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Reforestation in Macedonia: History, current practice and future perspectives

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Abstract

This paper presents data about forestry and reforestation in the Republic of Macedonia. The country is characterized with great diversity of natural conditions and rich floral and faunal biodiversity Forests in Macedonia cover 38% of its territory. About 71% represent coppiced and degraded and 29% tall forests. Historical, social and natural conditions caused gradual deforestation, forest and land degradation. Foundations of artificial afforestation were laid in the first decade of XX century. First reforestation started already in 1913/14 and continued, with various intensity, in the next decades. In the period between two world wars a foundation of modern forestry was established, as forestry education, scientific work etc., to help dealing with reforestation of waste bare and erosive lands. The most intensive reforestation was performed in 1971-1990 and during the following years significantly decreases. There is room for improving of some aspects of the reforestation, in aim to improve survival and development of the young stands.

Keywords

Macedonia; Natural Conditions; Land Use; Forest Structure; Deforestation; Reforestation

Contents

1 General data, natural conditions and land use

The Republic of Macedonia is located in the central part of the Balkan Peninsula (Fig. 1) and covers an area of 25,713 km^2. Approximately 80% of the whole territory belongs to hilly, hilly-mountain and mountain regions, and the difference of altitude varies from 40 to 2,764 m above sea level, with more than 100 summits higher than 2,000 m (Fig. 2).

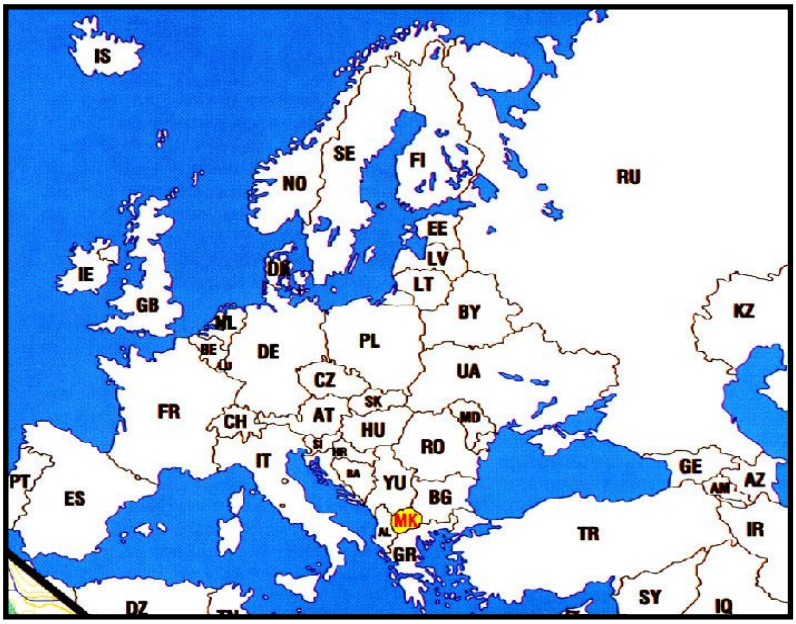

Figure 1. Position of the R. Macedonia in Europe.

Figure 2. Physical map of the R. Macedonia.

The country has semi-developed hydrographical net. The major part of the rivers, primarily the 1-st, 2-nd and 3-rd tributaries are dry during the summer, which has negative effect on the vegetation.

1.1 Land use distribution

About 43.57% (1,120,213 ha) of the total area of the country are agricultural lands of which 608176 ha are pasture and 511316 ha are arable lands. About 38% (981,812 ha) are forests. Water cover 81,741 ha or 3.18%, and other unproductive land covers 305,753 ha or 11.89% (Statistical review 2012).

Agricultural lands constitute of arable land and pastures, however fertile land is scarce, i.e. about 80% of the arable land has the fertility class IV to VII. Pasture land constitutes about 630000 ha but yields are significantly below its potential, indicating that some of the pastures should be used as forest land. In the past, much pasture land in Macedonia, as elsewhere in the Balkans, was forested (Blinkov and Petrovski 2000).

Forest land

The total stocked forest land in 2012 amounted to 988,835 ha of which 902,000 ha are managed, i.e. for which forest management plans are prepared (Vidal at al. 2016). Dominant tree species are various oaks (*Quercus spp*.) by 29.3% of total forest area, followed by the beech (*Fagus moesiaca* L.) with a share of 23.2%. Conifer forests take only 7.3% of total stocked forest land (Table 1).

Main part of the forests i.e. 89.5% are state owned forests and the rest part are private forests with average size on parcels of 0.45 ha (Trendafilov et al. 2008). By trees origin, a coppice forests together with different types of degraded forests occupy 71% of forest covered area. By the purpose, according to Forest management plans (2012) which manage 902,000 ha i.e. 91% of forest covered area, productive (economic) forests which primary function is wood production, occupy 841,000 ha i.e. 93% of managed forest. According to Forest management plans, the total volume of standing growing stock in 2012 was 88.67 million m^3, that is 98.3 m^3 ha^{-1}, and the annual increment 1.785 million m^3 (1.98 m^3 ha^{-1}). According to State Statistical Bureau, amount of cut timber volume in 2012 was 805,000 m^3. A substantial proportion of the forests are located on steeply sloping land, where the forest cover is necessary for soil conservation and watershed protection, and where logging is restricted (Blinkov and Stojanovska 2003).

2 Use, management of forests and deforestation in the past

In the past, the forest cover rate on the territory of Macedonia was much higher than in present. In the XIII-XIV century, on demand of King Dushan, German Saxon miners (called “Sasi”) started mining in Macedonia, especially in the east and northeast parts. They cut forests and used wood for fuel and mining construction, thus, as a consequence of this, the Kamenichka River catchment is highly eroded now. The first written document related to erosion and combating it on the territory of Macedonia is the “King Dushan Law” from 1349, i.e. the Article 123 (“For Sasi”) is a response to destruction of the forests made by the Saxon miners (Blinkov et al. 2007).

Table 1. Forests in Macedonia by the tree composition in 2012 (State statistical Bureau 2013).

