Genetically diverse landscapes require an integrated concept for conservation of genetic resources among domains

Hojka Kraigher[1, 2], Danijela Bojkovski[3], Gregor Božič[1], Andreja Ferreira[1], Jelka Šuštar Vozlič[4], Marjana Westergren[1]

[1]Slovenian Forestry Institute, Večna pot 2, Ljubljana, Slovenia
[2]Slovenian Academy of Sciences and Arts, Novi trg 3, Ljubljana, Slovenia
[3]Biotechnical Faculty – University of Ljubljana, Rodica, Slovenia
[4]Agricultural Institute, Hajdrihova 2, Ljubljana, Slovenia

e-mail: hojka.kraigher@gozdis.si

Abstract: *The Genetic resources strategy for Europe was prepared within the Horizon project "GenRes Bridge: Genetic resources for a food secure and forested Europe" in 2021. In it, three domains' networks: EUFORGEN (European Forest genetic Resources Programme), ECP-GR (European Cooperative programme for Plant Genetic Resources) and ERFP (European Regional Point for Animal Genetic Resources) have prepared domain-specific and a common genetic resources strategy. Furthermore, Hotspots of genetic resources for animals, plants and forests (Phillips et al. 2021. GenRes Bridge project, European Forestry Institute) was compiled, presenting five case studies, among which one was the Triglav National Park in Eastern Julian Alps in Slovenia. This case study shall be presented, leading to the key messages of the study: Strong interdependence exists between local breeds, crop and forest genetic resources, which provide a range of ecosystem services. The genetic resources are part of natural and cultural heritage, provide support for wider biodiversity in the area, support infrastructure and services for the local inhabitants, and require a multidisciplinary approach in their research and conservation.*

Key words: *genetic diversity, forest genetic resources, genetic resources strategy for Europe, Triglav National Park, inter-domain conservation strategy*

INTRODUCTION

Genetic resources allow and support production in agriculture and forestry; they are essential for long-term food security, delivery of non-food products and adaptation to the changing climate (www.genresbridge.eu). Within the HORIZON 2020 project (Grant Agreement No 817580, 2019-2021) entitled *Genetic resources for a food-secure and forested Europe* (acronyme GenRes Bridge) three domains, active in conservation of forest, agricultural plants and animals have collaborated, aiming to strengthen conservation and sustainable use of genetic resources by accelerating collaborative efforts and widening capacities in plant, forest and animal domains. Collaboration among these and wider biodiversity actors has enabled to widen capacities and increase the effectiveness of sustainable management of genetic resources through an integrated Genetic Resources Strategy for Europe. Within it, the three domains' networks: EUFORGEN (European Forest Genetic Resources Programme), ECP-GR (European Cooperative Programme for Plant Genetic Resources) and ERFP (European Regional Point for Animal Genetic Resources) have prepared three domain-specific and a common genetic resources strategy for Europe. Furthermore, Hotspots of genetic resources for animals, plants and forests (Phillips et al. 2021) have been compiled, including presentation of five geographically diverse case studies. From these, the Triglav National Park in Slovenia is presented.

We cite the common report on the action regarding hotspots of genetic diversity (Myking et al., 2020): "Forest trees, agricultural plants and livestock breeds in Europe and neighbouring countries have their individual histories with varying degrees of selection but sharing the quality of being indispensable for human life and wellbeing. A lesson from the recent past is that unless the genetic resources are sustainably managed, genetic diversity will be eroded or lost and become unavailable for use. Secondly, agriculture drastically affects the landscape in which it is taking place and interacts with the wider biodiversity in ways which in the last decades have been predominantly negative. … Finally, the positive interactions and dependencies between the three domains are

currently under-recognised, … while these perspectives need to be jointly addressed in planning and management."

The CBD defines 'genetic resources' as 'genetic material of actual or potential value', including any material of plant, animal, microbial or other origin containing functional units of heredity (www.cbd.int/doc/legal/cbd-en.pdf). It recognizes actual (current) and potential (future) value of biodiversity's genetic material as a whole, including their economic, social, cultural, and spiritual value. The main threats are:

- changes in land use practices, mainly along two lines, including abandonment and intensification;
- climate change, including water availability, extreme drought, causingnew fire regimes, increased tree mortality and replacement of forest with other vegetation types, therefore directly threatening forest genetic resources, insect outbreaks, extreme weather events and spread of pathogens and diseases, while in some areas increasing temperatures can have positive effects on longer growing season and more suitable conditions for a number of species;
- expanding populations of invasive alien species may modify or displace biodiversity and entire ecosystems, and introduce diseases to livestock, crops and forests.

On the other hand, the human genetic makeup and its diversity have been shaping and modulating biodiversity at the ecosystem, species and genetic levels. The traits that most likely influenced the impact of humans on other plant and animal species are those related to diet and choice of food, while human needs and ways of life have also been influencing the species composition, structural, spatial and temporal diversity of forest ecosystems, and genetic diversity of populations of forest tree species and other organisms living in or depending on forests.

The main aims as presented in this part of the study were:

- To describe the selected demonstration case in terms of management, policy and governance practices where all domains (plant, forest, animals) are integrated. Among five identified and selected demonstration cases, we present here the Triglav National Park in Slovenia.
- To investigate potential added value and adaptation of genetic resources to particular agricultural and forest ecosystems.
- To develop recommendations for integrated genetic resources conservation of relevance to support the Genetic Resources Strategy for Europe.

MATERIAL AND METHODS

The demonstration cases were considered a tool for formulating the rationale for genetic resources conservation of plants, farm animals and forest trees at landscape level. Since pan-European data on distribution of genetic resources diversity were found to be deficient for large areas in Europe, five demonstration cases were selected based on prior knowledge of genetic resources diversity within the three domains and with geographic distribution across the region of interest. Totally three areas with five demonstration cases were identified: Lebanon due to its position in the Fertile Crescent, the Alps as a glacial refugium genetic hotspot (three cases along an east-west axis – France, Italy, Slovenia) and Norway as a northern outskirt case but still with a surprising genetic diversity. Only the Slovenian demonstration case in Eastern Julian Alps is presented here.

