



Research Article

Volume 21 Issue 1 - April 2019

DOI: 10.19080/ARTOAJ.2019.21.556149

Agri Res & Tech: Open Access J

Copyright © All rights are reserved by Maia Akhalkatsi

Pine Forest on Tree-Line Ecotone in the Mountain Kazbegi in the Georgia (South Caucasus)



Maia Akhalkatsi*, Giorgi Arabuli, Zezva Asanidze, Tamar Goloshvili and Natalia Togonidze

Department of Plant Genetic Resources, Institute of Botany, Ilia State University, Georgia

Submission: March 25, 2019; Published: April 02, 2019

*Corresponding author: Maia Akhalkatsi, Head of Department of Plant Genetic Resources, Institute of Botany, Ilia State University, Faculty of Natural Sciences and Engineering, K Cholokashvili 3/5, 0162 Tbilisi, Republic of Georgia

Abstract

A widely distributed species of the pine in Georgia is - *Pinus kochiana* in the Caucasus Mountains. Central Great Caucasus higher is 5047m of Mt. Kazbegi and many summits are higher than 4000m. Caucasian pine from 300 to 2600m above of alpine tree line ecotone. Caucasian *Pinus kochiana* is on slopes from 784-2417m. Forest degradation will be activated to climate change in alpine zone and forest restoration is for protection of the environment. Other, planted pine species are migrated from Russia in Georgia in 1970s and this is mainly *Pinus sylvestris*. *Pinus kochiana* is synonym and accepted name is *Pinus sylvestris* var. *hamata* Steven. Other synonym names of this species are *Pinus sosnowskyi*, *Pinus caucasica*, *Pinus hamata*, *Pinus kochiana* var. *parviflora*, *Pinus sylvestris* subsp. *kochiana*, *Pinus sylvestris* var. *kochiana*. Forests occupy 32-35% of the territory of Georgia. The riparian and marsh forests occur in all regions of Georgia. The number of chromosomes in *Pinus kochiana* was precisely reported as $2n=24$ and no mutation has been found. Forests were destroyed and burned by Kazbegi district during the wars in old centuries. Scots pine (*Pinus sylvestris* L.) is planted in degraded areas. Flowering period of this species is April-May and seeds are matured in September-October. Caucasian pine rock scree forest is distributed on the slopes of rocky southern exposition dry ecotone or limestone layers.

Keywords: Pinus; Subalpine; Forests; Synonym; Accepted

Introduction

Georgia covers an area of 69 494 km². Forests cover are mountain forests spread from the lower mountain belt up to the tree line ecotone the highest summits of the Caucasus. Elevation range of the Caucasus Greater Mountains varies from sea level to 5633m of Mt. Elbrus. Western Great Caucasus in Georgia has a highest peak 5068m of Mt. Shkhara and Central Great Caucasus higher is 5047m of Mt. Kazbegi and many summits are higher than 4000m [1,2]. Thus, the alpine and subalpine belts are here much wider, and the possibilities for high mountain forest growth and diversity are greater. In addition to their ancient isolation, the differences within their high mountain forest have also been influenced by the following factors. Forest degradation will be activated to climate change in alpine zone and forest restoration is for protection of the environment. It presents a great variety of widely contrasting landscapes due to geological, geomorphological, hydrological, climate and soil conditions and frequently alternating and ranging from subtropical forests to Desert Steppes from Black Sea to the east. The western region Kolkhis has a subtropical climate, with a warm winter. In sharp contrast to this region is eastern and southern Georgia with a nearly continental climate. The vegetation in Kolkhis is represented by wetlands, forests and even dense subtropical forests, in high mountains (western and eastern Georgia) tree line ecotone and alpine meadows followed by the nival ecotone are representative; southern Georgia is covered by secondary

mountain steppes occupied area of primary forests growing in this area in the past; arid and semi-arid vegetation is widely spread in the eastern Georgia. Most typical of these include semi-deserts (with desert spots), steppes, vegetation of dry canyons, hemixerophilic shrub lands, foothill deserts, and dry open woodlands [3,4].

