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# Comparative analysis of forestry systems in the United States and Türkiye: Practices, technologies, and challenges

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**Abstract**

The current study provides a comprehensive comparative analysis of forestry systems in the United States (US) and Türkiye, covering various aspects of domains, such as forest ownership, natural resources planning, fire management, technological applications, silviculture, forestry education and environmental challenges that each country faces. The findings mainly stem from the author's first-hand investigations, field observations, and experiences during a postdoctoral research period in the US from 2022 to 2024. Additionally, a variety of information sources, including US forest plans, publications from the US Department of Agriculture Forest Service, relevant peer-reviewed literature, and open-source data, were used in the work that employed the verbal analysis method. While certain similarities emerge, particularly in technology utilization and the historical development of forestry education, significant disparities are evident in fire management strategies, land ownership structure, silvicultural practices, and forest planning approaches between the countries. These differences can be attributed to unique environmental and historical conditions, distinct regulatory frameworks, and varying economic development levels. The outcomes of this study suggest the presence of valuable forestry practices that each country can learn or adopt from the other, emphasizing the potential for mutual exchange and improvement in natural resources management practices.

**Keywords:** Forestry, forest sector, public forests, private forests, forest carbon market, Forest Inventory and Analysis National Program (FIA), the United States of America, Türkiye.

## Introduction

Various approaches are employed globally for the management of forest resources. The adoption and implementation of these approaches are influenced by factors, such as geography, historical conditions, economic development levels, legal regulations, and land ownership. The forestry system of a particular country can also evolve over time in response to scientific and technological advancements. For instance, the Hendek Mustafa Şeref Bey Forest in Sakarya (Türkiye), which has been under management for over a century, underwent a detailed examination through forest plans (Şahin et al. 2022). The study revealed significant technical and structural changes in the forestry approaches that had been applied to the area since 1917. Similarly, historical documents, forestry equipment, and forest plans from the Cradle of Forestry in North Carolina, where the first forestry school in the United States (US) was established, illustrate substantial changes in the US forestry system since the 1890s. The first forest management plan of the US emphasized natural regeneration, afforestation, and fire and grazing protection measures (Fig. 1). In contrast, contemporary forest plans often advocate for the multiple use of forest resources to address diverse societal needs and ensure the sustainability of the ecosystem (Vatandaşlar et al. 2023).

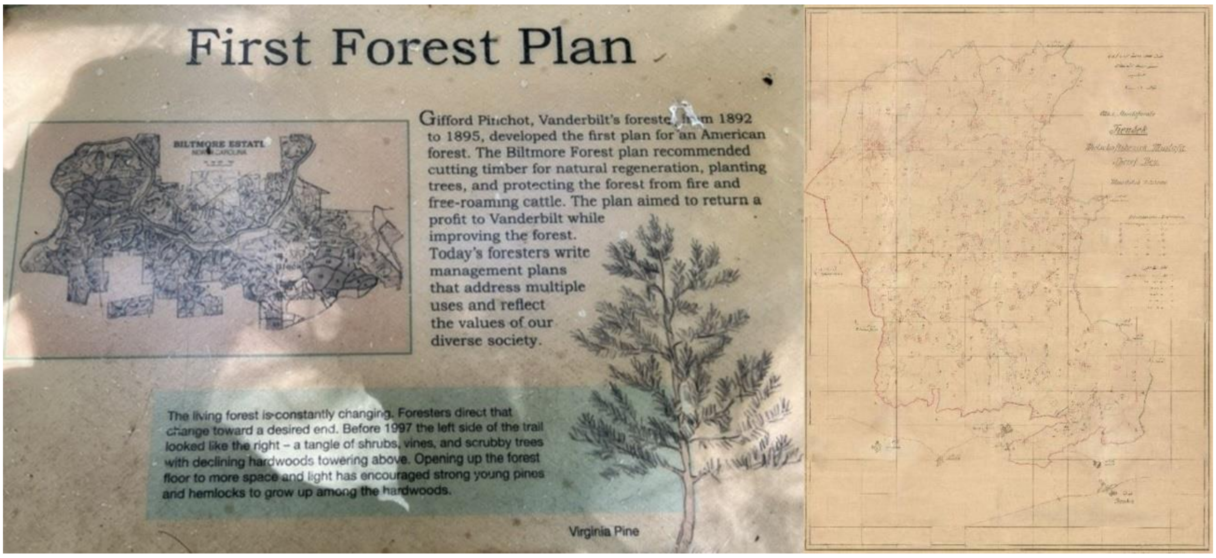


Figure 1. Comparison of the first forest management plans between the US (left) and Türkiye (right). Photo credit: Can Vatandaşlar (left), Abbas Şahin (right).

The need for new research to remain up-to-date and well-informed about ever-changing forestry approaches worldwide is crucial. Practices that are implemented by other countries may offer valuable insights that align with Türkiye's specific conditions, which could lead to direct or indirect benefits for Turkish forestry. Additionally, forestry practices that currently fall short of meeting the country’s conditions and needs can be revised and adapted. On the other hand, an understanding of diverse systems and applications serves as a wellspring of inspiration for the development of novel approaches that are tailored to the unique realities of the country. In this context, it is advantageous to undertake a comparative analysis of the most recent forestry approaches and on-the-ground practices in the US alongside those in Türkiye. Such an examination allows for a thorough discussion of the benefits and shortcomings that are associated with each approach and facilitates the identification of strategies that could be beneficially applied or adapted by each country.

To date, limited studies have undertaken specific comparisons between the forestry approaches and practices of the US and Türkiye. In a comparative analysis by Bettinger et al. (2013), forest management issues in Türkiye and the southern US were explored. The study highlighted that significant variability in the planning, management and utilization of forest resources in the two countries stems from political, social, and cultural differences. While southern US forestry faces risks from extreme weather events, forest planners in Türkiye encounter challenges in developing management plans that can simultaneously address the conflicting needs and demands of local communities and other relevant stakeholders. In another study, Vatandaşlar et al. (2023) analyzed 42 management plans in Türkiye and public forests in the US, focusing on forest sustainability. The study concluded that ecological sustainability was a more dominant theme than economic and sociocultural themes in the plans of both countries. Notably, terms such as silviculture, wood production, and multiple use were prominent in Turkish plans, but the US plans frequently emphasized terms, such as conservation and recreation. Gutierrez Garzon et al. (2020), on the other hand, compared forest certification program practices in

Türkiye, Bulgaria, and the US. They revealed that the Forest Stewardship Council (FSC) program has a broader framework for sustainable forest management (SFM) than other programs. The SFM criteria applied in Türkiye primarily concentrated on field indicators but lacked information on the relationship of these indicators with planning outputs. Finally, Güneş (2004) focused on environment and forest law systems and examined the historical development of legal regulations in both countries. The author highlighted that in Türkiye, environmental and forest laws were primarily established and implemented through regulatory legislations with a top-down structure. In contrast, in the US, these laws were shaped as a result of bottom-up social pressure.

Indeed, the aforementioned studies either concentrate on specific facets of the forestry field, such as planning, certification, sustainability, and environmental law, or may have become outdated based on the recent changes in legislation (USDA Forest Service 2012, OGM 2017), forest management philosophy, and technological advancements since their publication. Therefore, a compelling need exists for contemporary, comprehensive studies that comparatively assess the general forestry systems of the US and Türkiye, considering technical, social, administrative, and financial aspects of forestry. The present study seeks to fill this gap by presenting the current forestry approach in the US to the Turkish forestry community. The objective of this study is to conduct a thorough comparison of forestry practices in the US and Türkiye across a variety of domains. Through this comparison, the study facilitates discussions on the potential applicability of innovative methods and approaches in the context of Turkish forestry. The outcomes of this research are expected to offer valuable insights for policymakers in shaping effective strategies for the enhancement of the Turkish forestry sector.

## Material and Methods

### The US Forest Resources and Forestry System

The US has approximately 310 million ha of forested area, excluding an additional 23 million ha that are identified as *woodlands* (i.e., degraded forests and shrubby areas with 5-10% canopy cover). These forests constitute a significant portion of surface area, covering 36% of the country's terrestrial lands and representing 8% of the global forest extent. When the US is divided into five regions—south, north, Pacific (west), Rocky Mountains and Alaska—it is noteworthy that 32% of the total forested area is situated in the US south, while the Pacific region holds the smallest share at 11% (Álvarez 2018).