	Republic of Macedonia	Vardar Region	East Region	Southwest Region	Southeast Region	Pelagonia Region	Polog Region	Northeast Region	Skopje Region
Total forest area	988,835	134,936	155,227	187,029	141,216	133,010	91,064	70,182	76,171
Broadleaf	574,604	52,654	82,807	124,925	80,193	83,824	47,780	54,828	47,593
Beech	229,773	15,369	31,008	50,563	19,622	2,938	30,124	31,475	22,674
Oaks (all)	289,973	34,818	50,525	71,917	33,507	44,368	12,996	20,622	21,220
Chestnuts	2,754	-	-	647	1 875	-	189	-	43
Other hard Broadleaf	48,634	2,467	1,274	1,737	24,819	8,344	4,459	2,651	2,883
Other soft Broadleaf	3,470	-	-	61	370	2,174	12	80	773
Conifers	72,206	8,815	16,496	10,861	9,180	12,221	2,402	9,406	2,825
Spruce	1,152	-	-	139	317	191	156	342	7
Fir	5,703	136	-	2,358	1,365	522	1,248	38	36
Black pine	47,452	6,944	12,817	6,656	4,251	5,284	959	8,112	2,429
Scots pine	9900	147	3,545	440	1,934	2,873	29	845	87
Macedon. pine	4,270	989	-	-	-	3,281	-	-	-
Other conifers	3,729	599	134	1,268	1,313	70	10	69	266
Mixed forests	297,207	63,448	49,855	37,256	45,847	36,228	37,564	5,831	21,178
Degraded forests	44,818	10,019	6,069	13,987	5,996	737	3,318	117	4,575

The Ottoman Empire, which governed Macedonia for five centuries (from XIV to the beginning of XX century) proclaims "*res nullius*" *(no ownership)* for the forest, which means everybody can cut the forest for free.

For centuries the forests represented a major source for people's life. Brutal exploitation of the peasant masses during the medieval feudal period, as well as the later Ottoman regime drove people out into the forests, where they had to cope to survive. The time and circumstances did not allow acting with forests rationally and economically in term of the principle of sustainable forest management, which left heavy consequences on forests. In such way, and with help of unfavorable natural conditions, waste bare land and coppiced forests appeared (Krstić 1934).

The forests, especially in the Central part of the country, near the River Vardar, were fully cut and the wood was transported to Thessalonica. Today the region along Vardar River in Central Macedonia is desertified, although according to chronicles of *Evliya Çelebi* (famous Turkey traveler from the XVII century) these areas were fully covered with forests (Blinkov et al. 2007).

Not only wood was utilized from the forests. Em (1934) reports about resin exploitation in Austrian pine woods, which started in the middle of XIX century in few villages in Macedonia, and, further developed on plan basis and management projects (Marković 1950), lasts until 1980-ies. Bojić (1934) analyses possibilities and suitable methods of pollarding, i.e. specific management of forest, which was widely used to

provide tree foliage for feeding of goats and sheep (mostly in east part of the country) and for silkworm (south-east part, around Strumica and Valandovo). Mass deforestation was realized also during the First World War and Balkan wars.

Deforestation, poor arable farming, grazing management (extensive sheep and goat breeding and necessity of expansion of pastures) etc. in the past have contributed to erosion, a problem spread all over the country. A number of ecological factors (climate conditions, especially drought, topography, plant cover, hydrological characteristics etc.) contribute to high erosion processes and land degradation and desertification.

The average annual erosion intensity of European states is calculated as 3.18 Mg ha^{-1}. Balkan countries cover 765,891 km^2 or 12.85% of the territory of Europe. The average annual erosion intensity in the Balkan is 5.48 Mg ha^{-1} and vary from 2.3 (Bulgaria) up to 18.7 Mg ha^{-1} in Albania (Blinkov 2015). According to the Erosion map of Macedonia (Gorgevic et al. 1993), an area of 9,423 km^2 or 36.7% of the total state area is in the highest categories (I – III). The total annual erosion for Macedonia is about 17 10^6 m^3 $year^{-1}$ or 685 m^3 km^{-2} $year^{-1}$, or 6.85 Mg ha^{-1} and is among the most endangered countries in Europe by erosion (Blinkov 2015).

Drought is another natural phenomenon which has multiple effects on the forestry in Macedonia. Long-term dry periods cause physiological weakening of trees and number of secondary problems occurs (disease, insect pests, forest fires etc.) Drought has the biggest influence on reforestation, especially on lower altitudes. Rainless periods cause drying of young stands which requires re-planting and increases the costs. Natural conditions in the dry areas cause presence mostly of low productive thermophile vegetation (Juniper, Oriental Hornbeam, Oak etc.), which is the most endangered by forest fires.

2.1 Reforestation in Macedonia in the past

Reforestation, i.e. artificial regeneration, as a method of raising new forest stands, has been performed in Macedonia in term of reforestation (planting after tree logging), afforestation (planting on bare, barren and erosive lands) and establishing plantations (seed orchards, poplar plantations, windbreak and windshield belts etc.) Definitions for reforestation, afforestation and artificial regeneration are used differently in different disciplines and areas of research, however as all of these mean planting forests (Ivetić and Devetaković 2016), therefore for all these silvicultural activities we will also use the term reforestation.

For this article, reforestation in the past will be considered until the Second World War. After the Balkan wars (1912-13), Macedonia was liberated from the five-century long Ottoman rule and became a part of Kingdom of Serbia (until 1918) and Kingdom of Serbs, Croatians and Slovenians, i.e. Kingdom of Yugoslavia (until 1945). These political changes influenced positively on the position of the forestry and reforestation in the country. The new governmental structures paid serious attention on natural resources and their use, which marked a new approach toward forestry policy.

Marković (1934) states that in 1913/14, i.e. after the Balkan wars and the end of the Ottoman rule, a special forestry commission evaluated the situation in Macedonian forestry was very unsatisfying: presence of waste bare lands deforestated caused mostly by over-exploitation and over-grazing, problems with summer drought and forest fires, lack of planned management, deficiency of financial means, unsolved

property relations, lack of experts and skilled technicians who could conduct forestry policy and activities etc.

First reforestation started already in 1914. Besides of poor financial situation, lack of experts and field experience etc., reforestation in relatively small scale and on various terrains was performed even during the First World War. The first forest nursery was established already in 1913 in Kumanovo and 8,000 black locust seedlings produced in this nursery were planted in 1914 near Kriva Palanka (Krstić 1934). In 1928 there was established a big forest nursery in Skopje, and part of the seedlings were used for first reforestation of the Mt. Vodno, which rises above the city and occasionally causes serious damages with torrents.

Due to First World War and consequences of it, more extensive reforestations were postponed until 1928, when activities in forestry in Macedonia got more expert and scientific approach. Priority was laid on reforestation of bare lands in lower altitudes up to 500 m a.s.l. (Krstić 1934). First reforestations were financed by the government and some resulted with quite poor initial survival of seedlings. This opened many questions and needed solving of row of problems, as adequate species selection, type of soil preparation, stock type, age and manipulation with seedlings, planting season etc. In this term, numerous experimental reforestations in different parts of the country were performed (Šacki 1926, 1927; Marković 1934; Šalajev 1934, etc.) Šikić (1934) analyzed development of Austrian pine stands raised in period 1925-1932 around Kichevo, and a part of these stands grow until today. Gathered experiences improved the results of reforestation and justified this activity among people.

