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Distribution of Wood Pastures in Slovakia—Constraints and Potentials for Restoration of Multifunctional Traditional Land Use Form

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Abstract: Wood pastures represent specific ecosystems across Europe with diverse ecological, agricultural, and socioeconomic roles. Land-use changes and the cessation of traditional management in conjunction with socioeconomic changes led to shifts in their spatiotemporal distribution. Despite a recent increase in scientific interest, data on historical patterns of wood pastures in many European locations remain insufficient. This study presents wood-pasture habitat continuity and analyzes changes in their distribution over space and time in selected parts of Slovakia. Simultaneously, we analyzed the relation of wood pastures to selected environmental and landscape features. To achieve this, we examined the historical distribution of wood pastures using aerial imagery from the 1950s. We thoroughly examined an area of 16,209 km^2 to identify preserved wood pastures. To identify the present conditions and the spatial distribution of wood-pasture habitats, we compared the historical data with recent ortophotomaps. Based on landscape–ecological analyses of historical distribution, we determined prevailing environmental conditions of wood-pasture locations. The findings reveal that over 90% of wood pastures from the first half of the 20th century have now been lost or encroached and preserved in the form of a closed-canopy forest. In most of the encroached sites, we identified the presence of vital core veteran trees. For the identification of wood pastures and further analyses of the environmental variables, the ArcGIS 10.3 program was used; the R software was used for all statistical evaluations. The results show that the studied wood pastures were not established randomly, but were rather set within a certain landscape context, characterized by elevation, soil quality, and distance from settlements.

Keywords: agroforestry; cessation; encroachment; biodiversity strategy; carbon sequestration

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1. Introduction

The synergic effect and dynamic interplay of livestock grazing/agricultural crops and woody perennials have been well known since ancient times worldwide [1,2] and promoted by the European Commission through mixed farming systems (mixed farming, EIP-Agri Focus Group). The combination of woody perennials (trees, shrubs, etc.) within the same land-use unit as agricultural crops and/or livestock increases the general efficiency of the system [3], known as silvopasture agroforestry practice. A specific feature of agroforestry is its synergic effect—the combination of several components and their dynamic interaction—which increases the overall productivity of the system. Agroforestry systems, in addition to providing various production assets, also support a scale of environmental and socioeconomic benefits. This traditional practice is regarded as a promising tool for climate change adaptation and mitigation [4–6], enhancing biodiversity [7,8] and overall landscape resilience [9]. As a specific measure within agroforestry, wood pastures, due to their specific environmental, cultural, social, and economical aspects, enjoy a high level of interest from scientists, conservationists, farmers, and members of the public. Nevertheless, support from national and European policy perspectives is characteristically lacking due to several constraints, such as administrative burdens preventing wood pasture from being mainstreamed within the main agricultural support mechanisms and in agricultural practice [10].

Silvopastoral ecosystems represent a legacy of traditional landscape management and are one of the oldest land-use types across Europe [11] that should be maintained to enhance biodiversity. The concept of wood pastures is comprehensive as it generally refers to ecosystems with sparse trees through an open grassland [12]. Even intensively managed, wood pastures provide numerous benefits. In addition to grazing, they offer tree products (fuel wood, wild fruits, and fodder), wild edible plants, mushrooms, honey, and habitat for pollinators. The traditional multipurpose landscape management has created a mixture of habitats with high biodiversity at different scales across Europe [13]. Recent studies [14,15] mention a wide range of ecosystem services linked with wood pastures. Local stakeholders appreciated the provisioning and cultural ecosystem services, whereas regional stakeholders highlighted regulating and supporting ecosystem services more. Private- and public-sector respondents mentioned mainly provisioning ecosystem services, whereas the civil sector acknowledged supporting and regulating ecosystem services more [14].

Sustainable management and appropriate pasture schemes utilized through centuries were essential for the development of silvopastoral systems [16]. It is estimated that silvopastoral systems cover approximately 20 million hectares across the European Union [17]. Nowadays, only fragments of the former traditional land-use types [18] are distributed among all regions but more largely across Mediterranean and Eastern European countries [17]. Recent surveys underline that wood pastures have been experiencing significant changes in the past decades [19,20]. The transformation of agricultural management and forestry to more intensive forms in the mid-twentieth century led to a rapid decline of silvopastoral ecosystems [21]. On the other hand, the cessation of traditional use caused by depopulation resulted in serious negative effects and affected the functionality and structure of abandoned wood pastures as well [19,22].

