V.). In absolute terms, the agriculture fund EAFRD contributes most to green infrastructure (418 billion EUR between 2014 and 2020), but this is only one percent of its total budget. Furthermore, connectivity issues are underfunded, receiving only one percent of the overall green infrastructure funding (Trinomics B.V.).

According to the EU report, the various financing instruments have not been fully used, and it appears that awareness of existing opportunities needs to be improved (European Commission 2019). The Green Infrastructure Strategy recommends the development of a trans-European network for green infrastructure (TEN-G), as it would not only secure the resilience and vitality of European ecosystems but also provide social and economic benefits. A cost-benefit analysis was published in 2016, which came to the conclusion that a more strategic approach to green infrastructure at the EU level would double the current benefit-cost ratio (Trinomics B.V.).

13 Recommendations

1. Development of a common wildlife management strategy between neighboring states and regional administrations should involve scientists, managers, conservationists and other stakeholders from the respective regions.

2. Coordinated long-term monitoring efforts are needed to ensure that shared knowledge on species distributions, movement, changes in habitats and ecosystems is meaningful for decisions across larger landscapes. The methods, procedures and indicators need to be evaluated in order to determine their performance in providing evidence for the decision-making process.

3. Management in most countries is mainly exerted on an administrative border level. Management plans should be implemented for important species that are presently not managed and must consider the meta-population scale, not just the individual administrative region. A good example is the WESP planning tool (Wildlife ecological spatial planning – Reimoser), which incorporates a holistic approach to wildlife management over many different levels of administration and stakeholders.

4. Wildlife managers must acknowledge that hunting can impact behavior, social structure, and short- and long-distance movements of ungulates. Consideration of the use of hunting practices can limit negative impacts on the management goals while also addressing stakeholder objectives.

5. Climate change impacts require a dynamic and collaborative wildlife population management approach. Managers will be faced with new challenges especially concerning wildlife diseases. Climate-induced changes in wildlife distribution and density in the face of shrinking habitats will increase the risk of disease and disease transmissions. Ecological connectivity (EC) in this case is a two-sided sword, as EC can facilitate disease spread. However, knowledge of population connectivity is vital for effective disease management.

6. Institutions responsible for wildlife management need to promote the role of wildlife corridors and ecological connectivity on the level of the regional spatial planning process. They should be actively involved in the planning processes of large infrastructure projects.

14 Handbook: Wildlife Management

14.1 Austria

Extracted from Reimoser and Reimoser (2010)

Administration level:

Federal provinces: Burgenland, Carinthia, Vienna, Lower Austria, Salzburg, Styria, Tyrol, Upper Austria, Vorarlberg

14.1.1 Wildlife Management System

Hunting system: “Revier”/district-based system => Hunting right is tied to the property

Legal status of wildlife: Wildlife is considered *Res nullius* (belonging to ‘no-one’)

Hunting law: No federal hunting law exists, instead the administration of hunting is legislated by the nine federal provinces, resulting in nine different hunting laws and authorities:

I. Hunting authority: District authorities (magistrates and district administrations)
II. Hunting authority: Nine provincial governments

Hunting associations: One national hunting association (“Dachverband – Jagd Österreich”) and a provincial hunting association in every province. The provincial hunting associations have legal status (public corporation). Membership in the respective provincial hunting association is mandatory (in 8 of the 9 provinces) when becoming an active hunter. (Further division in local hunting groups).

Misc:

- Around 98% of Austria’s area is considered hunting ground.
- Minimum property size of 1.15 km2 (3 km2 in Burgenland/ 1 km2 in Tyrol) for permission to form a private hunting area.
- Hunting grounds of the municipality that are under the minimum size must be pooled into municipal hunting grounds and leased to hunters for monetary compensation (minimum size of 5 km2).
- The lease duration is 6-9 years.
- All rights and obligations concerning hunting are transferred to the leaseholder.
- Public administration has control function, supported by game wardens (which are, in effect, chosen by the hunting parties and accredited by the administration.)
    - Responsibilities of the game warden are the observation of the law in respect to hunting permits, licenses and practices, and the control of “wildlife damaging” animals/species (carrion crows (Corvus corone), magpies (Pica pica), Eurasian jay (Garrulus glandarius), stray dogs, stray cats).

Aim of the hunting laws:

- High diversity of wildlife species (i.e., game species)
- Protection of wildlife populations
- Avoidance of damages by wildlife to vegetation
- Sustainable use of wildlife

14.1.2 Hunting license

Every province has its own hunting license, which is not necessarily valid in the other Austrian provinces.

Minimum age: 18 years (special permissions administration/parents: 16 years)

The hunting license course takes approx. 4 months.

Costs: approx. EUR 750 full exam; EUR 50 – 100 for hunting license per year; Additional costs for hunting insurance and hunting license renewal

Written exam:

- Hunting related legal regulations, includes Nature, Animal, Environmental and Forestry law
- Handling, effect, and treatment of weapons and ammunition, including safety precautions
- Wildlife biology, ecology, and identification of game animals
- Hunting management, gamekeeping (Hege)
- Hunting language and traditions
- Field dressing and processing of game meat, hygiene regulations
- Principles of ecology
- Terminologies of forestry and agriculture
- First Aid for hunting-related accidents

Practical exam: Testing the abilities in rifle/shotgun handling and shooting.

14.1.3 Hunting management plans

- Shooting plans must be provided by hunters for all ungulate species (except wild boar) every year (or 3rd year- depending on the province).
- They define a minimum/maximum number to be culled.
- Another possibility is to define only minimum cull in relation to observed damages/impact on/to vegetation.
- The plans have to be prepared separately for each species, sex and age class.
- All provincial hunting laws and regulations define hunting seasons for the different game species (they only consider animal species that are mentioned in the respective hunting law). Thus, game species can differ between the provinces (e.g., Asiatic jackal (*Canis aureus*), Nutria (*Myocastor coyous*) and Moose (*Alces alces*)).
- District administrations can modify (shorten or lengthen) hunting seasons to adapt to regional requirements and needs.

14.1.4 Monitoring

No scientific or systematic census to monitor ungulate population sizes.

For the creation of the harvest plans, population levels are estimated by the hunters in their district, commonly based on the hunting bags of previous years.

Minimum regional stock estimated on assumptions:

- Sex ratio
- Population growth rate (surviving offspring when shooting season starts)
- Total recorded mortality = yearly number of offspring

Pellet counts, track counts, and IR photography by helicopter might be used on a local level, but this is not standard procedure.

For the planning of ruminant ungulate hunting bags, a nationwide monitoring program of browsing and debarking intensities is in place, which is led by the public forest administration.

These results are an important gauge to determine where ungulate populations levels are too high to reach the objectives in forestry.

Hunting bags are collected on the hunting-district level by Statistics Austria (provided by the hunters themselves).

Hunting bag data is available to the public only on the province level (free) and county level (paid). Lower levels (e.g., district) are not accessible.

14.1.5 Damages by Ungulates

Agriculture: No formal estimates of damages. Increases in wild boar population levels resulted in increases in agricultural damages.

This trend is continuing as wild boars are difficult to manage (reduce) by “hobby” hunters.

Forestry: approx. 218 million EUR per year, EUR ~218/ha – 10K km² of forest area damaged per year

Hunters are liable for wildlife damages, but only 20-30% of damages are compensated for and paid to the forest owners (owner has to report within one year).

Total damages in forests ~50% of the economic value of hunting in Austria

Monitoring system for forest damages established and shows an increasing trend

Updated and reported every 5 years

14.1.6 Supplementary feeding

Red deer, roe deer, and mouflon are generally fed (October/November – April/May).

Prevention of damages to forest stands and young growth is often a motivation for feeding practices.

Feeding is mandatory during ‘emergency times’ by law in some provinces.

In some provinces, red deer are held in enclosures (10-50 ha; 40-200 animals) over the wintertime to prevent these damages.

Feeding to lure animals in for hunting purposes is only allowed for wild boar, which is frequently done year-round.

Hunting close to feeding stations is forbidden

14.1.7 Common hunting practices

- High seats
- Stalking
- Driving (group hunts with beaters; popularity increasing)
- Hunting dogs (single/group)

14.2 Germany

Extracted from Wotschikowsky (2010)

Administration level:

Federal states: Baden Wuerttemberg (BW), Bavaria (BY)

14.2.1 Wildlife Management System

Hunting system: "Revier"/district-based system => Hunting right is tied to the property

Legal status of wildlife: Wildlife is considered *Res nullius* (belongs to no-one)

Hunting law: Germany has one federal law, but the federal states can have different/diverting regulations (hunting seasons, district size, communal hunting grounds, and others).

Hunting associations: Hunting associations in Germany are private entities, and membership is voluntary.

German Hunting Association (Deutscher Jagdverband (DJV)) is the head association. Every federal state has its own hunting association. These are further divided into county hunting associations.

Hunting associations have quasi-legal character.

Misc:

- Hunting district minimum size is 0.75 km² in BW and 0.81755 km2 in BY (3 km2 in Alpine areas).
- For communal hunting grounds, the minimum size is 2.5 km² in BW (can be low as 1.5 km2 with special permission) and 2.5 km2 in Bavaria (5 km2 in Alpine areas).
- All rights and obligations concerning hunting are transferred to the leaseholder.
- The lease duration is 12 years with red deer present in the area and 9 years without red deer.
- Public administration has control function, supported by game wardens (which are, in effect, chosen by the hunting parties and accredited by the administration.)
    - Responsibilities of the game warden are the observation of the law with respect to hunting permits, licenses, and practices.
    - Further responsibilities include the prevention of famines, wildlife diseases, and the control of poaching by dogs and cats.

14.2.2 Hunting license

Every province has its own hunting license, which is valid in all federal states.

Minimum age: 18 years (youth hunting license: 16 years; needs to be accompanied by an experienced hunter)

Hunting courses take approx. 6 months (120 h; 60/60 h theory/practice).

Costs:

- Hunting license course: EUR 700 - 2500+
- Hunting license per year: EUR 50-80 (BaWue), EUR 60 (Bay)
- Insurance: approx. EUR 30 per year

Written exam:

- Wildlife biology/ecology, habitat, nature protection
- Hunting management, planning, gamekeeping (Hege), population size estimation, game damage prevention, trapping, hunting ethics/history/traditions
- Weapon handling and safety (including guns), firearms law, treatment, ammunition, storage
- Dog keeping, dog breeds, training and use of hunting dogs, dog diseases
- Wildlife disease detection and handling, hygiene regulations
- Laws: Hunting, Animal welfare, Nature protection- and landscape conservation, accident prevention, and other safety regulations

Practical exam: Testing abilities in rifle/shotgun handling and shooting

14.2.3 Hunting management plans

- Annual harvest plans must be issued by the owner or lessor of the hunting ground for all ungulate species, except for wild boar.
- For better efficiency, hunting grounds are often organized in collective management units (CMU), where all involved landowners issue the harvest plan as one.
- Estimates of population size, composition, and the status of the forest vegetation must serve as a basis for the preparation of the harvest plan, which then has to be signed by the regional authority.
- The plans must be prepared separately for each species, sex and age class
- All provincial hunting laws and regulations define hunting seasons for the different game species and only consider animal species that are mentioned in the respective hunting law. Thus, game species can differ between the federal states.
- District administrations can modify (shorten or lengthen) hunting seasons to adapt to regional requirements and needs.

14.2.4 Monitoring

No scientific/systematic monitoring scheme for ungulates

Population sizes are calculated using hunting bags of the previous years.

Harvest has to be reported to local authorities and is published by the German Hunting Association (*Deutscher Jagdverband, DJV*) on the federal state level once per year.

Baden Wuerttemberg and Bavaria have web presences where hunting bags are published for different administrative levels.

14.2.5 Damages by Ungulates

Agriculture:

The compensation for damages done by wildlife is agreed upon in the lease contract.

In general, the hunters have to pay for damage created by ungulates.

The increases in wild boar population levels over the last decades resulted in increases in agricultural damages.

This trend is continuing, as an effective reduction of wild boar populations is difficult to accomplish by "hobby" hunters.

Forestry:

Different browsing and bark stripping monitoring schemes are in place.

No discrimination between causative agents (between different wildlife species).

Significantly greater damages in private hunting areas than state forests.

14.2.6 Supplementary feeding

Supplementary feeding is still part of the federal law and a long tradition in many areas (especially Bavaria).

Wild boar diversion feeding is practiced during summer

Feeding to lure animals in for hunting purposes is only allowed for wild boar, which is frequently done year-round

14.2.7 Common hunting practices

- High seat (preferred)
- Baiting in wintertime
- Stalking (less common, except for chamois in the mountains)
- Various types of drive hunts are used (with dogs and beaters)

14.3 France

Extracted from Maillard *et al.* (2010)

Administration level:

Departments: Ain, Alpes-de-Haute-Provence, Alpes-Maritimes, Ardèche, Bouches-du-Rhône, Doubs, Drôme, Haute-Saône, Haute-Savoie, Hautes-Alpes, Isère, Jura, Loire, Rhône, Savoie, Territoire de Belfort, Var, Vaucluse

14.3.1 Wildlife Management System

Hunting system: Mixed hunting system => Hunting right is tied to the property, but game is sold via game tags/licenses to hunters

Legal status of wildlife: Wildlife is considered *Res nullius* (belongs to no-one)

Hunting law: Two main hunting laws:

- The hunting law from 26 July 2000
- Law on the development of rural territories 23 February 2005

Included are regional guidelines for the management and conservation of wildlife and their habitats and the development of plans for hunting management

Management structure:

The management of hunting in France is organized on three levels.

On a national level, the responsible authority is the Office National de la Chasse (ONCFS) under the public agency Ministry of Ecology and Sustainable Development (MEDD) and the Ministry of Agriculture.

ONCFS's main responsibilities are:

- Monitoring of wildlife and environment (ONFCS employees)
- Control of hunting policies carried out by national wildlife protection officers
- Technical support to administrations, associations and people involved in rural development to assess the distribution, the trends in numbers and the health status of wildlife, as well as the validation of hunting licenses and the application of legal rules aims to integrate wildlife better into public policies
- Applied research and experimentation for conservation, restoration and management of wildlife and their habitats, both at national and international level

(Maillard *et al.* 2010)

The Departmental Hunters' Federations (FDC) are private hunting associations present in each department.

Their main responsibilities are the improvement of hunting conditions and the protection and management of wildlife and habitats.

Further:

- Promotion and defence of hunting and interests
- Support to ONCFS against/prevention of poaching
- Information, education, technical support for land managers and hunters
- Coordination of actions by hunters' associations
- Execution of actions to try to prevent game damages and solve problems of compensation
- Training, hunters' examination
- Coordination of specialized hunters' associations (National Big Game hunters association, mountain hunters' association, National Falconers and Hawkers Association, National Wolf-hunting Lieutenants Association, the Federation of Hound Hunters' Association, the Archery Hunters Association)

(Maillard *et al.* 2010)

Hunting associations: The Regional Hunters' Federations (FRC) represents the members of the FDCs at the regional level. They lead/coordinate actions for the preservation of wildlife species and habitats and contribute to the definition of policies on a regional level. The National Hunters' Federation (FNC) promotes, represents, and defends the interests of FDCs and FRCs on a national level. Voluntary collective management units are organized in the form of grouped local hunting associations (Groupment d'Interet Cynegetique – GIC). They serve to unify management efforts across large hunting areas. They also play an important role in the release/translocation of ungulate species (and prohibition of hunting in these areas for some time).

Regional Wildlife and Habitat Policies (ORGFH) are established by each Regional Environment Agency (DIREN) and ONFCS (in discussion with local and regional authorities) and are then validated by the government respectively by the prefect of the region. Each department is divided into management units covering many hunting territories, which are monitored by FDC (ONCFS lends technical assistance). These management units are mostly based on administrative or natural borders and can differ among species or species groups. There are also communal associations or private groups of hunters organized in these management units.

