Pinus patula Plantations in Africa: An Overview of Its Silvicultural Traits and Use under SDG

Wubalem Tadesse[1,2] and Teresa Fidalgo Fonseca[1,3]

[1] IUFRO Division 1 - Silviculture, Unit Ecology and Silviculture of Pine, Austria
[2] Ethiopian Forestry Development (EFD), Addis Ababa, Ethiopia
[3] Department of Forestry Sciences and Landscape Architecture, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal; Forest Research Centre (CEF), School of Agriculture, University of Lisbon, Tapada da Ajuda, Lisboa, Portugal

centro PINUS

Webinar | March 15, 2023

IUFRO
Interconnecting Forests, Science and People

Table of contents

1. Introduction
2. Distribution and ecology of *P. patula*
3. Silvicultural characteristics
   - Tree species characteristics, growth dynamics, and yield
   - Silvicultural guidelines
   - Models to support decision-making processes
   - Pests and diseases
4. Interest of *P. patula* within the framework of the sustainable development goal (SDG) 15
5. Conclusions

6. *Pinus patula* Plantations in Africa: An Overview of Its Silvicultural Traits and Use under SDG

By Wubalem Tadesse and Teresa Fidalgo Fonseca

https://www.intechopen.com/books/10983

centro PINUS

IUFRO Interconnecting Forests, Science and People

1. Introduction

- Forest resources have paramount socioeconomic and ecological importance in many African countries.
- They contribute to poverty alleviation in a variety of ways and provide important support mainly for sub-Saharan Africa's economic, social, cultural, and environmental development, especially in rural areas.
- Over two-thirds of all Africans rely directly or indirectly on forest resources for their livelihoods.
- In Ethiopia, for instance, most farmers describe trees around their homestead as 'life saviour', 'safety net,' or 'tree bank' as it is converted easily .








centro PINUS

IUFRO
Interconnecting
Forests, Science and People

1. Introduction contd..

- However, deforestation and forest degradation are hampering the forest resources of many countries in the continent.
- These forests have come under severe pressure from a growing demand for forest products, particularly fuelwood, and the expansion of agricultural land.
- The use of planted forests is a strategy that supports and benefits the achievement of SDG 15.
- To this end, knowledge of the biological traits and silviculture of forest species and decision on what appropriate species to use is essential.
- The information here presented intends to provide guidance on the use of this species as a management option to consider when the aim is to ensure the sustainability of forest resources on this continent

centro PINUS

IUFRO
Interconnecting
Forests, Science and People

2. Distribution and ecology of *P. patula*

2. Distribution and ecology of *P. patula*

Pinus patula Schiede ex Schltdl. & Cham. is a forest tree species native to Mexico, widely cultivated in tropical and subtropical regions of the world.

The species is largely used for plantations in tropical and subtropical regions of the world, including South America, Central and Southern Africa, Indonesia, Australia, and New Zealand

Agroforestry Database 4.0 (Orwa et al.2009)

2. Distribution and ecology of *P. patula* contd..

Pinus patula in Africa

- In 1907 it was introduced into South Africa,
- The area planted with *P. patula* worldwide is approximately 1 million hectares, of which 95% correspond to plantations in Central, Eastern, and southern Africa.
- Probably is the most widely planted pine in tropical Africa.
- The species is of particular importance in Kenya, where it accounts for about 25% of all forest plantations.
- It is also important species in Madagascar, Malawi, South Africa, Tanzania, and Zimbabwe.
- In South Africa, 54% of the total forested area is pine forest, with *P. patula* being the most widespread species, covering an area of about 375,000 ha.

2. Distribution and ecology of *P. patula* contd..

Pinus species in Ethiopia

- Pinus spp in Ethiopia was introduced In 1955 from Australia.
- *Pinus radiata, P. halepensis, P. patula, P. sabiniana, P. cembra, P. excelsa, P. calabrica, P. ponderosa, P. pinaster, P. pinea, P. canariensis, radiata,* were the first introduced pinus psecies.
- *Pinus patula* and *Pinus radiata* are the well adapted and widely distributed pinus species.
- *Pinus patula* is one the three commercially planted timber producing species.
- Well adapted Pinus species in research sites*: P. maximoini, Pinus taeda.*
- ***Pinus patula*** in Ethiopia does well in Moist and Wet agroclimatic zones, 1,900—3,000 m asl..

centro PINUS

IUFRO Interconnecting Forests, Science and People

2. Distribution and ecology of *P. patula* contd..

Pinus species in Ethiopia contd..