With increased scientific interest in wood pastures throughout Europe in the past two decades, there was a recorded rise in the number of studies dealing with specific aspects of wood-pasture ecology and dynamics. Several authors stressed the crucial role and ecological value of veteran trees, a typical element of traditional wood pastures [12,18,23–26]. Studies exploring vegetation dynamics and land-cover changes related to management methods were presented from several European countries [27–32]. Information on vegetation composition and conservation position are available mainly from Greece [33] and Romania [34]. Recently, there is an effort to re-establish the long-term connection between society and landscape [15,21], where the cultural importance of wood pastures is pronounced [35,36]. Silvopastoral systems certainly have the capability to combine production functions with biodiversity conservation and the maintenance of resilient agroecosystems or landscapes overall [37]; hence, they might play a pivotal role in tackling the main environmental crises we currently face.

Despite existing studies on wood-pasture benefits, we still lack knowledge and good practices regarding the identification and assessment of wood-pasture distribution, which is especially critical in regions where wood pastures have been historically present but are hard to identify due to the long-term cessation of active management. This is the case in Slovakia, where many remnants of historical wood pastures are still present but are currently virtually forgotten and heavily encroached. Nevertheless, there is huge potential for their restoration, especially when a vital population of veteran trees is still present at the various sites. In this paper, we focus on the distribution of perspective wood-pasture localities in selected regions in Slovakia, addressing issues related to the lack of information on the spatiotemporal distribution of wood pastures within the study area and the relation of selected environmental and landscape features determining the historical distribution of wood pastures in rural areas in Slovakia.

The aims of this paper are (i) mapping of past and preserved wood pastures and the identification of their present state, (ii) verifying the occurrence of wood pastures depending on environmental variables, and (iii) assessing the feasibility of re-establishing wood pastures based on their present state and suitable environmental variables and meeting new challenges related to global and socioeconomical changes.

2. Materials and Methods

Determining the potential for wood-pasture restoration came out of (i) the traditional knowledge on historical presence of silvopastoral ecosystems, (ii) recent conditions and distribution, and (iii) defining presence of the location and selected landscape–ecological conditions and identifying restoration potential of wood pastures. Data on the former distribution of wood pastures are a crucial point in the decision process on their perspective for future agroforestry purposes. Relict wood-pasture sites were identified using old records or maps or a combination of traits, such as the presence of old (veteran) trees, trees with symptoms of former grazing pressure (e.g., overall tree density, structure, and species composition), open or partially open-grown trees, uneven stocking, irregular site boundaries, patchiness with frequent glades, and areas with scattered trees [19]. Even in normally structured dense woodlands, the presence of open-grown veteran trees is invariably a sign of a former wood pasture or an open woodland [38]. The historical distribution of wood pastures was assessed based on aerial photographs taken in the 1940s and 1950s during the first complex aerial imaging of the Slovak territory. This dataset provided a unique image of the traditional landscape organization just before the initialization of the broad-scale process of collectivization and transformation of landscape management during the Communist era [39]. We thoroughly examined the area of two self-government regions—Banská Bystrica (9454 km^2) and Košice (6755 km^2)—identifying intact silvopastoral sites. Wood pastures were visually identified based on characteristic textural features in both areas, which were indicative for several well-preserved recent wood-pasture localities. These features mainly incorporated open-tree formations, solitary trees (particularly veteran trees), well-distinguished boundaries of the land-use form, macro signs of active grazing mainly in the form of eroded tracks, and no obvious transition zones to a closed-canopy forest. Within every wood pasture, the presence of core (veteran) trees was observed. The following cartographic materials were used as an input: aerial photographs from the 1940s and 1950s (black and white, resolution 0.5 m, © GEODIS Slovakia, Military Topographic Institute Banská Bystrica) and satellite images (© EUROSENSE, GEODIS Slovakia). These materials were used via the WMS server for further processing in the ArcMap 10.3 program (ESRI, Redlands, CA, USA), which was used for all procedures applied within this study.

To identify present conditions and spatial distribution of wood-pasture habitats, we compared the historical data with recent ortophotomaps (from 2021). This approach allowed for identification assessment of the management cessation and its impact on recent habitat conditions. We elaborated a comprehensive geodatabase on spatial distribution, historical area extent, and present state of silvopastoral habitats.

Based on landscape–ecological analyses of historical distribution, we determined prevailing environmental conditions of wood-pasture locations. In the ArcGIS 10.3 program (ESRI) 2000, random points were generated with a minimum mutual distance of 30 m. One half of these points was distributed at historical wood-pasture localities, and the rest was randomly dispersed within areas apart from wood pastures. Every single point had determined elevation, slope gradient (mean gradient within the 100 m circle radius), relative relief (the difference between the highest and the lowest points within a circle of 1 km radius), slope aspect, distance from settlement, and distance from road network.