In 10 of the 18 French departments in the EUSALP perimeter, mandatory membership in an Approved Communal Hunting Associations (ACCA) is required. This means that all landowners are automatically members in an ACCA and hunting is then allowed for all members on the hunting grounds of the other members of the same ACCA. The members do not pay for a lease but pay a subscription to the association. This system is partially present in five other departments but absent in Alpine-Maritimes, Bouches-du-Rhône, and Vaucluse.

14.3.2 Hunting license

Examination by National Hunting and Wildlife Agency (Office national de la Chasse et de la Faune Sauvage – ONCFS)

Minimum age: 18 years (15 years when accompanied by an experienced hunter (5+ years possession of hunting license)).

Costs: hunting license ~ EUR 45; hunting fees: ~EUR 150 for a departmental permit; ~ EUR 447 for a national permit

Consists of a theoretical and practical examination and is valid for life.

Written exam:

- Wildlife and its habitat; species identification and biology
- Hunting methods, hunting practice, and vocabulary
- Regulations concerning hunting organization, nature conservation, and police
- Firearms handling and safety/security

Practical exam: Testing abilities in rifle/shotgun handling and shooting

14.3.3 The right to hunt

Conclusion:

- Either be an owner of a hunting territory, lease a hunting territory (alone or as member of hunting society), have permission to hunt (free of charge), or be a member of an Approved Communal Hunting Association (ACCA).
- Hunting license (pass examination)
- Insurance
- Subscription Federation Departmentale des Chasseurs (FDC) – pay a federal contribution
- Pay national/departmental contribution
- Contribution to refunding of agricultural compensation balance accounts (each FDC)

14.3.4 Hunting management plans

Since 2005, each department must define regional wildlife policies and develop regional management plans for six years.

The hunting management plans consist of:

- Hunting quotas
- Actions proposed for improving the safety of hunters and non-hunters
- Actions proposed for improving management of target species (regulations of game releases, supplementary feeding methods)
- Actions to conserve and/or restore natural wildlife habitats
- Actions directed towards reaching a balance between hunting, farming, forestry

(Maillard *et al.* 2010)

The FDC produces management plans on department level in collaboration with the landowners, game managers, and hunters of the area. The plan has to be validated by the prefect of the department. The hunting commission must fix a yearly quota per species on department level.

- Local administrations, hunters, farmers, foresters, conservationists, experts
- Fixed in relation to the economic value of forest in most areas and the population density
- Department prefect has the final decision
- Each holder of the right to hunt can ask to be assigned an individual shooting plan

The harvest is controlled by tags, which must be attached to the hind leg of the animal before transport.

The price for the tags is defined at the national level for every species, but each FDC can additionally increase the cost for the tag for compensation of wildlife damages.

14.3.5 Monitoring

Censusing of wildlife populations has traditionally been used to create hunting management plans. Population sizes were estimated by drive counting methods in the past, which led to a significant underestimation of population sizes before the 1980s, which in turn partly led to an (over-) abundance of ungulates. Today, a browsing index to monitor changes in habitat quality, along with line transect counts and other ecological and species-specific indicators are used (female reproductive success, body mass of fawns, etc.).

14.3.6 Damages

Agriculture: The damages are declared by farmers, estimated by experts from the FDCs, and then compensated by the FDC with the funds raised by the hunters. Wild boar damages are responsible for 87% of wildlife damages and cost approx. EUR 21 Mio. (2004/2005) per year. Red deer damages make up around 10% in agricultural damages.

Forestry: For red deer and roe deer damages to trees, the forest owners can get compensation and receive funds to protect their trees under the condition that the damages are proven to be done by deer, and the local hunters must have fulfilled their minimum yearly deer quota.

14.3.7 Supplementary feeding

Supplementary feeding serves two purposes: to reduce crop damages, mostly done by wild boar, by acting as a diversion from the field crops (Apr-Oct) and vineyards (Jul – Sep), and to serve as a complement to natural food resources. This is thought to improve population performance, being compensation for bad habitat quality in wintertime or drought.

Shooting ungulates at feeding sites is prohibited

14.3.8 Common hunting practices

- Drive hunts with dogs, most common for deer and wild boar in forests
- Stalking mostly in mountainous areas
- Few hunters use high blinds

14.4 Italy

Extracted from Apollonio, Ciuti *et al.* (2010)

Administration level:

Regions: Friuli-Venezia Giulia, Liguria, Lombardia, Piemonte, Provincia Autonoma di Bolzano/Bozen, Provincia Autonoma di Trento, Valle d'Aosta

Veneto Provinces: Belluno, Padova, Rovigo, Treviso, Venezia, Verona, Vicenza

14.4.1 Wildlife Management System

Hunting system: Mixed hunting system => Hunters are linked to hunting districts…

Legal status of wildlife: Wildlife is considered *Res communitatis* (belongs to everyone).

Hunting law: Hunting is primarily regulated by the national hunting laws 152/92 and 157/92.

Besides these laws, there is no further level of national control on hunting management.

Additional regional bylaws pass responsibilities to the provinces and General Hunting Districts (ATC) or Alpine Districts (CA).

Hunting associations: Seven hunting associations are recognized by law 157 (to which is added a series of unrecognized local associations):

Federcaccia (400,000 members), Enalcaccia (80,000 members), Arci caccia (50,000 members), Libera Caccia (100,000 members), Anuu Migratoristi (30,000 members), Italcaccia (15,000 members), Ente produttori selvaggina (11,000 members)

Misc:

- In the Eastern Alps, hunting is organized on a municipal level in each of the provinces.
- In these municipal hunting districts, only provincial citizens are allowed to hunt.
- In the Central and Western Alps, the land is subdivided into ATC general hunting districts (ATC: Ambito Terriroriale di Caccia) and CA Alpine districts (CA: Comparto Alpino).
- These hunting districts are further subdivided into smaller hunting areas in relation to the management of specific ungulate species.
- The differences in hunting management are mainly due to the distribution of the different ungulate species.
- Individual hunters are linked to a district and can only hunt there, but some have the possibility to hunt in more than one area).

14.4.2 Hunting license

A hunting license can only be provided through proof of passing a general hunting examination.

Minimum age: 18 years

This examination is considered relatively easy and only tests basic knowledge, except in Trento and Bolzano, where testing is considered more extensive.

In some regions, there are also special examinations for hunters that want to hunt certain ungulate species.

The license is valid for 6 years.

For the first twelve months, hunting is only allowed in the presence of another hunter who has possessed a hunting license for a minimum of three years and is offense free.

Costs:

- hunting license: EUR 173 (government grant)
- Hunting fees are paid to provincial government: EUR 200-400 / year (in some areas up to EUR 2000 or more)
- Insurance

Written exam:

- Hunting regulations
- Zoology related to hunted species
- Guns and ammunition
- Protection of flora
- First aid

Practical examination: Testing abilities in shooting

14.4.3 Hunting management plans

- Harvest management plans are mandatory for cervids and bovids and must be prepared by the ATC, CA, or municipal reserve authorities to the level of the smallest hunting district.
- The plans have to be approved by the provincial government.
- The plans must be prepared separately for each species, sex and age class, and every hunter applying for a license to hunt is allocated a specific number of animals from this plan.
- Harvest plans for wild boar are not mandatory, and, if present, the hunters get an overall number to cull.
- Hunting seasons are fixed in the national hunting law 157/92 and set to three months for wild boar (October to January) and two months for all other ungulates (can be set variably and separately; usually October to November).
- The seasons are set on a provincial or regional level.
- Exceptions are present in the eastern Alps, where longer hunting seasons exist.
- Autonomous regions and provinces can lengthen the hunting seasons over the limits set by the national law.

14.4.4 Monitoring

No formal agreement exists on census coordination efforts among provinces. Chamois, are nearly always censused in the provinces where they are present. The other species are rather sparsely censused especially wild boar. There is high variability in the census methods used, which renders comparisons between provinces mostly impossible.

14.4.5 Damages

There are no reliable estimates of wildlife damages to agriculture and forestry available.

On a provincial or regional level, these estimates might be collected. In general, wild boar is the species with the highest damages done to agriculture (est. EUR 10 million). Farmers receive compensation for damages in most areas. These are paid by the provinces themselves and can be high in central and northern Italy. In the Alps, red deer might cause damages to forests through browsing and bark stripping, but these damages usually are not compensated.

14.4.6 Supplementary feeding

Feeding is provided primarily for wild boar, roe deer, and red deer. In the case of wild boar, the feeding is intended to divert the animals from crops but is often also motivated by increasing the productivity of the populations. Red and roe deer are mainly fed to avoid damages to forest regeneration and, in some cases, to prevent traffic accidents.

14.4.7 Common hunting practices

Ungulates are hunted by stalking with rifles (in some provinces, it is also permitted to hunt with dogs).

Wild boars are mostly hunted with the use of dogs.

Stalking, drives, and single dog hunting are also used for wild boar hunting.

14.5 Slovenia

Extracted from Adamic and Jerina (2010)

Administration level:

Hunting is managed on a hunting district level, which do not align to the administrative mapping levels of NUTS or the community level.

14.5.1 Wildlife Management System

Hunting system: “Revier”/district-based hunting system

Legal status of wildlife: Wildlife is considered *Res communis* (belongs to everyone) and is declared property of the state.

Hunting law: Wildlife management is based on the Law on Wildlife and Hunting (“ZDLov-1 - Zakon o divjadi in lovstvu” - 2004) and the Act on Hunting Seasons and Wildlife (“Uredba o določitvi divjadi in lovnih dob” - 2004).

Misc:

- Slovenia is divided into 14 Wildlife Management Areas (WMA). These WMAs include 11 State Wildlife Reserves (centers for the conservation of rare and endangered species and their habitats), which are administered by the Slovenian Forest Service (SFA).
- The other WMAs are subdivided into 415 hunting districts where hunting is performed by the members of local hunting families (hunting clubs).

14.5.2 Hunting license

Formal examination by Slovene Hunters Association

Minimum age: 18 years

Written exam:

- Basic knowledge of wildlife
- Basic knowledge of wildlife management
- Skills of handling firearms
- Knowledge of current hunting regulation

14.5.3 Hunting management plans

Wildlife management plans must be prepared by the District Wildlife Officers of the SFS for 10 years for each WMA.

Management plans for hunting units, which include harvest quotas, habitat improvements are prepared in collaboration with the hunters’ families and the SFS on a yearly basis.

Hunting periods are fixed in the Law on Wildlife and Hunting (2004), but special permissions for extended hunting seasons in areas of high damages to agricultural crops or forest stands are regularly issued by the Slovene Ministry of Agriculture and Forestry.

14.5.4 Monitoring

No scientific censusing methods were used until 2004. Since then, hunting bags are recorded in the 'Core Slovene Register of Large Game Species and Large Carnivores' and are based on the exact geographic location, which is then associated with a 1x1 km grid covering the entire area of Slovenia. The SFS had been monitoring the browsing intensity of permanent sample plots since 1994 (the method was found to be incorrect).

14.5.5 Damages

Agriculture: Widespread damages to crops, especially in crop patches between forests. Wild boar is the major contributor to agricultural wildlife damages (60%). The members of the hunting families pay compensation to the farmers. A representative of the hunting family and the landowner have to agree on the amount of compensation after a field visit.

Forestry: Wildlife damages to forests are monitored by the SFS on a national level. No compensation for damages in forestry (only a few exemptions: extreme browsing of plantations; repeated bark stripping).

14.5.6 Supplementary feeding

Ungulates, especially red deer, are commonly fed during winter months to decrease winter browsing in natural forest regenerations. These feeding practices are regulated through the 10-year wildlife management plan for each of the WMAs. Wild boar is regularly fed to divert the animals from crops.

14.5.7 Common hunting practices

Hunting practices depend on the density of game species and the presence of other outdoor activities.

- High-seat
- Shooting at baiting station (wild boar)
- Hunting with beaters (wild boar, red deer)
- Stalk hunting (red deer)
- Dogs only for seeking

14.6 Switzerland

Extracted from Imesch-Bebie *et al.* (2010)

Administration level:

Cantons: Aargau, Appenzell Ausserrhoden, Appenzell Innerrhoden, Basel-Landschaft, Basel-Stadt, Bern, Fribourg, Geneva, Glarus, Grisons, Jura, Luzern, Neuchâtel, Nidwalden, Obwalden, Schaffhausen, Schwyz, Solothurn, St. Gallen, Thurgau, Ticino, Uri, Valais, Vaud, Zug, Zürich

14.6.1 Wildlife Management System

Hunting system: The right to hunt belongs to the state; three hunting systems are present:

License system (Patentjagd) – 16 cantons, ~24k hunters, 70% of swiss territory:

- Hunter buys an annual license
- Number of culled animals limited (differs per species/canton)
- Game wardens are responsible for control / policing rights
- Wardens inspect the shot animals / give out tags
- Special after-hunts, when quota not fulfilled (mostly red deer)
- Wildlife management units sometimes over regional/cantonal level for efficiency (red deer)

Territory system (Revierjagd) – 9 cantons, ~12k hunters:

- Hunting right is leased to hunters/hunters' associations (by canton or local authority)
- Each association has its own management plan
- For certain species, combined management plans are created to manage the species on a populations level
- Hunter associations are generally self-regulated (except one)

In Geneva, hunting by "hobby" hunters is prohibited. Instead, hunting is done by professional game wardens.

Legal status of wildlife: Wildlife is *Res communis* (belongs to everyone)

Hunting law: Federal law 922.0 for the protection of wild mammals and birds and additional regulations.

In Switzerland, the federal hunting law acts as a species protection law in terms of species one is allowed to hunt, and when these species are under protection.

Every canton has to enact its own hunting law in terms of the scope of this framework legislation.

The protective seasons can be only extended, species can be additionally protected, weapons and ammunition types can be prohibited, and the definition of hunting examinations, permissions, and permitted hunting practices can be regulated.

Hunting associations:

The Swiss hunting umbrella association “JagdSchweiz” is the amalgamation of the other cantonal hunting associations.

Misc:

- There are federally constituted non-hunting areas, which are mostly in mountainous regions, and the respective cantons are bound to uphold their non-hunting status.
- However, total protection can be transformed into partial protection to prevent some species from becoming overabundant.
- Hunting in these areas is still strictly managed and often limited to a few species.
- Some cantons define additional non-hunting areas, which are often only partially protected for species and/or for a certain time.
- Additionally, wildlife protection zones or “wildlife quite zones” have been defined in some cantons to protect wildlife from disturbances by recreational activities. These zones are especially important in winter times, as disturbance of ungulates and other species at that time can be fatal.

14.6.2 Hunting license

A hunting license (hunting permit) is acquired on a cantonal level and consists of a theoretical and practical examination.

Minimum age: 18 years (in some cantons higher)

The hunting course takes around 1,5 to 2 years.

The ability to hunt is attained by passing the hunting license course. The permission to hunt can be attained by either buying a hunting permit (license-based system) or by admission to a hunting society (district-based system).

Every year, hunters have to prove their abilities in marksmanship.

Written exam:

- Hunting related legal regulations, includes Nature, Animal, Environmental and Forestry law
- Wildlife biology, ecology, and identification of game animals
- Handling, effect, and treatment of weapons and ammunition, including safety precautions

Practical exam: Weapon handling and safety

14.6.3 Hunting management plans

Annual management plans have to be prepared for all huntable species in discussion with representatives from hunting, forestry, agriculture, communities, nature conservation, and animal welfare.

Minimum requirements for shooting plans:

- Culling quotas must correspond to at least the annual growth rate of a population
- Minimum of 25% must be kids/calves of yearlings
- Sex ratio at least 1:1 (or female-biased)
- Centralized reporting to BAFU, gets all the statistics

14.6.4 Monitoring

The cantons organize censuses and, thus, the results vary in accuracy.

Generally:

In district-based cantons, estimates of population numbers are provided by the respective hunting association on a hunting district level.

In license-based cantons, population estimates are provided by the game wardens.

