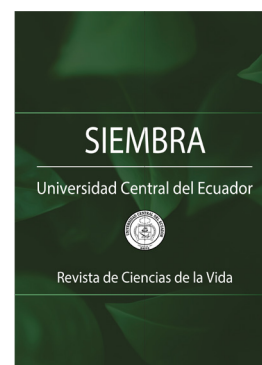


Contributions of agroecological principles to the sustainability of commercial forest plantations. Reflections from the Peruvian case

Contribuciones de los principios agroecológicos a la sustentabilidad de las plantaciones forestales con fines comerciales. Reflexiones a partir del caso peruano

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Abstract

This article discusses the application of agroecological principles to commercial forestry plantations based on reflections on the Peruvian case. The purpose is to contribute to the enrichment of the philosophical, theoretical and methodological framework of commercial forest plantations as sustainable agroecosystems. It is concluded that all forestry applies ecological principles but not all forestry applies agroecological principles as forestry and agroecology are considered to be entirely separate disciplines with different purposes. Although agroecology is strongly oriented towards agrifood systems it is also oriented towards agroecosystems and therefore its principles can be applicable to commercial forest plantations. Agroecological principles with their systemic approach, their socio-ecological and biocultural perspective, their commitment to native biodiversity and sustainability, their attachment to Good Living and their ethical-political character enrich the theoretical and methodological framework of commercial forestry plantations, transcending the strongly productivist orientation that prevails to date. This is why we propose commercial forestry plantations for life. We conclude that while forestry applies ecological principles, not all forestry applies agroecological principles, and, as such, forestry and agroecology should be considered separate disciplines, with different purposes.

Keywords: agroecology, agroecosystems, biodiversity, ecology, landscapes, forestry.

Resumen

El presente artículo discute la aplicación de los principios agroecológicos al diseño y manejo de las plantaciones forestales con fines comerciales a partir de las reflexiones sobre el caso peruano. El propósito es contribuir al enriquecimiento del marco filosófico, teórico y metodológico de las plantaciones forestales comerciales como agroecosistemas sustentables. Aunque la agroecología está fuertemente orientada a los sistemas agroalimentarios también se orienta a los agroecosistemas, y por lo tanto sus principios pueden ser aplicables a las plantaciones forestales comerciales. Los principios agroecológicos con su enfoque sistémico, su perspectiva socio-ecológica y biocultural, su compromiso por la biodiversidad

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nativa y la sustentabilidad, su adscripción al buen vivir y su carácter ético-político enriquecen el marco teórico y metodológico de las plantaciones forestales comerciales trascendiendo la orientación fuertemente productivista que prima hasta la fecha. Es por ello que se propone plantaciones forestales comerciales para la vida. Se concluye que toda silvicultura aplica principios ecológicos, pero no toda silvicultura aplica principios agroecológicos, en tanto se considera que la silvicultura y la agroecología son disciplinas totalmente separadas y con fines diferentes.

Palabras clave: agroecología, agroecosistemas, biodiversidad, ecología, paisajes, silvicultura.

1. Introduction

The dramatic growth of the global population and, consequently, the rising demand for timber forest products on one hand, and, on the other, the alarming loss of forest biodiversity in the world generate the tendency for the supply of wood products to be preferably from forest plantations. In addition, the establishment of big surfaces for forest plantations to face climate change results in a significant increase in the surfaces dedicated to forest plantations around the world, in such a way that the preference towards plantations is irremediable. According to the Food and Agriculture Organization (FAO, 2022, p. 10), the forest plantations include 294 million of hectares, which is supposed to represent the 7% of the global forest surface. Between 2015 and 2020 this surface increased by under 1% per year. In Latin America, the countries with the biggest surfaces of forest plantations are Brazil, Chile, Argentina and Uruguay. In Peru, forest plantations have been neglected (Dourojeanni et al., 2021), but recently they have recovered importance. Therefore, the importance of forest plantations results pertinent from a sociological perspective.

From an institutional perspective, forest sciences constitute a specialized field of the agricultural sciences that includes agriculture, forestry and fishing as specified in the Classification of the Scientific Areas by the Organisation for Economic Co-operation and Development (OCDE, 2015). In the Peruvian public administration, the topic of forest plantations is regulated by the National Service of Forestry and Wild Fauna [SERFOR], which is attached to the Ministerio de Desarrollo Agrario y Riego [MIDAGRI] (Dourojeanni, 2019).

The Strategy for the Promotion of Commercial Forest Plantations 2021-2050 in Peru (SERFOR, 2021, p. 46) has as main objective the increase in the production and profitability of the commercial forest plantations in Peru. Forest plantations are considered productive activities, highly profitable and that could generate quality jobs wherever there are not many opportunities (Dourojeanni et al., 2021). Although from the main objective, social and environmental positive impacts can be derived, the bias is strongly economist, as long as the activity is conceived as a business that has to be competitive (Pari Pérez et al., 2017). This is also helped by the fact that the wood is a *commodity* whose demand is in constant expansion as it has been explained.