As of 2016, statistics reveal that US forests played a substantial role, contributing to 18% of the world's total industrial wood production, amounting 393.6 million $m^3$. Primary wood products include lumber, wood board, paper, and pulp (Álvarez 2018). Notably, recent advancements in the bioenergy sector have introduced additional products, such as briquettes and pellets, derived from private pine plantations in the southern regions, which expands the array of wood-based offerings.

In the US, the management of federal (public) forests is primarily supervised by key agencies, such as the USDA Forest Service, the Bureau of Land Management (BLM), the National Park Service (NPS), and the Department of Defense (DoD). These forests are known National Forests and cover a vast expanse of 78 million ha across the nation (USDA Forest Service 2022a). The USDA Forest Service, established by Congress in 1905, initially sought to ensure the provision of high-quality water and wood products for the nation's benefit. Gifford Pinchot, a prominent figure in the North American conservation movement, served as the first director of the Forest Service. Over time, in alignment with the evolving paradigm in forestry approaches, the USDA Forest Service has broadened its objectives and management focus. A multipurpose utilization of forest resources, including considerations for wildlife, recreation, and forage has become a notable aspect of its mission (Vatandaşlar et al. 2023). The current mission of the USDA Forest Service, as articulated in USDA Forest Service (2019), is "to maintain the health, diversity, and productivity of the nation's forests to meet the needs of people and future generations". While the number of personnel of the Forest Service is approximately 31,000, its annual budget is $9 billion (USDA Forest Service 2023b). It is noteworthy that forest management practices in the US predate the establishment of the USDA Forest Service. In 1876, Congress took the initiative to create a Special Office under the USDA that was tasked with assessing the quality and quantity of forest resources. This office expanded in 1881 and was named the Forestry Division, and eventually became affiliated with the USDA Forest Service in 1905 (USDA Forest Service 2022a).

Similar to many countries, the forest resources in the US face various threats, including wildfires, insect outbreaks—particularly bark beetles in the western regions and *Adelges tsugae*, *Agrilus planipennis* in the east, diseases such as root diseases, invasive species like *Pueraria montana*, *Bromus tectorum*, and *Euphorbia esula* L., urban development, fragmentation, and climate change (Álvarez 2018, Potter and Conkling 2017). Despite these challenges, no significant change has been observed in the total forest area of the country over the past century (Álvarez 2018, McGinley et al. 2023). However, the threat of deforestation, which originated with the colonization of European settlers in the 17$^{th}$ century, intensified notably in the 19th century (Álvarez 2018, Birben and Güneş 2015). This rapid deforestation played a pivotal role in catalyzing the conservation movement and laid the foundation for the establishment of the USDA Forest Service.

**The Forest Resources and Forestry System of Türkiye**

Türkiye encompasses approximately 23.2 million ha of forest area, which constitutes 29.7% of the country's total land area (OGM 2022). Forestlands predominantly extend along the mountain ranges in the Black Sea and Mediterranean regions, and run parallel to the coast. However, due to lack of rainfall and anthropogenic effects throughout history, the proportion of forested areas in the Central and Eastern Anatolia regions remains comparatively low. Intensive agricultural practices, overgrazing, illegal logging, and improper land use have resulted in detrimental effects on forestlands.

As of 2021, the wood production derived from planned cuttings in timberlands at around 32 million m$^3$ (Kömürlü et al. 2022). An analysis of the annual production trends from the official statistics from the General Directorate of Forestry (GDF) reveals significant positive changes, particularly in recent years. Concurrently, wood and wooden product imports have declined with a noticeable increase in exports. Timber, wood board (fibre and chipboard), and paper wood emerge as the leading product groups in terms of volume (Koç et al. 2017). It should also be noted that, based on 2020 statistics, approximately 20% of the total standing stem volume in the country is still used for fuelwood (Özertan and Coşkun 2021).

The vast majority of forest resources in Türkiye are government-owned (public) and managed by the GDF. Established in 1839 as the Forest Directorate under the Ministry of Commerce (Gümüş 2016), GDF has evolved into one of the most well-established institutions in the country. Ahmet Şükrü Bey served as its first director from 1839 to 1840. In 1937, a significant legal enactment led to its current name and administrative structure. GDF's mission is clearly defined as follows: "to protect forests and forest resources, to develop them with an approach close-to-nature, and to manage them in a way that is sustainable within the integrity of the ecosystem and provides versatile benefits to the society" (OGM 2024). This statement underscores the commitment of GDF to the conservation, development, and sustainable management of Türkiye's forested areas and emphasizes a multiple-use ecosystem based approach, which ensures a range of benefits for society. While the number of personnel of GDF is approximately 38,000, its annual budget is $186 million (Sayistay 2022).

Several biotic factors pose threats to Türkiye's forest resources, including insect, such as *Thaumetopoea pityocampa*, *T. wilkinsoi*, *Lymantria dispar*, *Tortrix viridana*, *Tomicus piniperda* and *Ips sexdentatus*. Additionally, semi-parasitic plants, such as mistletoe (*Viscum album*) and various fungal diseases contribute to the challenges faced by forests (OGM 2013). Among abiotic factors, wildfires, unauthorized grazing, storm and frost damage, and drought are significant concerns. The Manavgat fire, a mega fire in the Mediterranean Region in 2021, lasted for 10 days and inflicted damage on an extensive forest area of 55,000 ha. This incident marked the largest fire in the country's history in terms of an area affected by a single fire (Bilgili et al. 2021). A growing concern persists that such events may become more frequent as a result of climate change (Bilgili et al. 2021, OGM 2013). Despite the biotic and abiotic damages mentioned above, Türkiye's forest area has increased since the 1970s (OGM 2022) owing to afforestation projects and human migration from rural areas to metropoles.

## Methods

Current forestry approaches and practices in the US and Türkiye were examined across various domains. The main differences between the countries, future directions and bottlenecks were discussed. Because of the primary focus on introducing contemporary practices in the US, the present study refrained from providing an extensive explanation of the current forestry practices in Türkiye. Instead, relevant studies that analyzed corresponding aspects of Turkish forestry in detail were cited as needed. Priority was given to the domains in which significant differences exist between the two countries:

- Forest ownership
- Forest management and planning
- Fire management
- The use of technology
- Silviculture
- Forestry education
- Other domains (wildlife management, carbon markets, forest inventories)

The study's findings predominantly stemmed from the author's first-hand investigations, observations, and experiences during a postdoctoral research period in the US from 2022 to 2024. Additionally, a variety of sources, including US forest plans, publications from the USDA Forest Service, national and international literature on the subject, and information from open sources on the Internet were used in the article. The assessment of these sources employed the verbal analysis method as outlined by Hancock (1998).

In instances in which cross-country comparisons were pursued, the study often provided examples from the US National Forest System. This choice was made due to the fact that National Forests are owned by the federal government and are predominantly managed by the USDA Forest Service. In this way, it was thought that a consistent comparison could be made with the public forests under GDF management in Türkiye. Nevertheless, case demonstrations from private forests in the US appear throughout the article as well.

## Results and Discussion

### Forest Ownership

Nearly all (99.5%) of the forest lands in Türkiye are government-owned and managed by the GDF on behalf of the Turkish government (Güneş and Coşkun 2008). In contrast, the ownership system in the US is notably diverse and complex, which can be categorized under *(1)* federal public forests (national forests), *(2)* non-federal public forests (state and local municipal forests), *(3)* private, corporate forests (owned by industrial companies and cooperatives), and *(4)* private non-corporate forest (family, church, and tribal) (Congressional Research Service 2021). Approximately 60% of the total forest area in the US is privately owned (i.e., $3^{rd}$ or $4^{th}$ categories) (FIA 2012). This ratio exhibits significant regional variation as public forests are predominantly situated in the northern and western regions, but private forest ownership is more prevalent in the southeastern region. Specifically, 81% of the total private forest area is concentrated on the east coast of the US (McGinley et al. 2023).