- *Pinus* tree plantations are established mainly in state-owned forests, occupying the third position in terms of plantation area coverage.
- They contribute to the production of round wood for sawn timber, poles and posts owing to their rapid growth.
- the rotation time for *Pinus* trees is usually about 26–30 years (Bekele, 2011).
- In some cases, the trees are deliberately left for more years than mentioned in order to provide large-sized logs.
- *Pinus* plantations are managed using a “plant, clear fell and replant” cycle method (Teshome, 2011).
- Retention of trees in some structure classes for ecosystem maintenance is not a common practice.

Ecology of *P. patula*

- *P. patula* is a species that tolerates most soils and will grow in grassland.
- The species thrives best when there is good water supply but can also overcome unfavorable conditions.
- It is often found in pure dense stands, but the occurrence is discontinuous, and now, for much of its range, it develops only in areas inaccessible to agriculture.
- *P. patula* demands deep, well-drained soils and grows best in the mist belt regions of South Africa above 1 000 m elevation.
- In southern Africa, the species are generally planted in areas with mean annual temperatures below 17°C.
- In Ethiopia, the species develops best with good water supplies but can also survive adverse conditions in 1900–3000 m.

Ecology of *P. patula* contd..

- In southern Africa female flowering starts when trees are 2–3 years old, and male flowering 1–2 years later.
- The flowering of both male and female cones occurs in August–October, with usually a secondary flush of only female cones in January–May.
- In Kenya, two flushes of male and female flowering normally occur in April–May and October–November, coinciding with the rainy seasons.
- Studies in Zimbabwe showed that synchronization of pollen shedding and female receptivity was good at 1,500 m altitude, whereas pollen shedding occurred progressively later at lower altitudes.
- Outcrossing is predominant, and pollination is mainly by wind.
- Female cones mature in 22–30 months.
- The production of viable seeds starts when trees are 5 years old, and is prolific in 8–10-year-old trees.
- Seed dispersal is usually by wind, but sometimes also by birds, rodents, or people.

centro PINUS

IUFRO Interconnecting Forests, Science and People

Ecology of *P. patula* contd..

- *P. patula* is a very demanding species in terms of light.
- It is considered an aggressive pioneer species that grows easily in forest gaps created by fire.
- In countries, such as South Africa, Swaziland, and Zimbabwe, it is now considered a serious weed, forest edges, moist grasslands, and road cuts.
- *Pinus patula* is invasive in parts of Tanzania (Lyons and Miller 1999), Kenya and Uganda (A.B.R. Witt pers. obs.) .

3. Silvicultural characteristics

Tree species characteristics, growth dynamics, and yield

- *P. patula* grows very fast.
- Under favorable conditions, it may attain a height of 15 m after 8 years and 35 m after 30 years.
- The species can reach a diameter at breast height of up to 1.2 m.
- The bole is usually straight and cylindrical .
- Sometimes the trunk fork produces two or more stems.
- When the growing area of the tree is large (wide-spaced plantation), the crown tends to spread out.
- In terms of shape, the crown can be rounded or spiral-shaped.
- The bark has distinct characteristics depending on the tree's stage of development.
  - When young, it has a reddish-orange color and is scaly.
  - In contrast, the mature bark is grey-brown and vertically ridged.

3. Silvicultural characteristics contd..

Tree species characteristics, growth dynamics, and yield (contd.)

- Mean annual increments in volume MAI are:
  10–40 m^3 ha^{-1} y^{-1}, in southern Africa,
  ranging from 18 to 28 m^3 ha^{-1} y^{-1} in Southern Africa.
- In East Africa, the species can show higher yields than in southern Africa due to a shorter dry season.
- The total yield (including thinning removals) under appropriate conditions maybe 630–700 m^3 ha^{-1}.
- this species presents a wood density of around 450 kgm^{-3} (dried basis) and 580 kgm^{-3} (12% of moisture).
  - In Ethiopia: 530 kgm^{-3} (dried) and 573 kgm^{-3} (with moisture).
- Wood density may vary depending on the altitude, presenting higher values when plantation occurs at lower altitudes, instead of higher ones.

3. Silvicultural characteristics contd..

Tree species characteristics, growth dynamics, and yield (contd.)