The Alps span eight countries, from the Mediterranean shores of Southern France to Slovenia, reach above 4000 m above sea level, and harbour about 30 000 animal species and 13 000 plant species, several of both endemic. The traditional alpine landscape is a mosaic of different biotopes and land uses due to the long - lasting human interaction, contributing differently to rural development in the past and in the present.

RESULTS – THE DEMONSTRATION CASE TRIGLAV NATIONAL PARK

A brief description of the Triglav National Park (Eastern Julian Alps - Slovenia)

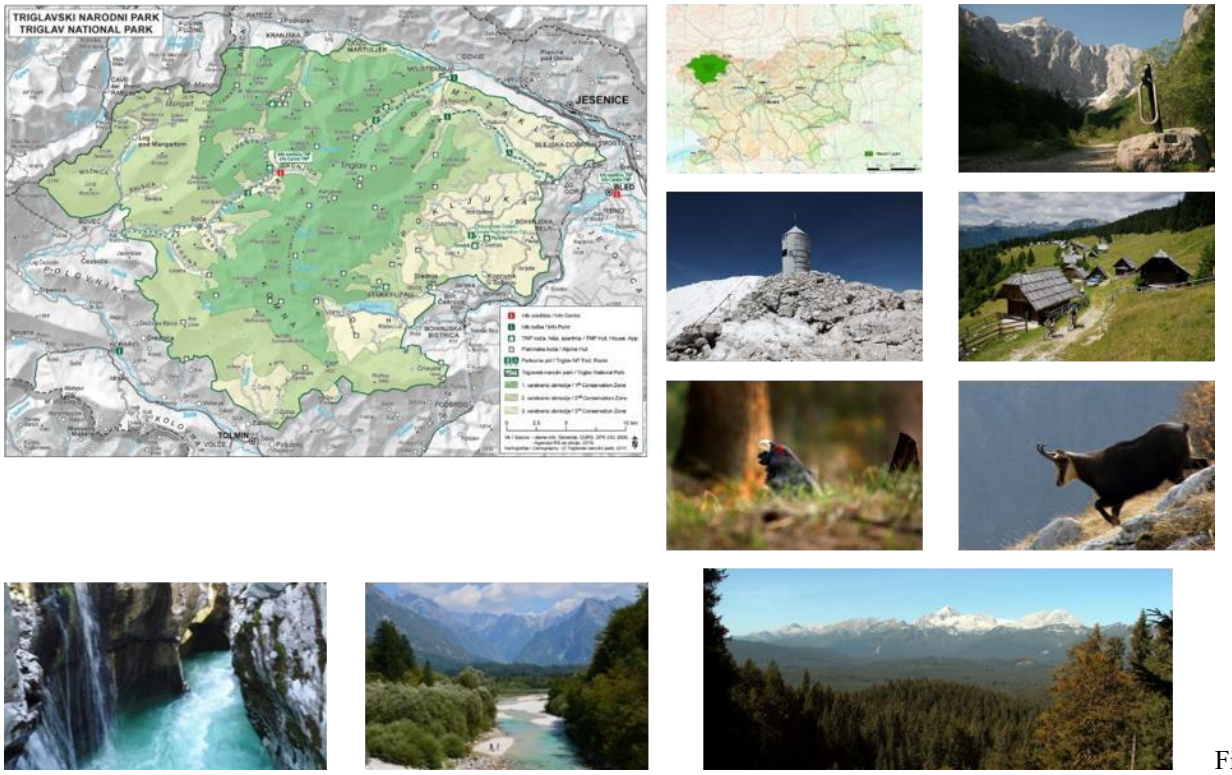

Figure 1: A composite figure presentation of the Triglav National Park (Location: NW Slovenia – Eastern Julian Alps; 46°20′N 13°46′. Photos of Pokljuka plateau with Triglav, the capercaillie and gams by Peter Čadež, others from internet

The Alpine landscape in the Eastern Julian Alps is a result of the predominantly limestone ground rock material (and consequently prevailing high karst phenomena), and co-existence of alpine pastures, shaping the mosaic of forests and alpine meadows, including characteristic groups of summer-cottages for shepherds and their cheese-production facilities. Forests in these areas were traditionally used not only for wood- and coal-production, for prevention of erosion and protection from landslides and snow avalanches, but due to 'grazing rights' also for feed for local breeds of domestic animals, for their grazing, and for collection of a number of non-wood forest products.

The Triglav National Park (TNP, founded in 1924), named after its highest peak, Triglav (2864 m a.s.l.), is a National park of the IUCN category II (national park) and Category V (protected landscape); part of the Julian Alps Biosphere Reserve (UNESCO MAB) since 2003; and a Natura 2000 area. It is geographically, historically and climatically split into two differently influenced parts, the north- eastern part (the Highlands - Gorenjska), with a harsher climate, history and characters of villagers, and the south-western part (Bovško) with the influences from the Submediterranean climates, reaching up the alpine valleys along the Soča river. This part is also the site of the major farmers' rebellion from 1713 ('Tolminski punt'), which was a consequence of the large-scale plague of cattle and of high taxes. Also, a several years long battle in the World War 1 influenced the landscape. The oldest Alpine botanical garden, Juliana, was founded in 1926 and is located in the national park.

The total surface area is 83.982 ha, within these 52.965 ha (63%) is forests. In forests, three different protective regimes are employed:

- First protective regime (mountaineering only): 31.488 ha, 22.422 ha forests
- Second protective regime (traditional use, no buildings): 32.412 ha, 17.980 forests
- Third protective regime (traditional use, different sports grounds): 20.082 ha, 12.563 forests

The area of TNP is part of the least favourable areas (LFA) for agricultural crop production in Slovenia. Crops are grown mainly in valleys whereas in the mountains alpine pastures predominate. Several agricultural plant varieties and breeds of domestic animals have been selected in the area, providing multipurpose uses which enable them to deliver ecosystem services in mountainous environments without irreversibly damaging the environment.