Depending on species, different methods are applied:

- Ibex: chamois: vantage point method
- Red deer: night lighting samples
- Roe deer: night lightning samples, kilometric index, or drive counting
- Wild boar: indirect counts (hunting bags, tracks, damages), capture-recapture method

Hunting bag statistics are collected centralized by the BAFU.

14.6.5 Damages

Agriculture:

Wild boar and red deer are the main species that cause damages to agricultural crops. Damages are assessed by game wardens or special damage experts (authorized by the canton). Farmers have to prove that they have made at least some minimal prevention efforts before compensation is granted. The compensation is paid partly by the hunters (amount depending on canton). In district-based cantons, hunters have to pay around 20-50% of the damages; in license-based cantons, the compensation is planned into the amount of the license fees. Total damages in agriculture amount to approx. CHF 1.7 million per year (2004) for the whole of Switzerland.

Forestry:

No statistics on economic costs are gathered, but they can be very high locally. The management plans are prepared with the goal to ensure that 75% of the forest area is regenerated naturally. Thus, hunting and forestry measures must be taken to prevent an overabundance of ungulate species. On this basis, the annual harvest plans are prepared. The state only provides subsidies for preventative measures, and direct compensations of damages are not possible.

14.6.6 Supplementary feeding

Supplementary feeding is forbidden.

14.6.7 Common hunting practices

Types of hunting practices depend on cantonal restrictions and traditions.

Ungulates are commonly hunted by stalking or stand/sit-and-wait hunting.

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1 Appendix I – Hunting seasons

1.1 Hunting season black grouse

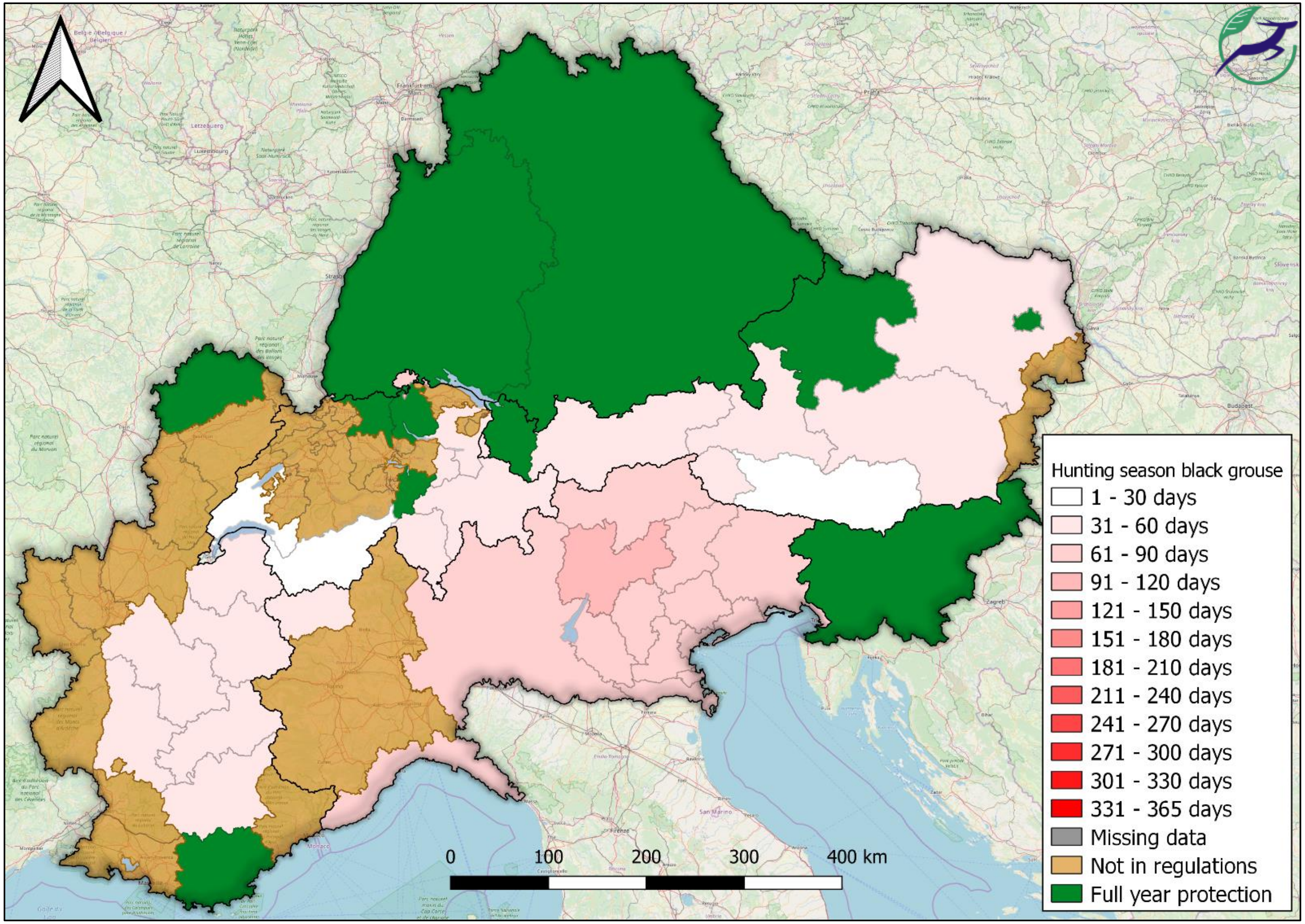

Figure 12 – Hunting seasons for black grouse; Data by EuroGeographics, and OpenStreetMaps

1.2 Hunting season capercaillie

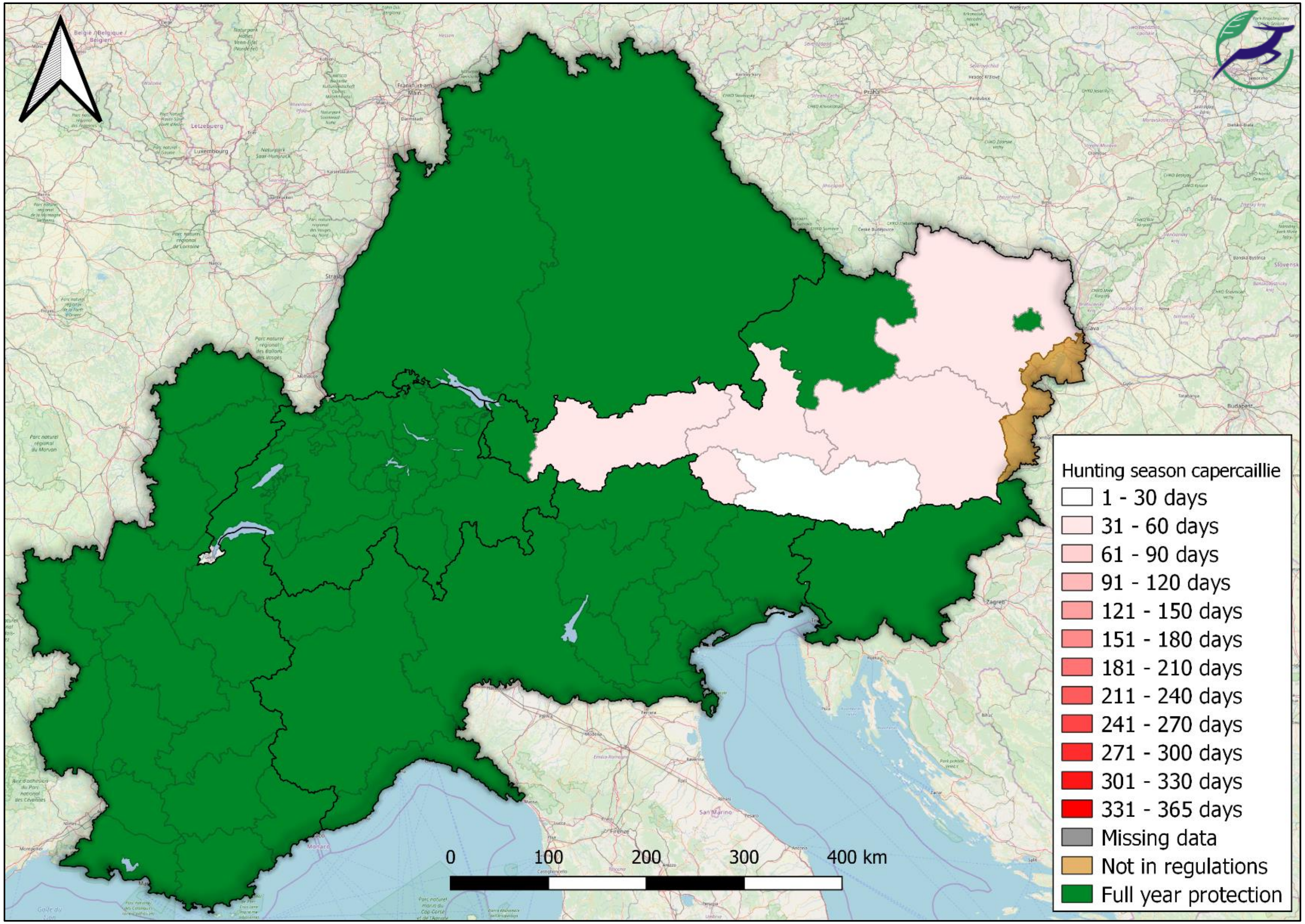

Figure 13 – Hunting seasons for capercaillie; Data by EuroGeographics, and OpenStreetMaps

1.3 Hunting season chamois

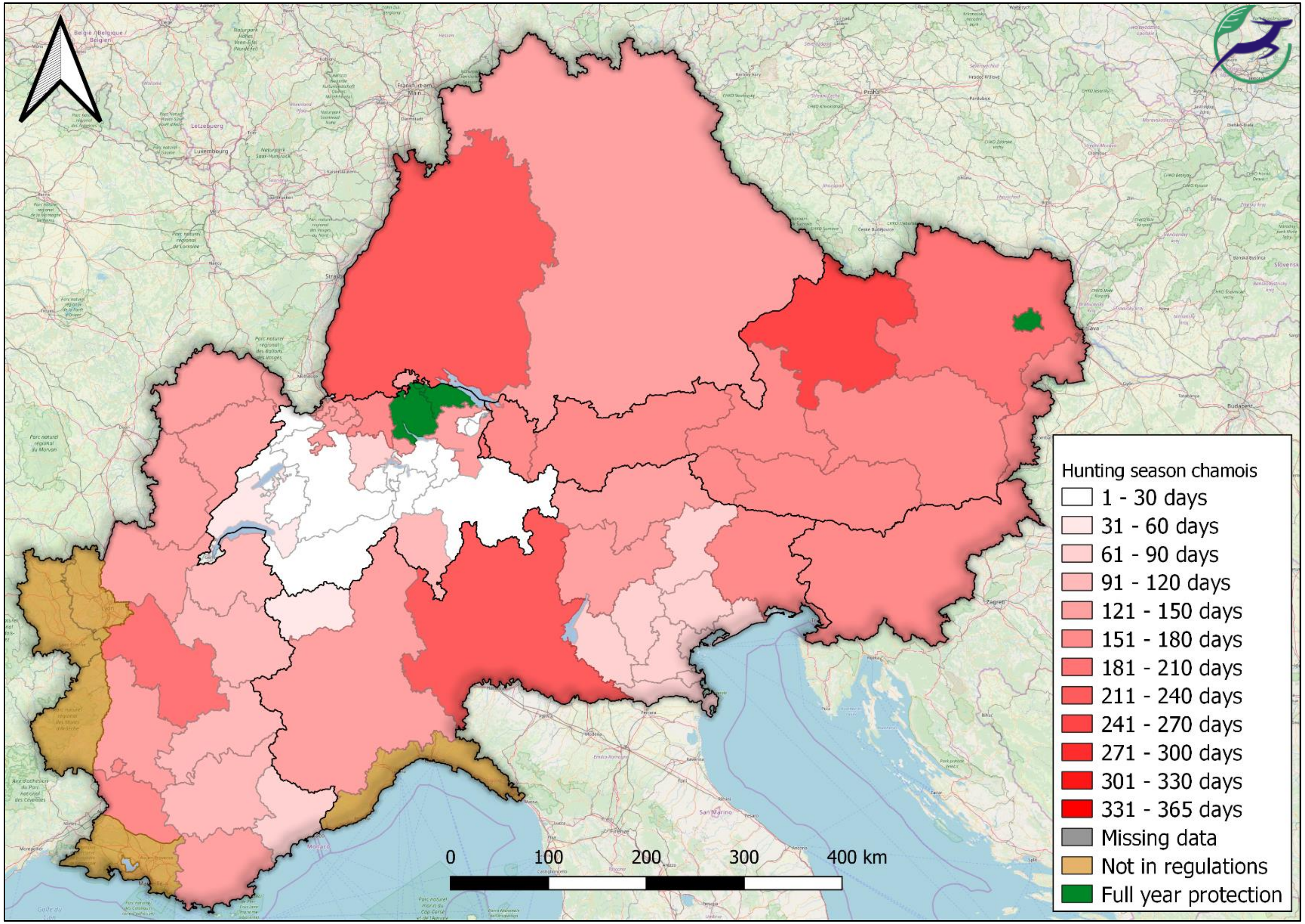

Figure 14 – Hunting seasons for chamois; Data by EuroGeographics, and OpenStreetMaps

1.4 Hunting season ibex

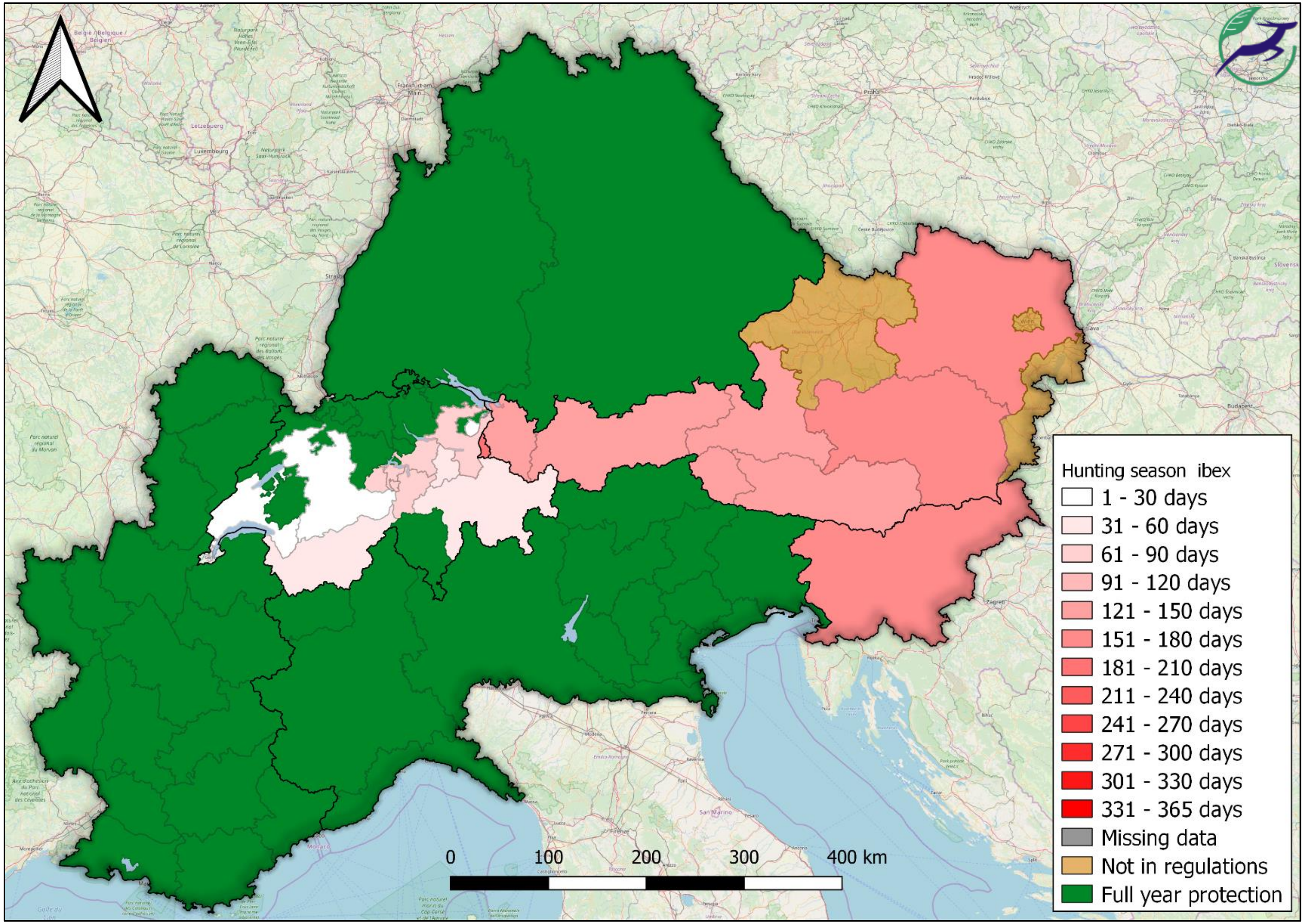

Figure 15 – Hunting seasons for ibex; Data by EuroGeographics, and OpenStreetMaps