- *P. patula* is mainly used for firewood, timber (boxes, general purpose), posts (treated with wood preservative), pulpwood, shade, and ornamental.
- The wood is highly appreciated for glued laminated timber for carpentry and furniture after the knots have been removed.
- It is also suitable for hardboard, particleboard, and wood wool.
- *P. patula* is an important source of pulpwood.

3. Silvicultural characteristics contd..

Silvicultural guidelines

Silvicultural guidelines

- Although mixtures can be found, typically, *P. patula* is managed in pure stands.
- Initial spacing in most countries is from about 2.4 m to 2.75 m or 3 m, corresponding to individual growing areas around 6–9 m^2 .
- Generally, for sawlogs, closer spacing is recommended for knot-free wood.
- Wider spacing is recommended on poorer sites.
- Sawlog regimes in common use are conceived to have about 250 trees ha−1 with an average diameter at breast height of 45 cm at a 45-year rotation.
- For pulp schedules, rotations range from 15 years in Swaziland to 25 years, as recommended in South Africa.
- During the first year after planting 2–3 operations to control spontaneous vegetation are required, to reduce the occurrence and growth of competitive vegetation and optimize yield.

Silvicultural guidelines for the management of pure P. patula plantations

Year	Activity	Description	Observation
0	Site preparation		
0	Stand establishment: artificial regeneration	Initial spacing about 2.4 m to 2.75 m, or wider (e.g. 3 m).	Closer spacing is recommended for saw log schedules. Wider spacing is recommended on poorer sites
1	Control of spontaneous Vegetation (weed)	2–3 weeding operations to reduce the occurrence and growth of competitive vegetation	The vegetation management is performed either manually or chemically
4–6	Pruning	Trees are pruned to a height up to 2.5 m	▪ The operation is recommended both for pulp and sawlog schedules. ▪ For the production of sawn timber, further pruning interventions are recommended at a later age to a height of 7 to 12 m. ▪ Whenever pruning coincides with thinning, it is carried out on the trees to be retained.
6–15	Thinning	One to two thinnings. Reduction of stems per hectare gradually or in a single heavy thinning, to a final density of 200 to 400 treesha−1	▪ Thinning applies for sawlog schedules but is not usual for pulp schedules. ▪ Frequently combines mechanical row thinning along with selective thinning within the strips with trees.
15–45	Final harvest	Final cut of the living trees.	Rotation of 15 to 25 years for pulp projects, rotation of 25–45 years for saw log schedules

Models to support decision-making processes

Existing models for *Pinus patula* developed for African forest systems (from GlobAllomeTree. http://www.globallometree.org/)

Allometric equation	Response variable	Explanatory variables	Geographical location
40551	Tree volume	d , h	Kenya
47709	Tree volume	d	Rwanda
41516, 41586	Tree biomass	d , ch	South Africa
45212, 46720	Tree biomass	d , h	South Africa
45871	Tree biomass	d	South Africa
38145	Tree volume	g	Tanzania
38656	Tree volume	d , h	Tanzania
39372	Tree volume	g , h , t	Tanzania
44165	Tree volume	d , h	Tanzania
46201	Stand volume	G , t , hdom	Tanzania

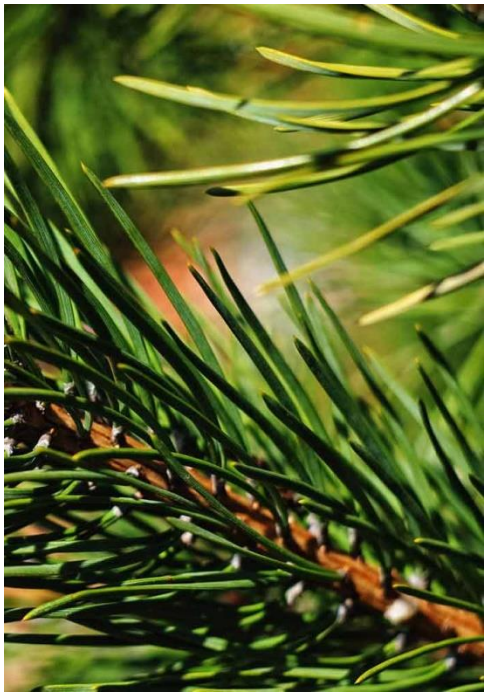
The equations to estimate tree volume or tree biomass used as repressors one or a combination of the following variables, diameter at breast height (d) , tree height (h) , crown height (ch) , tree basal area (g) , and age (t)

Pests and diseases

- Most of the insect pests harming *P. patula* are defoliators, particularly of the order Lepidoptera, the most noted being the families Arctiidae, Lasiocampidae, Noctuidae, and Saturniidae.
- The damage starts from the nursery stage by means of cutworms, several leaf rollers, and defoliators.
- The pests in plantations include adult leaf-eating beetles, adult bark beetles (mottled pine bark weevil) as well as sucking insects, such as pine wooly aphid.

