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Dinaric Karst – An Example of Deforestation and Desertification of Limestone Terrain

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1. Introduction

Dinaric Mountains are one of the main mountain systems of the Balkans. The name was given by of the imposing Dinara Mountain (1913 m) at the border between Herzegovina (Bosnia and Herzegovina) and Dalmatia (Croatia). Under the name of Dinaric Alps it appeared already in the 18th century (Hacquet 1785). The part of Dinaric Mountains which is mostly built by carbonate rocks, limestone predominating, is called Dinaric Karst. The name Karst as well as the international term “karst” derived from the plateau Kras (Carso in Italian, Karst in German), the north westernmost plateau of the Dinaric Karst ridges (Kranjc, 2011). Dinaric Mountains are a mountain chain approximately 650 km long and up to 150 km large, covering an area of about 60 000 km², stretching between 42° and 46° of northern latitude (Fig. 1).



Fig. 1. Delimitation of the Dinaric Karst after Roglić and Gams (Mihevc & Prelovšek, 2010).

Geologically, Dinaric Mountains consist of two parts: Inner Dinarides at Northeast and External Dinarides at Southwest (Mihevc & Prelovšek, 2010; Zupan Hajna, 2010). While in the Internal Dinarides non-carbonate rocks prevail, in the External one the carbonate rocks are predominant – therefore there is karst. A. Penck's student of Vienna "geomorphological school", Jovan Cvijić was probably the most influential scholar to propagate karst and to substantiate the karst science. In his basic works of 1893 and 1895 (Cvijić, 2000) he stated: "All the forms on the bare limestone, made by water, we will call karst features". Cvijić's connotation of karst is "bare limestone landscape". The travellers who travelled from Vienna to Austrian Adriatic port of Trieste were the most impressed by a sudden change of landscape. After Postojna, they entered a bare rock land, without surface water and especially without any greenery. In 1689, Valvasor in his topography wrote about the Kras (Karst) plateau: "Somewhere it is possible to see for some miles, but everything is only grey, nothing green, because all the country is covered by stones." Illustration from the same work shows the cultivated land at the bottom of dolines only (Valvasor 1689). In many parts of the Dinaric Karst it is true for the actual situation (Fig. 2). On 18th century military maps the entire Kras surface is shown as ""Steinigte Terrain" (rocky terrain) (Fig. 3). Description of individual settlements added as a comment to the maps often stated: "There are no forests or trees, just some bushes one hour away from the village" as shown by the example of the village Gabrovitza (actual Gabrovica pri Komnu) (Rajšp, 1997).



Fig. 2. On Dinaric Karst cultivated land is mainly in the bottom of dolines only (photo A. Kranjc).



Fig. 3. Military map of Kras plateau from the second half of the 18th century: great majority of the surface is “Steinigter Terrain” (Stony terrain) (Rajšp, 1997).



Fig. 4. About 1850 the nowadays woody hill Sovič above Postojna was bare (Schmidl, 1854).

Impressions of travellers across karst terrain between Postojna and Trieste are all depressing (Fig. 4). Count Karl von Zinzendorf wrote in 1771: "The country is *affreux*. All these terrible rocks and in the midst of them some small cultivated parts of land encircled by stones...; " and B. F. J. Hermann in 1780: "Anywhere you look, it is only desert..." (Panjek, 2006). To the end of the 19th century and even later the impression of karst got from the published works of scholars as well as of laymen was one of bare rock and dry landscape. But it was not always such. On the Dinaric Karst, nowadays there are completely bare landscapes, mostly on the Mediterranean side, but there are also extensive forests covering slopes of high mountains and the tops of karst plateaus in the interior. Good examples of preserved forests are Rajhenau primeval forest (Kočevski Rog plateau above Kočevje in Slovenia) (Rajhenavski pragozd, 2011) and the forest Lom (*Piceo-Abieti-Fagetum illyricum*) on the Klekovača Mountain in Bosnia (Prašuma Lom, 2011). The first one occupies about 50 ha of *Abieti-Fagetum dinaricum*. The forest of Kočevje is a part of the biggest uninterrupted forest complex in the Western and Central Europe, stretching from the Kočevje region (Slovenia) to Gorski Kotar (Croatia).

The aim of the case study of this chapter is to show that man is the main factor both at destroying his natural environment and at restoring it. The man is capable of both. In our case that means a complete deforestation, the changing of a heavy wooded landscape to a bare rocky desert and back again to a dense, although, to be true, not a "natural" or optimal, forest, as it shows the further text. Of course the time scale is different as well as the attitude towards these processes triggered in both cases by the human itself. The first dwellers millennia ago have not seen, they did not know and they could not imagine what a process they have started by cleaning land for pastures and fields. And the process of deforestation and finally desertification lasted thousands of years. If reforestation was premeditated by well planned actions the actors knew well their aim and purpose. Comparing the lasting of reforestation with deforestation this was a short but an intensive action. The karst terrain, Dinaric Karst especially, is such a terrain where the human activities leading towards desertification have shown their most disastrous consequences and where the opposite action, reforestation, demanded extremely great efforts and financial input. This case study is not meant to be just a history of a forest but also a warning what can happen, not only in the mist of history, but also nowadays.