A widely distributed species of the pine in Georgia is - *Pinus kochiana* Klotz. ex K. Koch. (synonyms *Pinus hamata*, *Pinus sosnowskyi*). Accepted species is *Pinus sylvestris* var. *hamata* Steven. Caucasian pine (*Pinus kochiana*) composed in the mountains from 300 to 2600m above of alpine tree line ecotone. Forests were destroyed and burned by Kazbegi district during the wars in old centuries. Scots pine (*Pinus sylvestris* L.) is planted in degraded areas. Caucasian pine is distributed on the slopes of rocky southern exposition. Scots pine grows in different slopes. These two pine species have the same 6 ectomycorrhizal fungal species and can growing in similar soils. In west Georgia it is mixed with coniferous forests, the pure stand is only in rocky locations. Vertical borders on the distribution of the pine forest are from 700 to 2400 meters a.s.l. Optimum conditions for the distribution are at the altitude of 1000-2200 meters. In certain places pine is found at the altitude of 2500-2600 meters. The pine grows both on limestone and volcanic layers. The pine rocky forest is especially distinguished in terms of the great variety of species [5].

The pine forest of limestone on Tetrobi-Chobareti range (1800-2000 meters) is characterized by a slightly different composition. Earlier the pine distribution here was considered as endemic *Pinus kochiana*, whereas a more widely distributed was called "Sosnowski pine" (*Pinus sosnowskyi*). At the moment they are considered as one species. However, the Tetrobi pine forest according to the composition is considered as a peculiar refugium where pine is mixed with mountain steppes. In this community overall 48 species of vascular plants are represented. The following species of herbaceous plants are associated with *Pinus kochiana*: *Steven arenaria* - *Arenaria steveniana*, *Sosnowski chickweed* - *Cerastium sosnowskyi*, *Voronov minuartia* - *Minuartia voronowii*, *caryophyllaceae campion* - *Silene dianthoides*, *Sosnowski houseleek* - *Sempervivum sosnowskyi*, *astragalus* - *Astragalus arguricus*, *A. campylosema*, *Javakheti lucerne* - *Medicago dzhawakhetica*, *sun rose* - *Helianthemum nummularium*, *H. orientale*, *Transcaucasian Daphne* - *Daphne transcaucasica*, *prickly thrift* - *Acantholimon glumaceum*, *hogweed* - *Heracleum antasiaticum*, *bedstraw* - *Galium grusinum*, *cornflower* - *Centaurea bella*, *hawksbread* - *Crepis pinnatifida*, *grapevine hyacinth* - *Muscari sosnowskyi*, etc. This phytosenosis is quite rich with endemic species that are mainly common on the limestones of the tetrobi plateau. *Diphelypaea coccinea* (the blooming parasite) and *asphodelo* - *Asphodeline taurica* need to be mentioned especially [6,7].

These range from the obvious timber to mushrooms, berries and edible plants that have become more important for rural populations during economic hardship. From soil and watershed protection to recreation, tourism, and the existence value associated with the conservation of biological and landscape diversity of forests. Pine forests yield excellent construction and carpentry timber, fuel, tar, resin, pitch, black or marine tar, carbon black, turpentine, essential turpentine oil, and colophony.

Materials and Methods

Caucasian pine trees growing in slopes with all exposition and are oriented as well on high inclination till 900. Natural habitat of this species is oriented on rocks and as well on other slopes with different geological rocks. The elevation is from 0 to 2100m a.s.l. Caucasian pine tree up to 35m tall and only to 15-20m high in Kazbegi high mountain areas. Snow cover is <0.3m. Sunny edge is low on North Slope; dappled shade is more not only on North Slope: North Wall, East Wall, and West Wall. Suitable for: light (sandy) and medium (loamy) soils, prefers well-drained soil and can grow in nutritionally poor soil. Suitable pH: acid, neutral and basic (alkaline) soils and can grow in very acid and very alkaline soils. It can grow in semi-shade (light woodland) or no shade. It prefers dry moist or wet soil and can tolerate drought. The plant can tolerate maritime exposure. It can tolerate atmospheric pollution.

