Ecosystem Services of Himalayan Alder

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Abstract

Alnus nitida (Himalayan Alder) is a monophyletic species of family Betulaceae. It is distributed in the mountainous ranges of Hindu Kush and western Himalayan of the Sino-Japanese belt. Family Betulaceae has a cosmopolitan distribution with 2 genera (*Betula* and *Alnus*) and 95 species. Previously, the family was divided into Betulaceae (*Alnus*, *Betula*) and Corylaceae (*Carpinus*, *Corylus*, *Ostrya,* and *Ostryopsis*). Various species of the family are used for different purposes such as timber, lumber, and household utensils production across the globe. Many species have been studied against for their therapeutic potential against various ailments, i.e. obesity, cancer, tuberculosis. Stem bark of *Betula utilis* is used for spiritual purpose as well as to treat various diseases. Himalayan Alder is among those species that offers numbers of ecosystem services. *A. nitida* being a riparian species is cultivated by farmers along the stream sides of their fields to control soil erosion. Wood is used by local people for the formation of different pots. Nodulation and biomass production are also the prominent characteristics of the family. Some studies revealed that *Alnus* acts as an indicator species of eastern North America for dry period. Ethno-ecological surveys have revealed that Alder is preferred by local communities in several ways such as fuel, fodder, and construction purposes. The species is ecofriendly to form a phyto-social association with about 146 species in its geographical range in Pakistan. The nitrogen fixation capability makes it more suitable for agroforestry and inter-cropping. Alder can be used as an alternate to discourage shift cropping and to enhance the

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ecofriendly and high yield techniques of inter-cropping. Alder has prominent role in the absorption of heavy metals and boost up water quality. Since few years population of this important species is continuously decreasing and facing problem of extinction due to drought, developmental projects, deforestation, and other anthropogenic activities. This chapter provides a baseline for further comprehensive studies on its molecular genetics, phyto-chemistry, and conservation priorities for this and many other associated species.

Keywords

Himalayan Alder · Morphological diversity · Ecosystem services · Conservation · Threats

Abbreviations

C	Carbon
CCA	Canonical correlation analysis
Cm	Centimeter
CO_2	Carbon dioxide
DCA	Detrended correspondence analysis
Mm	Millimeter
N. and S. America	Northern and Southern America

12.1 Introduction

Alnus nitida commonly known as Himalayan Alder (Shrol: Hinku; Geeray: Pashto). It belongs to family Betulaceae and characterized by unique roots with nodules. Alder is a tree species of riparian habitat and grows up to 22 m or more in height. Shoots are pubescent during young stages and become glabrescent when the plant gets old. The floral characteristics show that male flowering catkin reaches size up to 20 cm in length, bracts is 1.1 mm long, tepals are oblong-obovate to spathulate, and filament is 1 mm long. Female cones are woody and range from 3–2.9 in length and 1–1.2 cm in width. Fruiting scale is 5-lobed and 5–6 mm in length. Nut is 2.3–4 mm long with less leathery wings. The flowering period is from September to October. Leaves are elliptical to ovate (5–15 × 2.9–14 cm), acuminate, and glabrous (Perveen and Qaiser 1999) (Fig. 12.1).

According to Furlow (1990), about 40 species of Alder are distributed in Bhutan, China, Bangladesh, Europe, India, Korea, Japan, Nepal, America, and Northern Hemisphere. Only 18 out of 35 species were documented from Asia (Kennedy et al. 2010); 8 N. America (Lin et al. 2015); 4 Europe, 1 South America, and 2 species from Mexico (Chen 2004). The subspecies of *Alnus* were differing from each other based on fruiting bodies and seed morphology. According to Navarro

Botanical name: *Alnus nitida* (Spach) Endl.

Local Name: Kashmiri and Hindku: Shrol; Pashto, Geeray

Synonym: *Clethropsis nitida* Spach

Family: Betulaceae

Flowering & Fruit season: September to October

Type: 'in Emodo', *Jacquemont* (P)

Fig. 12.1 *Alnus nitida* in full bloom at riverside of Madyan (Swat), Pakistan

et al. (2003) the species are differentiated from each other based on seed size. In the subgenus *Alnobetula*, the seeds are borne on the twigs (Haq et al. 2020a, b). In China, there are five out of ten endemic species (Smith 1999). This family has higher rate of endemism in the eastern Asia. This region also hosts *Ostryopsis*, *Betula* (*Chinenses* and *Betulaster*): *Alnus* (*Cremastogyne, Acanthochlamys, Carpinus*, *Corylus,* and *Distegocarpus)* (Chen et al. 1998a, b). The Province Sichuan and its neighboring provinces are considered the hotspots for the extant species of this family. In 1873, genus *Ostryopsis* which is endemic to China was introduced. All six genera and 52 species are native to the above-mentioned region. Paleo-climatic and Paleo geographic characteristics revealed that, in the past, the Eurasian continent was divided into Late Cretaceous and Tertiary (Sun 2016).

Alnus nitida is the only single species reported from genus *Alnus* in Pakistan. In this chapter we have focused on the ethno-botany, pharmacology, photochemistry, ecology, taxonomy, and biomass and ecosystem services of family Betulaceae with special reference to Himalayan Alder.

12.2 Botanical Description and Phytosociology of Alder

The first section of this chapter highlights the detail description of family Betulaceae and *Alnus nitida* species. Along with that, it also throws light on the association of a single species of family Betulaceae with other species. The second portion contains ecosystem services of Alder plant. This chapter as a whole presents a complete package from occurrence of species, distribution, taxonomical variation, ecological linkages with associated species to ecosystem services.

Phyto-sociology is the study of vegetation in relation to its surrounding biotic and abiotic factors. This science is playing key role in quantification of ecological system services, vegetation mapping, and biodiversity conservation (Khan et al. 2013; Meena et al. 2018; Meena and Lal 2018). It is also used as a tool in the form of habitat for community and species level (Lin et al. 2015). Recently, Haq et al. (2019a, b) worked on *A. nitida* to explore vegetation structure, role of climatic and edaphic factors on the distribution, and formation of plant zonation in western Himalayas and Hindu Kush region of the Sino-Japanese belt. They recorded 146 plant species in association with *A. nitida* in the region. The reported species belong to 106 genera and 47 families. All associated plant species in different stations were classified through two-way cluster analysis into three major zones or communities, i.e., (1) *Celtis caucasia, Rubus fruticosus*, *Chenopodium murale,* (2) *Eucalyptus camaldulensis, Arundo donex, Mentha arvensis,* and (3) *Platanus orientalis, Saccharum munja, Oxalis corniculata* (Fig. 12.2). This association of Alder highlights is friendly nature towards other associated species in its vicinity.