A substantial portion of extensive forest lands previously owned by large forestry companies and families has been bought by entities known as Timber Investment Management Organizations (TIMO) and Real Estate Investment Trusts (REIT) in recent decades. The primary goal of these organizations is to maximize profit for their investor-clients through the professional management of forest lands. Furthermore, US citizens have the opportunity to invest in both forest land and the trees within the land and earn income by allocating their financial savings to REIT (Bettinger et al. 2013, McGinley et al. 2023).

Over half of the forests in the US are owned and managed by more than 10 million individuals (FIA 2012). The ownership diversity, involving various individuals, groups, and institutions, may present both advantages and disadvantages to managers. Varying landowners may have distinct management preferences and objectives, which could occasionally lead to conflicting goals. For example, non-profit forest landowners might allow the forest to develop naturally while they neglect active management. Bettinger et al. (2013) note that a substantial portion of privately owned and family forests lacks a forest management plan. In such instances, forests remain untouched, susceptible to threats, such as wildfires, invasive species, diseases, and more. The absence of a management plan increases the vulnerability of these forests, and their sustainability is jeopardized. In contrast, all public forests in Türkiye have a forest management plan. Even private forest owners in Türkiye, which are very rare, are required to prepare plans for their forestlands by law. This regulatory approach seeks to ensure forest sustainability in the long term.

On the other hand, in the US, certain forest landowners have the authority to convert their lands for alternative uses, such as housing or agriculture, with the anticipation of higher economic returns. Historically, such land use conversions have posed threats to the existence of forests in the country. To prevent this risk, federal programs, known as "conservation easements", have been instituted and widely implemented today to safeguard the integrity of forests (refer to Box 1). Such programs can balance the economic interests of forest landowners with the long-term conservation and sustainability of forested areas.

The government ownership and exclusive management of almost all forest resources by the GDF in Türkiye (except for National Parks), offers several advantages. Firstly, planning, management and decision-making processes can be swiftly executed from a single authority. Unlike private forests in the US, Turkish forests are not divided into small parcels. The area coverage of forest planning units is often between 5,000 and 10,000 ha. In comparison, the average size of private forests in the US is 10 ha (FIA 2012). Even with forest plans in place, such small forests likely struggle to meet multiple management objectives and the management cost per unit area tends to be considerably high (Siry et al. 2015). Another advantage of the government ownership lies in forest protection activities. In Türkiye, forest area boundaries are protected by law, and forest areas can be increased through afforestation efforts. As evidence, the reported increase in national forest area from 20.2 million ha in 1973 to approximately 23.2 million ha today highlights the success of afforestation and reforestation projects (OGM 2022). However, it should be noted that forest landowners in the US do not have unrestricted freedom over their lands in all circumstances. The well-known Dexter case in 1947, arising from dispute between the government and a private forest owner, illustrates that even in the US, the protection of natural resources can take precedence over private property rights. Further details about the case and its outcomes can be found in the study by Birben and Güneş (2015).

In government-led (public) forest management, there are perceived disadvantages, such as relatively low productivity, bureaucratic complexities, and a limited utilization of advanced technology. However, these challenges can be transformed into advantages through effective administrative management and the enhancement of technical expertise. By addressing these issues, public forest management can leverage its strengths and improve overall efficiency, ensuring better productivity and the adoption of cutting-edge technologies.

**Box 1. Conservation easements**

The conservation easement program stands as crucial environmental protection tool developed to ensure that both individuals and entities with ownership of private forests in the US refrain from converting their lands for non-forestry uses or disposing of them through sales. Conceived in the 1990s, this program aims to reconcile conflicting interests of conservation and development. Under this initiative, private forest owners have the opportunity to derive income or secure tax deductions/exemptions by selling or donating specific rights to their land to independent organizations. Contracts are established with these organizations for a defined or indefinite duration. These organizations may take the form of non-profit entities, such as The Nature Conservancy or Trust for Public Land, or government institutions. While the forest owner retains property rights, the independent organization assumes responsibility for preserving wildlife, safeguarding water resources, and maintaining natural areas on the land. Their role extends to preventing any activities that could negatively impact these valuable assets. Presently, close to 2% of the US lands is protected under the conservation easement program (Lamichhane et al. 2021). This percentage has gradually risen over the past three decades. Notably, similar programs have started gaining traction in Latin American countries, Canada and Australia in recent years, signifying a growing global recognition of the need for innovative approaches to balance conservation and development.

## Forest Management and Planning

When comparing the management plans of National Forests in the US with those of the forest planning units in Türkiye, several notable differences emerge. In the US, strategic goals and objectives are formulated with an emphasis on long-term sustainability, operating at a high level of abstraction. In contrast, Turkish forest plans tend to be characterized by detailed content, such as stand tables, silvicultural prescriptions, and harvest scheduling, reflecting a more granular approach. This juxtaposition underscores the American emphasis on providing an overarching framework for management, while the Turkish approach delves into specific elements of tactical and operational-level forest planning.

In the US, the concept of multi-purpose use is integral, and there is no strict zoning or classification of forest areas based on their functions. Instead, strategic considerations lead to specific spatial allocations. Certain areas, such as wilderness protected by congressional mandate, sensitive viewsheds adjacent to vista points or within sight of highways, high slopes prone to soil erosion, riparian zones, as well as roadless areas and “priority watersheds”, receive dedicated attention and restriction. The remaining forest areas, collectively referred to as “operable areas”, are actively managed by the USDA Forest Service. Management activities within these operable areas encompass a range of practices, including clearcutting, artificial regeneration, and restoration efforts. Additionally, the management strategy in forest plans may involve prescribed burns to maintain ecosystem health, increase the population of certain bird species, or the protection of rare ecosystems.

Another notable aspect in the US is the collaborative approach during the forest planning phase, where experts from diverse fields, such as wildlife specialists, biologists, social scientists, and GIS analysts work in tandem under the guidance of planning experts. This interdisciplinary collaboration ensures a comprehensive and well-informed forest planning. Moreover, the emphasis on public participation is a crucial aspect of the planning process. For example, in the plan renewal of the George Washington National Forest in Virginia, a participatory planning model was implemented through a series of steps as follows (GWNF 2014):

• Official Announcement: The USDA Forest Service formally announced the forest for which the plan would be renewed in the official gazette, providing transparency and initiating the engagement process.

• Stakeholder Meetings: Public meetings were organized to solicit and gather opinions from stakeholders. These sessions allowed for discussions on potential plan decisions and the exploration of alternative management scenarios, fostering an inclusive and democratic approach to planning.

• Draft Management Plan: A draft management plan was prepared, and it was made available for citizens to review and express their opinions. This step ensured that the community had the opportunity to provide valuable input and feedback.

• Conflict Resolution: In cases where conflicting demands or opinions arose, consensus was sought through additional meetings. This iterative process aimed at addressing diverse perspectives and achieving a balanced and widely accepted plan.

• Finalization and Implementation: The draft plan was finalized, published, and officially entered into force. This transparent and participatory approach not only enriched the decision-making process but also increased public awareness and acceptance of the forest management plan.

In addition to the forest plan renewals, public input plays a crucial role in various other management decisions related to US forests. A recent example can be found in the newly published announcement in USDA Forest Service (2024a). The announcement pertains to popular recreational activities such as rock climbing, skiing, and rafting in certain National Forests. The document outlines designated areas for these activities, the required equipment, and safety precautions. Before its official implementation, the guidelines undergo public scrutiny, allowing interested citizens to provide comments and suggestions after entering valid identification and address information. The feedback received is publicly accessible, guiding appropriate revisions to the guidelines. Any suggestions that cannot be accommodated is accompanied by explanations for their non-implementation.

Another interesting practice in US forestry is the permit system. This system enables citizens to purchase a permit, often for a fee, granting them access to federal forests to cut firewood or harvest Christmas trees. With the transition to an online system in 2020, permits can now be conveniently obtained over the internet (USDT Bureau of the Fiscal Service 2024). This transition has been accompanied by a notable surge in annual permit sales, reaching 306 thousand (Jacobo 2023). When obtaining a permit, individuals are required to specify the purpose of cutting, the designated cutting area, as well as the type and quantity of trees intended for harvest. Upon reaching the designated forest area, permit holders present their permit to field office officers for verification before entry. During exit, they ensure that the collected goods align with the type and quantity specified in the permit. Annually, the federal government releases maps detailing areas open for permit use on a state-by-state basis (Figure 2).