When the commercial forest plantations contained native species, they qualify as bio-business or bio-commerce, as these are business that are based on the production of nature, completed by human activities. When the forest plantations have domesticated exotic species, they no longer classify as bio-business. Independently, the commercial forest plantations, with native or exotic species, are part of the bioeconomy in the concept oriented to the sustainable management of natural resources (Braun, 2015).

Now, the fact that commercial forest plantations are treated as business, it does not exempt them from environmental and social compromises for them to be classified as responsible or sustainable forest operations (Pezzutti, 2014). Thus, the Forest Plantation Management Regulations force holders to guarantee that the management of exotic species does not cause negative effects at genetic or ecological levels on the native wild populations present in the area (SERFOR, 2015, p. 95).

To facilitate the reading of the article in an international context, a basic glossary is presented:

- **Agroecology:** Science dedicated to the holistic study of the agro-systems and food systems with the purpose of improving the resistance and durability of the food and agricultural systems, while conserving social integrity (CIDSE, 2018; Pengue, 2021).
- **Forest plantation:** Plantation with forest species that generates forest ecosystems constituted from human intervention through the installation of plantations of one or more native or introduced forest species. As a crop, the plantations include cultural activities, from the production of seedlings and reproductive material, preparation and land conditioning, irrigation system, fertilization, pest control and harvesting, including acquisition and machinery use, equipment and necessary inputs for these activities.
- **Forest Resource:** they are forest resources, located in any national territory, as follows: A) Natural for-

ests. B) Forest plantations. C) Land whose major use is for forests and for protection, with or without forest cover. D) The rest of wild components such as land or emergent aquatic flora, including its genetic diversity (art. 5 de la Ley Forestal y de Fauna Silvestre. Ley N° 29763, SERFOR, 2015). Forest resources play an important role in the economy and environment.

- **Forestry:** For Ford-Robertson (1971), forestry is the art of forest cultivation, applying biological and ecological principles, to take it to a desired state for profitable economic goals. It covers all the actions destined to regenerate, explode and protect the forests, as well as to collect their products (Basantes Morales, 2016, p. 3). Forestry is oriented to the continuous and sustainable production of the natural or planted forest. Espinosa Bancalari et al. (1990) recognizes that forestry does not only refers to the human-tree-environment relationship, but that involves the totality of the environment including the interactions with the social dimension.
- **Ecological Forestry:** it is the forestry that applies ecological principles: imitation of the nature through forestry, conservation of the productivity of the area, control of the structure, the mass, composition, density of the mass and the duration of rotation (Wilson, 2019). Ecological forestry is more applicable in mixed forests with native species (Donoso Hiriart & Navarro Cárcamo, 2023), which does not mean that traditional forestry does not use ecological principles. For Donoso Zegers (1989), it is impossible to separate forestry from ecology. However, when an economic focus prevails, the ecological principles remain subordinated.
- **Forestry 4.0:** It is also called precision forestry or smart forestry; it is located in intensive forestry. It is the application of digital technologies (drones and satellites, big data and data analysis, artificial intelligent and automatic learning, geographic information systems, robotic and atomization, among others) to forest practices (Cunha Neto et al., 2020; Medina Tello et al., 2021).

2. Metodology

The article has a review character. It is described as qualitative and interpretative. The epistemological focus is complex. The searching phrases were forest plantations, forest plantation and conservation, forest plantations and biological diversity, social and environmental impact of forest plantations, among others. Bibliographic searches were done, mainly in ProQuest (<https://www.proquest.com>), Academia.edu (<https://www.academia.edu>), ResearchGate (<https://www.researchgate.net>), Redalyc (<https://www.redalyc.org>), SciELO (www.scielo.org) and Google Scholar (<https://scholar.google.com/>).

The problem is supposed to be the weak connection between agroecology and commercial forest plantations. The general research question is: How do agroecology principles strengthen the sustainable management of commercial forest plantations? The field of study is located in Peru, but it extends to Latin America.

To answer the questions, the following topics are debated: conceptualization of the forest plantations, brief diagnosis about the management of forest plantations in Peru, critics to forest plantations, the link between agroecology and commercial forest plantations, agroecology principles, and finally, forest species and agro-industrial species are reviewed.

The purpose of the article is to contribute to the enrichment of the philosophical, theoretical and methodological framework of commercial forest plantations like sustainable agroecosystems based on contributions of agroecological principles.

3. Results

3.1. Conceptualization of forest plantations

According to the article 11 of the Forestry Law and Wild Fauna. Law N° 29763, the forest plantations:

Forest ecosystems are constituted from human intervention through the installation of [forest monocultures] or more forest species, native or introduced, with wood or forest production purposes different from timber, of protection, for ecological restauration, recreation, provision of environmental services or any combination of the previous ones (SERFOR, 2015, p. 28).

García Rivas and Aguilera Fernández (2023, p. 77) proposed that a forest monoculture can be extended like

“artificial forests composed of only one arboreal species, native or exotic, contemporaries, that monopolize all or most of the cultivated land in a region”.