2. Deforestation

Deforestation started in prehistoric times already, by the arrival of people with Neolithic culture, leading Neolithic way of life, the transition from gathering and hunting to stockbreeding and farming, the so called Neolithic revolution. The Balkan Peninsula is a sort of bridge between Near East, across Asia Minor towards Central and Western Europe and the Neolithic culture reached it between 6 500 and 6 000 BC. Neolithic farmers did not enter far into the Dinaric Mountains. Instead they advanced across the fertile plains along the Danube River on the North and along the Adriatic coastal strip in the South, so avoiding the mountainous regions (Velušček, 1999). So their impact on the forest of Dinaric karst had to be negligible, with some exceptions - the Butmir locality for example. Pollen analyses show that the intensive deforestation phase occurred due to grazing during prehistory on the plateau of Kras (Slapšak, 1995). To confirm the prehistoric deforestation Gams' (1991) research on Rillenkarren is very illustrative; he found out that they started to be formed on

the plateau Kras 3 000 – 3 500 years BP, which is when the forest was destroyed and bare rock started to appear on the surface (Fig. 5).



Fig. 5. Rillenkarren on a limestone rock: they start to form about 3 000 – 3 500 years ago while the smooth lower lying surface was covered by soil much longer (photo K. Kranjc).

During the Bronze Age, the situation changed dramatically. The population increased and due to their economy (farming, stockbreeding, and ore mining) entered deeply into the Dinaric Karst where they had to clear and cut the timber, which was used for buildings and defence installations as well as for ore smelting. In Dinaric karst the settlements were concentrated mainly in two border zones: on the Adriatic coastal plains (Low Periadriatic Karst) and on the karst plains and hills along the Pannonian plain (Low Peripannonian Karst). The innermost parts of Dinaric Karst seem to remain quite untouched. Thanks to archaeological research we know that during this population expansion the climax *Abieti-Fagetum* forest was already being replaced by lower association of *Quercus* type in some parts of Dinaric Karst (Turk et al., 1993).

During the Early Iron Age (Hallstatt culture) practically all the Dinaric Karst was settled and during the Late Iron Age (La Tène culture) Dinaric region entered into history: the native (Illyrian) tribes are known by names, in the southern Dinaric coast and islands Greek colonies were founded, from the North came a Celtic invasion and from the West the Roman one. From that period, the names of peoples living in the region are known: Illyrian tribes, Celtic tribes, Greeks and Romans. Regarding the use of timber and wood and the economy in general, the cause of deforestation, the choice of motives is very large: Illyrians deep in the interior of Dinaric Karst tended big flocks of sheep and goats using the transhumance system, and the farmers not abreast with the time used slash-and-burn system. To increase pasture areas shepherds also used the fire. On the Dinaric Karst, considering its climate, a forest fire does not only destroy trees and surface vegetation. Its consequence is much more important because it increases rain and wind erosion processes and rock aridity. In such cases woodlands can be really transformed into “rock deserts”. Metallurgy using so-called “bean ore” (Bohnerz) which is very frequent in karst soil and clay, had to consume big quantities of wood, as shown by modern experiments (Kranjc, 2002). Near Straža village by the town of Novo mesto (NW part of Dinaric Karst, Slovenian Low Peripannonian Karst), 24

smelting furnaces were burning simultaneously as is shown by the archaeological research (Dular & Božič, 1999). While the Romans (the army at the beginning and colonists later) and Greeks used wood for construction, industry (including metallurgy, charcoal and lime production, pottery), heating (thermae with big basins of hot water were necessity of townspeople everyday life) and many other needs connected with high developed culture.

Along the Dinaric area - that is the Adriatic coast, shipbuilding was important too, for both the Illyrians as well as for Greek colonies. From historical sources it is known that the fleets consisted of a big number of smaller boats (lemba and liburna), but also big boats were constructed. Ancient authors, Polybius for example, often mentioned numbers of ships of Illyrian fleets: "Scerdilaedas ... provided 40 lembas and Demetrios of Pharos 50". To build the liburna, 33 m long and 5 m large ship with 36 oars, quite a lot of wood was needed. Polybius reported that Macedonian king Philippos the 5th ordered to construct 100 liburnas during the winter 217/216 BC. For oars alone they needed 3 600 adequate straight young trees, not accounting for spare oars. That this was an important question proved the report of Andokidos who came to help to the army of Samos: "For the beginning, I prepared wood for oars for your army of Samos." When Brazida conquered the town of Amphipolis this fact "... provoked great fear among the Athenians ... because from there they got the wood for shipbuilding...", both quotations taken from Thucydides (Cabanes, 2002).

From the opposite part of the Europe, from Scandinavia it is reported that the Viking's shipbuilding came to a serious deadlock because there were no more suitable trees in their homeland (Atkinson, 1979). In the Dinaric Karst such a problem is not known from historical times but aroused seriously in the 19th century, as seen from the text below. The Ljubljana Moor lies at the foot of high karst plateaus of NW Dinaric Karst. Between the towns of Nauportus at the foot of the plateau with very important karst spring, and Emona, the Roman legion had to build a road across the Moor in the first years AD. For the base of the road structure they placed thinner round tree trunks on the marshy soil. Illyrians (and other native peoples) to defend their oppida used palisades while Romans used them to defend their legion camps and also to strengthen walls of stone and wood combined to protect towns.