1.5 Hunting season roe deer

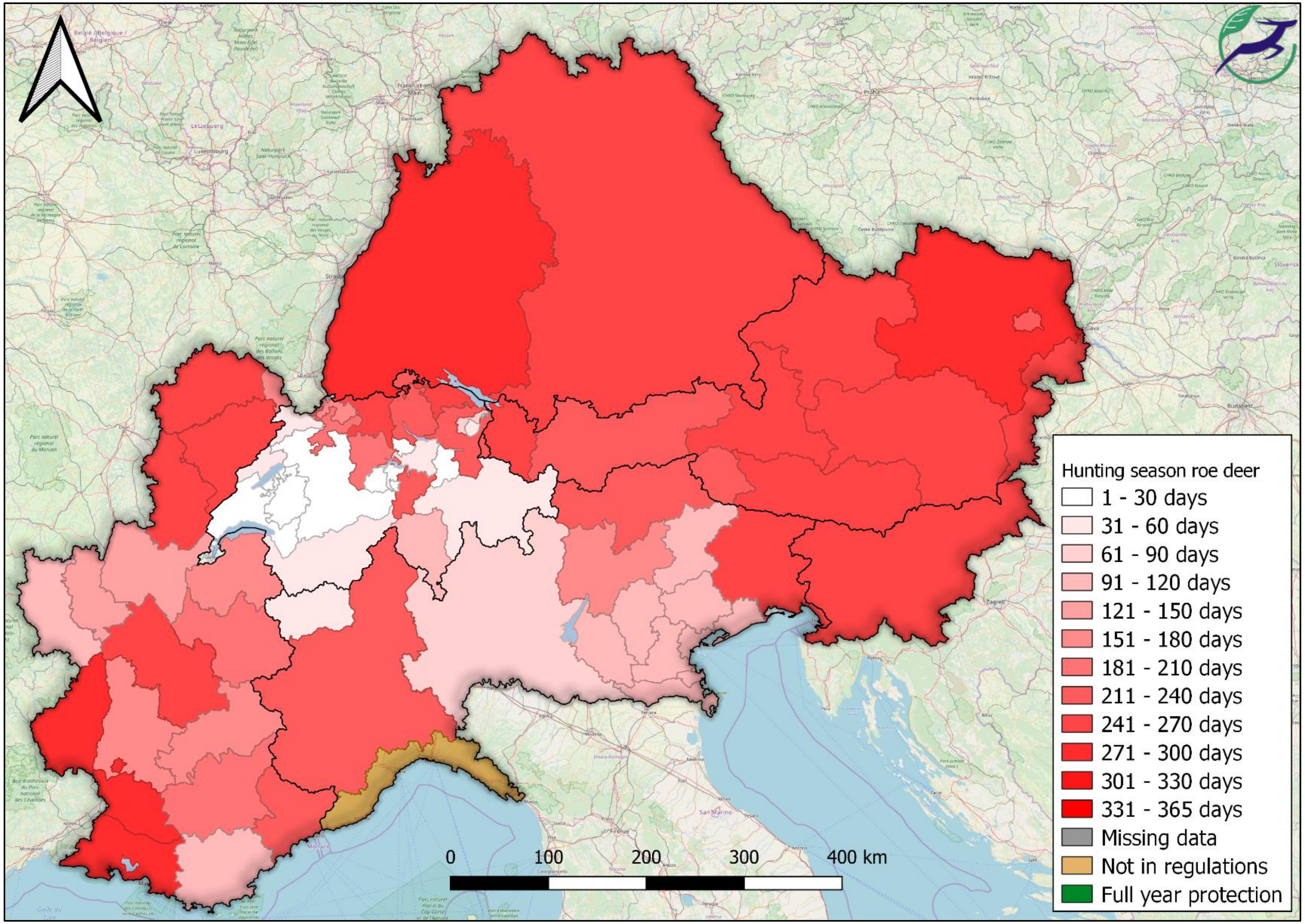

Figure 16 – Hunting seasons for roe deer; Data by EuroGeographics, and OpenStreetMaps

1.6 Hunting season wild boar

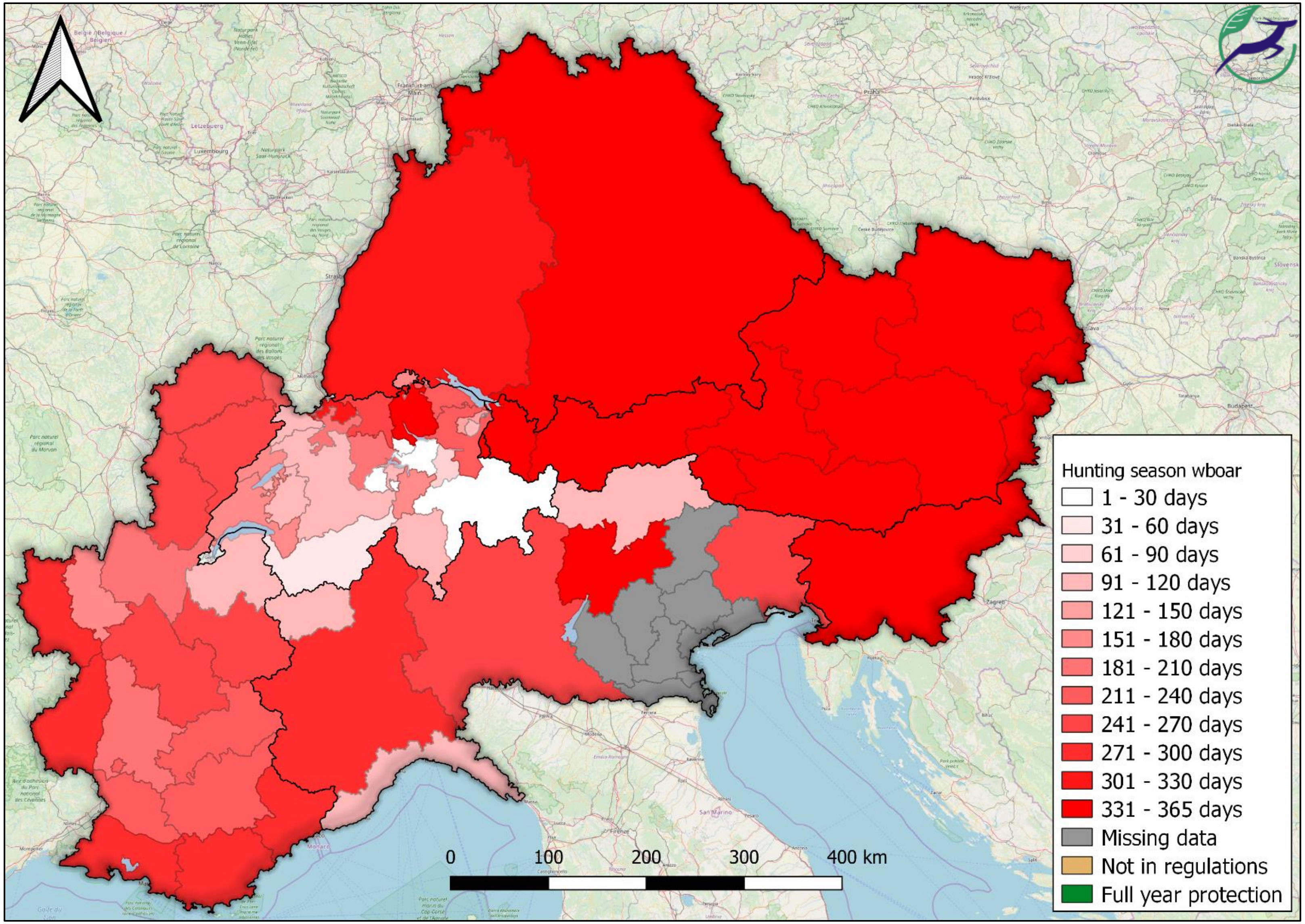

Figure 17 – Hunting seasons for wild boar; Data by EuroGeographics, and OpenStreetMaps

1.7 Hunting season European brown hare

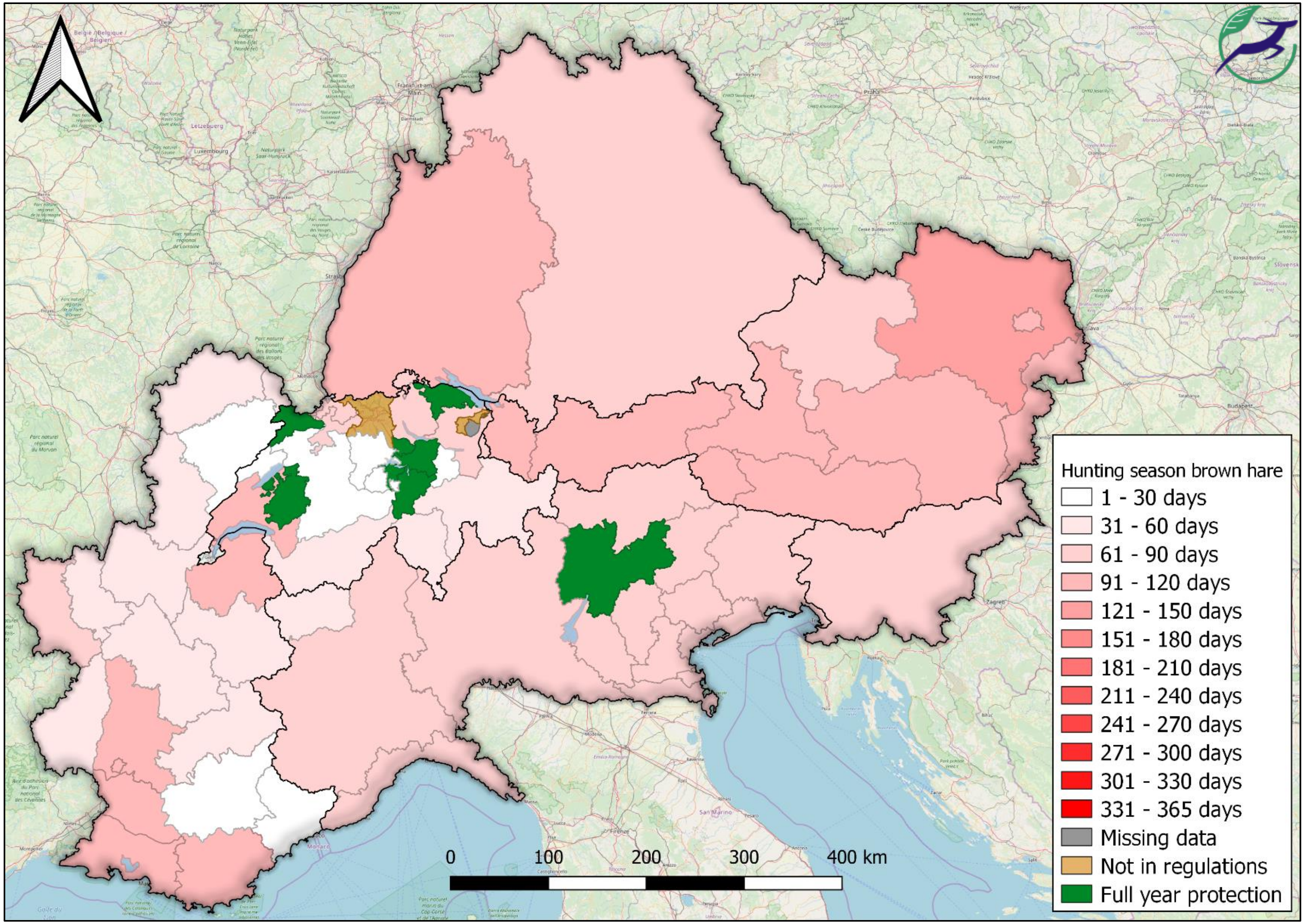

Figure 18 – Hunting seasons for European brown hare; Data by EuroGeographics, and OpenStreetMaps

2 Appendix II – Hunting season differences

2.1 Hunting season difference black grouse

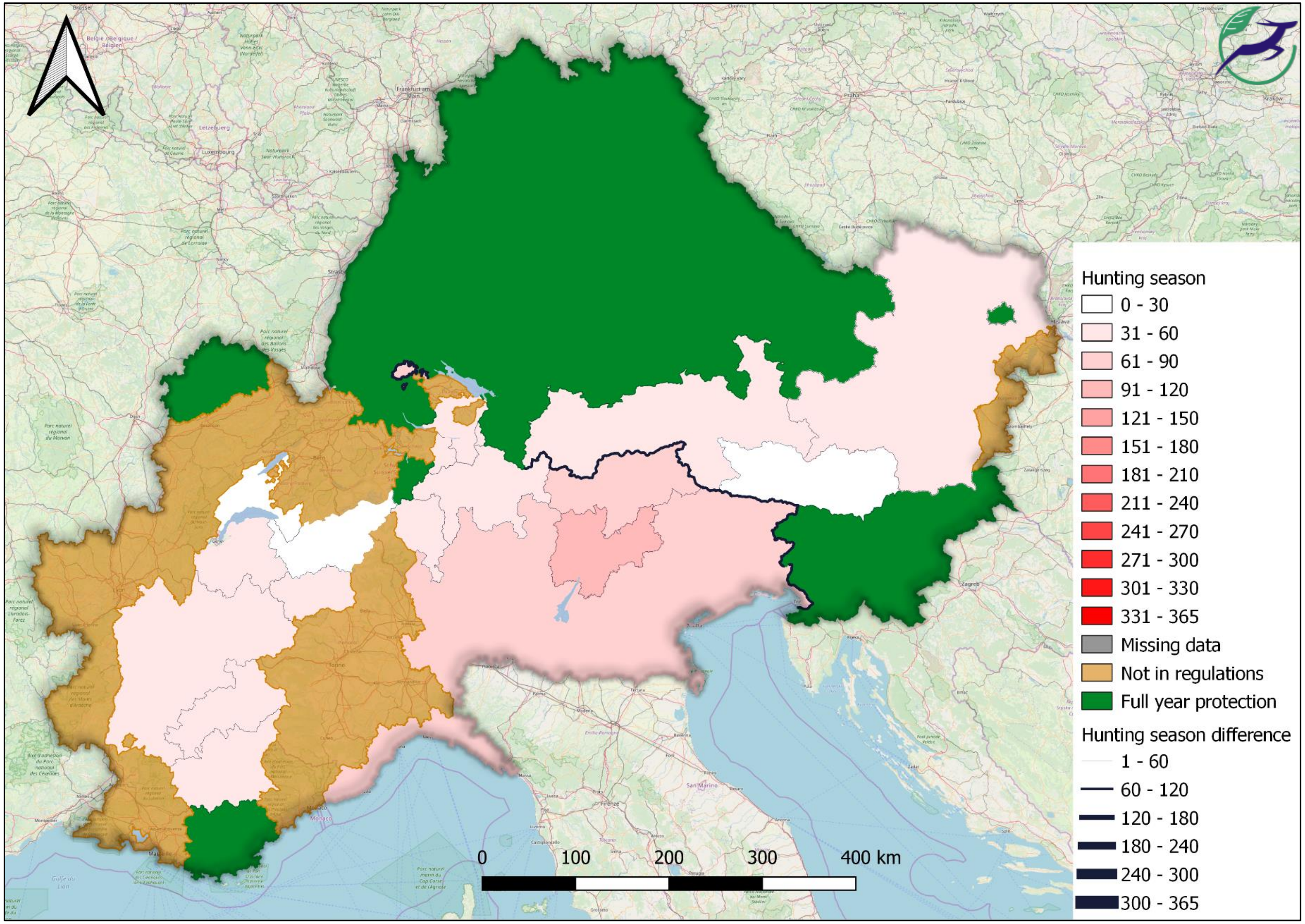

Figure 19 – Hunting season differences for black grouse; Data by EuroGeographics, and OpenStreetMaps