The permit system in the US forestry is governed by several important rules to ensure responsible and sustainable utilization of forest resources:

- Tree Diameter Limit: Trees with a diameter exceeding 15 cm are prohibited from being cut, promoting the preservation of larger, mature trees within the forest.

- Cutting Height Restriction: The cutting height is capped at a maximum of 15 cm from the ground, ensuring not to waste stump wood.
- Non-commercial Use: Trees cut under the permit system cannot be sold, preventing commercial exploitation.

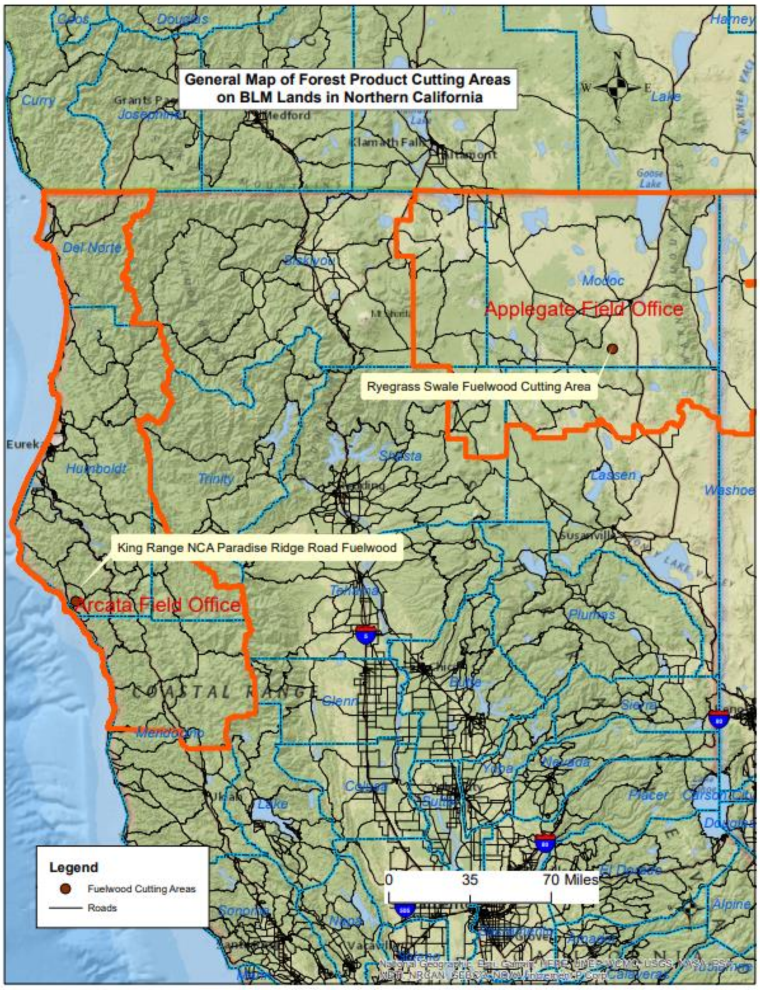


Figure 2. Map illustrating permissible cutting areas on public forests in California for the year 2023 (USDI Bureau of Land Management 2024).

- Protection of Fallen Trees: Deadwood and lying trees, which may serve as crucial habitats for various species, are not allowed to be removed. This rule supports biodiversity by preserving natural habitats.
- Distance Requirement: The tree to be cut must be at least 60 m away from roadsides, recreation areas, and camping sites. This rule helps in safeguarding recreational spaces and minimizing potential accidents.

Beyond generating revenue, such as the $10 cost for a Christmas tree, the US permit system is designed to contribute to the overall health of the forest. By allowing citizens to selectively remove trees from designated areas, several positive impacts are observed. These include the decreasing stand density, encouraging the remaining trees to grow more vigorously. The reduction of fire risk is achieved by clearing small trees from understory. Additionally, clear-cutting areas create grazing opportunities for certain wildlife species, enhancing biodiversity and supporting the overall health of the forest ecosystem (Jacobo 2023).

The US permit system appears interesting when compared to Turkish forestry practices because the regulatory framework in Türkiye does not allow private cuttings in public forests. However, individuals are allowed to freely collect wood residues after harvesting, under the supervision of rangers or forest engineers. Moreover, forest dwellers (named forest villager) in Türkiye have legal rights to purchase a certain amount of timber at an affordable cost (i.e., one seventh of the market price) every year. These wood material cannot be sold in the market; rather, it must be used for the villager's own needs, such as firewood and building materials.

**Fire Management**

Fire management in U.S. forestry has undergone a transformative shift, evolving from a historical emphasis on aggressive fire suppression to a more nuanced approach founded on two essential pillars: (i) prescribed burning practices and (ii) firefighting. Toward the close of the 20th century, the United States experienced an escalation in the frequency, size, and severity of forest fires, partly attributed to the impact of climate change (McGinley et al. 2023). In response to this escalating challenge, the USDA Forest Service adapted its current fire management strategy, articulated in NCWFMS (2014) and USDA Forest Service (2022b).

Historically, the USDA Forest Service had successfully curtailed the annual burned area through an intensive firefighting approach initiated in 1911. Particularly in the 1950s and 60s, this strategy significantly reduced the occurrence of forest fires. However, the organization recognized the drawbacks of this approach in the 1980s, as it heightened the risk of mega-fires by increasing the accumulation of flammable materials in the forest and adversely impacted ecosystems adapted to fire for centuries. Consequently, a shift occurred, introducing controlled burning practices, also known as prescribed fire or burning, into the fire management strategy (Stober et al. 2020, USDA Forest Service 2022b). Presently, the USDA Forest Service incorporates annually prescribed burning in approximately 10% of the forest areas it manages (Stober et al. 2020). Moreover, in cases where naturally occurring forest fires do not pose a threat to human safety, the organization refrains from early suppression, allowing the fire to progress to specific areas and utilizing wildfire as a management tool (USDA Forest Service 2023a). Prescribed burns, when executed appropriate sites and on schedule, yield a multitude of benefits:

- Preventing Mega Fires: By reducing the accumulation of flammable materials, prescribed burns mitigate the risk of large-scale, destructive wildfires.
- Controlling Insect and Disease Damage: Prescribed burns help curtail the spread of pests and diseases within the forest ecosystem.
- Eradicating Invasive Species: Undesired species threatening the natural ecosystem are effectively managed and eliminated through prescribed burning.
- Enhancing Grassland for Habitat: Prescribed burnings contribute to the creation of grassland areas that serve as forage habitat for certain wildlife species.
- Improving Endangered Wildlife Habitat: The controlled burning approach enhances the habitat of endangered wildlife species.
- Nutrient Return to Soil: Prescribed burns speed up the return of plant nutrients to the soil, fostering many ecological processes.
- Accelerating Tree Growth: By promoting the growth of trees, prescribed burnings contribute to overall forest health.
- Desired Forest Structure: Some management plans prioritize achieving desired stand structure through prescribed burns at the end of the planning horizon (Cunningham 2023, Stober et al. 2020, USDA Forest Service 2023a). This comprehensive strategy not only addresses the immediate challenges posed by forest fires but also aligns with long-term ecological and biodiversity goals,

showcasing a forward-thinking and adaptive approach to contemporary forest management challenges.

Before the initiation of prescribed burning, a crucial preparatory step involves thinning the stand where the application will take place. This process reduces stand density to levels characteristic of its natural/historical state before the 20th century. Thinning serves the purpose of preventing prescribed burn from escalating into a more severe and uncontrollable event. Following thinning, a controlled, low-intensity surface fire is initiated using a drip torch, as depicted in Figure 3. The torch typically utilizes a mixture of diesel and gasoline as fuel (Rizza and Berger 2023). Diesel fuel contributes to the continued burning of flammable materials in the forest, while gasoline aids in the initial ignition and the propagation of the flame. Though various ignition tools such as flame guns, drones, and back-mounted propane tube pitchers are available, the drip torch remains a preferred choice in forestry applications. However, there are instances where drones are employed to monitor the spread of the fire during the prescribed burning application (USDA Forest Service 2022b). Throughout the application, meticulous attention is given to smoke management, as detailed in Box 2.