First decades of reforestation partially marks conflict of interest between foresters and sheep and goat owners, because a part of terrains intended for reforestation was used for grazing. On the other side, reforestation was gladly accepted in areas where local people suffered consequences of erosion flows and torrents. In that point "governmental reforestation" gradually turned into "national reforestation" performed by citizens. State forest nurseries distributed seedlings to people, under condition of proper soil preparation (mostly deep holes) and quality planting. As an example, during 1930/31, the governmental reforestation was performed on 258 hectares with 625,000 seedlings with average survival rate of 73% (i.e. 70-90% in northern parts and 40-70% on arid bare land). Local people, on 1,000 hectares, planted 2,687,000 seedlings donated by government, with survival rate of 60%. Such practice decreased the costs of the reforestation (Maksimović 1934).

Tree species, which were grown in forest nurseries in that time, were various, but, what is interesting, many broadleaf allochtonous species were represented. Of conifer species, most often were *Pinus nigra* Arn. and *P. sylvestris* L., then *Abies borisii-regis* Mattf., *Picea abies* (L.) H. Karst., *Pinus peuce* Griseb., *P. halepensis* Mill., *Cedrus sp.,* etc. Of broadleaf, most common are *Robinia pseudoaccacia* L., *Fraxinus americana* L., *Acer negundo* L., *Gleditschia triacanthos* L., *Castanea sativa* Mill., *Juglans regia* L., *Morus alba* L., *Morus nigra* L., *Corylus avellana* L., etc.

Experiments conducted in nursery production (lower seeding density, low irrigation in seed beds etc., Marković 1934) should improve seedlings quality. Forest nurseries produced mostly non-transplanted seedlings, however there were suggestions to raise the quality of the seedlings by transplanting and growing for another 1 or 2 years in nurseries near the terrain where the reforestation should take place (Zaljesov 1934).

Krstić (1934) presents data about reforestation of bare lands for the period 1913-1930 (Table 2).

Table 2. Review on reforestation of bare land for the period 1913-1930 (FN=forest nursery; sdl= seedlings), Krstić (1934).

Forest district	No of FN	Total area of FN	Broadleaf species sdl produced (1,000)	Conifer species sdl produced (1,000)	Total sdl produced (1,000)	Refore-sted area (ha)	Planted broadleaf sdl (1,000)	Planted conifer sdl (1,000)	Total planted sdl (1,000)
Kumanovo	6	1.22	1,194	104	1,298	40	159	32	191
Skopje	2	2.47	2,758	160	2,918	58	209	11	220
Shtip	2	1.3	1,309	307	1,616	30	196	31	227
Gevgelia	4	1.07	673	987	1,660	30	98	103	201
Kavadarci	2	0.8	351	318	669	20	114	2	116
Bitola	1	1	1,200	605	1,805	30	63	106	169
Ohrid	1	0.33	983	809	1,792	40	59	39	98
Kichevo	1	0.3	421	547	968	25	75	78	153
Tetovo	4	1.8	1,131	2,192	3,323	50	340	439	779
Total	**23**	**10.29**	**10,020**	**6,029**	**16,049**	**323**	**1,313**	**841**	**2,154**

Generally, following was recommended for reforestation of bare lands (Marković 1934): soil preparation in gradoni (cordons) on erosive terrain, or deep holes on bare land; fall and winter planting, hoeing during spring of the first growing season, elimination of species which failed, experimenting with planting and sowing; collecting seed for most species within the region of use, promotion of a "Children reforestation day" etc.

Of 323 hectares bare lands reforested during 1913-1930 (Table 2), less than 10% were considered successful (Krstić 1934). Success of other reforestations varied greatly and the most common reason for poor reforestation was the summer drought (Šacki 1926, 1927), soil conditions (Šikić 1934), but also luck of experience, experts and trained staff (Marković 1934; Krstić 1934). According to Jovanović (2009), reforestation during the period of 1929–1941 was performed in various rates, depending on local conditions and adopted plans. During 1932/33, on the territory of Vardar Banovina (part of which was Macedonia) were planted 4 million seedlings with a cost of 0.3 million dinars, while the evaluated annual cost of damages of torrents was 16 million dinars. By 1937, a total of 37 million seedlings of broadleaf and conifer trees were planted, of which 7 million were planted on government cost, and the rest were distributed to people. About 54% of these seedlings (20 million) were planted in the period 1930-1935.

In 1937, the first 8 km of windbreaks and shelter belts were raised (Jovković 1950). Such plantations were later widely raised in Ovche Pole, Kumanovsko Pole, Pelagonia etc.

2.2 Reforestation after the Second World War

One more time, political flows changed the situation in Macedonia, which reflected on many fields. Macedonia became constituent federal republic in the

Yugoslav Federation, which meant bringing its own politics, financial plans, managing of natural resources etc.

For some period after the Second World War, due to post-war crisis in the country, reforestation activities temporarily slowed down. However, already in 1950s several laws were adopted (Law on Financing Melioration System in 1950, Act for afforestation of bare land in 1951, Act of erosion control on steep slopes in 1952, Act of steep slopes protection and torrent control in 1957), which put solid base for continuing the reforestation, at first place of bare and erosive lands.

The State Statistical Bureau of Macedonia (SBM) records its first official data of reforestation in 1953 (Statistical reviews). According to the annual reviews of SBM, from 1953 to 2014 (62 years) a total area of 214,523 ha was reforested, however, the scale of reforestation varied greatly (Fig. 3). These 62 years of reforestation will be analyzed in four periods, according to certain elements which marked them significantly.

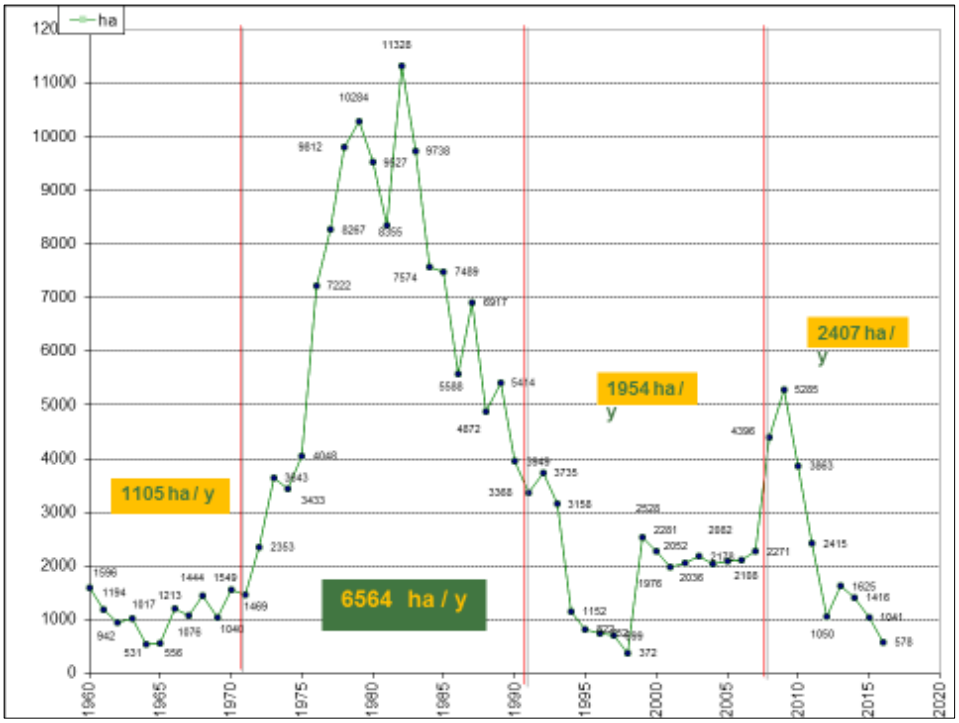

Figure 3. Reforestation for the period 1960-2013 (Blinkov 2015).