After the World War II the forested area increased due to abandonment of alpine pastures. In the recent decades the agricultural use was largely complemented by tourism and recreational functions of the territory, including transformation of farms, villages and pastures to tourist-farms, offering local products, visits to natural and historical landmarks, and numerous adrenaline sports activities. At present it is home to 2.337 inhabitants (January 2018) in 33 settlements from 8 municipalities, and is managed by the Triglav National Park Public Institution.

TNP holds a number of certificates (of excellence for transboundary collaborations, for sustainable tourism, for Ecological Connectivity) and prizes, such as the European Union Prize for cultural heritage / Europa Nostra awards for the safeguarding of a rare and authentic example of 18th century alpine heritage, the European Council Diploma of Protected Areas (2004). It is a member of Europarc Federation (since 1986) and ALPARC Network (since 1995).

Climate

The Triglav National Park has an Alpine climate, with cold winters and short summers, with a distinct differentiation between the warm south-western and cold north-eastern part of the area. The main difference in climatic conditions appears between the valleys on the Park's south-western side, which opens towards the Mediterranean and therefore has a milder climate, and the valleys in the north-east, which are affected by the harsher continental climate. This difference is greatest in the cold part of the year (Table 1).

Table 1: Climatic conditions of the Triglav National Park (Tolmin – SW valley, about 900 m/asl; Kredarica – central part, SE part of the main mountain range, about 2500 m/asl)

	Min	Max	Extreme
TEMPERATURE	-8,7^{O}C / 0,6^{O}C (Kredarica / Tolmin)	5,8^{O}C / 20^{O}C (Kredarica / Tolmin)	-49^{O}C (Komna 2009)
PRECIPITATION	134 days (Tolmin)	175 days (Kredarica)	2934 (Kredarica)
SNOW COVER	20 days (Tolmin)	265 days (Kredarica)	690 cm (Kredarica)

Why is Triglav National Park (TNP) an interesting demonstration case?

- Within TNP, there are two conflicting problems in the management of the mountain areas: forest overgrowth due to the abandonment of agricultural land use, and intensive use and overgrazing on the active alpine pastures.
- The traditional use of alpine pastures, existing in the TNP at least since medieval times, has created a unique landscape of forests, alpine meadows, pasture cottages, forests, and limited crop production areas in these unfavourable environments. Protection, sustainable forest management and restoration of agriculture in protected areas are the main elements for adaptation and resilience to the changing climate.
- Forestry, based on the Slovenian forestry school (sustainable, co-natural, multifunctional forest management) has an important role in socio-economic background for the local population, incorporating also the 'grazing rights', as well as in conservation of nature and biodiversity, in

carbon sequestration and in the supply of a wide range of products and services relevant to climate change adaptation, as well as in protections from landslides, soil erosion, water regime etc.

- Locally adapted species and populations of forest trees, domestic animal breeds and varieties of agricultural plants in TNP have distinctive characteristics that help them to cope with challenges of climate change and hence potentially increase the resilience of production systems to the effects of climate change.
- Some locally adapted animal breeds and plant varieties have been developed (selected) and conserved in this area. Unique characteristics of breeds include disease resistance, tolerance to climatic extremes, low consumption, and/or the ability to supply specialized products.
- The traditional 'grazing rights' in the forests maintains a successional stage of the understorey vegetation supporting edible mushroom production (in the lower protection regime areas) and some rare animals, plants and fungi in all three regimes.
- In marginal environments, where food and feed production are limited, locally adapted genetic resources provide food security and source of income for the local communities.
- Traditional landscapes and diversity of genetic resources play an increasingly important role in attracting tourists, which creates additional income, as well as threats, for mountain regions.

Landscape and agricultural history

Mountain agroecosystem and ecosystem services are based on the historical land-use rights and ownership characteristics, as well as protection and conservation of biodiversity and nature at all scales:

- Ownership includes a large number of small (forest) owners in the lower parts, traditional 'community' and 'grazing rights' in the alpine parts of the territory, while nationalization of large properties after World War II, and denationalisation of forests at the end of the 20th century have influenced conservation in the past and somewhat increasing demands for wood production at present
    - Agricultural community rights: the ownership is inscribed in the cadaster, and includes the right of each co-owner to cut as much wood as necessary to sustain his alpine cottage and repair the fences
    - Grazing community rights: alpine meadows and forests can be used for grazing; the number of heads of grazing animals is limited based on each participant's ownership capacity for sustaining his own herd
- Mountaineering & alpinism also shapes the area already since the 19th century: it includes maintenance and provision of mountain huts and footpaths (in Slovenia the mountaineering clubs and their association include almost every 10th citizen); recreational tourism is widespread; water (esp. on river Soča and the two big lakes) and winter sports (in alpine and cross-country skiing resorts, including a biathlon center on Pokljuka and the ski-jumping center in Planica).

SPECIES AND GENETIC DIVERSITY AS EXPRESSED BY CROP-WILD RELATIVES (CWR), FOREST GENETIC RESOURCES (FGR), DOMESTIC ANIMALS GENETIC RESOURCES (AnGR), AND THEIR ORIGIN

Forests and nature in TNP

Forests cover about 60% of the territory of Slovenia. Due to their traditionally and legally regulated sustainable, co-natural and multifunctional forest management, following "the Slovenian forestry school" principles, their species composition / vegetation at the country scale is to a large extent equal to or similar to the natural one.