12.3 Herbarium Specimen Recorded from Himalayas

Himalayan Alder is distributed in different areas of the Himalaya from Iran to Nepal. Numbers of herbaria in the region were visited to document herbarium records of Himalayan Alder. It was very interesting that specimens from the time of Indo-Pak were preserved in botanical centers of Pakistan. The herbarium visited were National herbarium of Pakistan (RAW), Quaid-i-Azam University herbarium also called Herbarium of Islamabad (ISL), University of Malakand Herbarium (BGH), Islamia college University Herbarium (ICP), Shaheed Benazir Bhutto University Herbarium. The 100-year-old specimen was recorded from Kashmir. The details are mentioned in the snapshot. Kulu (India) 1936, Rajanpur Kashmir 1917, Iran, India, China, and Nepal host more than one species but on the same belt Pakistan host only a single species of *A. nitida* distributed in area of 650 kilometer along the western Himalayas.

It is an enigma that the species has great variation in size of female and male catkin from zone to zone in Pakistan (Haq et al. 2020a, b). They investigated the reason to find whether it is due to variation in edaphic, environmental,

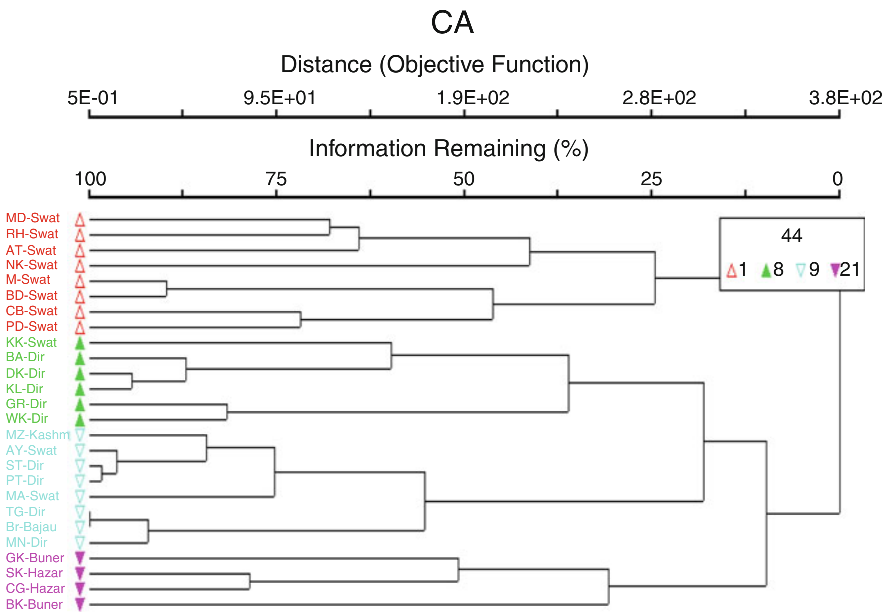

Fig. 12.2 Cluster dendrogram of 134 Quadrats based on Sorenson measures

micronutrients, and heavy metals. Their findings compile report of the only species of *A. nitida* along the western Himalayas in Pakistan (Fig. 12.3).

12.4 Taxonomy of Alder

12.4.1 Background of Family Betulaceae

The family Betulaceae consists of deciduous and few semi-deciduous shrubs and trees. Leaves are sessile having two or three scales. Leaves are dentate, serrate, rarely entire, or incised. Male inflorescence is cylindrical, elongate, and pediculate with overlapping bracts, having three to four bracteoles, sepals are 4 lobed, stamens one to four. The female inflorescence presents one or two in racemose or panicle, ellipsoid, or ovoid. Bracts are woody with numerous apexes 5-lobed. Nutlets on each bract are two in number. Flowering season is spring with some exceptions (Chen 2004). Family Betulaceae containing two genera and 95 species distributed in temperate and arctic zones of Asia, Europe, N. and S. America. This species also includes *Corylus* (hazel), *Betula* (birch), and *Carpinus* (hornbeam) (Li et al. 2004). Betulaceae is represented in Pakistan by both *Alnus* and *Betula* (Perveen and Qaiser 1999). Betulaceae is placed under the order Fagales (Perveen and Qaiser 1999). Geographically, Takhtajan (1980) classified it as a species of Holarctic Kingdom (the largest of all floristic kingdoms occupies more than half of the world terrestrial

Fig. 12.3 Photographs of herbarium specimen collected from Himalayas, i.e., Poonch (Kashmir) 1952; Muzzafarabad 1962; Kulu (India) 1936; Rajanpur Kashmir 1917; Hazara 1970; Buner 1998; Swat 1963; Dir 1998; Kohistan 1999; Buner 2001; Swat 2003; Swat 2007, respectively

kingdoms) and in separate monotypic order Betulales. Few species inhabit in subtropical regions, e.g., *Betula platyphylla. A. glutinosa* (L.) only occurs in Africa while *A. accuminata* in Argentina and America. The Betulaceae sensu lato was included in six extant genera. Authors divided the family Betulaceae into two tribes

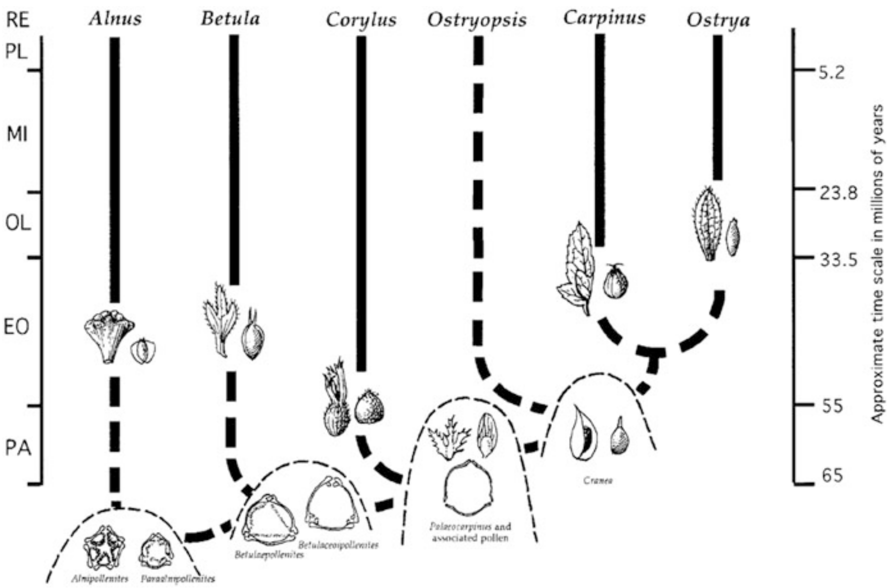

Fig. 12.4 Phylogenetic relationships within Betulaceae (Chen et al. 1998a, b)

or sub-families (Takhtajan 1980). In 1967, Hutchison ranked it in family—Betulaceae sensu stric to (*Alnus* & *Betula*) and Corylaceae (*Carpinus*, *Ostrya*, *Corylus,* and *Ostryopsis*). However, Abbe (1935) declares it as monophyletic family on the basis of morphology (Metcalfe and Chalk 1950), growth habit (Kikuzawa 1982), wood anatomy (Hall 1952), embryology, and S-type sieve tube (Behkne 1973). Fig. 12.4 shows the phylogeny and systematic evolution of different genus of family Betulaceae (Lachman et al. 2018).