FAO (2018, p.6) defines forest plantation as “Planted Forest, which is intensively managed and fulfills all the criteria for plantation and maturity of stand: one or two species, similar age, and regular spacing”.

Commercial forest plantations with exotic species present great economical benefits and environment services, such as the improvement of water cycle, soil conservation and carbon fixation (Dourojeanni et al., 2021). Positive impacts have also been reported in conservation terms. Even though, forest plantations are less diverse than the natural forests, it has been found cases where mammals have been able to prosper favorably (Lantschner et al., 2012; Sánchez-Londoño et al. 2021).

3.2. Management of forest plantations in Peru

The diagnosis of the management of the forest plantations in Peru (Capella, 2017; Cuéllar, 2021, 2017; Flores-Villegas et al., 2019; Guariguata et al., 2017; Llerena, 2017; Moscoso, 2017; Nalvarte, 2021, Quispe Santos, 2017, 2019a, 2019b, 2021a, 2021b, 2023; Yance Tueros, 2022) indicates that forest plantations have been established without any economic logic, without having clear objectives and without any major orientation to the demand of international markets.

The preferred species for forest plantations have been pine (*Pinus* spp.) and eucalyptus (*Eucalyptus* spp.). Although, this does not mean that we should ignore that in the case of the Amazon, tornillo (*Cedrelinga cateniformis*), white bolaina (*Guazuma crinita*), capirona (*Calycophyllum spruceanum*), chuncho pine (*Schizobium amazonicum*), shihuahuaco (*Dipteryx* spp.), marupa (*Simarouba amara*) and pumaquiro (*Aspidosperma macrocarpon*) have been prioritized. The main focus of the production has been the obtention of sawmill. However, high informality prevails. In the country, specific studies that measure the incidence of agrochemicals (herbicides, insecticides, fungicides, others) are not known, in contrast to Chile (Suazo Caamaño & Torres Salinas, 2023) or México (Flores-Villegas et al. 2019), where studies exist.

In the history of forest plantations in Peru, it is possible to recognize three stages. The first stage could be named as forest plantation promotion with traditional nursery installation and establishment of plantations with little technical development. Thus, low genetic quality seeds that have not been selected from plus trees were selected. There was limited knowledge about vegetative production and cloning that along with other factors, translated in seedlings of deficient quality.

Moreover, in plantations, various problems were linked to deficient selection of site quality and modern techniques of installation and plantation management regarding the management and soil conservation, weed control, pest and disease control, pruning techniques, thinning, fire control, among others that resulted in low productivity (Guariguata et al., 2017).

On the other hand, there were just a few qualified foresters and with specialization in landscape management. While a more ecological perspective is lacking, information about mixed plantations and forestry of diverse forest species is missing. Additionally, criteria of resilience for forest plantations are not considered. In general, with a weak focus on the quality chain, a weak link between forest production and forest industry is created, and authorities linked to the forest innovation attempt to fix through capacitation activities and manual publication.

In the second stage (since year 2004), an emergent technological turn can be recognized, based on the establishments of technical nurseries and clonal material use, which has gradually been permeating in the forester communities, and it is possible to appreciate some plantations of high performance and productivity.

A third stage, which is the current one, refers to the promotion and establishment of productive and competitive commercial forest plantations that has started to develop from the National Forest Authority, promoting different levels of investment. These stages in history still cohabit until current days. It is considered that the future of plantations lays on macro and micropropagation. Despite the precision forestry is not applied intensively in Peru, there are traces that leads to this direction.

3.3. Critics to forest plantations

In contrast to the benefits of forest plantations, the environmental and social negative impacts are also well documented, and it is necessary to take them into account to mitigate and eventually eliminate them. Among other impacts mentioned: deforestation and loss of carbon deposits, acidification and soil erosion, overex-

exploitation and water scarcity (Braun et al., 2017; Camino Velozo, 2007; Cordero Rivera, 2011; Cubillos Alvarado, 2021; Figueroa Jara et al., 2020; González et al., 2016; González Hidalgo 2016; Grosser Villar, 2021; Hofstede et al., 1998; Lehnert & Carrasco, 2020; McKay et al., 2021; Pino Albornoz & Carrasco Henríquez, 2019; Salinas, 2020; Torres et al., 2022).

High susceptibility of forest species, like pine (*Pinus* spp.) and eucalyptus (*Eucalyptus* spp.) (González Hidalgo, 2016) stands out, along with the susceptibility to pest and diseases. Conscious about the impacts in Chile, researchers are asking that forest plantations go through an environmental impact assessment (Carrere, 2021).

