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Old-growth grasslands of Central Anatolia (Türkiye) require better conservation and management

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Summary

The grasslands of Central Anatolia in Türkiye, including the steppes and forest-steppes, are often mischaracterized as degraded ecosystems due to long-standing human activities, particularly agriculture and domestic grazing. However, palaeoecological evidence and recent research suggest that these grasslands are ancient, biodiversity-rich systems that have persisted through various climatic changes and disturbance regimes. This manuscript challenges the conventional view that Central Anatolian grasslands are secondary and degraded, arguing instead that they represent old-growth ecosystems that coexisted with forests as alternative biome states throughout history. We emphasize the need to re-evaluate current land management practices, particularly afforestation efforts, which may undermine the resilience of these ecosystems to climate change. By recognizing the ecological value of these old-growth grasslands and adopting a comprehensive conservation strategy, the conservation and restoration of these vital ecosystems can be improved, ensuring their resilience and biodiversity in the face of future environmental challenges.

Grassland biomes comprise various types of ecosystems characterized by open vegetation dominated by grasses and low shrubs, typically with low or no tree cover. Recent research has emphasized the importance of old-growth grasslands in both tropical and temperate regions (Parr et al. 2014, Veldman et al. 2015, Bond 2016, 2019), significantly enhancing understanding of these ecosystems. These grasslands or mixed tree–grass systems may extend over large regions determined by climate conditions, where low rainfall or cold temperatures limit tree growth (Whittaker 1970). In the tropical and subtropical zones, feedback mechanisms between disturbances such as fire and herbivory and grasses can also maintain grasslands as alternative states in regions with sufficient precipitation to support closed-canopy forests (Sankaran et al. 2005, Hirota et al. 2011, Staver et al. 2011, Bernardi et al. 2016, Dantas et al. 2016, Bond 2019). In temperate regions, similar feedbacks can also sustain open states, suggesting that alternative biome states (Pausas & Bond 2020) can coexist within the same environmental conditions (Ratajczak et al. 2014, Stritih et al. 2023). These insights are crucial for understanding tree-cover patterns in understudied regions such as Türkiye's Central Anatolian steppes.

Central Anatolia is renowned for its biodiversity-rich grasslands (Kurt et al. 2006), but human activities over millennia have caused the loss of much of its original habitats (Şekercioğlu et al. 2011, Ambarlı et al. 2016), leading to the region becoming part of the Irano-Anatolian biodiversity hotspot (Mittermeier et al. 2005). Today, human land use continues to pose a significant threat to the ecosystems of Central Anatolia. The ongoing expansion of croplands has reduced the extent of steppe habitats by nearly 50% over the last century. The remaining grasslands are intensively used for grazing, which has led to overgrazing and degradation of the natural steppe vegetation, and they have more recently been targeted by afforestation initiatives (Şekercioğlu et al. 2011, Ambarlı et al. 2016, Ayan et al. 2021, Yıldız et al. 2022). Many biodiversity-rich areas in Central Anatolia lack effective protection (Şekercioğlu et al. 2011, Ambarlı et al. 2016, Eken et al. 2016), making grassland habitats increasingly vulnerable to human-related threats. Additionally, the history of human modification in the region spanning thousands of years complicates understanding of the original distribution of forests and steppe vegetation (Asouti & Kabukcu 2014), which in turn hinders their effective management. For instance, the misconception that these steppes and forest-steppes were originally forest areas degraded by human activity has led to the widespread afforestation efforts across Central Anatolia (Çalışkan & Boydak 2017, Ayan et al. 2021, Olowu et al. 2024).

Palaeoecological data indicate that much of Central Anatolia has retained its steppe and forest-steppe vegetation throughout the Holocene period (Turner et al. 2010, Şenkul et al. 2018), despite changes in climate, fire patterns and human activity since the last glacial maximum. Today, although several patches of black pine (*Pinus nigra*), juniper (*Juniperus* spp.) and oak (*Quercus* spp.) forest exist in the highlands of the Central Anatolian plateau (Ambarlı et al. 2016,

Kahveci 2022), the region is predominantly covered by grass- or subshrub-dominated steppe vegetation, or by forest-steppes with varying degrees of tree and shrub cover, ranging from isolated trees to open woodlands, alongside the croplands that occupy much of the area (Çetik 1985, Kürschner & Parolly 2012). Unlike many tropical grassland systems that are dominated by C4 plants, C3 plants have been prevalent in the Central Anatolian region since the Miocene period (Edwards et al. 2010). Annual precipitation, sometimes as little as 300 mm, combined with harsh temperature extremes, including freezing conditions and water stress in many parts of Central Anatolia, as well as poor and acidic soils restrict tree growth and can account for the prevalence of steppic grasslands (Kenar & Kikvidze 2019, Kahveci 2022, R Bernardi et al., unpublished data 2024). In the forest-steppes of Central Anatolia, the growth dynamics of trees, particularly junipers, depend heavily on precipitation (Kahveci et al. 2018). In addition, the presence of forest-steppes in certain areas of Central Anatolia, where local conditions are conductive to tree growth, may also be influenced by past and ongoing disturbance regimes such as fire and livestock grazing (Tavşanoğlu 2017). Nevertheless, Anatolian forest-steppe vegetation is often perceived in Türkiye as a degraded ecosystem due to human activity, a common misconception in many Eurasian countries where this vegetation type is found (Erdős et al. 2019). This belief extends to much of the Central Anatolian steppe vegetation, which is frequently mischaracterized as secondary vegetation resulting from the loss of primary forests, despite palaeoecological evidence showing the dominance of steppe and forest-steppe vegetation throughout the region (Turner et al. 2010, Şenkul et al. 2018), which has transitioned over time with climatic fluctuations (Oybak-Dönmez et al. 2021).