12.4.2 Himalayan Alder Taxonomic Variations

Betula and *Alnus* are separated from each other by unique characters of nodules (Chen 2004). The reported species of *Alnus* in the world are up to 35, five in Europe, 18–23 in Asia, and nine in new world (Furlow 1990). The close geographic distribution and closely related subspecies of *Alnus* have led to confusion in taxonomical classification. Majority of *Alnus* species has been divided on the basis of palynology and morphology (Chen 2004). Few species have been reclassified based on DNA sequence (Navarro et al. 2003) and few other scientists recognized subgenus Gymnothyrsus and Alnobetula (Yu et al. 2007) declared the *Alnus* genus as monophyletic group. Chen (2004) introduced three subgenera, i.e., *Clethropsis*, *Alnobetula,* and *Alnus*. This classification trace back to species level. *Alnus viridis* complex and *Alnus incana* complex are further divided by Li et al. (2004) and they arranged three subgenera of *Alnus*: Alnobetula, Clethropsis, and *Alnus.* According to

Fig. 12.5 Variation in catkins of Himalayan Alder

Furlow (1990), two species in the *Alnobetula* subgenus are shrubs. The three subspecies of *Clethropsis* are limited to Asia, Japan, and the USA. Previous reports show that flora of Iran host two species of which two are considered as varieties and one subspecies. However, recent findings increased the number to five species. After studying cone morphology and 28 leaves of 140 Alder plants, 11 different characters were recorded new, i.e., blade shape at the base, velocity intensity, leaf angle in apex, serration type, cone shape, and leaf hairs on both surfaces. The new species were *Alnus subcordata* varieties allocated to *villosa* and vice versa (Fig. 12.5). The morphological characters of the two newly introduced species consist of *Alnus dolichocarpa* and *Alnus djavanshirii* were most similar to that of *Alnus subcordata var. subcordata.* On the other hand, three subspecies of *Alnus glutinosa* were differentiated by similar character. To confirm the new taxa DNA bar-coding techniques were used to confirm the new taxa in Iran (Colagar et al. 2016). In Himalayan region the variation among catkin and leaf size of Alder still indicating chances of new species discovery.

12.4.3 Palynological Aspects

Palynology is considered the only genuine technique to identify fossil, as no other proper discovery happened yet (Blackmore et al. 2003). Various scientists had studied different aspects of Alder, but ample work is needed to be done on the genus *Alnus* (Lacourse 2007). *Alnus viridis* type and *Alnus rubra* type were classified based on pollen study (Arsenault et al. 2007). These morphotypes were based on European and American Alder pollens (Mayle et al. 1993). This pollen morphology provides base for differentiation of species or subspecies. The *A. incana* subsp. *tenuifolia* is classified into subspecies based on pollen morphological variations. The same thing happened for the pollen of two shrubs Alders (*A. incana* subsp. *tenuifolia* and *A. viridis* subsp. *Sinuate*) where they were also classified on the base of pollen study (Heusser 1969). Three species of *Alnus*; *A. djavanshirii* Zare, *A. orientalis* Decne, and *A. dolichocarpa.* Zare and Amini (2012) dissected into two subspecies *A. glutinosa* Gaerth subsp. *Antitaurica* Yaltrik and *A. glutinosa* Gaerth subsp. *Glutinosa* based on the supporting characters of palynology.

12.5 Ecosystem Services of Alder

Sustainability in forest ecosystem needs diversity of both flora and fauna. Biodiversity conservation and its ecosystem services studies have gain prominent importance and keen interest issues in last few decades (Raj et al. 2018; Jhariya et al. 2019a, b; Khan et al. 2020a, b). The diversity maintains and sustains greater nutrients supply, ecosystem stability, and plant communities (Raj et al. 2020; Banerjee et al. 2020). Diversity is a phenomenon because it can be linked to maturity, stability, evolutionary time, maturity, and predation pressure. It is also an important key to sustain thick forest, its niches, and habitats (Van Wieren 1996) (Fig. 12.6).

12.5.1 Ethno Ecological Importance

Different parts of *Alnus* are used by traditional communities for medicinal purposes for centuries (Sun 2016). Bark of *Betula utilis* is used for spiritual purpose as well as to treat different diseases (Fig. 12.7). *A. nitida* is used for the formation of different

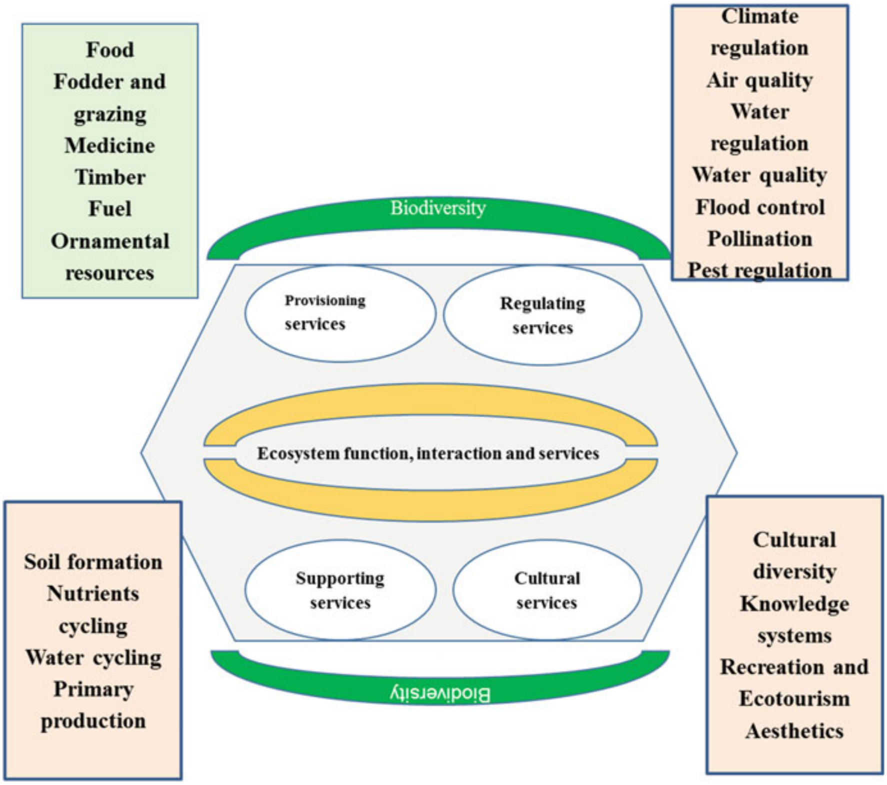

Fig. 12.6 Ecosystem services by plant species (Khan et al. 2013)

Fig. 12.7 Author interviewing medicinal plant experts (Mazharul Haq, Fazal-i-Subhan and Sirajul Haq) regarding ethno botanical importance of Himalayan Alder

handicrafts, pots, dolls, and furniture (Austin 2004). According to local inhabitants of the western Himalaya, i.e., Swat, Dir, Bajaur, and Buner in Pakistan, animal skins are salted and spread over the branches of *Alnus* for better dryness. Alder product particleboards fulfill the EN standard due to its elasticity and static binding (Nemli et al. 2003). The shoot bark is utilized for the treatment of diabetes mellitus by local *vaids* as economical remedy.