Of course there is little direct evidence of larger deforested surfaces existing during Prehistoric and first Historic times. In the Smederevo polje of Lika (Croatia), the position of skeletons in burial mounds shows that the landscape was open with a thin soil cover, that means there were no (more) forest at the time of a funeral (Horvat, 1957). Many parts of the Dinaric Karst that are nowadays forest-covered again were dramatically different during the Iron Age, when this was an open country with small fields and pastures, and fortified hilltop settlements. In Bosnia and Herzegovina the majority of actual barren landscape is found around the former Illyrian hill forts and settlements (Djikić, 1957). Nevertheless, at the beginning of the historical times there must still have been much of forest-covered land as proved by the topographical names. The Island of Korčula (Dalmatia) was called Korkyra Melaina by Greeks and Korkyra Nigra by Romans, both names meaning Black Korkyra because of its dense pine forest cover. On the plateau Kras cultivated land was in form of islands around the settlements and quite a lot of forest remained in between (Slapšak, 1995). Knowing people and their history it is sure that the wars and clashes of arms existed in Prehistoric times, too. From the beginning of history on there are records of them from all periods. These violent activities had and has (just to remember the Vietnam War) a very great impact on forest. "Plunder and burn" was the most common motto: to get the booty and to devastate enemy's country, that means to ruin it economically. Burning a forest was not just

an economical measure; it was used as a war or raid tactics, too. For example, the Turkish regular army cut down and burned woods to make easier way for the cavalry and heavy artillery, and to destroy Hajduks (Balkan guerrillas) hidouts and dwelling places. The army was ordered to destroy forest on both sides of roads to get clear zones to thwart ambushes by the Hajduks. From the 17th century there are picturesque descriptions of such activities in the diary of the Turkish traveller Evliya Çelebi (Evlija, 1957). Reciprocally, forest was sometimes burned too by the defending population in attempts to prevent the enemy's attack.

During the late Antiquity another reason joined "traditional" deforestation – invasions of Barbarian peoples. Between 3rd – 8th centuries they crossed and often settled the territories of the Roman Empire, in our case the Roman provinces of Illyricum and Dalmatia. Especially frequented was the direction of the Roman road Aquileia - Carnuntum, leading across Dinaric Karst on the section between Tergeste (Trieste) and Emona (Ljubljana). The consequence of their approaching and settling was the movement that is flight, of Romanised inhabitants towards the coast and especially on the normally overgrown islands which are stretching all along the Adriatic coast. Today these islands are effectively uninhabited but traces proved that they were relatively densely populated during the Late Antiquity. Maybe the population increase was not the worst. Such troubled times favoured stockbreeding over farming and overgrazing together with burning to increase pasture lands left many of the previous mentioned islands completely bare. Such conditions remained to modern times and now these islands are used as meagre pasture for sheep only, not to mention the summer tourism (Fig. 6).



Fig. 6. Kornati islands, practically nothing but dry pastures for sheep (photo A. Kranjc).

The next troubled times after the barbarian invasions regarding human pressure and impact on the forest was the Turkish occupation of the majority of the Balkans and Turkish raids into the neighbouring countries, which seriously began in the 14th century. The interior of the Balkans was Turkish Empire, much of the Adriatic coast belonged to the Venetian and Dubrovnik (Ragusa) Republics, and small part of the NW part belonged to Austria, either in the frame of so-called Military Zone (nowadays Croatia) or the Duchy of Carniola. Before the 14th century the forests which were not commune were divided into forests for hunting, oak forests and small forests, in the frame of the Austrian lands. Animal grazing was forbidden in them and for cutting or burning wood severe fines were foreseen. An Act from 1550 allowed all the inhabitants of Trieste, mule drovers and butchers to cut wood and grass in all of the commune's forests. In 1689 two revisers reported: "In the town, there is a shortage of fire-wood, it is impossible to make a stock, because all the forests are destroyed". In 1719 the port of Trieste was proclaimed a "free port". To the Austrian annexation of Bosnia in 1878 in

outline the situation remains the same. A significant part of the Christian population fled before the Turks and re-settled in Austrian, Hungarian, Venetian or Dubrovnik lands not far from the borders. These migrations included some long distance displacements. For instance, entire “tribal families” from the inner parts of Serbia moved to the Istria Peninsula in the most north westerly corner of the Adriatic Sea, and even to Carniola – nowadays Slovenia (Cvijić, 1966). These groups moved with their flocks and commonly they continued primarily as owners and herders of grazing animals. Pressure on grazing land led to another increase in the rate of deforestation. The emigrants brought their slash-and-burn techniques, too. Transhumance together with burning, later also cutting of the forest, was preserved locally until the 20th century, when they were observed by the first researchers, J. Cvijić among them. According to the eyewitness Gušić, the main reason of deforestation was clearing the land for new pastures or meadows and sowing of grain in “novine” (new fields), used once only (Gams & Gabrovec, 1999). That cutting and burning of a forest could locally trigger accelerated soil erosion is proved by the practice in the near past, when farmers in remote mountains have burned forest in order to create such “novina” (Kranjc, 1979). This process is not connected with the Dinaric Karst only but largely with the Mediterranean (Fig. 7). On Balears Islands on the land not suitable for agriculture grazing was practised at least from the Catalan conquest (1229). Traditional economy was based on the repetitive burning of herbaceous brushwood of *Ampelodesmos mauritanica*. This released active soil removal as well as the progressive degradation of scrub formation. At the end of the chain the bare rock results (Ginés, 1999). For some of authors, the main reason of not only deforestation but of the degradation to the bare rock country was grazing, grazing by goats especially (Wessely, 1876).



Fig. 7. In some parts of Dinaric Karst the burning of shrubs is still practised (photo K. Kranjc).