The first period, from 1953-1970, marks an annual scale of reforestation of 1,105 ha year[1]. The reforestation was planned, financed and performed by forest enterprises and local municipalities.

The second period, from 1971 to 1990, characterizes significantly intensified reforestation. This was accomplished thanks to the Long-term program for reclamation of the bare lands for the period 1971-1990, where the scientific foundations and activity plans were implemented (Lazarovski 1967; Nikolovski 1971, 1972; Trajkov 1973, 1977 etc.) At the same time, a Fund for afforestation of bare lands was

established, which provided the financial support for the activities. The Fund was financed both by the Government (80%) and the local municipalities (20%); for example, by retaining a certain per cent of the car registration fee, so called "ecological tax". Thanks to the Fund, during the second period there were reforested 131,262 ha, (the annual average of 6564 ha year^{-1}) and the largest area was reforested in 1982 (11,382 ha).

The third period starts after Macedonia gained its independence in 1991 and lasts until 2007. This period is characterized by very low scale of reforestation, in comparison with last two periods. The main cause for the negative trend in reforestation lies in political, economic, social and other changes in society, which put reforestation into second plan. The Fund for afforestation was abolished and reforestation significantly decreased. In this period were reforested 33,570 ha (annual average 1,954 ha year^{-1}).

In 2008, as a reaction on extremely high number of forest fires in 2007 (652 fires on more than 35,000 ha), emerged a civic initiative for reforestation called a "Tree Day", which, in followings years, raised the ecological awareness of the people, but also brought many problems to the experts and operative workers. From 2008 up to now, PE Macedonian Forests and the "Tree Day" reforested 21,669 ha or 2,407 ha year^{-1}.

3 Planed activities and current state in reforestation

As for the "current state", in this paper we consider the period from 1998 until today. Namely, in 1998 a Public Enterprise "Macedonian forests" was established, as a legal successor of the previous 30 forest enterprises. Reforestation of bare and erosive lands, which still occupy significant portion of the territory, represents (or should represent) one of the basic activities of the PE.

Reforestation in Macedonia has been/is planned with several general development documents: Long-term program for reclamation of the bare lands for the period 1971-1990 (1969), Long-term program for development of the forestry (1971), Spatial Plan of the R. Macedonia (2004), Strategy for development of agriculture, forestry and water utilization (1996) and Strategy for sustainable development of the forestry in the R. of Macedonia (2006), as well as Forest management plans which the PE "Macedonian forests" passes for each forest management unit for the period of 10 years.

In 1996, according to the Spatial Plan, the purpose of lands is re-defined and 217,749 ha of bare forest land and erosive terrains are registered, of which 129,000 ha of bare lands, rock lands and non-productive agricultural land are determined for reclamation by reforestation. Besides the reforestation of the bare lands, melioration of degraded coppice forests, which occupy an area of about 260,000 ha, is planned. A part of these forests is degraded in degree that they, beside of losing productive function, and lost their protective role as well.

Adopting the Spatial Plan and Strategy for sustainable development of forestry (2006), the Government takes responsibility of providing financial means to support the realization of quite ambitious plans for reclamation of bare lands and degraded forests. Table 3 shows planned activities for reforestation and melioration activities for the period 1996-2020.

Table 3. Planned activities on reforestation and melioration of degraded forests for the period 1996-2020 (Spatial plan 2004).

Period	Reforestation after logging (ha)	Bare lands intended for reforestation (ha)			Reclamation of degraded forests (ha)		
		within the forests	out of the forests	total	direct conversion	indirect conversion	total
until 2010 (1998-2010)	22,500	41,300	37,920	79,220	40,000	70,000	110,000
2011-2020		30,500	40,280	70,780	60,000	90,000	150,000
total		71,800	78,200	150,000	100,000	160,000	260,000
Annual average		3,122	3,400	6,522	4,348	6,956	11,304

However, planned activities (Annual report of realization of Spatial plan of the R. of Macedonia for 2010), are far from realization, i.e. reforestation is realized in 45%.

3.1 Current state in reforestation

Seed sources

In 2007 in Macedonia a new Law for forest reproductive material of forest tree species (2007), which is in accordance with EU legislative, was passed. This law should promote the quality of the reproductive material, especially its genetic value. However, even though 10 years passed, implementation of the law is beyond expectations.

First seed sources in Macedonia were evaluated and registered in 1960-ies. Since then, a re-evaluations in 1996 (Andonoski et al. 1996; Kolevska 2006) and in 2010-2013 were performed and new objects were registered. During 2010-2013, totally 34 seed objects of 14 tree species (9 coniferous and 5 broadleaf) in two categories (identified, i.e. seed source and selected reproductive material) were registered (Kolevska, unpublished data). Two seed orchards (plantations) are currently in the process of evaluation. However, seed is rarely collected of seed sources. Among many reason, responsible authorities state lack of seed collectors, financial reasons, low degree of control on seed collection etc. Having in mind that seed collectors in Macedonia don't possess any technical equipment (they promote "free style" climbing), it imposes conclusion that part of collected seed origins from genetically inadequate sources, which will reflects on the future quality of the stands.

Seed quality

Generally, seed quality of examined species meets demands of national quality standards (MKS Broadleaved species, MKS Conifer species, 1971). The germination rate is very high in *Pinus nigra, Pinus silvestris* and *Picea abies* (70-90%), in *Pinus peuce, Acer pseudoplatanus* L.*, Robinia pseudoaccacia* etc. 60-75%, in *Abies borisii-regis* Mattf.*, Pseudotsuga menziesii* 30-40%, in *Cupressus arizonica* Greene 15-25% (Kolevska – unpublished data).

Nurseries, seedling types and seedling production

The PE "Macedonian forests" currently owns 19 nurseries with total production area of c/a 25 hectares. The capacity of the nurseries is 8 million container seedlings and up to 10 million bare root seedlings. The nurseries lie on altitude of 210-1,250 m a.s.l. and feature with various ecological conditions, from medium - to - highly favorable. The production technology is traditional (bare root seedlings, 16 nurseries) and container (3 nurseries).