12.5.2 Role in Flood and Erosion Control

Flooding is natural disasters, and plants are the only economical solution to cope with this issue. *Alnus* spp. is an important tree which grows on the side of rivers and streams. This plant has gained importance from decades due to soil improvements, for controlling soil erosion, fencing roadsides, re-vegetating, and reclaiming strip mine areas (Raj et al. 2019a, b). The *A. japonica* shows morphological changes in its various parts to cope with flood (Edgerton 2014).

Flooding reduces gas diffusion which results in reduction of chemical production. It also decreases soil pH which directly decreases oxygen demand and phytotoxic accumulation along lakes and rivers of northwest Asia, *A. japonica* in swamp areas (Iwanaga and Yamamoto 2007) and Japan (Hokkaido) in flooded areas (Yu et al. 2007). Oil shale mining in north Estonia causes degradation for which restoration is needed. Restoration also adds landscape functions. The plantation of Alder sustains the reclamation of mining sites (Parrotta et al. 1997). Beside Alder other trees recommended for nutrients (N, P, and K) fluctuation are silver birch, scots pine, and black alder. According to Kozlov et al. (2009) *Alnus* genus can be utilized to stop soil and its nutrients erosion.

12.5.3 Alder and its Phytochemicals

Genus *Alnus* provides numerous services in the form of chemicals such as yashabushiketol and dihydroyashabushiketol, flavonoids, triterpenes and methanols, etc. Alder is used to treat tuberculosis. *A. incana* buds' decoction is used for lungs pain (Wopara et al. 2020) means that it has some special types of chemical compounds with therapeutic potential against T.B. A precise summary of published information regarding phytochemicals present in *A. nitida* is given in Table 12.1.

12.5.4 Role in Heavy Metals Accumulation

The term heavy metal is used (chemical point of view) for transition metals with gravity above 5 and atomic mass over 20. From biological point of view, the metalloids and metals that are or can be harmful both for animals and plants at low concentration. Mainly the metals are divided into essential and non-essential types. Non-essential metals, i.e., Pb, Hg, Se, As, and Cd, do not play significant physiological functions in most of the cases. Essential elements are required for metabolism, i.e., Cu, Ni, Zn, Mo, Co, and Fe (Rascio and Navari-Izzo 2011; Meena et al. 2020b, c). Environmental pollution due to disturbance of biogeochemical cycles and rapid industrialization creates an alarming situation in the form of heavy metal pollution in the environment (Khan et al. 2013). Both, anthropogenic and natural activities add heavy metals into the surrounding environment.

Natural activities are soil erosion, weathering, and volcanoes. The anthropogenic activities are mining, smelting, use of pesticides. Heavy metal accumulation potential of Himalayan Alder was assessed in different countries. As compare to *Salix* and *Acer*. *Alnus glutinosa* the plant species grow vigorously in highly alkaline anthropogenic sediment (Sarma 2017). The *Alnus nitida* heavy metal accumulation potential was studied first time from Pakistan by Haq et al. (2020a, b). They summarized that the plant species has great capability of bioaccumulation for heavy metal in hilly areas. *Alnus nitida* being a riparian species play important role in water filtration and quality enhancement and make it drinkable. Unfortunately, in recent decade the Himalayan Alder population is eroding and facing conservation problems. Conservation in its natural habitat through afforestation and controlling deforestation is essential for future generation, otherwise the recent speed of deforestation will be led it to extinction from western Himalayan regions of Pakistan (Haq et al. 2020a, b) (Fig. 12.8).

12.5.5 Role in Nitrogen Fixation

Alnus nitida being a riparian species is characterized by well-developed nodulation system. The nodules host nitrogen fixing bacteria. Nitrogen fixing bacteria fix atomic nitrogen into molecular nitrogen and boost up soil fertility. Soil fertility not only fulfills nutritional requirements of *Alnus nitida* but also of other associated species

Table 12.1 Alder species usage, chemical compounds, and methodology

S. no.	Plant name	Part use	Chemical name	Usage	Methodology	Reference
1	*Alnus incana* (L.) Moench	Cones/ bark	Triterpenoids	Scrofula caused by tuberculosis	Poultice usage on diabetes person effected area	Kaul (2011)
		Bark	Triterpenes	Tuberculosis (TB)	Betulin: anti-mycobacterial constituents in the bark of *A. incana* the functionality	Kaul (2011)
2	*Alnus nepalensis* (D. Don)	Leaves	Diarylheptanoids	Antifilarial activity	Lymphatic filariasis	Yadav et al. (2013)
		Leaf, roots, and bark	Taraxeryl acetate	Decoction used for wounds and cuts as a hemostatic	In dysentery, stomachache, and diarrhea	Pande et al. (2006)
3	*Alnus sieboldiana* (Matsum.) Murai	Flower	Dihydroyashabushiketol			Joo et al. (2009)
		Flowers and young shoots	Tannins and flavonoids	Used in infection, injury	Tumor necrosis	Barbara et al. (1994)
4	*Alnus glutinosa* (L.) Gaertn.	Bark	Methanol	Oregonin	Antimicrobial activity	Amin et al. (2016)
		Bark	Triterpenoids, diarylheptanoids, and flavonoids	Antioxidative activities and anti-inflammatory	Fever, diarrhea, and alcoholism	Kikuzaki et al. (1991)
5	*Alnus japonica* (Thunb.) Steud.	Bark	Diarylheptanoid	Atopic dermatitis	Fever, diarrhea, hemorrhage, and alcoholism	Joo et al. (2009)
		Leave	1,7-diarylheptanoids, yashabushiketol		Leaves have potent cytotoxic activities against murine human SNU-C1 and B16 melanoma cells gastric cancer cells	Choi et al. (2008)
		Bark	Diarylheptanoids	Anticancer	Mouse and human cancer cell lines	Choi et al. (2008)
		Bark	Diarylheptanoids	Obesity	The inhibitory activities of report of melanogenesis and cyclooxygenaxe-2 expression	Hussain and Kline (2004)

6	*Alnus hirsuta* Turcz. f.	Bark	Diarylheptanoid xyloside, oregonin		Antibiotic	Li (2015)
7	*Alnus rubra* Bong.	Leaves	Flavonoids and triterpenoids		To control HIV-1 virus replication and related enzymes	Yu et al. (2007)
8	*Alnus firma* Siebold & Zucc.	Young shoots			Two novel hydroxyketones, i.e., yashabushiketol and dihydroyashabushiket	Yu et al. (2007)
		Bark		Pharmacological use	Stop LPS-induced NF-*k*B activation and NO and TNF-a production	Jin et al. (2007)
9	*Alnus hirsute* Kunth	Male flower	Diarylheptanoids oregonin		Control 12-O-tetradecanoylphorbol-1, 3-acetate (TPa)-cyclo-oxygenase- 2 (COX-2) expression in immortalized human chest epithelial MCFIOA cells	Lee et al. (2000)
10	*Alnus sieboldiana* Kunth	Male flower	Diarylheptanoids oregonin		Showed significant inhibitory effect on 12-O-tetradecanoylphorbol-1, 3-acetate (TPa)-cyclo-oxygenase- 2 (COX-2) expression in immortalized human chest epithelial MCFIOA cells	Lee et al. (2000)