In parts of the Dinaric Karst under Austrian and Venetian influence, the agrarian pressure was not the only economic reason for deforestation. In the Venetian territory construction work and shipbuilding demanded large quantities of timber. It is reported that 1 200 000 tree trunks were needed for use as piles to support the church of Santa Maria della Salute in Venice (Horvat, 1957). It is difficult to imagine the whole number of piles, using for the churches, palaces and other buildings in Venice. Without doubt a great part of them came from the Dinaric Karst. There is a popular saying that the Venice “stands on oaks from Karst”. In the time of the French Revolution (1792), the duty of the French consul in Albania was to take care of “cutting down construction timber for navy base at Toulon”. Marshal Marmont for example, the Governor of the Illyrian provinces under Napoleon, ordered to cut off the tops of all the trees in one of the still remaining oak forest in the vicinity of Trieste, called Frned, to use them as a timber for ships. As a consequence the forest decayed completely to 1820. In the Austrian part of the Dinaric Karst the farmers (villeins and serfs) did not have the right to cut timber for trade before the so-called “Land Release” issued by the Empress Maria Theresa in 1848. In NW part of the Dinaric Karst the Austrian Navy had forest reserves, mainly oak. In these forests it was forbidden to fell timber for other purposes. The Navy’s demand was great: the navy’s forester (by the way the inventor of the vessel screw, too) J. Ressel reckoned up that to construct and maintain during its 150-year life a wooden battle ship 120 000 tree trunks were needed. In that time Austrian merchant navy had 523 big ships. To maintain the number 6.244 m³ of wood would be needed, while the production of the Istrian forests was 7.030 m³ (Piškorić, 1993). Good husbandry would thus not cause the deforestation by itself. But In 1819 the marine forest reserve was cancelled and massive felling programme started. Timber was sold to Venice, France, and especially to England (Murko, 1957). It is not surprise that the emperor Maximilian when visiting Trieste in 1850, described the plateau Kras as a rock desert with a curse hanging over it (Anonym, 2001) (Fig. 8).



Fig. 8. The view of the plateau Kras above Trieste in 1901 (Anonym, 2001).

The consequence of the mentioned “Land-Release” was disastrous for the forests in the Austrian parts of the Dinaric Karst. According to this act farmers became owners of the land

which included right to cut down trees and to sell them. And they used new rights to a full extent, not thinking of replanting young trees. Parallel to this process, industrial development, especially mining and metallurgy contributed significantly to deforestation, even on remote karst plateaus in Slovenia and Bosnia and Herzegovina. During the second half of the 19th century, special narrow-gauge railroads were laid down to facilitate exploitation of the Dinaric Karst forests. The changes or regression in some branches of industry, metallurgy especially, can show indirectly the changes in forest structure or deforestation even. An example is the decrease of iron industry of the well known industrial Ž. Zois of Kranjska (Carniola) at the end of the 18th century. Some of his ironworks went short of fuel that is of charcoal. The so called “Slovene furnace” needed 50-60 % more charcoal than ore. Zois tried to use charcoal made of soft trees (spruce) instead of hardwood (beech). This is also one of the reasons of the change of the forest structure: for the shipbuilding the oak was over exploited and for the iron industry the beech (Kranjc, 2002) (Fig. 9).



Fig. 9. “Cooking” of charcoal on the Dinaric Karst at the beginning of the 20th century (Anonym, 2001).

As indicated in the text above, there were different factors causing deforestation of the Dinaric Karst and there are regions affected by different steps of deforestation. In any case the factor was man, either through his economy as stockbreeding and transhumance, slash-and-burn agriculture, fire wood gathering, construction and different branches of industry, shipbuilding and metallurgy emphasized or other, hostile activities, as “plunder and burn”, army movements, attacks and protection of them, and last but not least the pressure on agricultural land. Some parts, relatively small and rare, of the Dinaric karst are practically unaffected by the process of deforestation and still nowadays covered by a dense forest; some others have still forest cover but heavily changed, and the last stage is “šikara”, shrubberies and thickets. Big surfaces are pastures without any trees and some parts of the Dinaric Karst are bare rock landscape. Generally speaking the bareness of the Dinaric Karst is lesser in the central parts, and going towards the Adriatic coast, it increased reaching real rocky desert on Adriatic slopes and on the islands.



Fig. 10. Bare high ridge of the Velebit Mountain (photo A. Kranjc).



Fig. 11. Stony pasture on the Pag Island, sea side slopes of the Velebit Mountain in the background (photo A. Kranjc).

While the number of inhabitants increased, economic facilities did not follow the population growth. Data from the Karlovac district of Croatia, which has an extremely great proportion of karst landscape, can be shown as an example. In the middle of the 18th century, there were 940 inhabitants per square mile, while hundred years later, in 1850, there were 1824. This means that the population nearly doubled in a hundred years (Wessely, 1876). It was not a specific of the Karlovac district, in many parts or even in majority of Dinaric Karst the greatest population pressure on karst land was during the 19th century. Regarding the available data the example of Dinaric Karst in Slovenia can be taken into consideration. In

Slovenia as a whole there was a minimum of forest cover around 1875. Forest then covered 37 % of the surface, while in the district of Postojna, which included a great part of the Dinaric Karst in Slovenia, the forest covered 26 % in the year 1880 (Azarov, 1994). According to Gams (1991) the plateau Kras had only 20 % of forest surface in 1900. In 1989 the share of forest increased to 51 % and nowadays the rate of forest still increases, its share being estimated to be over 60 % of Slovenia and over 50 % of the Kras plateau. On Kras, it is mostly the monoculture black pine tree forest. The course of reforestation is now going on by itself; pastures are becoming overgrown by shrubs and being slowly transformed into forests. The surface is slowly overgrown first by tall herbs, then with shrub species, and finally by trees and forest ground flora. The front of pine forest, if not interfered by human, progresses at a maximum of 17 metres per year; computer modelling forecasts that the whole region of Kras will be overgrown by shrubs and trees till 2013 (Pertot, 1989).