It is important to consider the serious critics towards forest plantations, such as the ones proposed by the Global Movement for the Tropical Forests (WRM, 2021). From this movement, the Latin American Network Against Tree Monocultures [RECOMA] has been promoted, and it has been proposed the International Day for the Fight against Tree Monocultures on September 21st. Even though the agreement or disagreement on the WRM position, it is important to pay attention to its observations and proposals. For example, studies done in Tome, Chile, condemn forest extractivism as it “has fractured the socio-environment metabolism through four intercorrelated processes: corporative appropriation of land and soil degradation, water uncertainty, contamination by fumigation and agrotoxics, and a growing threat of forest fires” (Pino Albornoz & Carrasco Henríquez, 2019; Suazo Caamaño & Torres Salinas, 2023, p. 1; Uribe Sierra & Panez Pinto, 2022). Mora-Motta (2018, p. 100) mentioned that in Chile’s case, the pine and eucalyptus plantations “suffer from a legitimization crisis that derives from a deep social discontent due to its social-ecologic effects at local level” (Vives, 2016).

Forest plantations detractors consider that we cannot talk about “forest plantations” as FAO (2023) does, and that forest plantations in monocultures and big scale can be considered to be within forest extractivism (Catalán Ovalle & Valenzuela Van Treek, 2021; Croft-Cusworth, 2017; Suazo Caamaño & Torres Salinas, 2023). According to Cordero Rivera (2011, p. 5), forest plantations are not forest, but some of them could be if native species are used and ecology succession is applied (González et al., 2016). For this reason, promoters of forest plantations point out that one of the conditions for its development is to stop seeing them as “green deserts” (Brazeiro et al., 2018; Croft-Cusworth, 2017; Guariguata et al., 2017).

In this regard, it is symptomatic that Law of Climate Change Framework from the Ministry of Environment of Chile (Ley 2145), considers the establishment of regulations towards the conservation of ecosystems, ecologic restauration, forestation and reforestation with native species, technologies and practices for the carbon capture and storage. Consequently, the regulations will not encourage monoculture in forest plantations.

3.4. *The link between agroecology and commercial forest plantations*

It is frequently considered that forest plantations are destined to timber production under forest systems that are totally different from the agroecology practice oriented to agri-food systems. However, even more than its contribution to security and food sovereignty, agroecology also refers to the ecological management of natural resources, as mentioned by Zúñiga and Mendoza (2021). Without ignoring the important orientation of agroecology towards agri-food systems (Cardona Calle, 2017), the present article proposes that a commercial forest plantation can be agroecological if conservation principles for biodiversity, social equity, integration of scientific knowledge and local knowledge, among other ecological principles are applied.

In this matter, Sarandón and Flores (2014), and Salcedo Pérez (2012) consider that agroecology comprehends the agro-systems in which plantations and agro-forest systems that applied agro-ecological principles are considered. An agro-ecological focus applies to parcel matters, the agro-system and the agro-food system (Noguera-Talavera et al., 2019; Wezel and Soldat, 2009), even at a territory level (Wezel et al., 2016). In this way you make the most of your experiences from the agroecology linked to culture, to traditional knowledge, the closest bond to the Earth and to its ethical-political character (Cruz León and Franco Gaona, 2021; Giraldo, 2018; Rosset et al., 2019).

The commercial forest plantations have a clear orientation to productivity, economic and financial rentability and competitiveness, “in addition to social and environment benefits that are inherent” (Quispe Santos, 2019a, p. 2). Like forest business that are located in the framework of investments. From the other side, agro-ecology as socio-ecological focus has more developed epistemological and ontological discussions than forest plantations with commercial purposes so it has a holistic character (Aguilar, 2022). In this sense, agro ecology has an emancipator character with respect to market colonialism (Giraldo, 2022; Lugo Perea and Rodríguez Rodríguez, 2022). This is why “agroecology constitutes an alternative for social transformation that

guarantees life sustainability in the face of crisis [...] the world is facing” (Alava Atiencie et al., 2020, p. 51). This ethic-politic perspective is present in commercial forest plantations in an indirect manner as it is assumed that financial growth will generate social opportunities and environmental conservation options (Quispe Santos, 2019b). As mentioned by Guariguata et al. (2017, p. vii):

... in the last years, the politic will have emerged from the Peruvian Government to invest in the forest sector as one of the new motors of the economy in the fight against poverty, forest deforestation and global climate change. In this sense, it is recognized that the forest plantations are a great opportunity for business, job market, and restoration of degraded areas.

From the other side, the agroforestry, one of the applications of agro-ecology, generally emphasizes the agricultural crops in which trees have a role complementary to the agro-system, but that is also possible to design agro-forest systems in which the commercial use of system trees receives more or the same attention than the one that is given to crops (Gassner and Dobie, 2023).

Mellado (2021) discusses the tensions that exists in the cohabitation between forest plantations described by the forest extrativism and agro-ecological activities in the area of San Nicolas, Chile. Studies that interrelate the agro-forestry and agro-ecology are also found.

3.5. Agro-ecological principles

The agro-ecological principles are oriented to the ecological dimensions, socio-cultural and political, and they are oriented to reach a dynamic balance of the agro-system taking into account the non lineal dynamics of the biophysical flows and their interaction with socio-economic and cultural systems. To get this effect, the elimination of agrochemicals is proposed, the promotion of the use of resources and local knowledge, and the adaptive management according to the particular conditions of the agro system (Pengue, 2021).