2.2 Hunting season difference capercaillie

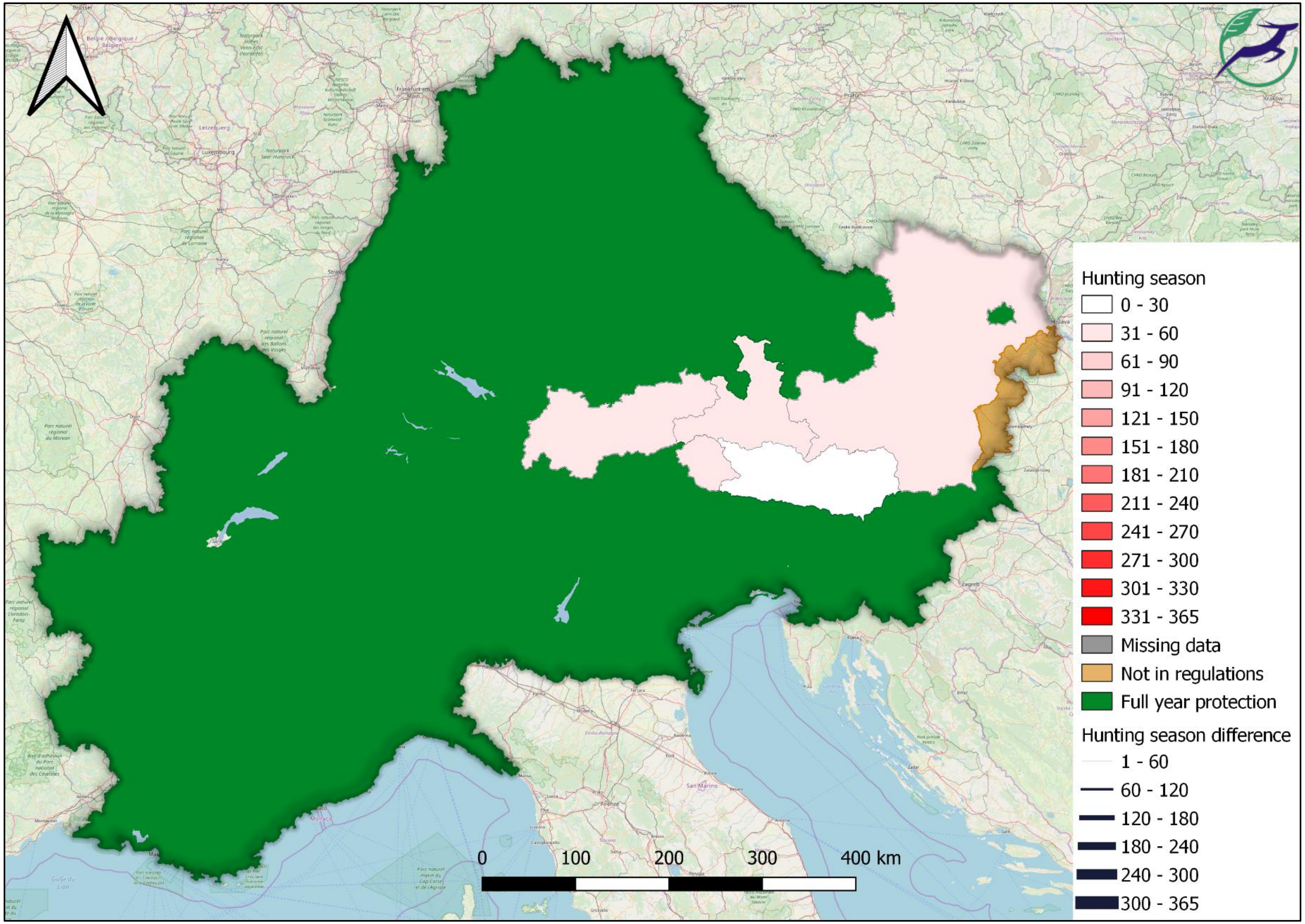

Figure 20 – Hunting season differences for capercaillie; Data by EuroGeographics, and OpenStreetMaps

2.3 Hunting season difference chamois

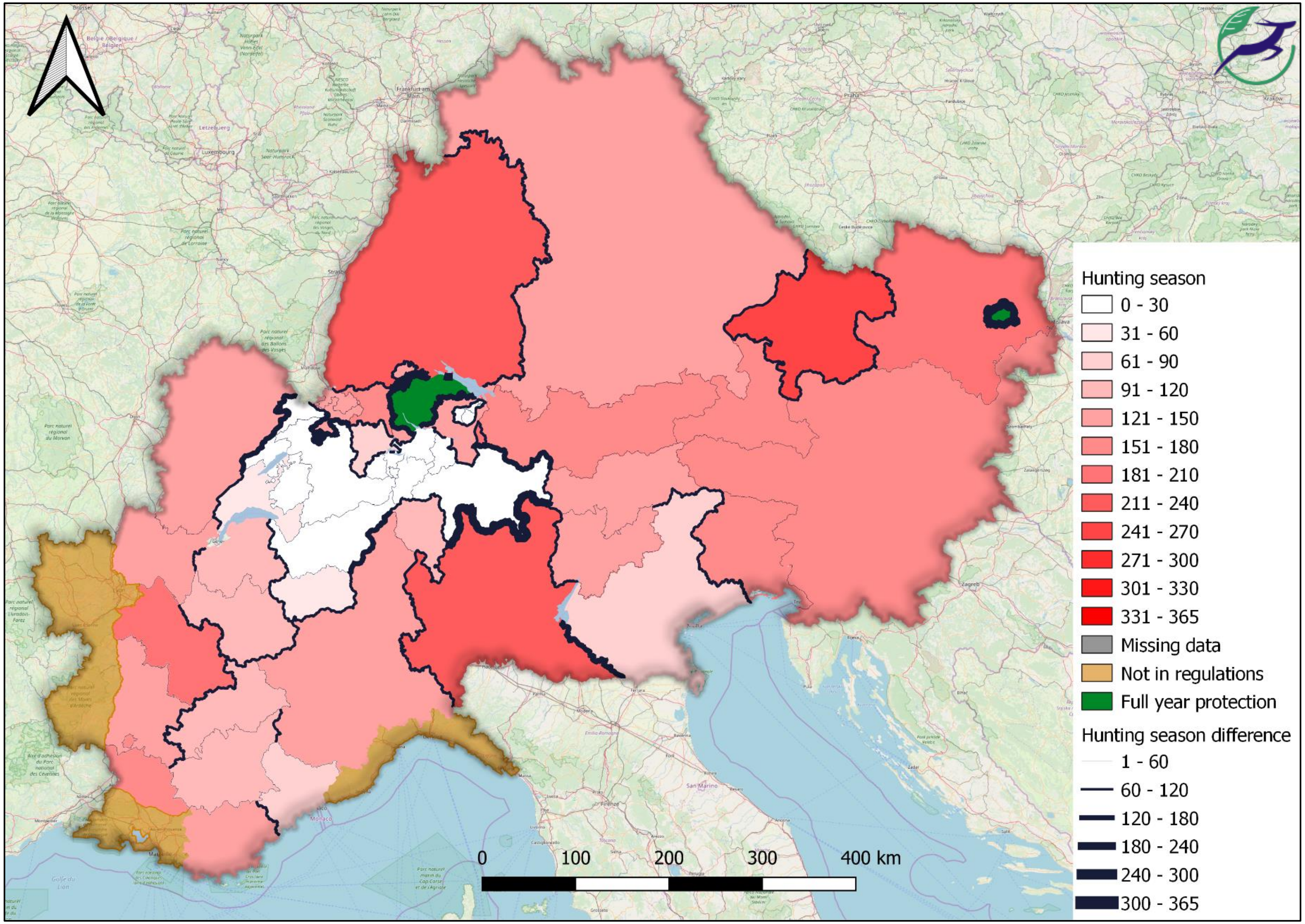

Figure 21 – Hunting season differences for chamois; Data by EuroGeographics, and OpenStreetMaps

2.4 Hunting season difference ibex

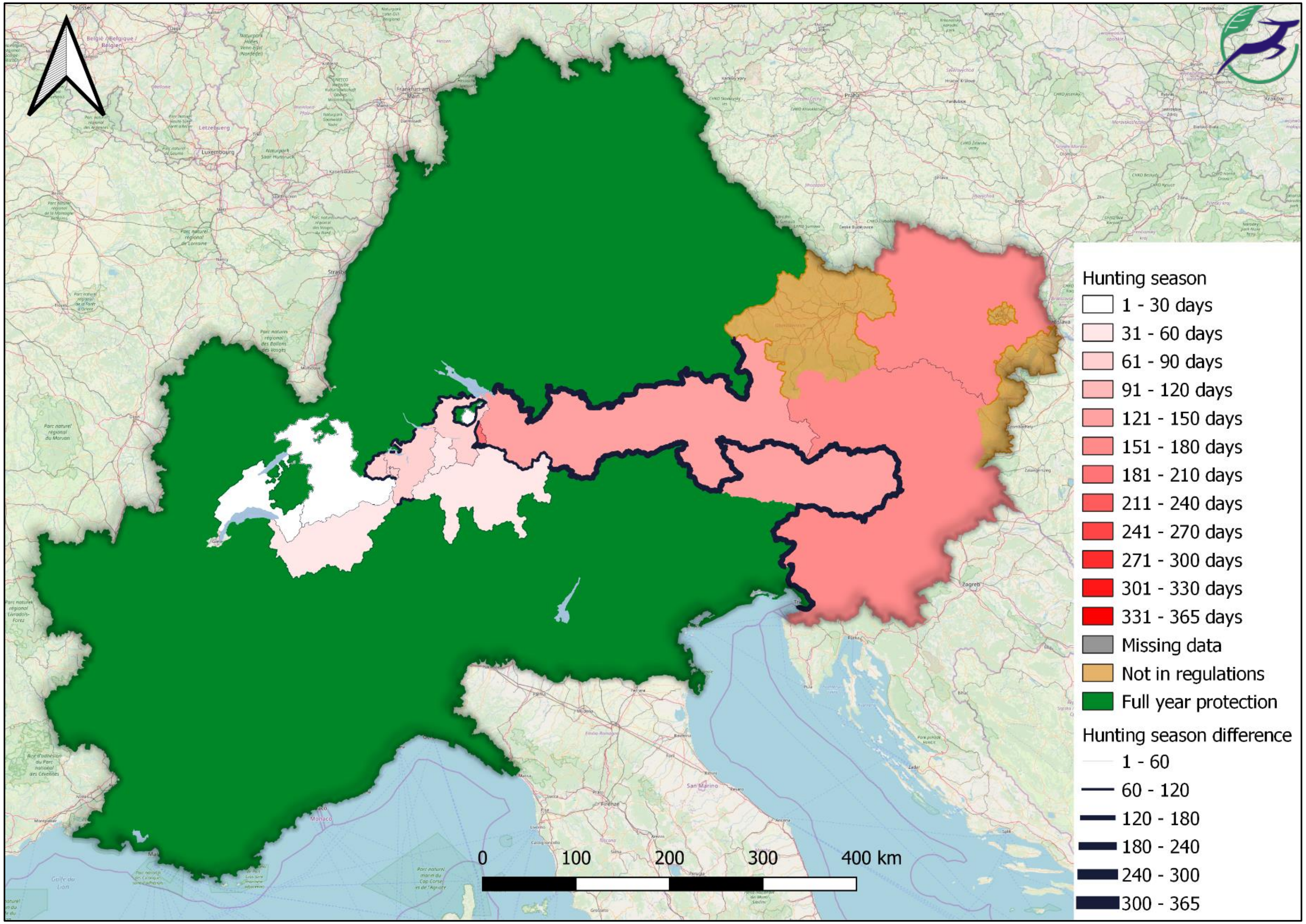

Figure 22 – Hunting season differences for ibex; Data by EuroGeographics, and OpenStreetMaps

2.5 Hunting season difference roe deer

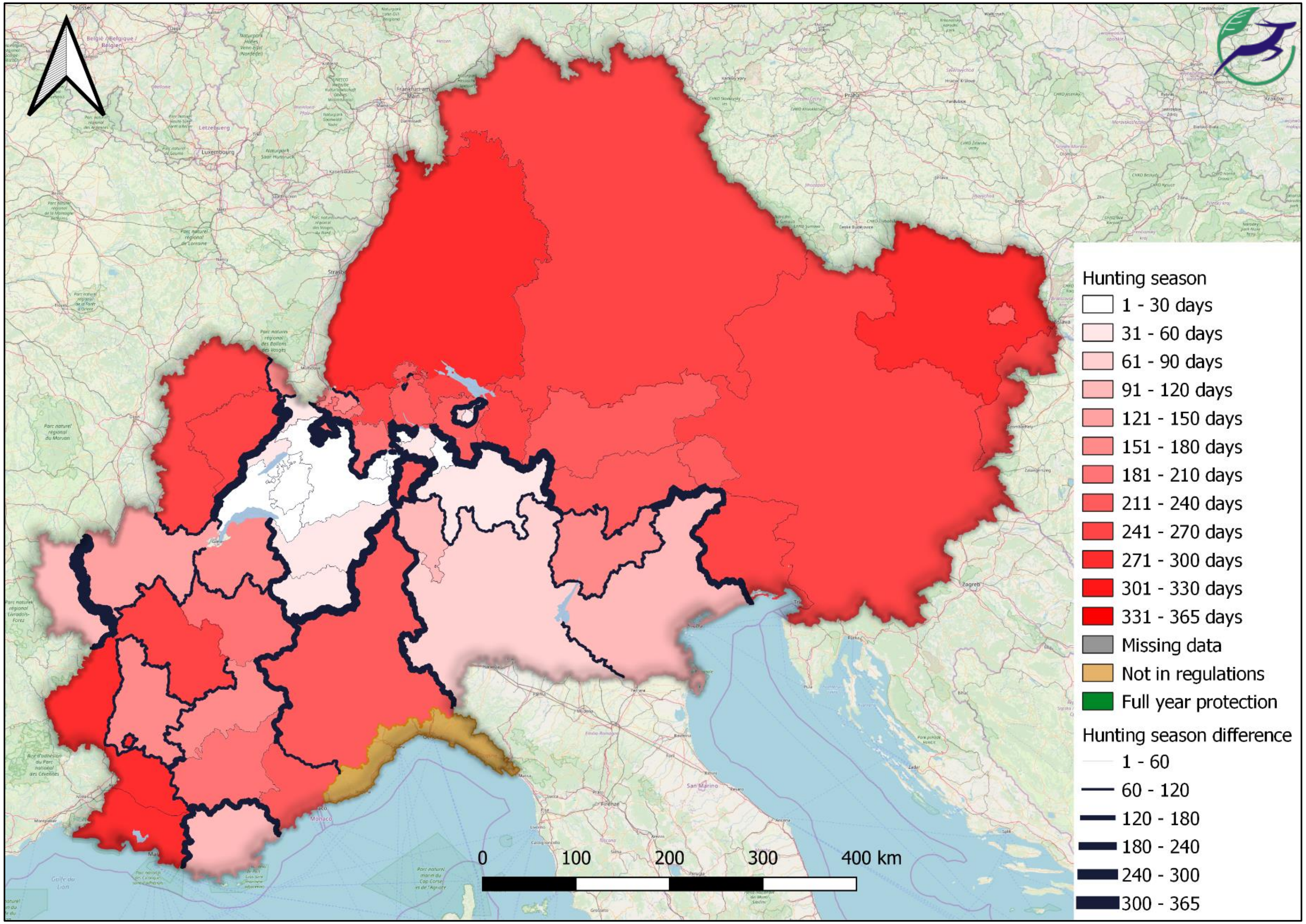

Figure 23 – Hunting season differences for roe deer; Data by EuroGeographics, and OpenStreetMaps