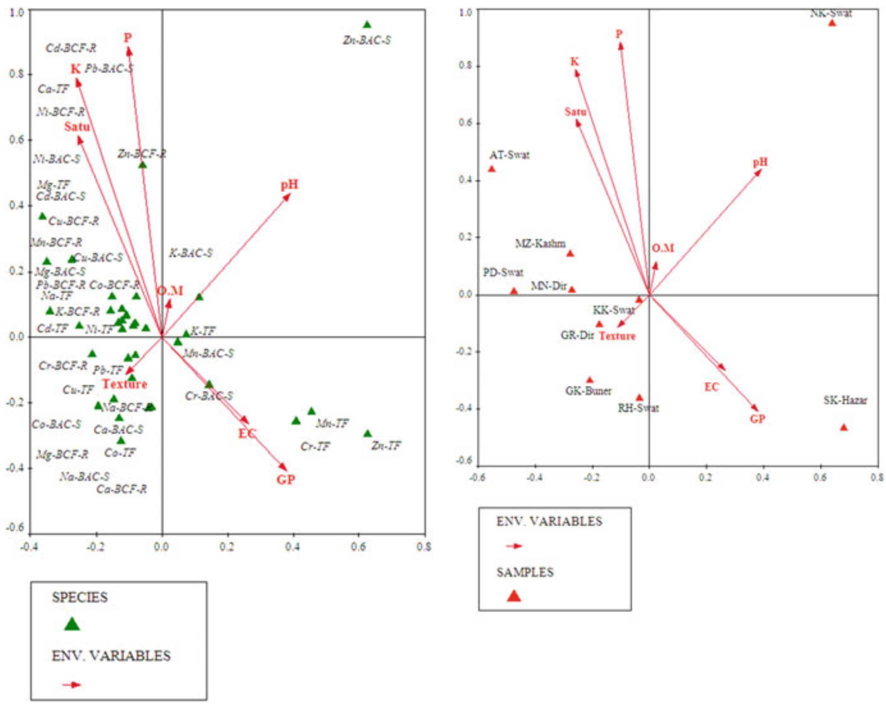

Fig. 12.8 Heavy metals accumulation in different parts of *Alnus nitida* in the Sino-Japanese belt

(Romero et al. 2004). There are two ways adopted by plants to fix nitrogen. Few plants are bestowed with special nodules such as legumes while some form mycorrhizal association (Table 12.2). *Alnus* is also among those species which fix atomic nitrogen into molecular form. Different species were considered and researched in this regard. *A. crispa* root nodules have the capability of nitrogen fixation. It utilizes insoluble metals through inoculated mycorrhiza (Becerra et al. 2005). *A. nepalensis* forms an association with *Frankia* spp. to form nitrogen fixing actinorhizal nodules (Chaia et al. 2010). On the other hand, PGPR are bacteria in soil that help in root colonization and stimulate growth. They adopt different mechanism like release of plant hormones (gibberellin, auxin, cytokinin, or ethylene) that directly stimulate growth (Kloepper et al. 2004). Indirect mechanisms involve production of metabolites that affect other factors in rhizosphere, resulting to enhanced growth of plant. The best known mechanisms in this group are inhibition of deleterious rhizobacteria and plant pathogens, and the release of either siderophores and/or antibiotics or lytic enzymes or HCN. *Alnus* species can fix nitrogen and provide utmost benefit to disturbed soil (Chen 1994). Black alder forms an association with bacteria and fungi for nitrogen fixation. *Alnus* with fungal associated root helps to make the uptake of nutrients more feasible. This association helps the plant to survive in fragile environmental conditions (Berliner and Torrey 1989). The mycorrhizal association is advantageous for plant growth in nutrient poor soil (Smith

Table 12.2 Alder species and its relationship with nodulated species

S. no.	Plant name	Nodulated species	Locality	Growing area	Reference
1	*Alnus incana* ssp. *Rugosa*	*Frankia*	New York Adirondack Mountains	Wetlands low accumulated area of NO3 and NH4	Kiernan et al. (2003)
		Frankia	Southern and eastern part of France	Poor calcareous soils	Normand et al. (2018)
2	*Alnus rubra* Bong.	*Frankia*	Washington	Maintain calcium and pH level.	Hilger et al. (2000)
		Frankia	Greenhouse	Cadmium effect, the nitrogen fixation	Lee et al. (2000)
		Frankia	USA	Forest floor	Neilson and Doudoroff (1973)
3	*Alnus glutinous* Kunth	*Frankia*	Netherlands	Waterlogged soils	Wolters et al. (1997)
4	*Alnus nepalensis* D. Don	*Frankia*	Eastern Himalayas	Different seasons study, i.e., rainy, summer, winter	Sharma et al. (1995)
		Streptomyces alni	China	ISP media 2, 3, 4, 5 and 7 and yeast-starch medium (DSMZ medium 1027). The type strain, D65T	Liu et al. (2009)
		Frankia	Kalimpong forest division of the Eastern Himalayas	Temperate forests	Sharma et al. (1995)
5	*Alnus tenuifolia* Nutt.	C2H2 assay	Lake Tahoe basin of California and Nevada	In vitro	Fleschner et al. (1976)
6	*Alnus acuminata* Kunth	*Frankia* and mycorrhizal fungi	Andes	Terrestrial processes	Becerra et al. (2009)

1999). Fleschner et al. (1976) worked over the springs where primary production in castle Lake of California was supported by *Alnus tenuifolia* growing on the shore.

12.5.6 Role as Biomass Producer

Biomass is alternate source of energy or other form of power. High and fast-growing plant species are the organic sources of energy. Alder tree is also among such species. *Alnus* is one of those trees having productive life cycle with maximum biomass and other uses. Alder tree is the best woody plant to rotate its life cycle. Alder produces 1.9–2.2 times more wood than Aspen and Birch at the age of 15–20 years (Daugavietis et al. 2009). Alder is mainly harvested for pulp, firewood, and timber. Alder species can be used for management in agroforestry, watershed protection, land reclamation, and erosion control (Becerra et al. 2005; Jhariya et al. 2018a, b). Due to vigorous growth Alder is usually considered as plant of top priority for cultivation and maximum biomass producer in different forests zones across the globe. Factors affecting site conditions for growth of black alder will result in progressive effects on wood production and forest growth. However, on contrary, increasing disturbance risks and drought will cause severities, which should be acknowledged in forest management practice (Socha and Ochał 2017). *Alnus* species are landscape plants, for example, *A. glutinosa* shows maximum stress of soil moisture. It was noted that in early Pleistocene era and Late Pliocene era the Nepalese alder more spread to eastern side as compare to the western side of the west. The *A. nitida* in Kashmir was migrated in latter stages. In arid mountains, the alder dominated the riparian habitat for landscape, it is valued due to its soil stabilizing capability, tree structure, shade in cool streams, host to bacteria and fungi and improve fish habitat. Except all these, it is a great source of fodder (Li 2015).