Figure 3. Prescribed burning conducted in a longleaf pine ecosystem in the Southern US (left). An outdated drip torch used for fire initiation in prescribed burns (right). Photo credit: USDA personnel (left) and Can Vatandaşlar (right).

An interesting example of traditional knowledge is that Native Americans have been practicing controlled burning in forests for centuries (USDA Forest Service 2022b). This approach involved locals naturally regenerate the forest and creating open grazing lands for the animals they raised. Thora Padilla, a leader of the Mescalero Apache Tribe residing on the Mexico-USA border, offers valuable insights into their perspective on forest fires. According to Padilla, their community does not view forest fires with fear; instead, they recognize the significant role that fire plays in the ecosystem. She emphasizes that fires are an integral part of forest ecosystems, and the natural processes that have unfolded for millennia should not be altered solely to meet certain human needs (Fry 2023). This acknowledgment of the historical and ecological role of fire by Native American communities underscores the importance of integrating traditional knowledge into contemporary forest management practices. Their long-standing practices of controlled burning contribute to a broader understanding of the symbiotic relationship between fire and ecosystems, emphasizing the need for a balanced and informed approach to fire management in modern conservation efforts.

The knowledge base of indigenous tribes living north of the Rocky Mountains offers another compelling example of traditional practices. For centuries, locals have engaged in the practice of peeling the bark of Ponderosa pine (*Pinus ponderosa*) to access the rich inner bark, which is high in sugar, using it as a food ingredient. The inner bark is exclusive to natural old pine trees characterized by orange outer bark. In an effort to protect these old pine trees from large fires and create open spaces around them, indigenous communities periodically initiated low-intensity surface fires. While this practice was predominantly observed in cooler regions and typically did not escalate into canopy fires, the federal government prohibited this indigenous traditional practice in 1911 (USDA Forest Service 2022b). It is noteworthy that today, the USDA Forest Service recognizes and actively collaborates with indigenous communities to leverage their traditional knowledge in reducing the risk of fires in National Forests (Fry 2023). An example of active fire management can be seen in the Talladega National Forest, where the historical fire frequency of pine and fire-dependent deciduous stands is known to be approximately every three years. However, due to "successful" firefighting efforts, these forests remained fire-free from the 1940s to the 1990s, leading to damage to their original stand structures. Consequently, current National Forest managers employ prescribed burning as a management tool to mimic historical fire dynamics, as depicted in Figure 3 (Stambaugh et al. 2018, Stober et al. 2020). Despite the success of prescribed burning processes, the inevitability of wildfires necessitates a strong firefighting system. In the US, the firefighting system primarily relies on high-tech equipment and advanced decision support systems. This critical aspect is evaluated under the next subsection, the Use of Technology.

Forest fires are among the most significant environmental challenges facing Türkiye. More than half of Türkiye's forested areas are categorized as fire-sensitive (Bilgili et al. 2021), with the most vulnerable regions located Mediterranean forest ecosystems dominated by Calabrian pine (*Pinus brutia*), black pine (*Pinus nigra*) and *maquis* shrublands. In parallel with many other parts of the world, the frequency of forest fires has been increasing, especially in the last few decades. For instance, a singular fire event in the Antalya province in 2021 seriously affected 55,000 ha of forest (Bilgili et al. 2021).

Unlike the US, the practice of prescribed burning is not currently implemented in Türkiye, perhaps due to incorrect perceptions among local people, negative media pressure, and strict legislative frameworks (e.g., the Forest Law). Nevertheless, the country's monitoring and firefighting system is highly regarded as well-established and robust (Bilgili et al. 2021). For example, the technique of setting a reverse fire is employed under particular circumstances to control spreading wildfires, although it is not a common practice.

**The Use of Technology**

High-tech applications play a crucial role in various aspects of forestry in the US, particularly in the realms of remote sensing, fire prediction/monitoring, and decision support systems. Among the technological tools utilized, products from the USDA's National Agriculture Imagery Program (NAIP) stand out prominently. The NAIP produces natural color and near-infrared orthophoto mosaic images, which are instrumental in monitoring, mapping, and estimating the biophysical attributes of forest areas. These images have a spatial resolution of 60 cm (pre-2018 data was at 1 m resolution) and are updated annually for most states, covering the entirety of terrestrial land in the US. NAIP also archives images from previous years.

**Box 2. Smoke Management**

The management of smoke, whether arising from prescribed burns or wildfires, is a critical aspect of overall fire management. Smoke not only poses risks to air quality but also diminishes visibility, impacting transportation routes like highways and airports. It can lead to traffic jams and serious accidents. Therefore, relevant organizations in the US prioritize both combating the fire itself and managing the resulting smoke. Managing smoke during naturally occurred wildfires presents significant challenges. For instance, during the summer of 2023, numerous wildfires in Canada generated smoke that, propelled by storms, moved southwards, reaching cities even in the southeastern US and creating an orange haze in the sky (The New York Times, 2023). When this is the case, people rely on real-time air quality indices and smoke forecast maps to navigate their daily lives, emphasizing the importance of monitoring and mitigating the impacts of widespread smoke (AirNow 2024). In contrast, prescribed burnings allow for more active smoke management. Strategies can be employed to adjust the timing of burning based on the speed and direction of the wind on a given day. This approach not only safeguards firefighting personnel but also helps protect nearby settlements and structures from the effects of smoke. In instances where prevention is not feasible, residents in affected areas are typically informed through official announcements. They may be advised to stay indoors during specific hours or, in more severe cases, to evacuate the area entirely. Similarly, for interstate highways passing through large forest expanses, prescribed burning is often scheduled during periods of minimal traffic or when traffic flow can be temporarily halted to minimize the impact on commuters (NIFC 2023). This proactive and adaptive approach to smoke management is crucial for mitigating the broader impacts of forest fires on public health, safety, and infrastructure.

While it is reported that the aerial photographs forming the basis for these orthophotos are collected during the vegetation period, recent data from the US south has revealed that deciduous trees shed their leaves. One of the most noteworthy features of NAIP is its accessibility, as the products offered by county or state can be downloaded free of charge from the USDA Natural Resources Conservation Service's website (USDA NRCS 2024). Researchers and practitioners often leverage these images for various forestry studies, exemplified by Ucar et al.'s (2018) research, which utilized NAIP imagery.

In addition to optical images, the availability of active remote sensing sources, such as airborne laser scanning (ALS), further enriches the technological resources accessible for forestry applications. Notably, ALS data covering almost the entire land area of the US (Figure 4) is freely available on the USGS website. However, its temporal resolution is not as frequent as NAIP. Some geographical regions may have the most recent LiDAR data dating back almost 10 years. Despite this limitation, the provision of such valuable products with open access proves invaluable for institutions, researchers, and users related to natural resources management. Numerous research endeavors worldwide have utilized these products, as evidenced by studies of Ucar et al. (2018) and Akturk et al. (2020).