An agro-ecosystem can be inscribed in the framework of adaptative complex system that looks to the totality of the agro-ecosystem inscribed in a space and context, recognizes the diversity of elements and their interactions, considers recycling and an effective use of the resources, and additionally offers a social, cultural and political value (Céspedes León & Vargas Schuldes, 2021; Montes Pulido, 2014).

Even though it exists various proposals of agro-ecological principles (Altieri, 2001; CIDSE, 2018; Noguera-Talavera et al., 2019), in this article, the principles that have been proposed by Zúñiga and Mendoza (2021, p. 7) are taken as a base:

1. Integral focus as a guide for the knowledge of relationships between humans and nature.
2. Respect and comprehension of the biological and cultural diversity, environmental ethics inspired in the sentiment of belonging and interdependence with the biotic community.
3. Sustainable styles of production and life.
4. Social justice, intergenerational and gender.
5. Respect to human rights, laws and agreements on relationships with nature and jobs.
6. Increase the biological diversity of the system (functional diversity) through rotation and crop association, medicinal, aromatic and floral species.
7. Promote the use and management of water, soil and air, minimizing the use of pesticides and other non-environmental practices.
8. Generate live, not kill it.

Table 1 shows the agro-ecological principles applied to the forest plantations.

Table 1. Agroecological Principles Applied to Forest Plantations.

Agro-ecological Principle	Current situation in Peru	Incorporation Proposals of the Principle in Forest Plantations
Integral approach as a guide for the knowledge of the relationships between human beings and nature.	A commercial approach prevails, in which forest plantations are seen as a business activity. It operates within a disjunctive ontology, where humans are distinct, distant, and external, thus reducing nature to a mere forest resource.	It is important to move beyond a narrow focus on the forest plantation area itself and instead situate it within the broader landscape. This means viewing it as part of an agroecosystem-landscape continuum (Rosset & Altieri, 2018). The fact that a forest plantation has productive purposes does not reduce it solely to a timber supplier. Rather, it is also essential to recognize it as a source of life for biodiversity and its relationship with humans.

Agro-ecological Principle	Current situation in Peru	Incorporation Proposals of the Principle in Forest Plantations
Respect and understanding of biological and cultural diversities; environmental ethics inspired by a sense of belonging and interdependence with the living community.	The predominant trend favors either monoculture forest plantations or mixed plantations comprising few species. This approach disregards both biological and cultural diversity, with market considerations primarily determining species selection. It fails to account for the interdependence between biological and cultural diversity.	A commercial forest plantation is not strange to the associated biodiversity. Moreover, forest plantations present interactions with human society, thus it keeps the character of socioecological systems.
Sustainable life and production styles.	Sustainability is searched for through forestry and forest management.	Sustainability in a forest plantation is not only a question of business, but it is a bet for life.
Social justice, intergenerational and gender equality.	Forest plantations are rarely linked to social and intergenerational justice. Gender considerations are beginning to be considered.	Ecological justice, water justice, social justice, and economic justice are all aspects that must be considered in the management of commercial forest plantations.
Respect to human rights, laws and agreements about nature and jobs.	Respect for human rights is taken as implicit. National regulations governing forest plantations are followed whenever possible. Labor regulations and decent work standards are observed where feasible (Unidad de Planificación Rural Agropecuaria [UPRA], 2018). The rights-of-nature approach is not considered in forest plantations.	It is crucial to strengthen policies and procedures aimed at respecting human rights, indigenous peoples' rights, and the rights of nature within forest plantation management systems. Labor rights are included as part of forest plantation certification standards.
Increase the biological diversity of the system (functional diversity) through rotation and association of crops, medicinal, aromatic and floral species.	The key feature of plantation forestry is the simplification of systems. In some cases, forest plantations are considered as part of an agroforestry system design. They may also incorporate cover crops (grasses or legumes) to reduce maintenance costs and promote plantation growth.	Commercial forest plantations must not be reduced to vast monoculture tree stands, but should also incorporate mixed plantation systems, preserved patches, or ecological corridors of natural forests where applicable (Cordero Rivera, 2011). A principle aimed at the sustainability of forest plantations refers to the diversification of goods (timber and non-timber) and the plantation's ecosystem services (Rivera-Ríos et al., 2008).
Promote the use and healthy management of water, soil and air, minimizing the use of pesticides and other non-environmentally friendly practices.	Agrochemicals are used as fertilizers and pesticides.	Whenever possible, minimize agrochemical use through organic alternatives. Fertilizer and soil amendment treatments must be applied with careful consideration (Echeverri Restrepo, 2019). Genetic modified organisms [GMOs] should be avoided where feasible. It is acknowledged that strong debates exist between GMO proponents and opponents (Canadian Biotechnology Action Network [CBAN], 2022; Herrera & Gómez, 2018)
Generate life, not kill it.	Lack of discussion. The orientation of forest plantation is commercial.	A forest plantation hosts interconnected life that must be treated with care and respect. The intrinsic value of life within forest plantations and their associated biodiversity is recognized. We propose life-centered forest plantations.