The above qualities favor the plant to survive better than any other angiosperm. That's why, Grey Alder at the age of 16-year yield 2.8 times more wood than Birch (Daugavietis et al. 2009). Proper management of Grey Alder can provide more biomass as compare to aspen, birch, and black alder. The same experiment was carried out by Saiz et al. (2006). The *A. viridis* observed with estimated production of 6.18 t/ha/year, of which 61.5% was leaf mass, 21.6% to stem, and 16.8% is branchwood mass. The mass production of *A. viridis* is high as compare to scrub woodland due to its unique colonal growth quality (Wiedmer and Senn-Irlet 2006). The *A. glutinosa* at the age of 14-year may give 20–60 mg/ha as compare to other local plants (Bohanek and Groninger 2004). *A. incana* biomass at the age of 12 years was recorded up to 68.8 t ha^{-1} (Saiz et al. 2006) (Fig. 12.9).

12.5.7 Alder as a Source of Energy/Fuel Wood/Firewood

Woods are sustainable and vital sources of energy in the rural as well as urban areas of developing countries. The Agency for International Development (AID) has specially designed an international forum to aware the people regarding the

Fig. 12.9 *Alnus nitida* (1) Seedling of *Alnus* (2) Female catkin (3) Stump (4) cut down branches (5) Male catkins (6) Hide for drying

importance of plantation, fuel wood, and forestry. Fuel wood plantations are not only source of energy but also bring employment and environmental protection resources an area. Oil products, resin, dyes, paper, and green manure are the secondary benefits of plantation. Nearly 80% of Indian rural people depend on fuel wood for getting energy (Kataki and Konwer 2002).

Alder is used by local communities in Himalayan region for fuel purposes. They are unaware regarding the importance of it for medicinal uses and other services of the species, that is why they only prefer to use it for fuel purposes (Haq et al. 2020a, b). Important species growing in the Himalayan ranges and used by local for fuel purposes are *Celtis australis*, *M. nigra*, *Morus alba*, *Pinus roxburghii*, *Diospyros lotus,* and *Alnus nitida*. The market value of different species is different, few species ranges from 400–450 per mound, and other ranges from 450–600 per mound. Sohail et al. (2020) surveyed different markets and found that *A. nitida* local market rate is 420 per mound. According to wood sellers; the price of wood per mound depends on the ash amount and burning duration. If the wood of a species burns for long time, the highest will be the price and vice versa. Himalayan Alder is a source of livelihood and income for indigenous communities. Rapid and unplanned cutting may lead to extinction. Sustainable usage maybe adopted by the local inhabitants to maintain its availability for ever.

12.5.8 Alder as a Source of Fodder

Alnus is believed to be a delicious food and prefer by buffalos and cows. But some informants also reported that it is not a pleasant food for cattle like goat and sheep and they prefer other plants such as *Morus spp., Ailanthus spp., Melia spp.* etc. than Alder. Shepard usually visits the meadows with grass instead of trees dominant area, as many trees are not a hearty fodder for their cattle (Haq et al. 2020a, b). The green and fresh leaves are eaten by few mammals. By acquiring from local Shepard the reason of not eating shoots, they told me that shoots may be bitter when it is fresh. However, local dairy owners prefer to cut fresh leaves of Alder as fodder which effects its population. In meadow of Horret Wood *Alnus glutinosa* population reduce due to excessive grazing. Grazing pressure effect the new seedlings of *Alnus* to become a mature tree. New seedlings are very much sensitive to grazing. Alder has a very little germination capability which restricts its population. Therefore, suitable and alternate season for grazing is recommended in Alder hosting the areas (Vinthert 1983).

12.5.9 Role of Alder in Carbon Storage and Sequestration

Carbon sequestration is one of the ecosystem services provided by Alder species. The carbon sequestration is usually defined via population size, cultural perceptions, and consumption patterns. Carbon sequestration is the storage of carbon by a tree per year. Alder is evaluated by different scientist regarding carbon accumulation. Frouz et al. (2009) in Dakota (USA) designed an experiment with three stand design based on supply, demand, and anthropogenic activities to find the carbon accumulation ability of Alder. There results indicate that Alder was one among the trees to accommodate 1735.69 million kg carbon. According to Uri et al. (2014) the carbon accumulation capacity of Alder ranges from 0.60 ± 0.09 to 2.31 ± 0.23 t/ha/year. The biomass of a tree is usually linked to the amount of carbon absorbed from the environment (Zhao and Sander 2015). The young and old trees of Alder have the same potential to accumulate carbon. Plantation of Alder along polluted and industrial zones across the globe will help to reduce flow of carbon towards atmosphere which will ultimately lead to pollution control.

12.5.10 Productivity of Alder

Local folks in different areas of the world utilize their expertise to showcase Alder species in different ways for business purposes to enhance their economic conditions. Alder sapwood is used in industry to produce low-cost furniture, idols, timber, meter box, bulb holder, electric wiring support chips, socket box and junction box, etc. The age, buying cost, wood size, and selling cost overall affect the cost of final product of Alder. The log of 85 cm is first hollowed and then rubber or leather is attached to make it musical instruments: *Damru, Sarangi,* and *Madal* (Lohmus et al. 1996). The toys and goddesses are also the products of Alder. Chip piece and board for learner, electric wiring chips, mirror frame, bulb holder are the different products of Alder. The switch board made up of Dry Alder support electrical appliance as dryness make it insulator. Alder wood is excellent source of different designs of school benches and shelves of cupboard with long lasting products (Sharma et al. 2008). The productive nature of Alder made it a cash crop for the locals and farmers. They grow at least 4–5 trees in their fields for making different goods and earn penny (Fig. 12.10). Alnus log is fully utilized by carpenter to make different valuable items for sale. To enhance the livelihood of poor farmers in Himalayan region government should grow maximum Alder tree saplings that would be freely distributed to farmers to grow it in their respective areas.

12.6 Alder Based Agroforestry for Resources Conservation and Ecological Sustainability

Alnus nitida forms symbiotic association with *Frankia alni*, actinomycetes, and nitrogen fixing bacteria. Beside fixation of nitrogen these association helps in the provision of ecosystem services, i.e., biomass production, soil fertility, climax structure, successional trends, and productivity. Commercial production of plants with functional roots nodules is important in two reasons (Malézieux 2012). The grower of *A. nitida* uses relatively less N fertilizers in their fields which reduce production cost and environmental problems caused due to the runoff of water during irrigation. Second, the soil in which *Alnus* is placed may not be compatible for *Frankia*, but *Alnus* cultivation has the capability to overcome this possible barrier to N fixation in landscape (Kimmins 2011).