On the karst of Croatia, forest cover decreased to an alarming state during the 19th century, too. In this time there was hardly any forest on the coastal side of the Dinaric Mountains. But the records of "Trieste Commercial Commissariat" for 1756 showed millions of trunks (Wessely, 1876). In the second half of the 19th century on the "Mountain Karst" (Fig. 10) of Croatia 39 % of surface was categorized as bare (non-productive) land, the "karst" in narrow sense of meaning, while on the "Sea Side Karst" such category includes 93 %, as shown by the same author (Fig. 11). It is difficult to imagine that nearly the entire country was "unproductive" bare rock landscape. In that time, the meaning of karst was just a "bare limestone landscape". And what was the prospect for the future: "General-Domänen-Inspektor und Forstakademie-Direktor a.D." reckoned that the surface of forest diminishes every year for 1 % in the frame of the Austrian Littoral and Dalmatia.

3. Natural vegetation of the Dinaric Karst

Available data suggest that originally about 90 % of Dinaric Karst were covered by a forest, in some areas even more. Many temperate taxa appear to have survived in the region during the last glacial in low but persistent population. A greater diversity of taxa existed in the mid to high altitude sites probably where the climate was more humid. At theateglacial/Holocene transition many tree taxa expanded simultaneously. Changes in the composition of the early Holocene woodland included a change in the forest dominants between 8 000 and 7 000 BP, and the appearance and increase of *Carpinus orient./Ostrya*, *Abies*, *Carpinus betulus* and *Fagus* between 7 500 and 5 000 BP (Willis, 1994). In the north-western part of Dinaric Karst mixed oak forest (*Quercetum mixtum*) prevailed during the first postglacial warm (Boreal) period. During the Atlantic period fir and beech (*Abieti-fagetum*) had already developed as a climax forest. Dinaric Mountains' flora belongs to both the Mediterranean and the Euro-Siberian-North American phytoregions. In the Mediterranean region the main forest type includes Mediterranean (evergreen) oak (*Quercus ilex*) and Black Dalmatian pine (*Pinus nigra dalmatica*) while Dinaric fir and beech forest (*Abieti-fagetum dinaricum*) prevails in the interior. Black pine (*Pinus nigra*) is indigenous to some small karst areas of Slovenia (Culiberg et al., 1997; Šercelj, 1996) (Fig. 12). Development of the present day landscape started at approximately 4 500 BP with the onset of anthropogenic disturbance. Clearance resulted in increase of open ground herbaceous types with grasses (Willis, 1994).

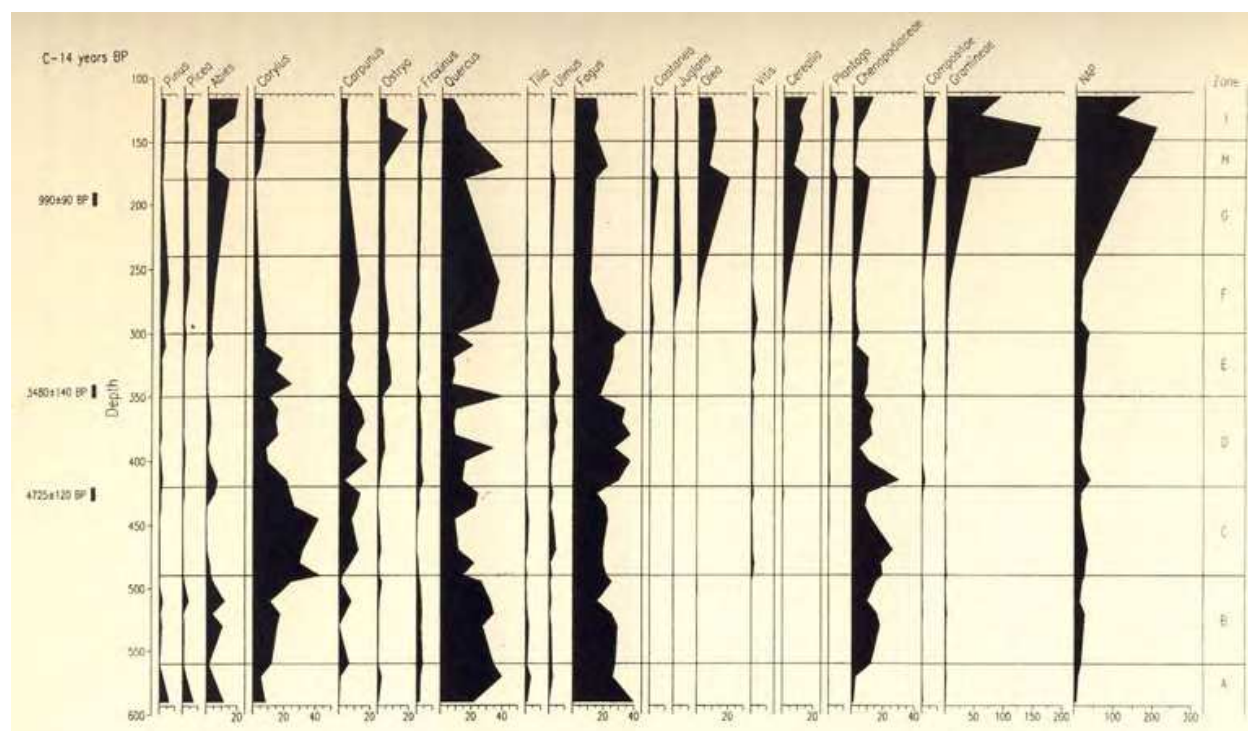


Fig. 12. Pollen diagram, showing great change around the year 1 000 BC as well as around 1 000 AD (Culiberg et al., 1997).