Data for landscape–ecological analyses were used as follows: relief inputs—morphographic type, slope gradient, elevation, slope orientation, and relative relief were derived from 10 m digital elevation model (DEM 3.5) provided by the Geodesy, Cartography and Cadastre Authority of the Slovak Republic. For modeling the Euclidean distance from the center of settlements, we used Corine Land Cover layer from 2018 [40]. The road network was extracted from the Open Street Map website [41]. Only roads of the third class and higher were used in the analyses. Soil quality was derived from typological and production categories of agriculture soils (see: Supplementary material for details, Table S1) [42] and was divided into 15 categories as follows: 1—forest; 2—unsuitable for agroecosystems; 3—low-yielding permanent grassland; 4—medium-productive permanent grassland; 5—productive permanent grassland; 6—low-productive fields and productive grasslands; 7—less-productive fields and productive grasslands; 8—medium-productive fields and productive grasslands; 9—low-productive arable land; 10—medium- to low-productive arable land; 11—medium-productive arable land; 12—productive arable land; 13—very productive arable land; 14—highly productive arable land; and 15—the most productive soils. The dependency between occurrence of wood pastures and individual variables was then tested using Pearson's contingency table chi-square goodness-of-fit test [43–45], based on comparison of differences between observed and expected frequency values. If the difference was statistically significant, the null hypothesis was rejected; hence, the two criteria of classification are not independent [44].

Cramer's V coefficient was used as a measure of the strength of the association between the variables. The R software (version 4.1.0) [46] was used for all statistical evaluations.

We used Cramer's V coefficient (phi values) according to [47] as criteria for identifying the magnitude of an effect size (for contingency table $2 \times k$) as follows: small effect size: $0 < p < 0.30$; medium effect size: 0.30 s $< p < 0.50$; and large effect size: $p > 0.50$.

Dependencies between wood-pasture historical presence and particular landscape–ecological variables were evaluated using tree-based model. Tree-based models are used for exploratory data analysis and prediction due to their simplistic nonparametric design. Instead of fitting a model to the data, tree-based models recursively partition the data into increasingly homogenous groups based on values that minimize a loss function (such as Sum of Squared Errors (SSEs) for regression or Gini Index for classification) [48]. We used Rpart package [49] for generating tree-based models in R (R Foundation for Statistical Computing, version 4.1.0, Vienna, Austria) [46].

3. Results

3.1. Historical and Recent Distribution of Wood Pastures

Based on historical data (aerial imagery) of Slovakia taken in the late 1940s and the early 1950s, we identified 100 wood-pasture habitats across the whole study area, clustered into three broader groups (Figure 1). Within these two respective regions, the total area of the wood-pasture localities covered 20.84 km^2. They represented a relatively diverse group of wood-pasture habitats, regarding their area, cover, and age of trees; nevertheless, all the sites bear common representative features, namely obvious erosion tracks from grazing animals, well-defined spatial delimitation, and no signs of excessive shrub encroachment. During the 1940s and the 1950s, most wood pastures were intensively managed and had no signs of abandonment or cessation.