In TNP forests cover 63% of the area, of which high forests constitute 41.616 ha (50%) and alpine pine (forested landscape) 11.349 ha (21%). They belong to 10 European Forest Types (EFT),

including Alpine rivers and woody vegetation with grey willow, Alpine pine (*Pinus mugo*) and hairy rhododendron (*Mugo-Rhododendretum hirsutii*), Central European acidophyllous beech forests (*Luzulo_Fagetum*), *Tilio-Acerion* forests on slopes, screes and ravines, *Lamio orvalae – Salicetum elaeagn*i willow, alder and ash forests along rivers, *Aremonio-Fagion* - Illyrian beech forests, Acidophyllous spruce forests from montane to subalpine zone, High moor (peat bog) forests (*Sphagno-Piceetum, Sphagno-Pinetum mugo*), Alpine larch forests (*Rhodothamno-Laricetum*), and Mediterranean Austrian pine forests (*Fraxino orni-Pinetum nigrae*).

In almost half of all forests (48%) in TNP, forest management (with differing restrictions according to the conservation regime, visible also in definition of forest functions) is allowed. Forest functions include nature protection and conservation of biodiversity, protective function against erosion, land- and rock-slides, snow avalanches, protection of the infrastructure, hydrological function, recreation and tourism, production of wood and non-wood forest products. High quality wood (resonant spruce wood), wood for building and biomass (such as for firewood) are important features for the local community and forest owners.

The most widespread forest tree species is Norway spruce (*Picea abies*); in natural vegetation it should represent around 20% of the growing stock, however due to planting and cutting of the beech for coal production in the past (used for iron-ores), its present growing stock in the area amounts to around 57%. The second conifer is larch with 3,7%, reaching its southern-most limits in the Eastern Julian Alps and pre-alpine mountains, and silver fir with 2,5% of the growing stock. Other conifers, Austrian and Scots pine, and yew, are also present, while the mountain pine (*Pinus mugo*) overgrows large areas at the upper forest limit, however with low growing stock.

The genetic diversity of Norway spruce populations at the upper tree line is similar to the diversity in the continuous stands in the center of the distribution measured as He and Ar with isoenzyme and SSR markers. Norway spruce in the TNP belongs to the alpine lineage which survived the lastglaciation most likely in the wider area of the south-eastern Alps. Comparison of the genetic structure of the two subpopulations of Norway spruce from very different site conditions within the Šijec population on Pokljuka plateau showed that they did not vary in genetic multiplicity and genic (allelic) diversity, while they are different in the frequencies of some alleles, genotypes and in heterozygosity levels. It is indicated that among mature trees heterozygotes are favoured under extreme site conditions on mire while more suitable site in the forest acts against heterozygotes.

The second most widespread tree species is European beech (*Fagus sylvatica*) with 31,7% of the growing stock; its stocks have decreased in the past centuries due to use for coal production. The European hop-hornbeam (*Ostrya carpinifolia*) share is around 1,9%, and the sycamore (*Acer pseudoplatanus*) around 0,6% of the growing stock, while other (around 25 different) tree species are only noted collectively as noble hardwoods or as softwood broadleaves. Among these is also the invasive species black locust (*Robinia pseudoacacia*).

Harsh and equalized growth conditions enable growth of forest trees of specific wood characteristics, some of which are utilized as resonance wood (spruce) for musical instruments, or showing specific esthetical characteristics, highly demanded in furniture production.

All together 8 seed objects (seed stands as basic material) have been approved in the broader area of TNP, from which there are two forest gene reserves, included also in the EUFGIS database, namely *Picea abies* - Rudna dolina, and *Larix decidua* - Macesnovc – Ponce, while two further are at its borders, namely *Fagus sylvatica* - Gomila – Čezsoča, and *Abies alba* - Konjske ravne. An additional seed object – forest gene reserve of *Laburnum alpinum* and one of *Taxus baccatta* is envisaged to be approved in the area in the near future.

AnGR – Alps as hotspot of biodiversity: breeds at risk

The area of the TNP represents the area of origin for three local/autochthonous Slovenian livestock breeds: Drežnica goat, Bovec sheep and Cika cattle. While population of Drežnica Goat and Bovec sheep are typically kept in TNP only, Cika cattle nowadays can be found also in other Slovenian regions. The sustainable use and conservation of all three local breeds is important from the cultural, historical and heritage point of view and represents an important genetic foundation as well as providing a range of ecosystem services, such as conservation of the typical landscape and habitats of high mountain grasslands and pastures.

Drežnica goat: It was an important source of meat, milk, dairy product and source of income for poor farmers and families. Despite the prohibition of goat grazing, the breed was not abandoned, and two types were developed: milking goats in the Bovec area and meat goats in Drežnica area. Goat milk is mixed with cattle milk and unique dairy products including excellent cheese are made (Stock: rams: 113; ewes 722; total: 835; critically endangered).

The Bovec sheep and the particular cheese of its milk was first mentioned in 1178. During summer time they traditionally make use of mountain pastures. The cheese is marketed under the trademark "Bovec sheep cheese" and has a geographical protection of origin. In 1924/25 the sheep population in Bovec area was 13.856 individuals, whereas today it is only 2.970 animals. Consequently, the breed is critically endangered.

Figure 2: Drežnica goat (on the left) and Bovec sheep (centre). On the right “Cika cattle” and Carniolan honey bee.

Slovenian Cika cattle were first described in 1872 as small cattle due to the very poor feeding and rearing conditions, with light bones and light body weight between 225-280 kg. Breeders were selecting small animals, more appropriate for the high mountains with lower feed requirements during the harsh winters. Heavier animals were sold to the farmers in lowlands. Cika drastically decreased towards the end of 20th century and was cross-bred with other cattle breeds. Fortunately, breeders in the high mountains didn’t follow the policy and have managed to conserve a few pure Cika cattle. The population of Cika cattle is nowadays widespread across the country and their population increased from 400 animals in 2000 to the 5.253 animals in 2019. Mainly they are bred for meat production, only some breeders are still using them for milk. Animals today are heavier, but still lighter than other traditional breeds and therefore appropriate for the mountain pastures.