4. Forest protection and reforestation of the Dinaric Karst

As it was seen the main cause of the deforestation of the Dinaric Karst was man. But it does not mean that nobody cared for forests and did not see their importance. Officials, administrators, town councils realized at an early stage already, that deforestation could be a great threat and even an economic catastrophe, and a disaster for the everyday life of people. Many attempts of protecting and safeguarding forests by administrative, economic, penal and other measures are known from history, sometimes very strict. In spite of them deforestation reached alarming proportions.

From the 12th century on various Acts and documents are known, attempting to regulate tree cutting, protection of forest and reforestation. The town of Trieste, an important port at the foot of the plateau Kras introduced such an act in 1150 already. Similar to Trieste, who has no (more) forest in his hinterland, other towns of the Adriatic coast and islands, such as Korčula, Trogir, Dubrovnik, Skradin, Hvar, and Poljica, regulated the exploitation and protection of forest by town statutes enacted between 1214 and 1444. Venice edited a forest act in 1452 (Fig. 13) while for Istria Peninsula, Friuli and Karst the “Waldordnung” (the Forest Act) from 1541 is well known (Gašperšič & Winkler, 1986).

Despite the concern for forests these acts show that at that time the deforestation by cutting, clearing and burning had already seriously started. However in some presently barren places, forests still existed (Horvat, 1957). That the matter was taken seriously shows the example of Trieste, where an armed guard had to be organised by the town to protect the local forest in 1583 (Guttenberg, 1881) (Fig. 14). The said Acts commonly included a ban on goats, or a complete ban on grazing in the forest. In 1764 the edict was issued banning the free pasture of goats in the Military Croatia. Thousands of goats have been sold or

slaughtered but at the end of the century there were again about 64 000 of them in Karlovac district only. In 1771 the Court office in Vienna issued a ban on the practice of transhumance across the karst of Carniola, which involved winter sheep grazing in Istria Peninsula lowland along the Adriatic coast, and summer grazing on the Kras and on higher karst plateaus (Nanos, Snežnik). Despite the interdiction a long distance transhumance, from Bosnian karst plateaus along the Adriatic coast to the Slovenian part of the Dinaric Karst and back to Bosnia along the Sava River valley, was practised from time to time until the second half of the last century. The last time it happened the police put the flock and the shepherds on the train and they were sent back to Bosnia. The administration repeatedly issued acts on ban of goats: 1844 in Istria, 1870 in Gorizia, and 1874 in Trieste. The Republic of Slovenia (in the frame of Yugoslavia) banned goats by a decree in 1952, and finally Yugoslavia banned goat breeding, except in stables, in 1954 (Wessely, 1976; Papež, 1991).

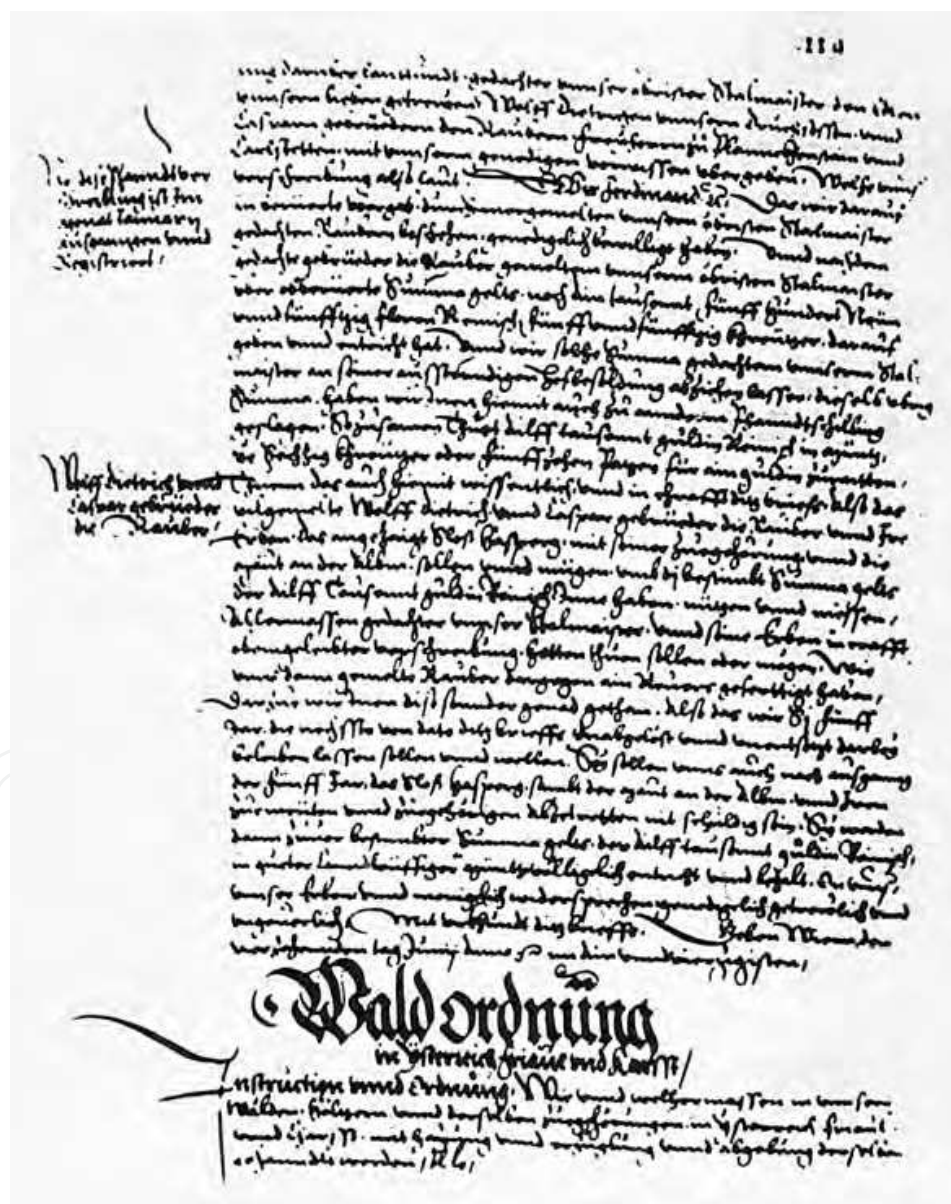


Fig. 13. Venice "Waldordnung" (Forest Act) of 1452 (Gašperšič & Winkler, 1986).