Its N fixation capability has made it more suitable for species for agroforestry and inter-cropping; one of the oldest practices is shift farming which is in practice from centuries. One of the oldest practices is shift farming which is in practice from centuries. In shift farming, an area with forest cover is cut down into a land with no tree. Then people wait for many years to fully demolish the nutrients so that it becomes part of the soil. This technique enhances the crop production as the soil

Fig. 12.10 Products of *Alnus* (Chhetri and Gauchan 2008)

receives ample amount of nutrients. In shift farming an area with forest cover is cut down into a land with no tree. Then they wait for few years to fully demolish the nutrients in the soil. This technique enhances the crop production as the soil receives ample amount of nutrients. The people from different tribes of Nagaland used to practice it to get maximum yield and fertile soil (Rathore et al. 2010). But this practice is now ban in Pakistan, India, and British due to few reasons. The forests

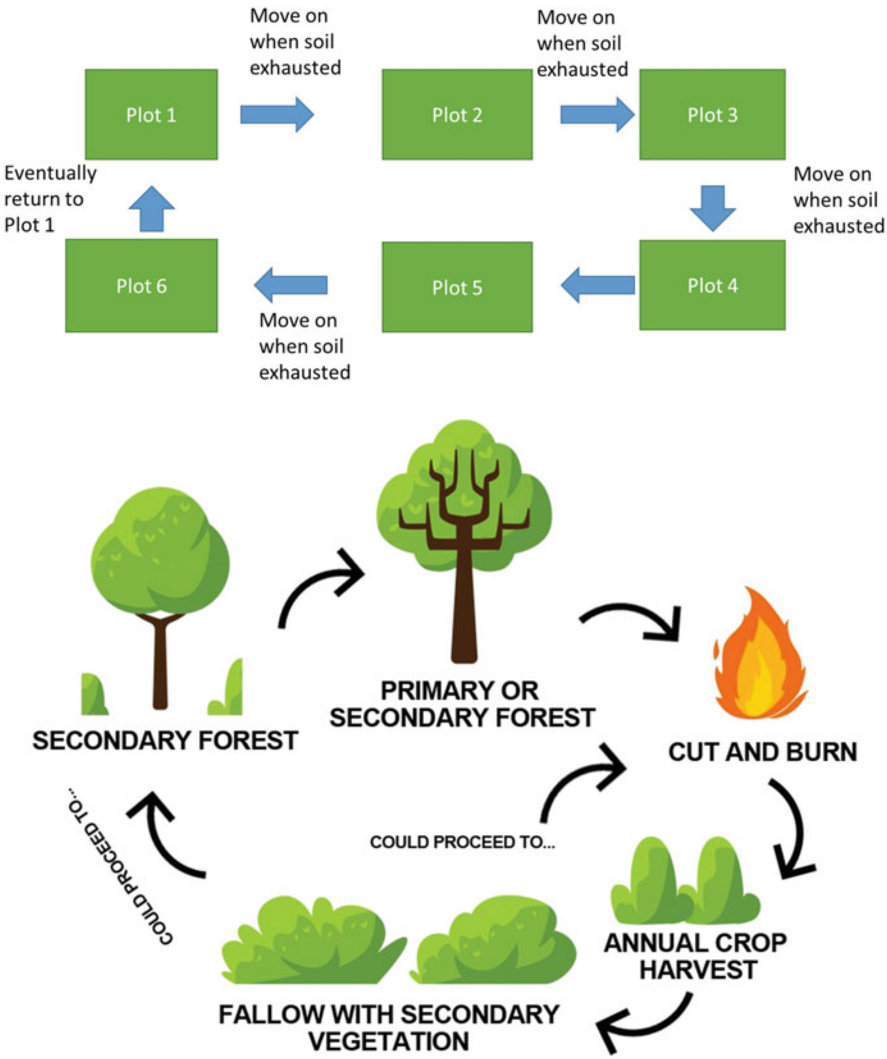

Fig. 12.11 Shift cropping technique used by the farmers to get fertile soil (Liang et al. 2009)

burn may affect the surrounding precious timbers, grasses, birds' nests, and wood land. It is too hard to calculate the tax by government from the area. The most important point is the deforestation which affects our environment and climate at local as well as global levels (Fig. 12.11).

There are many alternative solutions to address this issue. One of these solutions is intercropping. In the case of intercropping two or more crops are cultivated in an area with harmony to each other (Kehie et al. 2017). This technique is usually termed as agroforestry. Alder based agroforestry is an old age system of farming. It is in practice from centuries indigenous communities especially in India and some other areas are involved. The effective intercropping of Alder in crops fields could be maintained with spacing of 3–4 m in vertically (column) and 5–6 m horizontally (rows). In the first year, the primary crops (rice) and secondary crops (*Colocasia*, *Amaranthus*, tapioca, chilli, and potato) are grown in close harmony to Alder trees. This operation maybe repeated for second year as well. The Alder do not need high fertile soil as it has its own N-fixing capability (Yano and Lanusosang 2013).

12.7 Role as an Indicator Species

Indicator species disclose all the aspects of an area. When we talk about an indicator species, then we will focus on its edaphology, environmental and anthropogenic factors. Different areas have different indicators, *Urtica dioica* indicates the high pH contents in the soil, *Viburnum* species indicate snow factor and extreme cold temperature, *Dodonaea viscosa* indicates the moon soon waves flow across the area. The overall scenario of an area can be better explained by its indicator species. *Alnus crispa* is recorded in the Northeastern USA and Atlantic Canada which vigorously grows in extreme cooling environment. There is continuous peak in pollen percentage of *Alnus* in England and Canada. This may be the reason why it is declared as an indicator species of dry period (Mayle et al. 1993).

12.8 Threats to Alder Plant

The Alder is a tree species of temperate regions. It is riparian tree and sometimes it is considered as successional tree to initiate flora in nearby rivers. Many water related problems affect the growth and survival of the tree. The drought was found to be the main limiting factor as *A. maritima* subspecies *georgiensis* reduces photosynthesis, growth and sometime causes the leaf senescence (Zhang and Chen 1991; Packer et al. 1999). The growth of shoot reduces more in drought to sustain water hydration. The species considered as threat to endangered species black grouse based on long term landscape evolution (*Tetrao tetrix* L.) in subalpine belts (Wada et al. 1998) because it produces dense shrub cover (Kikuzaki et al. 1991). In subalpine regions anthropogenic activities are considered as the main reason for treeless land (Brunner and Fairbrothers 1979). *A. nitida* growth and photosynthesis reduce in drought but ample water supply increases its growth (Holtmeier 2009). *A. nitida* is facing water drying conditions in research area. Beside drought factor that *A. nitida* is facing restriction not only in research area but also due to cutting and deforestation, constructions, etc. The genus is ethno-botanically important as the *Betula* species stem bark is used to write spiritual versus for the cure of various diseases. They collect the bark and left the tree barks less; this ultimately leads to the drying of Alder tree. The unchecked cutting of *A. nitida* stem used to make various pots, dolls and furniture is also a threat to the species extinction.