The traditional nurseries are technically poorly equipped and all production operations, with the exception of mechanical soil preparation, as seedbed preparation, sowing, covering, cultivation, weeding etc. are carried out manually. Soil analyses is not performed and fertilization of the seedlings is carried on basis of empirical experience.

The container nurseries are equipped with modern infrastructure, shading and irrigation system, however, again, all operation (filling of the containers, sowing, covering, thinning, weeding etc.) are performed manually.

For the purposes of reforestation only non-transplanted seedlings 1+0, 2+0 and 3+0 are grown.

Species selection

As stated earlier, pure and mixed broadleaf forests cover near 90 % of the total forest area, while coniferous forests only some 7%. However, oak forests, which occupy some 30% of the total area, represent mostly highly degraded stands with low production. Such situation was considered as unsuitable (Long-term program for development of the forestry 1971); therefore, based on this documents and earlier mentioned development plans and strategies (Spatial plan 2004; Strategy for sustainable development of forestry 2006), a revised tree species composition was planned. Thus, in the future, coniferous species should be planted on 57% and broadleaf species on 43% of reforested area. According to the Spatial plan (2004), in the lower oak zone should be used *Pinus nigra, Cupressus arizonica, Quercus frainetto* Ten*, Querqus robur* L.*, Acer platanoides* L.*, Carpinus betulus* L., etc., in the upper oak zone *Pseudotsuga menziesii, Pinus silvestris, Abies borisii-regisLarix decidua* Mill., *Quercus petraea* (Matt.) Liebl.*, Acer pseudoplatanus*, and in the beech zone *Pinus silvestris, Picea abies, Abies borisii-regis, Larix decidua* and *Pinus peuce.*

Nursery species selection should rely on management plans and other documents, but in practice it is not the case and depends mostly on available seed in current year. In Table 4 is presented a common tree species selection in Macedonian forest nurseries in 2016 (Kolevska, unpublished data from 2016). More than 40% of the total number of the seedlings represents Austrian and Scots Pine, while the Black Locust with almost 25% seedlings is the most common broadleaf species. Coniferous: broadleaf species ratio in 2016, but also in different years, varies in rather narrow range (c/a 60:40%).

In some years, in small scale, also seedlings of *Cedrus deodara* (Roxb.) G. Don, *Sequoiadendron giganteum* (Lindl.) J. Buchh.*, Pinus pinaster* Aiton*, Ginkgo biloba* L.*, Fraxinus ornus* L.*, Fraxinus angustifolia* Vahl.*, Eleagnus angustifolia* L.*, Celtis australis* L.*, Catalpa bignonioides* Walter and others are grown. Small part of the seedlings is transplanted to produce bigger seedlings for decorative purpose.

In some years, when the yield of seed of planned species is insufficient, or for certain "special" actions (as already mentioned the "Tree Day"), or just as a "desire" of the nurserymen, the species selection is questionable. In 2016, as seen in Table 3, among other species, relatively high presence (8.9%) has White Ash (*Fraxinus americana*). In 2010, in the "peak" of demand for seedlings for the "Tree Day", of c/a 16 million produced seedlings, 13%, i.e. 2.14 million seedlings, was White Ash. This means that this species was planted on an area of c/a 1,000 ha, which is far of reasonable, because some other species, both domestic and allochtonous, would be much more suitable for this purpose. The main reason for its mass-production is the available and easy-to collect seed, and easy and quick nursery production.

Table 4. Tree species selection in Macedonian forest nurseries in 2016.

Species	Seedlings production technology		Quantity of produced seedlings (in thousands)	Percent (%)
	Container	Bareroot		
Total			3,680.6	100.0
Coniferous species			2,312.5	62.8
Abies borisii-regis	*	*	24	0.7
Cupressus arizonica	*	*	276	7.5
Picea excelsa	*	*	218	5.9
Pinus nigra	*	*	917	24.9
Pinus silvestris	*	*	642	17.4
Pseudotsuga menziesii	*	*	234	6.4
Thuja orientalis	*	*	1.5	0.0
Broadleaf species			1,368.1	37.2
Acer negundo		*	4	0.1
Acer pseudoplatanus		*	27	0.7
Aesculus hippocastanum		*	1.7	0.0
Albizzia julibrissin		*	8	0.2
Betula verrucosa	*	*	5	0.1
Castanea sativa		*	21.5	0.6
Cercis siliquastrum		*	5.5	0.1
Fraxinus americana		*	327	8.9
Juglans nigra		*	1.3	0.0
Koelreuteria panniculata		*	3.1	0.1
Populus x euroamericana		*	4	0.1
Quercus macedonica		*	34	0.9
Quercus sp.		*	23	0.6
Robinia psedoacacia		*	898	24.4
Sophora japonica		*	5	0.1

Seedling production technology

The production technology of bare root seedlings is rather primitive, mostly due to scattered nurseries with small production area and poor equipment; therefore application of any advanced methods is quite difficult (Fig. 4 and 5).

Figure 4. Manual irrigation; nursery Kichevo.

Figure 5. Manual excavation of black locust seedlings; nursery Kriva Palanka.

In 2001, a project for central nurseries in Republic of Macedonia was prepared (Kolevska 2001), as an answer to the Strategy for development of agriculture, forestry and water utilization (1996) and ambitious plans for future reforestations, with maximum scale of mechanization, i.e. automatization. The new concept of nursery production was planned to satisfy requirements not only in term of quantity, but also quality and stock type diversity of seedlings for various purposes and terrains

(containerized seedlings with different size, bare-root not transplanted and transplanted seedlings, seedlings with cut roots etc.) However, the project was implemented only in 3 container nurseries, while the traditional nurseries continued with "old" practices.

For production of container seedlings, there were built 3 modern nurseries, with full infrastructure. At the beginning of use of container seedlings in Macedonia, since 1970-ies, two container types were used: Paperpots (Popovski and Levkova 1977) and a hard plastic container Yukosad (Arsovski and Stankovski 1980). After some 20 years of use, the Paperpots containers were shortly replaced with domestic Siset (made of grey cardboard with white coating). For the last 15 years, only Yukosad containers are used in all three nurseries. The nurseries are well equipped (Fig. 6), however filling and sowing are still performed by hand (Fig. 7).

Figure 6. Yukosad nursery in Sveti Nikole.

Figure 7. Manual filling of the containers; nursery Sveti Nikole

Quality of produced seedlings

Coniferous seedlings from Macedonian nurseries generally satisfy national (MKS D.Z2.110 1968) and EU seedling quality standards (Council Directive 1999/105/EC) in term of shoot height, but not always in the term of RCD (Kolevska 1998, 2004a, 2004b). Generally, the quality of the seedlings within one particular nursery in different years is considered more or less uniform. In Table 5 are presented features of different stock types, ages and production technologies of Austrian Pine (*Pinus nigra)* seedlings, produced in Macedonian nurseries in period 1995-2004 (Kolevska et al. 2006).