Fig. 14. The first black pine plantations of Kras plateau needed an armed guard (Anonym, 2001).

Even the Turkish threat sometimes had results that were favourable for forest conservation. To maintain the protection zone of dense forest against the advance and passage of irregular Turkish raiding bands, it was forbidden to touch any tree or bush in the forest within a few hours ride of the south-eastern border of Carniola.

But all the administrative measures were of little help and there was less and less forest. Early already some specialists suggested the reforestation. In his book "Hydrographical letters from Carniola" (Kranjska, the Austrian hereditary land) which is in fact a description of Carniolian karst, T. Gruber proposed reforestation as the most effective measure against the wind "burja", which caused quite an important damage and transport obstacle, especially in winter (Gruber, 1781). On the Istria Peninsula and in other parts of Dinaric coast under the Venetian Republic, all the oak forests and all oak trees everywhere were reserved for its shipyards, the Arsenal. The owner of the forest has the right to use only those forest products, trees, which the Arsenal did not need. Sentences were severe, including capital punishment. Of special value were naturally curved trunks of *Quercus pubescens*. In 1815, after the Vienna Congress, former Venetian territories of Istria and northern Adriatic Sea belonged to Austria. Soon after, in 1819, Austria had cancelled the navy oak reserve. The main forest keeper and navy manager of forest in Carniola, J. Ressel, realised that soon there would not be enough timber for navy needs. He proposed another type of navy forest reserve, different from the Venetian one, based upon constraint and punishment. He named his system "buying reserve" – the owner would get paid in advance, for each 10-years addition through growth, before cutting down a tree. Later, in 1842 Ressel proposed "Die Wiederbewalderung der Gemeinde Gründe Istriens" (The new reforestation of the commons of Istria) project. He tried to achieve reforestation by planting acorns, stating that the oak to be the best, but it proved unsuccessful (Piškorić, 1993). Later, in 1852 he proposed a similar plan for the part of Kras belonging to the towns of Trieste and Gorizia (Fig. 15).



Fig. 15. Josef Ressel (1793-1857) and the first page of his “History of E.&K. Navy Forests” of 1855 (Gašperšič & Winkler, 1986).

Meanwhile, the Ministry of Agriculture began to stimulate and finance reforestation, in response to complaints from karst communities and professionals, from the forestry bodies and J. Ressel especially, about the rigours of life on a barren rock landscape. A detailed study of such a life was made by Wessely (1876). In 1857, the first railway which crossed the Karst was completed, that is the connection of Vienna to Trieste. There were great problems protecting the railroad against the strong northeast wind called Burja in Slovene, Bura in Croatian, and Bora in Italian language, probably meaning or coming from “Borealis”. The major obstacle were snowdrifts formed by this wind. The Southern Railways Company had to build high drystone walls along the route of the railway; but they found it cheaper and better to plant trees along it; so they support and even join the reforestation programme. In 1859 the first successful reforestation occurred, using young black pine (*Pinus nigra* var. *austriaca*) seedlings on the plateau of Kras at Bazovica in the vicinity of Trieste, by J. Koller. The first successes boosted confidence and the activity spread to other parts of the karst within and outside of the Austrian lands (Fig. 16).

In 1885 finally the “Reforestation Act for Carniola (=Kranjska)” was issued, regulating the entire process, which included major work and investment as tree nurseries, wall construction, land preparation, and seedlings planting. On the karst terrains there were entire villages where reforestation provided the main or perhaps the only income. Everybody, men, women and children, was involved in these works: men were digging holes; women were planting seedlings, while children were bringing water and watering seedlings (Goll, 1898) (Fig. 17). Publications showing their success were published on different occasions (Goll, 1898). From all over Europe specialists came to Kras to see this successful reforestation, the senator Marquis de Campo and forestry engineer don Carlos de Mazedredo from Spain as an example (Rubbia, 1912).



Fig. 16. The first black pine plantations along the railway towards Trieste (Goll, 1898).



Fig. 17. Managing of black pine plantation above the Trieste in 1905 (Anonym, 2001).

Different activities were taking place in other parts of the Dinaric Karst too, the difference being due to local political and administrative particularities. There are also differences in the accessibility of documents and of publications. For some regions, in the frame of Austria for example, there is quite a lot of published works, technical documentation even, while for the parts which were in the frame of the Ottoman Empire, documentation is maybe more scarce and in any case more difficult to find and more difficult to understand, if written in Turkish language and in Arabic script. Under Hungarian administration Croatia was divided into Military Zone or Military Croatia (along the border with Turkish Empire) and

Provincial (Civil) Croatia. Due to Napoleon's ultimatum, Doge Ludovico Manin surrendered unconditionally on May 12, 1797 and abdicated, while the Major Council declared the end of the Venetian Republic. The Illyrian Provinces were created by the Treaty of Schönbrunn in 1809, and embraced a big part of the Dinaric Karst, beside Carniola the former Venetian territories along the Adriatic coast. Bosnia and Herzegovina remained in the Ottoman Empire until 1878 when it was annexed by Austria. In 1918, when the Kingdom of Serbs, Croats and Slovenes, later the Kingdom of Yugoslavia, was founded, Bosnia and Herzegovina as well as the great majority of the Dinaric Karst were included in it.