12.9 Anthropogenic Activities and Alder Population Destruction

Human population continuously increases. It is believed that urbanization is an alarming threat for forest conservation. Indigenous communities depend on forest resources for fuel, timber, food, ploughing, and thatching on the forest ecosystem. Alder is also among such species occurring in great abundance in subalpine meadow. Overexploitation of Alder erodes its density and leads towards its extinction. Therefore, its conservation and sustainable utilization in its natural habitat are essential. Keep in mind sustainability here we present an example of French Alps, hosting a great diversity of population and condensed cover of Himalayan Alder. They use Himalayan Alder and its associated species in a sustainable way. However, few scientists claim that Himalayan Alder reduction occurs in subalpine meadows due to its topography and geology. Brunner and Fairbrothers (1979) recorded that anthropogenic pressure is responsible for the reduction of its population (David 2010). Construction of mega projects, roads, industries, and restaurants across the Sino-Japanese belt are the eroding factors for Alder population. Various areas of Himalayan, i.e., Kashmir, Gilgit Baltistan, and Chitral are important spots for tourism. Every year tourists go to visit the beautiful valleys, waterfall, and National Parks across of these areas. Therefore, local people construct hotels and restaurants on the bank of rivers to facilitate them, where they cut down the vigorous population of *A.nitida* and other plants species in its surrounding (Haq et al. 2020a, b).

12.10 Conservation Status of Himalayan Alder

Species extinction is an alarming threat for biodiversity conservation. The protection of threatened species and its conservation are major challenges for conservationists in present scenario (Deb 2017). It is estimated that many species are going to extinct at the rate of 100 to 1000 times faster than any geological time. The same rate of extinction will lead to disappear up to 100,000 species in near future. Anthropogenic activities, habitat destruction (Luetz 2017), and climate changes (Alam and Ali 2010) are the main causes for their erosion. The IUCN Red list categories are designed to identify the conservation status of any species across the world. It also provides explicit objectives and framework for species extinction and defines the status as well as assign priorities for its conservation and protection (Duckworth et al. 2012). The three main categories to check the status of plants are Threatened, Extinct, and Least concern. *A. nitida* has been declared by IUCN red list as least concern (LC) (Shaw et al. 2014). While Haq et al. (2020a, b) categorized it as endangered in few division of Pakistan according to Criteria A, B, C, and D. Due to recent climatic changes and population increase revisiting and documentation of the Alder are required to find its status in different areas of the globe.

12.10.1 Tissue Culture

The most promising technique for sustainability and conservation of Alder is tissue culture. *Alnus* tissue culturing is an important technique to increase its population. *Alnus* being an important plant species provides numerous services. *Alnus* forms an association with *Actinomyces* which forms nodules with its roots and fixing atmospheric N into molecular N, increases soil fertility and biomass. Forest breeding and silviculture require ample amount of *Alnus* in forest ecosystems (Kopelman 2000). To fulfill this demand tissue culture could be an important step (Richard and Tonnel 1987). Protoplast fusion will be homozygous breeding line. Tissue culturing is possible from protoplast of *A. glutinosa* (L.) Gaertn and cell wall of *A. incana* (L.) Moensch. This modern technique of tissue culture will help in cryopreservation of Alder for future studies, genetic record, and conservation.

12.10.2 Regeneration and Plantation

The species facing threats in different region of the world due to various factors, i.e., construction of tourist facilitation centers, hotels, housing schemes, fodder, furniture, water supply scheme (Nalla) are the major threats responsible for Alder population destruction. Mining degraded land in Estonia needs restoration (Kaar and Tomberg 2006). The restoration or afforestation of trees is usually designed for long term to sustain usage of resources (Chambers et al. 1994; Kumar et al. 2020; Meena et al. 2020a). On one side restoration of flora is a challenge due to multifunctional land area while on the other side it provides a base to landscape survival (Groot 2006). Scientist highly recommends reclamation on mining sites (Kuznetsova et al. 2010).

In Himalayan range it is recommended to develop tourism spots where least species may affect. Different economic routes affect the vigorous population of Alder and other species. Housing societies should be ban in those areas where natural environment is affected. The species is facing vulnerable status in western Himalayas (Haq et al. 2019a, b). If government, non-government organization, and local societies are not concern about the population or conservation status of the Alder in different areas of the world and especially in Himalayas, then plant scientists and conservationists should come forward to aware the local community regarding the present status of the plant in the area, future availability, and its effect on the local societies. To demolish a species means, we are putting ourselves away from the free of cost services provided by nature. The Himalayan Alder is one of the very special species which provide wood, fodder, furniture, and heavy metals accumulation facilities. We should take special care of it to keep continue its services for ever.

12.11 Conclusion

Himalayan Alder is ecologically and economically important Holarctic plant species distributed in different areas of Himalaya. It is a multipurpose plant providing ecosystem services to the community. The local people are using it for fuel, fodder, and construction purposes and the thick forest has reduced to sparsely distributed specimens. The species is facing conservation problems due to over exploitation its population decreasing continuously. Nowadays, the species is categorized against IUCN categories and criteria's critically endangered in different habitats due to habitat loss, anthropogenic activities, urbanization, developmental projects, and drought. The plant has great capacity in the accumulation of heavy metals and has been declared as the best bio-accumulator of heavy metals in hilly areas. The species absorb heavy metals from water and make it more suitable for drinking. Conservation strategies, awareness, afforestation, and reforestation will save Himalayan Alder for future generation otherwise the recent speed of deforestation will be led it to extinction from western Himalayan regions.

12.12 Future Perspective

Himalayan Alder is an economical, medicinal, agro-forestry, and fertility sustainer species found in Himalayan region. Many aspects of the species have been untouched and covered by different scientists across the globe. But still we have many aspects of the species to be discovered. Pharmaceutical industries should be involved in phyto-chemical analysis for the extraction of more chemicals because it contains number of chemicals extracted time by time (Sajid et al. 2016). Various chemicals isolated from Alder are used for multiple diseases. Many spiritual beliefs consider its shoots and bark very important. The species also has great variability in cone size and morphology. Therefore, its genetic studies are recommended to evaluate the macro-morphological difference, either it is due to environmental factors or it is a separate new or subspecies. Deforestation of *A. nitida* reducing its population with alarming speed, inhabitant of the area should be educated to conserve its population. Afforestation of *A. nitida* on riverside will be helpful to enhance water quality and purity through its heavy metals accumulation capacity (Haq et al. 2019a, b). Besides practicing ban technique of shift cropping, intercropping in agroforestry of Himalayan Alder will provide benefits to the inhabitants of Himalayan region (Uri et al. 2011). Due to multiple benefits of Alder tissue culturing technique may be applied for vigorous germination and propagation.

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