As seen from the table, the quality features of the Austrian Pine seedlings from different nurseries vary significantly, even in the same stock type and age. Macedonian forest nurseries differ greatly in ecological conditions, and difference in quality features of seedlings from lower and higher positioned nurseries can be significant. The production process in each nursery, except of ecological conditions, lies on the experience of the staff and technology (container-seedlings versus bare root-seedlings nurseries).

The broadleaf species are produced only as bare root. Their morphometric features and quality depend more on ecological conditions (soil type, climate etc.) in the nursery, which vary greatly generally, but generally they meet Macedonian quality standards (MKS D.Z2.110-112. 1968).

Except of ecological conditions, some nursery practices, as sowing density (Kolevska 1997, 1998), cutting roots (Kolevska and Grazhdani 2006), sowing pattern (Kolevska et al. 2015a), and different container type (Kolevska et al. 2015b) etc. influence the seedlings quality.

Table 5. Morphometric features of Austrian Pine seedlings and correlation between some parameters of shoot and root system (Stock type: PP= PAPERPOT, type FH 508, 122 cm^3; YS=YUCOSAD, hard plastic container, height (h) 8 cm, ∅, 4.0 cm, 75 cm^3; PS= PIROSAD, hard plastic container, h= 12 cm, ∅ 5.0 cm, 160 cm^3; SS= SISET (multipot container with 35 cells of grey cardboard with white coating), 4.2x3.8x8.0 cm, 128 cm^3); BR= BAREROOT, BR/ =bareroot seedlings with cut roots (in June 2+0); TRS 1+1 = BR seedlings transplanted in spring as 1+0, at 10x10 cm scheme; Seedlings morphometric features: H=height of the shoot; RCD=root collar diameter; WS=dry weight of the shoot; WR=dry weight of the root system.

Stock type	H	RCD	WS	WR	H: RCD	H: WS	H: WR	RCD: WS	RCD: WR	WS: WR
1.PP 1+0	9.8	2.2	0.5	0.3	4.4	20.8	39.1	4.7	8.9	1.9
2. YS 1+0*	7.5	2.1	0.4	0.3	3.6	17.9	30.1	5.0	8.4	1.7
3. YS 1+0*	13.1	2.0	0.8	0.3	6.6	16.9	42.1	2.5	6.4	2.5
4. PS 1+0	8.5	2.1	0.6	0.4	4.0	14.6	22.3	3.7	5.6	1.5
5.SS 1+0	11.2	1.9	0.6	0.3	5.9	19.6	39.9	3.3	6.8	2.0
6. BR 1+0*	7.5	2.5	-	-	3.2	-	-	-	-	-
7. BR 1+0*	6.6	1.2	0.2	0.1	5.7	41.2	65.9	7.3	11.6	1.6
8. PP 2+0	17.0	3.9	-	-	4.4	-	-	-	-	-
9. YS 2+0	9.9	2.8	-	-	3.5	-	-	-	-	-
10. PS 2+0	15.5	3.9	-	-	4.0	-	-	-	-	-
11.BR 2+0*	14.0	3.8	-	-	3.7	-	-	-	-	-
12. BR 2+0*	22.1	4.5	7.2	1.4	4.9	3.1	14.8	0.6	3.0	5.1
13. BR/ 2+0	19.6	4.1	4.0	1.1	4.8	4.9	18.7	1.0	3.9	3.8
14. TRS 1+1	9.3	3.3	1.9	1.3	2.8	4.8	7.1	1.7	2.5	1.5

Reforestation by seed

In Macedonia, reforestation with seed is performed most in Fir (*Abies borisii-regis* Mattf.), and very rarely in Austrian Pine and Douglas fir. In Table 6 are presented data for artificial reforestation by Fir seed between 2011-2016 (internal data, PE Macedonian forests).

Table 6. Tree species selection in Macedonian forest nurseries in 2016.

Year	Reforested area (ha)	Fir seed used (kg)	Average seed consumption (kg ha^{-1})
2011	285.9	2,865	10.0
2012	179	1,699	9.5
2013	268	2,925	10.9
2014	154	1,540	10.0
2015	-	-	-
2016	130	1,130	8.7
Average	169.4	1,693.3	8.2

3.2 Phases and techniques of reforestation

Soil preparation

The choice of the most appropriate method of soil preparation prior reforestation depends on number of factors: altitude, relief, climate conditions, micro-site conditions, geological layer, type and depth of soil, seedling type etc. In Macedonia the soil preparation is almost exclusively performed mechanically. Where possible, the soil is prepared by tractor and plow (one, rarely two furrowed), or with a "soil ripper" with or without side "wings" for weed removal. Both techniques have their own advantages and disadvantages, but they give good results if used professionally. Such mechanical soil preparation is performed on c/a 80% of areas for reforestation. The furrows are opened on contour line, 2-4 meters apart. Soil preparation by ploughing causes problems in following term: if a common plow is used, which is usual in the forest operative (not turn-wrest plough), and to increase the efficacy of the machinery (to plough in both directions), in every second furrow the ploughed mound deposits up-hill (Figure 8). After that, the mound (plowed soil) is not returned to the furrow mechanically, but by hand tools during the planting, which makes the planting more difficult and less appropriate for the seedlings survival.

Figure 8. "Proper" (right) and "improper" furrow (left).

Opening furrows by tractor with a soil ripper differ from ploughing because the soil is not turned out; only a deep (up to 50-60 cm) narrow crevice opens. If lateral "wings" are added, the soil surface in a belt parallel to the furrow is taken off, to remove weeds (Fig. 9). This method of soil preparation requires high planting skill, in term of proper fixing of the roots of the seedling and closing all gaps during the planting. On clay soil or in dry conditions this kind of soil preparation may cause opening new crevices and intensive evaporation (Fig. 10).

Figure 9. Furrow opened with soil ripper with side “wings”.

Figure 10. Deep crevice next to the seedling.

Soil preparation with drilling machine (mostly with diameter of the drilling part of 15 cm) is performed more often, as new drilling equipment is procured, and now is applied on c/a 20% of the areas for reforestation.

Manual soil preparation is applied in cases when mechanical preparation is impossible, on steep slopes, shallow soil, on terrain with various obstacles (parental rock, remains of woody vegetation), relatively small weeds and for small container seedlings. The main ways of manual soil preparation are:

- manual digging of holes, with diameter and depth 25-40 cm,
- manual digging of trenches (cordons, “gradoni”), on slopes with bigger inclination, with various length, and depth and width 25-30 cm.