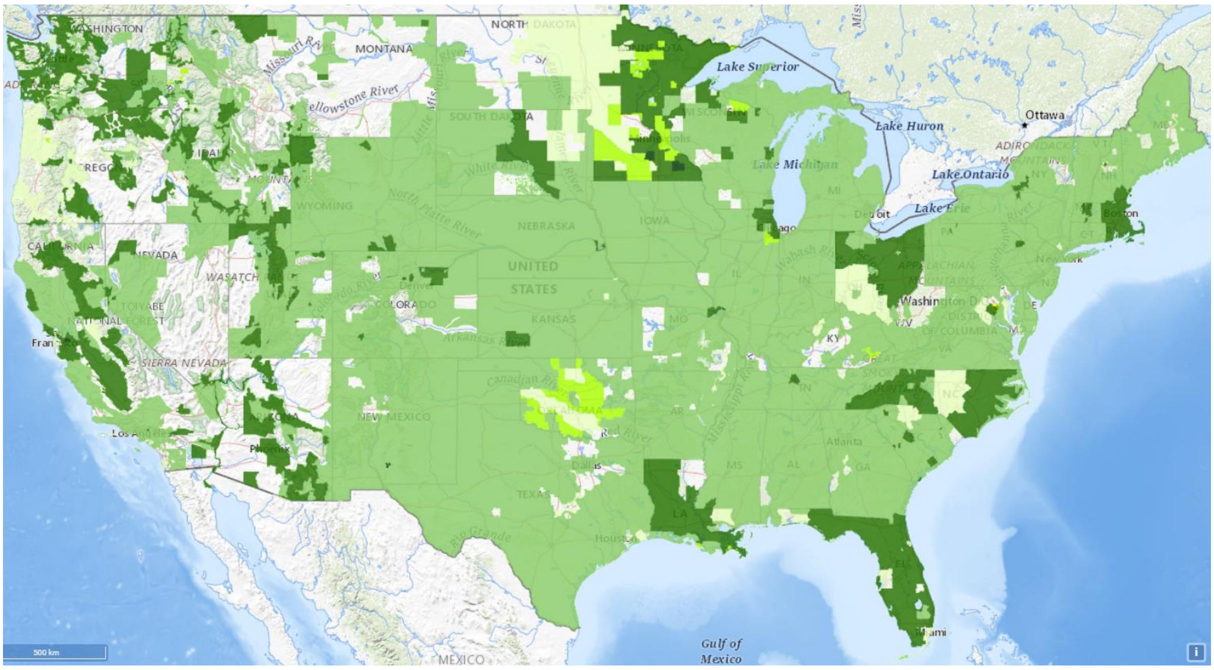


Figure 4. Coverage map of freely available airborne laser scanning (LiDAR) data provided by the US Geological Survey for the conterminous United States. Please note that nominal point spacing of the data decreases towards areas marked in dark green (0.35-1.4 m) (USGS 2024).

The USDA Forest Service collaborates extensively with NASA on various projects, particularly in the field of forest fire management. The notable density of fire projects underscores the federal government's commitment to addressing the increasing frequency, severity, and size of mega forest fires, especially in the Pacific region. The substantial budget allocation reflects the urgency and importance attached to forest fire-related projects and studies. One noteworthy collaborative initiative is the Fire Information for Resource Management System (FIRMS), a project that provides real-time information on active fires and thermal anomalies in both the US and Canada. FIRMS utilizes satellite-based Moderate Resolution Imaging Spectroradiometer (MODIS) (1 km) and Visible Infrared Imaging Radiometer Suite (VIIRS) (375 m) spatial data to detect active fires and thermal anomalies. The system's algorithm, which operates with a rapid response time (within 1-30 minutes), identifies pixels with high reflection values in the infrared band image of MODIS and classifies those above a certain threshold value as active fires. VIIRS contributes to the system by minimizing false alarms through the use of additional band and radiometric signals. The resulting active fire information, including pixel coordinates, can be promptly communicated to decision-makers via email. The website accessible to the public provides a comprehensive map displaying active fires, recently extinguished fires, historical fire data, burned area statistics, start-end times, and more (Figure 5). Detailed reports containing information on the number of responders, loss of life and property, and other relevant data can also be obtained from the system (NASA 2024).

Beyond FIRMS, other systems contribute to fire management efforts, such as the Wildland Fire Assessment System (WFAS) that forecasts daily wildfire danger for the US (WFAS 2024) and the National Interagency Coordination Center (NICC) that predicts the potential for major fires in the next

7 days (USDI NIFC 2023). Additionally, the US Geological Survey's Wildland Fire Science Program provides spatially explicit information on the probability of fire spread (USGS WFSP 2024).

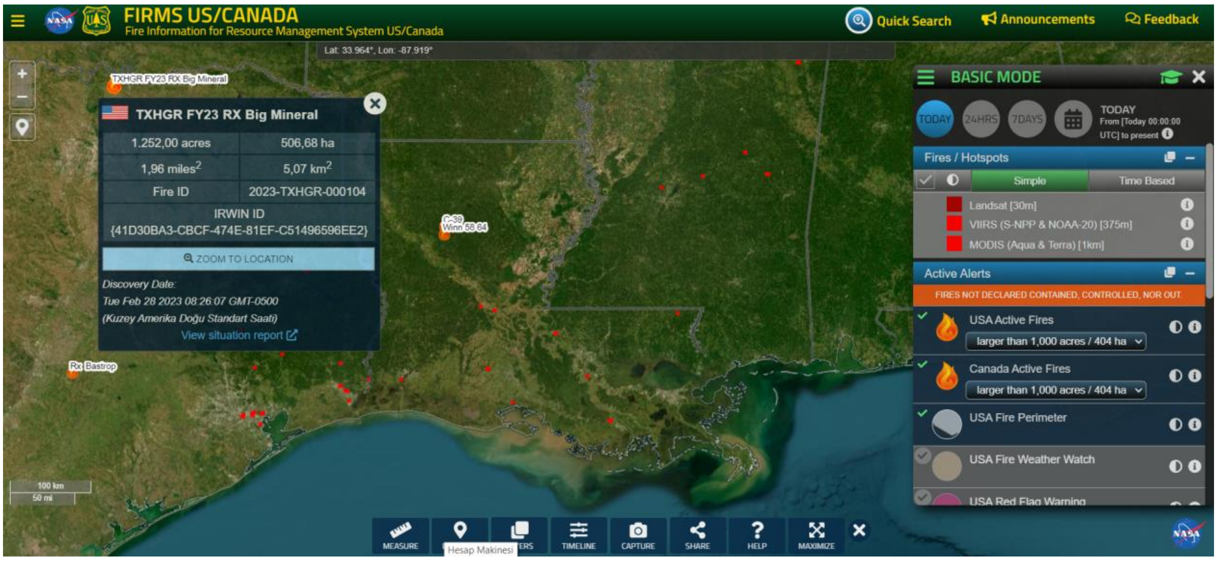


Figure 5. Screenshot depicting active fires in the Southern US as of December 22nd, 2023. Notably, graphical and attribute data can be accessed for specific fire incidents via NASA (2023).

In Turkish forestry, the utilization of fixed-wing drones in early detection of wildfires (BAYKAR 2024, Kadıoglu et al. 2023), automatic extraction of surface deformation on forest roads (Eker 2023), enhanced forest inventories through handheld mobile laser scanners (Vatandaşlar et al. 2022), and the development of decision support systems for effective fire management (Coşkuner et al. 2021) represent examples of cutting-edge technologies. However, these advancements are primarily perceived as research and development efforts. The operational implementation of these tools and techniques by the GDF is questionable.

**Silviculture**

While there are notable similarities between the US and Türkiye in silvicultural practices, such as large-scale shelterwood harvest, clear-cutting, and restoration, differences emerge in the rotation ages, particularly in privately owned and intensively managed forests. In the southeastern US, where the Loblolly pine (*P. taeda* L.) is a significant commercial tree species covering 14.4 million ha (Restrepo et al. 2019), typical rotation age ranges between 20 and 30 years. This short harvesting cycle contrasts with practices in Türkiye, where rotation periods tend to be longer, typically 60 years for fast-growing species and 100 years for slow-growing species. However, these ages may vary by up to ± 20 years depending on site conditions.

Loblolly pine stands have the capacity to produce logs with a diameter of 25 cm within 50 years without the need for any silvicultural intervention (Cunningham 2023). This rapid growth enables wood production suitable for various purposes, such as paper and chipboard, within rotations under 20 years. Additionally, it is important to highlight that while Loblolly pine is known for its fast growth, there are stands across the US that can reach approximately 250 years old (Baker and Langdon 1990).

In the US National Forests, rotation ages are generally higher than those in private forests. For instance, in the Francis Marion National Forest in South Carolina, the rotation ages for pure Loblolly pine and mixed pine+hardwood stands are 60 years, while it is 100 years for pure deciduous stands (FMNF 2017). Despite these relatively longer rotation ages, they still appear shorter when compared to those typically determined in Türkiye. One reason for this difference could be attributed to the fact that the majority of Türkiye's forests are (semi-)natural in origin. Unlike the practice in Türkiye, the site index class (a.k.a. bonitet) is not directly taken into account in determining rotation age in the US National Forests. Instead, different rotation ages are determined for stands of the same species located in different locations, such as the upper slope, lower slope, or bottomland.