Apis mellifera carnica **or Carniolan honey bee** is the Slovenian native honey bee, first described in 1879 and named after the region of Carniola. Slovenian beekeepers were well known in Maria Theresia period. Today, the Slovenian honey bee is protected as an autochthonous species. Beekeeping in Slovenia is an important agricultural activity with a long-standing tradition. Slovenian beekeepers are only allowed to Slovenian beekeepers are only allowed to breed 100% pure native honey bees. Honey is one of the key elements in traditional Slovenian cuisine.

Plant genetic resources – crop-wild relatives

Major crops that were traditionally cultivated in the area in the past were maize, potatoes and buckwheat. Whereas the cultivation of traditional old maize (corn) varieties is still popular today (or even gaining importance), cultivation of old potato and buckwheat varieties was abandoned. They are nowadays found only in the Slovene plant gene bank, which holds altogether more than 5440 accessions of 248 species that were predominantly collected in the Slovenian territory.

Conservation of genetic resources of maize / corn in Bohinj is combined with their traditional use. **Trdinka (or 'Bohinjka' corn)** is a traditional Slovenian maize variety originating from Bohinj and adapted to the Alpine regions. The kernels are yellow, orange, and red-coloured and typically milled into coarse flour. The flour is used to prepare a local polenta-like specialty known as 'bohinjski žganci'. The corn fields should be in a sunny spot, and are fertilised and ploughed in the autumn. The corn is then stored in a dry place and the cobs are often hulled in the week before Palm Sunday. On the good cobs, a few husks are left intact before they're braided and the cobs are left to dry. Later on, the kernels are milled into corn flour. Žganci made from trdinka have a better flavour, aroma, and different colour than other types of žganci. The food of Bohinj are typically simple dishes that the herders and dairy farmers would bring to the high mountain pastures. Once a week they would get a supply of flour from the valley. Then every day they would have sour milk and a corn mash made of coarse-ground hard native maize garnished with pork cracklings. A typical cheese-maker's meal consists of potatoes boiled in their skins and sweet ricotta cheese from the milk of Bohinj cows.

Fruit tress: Because of unfavourable climatic and growing conditions cultivation of fruit species was and still is very limited in TNP. Cultivation on a small scale is reported in Srednja vas, Bohinj (predominantly apple and pears). A traditional old fruit variety was cultivated in this area, 'Tepka' pear, but there are scarcely any old trees left.

Figure 3: Tepka pear (left; photo. B. Godec), Bohinjska trdinka (in the field, village Studor Bohinj – centre, kernels – right; photos M. Kalan)

Berries: Several collecting missions have been organized in the past to collect and evaluate wild berries in TNP, for example bilberries (*Vaccinium myrtillus* L.) and blueberries (*Vaccinium corymbosum* L.) were collected in Zatrnik, and in high moors of Pokljuka cranberries (*Oxycoccus palustris*) were collected.

Fodder crops and related species: Several collecting missions have been made in the last 25 years in TNP aimed at collecting fodder crops and meadow plant species. The seeds of the following species were collected in Pokljuka, Bohinj and surrounding area and are included in the Slovenian plant gene bank: *Alopecurus pratensis, Agrostis gigantea, A. stolonifera, A. capillaris, Anthyllis vulneraria, Brachypodium sp., Cirsium eriophorum, Cynosurus cristatus, Dactylis glomerata, Deschampsia cespitosa, Eriophorum sp., Festuca pratensis, F. rubra, Festuca sp., Koeleria pyramidata, Lathyrus sp, Lolium perenne, Lotus cornicultaus, Medicago lupulina, Medicago falcata, Molinia caerulea, Phleum pratense, P. alpinum, P. rhaeticum, Plantago major, P. media, Poa pratensis, Poa sp., Trifolium repens, T. pratense, T. medium. T. montanum, T. bradium, Vicia* sp.

MANAGEMENT, POLICY AND GOVERNANCE PRACTICES THAT CAN ENHANCE THE LONGTERM VIABILITY OF THE DEMONSTRACION CASE

Important dates in history of forest management in TNP start with the order of Maria Teresia (1771), which recommended to avoid clearcutting on the Karst territories. In 1837 the first forest inventory was done, and forest management plans were proposed from 1859, and regularly from 1886 onwards. In these times especially forests on the high plateau of Pokljuka were intensively used for coal production (from beech wood) for the local iron ore extraction, and Norway spruce from Austrian – German origin was planted instead. These practices resulted in partially natural and partially planted spruce monocultures at the elevations of 1100-1300 m a.s.l.

After World War II the concept of sustainable co-natural multifunctional forest management (SFM) was included in the forestry legislation. Still, spruce forests on the high plateau of Pokljuka have been exposed to severe windthrows (approximately every 7 – 10 years), and some parts have been subjected to the heavy ice-fall in early 2014, followed by outbreaks of bark beetles. Furthermore, in contrast to the autochthonous Norway spruce monocultures growing well around the high-moors (mires - peat bogs) and in specific harsh sites, the planted spruce forests have been subject to spreading of the fungus *Heterobasidion annosum* (root rot).

The area is highly interesting for tourists, with almost 2 million visitors overnighting there per year. Sports and recreation are in increasing conflicts with forest management and conservation. Coordination of grazing helps maintain the cultural landscape, however, it also influences the spread of diseases on forest tree roots, as well as maintains a specific successional stage of the understorey vegetation and litter layer which allows growth, and subsequently an over-use of mushroom picking in times of their fruiting.