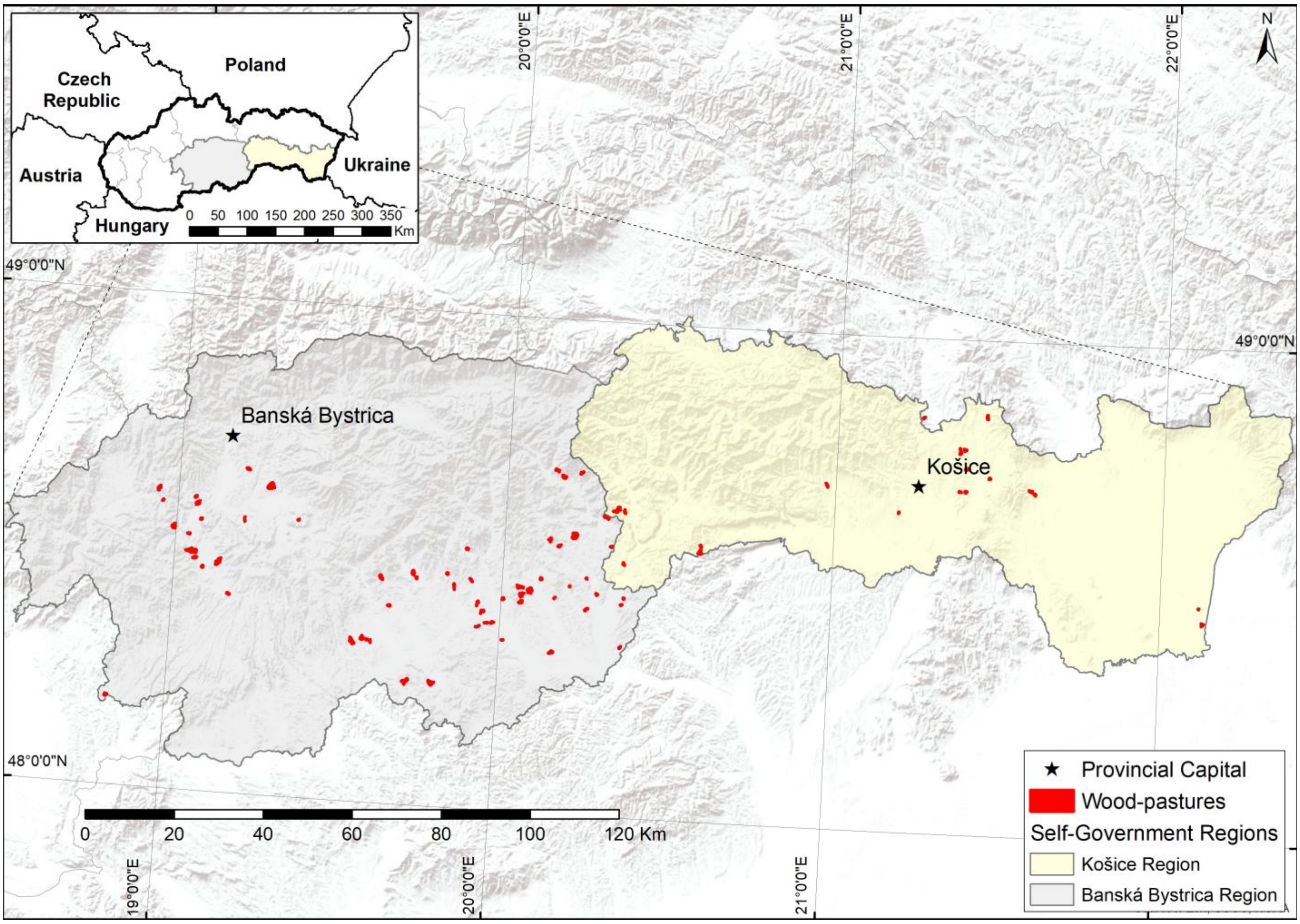

Figure 1. Location of intact wood-pasture habitats based on aerial photographs from early 1950s.

The assessment of the recent situation identified that only eight wood-pasture localities retained the original and relatively open structure (see: Table 1). Most of the remaining localities (61 sites) are currently heavily or moderately encroached considering the previous land use and are currently preserved in a form of closed-canopy forest because of long-term cessation of traditional management. Altogether, 31 former wood-pasture habitats were actively changed to different land-use forms, with mainly arable land and intensively mowed or grazed grassland being the most frequent (Figure 2).

Table 1. Land-use change of wood pastures in the period 1950–2021 in the study area expressed as km^2 and percentage of total wood-pasture area.

Recent Land Use	Number of Sites	Area (km^2)	Area (%)
Wood pastures	8	3.95	18.96
Wood pastures with different levels of encroachment	61	10.09	48.41
presence of vital core (veteran) trees remained	36	6.76	32.44
without/or less than 30% of remained vital core (veteran) trees	25	3.33	15.97
Conversion (pastures, arable land, built-up, etc.)	31	6.80	32.63
Total	100	20.84	100.00