Plant material

Forests occupy 32-35% of the territory of Georgia. The riparian and marsh forests occur in all regions of Georgia. Mountain forests are represented by lower, middle and upper belts. Oak, beech (*Fagus orientalis*) and beech to chestnut forests grow in the lower

and middle belts changing higher in the mountains into the Caucasian fir (*Abies nordmanniana*) and Oriental spruce (*Picea orientalis*) forests. *Pinus kochiana*, *Acer trautvetteri* or *Quercus macranthera* grow at tree line ecotone in different regions. There are also well-developed crooked stem birch forests (*Betula litwinowii*) in the tree line, usually occupying the steepest northern slopes. Dry open woodlands relict forests are to be found in semi-arid regions of the eastern Georgia and are composed by *Pistacia mutica*, *Juniperus spp.*, *Pyrus spp.*, etc.

Methodology

Forested land in Georgia occupies 2.773.400ha. About 2.2 million ha are classified as state forest under the responsibility of the Department of Forest Management (DFM) and the remaining consists of former "Kolkhoz lands" part of which are now in the process of being transferred to the DFM [8]. About 98% of forest is located on the mountain slope. There are about 400 species in forests, among them are: trees 153, high shrubs 202, low shrubs 29, and lianas 11. Conifers are 11 species belonging to three families Pinaceae (4), Taxaceae (1) and Cupressaceae (6). 81% of total forest area is occupied by broad-leaved forests of Beech, Georgian and high mountain oak, hornbeam, chestnut, ash, maple etc. 19% is coniferous forest composed by Caucasian fir (8.5%), Oriental spruce (5.8%), Caucasian and Bichvinta pines (4.7%), yew and juniper species.

Approximately 208.000ha of forest areas were included in the Protected Areas, which amounts to 7.5% of the total forest area of Georgia. According to the "Forest Code of Georgia" a number of forest categories are subjected to some restrictions, which allow us to consider them as Protected Areas. The calculated area of "protected forest categories" (resort, green zone, steep slope, tree line and riparian forests belong to the corresponding IUCN categories; V, V-VI, IV-V, IV-V, IV-V) amounts to 1.113.130ha, which is almost 15.9% of Georgia's territory.

Statistical analyses

The analysis was performed using the software packages SPSS v.16.0 for Windows and Statistical 6.0. We used ANOVA ($p < 0.05$) post hoc range test to investigate whether the average soil T °C, minimum soil T °C, June minimum T °C and GDD changed in the 1m x 1m quadrates from 2012 to 2018. We used Canonical Component Analysis (CCA) of the species cover in 1m x 1m permanent plots and Dominance Curves test of PCORD. 5 statistic program in order to test the species composition and determine dominant species on each summit. The species are ranked by cover and abundance.

Results and Discussion

Georgian pine species

Pinus kochiana Klotzsch ex K. Koch is a species of the Caucasus Mountains and this is synonym from other same (Table 1) and it is related to the Scots pine group with accepted name as *Pinus sylvestris* var. *hamata* Steven. Other synonym names of this species are *Pinus sosnowskyi*, *Pinus caucasica*, *Pinus hamata*, *Pinus kochi-*

ana var. parviflora, *Pinus sylvestris* subsp. kochiana, *Pinus sylvestris* var. kochiana. Coniferous forest has 19% territories and composed by 8.5% of Caucasian fir (*Abies nordmanniana*), 5.8% of Oriental spruce (*Picea orientalis*), and 4.7% of and Bichvinta (*Pinus pityusa*) pines. Coniferous forests mainly composed in the Western Georgia of fir, spruce and The Central and Eastern Great Caucasus contains only Caucasian pine and some species of Cupressaceae. The number of chromosomes was precisely reported as $2n=24$ and no mutation has been found. It is the species related to the European pine (*Pinus sylvestris* L.). *P. sylvestris* is located in north areas of the Europe and Asia and it has many subspecies and varieties. However, *P. sylvestris* has different number of chromosomes – $2n=18$; 24; 25; 36; 48. It is used as planted tree and it is used for multiplication in nursery which might be used by chromosome