Pests and diseases contd...

- The pests in plantations include adult leaf-eating beetles, adult bark beetles (mottled pine bark weevil) as well as sucking insects, such as pine wooly aphid.
- Diseases of the species comprise foliage leaf cast, tip die-back of the branches, and armillaria root rot.
- Armillaria root rot was the most common disease, associated mainly with *Pinus patula* in Ethiopia
- *Sphaeropsis sapinea* was also mentioned as an economically important pathogen of *P. patula* in South Africa, causing rapid die-back and mortality of hail-damaged trees .
- *Fusarium circinatum,* known as the pitch canker fungus (PCF), is one of the most important pathogens to natural and industrial pine forests, being a serious threat to *P. patula*.
- *P. patula* has been identified as being particularly susceptible to the PCF.



Pests and diseases contd…

- In addition to insect pests and diseases, rodent-induced damage has also been reported in first-rotation pine plantations in South Africa 4–5 years after planting.
- Tree mortality was attributed to changes in the structure of shrub and grass assemblages within the plantation, causing rodents to feed on the pine trees.

Pine seed predation by mice: an experimental assessment of preference R. Flores–Peredo & B. S. Bolívar Cimé

Effects on biodiversity and relevance on aboveground carbon stock

- The usage of *P. patula* in a plantation system does not appear to negatively impact biodiversity.
- In a study conducted in western Kenya, the authors reported there was no significant variation in woody species richness among disturbed primary forest, old-growth secondary forest, middle-aged secondary forest, mixed indigenous plantation, and *P. patula* monoculture plantations.
- Old-growth and middle-aged secondary forests had relatively higher woody species diversity indices than *P. patula* monoculture plantations, but the difference was not statistically significant.

Effects on biodiversity and relevance on aboveground carbon stock

- Regarding the contribution to aboveground carbon offset, results indicated that *P. patula*, had a lower carbon stock than other types of forests.
- This was explained by the smaller stem diameter and wood specific gravity lower than or comparable to the other species and forest types in the study, being predominantly associated with the schedules adopted for the plantations of P. patula of short (pulpwood) to medium rotation length.
- A short rotation length affects biomass accumulation (which will be comparably lower) and wood density.

Soil Fungal Communities under *Pinus patula* in Ethiopia

- Alem (2022) assessed the soil fungal communities in *Pinus patula* stands aged 5, 11, or 36-years-old using DNA meta barcoding of ITS2 amplicons.
- The diversity of ECM fungi was higher in the 5 and 36-year-old stands than in the 11-year-old P. patula stands.
- A high level of ECM species diversity was observed in young stands, suggesting that these ECM species could compensate for the effects of nutrient stress in these stands.

4. Interest of *P. patula* within the framework of the sustainable development goal (SDG) 15

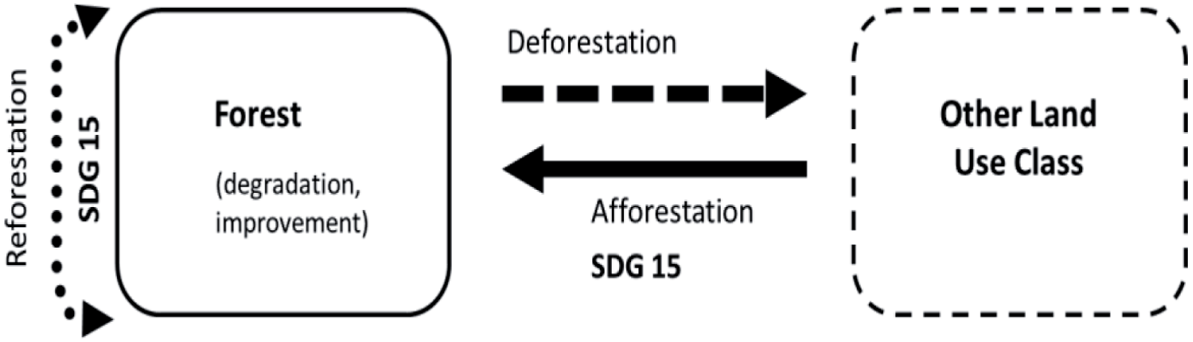
4. Interest of *P. patula* within the framework of the sustainable development goal (SDG) 15

- Reforestation envisages the recovery of forest areas and can be achieved with the plantation of forest species. Forest plantation is expanding in African countries.
- The great majority of planted trees are exotic species chosen for their capability to grow rapidly to produce wood of desired quality. Eucalyptus is the most widely planted genus covering 22.4% of all planted area, followed by Pinus (20.5%).
- Well-managed forest plantations can help to alleviate pressure on natural forest resources.