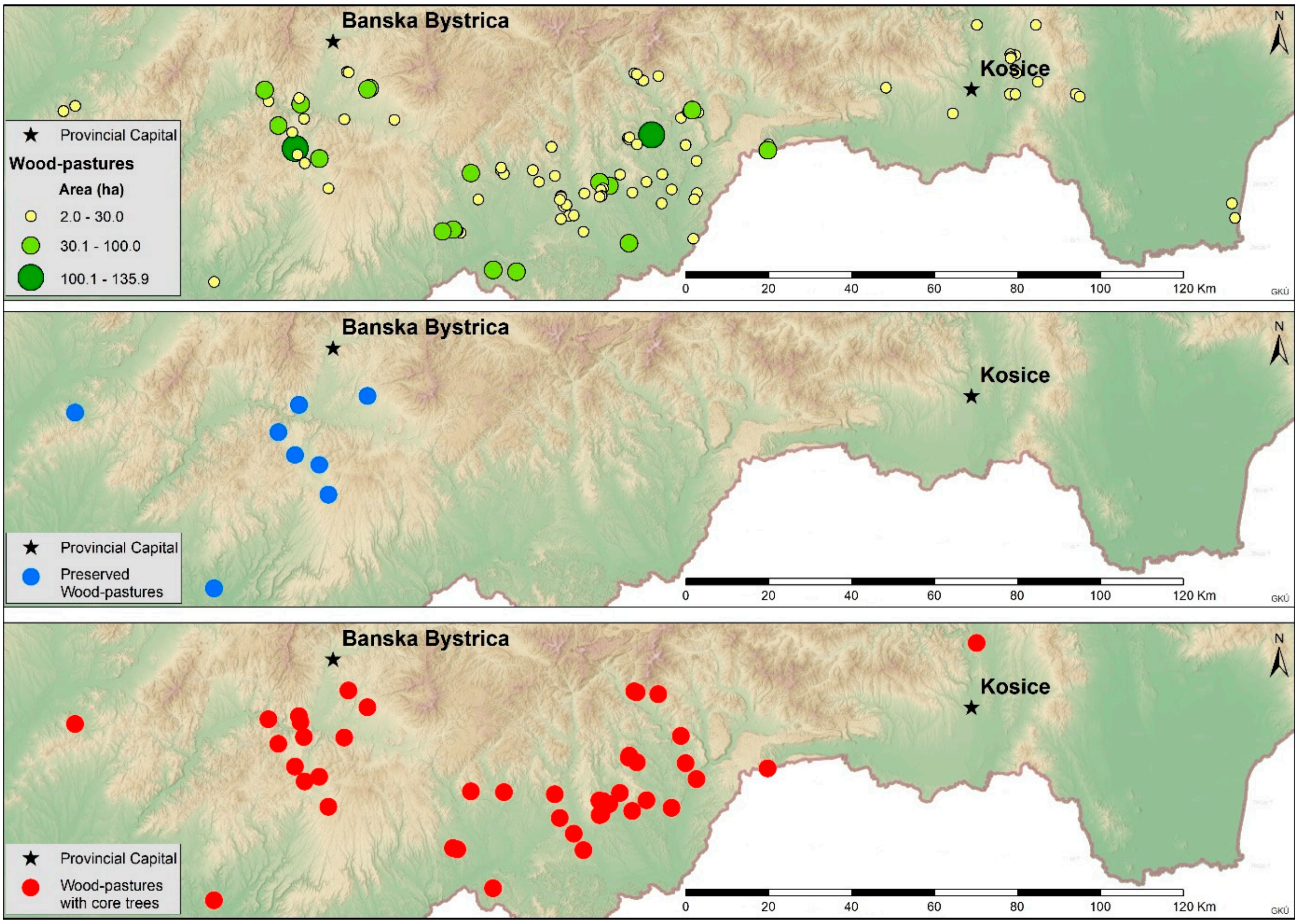

Figure 2. Detail of historical and present state of wood pastures: (i) historical wood-pasture area and distribution (**top**); (ii) preserved wood pastures (**middle**); and (iii) abandoned wood pastures with high restoration potential and preserved veteran trees (**bottom**).

In order to identify abandoned localities with the potential for restoration of wood-pasture habitats, we inspected the aerial photographs of all sites for the presence of vital veteran trees from the original wood pasture. From the total number of 61 localities with varied levels of shrub and tree encroachment, we identified residuals of vital veteran trees in 36 localities with a total area of 6.76 km^2.

3.2. Spatial Location of Wood Pastures within the Landscape–Ecological Context

The spatial analysis confirmed that wood-pasture sites are aggregated at a higher significance level as 99% (p < 0.000001). The dependency between the wood-pasture historical presence and different landscape–ecological variables is shown in Table 2 and in Figure 3 after using the tree-based model. Table 2 contains Pearson's contingency table chi-square test and Cramer's V, which is frequently used to explain the strength of association from chi-square analyses.

Table 2. Association between historical presence of wood pastures and evaluated environmental variables.

Environmental Variables	X-Squared	df	*p*-Value	Cramer's V
Slope gradient	153.96	5	2.2×10^{-16}	0.277
Elevation	553.7	5	2.2×10^{-16}	0.526
Slope orientation	15.071	7	0.0351	0.087
Relative relief	289.83	4	2.2×10^{-16}	0.381
Distance from center of settlements	108.02	9	2.2×10^{-16}	0.232
Distance from road network	60.491	10	2.926×10^{-9}	0.174
Typological and production categories of agriculture soils	350.62	10	2.2×10^{-16}	0.419

Where Cramer's V: 0–0.1—no association; 0.1–0.3—weak association; 0.3–0.5—medium association; and over 0.5—high association.