The ownership is predominantly private, including a large area of forests that were denationalized and belong to the Rimo-catholic church, while also in large areas agricultural community rights, and grazing rights are implemented. Forest management planning in Slovenia is done irrespectively of ownership, through participatory forest management, by the Slovenia Forest Service, and executed by the forest owners or the Slovenian Public Forests enterprise SiDG. Within TNP conservation regimes 2 and 3 forest and wildlife management planning, as well as conservation of forest genetic resources are part of the public forest & wildlife service, and have to follow:

- nature conservation directives, and regulations based on NATURA 2000 SPA and SPS directives,
- participative forest management (forest owners participating in preparation of forest management and detailed silvicultural plans),
- agricultural communities and grazing rights,
- the resolution on the national forestry programme,
- the directives, prepared at the time of the approval and certification of forest reproductive material, and management of DCU – forest gene reserves, are also an obligatory part of the forest management plans, while also
- interferences with recreation, tourism & sports have to be resolved, and
- interferences with use of non-wood forest products (such as (over)collection of edible mushrooms and berries) occur regularly.

Intra- and inter-domain management reliance:

- Gene conservation units (forest gene reserves) and conservation principles are developing currently to include also economically less important forest tree and shrub species, considering e.g. edible fungi and berries production and use. Support for and monitoring of genetic diversity in core

and marginal populations of forest trees, growing in specific conditions, especially when impacted by large-scale disturbances, needs a long-term support.

- Due to the increasing frequency of large-scale disturbances in forest stands, the current sustainable silvicultural principles need further development to shortening rotation periods, reducing the size of the mosaic structure in the predominantly irregular shelterwood systems, support and increase the number of well adapted forest tree species, increase genetic diversity of the regeneration centres and include better supported enrichment planting, support forestry techniques that least influence the soils, and regulate grazing rights according to the sustainable capacity of forests.
- Communication between forest managers, forest techniques, forest and forest- and grazing-rights-owners, nature conservation organisations, education, tourist and recreation users of the area should be recognized as being of utmost importance.
- Crops with different characteristics (e.g. different root lengths, vegetative architectures, or planting and harvesting times) can complement each other in terms of resource use; introducing trees or shrubs can benefit crop yields through improved nutrient cycling and fixation, groundwater recharge and the provision of shade from which also livestock can benefit, shelter and/or provide additional feed supplied by woody species. Livestock in turn can provide manure to fertilize crops.
- On degradation-prone or fragile soils, the weight of the animals, their use of the terrain and their spatial mobility are extremely important. Lighter breeds are more appropriate than heavier ones. The low body weight of local/autochthonous Cika cattle and its multipurpose uses enables this breed to deliver ecosystem services in mountainous environments without damaging the environment.
- Collaboration between nature conservation (organizations), livestock keepers, businesses and policy makers to establish programmes and define projects with the common biodiversity goals are essential.
- Genetic resources in TNP should be managed in an integrated way with involvement of all different stakeholders.
- Support of infrastructure and services to owners and managers of genetic resources in remote and marginal areas is essential.

Interdependencies between domains & interdependencies between landscape and genetic resources of use (e.g. valley bottom versus hillside)

- In TNP high interdependences exist between local breeds, crops and forest genetic resources. They provide a range of different ecosystem services as well as conservation of specific breeds and plant varieties, help maintain the specific mosaic landscape, and support natural (non- agricultural) diversity of species and habitats.
- The traditional management of grazing on mountain pastures, regulated implementation of
- ‘grazing rights’ in the forests, and implementation of the sustainable, multifunctional, co-natural forest management practices, deliver aesthetic and traditional appearance of landscape and provide in situ conservation of native plants, animals and other organisms.
- Sustainably managed forests, crops and livestock support their multifunctional roles, including soil protection against erosion, landslides, and snow avalanches, as well as protection of biodiversity at all levels, including endemic, rare, threatened, vulnerable and endangered species of plants, animals, and fungi., and increase their ability to capture carbon.
- Through interconnected uses of AnGR, PGR and FGR, TNP is important for tourism, offering visitors traditional landscape, diversity of plants, animals and forests, providing a wide range of specific products, diverse recreational activities and educational roles and means.

How our diet choice affects the landscape

Slovenia has 24 gastronomic regions and each of them has its own culinary specialities. The area of TNP is known by its excellent milk and meat products.

Rich in mountain pastures with cattle, sheep and goats, high quality dairy products are processed, such as cheese, cottage cheese and other dairy products. Mohant is a cheese variety with distinctive smell and piquant taste and awarded by geographic designation of origin. Several small and large dairy farms create their own brands and household names. Few well known traditional dishes came from the area of TNP: «čompe s skuto» – potatoes with cottage cheese, žganci (polenta) made from buckwheat, different dishes with dairy products, as well as traditional sausages and pork products, salty and sweet štruklji - rolled dough dumplings and many others.

Arable land is planted by buckwheat, barley and millet. Bohinj is known by taty reddish-brown flint corn trdinka, ground into flour form which excellent žganci cooked and traditionally eaten with sour milk. Arable land is excellent for production of potatoe. Forests are full of mushrooms, berries and animals. Tepka, a rare variety of pear came back into local dishes.

Bovški sir (Bovec cheese) was protected and registered in EU by designations of origin. The traditional bovški sir is made of sheep milk, with cow or goat milk added occasionally. The milk comes from a sheep breed indigenous to the Upper Soča Valley.

The area built foundations of Slovenian and European apiculture, and beekepers produce several types of honey and other products. Dražgoše honeybreads are famous and used as traditional gifts at several occasions.

A number of farm-vegetable gardens are protected from deer browsing by fences, and regulated cattle and sheep grazing requires fencing by wood or electrical-shepherds. Already for half a century the use of spiny wires has not been allowed, however, some remnants can still be found in remote areas, along with remnants of soldiers' constructions from World War I and II. The wooden fences, and the specific constructions for drying the hay are a specifics of the area.

Drying hay in the SE part of TNP is done mainly as in other parts of the Alps, in hay-stacks, while the NE part uses the traditional Slovenian constructions called 'kozolec' – the hayracks: these are single or double wooden (sometimes combined with cement standing parts) constructions with a roof where fresh hay is mounted into several heights on horizontal racks. When reaching the glacier valley of the lake Bohinj from the high-plane Pokljuka, one whole village, called Studor, has been protected due to its traditional double-hayracks at the entrance to the village.