Source: Principles considered by Zúñiga and Mendoza (2021).

Table 2 compares forestry with agro-ecological focus and intensive forestry in orientation to forestry 4.0.

Table 2. Comparison between agroecological forestry and forestry-intensive forestry with a 4.0 orientation.

Variable	Forestry with agro ecological focus	Intensive forestry (with focus on forestry 4.0)
Dominant ontology	Biocentric, ecocentrism	Anthropocentric
Relationship with nature	Trees and forests as living beings	Forest resource, natural capital, goods and services

Variable	Forestry with agro ecological focus	Intensive forestry (with focus on forestry 4.0)
Agroecosystem complexity	Complex	Maximal simplification
Preferred species	Native	Exotic (for exemple: pines and eucalypt)
Biodiversity management	Higher	Lower
Cultural management/traditional and ancestral knowledge	Higher	Minimal or none
Biocultural management	Major	Non-existent
Spiritual values	Present	Absent
Digital technologies	Absent or minimal	Maximal
Forest mechanization	Minimal or non-existent	Maximal
Agrochemical use	Minimal or non-existent	Necessary
Effectiveness (efficacy + efficiency)	Maximal in function to the established objectives	Maximal in function to the economic objectives
Productivity	Low or medium	Very high
Economic profitability	Low or medium in function to the established objectives	Very high
Competitiveness	Low	Very high

Even though forestry with agro-ecological focus can have some disadvantages compared to intensive forestry, everything depends on the stablished goal.

3.6. The case of the forest species and agro-industrial species

The assessment of the relationship between humans and commercial forest plantations would not have been complete if the role of human beings in the domestication process of plants and its implications is not discussed regarding to moral conservation on them. Despite in general lines, the Peruvian institutionality has been divided as for the rectory of the domestic and wild species. In some cases, the limitation becomes blurred. To this respect, it exists a progression regarding the degree of human intervention in wild species. In the middle, we found wild species in process of domestication. It is symptomatic the fact that the semi-domesticated species or in process of domestication are called domesticated o cultivated (Corona Martínez et al., 2021, p. 81). In addition, the domestication does not only involve changes in the plant, but also it affects the environment and the ecological interactions with other species that relates (Pacheco Huh & Chávez-Pesqueira, 2020, p. 5).

Sotelo Montes et al. (2000) present the case of participative domestication of agro-forest trees as a way to improve the productivity in the parcel. The topic gets complicated with genetically modified trees.

There are people who consider that there are no wild species but there has been a long process of landscape modeling by human beings. The case of cultivated forest in the Amazon is known, and the evidence is manifested in the black lands of anthropic origin (Corona Martínez et al., 2021, p. 82). The natural-artificial binomial reveals that humans have not only intervened on nature, but they have also modeled this process (Moya, 2010).

Considering the three last Peruvian forest laws, it is found that the plantations are considered as forest resources. Forest and Wild Fauna Law (Ley N° 27308 of the 16 July 2000), and the Forest and Wild Fauna Law (Ley N° 1090 of the 27 June 2008) consider that the forest plantations, regardless of their location in the national territory, are considered as forest resources. On the other hand, the Forest and Wild Fauna Law (Ley N° 29763 of the 22 July 2011) mentions that the forest plantations in private and communal parcels and their products are considered forest resources, but they are not part of the forest heritage or wild fauna heritage of the nation (Dourojeanni et al., 2021). Likewise, it is announced that agro-industrial crops are not plantations, nor agro-energetic crops.

For the benefit from the forest plantations, the Law N° 27308 required permissions for the forestry exploitation with commercial purposes for the case of forest plantations. The Law N° 1090 demanded the approval of a management document. In the case of the Law N° 29763, the forest plantations in communal and

private parcels do not require the approval of the management plan by the forest or wild fauna authority. It is interesting to mention that in the Law N° 27308, and in the Law N° 1090, the palm oil tree (*Elaeis guineensis*) was considered as a forest species to promote. As mentioned previously, this is not stated in the Law N° 29763, that explicitly excludes the agro-industrial crops and the agro-energetic crops.

Both the oil palm tree (*Elaeis guineensis*) and coffee (*Coffea arabica*) in their original zones correspond to forest species. However, as soon as they have certain agronomic management, they stop to be forest species because they become crops. FAO (2023, p. 7) explicitly mentions that oil palm plantations and agro-forestal systems with crops under a cover of trees does not constitute a forest. In the Peruvian case, this differentiation is key because when the palm oil is considered as forest species then it could demand forest management. The linked companies to the production of palm oil pretend the palm oil crop to be recognized as forest species. However, Pautrat and Segura (2010) have studied the technical and legal aspects of the risk of incorporating the crop *Elaeis guineensis* in the forest regulations.