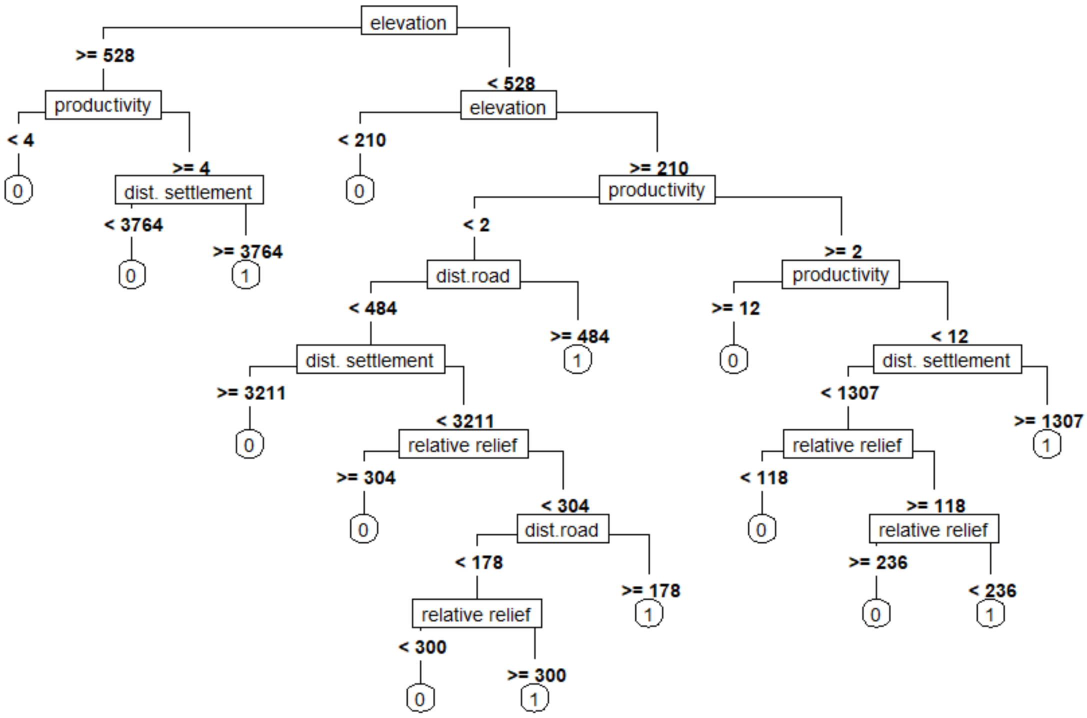

Figure 3. Tree-based model of dependency between silvopastoral historical presence and evaluated environmental variables. Zero is interpreted as a low probability (below 50%) to be wood pasture, and one means a higher probability (above 50%) to be wood pasture. Numbers below 0 and 1, e.g., 325/9 on the far left, mean how many points met the criteria of 0 (before the slash) or 1 (after the slash).

The most Important selective feature was related to the elevation. The actual location of wood pastures was limited to elevations under 210 m, where the probability of a wood pasture being situated in such conditions was well below 50%. Most of the wood pastures were situated in the elevations between 210 and 530 m, and above the upper threshold, wood pastures were found only in remote areas, where the distance from the nearest settlement was greater than 3760 m and confined to at least a medium quality of soil (not below grade 4 of the production category). In the core elevation area of wood-pasture occurrence, their location was further characterized by a variety of factors and their combinations, mainly the soil productive potential, distance from settlements and roads, and relative relief. On the best soils (production category over 12), wood pastures were established less frequently, with a probability below 50%. On the worst soils (production category below 2), they were established rather within the combination of a medium distance from settlements (above 3200 m) and with no adjacent roads (distance above 178 m) on medium-rugged reliefs (category of hills and highlands). On medium- and better-quality soils (production category 2–11), the distance from the settlements started from 1300 m, and the sites were also located on a rugged relief in the category of highlands. The establishment was then rather sporadic within a slightly rugged relief (plains) and a very rugged relief (mountains). More detailed data on the association of the historical presence of wood pastures and the evaluated environmental variables are shown in Figure 4. The graphs in Figure 4 compare the observed values and expected values of wood-pasture occurrence. The greater the difference between the compared values, the greater the affinity—either positive or negative. Greater observed values than expected values express more frequent wood-pasture occurrence than would be expected by chance within the category of environmental variables and vice versa.