The manual digging of gradoni was widely performed earlier, mostly in reforestation of bare and erosive lands. Even a very expensive method, it offers very good conditions for seedling survival and development. The Figure 11 shows gradoni on Mt. Vodno near Skopje, manually dug more than 60 years ago, as a reminder of highly quality soil preparation.

Figure 11. Gradoni still recognisable after 60 years.

Planting techniques

Only manual planting is used for the purpose of reforestation in Macedonia. It is applied both on mechanically and manually prepared soil.

The most common method of planting is by using various wooden or metal tools, usually manufactured by the planters, or by adaptation of shovels, spades, planting sword, pickets, harrows etc. The seedlings can be planted by putting into slanting or vertical cut, into small holes made by some kind of cylindrical narrow planting picket, or into a usual hole. The quality of planting depends on the previous site preparation, soil conditions, type of planting tool, skills, individual capabilities and conscience of the workers.

The quality of planting may have a decisive influence on the final outcome and success of reforestation. The practical experience proves that this segment of reforestation should be considered very seriously. Bad quality of planting (shallow planting due to improper soil preparation or improper planting tools, insufficient fixing of the seedling in the soil, deformation of root system etc.) present the most often errors. This happens when using unskilled stuff for planting in various ecological reforestation actions. In this point, financial, material and time loss outcome the benefit of such action, i.e. raising ecological awareness.

As already mentioned before, the civic action “Tree Day”, which started in 2008, was promoted as a reaction on 652 forest fires in 2007, which destroyed 35,248 ha of forests. This action (proposed and promoted by an opera singer) was at first financially supported by the Government, while the PE “Macedonian forests” had the

executive role (soil preparation, seedlings production, logistics etc.) Planting was done by volunteers, i.e. citizens, pupils, soldiers etc. Despite its indubitable positive idea, the realization of this action confronted professional versus amateur (but politically supported) attitude. Numerous aspects to gain successful reforestation, as species selection, time and method of soil preparation, planting tools (Fig. 12 and 13) and above all – quality of the planting (Fig. 14, 15 and 16) were neglected, and as a result, poor survival of seedlings on such reforested areas was expectable.

Figure 12. A young and a senior volunteer during the Tree Day. Both planting tools are improper for planting seedlings of black locust (in the hands of the older man).

Figure 13. A planting tool.

Figure 14. Shallow planted seedling: left black locust seedling (the roots are above the ground), right an Austrian pine seedling.

Figure 15. The seedlings of black locust should be planted at least 10 cm deeper.

Figure 16. A black locust seedling planted with the roots up and branches down.

Even though this action gradually converted, and during last 2-3 years more attention was pointed toward planting trees around and in cities, along roads etc., it still exceeded the range of regular reforestation (Table 7).

Table 7. Range of reforestation versus the "Tree Day".

Year	Simple biological reproduction (Reforestation after logging) (ha)	Extended biological reproduction (reforestation of bare lands) (ha)	Tree Day (ha)	Number of seedlings planted during the Tree Day
2008	1,015	801	2,560	5,225,000
2009	859.3	575	3,915	7,908,035
2010	1,090	696	2,017	7,645,454
2011	515	638	987	3,405,162
2012	468.1	40	365	1,237,918
2013	365.5	50	941	3,462,490
2014	362.1	50	1,004	3,462,490
2015	266	50	725	2,235,840
2016	173	50	355	885,937
Total	5,114	2,950	12,869	35,468,326

3.3 Cultivation measures after reforestation

Cultivation measures, i.e. nurturing of young stands, should take an important place in reforestation in the R. of Macedonia, mostly because of unfavorable ecological conditions for survival and development of seedlings. In the country, especially after reforestation of bare lands which occupy territory with altitude up to 600-700 m a.s.l., seedlings usually face hot and dry summers. During an experimental reforestation in 2012 on arid region on 240 m a.s.l., Velichkovska (2015) established that the average temperature in July 2012 was 4.7°C higher than an average July temperature for the period 1967-2011. The sum of precipitations for July-September 2012 was only about 10-30% of the average sum during these months in 1967-2011. In 2012, sum of precipitations for July-September was only 33.8 mm m^{-2}. In such harsh conditions cultivation measures play an important role.

Depending on the conditions, after spring rains, 2-4 cultivation would be necessary during the first growing season, to enable the soil moisture to be kept longer in the root zone. Weeding would be executed in parallel with soil cultivation. However, these cultivation measures, less because of poor economic situation and more because of underestimating of the importance of them, are not applied at all, or are applied in a minimal range. In 2014, according to the internal evidence of PE Macedonian forest, all 30 subsidiaries performed reforestation, but only 9 of them planned cultivation measures, of which 70% were realized.

Another important measure for cultivation of young stand is protection from diseases, insect pests, domestic animals and fire.

Protection from diseases and insect pests is a must for many reasons. In the R. of Macedonia, in almost all cases of reforestation (reforestation after logging, reclamation of degraded forests, reforestation of bare and erosive lands etc.), only

monocultures i.e. stands composed of only one species, are raised. This implies a great danger of occurrence and over-multiplying of various diseases and insect pests. In Austrian Pine stands, raised on lower altitude, the trees physiologically weaken which allows occurrence of *Neodiprion sertifer* Geoffroy and *Thaumatopea pityocampa* Denis & Schiffermuller (Nacheski and Papazova Anakieva 2014; Nacheski et al. 2015, 2016, etc.)

Also fire represents one of the biggest problems in the country, especially in the areas where bare lands are most present. During the period 2004-2013, there were total 2,046 (average 205 year^{-1}) forest fires, on about 91,800 ha (average 9,180 ha yr^{-1}). Only in 2007, there were recorded 652 forest fires, which destroyed 35,248 ha (Forest Fires Country Study 2015).About 72.5% of fires are of anthropogenic origin (65% due to negligence, 7.5% were ignited intentionally); only 2% were caused by lightning. For 25.5% of fires, the cause is unknown due to difficulties in discovering the "culprit" (Nikolov 2006). The damage caused by forest fires is multiple, not only loss of the wood. After the fire, if not cover by reforestation soon, on the burned area emerges process of erosion, appearance of bark beetle, especially in pine forests etc. A number of measures for prevention and various activities are undertaken, from education of local people over equipping and modernizing of rangers and information services (Nikolov 2006).

Having in mind natural conditions and distribution of bare and erosive lands, which suffer the most severe impact of drought and danger of fires, Nikolov and Acevski (2006) propose a list of pyrophytic plants, which should be used for raising preserving belts around reforested areas. As few examples, among proposed species are: bushes *Rhus sp., Euonymus verrucosa* Scop*., Syringa sp*. etc., trees *Acer platanoides, Juglans sp., Aesculus hippocastanum*L*., Celtis australis* L*., Robinia pseudoacacia, Cercis siliquastrum* L., and especially *Crataegus sp., Rhamnus sp.* as well as *Juniperus excelsa* M. Bieb.