Fig. 18. The title page of the Venetian Forest Act for Istria of 1777 (Gašperšič & Winkler, 1986).

In 1871 when the military organisation of Croatia ended, the Austro-Hungarian Emperor wrote: "... the income of the sale of wood from the country's state's forests has to be used for investing, especially for the reforestation of karst." (Wessely, 1876). This was followed by the 1864 "Waldordnung" (The Forest Act) of the Military Croatia aimed at planting the barren land with a beech and a fir. Interesting illustration is the example of so-called "Laudonov gaj" (General Laudon's Wood) at Krbavsko polje in the Lika region. The western part of the polje was covered by moving sands. The later famous Austrian "Generalfeldwachtmeister" (major-general) G. E. Laudon served there, at Bunić in Karlovac region in 1740s. After becoming the major-general, he ordered to plant the forest there to fix the sands and to prevent damage to agriculture. Under the Military administration about

700 ha was planted with black pine and oak, in the form of a military formation as said. In 1965, it was proclaimed a forest reserve (Jaić, 2011).

Reforestation of the karst pastures in the hinterland of the port of Rijeka began in 1857 (Horvat, 1957). In Dalmatia, they tried to start reforestation under the Venetian regime already, by the so-called Grimani Act of 1756, but due to bad administration and corrupt officials the work did not even start (Fig. 18). During the time of the French Illyrian Provinces (1809-1813) each commune had to plant a “sacred wood” (bois sacré), but the provinces’ period was too short to achieve the desired results. Successful reforestation began in the 1880s following the example of Trieste. Yet in the countries of the Ottoman Empire, there are no Acts and no activities for protection of the forest or for reforestation known. From 1918 practically all of the Dinaric Karst was within the borders of the Kingdom of Yugoslavia. Not earlier than in 1929 the State’s Act on forest was issued with the essential prescription: “...all deforested lands especially on karst has to be set apart in the period of 10 years with the aim to be afforested as soon as possible. Reforestation has to be realized in 50 years...”. Even the state did not last 50 years and such a decree was impossible to implement, so it survived on paper only (Djikić, 1957). Systematic reforestation slowly spread over the entire of the Dinaric Karst and continued into the 1950s. In the socialist Yugoslavia, immediately after the end of the 2nd World War, massive actions of reforestation in the form of “Mladinske delovne brigade” (Youth work brigade), a form of a voluntary youth work were organized in the form of summer camps. On the karst of Slovenia one of the last actions was the reforestation work in 1950s on the Vremščica Mountain between Postojna and Trieste. From these times on, reforestation is mainly the duty of the forestry organization and of the owners of the forests.



Fig. 19. On a karst plateau, a pasture started to be overgrown by trees (photo K. Kranjc).

5. Conclusions

Deforestation, degradation and in some cases desertification even of Dinaric Karst started early in prehistoric times. They reached the peak in the second half of the 18th and in the first half of the 19th century. In any case, the reason was human factor, the economy with no attitude to sustainability at all. During the last thousand years it is possible to see the attempts to prevent the forest or even to meliorate, to reforest degraded lands. By the middle of the 19th century such attempts were mainly unsuccessful, but from that time on the situation started to change rapidly. At the beginning, reforestation was a sort of mass-activity while nowadays other factors join it. The general perception of the importance of a forest and of the sustainability helped a lot, but also the change of economy and activity of the population of the Dinaric Karst, the decline of the agriculture emphasized. Maybe the Dinaric Karst is turning to the other extreme – to be overgrown (Fig. 19). In Slovenia, on the Kras particularly specialists as well as laymen started to ask: how to prevent the Kras from becoming overgrown? “How to reasonably stop the overgrowing of Kras” is the title of a round table organized by the review “Kras” at Nova Gorica in 1997. The discussion also showed that foresters suggested replacing slowly black pine with oak (Mlinšek 1993).

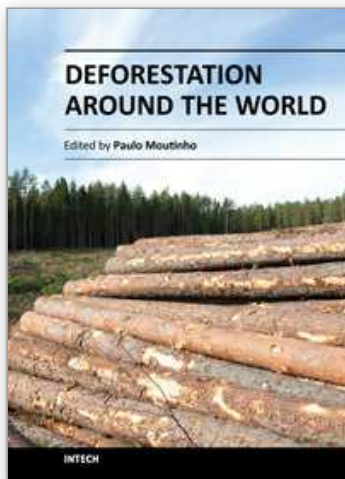
The foresters also suggested that Kras should be a field experimental laboratory of international importance to study the revitalization of a completely degraded landscape. Especially important should be the study of the revitalization of thermophile associations, which are the most affected and at the same time the most suppressed and neglected by the World’s public (Mlinšek, 1993).

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Deforestation and forest degradation represent a significant fraction of the annual worldwide human-induced emission of greenhouse gases to the atmosphere, the main source of biodiversity losses and the destruction of millions of people's homes. Despite local/regional causes, its consequences are global. This book provides a general view about deforestation dynamics around the world, incorporating analyses of its causes, impacts and actions to prevent it. Its 17 Chapters, organized in three sections, refer to deforestation impacts on climate, soil, biodiversity and human population, but also describe several initiatives to prevent it. A special emphasis is given to different remote-sensing and mapping techniques that could be used as a source for decision-makers and society to promote forest conservation and control deforestation.

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