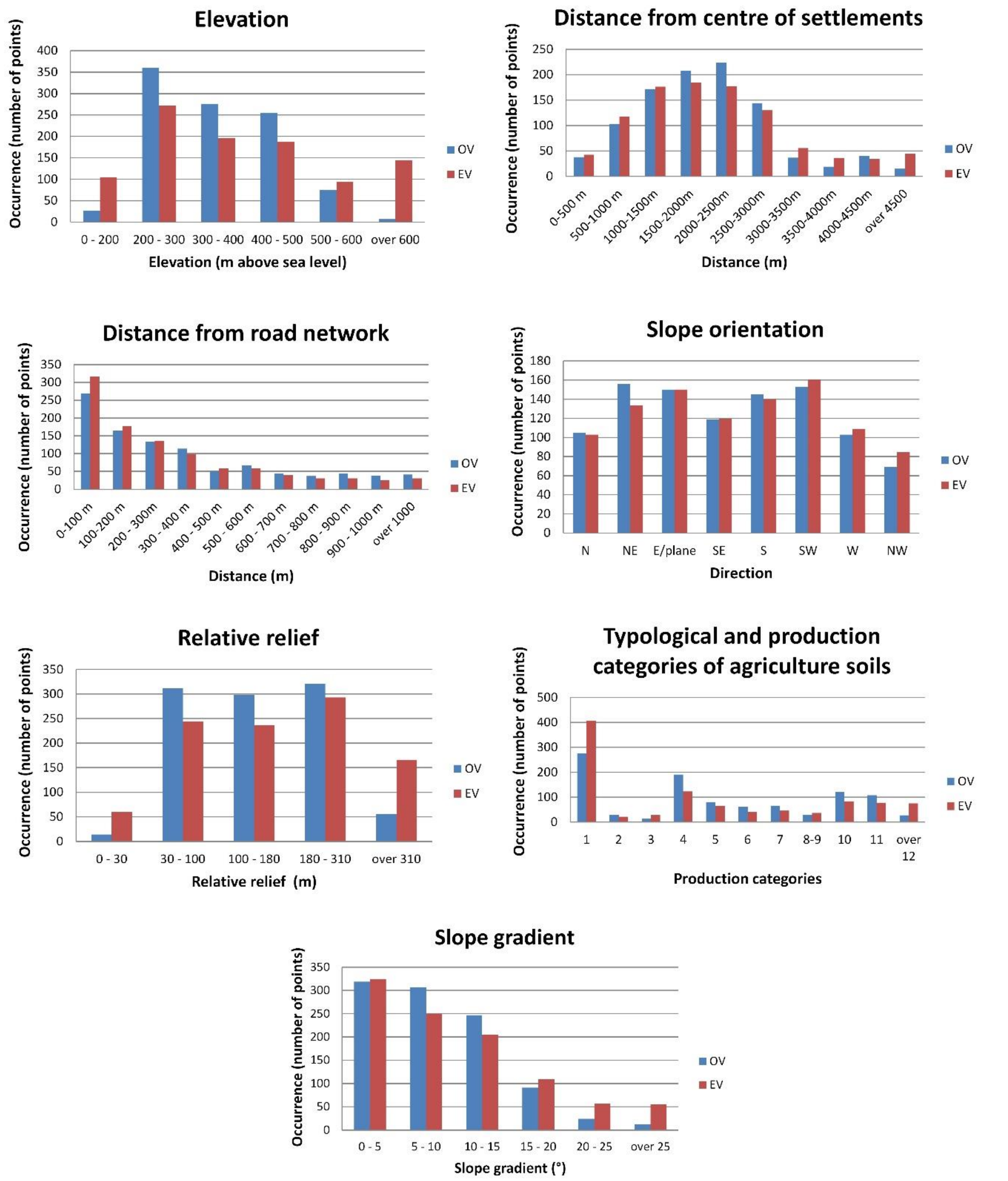

Figure 4. Association of historical wood-pasture presence and evaluated environmental variables; OV—observed values and EV—expected values.

3.3. *Potential for Restoration of Historical Wood Pastures*

Out of the 100 historical wood-pasture localities identified during our research, only eight maintained their characteristic structure and are preserved relatively unchanged and with the continuous traditional management based particularly on grazing, in combination with sporadic removals of extensive shrub encroachments. From the dataset of 100 wood pastures identified on historical aerial photographs, 61 showed different levels of extensive woody species encroachment (Figure 5); nevertheless, vital core trees, as a significant structural element, were identified within 36 localities (Figure 2).