3.7. More sustainable forest plantations

To overcome the critics towards the forest plantations is necessary to force the principles and practices oriented to their sustainability. For this, it is more convenient to use native species in the framework of ecological forestry (Cordero Rivera, 2011; Promis, 2020). This does not ignore that forestry with native species is unknown in many cases, and that although there are commercial species of rapid growth, there are also species of slow growth (Silva, 2020). There is no doubt that technology of exotic species is more developed and because of this, clonal forestry of high yield is applied (Rocha et al., 2016).

In addition to the application of the principles and criteria for the certification for forest plantations, that is not free of questioning (Cordero Rivera, 2011), the application of the agro-ecology principles could contribute to improve yield and the sustainability of production systems (Hecht, 2018). Generally, forest plantations are not considered as part of the agro-ecological focus, but the agro-ecological characteristics of the site of plantation are recognized. As mentioned by Telles Antonio et al. (2022), “it results indispensable to know the biology of species to stablish in plantations and the agroecological characteristics of the site to sown, and to define the objectives of production destiny”.

To integrate forest plantation with the management of ecosystems is important to consider species, composition of species, structure, density, special design, biological corridors and connectivity, the complementary treatments to the soil to favour infiltration, among others (Barrette, 2014; Ipinza Carmona et al., 2023).

A commercial forest plantation cannot be reduced to a parcel because it is part of a landscape that can present natural or remaining forests, agriculture, livestock. These units of landscape are frequently interrelated through ecological services, such as pollination or biological control of pests, among others (Ipinza Carmona et al., 2023). An aspect that cannot be neglected is the susceptibility to forest fires that could affect all the landscape.

Ipinza Carmona et al. (2023) show that plantations can never substitute native forests, but if there are forest plantations in areas that previously were deforested, this could be successful with favorable repercussions for biodiversity if applying an ecological forestry management. It is also important to signal that the natural forest loss with all of their complexity cannot be compensated only with forest plantation or agroforest systems. Lewis et al. (2019), as cited in Carabias (2021), point out that natural forests are six times more efficient than agro forestry for carbon storage and 40 times more than plantations. These two forms of interventions are complementary to forest conservation, but they cannot replace it.

4. Discussions

Even though there could be a high-productivity impression and competitiveness of intensive forestry, this is the only way to get success in commercial forest plantations, it is necessary to consider other variables.

As a manifestation of the civilizational crisis, there is the overcoming of ecological thresholds, where we find climate change, biodiversity loss, the change in use of land and deforestation, the alteration of the biogeochemical cycles, contamination, water crisis, and others. It is important to recognize that various of these ecological thresholds are found interrelated and that are strongly linked to agriculture activities (agriculture, fishery and forestry).

Without ignoring the important advances and possibilities of digital technologies, it is also important to recognize that intensive forestry has a strong orientation towards rentability and competitiveness, that appear as values or maximal aspirations of professionals and organizations or institutions focused to forest development. This does not mean that the environmental and social dimensions are not considered, but they remain subordinated to the economic and financial rentability. As it can be appreciated, this position is found in the framework of an anthropocentric and mercantilist ontology that reduce forests and trees to forest resources or natural capital. However, this form of connection with nature is the case, and it is one of the main lessons of coronavirus (Santos, 2020, 2021).

It is necessary to recover some of the principles of agroecology, such as the matrix science of the management of agroecosystems, that can enrich the theoretical framework and practices of commercial forest plantations. For this purpose, it is necessary to recognize that forestry can be part of the agro ecology, like when agro forest systems are established, and when agro-ecological principles are applied to forestry, it is possible to talk about forestry with agro ecological focus. Despite being frequent, from a disjunctive perspective

Despite being frequent, from a disjunctive perspective, consider that natural sciences and social sciences are completely different sciences, there exists a slope of epidemiology of the complexity that consider that these separations are artificial, such as is the artificial separation between science, philosophy, and art. From this, socio-ecological, territorial, landscapes and biocultural focuses have become important for their integrative character. In Figure 1, the trajectory of the forestry currents is graphed. It would be important to have an orientation towards forestry with ecological aspects.

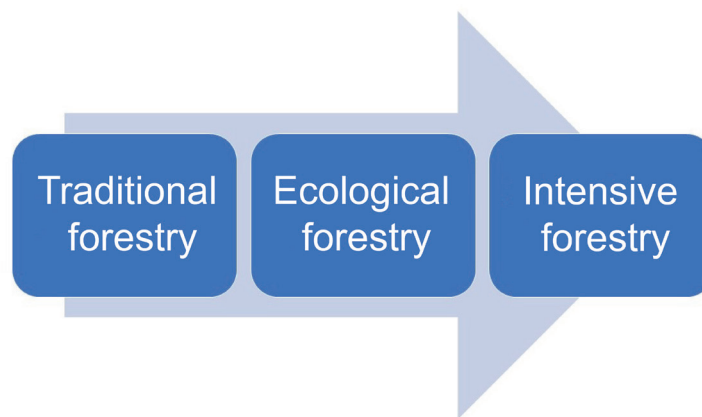


Figure 1. Forestry trajectory.