Another feature is the painted doors of the bee-hives. The Slovenian variety of honey bees *Apis mellifera carniolica*, its beehives and honey-bee products are an important product also in TNP.

Wider biodiversity supported by genetic resources for agriculture and forestry

Wildlife and nature protection conservation and management: TNP hosts a rich wildlife that is part of the Act on wildlife and hunting (such as red deer, elk, gams, chamois etc), as well as of other fauna and flora (such as the capercaillie Tetrao urrogallus and other birds), the endemic trout from river Soča, a number of insects, etc, protected through the Act on nature conservation.

In forestry, nature conservation directives and regulations based on NATURA 2000 SPA and SPS directives form the basis for forest management planning, and special protection areas include so

called ‘eco-cells’. These are (usually small) habitats of most interesting (rare, vulnerable, endangered) species, such as nesting sites of some owls, woodpeckers, the four different Tetrao spp that live in the area etc.

Occasionally brown bears visit the area, and in the last decade the brown bear family with cubs was spotted every few years, while wolves and lynx don’t usually cross over from the large forest complexes in the SE part of Slovenia.

With altering the vegetation, livestock often maintains vital habitats for birds. Their selective feeding can help the growth of, or allow access to plant species and parts preferred by wildlife (feed facilitation). By carrying seeds in their guts and coats, livestock distribute plant life across habitats.

Transboundary use of breeds: Only Bovec sheep can be classified as a transboundary breed, as it is also bred in Italy and Austria. To our knowledge, Cika cattle can only be found in Slovenia. Carniolian honey bee can also be found in other countries.

CONCLUSIONS - KEY MESSAGES

- Genetic resources in TNP should be managed in an integrated way with involvement of all different stakeholders. Communication and collaboration between all stakeholders within the TNP area and common programmes and projects should be designed with the common goal to protect natural ecosystems, biodiversity, soil, water and all specific habitats, and traditional land- uses, to support the natural and cultural heritage and specific mosaic features of its landscape.
- Assessment and/or long-term economic valuation and recognition of provisioning roles of genetic resources in TNP should be established and support defined & provided for their conservation and management (including comparative valuation of sustainable and traditional management versus management leading to the need for water regulation measures downwards, soil protection etc.).
- Support of infrastructure and services (such as: labelling systems, support to niche markets, different incentives) to owners and managers of genetic resources in remote and challenging environments is essential.
- Research on genetic resources needs to become more multidisciplinary, more participatory and more focused on interactions between different domains and components of genetic resources. Cooperation across disciplines, and greater involvement of all stakeholders in research projects, can help overcome knowledge gaps.

ACKNOWLEDGEMENTS

The major part of the text was prepared within the GenRes Bridge project as part of a deliverable entitled D3.2 Conservation of GenRes at Landscape Level through Demonstration Cases (2020). The present compilation was done within the research programme Forest Biology, Ecology and Technology (P4-0107; Slovenian Research and Innovation Agency), the target developmental project V4-2222 Measures for conservation of biodiversity in forest ecosystems, and the public forest service task 3 (financed by the Ministry for Agriculture, Forestry and Food; all lead by HK), as well as Research programme Agrobiodiversity (P4-0072; Slovenian Research and Innovation Agency).

REFERENCES

1. About the park (TNP) 2020. https://www.tnp.si/en/learn/about-the-park/ (accessed April 2020)
2. BIRTIČ D, BOJKOVSKI D, HORVAT S, LUŠTREK B, MALOVRH Š, POTOČNIK K, SIMČIČ M, TERČIČ D, ZAJC P, ŽAN LOTRIČ M, ŽGUR S (2020). Program varstva biotske raznovrstnosti v slovenski živinoreji : poročilo za leto 2019. Domžale: Biotehniška fakulteta, Oddelek za zootehniko, CD-ROM.