number change. Morphologically *P. kochiana* has different structure of cones (Figure 1A & 1B) to *P. sylvestris* (Figure 2A & 2B). Therefore, it might be remained as other species. Caucasian pine tree grows till 35 m in the subalpine zone and leaves stiff, straight or slightly curved, mucronate, glaucescent, 3-7cm long and 1-2mm broad; male cones dense, ovoid-conical, the scales slightly denticulate on the margin; ovulate cones solitary or in 2's-4's, at first green, turning reddish-brown, at length brownish-gray, ovaloid/spherical, recurved, lustrous, 1.5-5.5cm long and 2-4cm broad at base; epiphysis subrhombic, rugose, flat or pyramidal, the umbo of scales on the illuminated side of the cone produced into a hooked spine; seeds 4-5mm long, the wing 13-15mm long and 4-5mm broad.

Table 1: Accepted species is *Pinus sylvestris* var. *hamata* Steven and synonym species are in Georgia. Chromosome numbers are for genes synonyms species ($2n=$). $N=7$.

N	Synonym Species	$2n=$ gene	Accepted Species
1	<i>Pinus kochiana</i> Klotz. ex K. Koch	24	<i>Pinus sylvestris</i> var. <i>hamata</i> Steven
2	<i>Pinus sosnowskyi</i> Nakai	24	<i>Pinus sylvestris</i> var. <i>hamata</i> Steven
3	<i>Pinus caucasica</i> (Medw.) N.Busch	24	<i>Pinus sylvestris</i> var. <i>hamata</i> Steven
4	<i>Pinus hamata</i> (Steven) Sosn.	24	<i>Pinus sylvestris</i> var. <i>hamata</i> Steven
5	<i>Pinus kochiana</i> var. <i>parviflora</i> (Fomin) Grossh.	24	<i>Pinus sylvestris</i> var. <i>hamata</i> Steven
6	<i>Pinus sylvestris</i> subsp. <i>kochiana</i> (Klotzsch ex K. Koch) Eliçin	24	<i>Pinus sylvestris</i> var. <i>hamata</i> Steven
7	<i>Pinus sylvestris</i> var. <i>kochiana</i> (Klotzsch ex K. Koch) Fomin	24	<i>Pinus sylvestris</i> var. <i>hamata</i> Steven



Figure 1A: Native pine subalpine forest – *Pinus kochiana*.



Figure 2A: Planted pine forest – *Pinus sylvestris*.



Figure 1B: Cone of *P. kochiana*.



Figure 2B: Cone of *P. sylvestris*.

Coniferous forest areas

Table 2: *Pinus kochiana* are in different Mountain heights in Georgia. N=15.

S. N	Location	Coordinates	Elevation (m)
1	Loshkilo, v. Godgadzeebi, Khulo, Adjara	41° 39' 27,7 N	784
		42° 20' 19,5 E	
2	Borjomi, Chita Khevi	41° 47' 16" N	865
		43° 17' 42" E	
3	Borjomi-Bakuriani road	41° 48' 86,6 N	892
		43° 24' 99,6 E	
4	Tsriosis R., Tsriosis Empelo the Castle	41° 44' 52,6 N	1057
		43° 07' 97,8 E	
5	Upper Lue 19km is Mestia	43° 02' 52,8 N	1129
		42° 25' 09,3E	
6	Uraveli gorge, after v. Uraveli	41° 32' 93,7 N	1202
		43° 03' 48,1 E	
7	V. Abastumani in the Samtskhe-Javakheti Region	41° 45' 44" N	1291
		42° 49' 42" E	
8	Goderdzi mountain resort in Georgia's	41° 39' 92,6 N	1460
		42° 36' 65,0 E	
9	Manglisi, Algeti preserve	41° 43' 29" N	1481
		44° 16' 37" E	
10	V. Abastumani, Zekari Pass, Adigeni distr.	41° 47' 24,3 N	1696
		42° 50' 32,8 E	
11	Zazalo, Samtskhe-Javakheti	41° 37' 11,8 N	1709
		43° 43' 99,2 E	
12	V. Abastumani, Zekari Pass, Adigeni distr.	41° 48' 74,1 N	1878
		42° 50' 94,6 E	
13	Tetrobi in Autonomous Republic of Adjara	41° 36' 24" N	2084
		43° 23' 27" E	
14	Sameba-Fansheti, Kazbegi in the Mtskheta-Mtianeti region	42° 66' 7,21 N	2093
		44° 61' 9,06 E	
15	Tetrobi in Autonomous Republic of Adjara	41° 36' 20" N	2417
		43° 23' 07" E	