2.6 Hunting season difference wild boar

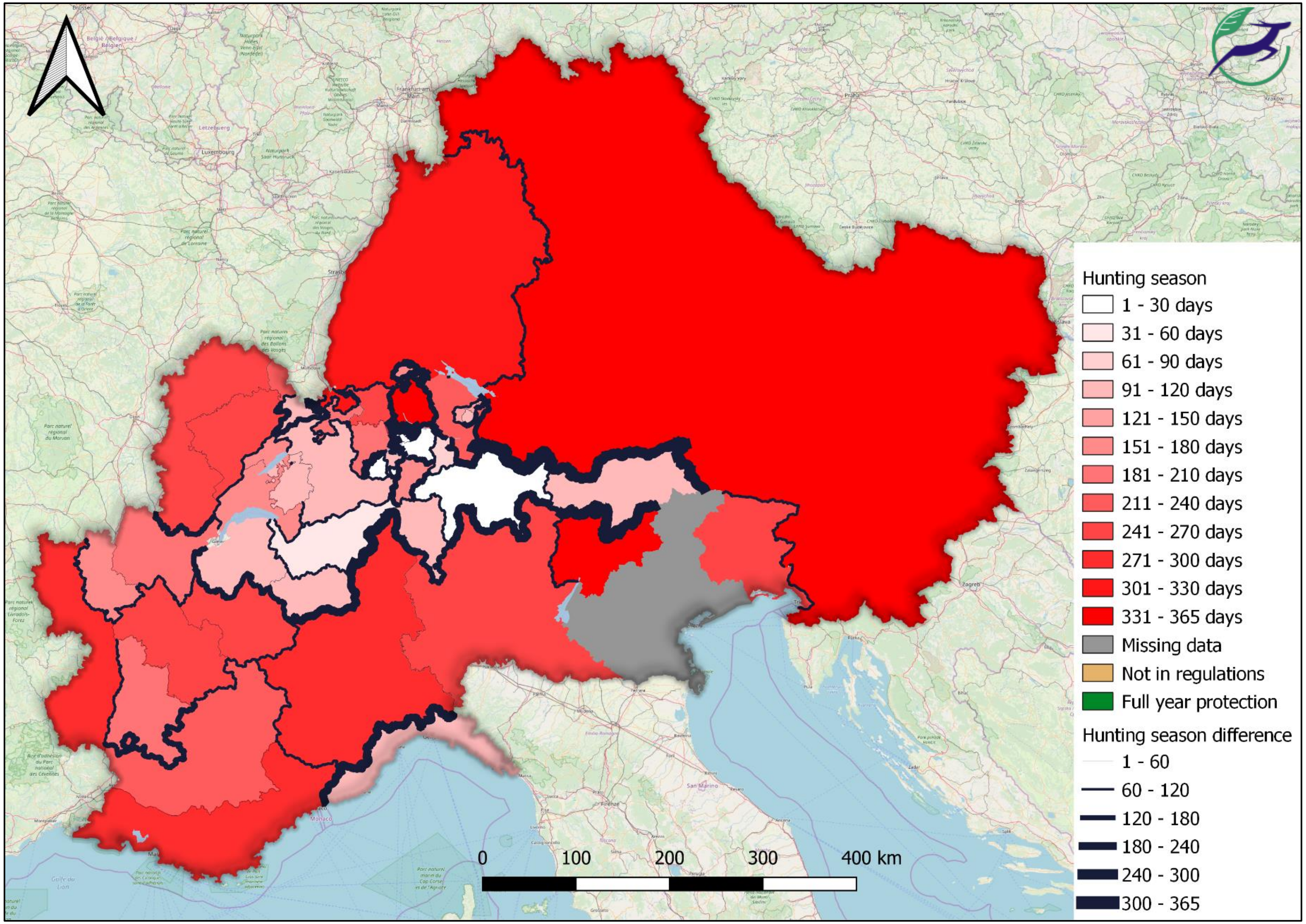

Figure 24 – Hunting season differences for wild boar; Data by EuroGeographics, and OpenStreetMaps

2.7 Hunting season difference European brown hare

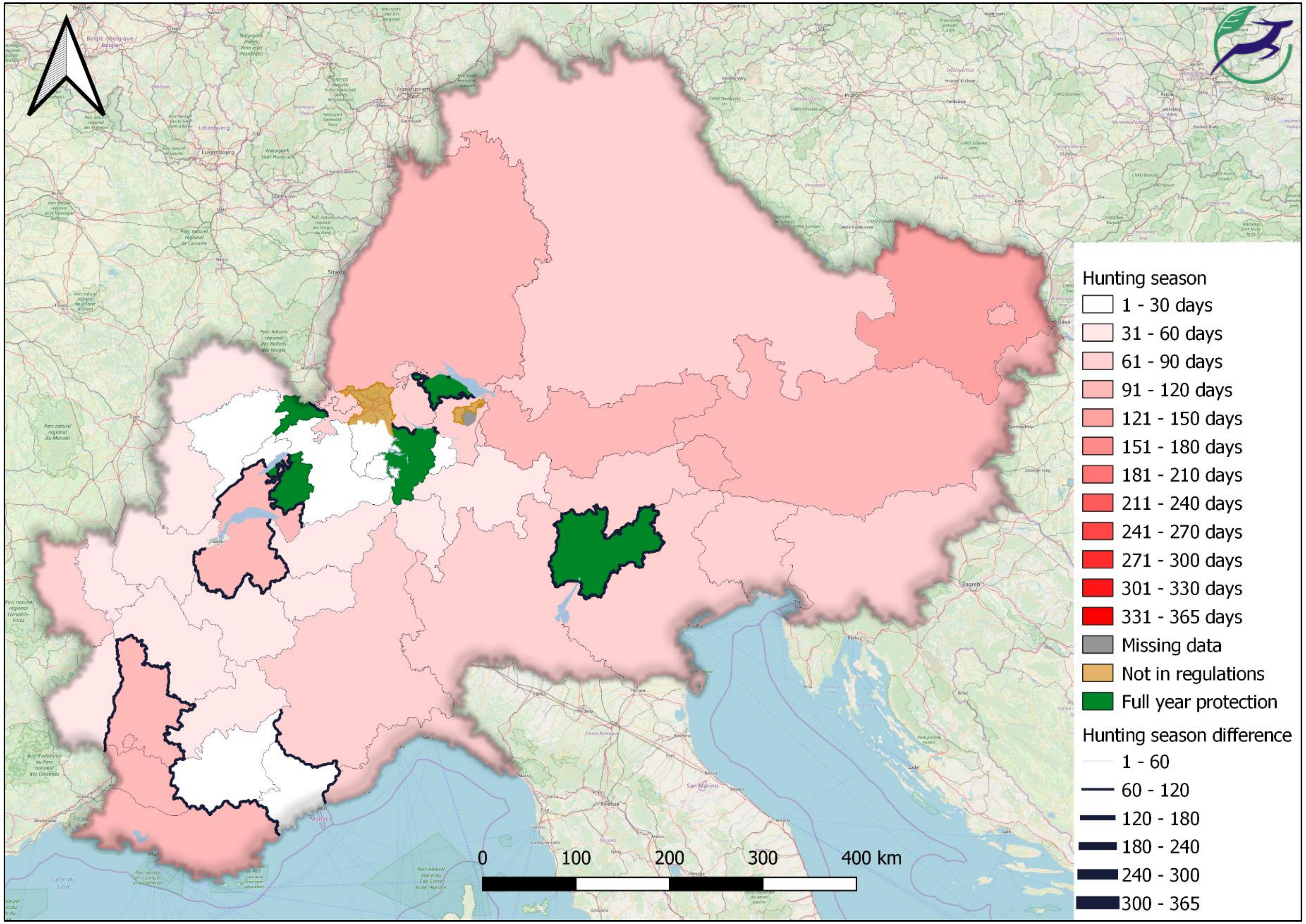

Figure 25 – Hunting season differences for European brown hare; Data by EuroGeographics, and OpenStreetMaps

3 Appendix III – Species distribution

3.1 Distribution map chamois

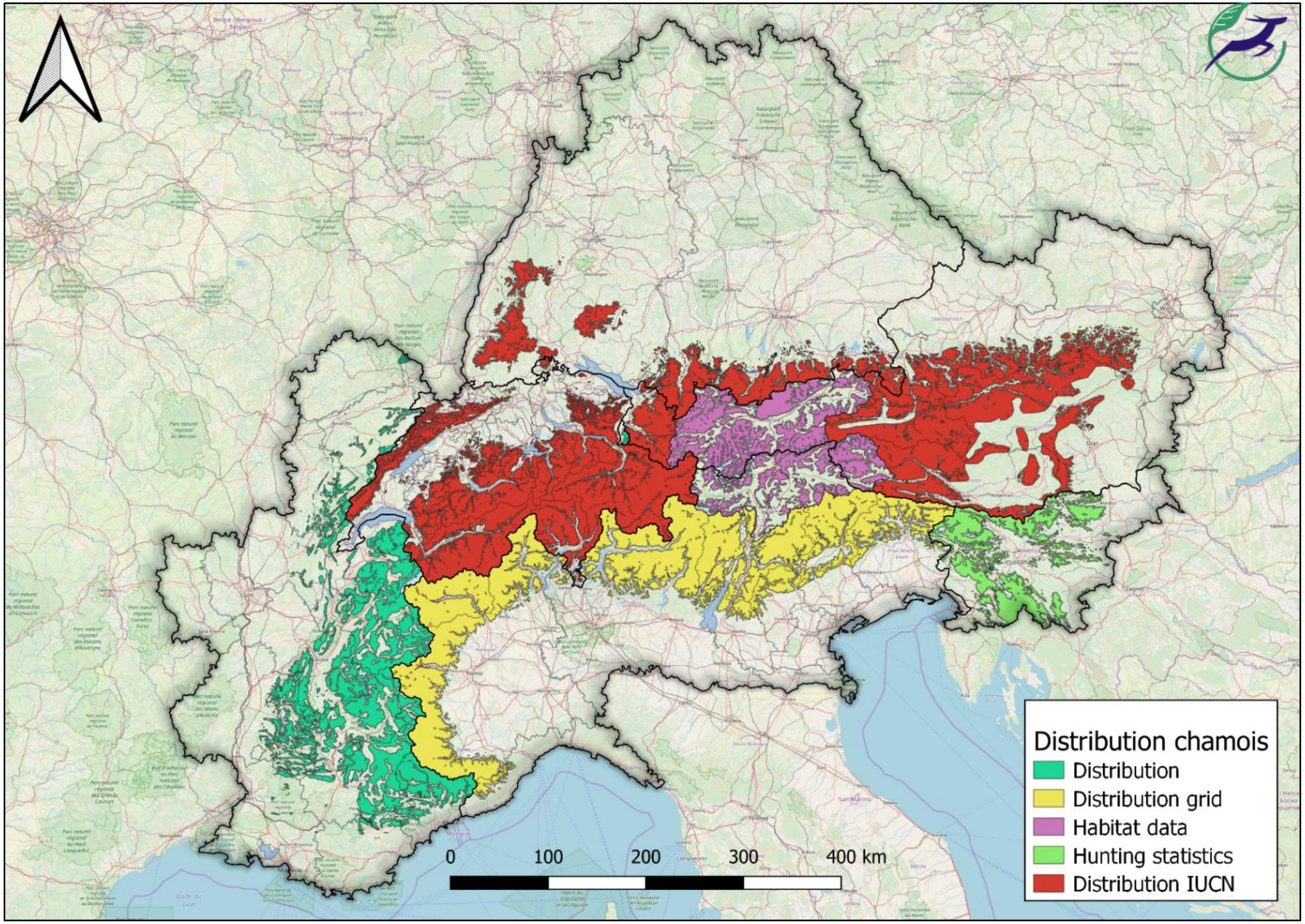

Figure 26 - Distribution data for chamois; Data source:see Sources below;Data by EuroGeographics, and OpenStreetMaps

3.1.1 Sources chamois geodata

Distribution data

Dataset	Country / Region covered	Country / Region applied	Year created	Year updated	Source	Type
Tirol Gams Sommerlebensraum	Tirol	AT33			Amt der Tiroler Landesregierung	Habitat
IUCN chamois distribution	EU	AT		2008	IUCN Red List	IUCN
IUCN chamois distribution	EU	DE		2008	IUCN Red List	IUCN
IUCN chamois distribution	EU	CH		2008	IUCN Red List	IUCN
France chamois distribution	France	FR		2011	ONCFS France	Distribution
Haute-Savoie chamois distribution	Haute-Savoie	FR718		2016	FDC Haute-Savoie (FDC74)	Distribution
Italy chamois presence	Italy	IT			Institute for Environmental Protection and Research	Distribution grid
Südtirol Gams Lebensraum	Südtirol	ITH1			Südtiroler Landesverwaltung	Habitat
Liechtenstein Gams Verbreitung	Liechtenstein	LI			Amt für Umwelt Liechtenstein	Distribution
Hunting statistics Slovenia	Slovenia	SI			Slovenian Forest Service	Hunting bag

Table 5 – Sources distribution data chamois

Absence data

Dataset	Country / Region covered	Country / Region applied	Year created	Year updated	Source
TLM Siedlungen Schweiz	Switzerland	CH			Bundesamt für Landestopografie swisstopo
Ortslage Berchtesgaden	Berchtesgaden	DE215		2014	AdV Deutschland
Corine Landcover	EU	EUSALP		2012	Copernicus Land Monitoring Service
Landnutzungsplan Südtirol	Südtirol	ITH1		2018	Autonome Provinz Bozen - Südtirol

Table 6 – Sources absence data chamois

Special parameters

Dataset	Distribution / Absence	Parameters
France chamois distribution	distribution	nuts3_id != FR718
Hunting statistics Slovenia	distribution	intersect with community NUTS
Italy chamois presence	distribution	nuts2_id != ITH1, point layer 80 km buffer intersect with community NUTS
IUCN chamois distribution	distribution	cntr = DE, intersect with community NUTS
IUCN chamois distribution	distribution	cntr = AT AND nuts2_id != AT33
IUCN chamois distribution	distribution	cntr = CH
Corine Landcover	absence	legend_lab ~* artificial
Landnutzungsplan Südtirol	absence	bez_d ~* gewerbe, spielplatz, wohn, parkplatz, verkehrsinsel, zone