4 Results of reforestation: survival, advantages and disadvantages, and future concerns

In the last 60 years, in the Republic of Macedonia were reforested about 200,000 ha, which represents c/a 7% of the total area of the country. This (unpublished) number represents sum of official (c/a 130,000 ha) and internal data from "Afforestation books", which runs every subsidiary of PE "Macedonian forests" (former Forest enterprises) for reforestation activities. Inspection on these books reveals that some areas were planted several times (on the same place, over and over) because of poor survival of the seedlings (due to extremely eroded and poor terrains, poor planting quality, fires, pests, diseases, grazing, etc.) and every time the "new" reforestation was ascribed to the previous sum of reforested areas. In such way it is extremely difficult to gain realistic information about reforestation works in the country.

Presently only about 50% of reforested stands are alive and of very different quality, while others were destroyed due to various causes. A part of reforested stands were destroyed during the first growing season, while the other part died in the latter period, although the initial development of the seedlings was promising. Trajkov et al. (2006, 2007) questioned the very essence of raising and survival of Austrian Pine stands in unfavorable ecological conditions (low altitude), not only due to their

enormous low production features, but also due to low physiological condition and resistance toward drought and frost.

The results of performed reforestation vary in different stands (internal data of PE "Macedonian forests"). Some stands show excellent initial seedling survival and growth, while others survived in low per cent, which needs additional investment and activities on re-afforestation (completion of died seedlings) and nursing of stands. Causes for poor survival of seedlings mostly are complex, i.e. consequences of bad reforestation, as improper or insufficient soil preparation, poor planting, improper stock type or poor seedling quality - both morphological and physiological, and many other factors as drought, frost, weed, diseases and insects, damages of grazing, fire etc. during the first few years of development of young stands.

The approach toward the reforestation in the past has been changing. The manual labor on soil preparation was almost completely replaced by mechanical work; bare root seedlings have been partly replaced with container seedlings. Facing consequences of long periods of drought, use of superabsorbents in reforestation is tested.

Introducing the container seedling production technology some 40 years ago enabled to extend the scale of reforestation and the possible period of planting. Also rising of the success of the reforestation was expected. Early results of reforestation showed that seedlings from Paperpots survive in very high scale and promise successful development (Popovski 1986), while dying of stands from hard-plastic container seedlings (Yukosad) up to age 8-10 years due to roots deformations was predicted (Popovski 1985). However, Kolevska (1995, 2012) and Kolevska and Trajkov (2012) found that survival and growth of "container stands" doesn't primarily depends on the container type and root deformations, but on the quality of planting and ecological conditions. The stands of both containers, Paperpots and Yukosad, up to the age of 17 years, developed well.

Use of superabsorbent effected better survival in experiment of Nacheski et al. (2012), but Velichkovska (2015) recorded mass drying of all seedling types, both treated with superabsorbent and control, after the period of extreme drought in 2012.

The reforestation activities in Macedonia will continue in the future in various scales, which depends on short-term plans, because national plans and strategies (the actual ones cover the period until 2020) aren't passed yet. It is necessary to assume a critical approach to the executed works and to act in direction of developing and improve the strong sides of the process of reforestation and to change and correct the deficiencies.

Some reforested areas, i.e. stands which grow on them, witness that reforestation in Macedonia can be very successful, if all phases of the process are performed on necessary quality level. Even stands, rose many decades ago in rather more primitive conditions, are positive examples, that whether it's for seedlings quality or for soil preparation, planting or cultivation, good results can be achieved. Generally, we can produce good quality seedlings, perform proper soil preparation and planting, but not always and everywhere. Reforestation success depends also on ecological conditions, especially climatic, so reforestations performed on lower altitudes are more often less successful than in higher altitudes. However, we have in Macedonia examples of good stands in unfavorable conditions (Fig. 17) which show that the most important for reforestation success is the right, expert, time-based and dedicated

approach to this activity. In such approach lies the "secret" of success which should be followed.

Certainly there are still many aspects which need to be changed, corrected or improved for better future reforestation. We need to proceed with an evaluation and registration of seed objects for more tree species and perform strong control on collection of reproductive material from the seed objects. It is necessary to consider changing species selection for reforestation in term of upcoming climate changes and on typological basis. Rising more mixed instead of pure stands will contribute toward the combat against forest fire. The nursery technology also needs some adaptation in term of production of more seedling stock types with specific (ecological) purpose, as for example bigger transplanted seedlings for reforestation and reclamation of dry, erosive or weeded areas, container seedlings with bigger volume of the container for arid and erosive lands etc. The site and soil preparation need to be performed in accordance with specific conditions of each site, and uniform approach should be avoid. Some planting tools also need to be improved, i.e. adapted for applied soil preparation and seedling stock type. Planting operation, as a crucial moment for successful survival, at least for massive scale reforestation, must be performed only by skilled stuff. Performing consistent cultivation measures should improve the reforestation success. Hopefully, such approach, together with secure financial funds, will contribute to better reforestation in Macedonia.

Figure 17. The green "fingerprint" of reforestation on bare dry land near Sveti Nikole is very beautiful.

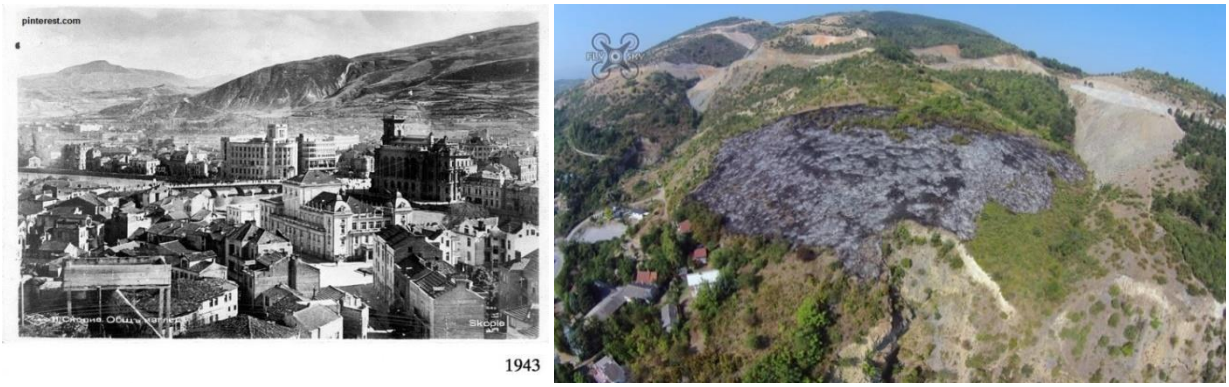

Figure 18. Vodno Mt. before (left) and after reforestation (right; a forest fire destroyed a part of stands).

Figure 19. Reforestation on arid land (1980s). The most common way of mechanical soil preparation.

Figure 20. Reforestation in Prespa region (left 1969, right 2010).

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