Caucasian pine from 300 to 2600m above of alpine tree line ecotone. Caucasian *Pinus kochiana* is on slopes from 784-2417m (Table 2). The area of its common distribution is Caucasus, Crimea and western part of small Asia, Ponto mountains. In Georgia pine forests are mainly common in the mountains. The pine grows in Kazbegi District on rocks of volcanic layers. The pine rocky forest is especially distinguished in terms of the great variety of species. Caucasian pine rock scree forest is distributed on the slopes of rocky southern exposition dry ecotone or limestone layers. Forested land in Georgia occupies 2.837.900 ha which is a 43.18% of Georgian territory (69494 km²). About 98% of forest is located on the mountain slopes. 81% of total forest area is occupied by broadleaved forests of beech (*Fagus orientalis*), Georgian and Caucasian oak (*Quercus iberica*, *Q. macranthera*), hornbeam (*Carpinus caucasica*), chestnut (*Castanea sativa*), ash (*Fraxinus excelsior*), maples (*Acer* spp.), etc. North Ridge Mountains of the Central

Great Caucasus mainly created with crooked steam forests/elfin woods of birch species (*Betula litwinowii*, *B. raddeana*, etc.) Caucasian oak and pine are on south and eastern slopes as subalpine forest till alpine tree line.

Native subalpine pine forest

The pine forests are widely distributed in the Caucasus Mountains. The forests of Kazbegi National Park are located on steep slopes (4790ha). Birch forest is covered in 2595ha and native subalpine pine forest (369ha) is located in protected area of north ridge of Central Great Caucasus. 105 species of wood plants can be found in these forests. Dominant species of the subalpine pine forest is Caucasian pine (*Pinus kochiana*) distributed in many areas of Georgia. Other trees are *Quercus macranthera*, *Fagus orientalis*, *Juniperus* spp. etc. Mountain pine forests of relatively dry ecotones can be found almost everywhere within the distribution area of

P. kochiana. It is best to sow the seed in individual pots in a cold frame as soon as it is ripe if this is possible otherwise in late winter. A short stratification of 6 weeks at 4 °C can improve the germination of stored seed. Plant seedlings out into their permanent positions as soon as possible and protect them for their first winter or two. Plants have a very sparse root system and the sooner they are planted into their permanent positions the better they will grow. Trees should be planted into their permanent positions when they are quite small, between 30 and 90cm. We actually plant them out when they are about-10cm tall. So long as they are given very good weed excluding much, they establish very well larger trees will check badly and hardly put on any growth for several years. This also badly affects root development and wind resistance. Cuttings. This method only works when taken from very young trees less than 10 years old. Use single leaf fascicles with the base of the short shoot. Disbudding the shoots some weeks before taking the cuttings can help. Cuttings are normally slow to grow away.

Reproduction and growth characteristics

Caucasian pine tree with whorled branches and two types of shoots: Long shoots appearing in spring and becoming woody, and dwarf shoots growing from the axils of scale-like leaves and also bearing scale-like and true acicular leaves, in clusters of two, three, or five. Caucasian pine has crown wide, twigs spreading and directed upright. Bark dark greyish dark browns or dark browns. Needles greyish-green, margins fringed, 3.5-5 or 5-8cm long, to two, rarely to three of tree. Leaves in clusters of two or three; Male cone is round or oblong-cylindrical, clustered into globose or broadly ovoid racemes. Male strobilus develops at the base of young long shoots in the axils of scale leaves. Female cones woody, maturing in two to three years, bract scales coriaceous, shorter than the broad ovuliferous scales; seeds winged, less often nut-like, wingless. Female cones opening at seed maturity; mature female cones 3-7cm long, dull, light brown or gray 6 seeds winged 4. Seed cones ovate, solitary, pink brown or yellowish when mature, glossy, directed horizontally or upright. Seed scales with pyramidal and hooked apophysis. Seed obovate, acute, 4.5mm long, wing with brown stripes. Needles persisting for four to eight years, yellowing in winter, 3-3.5 cm long; cones 3-3.5cm long. Flowering period of this species is April-May and seeds are matured in September-October. It forms woods forests or grows as single trees on rocks, reaches tree line.