Although the current dominant paradigm is commercial forest plantation oriented to satisfy the timber demands of the market, and therefore, oriented to the contribution to national economies, what is proposed in this article are the forest plantations for life, in which the economic dimension is not denied but it remains immersed in the major objective to contribute to the human and nature wellbeing from which we take part. This is why it is called forest plantations for life. In this context, the proposal of the application of the principles of agro ecology are inscribed in forest plantations as an important complement to the certification of forest plantations. It is important to highlight that there does not exist in Peru an hectare of commercial forest plantations certified by independent entities.

Beyond the model that Latin American countries have used to substantially increase their forest plantation areas, in the case of Peru, diversity must be taken as a key element in designing a forest plantation policy. This refers to the diversity of stakeholders with their cultural particularities and investment levels, the diversity of knowledge and access to technologies, the geographic and ecological diversity, and the diversity of enabling conditions for a plantation to thrive. In other words, a one-size-fits-all model cannot be applied. Although all commercial forest plantations seek economic profitability, not all assign it the same value. There are also perspectives from social and solidarity economies. Therefore, diversifying models allows for greater flexibility in adapting to the particular conditions of different stakeholders. It is within this context of diversity that agro-ecological approaches and principles applied to forest plantations can be valued.

The agro-ecological principles contribute to a pluralism of objectives from a forestry with agro-ecological focus. Thus, without ignoring economic objectives, they can contribute to the management of territories and

landscapes, contribute to the wellbeing that includes new forms of relationships with one another, with society, with nature and the cosmos. When incorporating biocentric, ecocentric, and cosmocentric perspectives, the objectives are not reduced to the conventional development, but to the objective of living together in harmony. It is necessary to give an answer to the questioning about environmental impacts of forest plantations, and in this sense, the application of the agro ecological principles constitute an alternative. This proposal is inscribed in the agro ecological principle to generate life, not kill it (Zúñiga & Mendoza, 2021). Notice that this perspective transcends the disjunctive ontology that predominates in the current model, in which the commercial forest plantations are privileges for the supply of forest industries and the economic growth.

One issue that deserves discussion is the ontological status of commercial forest plantations when referring to domesticated plants. Does the fact that they are largely the result of human intervention distance them from their natural character? Where does the natural end and the artificial begin? Does their artificiality preclude the extension of moral consideration toward living beings? Who owns the life of domesticated plants? Is it possible to separate the life of the plant from its products? These are questions that have not yet been raised, but must be addressed if we are to redefine our relationship with forest plantations (Ocampo, 2014).

The contribution of agroecological principles to forest plantations has multiple applications. A first contribution involves broadening the perspective beyond the net surface area of the plantation to incorporate a landscape-based approach. By integrating the plot or plots of plantations into the wider landscape, the importance of mixed plantations becomes evident in the establishment of ecological corridors that ensure connectivity, thereby contributing to biodiversity protection. In its pursuit of extensive forested areas, conventional forestry often overlooks these considerations.

A second great contribution has to do with the substantial reduction of agrochemicals, reducing the potential for contamination of people, fauna, soil, and water. In each case, the use of fertilizers is more careful, and it searches for a better provision and administration of organic matter in the soil. This consideration opens the way to the use of cover legumes (Guevara Bonilla, 2018). It is also important the use of forest legumes in mixed designs (Tarazona-Delgado et al., 2022). From the agro ecology is urged the use of organic alternatives to glyphosate to control weeds (National Geographic, 2017).

A third great contribution alludes to the emphasis on ecological relationships in the agro system and their relations with the landscape matrix. In this manner, the complex soil-plant-water-biodiversity is appropriately weighted. The agroecology does not deny the technological advances, but it enters in a dialog with local knowledge and practices.

Finally, a fourth contribution that should be highlighted is the ethical-politic dimension. It is a form in which the parcels of commercial forest plantations are inscribed as part of a major process of management of territories and landscapes that include processes of territorial governance. This proposal goes according to conservational principles of biodiversity that are not reduced to protected areas only.

5. Conclusions

All forestry applies ecological principles, but not all forestry applies agroecological principles, since forestry and agroecology are often considered entirely separate disciplines with different objectives. Although agroecology is strongly oriented toward agri-food systems, it also focuses on agroecosystems, and therefore, its principles can be applicable to commercial forest plantations. Agroecological principles—with their systemic approach, socio-ecological and biocultural perspective, commitment to native biodiversity and sustainability, alignment with Buen Vivir (good living), and their ethical-political dimension—enrich the theoretical and methodological framework of commercial forest plantations, moving beyond the strongly productivist approach that has dominated until now. This is why we propose commercial forest plantations for life.

Contributor roles

- Rodrigo Severo Arce Rojas: conceptualization, data curation, formal analysis, investigation, methodology, software, validation, writing – original draft, writing – review & editing.

Ethical Implications

Ethics approval not applicable.

Conflict of Interest

The authors declare that they have no affiliation with any organization with a direct or indirect financial interest that could have appeared to influence the work reported..

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