3. Bohinj cuisine (2015). Bohinj and its crystal lake in the heart of the Alps. https://www.slovenia.info/en (accessed 6 May 2020)
4. BOJKOVSKI D, CIVIDINI A, ČEPON M, HOLCMAN A, KOMPAN D (avtor, urednik), KOVAČ M, KOMPREJ A, ŽAN LOTRIČ M, MALOVRH Š, POTOČNIK K, SIMČIČ M, TERČIČ D, ZAJC P. (2014) Slovenske avtohtone in tradicionalne pasme domačih živali. Ljubljana: Ministrstvo za kmetijstvo in okolje, 80 str.
5. BOŽIČ G, KONNERT M, ZUPANČIČ M, KRAIGHER H, KREFT I (2003) Genetic differentiation of the indigenous Norway Spruce (Picea abies (L.) Karst) populations in Slovenia investigated by means of isoenzyme gene markers. Zbornik gozdarstva in lesarstva, 71: 19-40.
6. BOŽIČ G, URBANČIČ M (2003) The morphological and genetical characterisation of a native Norway spruce (Picea abies (L.) Karst) population in the area of Pokljuka mire. Acta biologica slovenica : ABS, 46 (1): 17-25.
7. FAO. 2019. The State of the World's Biodiversity for Food and Agriculture, J. Bélanger & D. Pilling (eds.). FAO Commission on Genetic Resources for Food and Agriculture Assessments. Rome. 572 pp.
8. FERREIRA A. (2005) Vloga gozda v trajnostno-sonaravnem razvoju Zgornje Gorenjske. Ljubljana, Filozofska fakulteta, Oddelek za geografijo, 271 s.
9. FERREIRA A, PETEK F (2005) Land-use changes and the resulting socio-economic population structure in the Upper Gorenjska region. Zbornik gozdarstva in lesarstva, 77: 159-178.
10. Growing and using trdinka corn in Bohinj (2020). https://www.youtube.com/watch?v=aR3Oj11shUg&t=7s (accessed 6 May 2020)
11. KRAIGHER H (1996) Kakovostne kategorije gozdnega reprodukcijskega materiala, semenske plantaže in ukrepi za izbolšanje obroda. Zbornik gozdarstva in lesarstva 51, 199-215
12. KRAIGHER H, ŽITNIK S (1999) Slovenian forest gene bank. Sodobno kmetijstvo 32(1) 46-50
13. KUTNAR L, ZUPANČIČ MITJA, ROBIČ D, ZUPANČIČ N, ŽITNIK S, KRALJ T, TAVČAR I, DOLINAR M, ZRNEC C, KRAIGHER H (2002) Razmejitev provenienčnih območij gozdnih drevesnih vrst v Sloveniji na osnovi ekoloških regij. Zbornik gozdarstva in lesarstva 67, 73-117
14. MOŽE BORNŠEK Š, POLAK T, DEMŠAR L, KORON D, VANZO A, POKLAR ULRIH N, ABRAM V (2011) Phenolics in Slovenian bilberries (Vaccinium myrtillus L.) and blueberries (Vaccinium corymbosum L.). Journal of agricultural and food chemistry, vol. 59 (13): 6998-7004.
15. MYKING T, BAKKEBØ K, SÆTHER N, KRAIGHER H, WESTERGREN M, PHILLIPS J, MAXTED N, STURARO E, LEFEVRE F, BOU DAGHER KHARRAT M, AZLLOUA P, PEREZ-ESPONA S (2020) D3.2 Conservation of GenRes at Landscape Level through Demonstration Cases. Conservation of GenRes at Landscape Level through Demonstration Cases. Barcelona: EUFORGEN Secretariat, European Forest Institute, 134 pp.
16. PHILLIPS J, WESTERGREN M, FJELLSTAD KB, BOJKOVSKI D, BOZZANO M, BOU DAGHER KHARRAT M, KRAIGHER H, LEFEVRE F, MAXTED N, PEREZ-ESPONA S, SÆTHER N, STURARO E, ŠUŠTAR VOZLIČ J, MYKING T. (2021) Hotspots of genetic resources for animals, plants and forests: lessons learned from case studies. Rome: ECPGR Secretariat, Alliance of Biodiversity International and CIAT; Paris: ERFP Secretariat, Institut de l'Elevage; Barcelona: EUFORGEN Secretariat, European Forest Institute, 20 pp
17. POLJANEC A (ED), SKOBERNE P (ED), ŠOLAR M (ED), VESELIČ Ž (ED) (2015) Forests in the Triglav National Park: Ecology and Management; ZGS & BF UNI-Lj, Bled, TNP, 154 pp
18. Pravilnik o ohranjanju biotske raznovrstnosti v živinoreji. Rules on the conservation of livestock biodiversity. Uradni list RS, št. 90/04 in 88/14.
19. Pravilnik o označbi geografskega porekla Bovski sir. 2004, Uradni list republike Slovenije, 47, 2238: 6289 – 6289.
20. SIMČIČ M. (2015) Phenotypic and genetic characterisation of Cika cattle: doctoral dissertation. Ljubljana. X, 139, [7] f. http://www.digitalna-knjiznica.bf.uni- lj.si/zootehnika.htm.
21. SRGB (2020). Slovenian Plant Gene Bank (internal database, not yet publicly accessible,
22. accessed, 6 May 2020)
23. TOLLEFSRUD MM, KISSLING R, GUGERLI F, JOHNSEN Ø, SKRØPPA T, CHEDDADI R, VAN DER KNAAP WO, LATAŁOWA M, TERHÜRNE-BERSON R, LITT T, GEBUREK T, BROCHMANN C, SPERISEN C. (2008) Genetic consequences of glacial survival and postglacial colonization in Norway spruce: combined analysis of mitochondrial DNA and fossil pollen. Molecular Ecology 17: 4134–4150
24. Trdinka (2020). Trdinka Corn, Bohinj Corn. https://www.tasteatlas.com/trdinka (accessed 6 May 2020)
25. WESTERGREN M, BOŽIČ G, KRAIGHER H (2018) Genetic diversity of core vs. peripheral Norway spruce native populations at a local scale in Slovenia. IForest, 11: 104-110.
26. Zakon o agrarnih skupnostih (Uradni list RS, št. 74/15)
27. Zakon o divjadi in lovstvu (Uradni list RS, št. 16/04, 120/06 – odl. US, 17/08, 46/14 – ZON- C, 31/18 in 65/20)
28. Zakon o gozdnem reprodukcijskem materialu (Uradni list RS, št. 58/02, 85/02, 45/04 – ZdZPKG in 77/11)
– Zakon o gozdovih (Uradni list RS, št. 30/93, 56/99 – ZON, 67/02, 110/02 – ZGO-1, 115/06 ORZG40, 110/07, 106/10, 63/13, 101/13 – ZDavNepr, 17/14, 22/14 – odl. US, 24/15, 9/16 – ZGGLRS,77/16)
29. Zakon o ohranjanju narave (Uradni list RS, št. 96/04, 61/06 – ZDru-1, 8/10 – ZSKZ-B, 46/14, 21/18 – ZNOrg, 31/18)
30. Zakon o Triglavskem narodnem parku (Uradni list RS, št. 52/10, 46/14 – ZON-C in 60/17)

31. ŽAN LOTRIČ M (2017) "Zimsko lovljenje" drežniških koz. Drobnica : strokovna revija za rejce in ljubitelje. letn. 22 (2): 12-13
32. ŽAN LOTRIČ M (2018) Modrost v izročilu bovških pastirjev : ohranjanje biotske raznovrstnosti. Delo. letn. 60 (49): 15.
33. ŽAN LOTRIČ M (2018) Ohranjanje drežniške koze in tradicije planšarstva : Bovška planina Bošca (1.370 m. n. m.). Kmetovalec : glasilo c. kr. Kmetijske družbe vojvodstva kranjskega, letn. 86 (3): 26-29