4. Interest of *P. patula* within the framework of the sustainable development goal (SDG) 15

- Two SDG targets of SDG 15 are explicitly identified —*ensuring the conservation, restoration, and sustainable use of terrestrial and inland freshwater ecosystems and their services, particularly forests (15.1); promoting the implementation of sustainable management of all types of forests, halting deforestation, restoring degraded forests, and increasing afforestation and reforestation globally (15.2)*

- The use of forest species, such as *P. patula*, in forestation or afforestation programs in Africa can be beneficial in counteracting or minimizing the pattern of forest area loss.



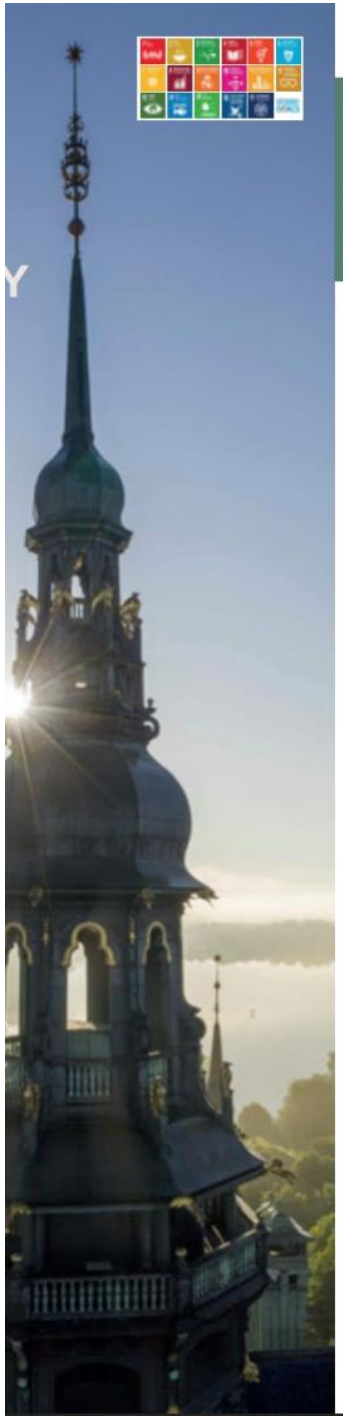
Major forest changes processes with a reference to SDG 15.

5. Conclusions

5. Conclusions

- *P. patula* is a very fast-growing tree and the most widely planted pines species within African commercial plantations.
- The species is planted in Ethiopia, Kenya, Tanzania, Malawi, Zimbabwe, Madagascar, and South Africa and is mainly used for timber and firewood.
- The increase in forest area and its maintenance in good conditions contribute to the Sustainable Development Goals of UN Agenda 2030.
- Besides the positive impacts explicitly associated with SDG 15, positive effects of the forest sector might be expected in SDG 1 (income to fight poverty), SDG 6 (freshwater), and SDG 13 (carbon capture).
- Achievement of any of the goals requires appropriate knowledge of the forest species traits and their adequate forest management.
- The review here presented aims to help accomplish these purposes, by providing information on the species and identifying research priorities.

wubalem16@gmail.com



Welcome to Stockholm June 23-29, 2024

Sweden in close partnership with the Nordic-Baltic countries

STOCKHOLM 2024

IUFRO

WORLD CONGRESS FORESTS & SOCIETY TOWARDS 2050

www.iufro2024.com | IUFRO2024@slu.se

SLU
SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES

IUFRO
Interconnecting Forests, Science and People

THE WORLD GATHERS IN STOCKHOLM

- Foundations for innovation and collaboration
- Scientific solutions for a sustainable future
- 5 000 scientists from all over the world
- Dialogue with stakeholders
- Focus on next generations

FORESTS & SOCIETY TOWARDS 2050

www.iufro2024.com | IUFRO2024@slu.se