Forest degradation and restoration

The degradation of qualitative consistence and productivity of the forest lead to the reduction and sometimes even caused loss in the functionality of forests. Forest area was diminished in the Kazbegi district due to anthropogenic factors such as fires, cutting of trees, and uncontrolled grazing. Forests were destroyed and burned by Kazbegi district during the wars in old centuries. As a

result, avalanches and landslides are happening quite often in the mountainous regions. They are mainly located on steep slopes of Great and Minor Caucasus where the access is restricted. The loss of diversity and changes in species composition in forests is mainly a result of anthropogenic influence. Therefore, the degraded forest should be restored, and climate change will be ended. Other, planted pine species are migrated from Russia in Georgia in 1970s and this is mainly *Pinus sylvestris* L. and some other individuals' *P. nigra* subsp. *pallasiana* (D. Don) Holmboe. These planted species are in all regions, from the subarctic to the forest steppe zone, it forms pure pine forests in the mountains, on sandy soils of the plains and mixed forests on loamy soils and podzols

Conclusion

Caucasian pine forms forests or grows as single trees on rocks. They occur on skeletal and poorly developed soils of prominent southward slopes. These pine forests are characterized by rich and diverse ground vegetation. The pine rocky forest is especially distinguished in terms of the great variety of species. Caucasian pine rock scree forest is distributed on the slopes of rocky southern exposition dry ecotone or limestone layers. These range from the obvious timber to mushrooms, berries and edible plants that have become more important for rural populations during economic hardship. From soil and watershed protection to recreation, tourism, and the existence value associated with the conservation of biological and landscape diversity of forests. *P. kochiana* pine forests yield excellent construction and carpentry timber, fuel, tar, resin, pitch, black or marine tar, carbon black, turpentine, essential turpentine oil, and colophony. The foliage yields 170 so-called pine- wool and bedding litter; young shoots have medicinal use. The pollen is used in pharmacies as a substitute for lycopodium.

References

1. Akhalkatsi M (2002) Country report on national activities on gene conservation of Conifers Network. Conifers Network 3. EUFORGEN.
2. Nakhustrishvili G (2013) The Vegetation of Georgia. (South Caucasus). Berlin, Heidelberg, Germany: Springer-Verlag.
3. Dolukhanov AG (1989) Rastitelnost Gruzii (Vegetation of Georgia). Metsniereba, Tbilisi, Georgia.
4. Gottfried M, Pauli H, Futschik A, Akhalkatsi M, Barančok P, et al. (2012) An early warning signal for a continental-scale response to ongoing climate change. *Nature Climate Change* 2: 111-115.
5. Ketskshoveli N (1959) Sakartvelos mtsenareuli sapari (Vegetation of Georgia). Publ Georg Acad Sci, Tbilisi, Georgia.
6. khalkatsi M, Tarkhnishvili D (2012) Habitats of Georgia, GTZ, Tbilisi, Georgia.
7. Akhalkatsi M (2015) Forest Habitat Restoration in Georgia, Caucasus Ecoregion. Mtsignobari, Tbilisi, Georgia, pp.115.
8. Akhalkatsi M (2017) Structural and functional aspects of plant reproductive strategy. Tbilisi, Georgia.



This work is licensed under Creative Commons Attribution 4.0 License
DOI: [10.19080/ARTOAJ.2019.21.556149](https://doi.org/10.19080/ARTOAJ.2019.21.556149)

**Your next submission with Juniper Publishers
will reach you the below assets**

- Quality Editorial service
- Swift Peer Review
- Reprints availability
- E-prints Service
- Manuscript Podcast for convenient understanding
- Global attainment for your research
- Manuscript accessibility in different formats
(Pdf, E-pub, Full Text, Audio)
- Unceasing customer service

Track the below URL for one-step submission
<https://juniperpublishers.com/online-submission.php>