Table 7 – Special parameters chamois

3.2 Distribution map ibex

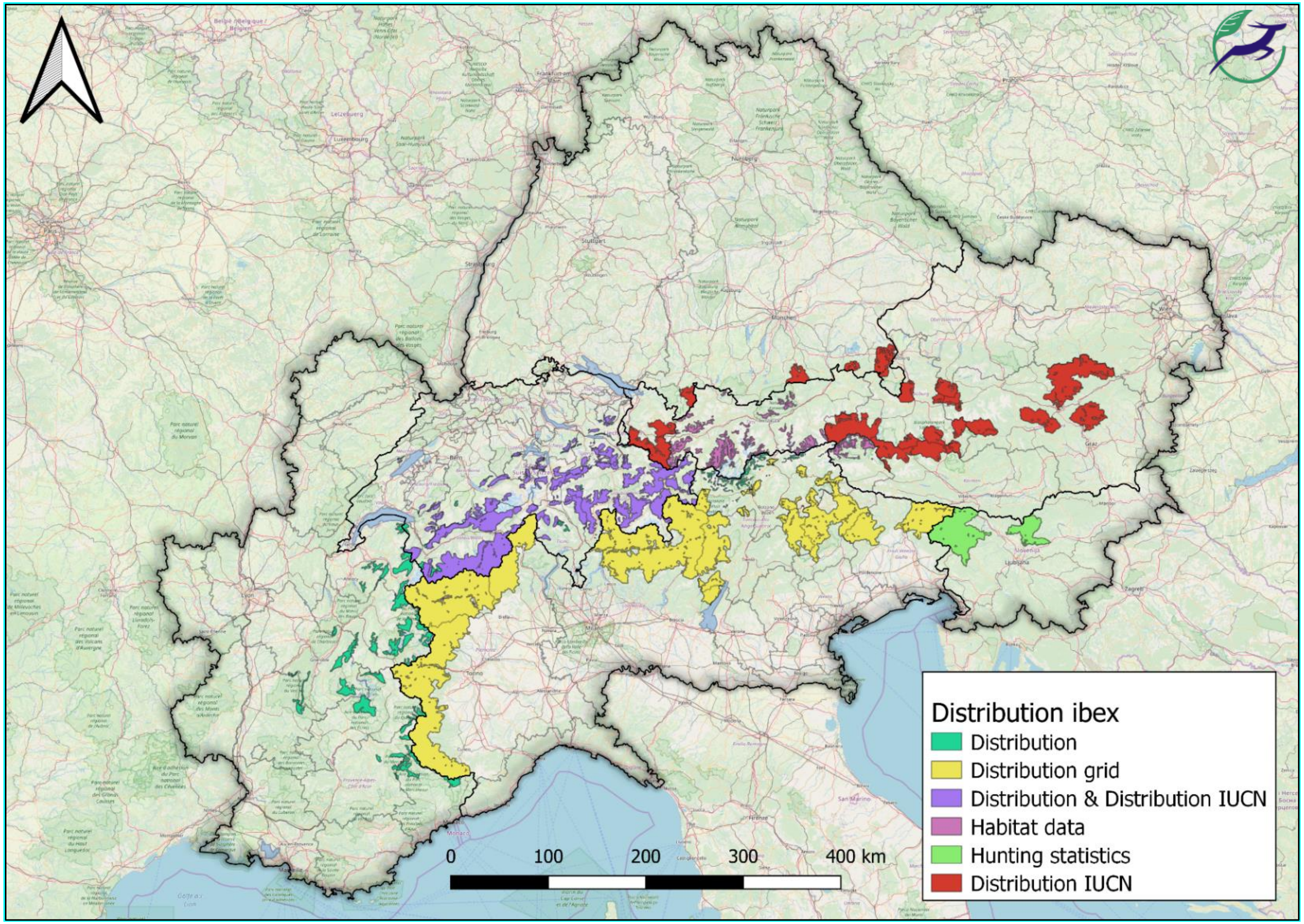

Figure 27 - Distribution data for ibex; Data source:see Sources below;Data by EuroGeographics, and OpenStreetMaps

3.2.1 Sources ibex geodata

Distribution data

Dataset	Country / Region covered	Country / Region applied	Year created	Year updated	Source	Type
Tirol Steinbock Sommerlebensraum	Tirol	AT33			Amt der Tiroler Landesregierung	Habitat
Schweiz Steinbock Kolonien	Switzerland	CH	2011	2015	Bundesamt für Umwelt Schweiz	Distribution
IUCN ibex distribution	EU	DE		2008	IUCN Red List	IUCN
IUCN ibex distribution	EU	CH		2008	IUCN Red List	IUCN
IUCN ibex distribution	EU	AT		2008	IUCN Red List	IUCN
France ibex distribution	France	FR		2010	ONCFS France	Distribution
Haute-Savoie ibex distribution	Haute-Savoie	FR718		2016	FDC Haute-Savoie (FDC74)	Distribution
Italy ibex presence	Italy	IT			Institute for Environmental Protection and Research	Distribution grid
Südtirol Steinbock Kolonien	Südtirol	ITH1	2011	2015	Südtiroler Landesverwaltung	Distribution
Südtirol Steinbock Kolonien Winter	Südtirol	ITH1	2011	2015	Südtiroler Landesverwaltung	Distribution
Sütirol Steinbock Kolonien Sommer	Südtirol	ITH1	2011	2015	Südtiroler Landesverwaltung	Distribution
Liechtenstein Steinbock Verbreitung	Liechtenstein	LI			Amt für Umwelt Liechtenstein	Distribution
Hunting statistics Slovenia	Slovenia	SI			Slovenian Forest Service	Hunting bag

Table 8 - Sources distribution data ibex

Absence data

Dataset	Country / Region covered	Country / Region applied	Year created	Year updated	Source
TLM Siedlungen Schweiz	Switzerland	CH			Bundesamt für Landestopografie swisstopo
Ortslage Berchtesgaden	Berchtesgaden	DE215		2014	AdV Deutschland
Corine Landcover	EU	EUSALP		2012	Copernicus Land Monitoring Service
Landnutzungsplan Südtirol	Südtirol	ITH1		2018	Autonome Provinz Bozen - Südtirol

Table 9 - Sources absence data ibex

Special parameters

Dataset	Distribution / Absence	Parameters
France ibex distribution	distribution	nuts3_id != FR718
Hunting statistics Slovenia	distribution	intersect with community NUTS
Italy ibex presence	distribution	nuts3_id not in (ITH33 , ITH10 , ITH20), point layer 80 km buffer intersect with community NUTS
IUCN ibex distribution	distribution	cntr = CH
IUCN ibex distribution	distribution	cntr = AT AND nuts2_id != AT33, intersect with community NUTS
IUCN ibex distribution	distribution	cntr = DE, intersect with community NUTS
Corine Landcover	absence	legend_lab ~* artificial
Landnutzungsplan Südtirol	absence	bez_d ~* gewerbe, spielplatz, wohn, parkplatz, verkehrsinsel, zone

Table 10 - Special parameters chamois

3.3 Distribution map red deer

See page 33

3.3.1 Sources red deer geodata

Distribution data

Dataset	Country / Region covered	Country / Region applied	Year created	Year updated	Source	Type
Jagdstatistik Österreich	Austria	AT			STATISTICS AUSTRIA	Hunting bag
Tirol Rotwild Sommerlebensraum	Tirol	AT33			Amt der Tiroler Landesregierung	Habitat
Jagdstatistik Schweiz	Switzerland	CH			Bundesamt für Umwelt Schweiz	Hunting bag
Deutschland Rotwild Lebensraum	Germany	DE			Bayerisches Landesamt für Umwelt	Habitat
France red deer distribution	France	FR		2015	ONCFS France	Distribution
Italy red deer presence	Italy	IT			Institute for Environmental Protection and Research	Distribution grid
Südtirol Rothirsch Lebensraum	Südtirol	ITH1	2005	2017	Südtiroler Landesverwaltung	Habitat
Liechtenstein Rotwild Verbreitung	Liechtenstein	LI			Amt für Umwelt Liechtenstein	Distribution
Hunting statistics Slovenia	Slovenia	SI			Slovenian Forest Service	Hunting bag

Table 11 Sources distribution data red deer

Absence data

Dataset	Country / Region covered	Country / Region applied	Year created	Year updated	Source
Elevation	EU	EUSALP			Eurostat
TLM Siedlungen Schweiz	Switzerland	CH			Bundesamt für Landestopografie swisstopo
Ortslage Berchtesgaden	Berchtesgaden	DE215		2014	AdV Deutschland
Corine Landcover	EU	EUSALP		2012	Copernicus Land Monitoring Service
Landnutzungsplan Südtirol	Südtirol	ITH1		2018	Autonome Provinz Bozen - Südtirol

Table 12 - Sources absence data red deer

Special parameters

Dataset	Distribution / Absence	Parameters
Hunting statistics Slovenia	distribution	hunting statistics 1x1 km grid
Italy red deer presence	distribution	cntr = IT AND nuts2_id != ITH1, point layer 80 km buffer intersect with community NUTS
Jagdstatistik Österreich	distribution	nuts2_id != AT33, intersect with community NUTS
Jagdstatistik Schweiz	distribution	intersect with community NUTS
Corine Landcover	absence	legend_lab ~* artificial
Elevation	absence	over 3000 m
Landnutzungsplan Südtirol	absence	bez_d ~* gewerbe, spielplatz, wohn, parkplatz, verkehrsinsel, zone

Table 13 – Special parameters red deer

3.4 Distribution map roe deer

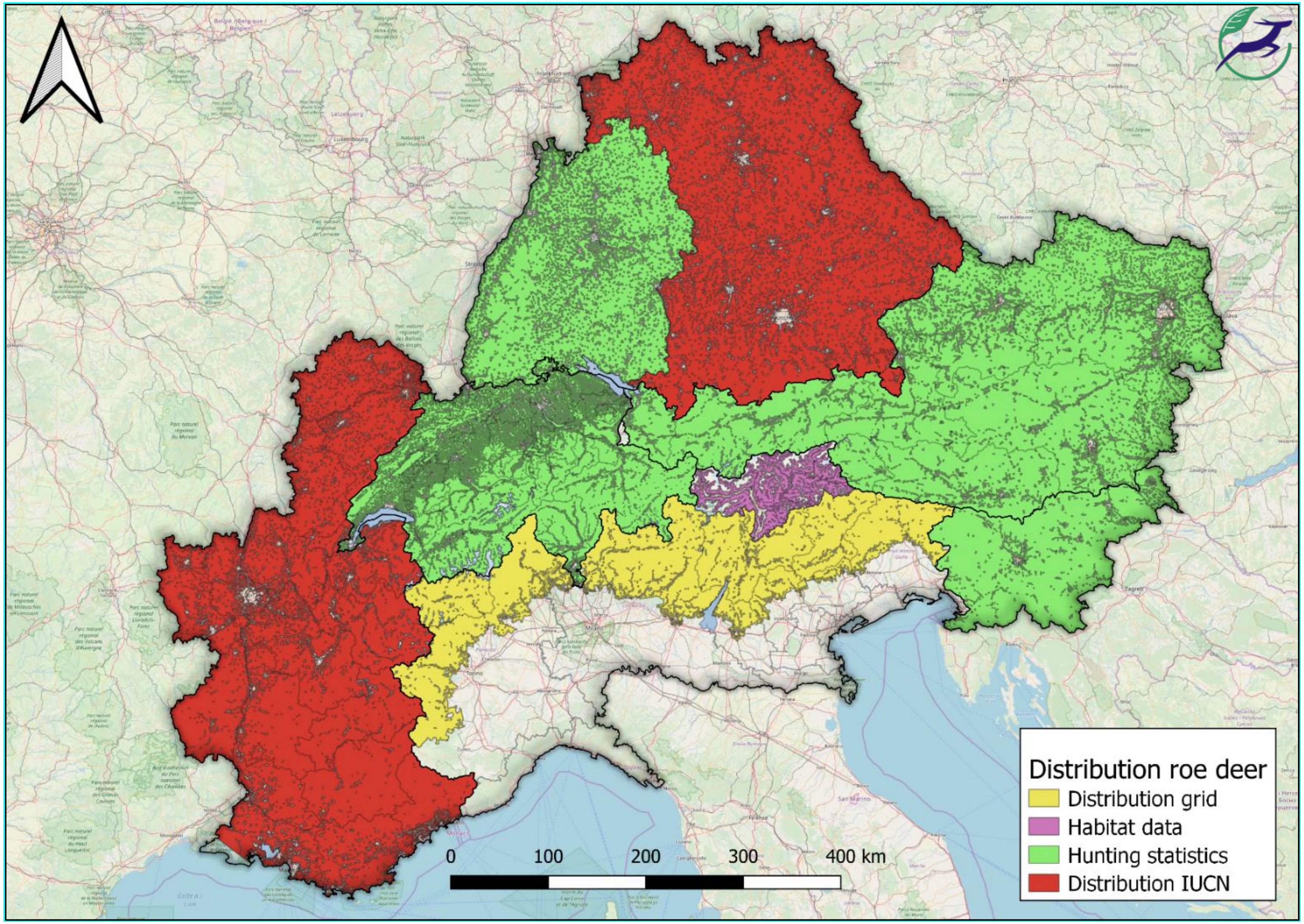

Figure 28 - Distribution data for roe deer; Data source:see Sources below;Data by EuroGeographics, and OpenStreetMaps

3.4.1 Sources roe deer geodata

Distribution data

Dataset	Country / Region covered	Country / Region applied	Year created	Year updated	Source	Type
Jagdstatistik Österreich	Austria	AT			STATISTICS AUSTRIA	Hunting bag
Jagdstatistik Schweiz	Switzerland	CH			Bundesamt für Umwelt Schweiz	Hunting bag
Jagdstatistik Baden-Württemberg	Baden-Württemberg	DE1			Landwirtschaftliches Zentrum Baden-Württemberg	Hunting bag
IUCN roe deer distribution	EU	DE2%%		2016	IUCN Red List	IUCN
IUCN roe deer distribution	EU	FR		2016	IUCN Red List	IUCN
Italy roe deer presence	Italy	IT			Institute for Environmental Protection and Research	Distribution grid
Südtirol Reh Lebensraum	Südtirol	ITH1			Südtiroler Landesverwaltung	Habitat
Liechtenstein Rehwild Verbreitung	Liechtenstein	LI			Amt für Umwelt Liechtenstein	Distribution
Hunting statistics Slovenia	Slovenia	SI			Slovenian Forest Service	Hunting bag

Table 14 - Sources distribution data roe deer

Absence data

Dataset	Country / Region covered	Country / Region applied	Year created	Year updated	Source
Elevation	EU	EUSALP			Eurostat
TLM Siedlungen Schweiz	Switzerland	CH			Bundesamt für Landestopografie swisstopo
Ortslage Berchtesgaden	Berchtesgaden	DE215		2014	AdV Deutschland
Corine Landcover	EU	EUSALP		2012	Copernicus Land Monitoring Service
Landnutzungsplan Südtirol	Südtirol	ITH1		2018	Autonome Provinz Bozen - Südtirol

Table 15 - Sources absence data roe deer

Special parameters

Dataset	Distribution / Absence	Parameters
Hunting statistics Slovenia	distribution	intersect with community NUTS
Italy roe deer presence	distribution	nuts2_id != ITH1, point layer 80 km buffer intersect with community NUTS
IUCN roe deer distribution	distribution	nuts2_id ILIKE DE2%%, intersect with community NUTS
IUCN roe deer distribution	distribution	cntr = FR, intersect with community NUTS
Jagdstatistik Baden-Württemberg	distribution	intersect with community NUTS
Jagdstatistik Österreich	distribution	intersect with community NUTS
Jagdstatistik Schweiz	distribution	intersect with community NUTS
Corine Landcover	absence	legend_lab ~* artificial
Elevation	absence	over 3000 m
Landnutzungsplan Südtirol	absence	bez_d ~* gewerbe, spielplatz, wohn, parkplatz, verkehrsinsel, zone