Another conventional approach to the Anatolian steppes is to label some areas as secondary steppes that have lost their primary steppe vegetation community due to centuries of grazing (Kurt et al. 2006, Kürschner & Parolly 2012). This perspective overlooks the natural role of herbivory in shaping vegetation patterns and fails to consider that current grazing by domestic herbivores has replaced the herbivory of large-mammal communities during the Pleistocene. These so-called secondary steppes possess high biodiversity value and support numerous endemic and narrowly distributed plant taxa (Çetik 1985). In fact, in regions where the historical cover of woody plants is uncertain, the current biodiversity can serve as an indicator of old-growth vegetation. Many characteristics observed in these steppes and forest-steppes align with the markers of old-growth grasslands (Veldman et al. 2015, Bond 2019). Specifically, old-growth Central Anatolian grasslands feature unique species assemblages not found in young secondary grasslands (such as old-fields), high species diversity in the herbaceous layer, abundant small-scale species richness, the presence of persistent bud banks, strong resprouting ability and widespread clonal growth, while low-intensity domestic livestock grazing helps preserve species diversity (Çetik 1985, Kurt et al. 2006, Fırıncıoğlu et al. 2008, Kenar 2017, Özüdoğru et al. 2021, Bahar & Tavşanoğlu 2024, Ülgen & Tavşanoğlu 2024, Ç Tavşanoğlu, unpublished data 2021). For example, local-scale plant diversity is notably high in many Central Anatolian grasslands, with 116 species recorded in just 32 plots of 1 × 1 m in size (Özüdoğru et al. 2021), 41 species in eight plots of 8 × 8 m in size (Kenar & Ketenoğlu 2016) and 78 species in 37 point transects of 50 m in size (Fırıncıoğlu et al. 2008), exceeding or comparable to many species-rich grasslands in the Palearctic (Sankaran 2009, Biurrun et al. 2021). At least a third (514 taxa) of polycarpic hemicryptophytes in Anatolian steppes possess belowground organs with clonality or perennation functions (Ülgen & Tavşanoğlu 2024), and resprouting perennial species constitute 35% of the vegetation in a specific Central Anatolian habitat (Özüdoğru et al. 2021). As a defining characteristic of natural grasslands, the widespread occurrence of clonal growth and resprouting ability enhances the resilience of Central Anatolian vegetation to various disturbances and harsh climatic conditions. Modelling suggests that moderate grazing supports the diversity and abundance of different plant functional groups in Central Anatolian steppes (Bahar & Tavşanoğlu 2024). These indicators of the old-growth nature of treeless steppe vegetation in Central Anatolia can also be applied to the forest-steppes in the region, which exhibit a high proportion of herbaceous species relative to tree species (Çetik 1985, Kenar 2017, Balpinar et al. 2018, Ç Tavşanoğlu and R Bernardi, personal observations 2022) and host unique plant assemblages that are clearly distinct from other steppe vegetation types (Kenar & Ketenoğlu 2016, Balpinar et al. 2018). These observations on the forest-steppes of Central Anatolia align with findings from other Eurasian grasslands that have steppe and forest-steppe characteristics (Dulamsuren et al. 2005, Erdős et al. 2015, Tölgyesi et al. 2018).

In conclusion, we argue that the grasslands of Central Anatolia, including both steppes and forest-steppes, are old-growth systems that deserve conservation. They should not be viewed as degraded vegetation but as diverse ecosystems that may have coexisted as alternative biome states with forests at different times in history. Therefore, it is crucial to prioritize and value these grassland ecosystems to improve their management, preservation and resilience to climate change. This effort should include re-evaluating current afforestation initiatives, as the region's limiting climate conditions for tree growth could be exacerbated by climate change. The rich and highly diverse grasslands of the region may be more resilient than woodlands created by afforestation, which could face die-off or widespread fires in the future. A comprehensive conservation approach should address the loss of old-growth grasslands in Central Anatolia and explore opportunities to restore and rewild both steppes and, where local conditions are favourable, steppe-forests, informed by a deeper understanding of the historical distribution and current dynamics of these vegetation types.

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