Significant emphasis is placed on stand tending in the US. In pine ecosystems, for example, post-planting operations are carried out in the first 3-5 years following regeneration (Allen et al. 2005, Cunningham 2023). Baker and Langdon (1990) recommend reducing the number of individuals per hectare in Loblolly pine stands to 1235-1730 by the 5th year. The first thinning is typically conducted between the 12th and 15th years. Since these years coincide with the middle of the rotation age, fertilization (nitrogen and phosphorus) is also undertaken at this stage. Concurrently with fertilization, any hardwoods in the understory are removed. This step is crucial to ensuring that pine trees derive maximum benefit from the applied fertilizer (Cunningham 2023). Subsequent (improvement) thinning is performed every 5-8 years after the first thinning. Toward the end of the rotation, if artificial regeneration is desired, clear-cutting is often preferred, whereas seed tree harvest is favored for natural regeneration.

The intensive use of chemical control methods in the US for site preparation, post-planting operations, and throughout the rotation age is a notable divergence from common forestry practices in Türkiye (Allen et al. 2005, Bettinger et al. 2013, Cunningham 2023). Herbicide application, typically conducted by licensed applicators, is employed to eradicate woody vegetation and weeds that compete with the desired tree species (Cunningham 2023). Suitable chemicals are applied using aircrafts and drones. While aerial application is feasible for dense forest conditions, ground-based application becomes essential, particularly in sparsely covered forests. In cases where undesirable tree species have reached a certain size, herbicide application is carried out by directly injecting the chemical into the trunk (Cunningham 2023).

The common perspective in the Turkish forestry is to be cautious about chemical applications due to concerns about potential environmental pollution and ecosystem damage. However, Bettinger et al. (2013) highlighted that chemical control methods, including herbicides and fertilizers, commonly used in US forestry are not applied intensely like cases in agricultural lands. Furthermore, they note that no negative consequences have been reported as a result of these treatments.

Another difference between the US and Turkish forestry exists in the field of genetics, particularly in tree improvement programs. The US, especially in the southern regions, widely implements these programs to introduce genetically superior individuals to plantations, with a focus on commercially valuable species such as Loblolly pine (*P. taeda*) and slash pine (*P. elliottii*) (Allen et al. 2005). Notably, the cooperative affiliated with the University of North Carolina alone annually plants an expansive area of 300 thousand ha with genetically selected and improved saplings (McKeand 2015). These programs accelerate increment and growth, enhance resistance to extreme weather conditions like frost and drought, and improve wood quality.

The benefits of these programs are evident, especially in plantations established with genetically improved saplings of Loblolly pine. These sites show a 45% increase in height growth at the 10th age compared to regular sites, and the average stem volume in these sites has 3.4 times more than an ordinary stem. Additionally, artificial hybridization studies are conducted to combine advantageous traits of different tree species into a single species. For instance, hybrids like the one between pitch pine (*P. rigida*) and Loblolly pine exhibit both the cold resistance of the former and the fast-growing nature of the latter species (Baker and Langdon 1990). The return on investment from such genetic studies, ongoing in the US since the 1950s, is estimated to be around $2.5 billion, bringing significant benefits to private forest owners and US citizens (McKeand 2015). This highlights the importance and success of genetic improvement programs in enhancing the overall performance and resilience of forests in the US.

**Forestry Education**

Forestry education in the US traces its roots back to the Biltmore Forest School, founded by forester Carl Alwin Schenck, who was brought from Germany (Figure 6). Established in 1898 in where is now Pisgah National Forest (N. Carolina), the school pioneered the training of foresters to manage public and private forests in the US (Croom 2023). Recognized as the Cradle of Forestry in the US, the school is now showcased as a museum alongside its current campus (Figure 7). While additional schools focusing solely on forestry education were later established, the names of these institutions and programs have evolved over time in response to changing forestry approaches. Presently, many programs in the US feature names such as forest resources, natural resources, environmental sciences, wildlife, etc., instead of "forestry." This shift reflects a broader perspective on the interconnected aspects of natural resource management.

In the early 20th century, several forestry schools affiliated with institutions such as the State University of New York at Syracuse, University of California−Berkeley, Yale University, University of Minnesota, Oregon State University, Iowa State University, and the University of Washington were the first to receive accreditation from the Society of American Foresters (SAF) (Green 2006). As of 2023, there are approximately 50 forestry schools in the US (ForestryUSA 2022), offering programs in forestry, natural resource management and sustainability, fisheries and wildlife, recreation and ecotourism, and forest management. While students across these schools share common courses, the specific vocational courses they take vary based on the program and major they are enrolled in. It's worth noting that the numbers of undergraduate and graduate students in forestry programs in the US are relatively balanced. For instance, at the Warnell School of Forestry and Natural Resources (University of Georgia, UGA), there are 265 undergraduate students and 240 graduate students. The school boasts a faculty of 68 members and a staff of 100.

Figure 6. Classroom of the Biltmore Forest School (1898-1914). Exterior views (left) and interior views (right) of the building. Photo by Can Vatandaşlar.

Many forestry schools in the US manage their own forest lands, utilizing these areas not only for educational and research purposes but also for generating income through business purposes. Taking the Warnell School (UGA) as an example, the institution oversees a total of 7,000 ha of forest land spread across State of Georgia. Substantial revenue is generated for the school through the sale of goods obtained from logging activities conducted in these forests. Moreover, depending on market conditions, some forest lands may be sold. For example, in 2023, around 1,000 ha of land near Lake Blackshear were sold for $18.5 million. The dean of the school has announced that this income will be invested in modernizing school buildings, hiring additional post-doctoral researchers and assistants, and acquiring new technological equipment (UGA 2023). This underscores the multifaceted role of forest lands managed by forestry schools, not only as educational and research assets but also as valuable sources of revenue contributing to the enhancement and sustainability of the educational institutions themselves.


Figure 7. The visitor center was located at the site of the first forest school in the US. External views (left) and internal views (right) of the center. Photo by Can Vatandaşlar.

Forestry education in Türkiye also has a longstanding tradition dating back to the establishment of the Forest School in Istanbul in 1857 by Louis Tassy, who was brought from France (Kutluk 1957). Although initially considered semi-official and catering mainly to the non-Muslim minority fluent in French, it evolved into a formal educational institution providing genuine forestry education during the tenure of Charles Simon as the school principal in the 1870s (Gümüş 2016). With the enactment of the Forest Regulations and the active engagement of the forestry organization under the GDF, graduates of the school in the 1870s could embark on careers as Forest Inspectors in the newly established forest directorates across provinces.

Over the years, the institution underwent several name changes, evolving from Türkiye's first forestry school to the Forestry and Mining School, Halkalı Agricultural College, Forestry College, and finally the Ankara Higher Agricultural Institute Faculty of Forestry (Gümüş 2016). In 1948, it has become part of Istanbul University Faculty of Forestry. Following the Istanbul University (Cerrahpaşa) Faculty of Forestry, 11 additional forest faculties have been founded in Türkiye. These faculties not only feature the traditional 4-year Forest Engineering department but also include departments such as Forest Industrial Engineering, Landscape Architecture, and Wildlife Ecology and Management. Almost every faculty offers master's and doctoral programs at this time.

Similar to their counterparts in the US, both Istanbul University (Cerrahpaşa) and Artvin Çoruh University Forestry Faculties have their own research forests. However, in contrast to the US, these forests in Türkiye are not utilized for income generation through trading, as such decisions are not under the purview of the faculty deanery. Instead, the emphasis is on leveraging these forests for educational and research purposes within the academic framework.