Table 16 - Special parameters roe deer

3.5 Distribution map wild boar

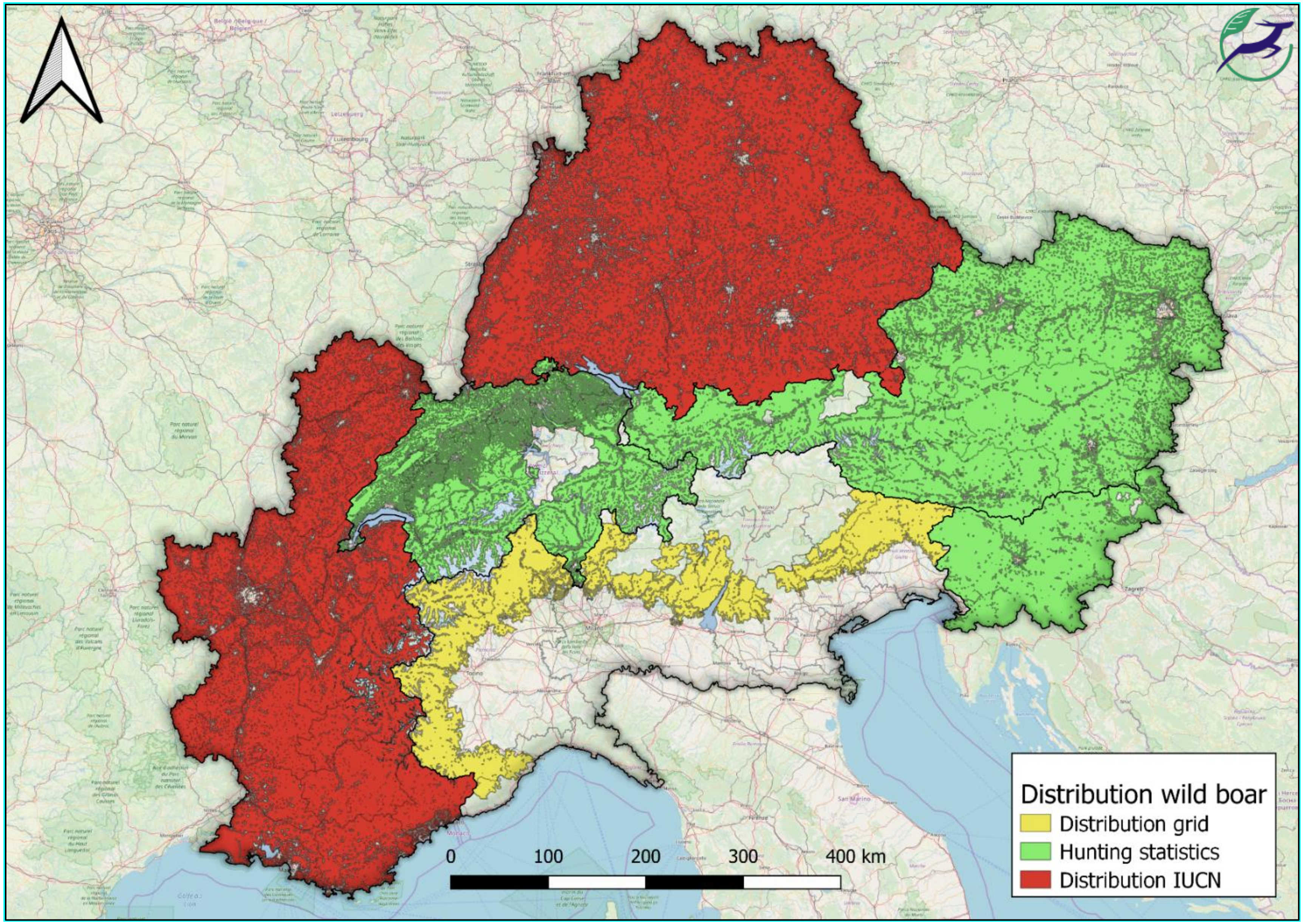

Figure 29 - Distribution data for wild boar; Data source:see Sources below;Data by EuroGeographics, and OpenStreetMaps

3.5.1 Sources wild boar geodata

Distribution data

Dataset	Country / Region covered	Country / Region applied	Year created	Year updated	Source	Type
Jagdstatistik Österreich	Austria	AT			STATISTICS AUSTRIA	Hunting bag
Jagdstatistik Schweiz	Switzerland	CH			Bundesamt für Umwelt Schweiz	Hunting bag
IUCN wild boar distribution	EU	DE		2008	IUCN Red List	IUCN
IUCN wild boar distribution	EU	FR		2008	IUCN Red List	IUCN
Italy wild boar presence	Italy	IT			Institute for Environmental Protection and Research	Distribution grid
Hunting statistics Slovenia	Slovenia	SI			Slovenian Forest Service	Hunting bag

Table 17 - Sources distribution data wild boar

Absence data

Dataset	Country / Region covered	Country / Region applied	Year created	Year updated	Source
Elevation	EU	EUSALP			Eurostat
TLM Siedlungen Schweiz	Switzerland	CH			Bundesamt für Landestopografie swisstopo
Ortslage Berchtesgaden	Berchtesgaden	DE215		2014	AdV Deutschland
Corine Landcover	EU	EUSALP		2012	Copernicus Land Monitoring Service
Landnutzungsplan Südtirol	Südtirol	ITH1		2018	Autonome Provinz Bozen - Südtirol

Table 18 - Sources absence data wild boar

Special parameters

Dataset	Distribution / Absence	Parameters
Hunting statistics Slovenia	distribution	intersect with community NUTS
Italy wild boar presence	distribution	point layer 80 km buffer intersect with community NUTS
IUCN wild boar distribution	distribution	cntr = DE, intersect with community NUTS
IUCN wild boar distribution	distribution	cntr = FR, intersect with community NUTS
Jagdstatistik Österreich	distribution	intersect with community NUTS
Jagdstatistik Schweiz	distribution	intersect with community NUTS
Corine Landcover	absence	legend_lab ~* artificial
Elevation	absence	over 2500 m
Landnutzungsplan Südtirol	absence	bez_d ~* gewerbe, spielplatz, wohn, parkplatz, verkehrsinsel, zone

Table 19 - Special parameters wild boar

3.6 References of distribution geodata

Dataset	Area covered	Source	Citation / copyright
Aree divieto di caccia	Friuli-Venezia Giulia	Regione Autonoma Friuli Venezia Giulia	Regione Autonoma Friuli Venezia Giulia
Corine Landcover	EU	Copernicus Land Monitoring Service	© European Union, Copernicus Land Monitoring Service 2018, European Environment Agency (EEA)
Deutschland Rotwild Lebensraum	Germany	Bayerisches Landesamt für Umwelt	© LFU Bayern
Elevation	EU	Eurostat	© EuroGeographics for the administrative boundaries
EUAP Protection areas no hunting	Italy	Ministero dell'Ambiente e della Tutela del Territorio e del Mare	Ministero dell'Ambiente e della Tutela del Territorio e del Mare - Direzione generale per la protezione della natura e del mare, CC-BY-SA-3.0
France chamois distribution	France	ONCFS France	© ONCFS, CC-BY 2.0
France ibex distribution	France	ONCFS France	© ONCFS, CC-BY 2.0
France red deer distribution	France	ONCFS France	© ONCFS, CC-BY 2.0
Fribourg Wildruhezonen	Fribourg	Service des Forêts et de la Faune Fribourg	© Staat Freiburg – WaldA – ABT_2017_01
Graubünden Wildschutzgebiete	Graubünden	Amt für Jagd und Fischerei Graubünden	© Kanton Graubünden
Haute-Savoie chamois distribution	Haute-Savoie	FDC Haute-Savoie (FDC74)	© Fédération des Chasseurs Haute-Savoie (FDC74)
Haute-Savoie ibex distribution	Haute-Savoie	FDC Haute-Savoie (FDC74)	© Fédération des Chasseurs Haute-Savoie (FDC74)
Haute Savoie Reserve de Chasse	Haute-Savoie	FDC Haute-Savoie (FDC74)	© Fédération des Chasseurs Haute-Savoie (FDC74)
Hunting statistics Slovenia	Slovenia	Slovenian Forest Service	© Slovenia Forest Service, Data usage contract
Italy chamois presence	Italy	Institute for Environmental Protection and Research	© ISPRA - Institute for Environmental Protection and Research
Italy ibex presence	Italy	Institute for Environmental Protection and Research	© ISPRA - Institute for Environmental Protection and Research
Italy red deer presence	Italy	Institute for Environmental Protection and Research	© ISPRA - Institute for Environmental Protection and Research
Italy roe deer presence	Italy	Institute for Environmental Protection and Research	© ISPRA - Institute for Environmental Protection and Research

Dataset	Area covered	Source	Citation / copyright
Italy wild boar presence	Italy	Institute for Environmental Protection and Research	© ISPRA - Institute for Environmental Protection and Research
IUCN chamois distribution	EU	IUCN Red List	Aulagnier, S., Giannatos, G. & Herrero, J. 2008. Rupicapra rupicapra. The IUCN Red List of Threatened Species 2008: e.T39255A10179647. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T39255A10179647.en [Add to Citavi project by DOI] . Downloaded on 11 February 2019.
IUCN ibex distribution	EU	IUCN Red List	Aulagnier, S., Kranz, A., Lovari, S., Jdeidi, T., Masseti, M., Nader, I., de Smet, K. & Cuzin, F. 2008. Capra ibex. The IUCN Red List of Threatened Species 2008: e.T42397A10695445. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T42397A10695445.en [Add to Citavi project by DOI] . Downloaded on 11 February 2019.
IUCN roe deer distribution	EU	IUCN Red List	Lovari, S., Herrero, J., Masseti, M., Ambarli, H., Lorenzini, R. & Giannatos, G. 2016. Capreolus capreolus. The IUCN Red List of Threatened Species 2016: e.T42395A22161386. http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T42395A22161386.en [Add to Citavi project by DOI] . Downloaded on 11 February 2019.
IUCN wild boar distribution	EU	IUCN Red List	Oliver, W. & Leus, K. 2008. Sus scrofa. The IUCN Red List of Threatened Species 2008: e.T41775A10559847. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T41775A10559847.en [Add to Citavi project by DOI] . Downloaded on 11 February 2019.
Jagdstatistik Baden-Württemberg	Baden-Württemberg	Landwirtschaftliches Zentrum Baden-Württemberg	© Wildforschungsstelle des Landes Baden-Württemberg, 2017
Jagdstatistik Österreich	Austria	STATISTICS AUSTRIA	© Copyright Statistics Austria
Jagdstatistik Schweiz	Switzerland	Bundesamt für Umwelt Schweiz	© BFS - Statistisches Lexikon der Schweiz
Kalkalpen Nationalpark	Oberösterreich	Nationalpark O.ö. Kalkalpen	© Nationalpark O.ö. Kalkalpen
Landnutzungsplan Südtirol	Südtirol	Autonome Provinz Bozen - Südtirol	© Provinz Bozen - Südtirol, Creative Commons Zero (CC0)
Liechtenstein Gams Verbreitung	Liechtenstein	Amt für Umwelt Liechtenstein	© GDI-Liechtenstein
Liechtenstein Rehwild Verbreitung	Liechtenstein	Amt für Umwelt Liechtenstein	© GDI-Liechtenstein
Liechtenstein Rotwild Verbreitung	Liechtenstein	Amt für Umwelt Liechtenstein	© GDI-Liechtenstein
Liechtenstein Steinbock Verbreitung	Liechtenstein	Amt für Umwelt Liechtenstein	© GDI-Liechtenstein

Dataset	Area covered	Source	Citation / copyright
Liechtenstein Wildruhezonen	Liechtenstein	Amt für Umwelt Liechtenstein	© GDI-Liechtenstein
Nationalpark Gesäuse	Niederösterreich	Nationalpark O.ö. Kalkalpen	© Nationalpark O.ö. Kalkalpen
Nationalpark Hohe Tauern non-hunting areas	Tirol/Kärnten	© Nationalpark Hohe Tauern Tirol & Kärnten; TIRIS; KAGIS	Nationalpark Hohe Tauern
Non-Hunting areas (Oasi)	Valle d'Aosta	Regione Autonoma Valle d'Aosta	Regione Autonoma Valle d'Aosta
Non-Hunting areas (Parchi giusti)	Valle d'Aosta	Regione Autonoma Valle d'Aosta	Regione Autonoma Valle d'Aosta
Non-Hunting areas (Riserve)	Valle d'Aosta	Regione Autonoma Valle d'Aosta	Regione Autonoma Valle d'Aosta
NP Berchtesgaden Jagdgebiete	Berchtesgaden	Nationalpark Berchtesgaden	Geofachdaten: © Nationalpark Berchtesgaden (www.nationalpark-berchtesgaden.de) © Bayerisches Landesamt für Umwelt (www.lfu.bayern.de) Geobasisdaten: © Bayerische Vermessungsverwaltung (www.geodaten.bayern.de)
Ortslage Berchtesgaden	Berchtesgaden	AdV Deutschland	© AdV Deutschland
Schweiz Jagdbanngebiete	Switzerland	Bundesamt für Umwelt Schweiz	© BAFU AOEL
Schweiz Steinbock Kolonien	Switzerland	Bundesamt für Umwelt Schweiz	© BAFU, VARIANTE "O-By"
Schweiz Wildruhezonen	Switzerland	Bundesamt für Umwelt Schweiz	© BAFU
Schweiz Wildtierschutzgebiete	Switzerland	Bundesamt für Umwelt Schweiz	© BAFU
Schwyz Jagdbanngebiete	Schwyz	Amt für Natur, Jagd und Fischerei Schwyz	© SZ Amt für Natur, Jagd und Fischerei
Steiermark Wildschutzflächen	Steiermark	Amt der Steiermärkischen Landesregierung	© GIS-Steiermark, 2017 www.gis.steiermark.a
Südtirol Gams Lebensraum	Südtirol	Südtiroler Landesverwaltung	© Amt 32.3 - Amt für Forstplanung Südtirol
Südtirol Reh Lebensraum	Südtirol	Südtiroler Landesverwaltung	© Amt 32.3 - Amt für Forstplanung Südtirol
Südtirol Rothirsch Lebensraum	Südtirol	Südtiroler Landesverwaltung	© Amt 32.3 - Amt für Forstplanung Südtirol
Südtirol Steinbock Kolonien	Südtirol	Südtiroler Landesverwaltung	© Amt 32.3 - Amt für Forstplanung Südtirol
Südtirol Steinbock Kolonien Winter	Südtirol	Südtiroler Landesverwaltung	© Amt 32.3 - Amt für Forstplanung Südtirol

Dataset	Area covered	Source	Citation / copyright
Südtirol Wildschutzgebiete	Südtirol	Südtiroler Landesverwaltung	© Amt 32.3 - Amt für Forstplanung Südtirol
Sütirol Steinbock Kolonien Sommer	Südtirol	Südtiroler Landesverwaltung	© Amt 32.3 - Amt für Forstplanung Südtirol
Tirol Gams Sommerlebensraum	Tirol	Amt der Tiroler Landesregierung	Land Tirol - data.tirol.gv.at
Tirol Rotwild Sommerlebensraum	Tirol	Amt der Tiroler Landesregierung	Land Tirol - data.tirol.gv.at
Tirol Steinbock Sommerlebensraum	Tirol	Amt der Tiroler Landesregierung	Land Tirol - data.tirol.gv.at
Tirol Wildruheflächen	Tirol	Amt der Tiroler Landesregierung	Land Tirol - data.tirol.gv.at
TLM Siedlungen Schweiz	Switzerland	Bundesamt für Landestopografie swisstopo	© Bundesamt für Landestopografie swisstopo
Valais Jagdbanngebiete	Valais	Kanton Valais	Kanton Wallis - Dienststelle für Geoinformation (DGI) - CC GEO
Valais Wildruhezonen	Valais	Kanton Valais	Kanton Wallis - Dienststelle für Geoinformation (DGI) - CC GEO
Vaud Reserve faune	Vaud	Direction générale de l'environnement (DGE)	Département du territoire et de l'environnement Direction générale de l'environnement (DGE)
Vorarlberg Wildruhezonen	Vorarlberg	VoGis Voralberg	Datenquelle: Land Vorarlberg – data.vorarlberg.gv.at, Creative Commons Namensnennung 3.0 Österreich (CC BY 3.0 AT)
Wildnisgebiet Dürrenstein	Steiermark	Nationalpark O.ö. Kalkalpen	© Nationalpark O.ö. Kalkalpen

Table 20 – References of distribution geodata