**Other Areas: Wildlife Management, Carbon Markets and Forest Inventory**

A significant area where differences between the US and Türkiye are evident is in wildlife management. In the US, comprehensive management mechanisms, often going beyond regulatory legislation like the Endangered Species Act, are in place, particularly for the protection of rare species. One such mechanism involves designating certain wildlife species as conservation targets in forest plans and implementing active management and restoration activities to enhance their populations. For instance, the red-cockaded woodpecker (*Leuconotopicus borealis*) is a species found in longleaf pine (*P. palustris*) forests within the natural/historical ecosystems of the southeastern US. Due to historical land use changes, this forest type underwent conversion, leading to its destruction. Presently, the red-cockaded woodpecker is restricted to less than 5% of its original habitat. As a response, this bird species has been federally protected since 1973 (Smart et al. 2012, Garabedian et al. 2014). To increase the population of the red-cockaded woodpecker, suitable habitat types are created both naturally and artificially. Practices such as thinning and prescribed burning in longleaf pine stands in the Talladega National Forest (Figure 3) serve as an excellent example. These activities reduce canopy cover and clear understory vegetation, creating the necessary habitat for the species (Stober et al. 2020). Additionally, projects involve the creation of artificial cavities by climbing suitable tree stems in the same stands. While there are several projects in Türkiye that include "umbrella" or "flag" species as conservation targets in management plans, these plans are often considered "model plans" and constitute exceptions considering 2000+ forest planning units found in the country. A critical aspect is the practical implementation of these plans on the ground, where the impression is that recommendations regarding these species often remain on paper. To effectively disseminate such model plans nationwide and take active measures in the field, it is essential to first determine the habitat needs of endangered species with habitat suitability maps and then integrate these models into ecosystem-based multi-purpose forest management plans. For modeling studies related to the red-cockaded woodpecker, Smart et al. (2012) and Garabedian et al. (2014)'s research may provide valuable insights.

One significant source of income in US forestry is carbon projects, particularly involving private forest owners who undertake projects to promote greenhouse gas reduction on their lands. They then sell the additional carbon credits generated by these projects in carbon markets. This approach allows organizations in various industries or sectors with high carbon emissions to meet their carbon emission reduction targets by purchasing these credits (Vacchiano et al. 2018). Various project types are implemented, including forestation, afforestation, agroforestry, improved forest management, and prevention of land use changes (a.k.a. REDD+ projects) (Medina-Irizarry et al. 2022).

For instance, with improved forest management projects, it's possible to store more carbon in the above- and belowground components of the ecosystem by extending the rotation age of the forest. Although this may lead to a slight decrease in the wood production of the forest landowner, the loss is often compensated by selling additional carbon credits. Depending on carbon credit prices, this approach can potentially result in more income from wood production over the long run. Additionally, protective functions and biodiversity value of the forest generally increase through these projects. While there is a voluntary carbon market in the energy sector in Türkiye, there is no forest carbon market or any carbon certification program in place (Başsüllü and Tolunay 2014). Some researchers suggest that if a forest carbon market and related certification programs are established in Türkiye, the country's forestry sector could yield significant benefits from them (Başsüllü and Tolunay 2015, Demirci and Öztürk 2015, Serengil 2020).

The Forest Inventory and Analysis (FIA) program in the US plays a crucial role in collecting data, information, and statistics on a national scale in forest areas of all ownership types. The digital database is freely shared via the Internet since 1996 (USDA Forest Service 2024b). This program provides valuable information that is used to publish a report known as "The Forest Resources of the United States" every five years, detailing the current status of the forest, spatiotemporal changes, and trends in certain forest attributes (Oswalt et al. 2019). The FIA program has expanded its scope in recent years to include urban trees and agroforestry practices. The national-scale inventory is based on permanent sample plots, and inventory cycle occurs at 5 or sometimes 10-year intervals. Metal piles buried in the center of the sample plot are detected with a detector during subsequent visits. The circular sample plots have an approximate radius of 9 m, and smaller-sized subplots are also sampled around them. Each sample plot represents a forest area of approximately 2,500 ha, and the measured parameters in macro sample plots (i.e., 9 m radius) are comparable to those in Türkiye (Figure 8). A notable difference is that, unlike in Türkiye, sampling data collected in the field are stratified and then combined with remote sensing data to obtain more precise information about the biophysical structure of large forest expanse. Moreover, in about one every 15 sample plots, detailed measurements and sampling are conducted for, e.g., saplings, lying deadwood, and soil properties (NFI 2024).

Figure 8. Views of a forest sample plot (left) and a metal tag attached to a sample tree (right) in a national forest in the US. Photo by Can Vatandaşlar.

Another notable aspect of the FIA program is its provision of detailed information on the quantity, type, quality, and industrial use of wood extracted from harvesting sites (Harvest Utilization, HU). Additionally, it can retrieve data on the volume of wood processed by mills, including details such as tree type, product group, and origin (Timber Products Output, TPO). This comprehensive dataset plays a crucial role in national and international reporting systems, forest planning studies, and the decision-making processes of investors. Some private companies regularly analyze these datasets and provide reports to their customers, such as timberland investors. However, it's worth noting that some researchers conducting scientific projects at US universities may find FIA data to be not entirely reliable, leading them to either have their own sampling conducted by professional organizations for a fee or conduct field measurements themselves.

In Türkiye, forest inventory studies are conducted in two main ways:

- National Forest Inventory (NFI) based on permanent sample plots: Conducted every 5 years for international reporting schemes and monitoring of ecosystem health, this inventory is carried out on a national scale.

- Forest inventories based on temporary sample plots: Carried out approximately every 10 years, this inventory is used for forest plan renewals at the scale of forest planning units. More information on those studies can found in Kayacan et al. (2016).

While detailed information collected through these inventory studies in Türkiye is not publicly shared, annual forestry statistics prepared with the help of these data are published by the GDF at the country and regional directorate level. Forest management plans and their geodatabases can also be obtained in digital format for a fee by applying to corresponding forest enterprises with a petition.

## Conclusion

In this research, we present an in-depth exploration and comparison of the current forestry systems in the US and Türkiye. Our analysis encompasses an examination of the overall state of forest resources and practices, along with specific focal points. Additionally, we provide illustrative examples to highlight independent cases.

In the realm of forest ownership, we delve into the management dynamics of the predominantly private forest-owned structure in the US, contrasting it with the pros and cons associated with public forest management in Türkiye. Regarding forest management and planning, positive aspects in the US include a participatory planning approach, a strategic emphasis on long-term sustainability, and developing forest plans by multidisciplinary teams. In contrast, Turkish plans stand out for their tactical-level recommendations, operational-level details, the presence of a comprehensive geodatabase including useful stand-types maps, and functional allocation of forest areas. It is important to note that many private forest lands in the US lack a management plan. Thus, a regulatory amendment is highly advisable for the country to develop plans for forest landowners.

Current examples showcase the US's advanced capabilities in fire management, leveraging cutting-edge technology and decision support systems alongside widely practiced prescribed burns. The US's proactive approach extends to managing smoke generated beyond forest fires. In Türkiye, we advocate considering prescribed burning in appropriate areas and at suitable times as a management tool in preventing more severe future fires by mitigating the stand fuel particularly on the forest floor.

Exploring technological applications, both countries exhibit a focus on remote sensing, geospatial technologies and fire management systems. While accessing airborne laser scanning (ALS) data and near-infrared aerial photography from the USDA website is free of charge, obtaining similar photographs collected by the Turkish Air Force presents challenges. On the other hand, there is no ALS data available in Türkiye at this time. Overcoming data scarcity issues is crucial for decision-makers in the country with providing more comprehensive information for effective natural resources management.

Significant differences in silviculture area between the two countries include shorter rotation ages and widespread use of herbicides, pesticides, and fertilizers in US forestry. Silviculture in the US places considerable emphasis on stand tending, incorporating genetically improved species to enhance tree growth and timber quality. In Türkiye, there is a prevailing belief that the use of such chemicals could harm the environment underscoring the need for a careful evaluation of their potential impact on the ecosystem, which deserves further research in this area.

While Türkiye boasts a more established history in terms of forestry organization and vocational education, the US took a pioneering step by preparing its first forest management plan 22 years ahead of Türkiye in 1895. Interestingly, the establishment of the first forest school in both countries involved expert foresters from continental Europe, marking the initiation of formal forestry education.

Beyond these areas, we explored topics such as wildlife management, carbon credits/markets, and forest inventory exercises. Accordingly, the study suggests determining optimal habitat conditions for forest-dependent wildlife species and integrating them into Turkish forest plans, establishing a forest carbon market and developing carbon projects tailored to the Turkish forestry, and conducting forest inventories in permanent sample plots installed in forest planning units in Türkiye.

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