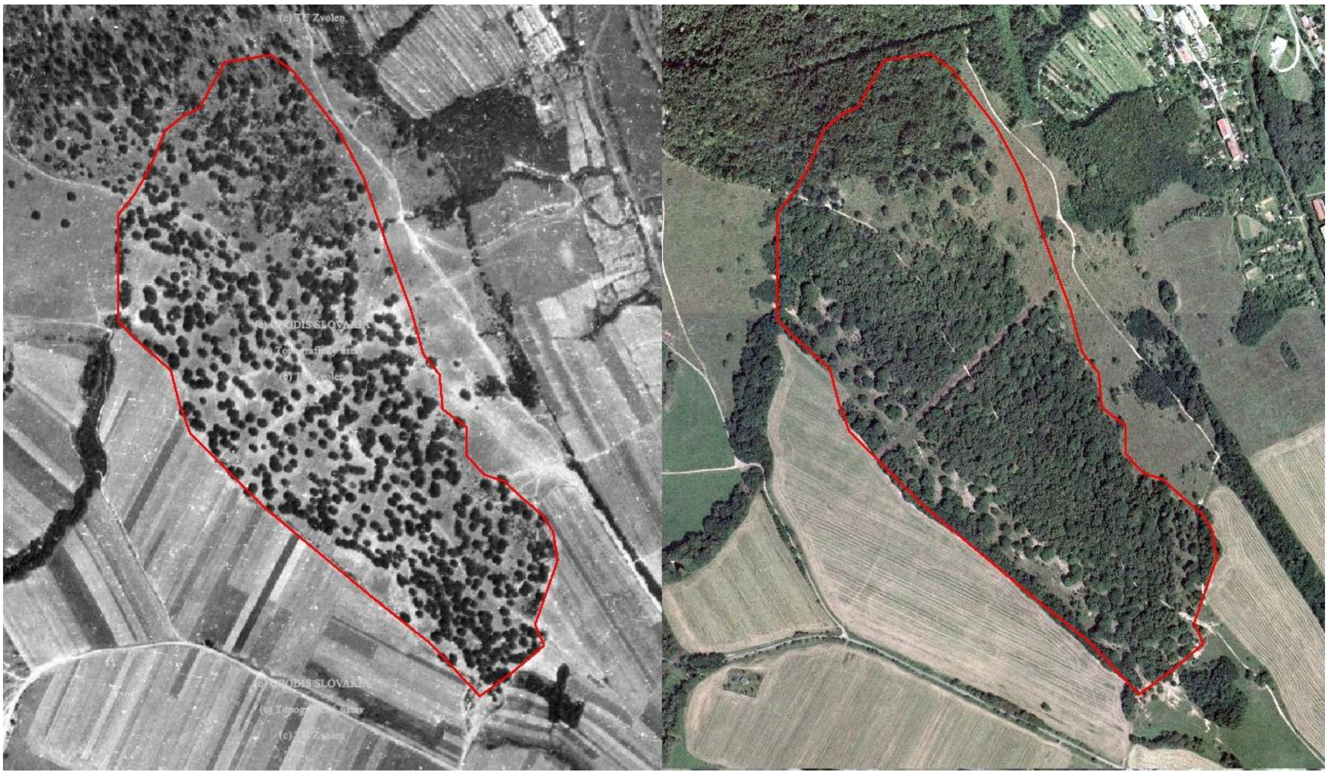

Figure 5. Comparison of historical wood pasture with present situation typified by excessive woody species encroachment because of the long-term cessation of grazing at the locality of Katarínska Huta, Central Slovakia. Even after 70 years, the veteran core trees are present at the locality and represent a potential for effective restoration of historical structure. Historical orthophotomap © GEODIS SLOVAKIA and historical aerial imagery © Topographic Institute Banská Bystrica, ortophotomap © EUROSENSE, GEODIS Slovakia.

The presence of vital core trees in recent wood pastures is crucial for the short-term restoration of functional silvopastoral ecosystems. Hence, we identified these 36 localities as top priorities for potential restoration, since the re-establishment of historical conditions would require only moderate restoration management based on the removal of excessive woody plant encroachment and the reintroduction of a traditional grazing regime. Because the presence of mature core trees within a typical spatial matrix is one of the basic structural and functional features, the restoration potential of the rest of the localities, with the historical removal of core trees, or even extant land-use change, is much more limited and would require significantly more effort and time to restore the historical and characteristic structure and functioning (Figure 6).

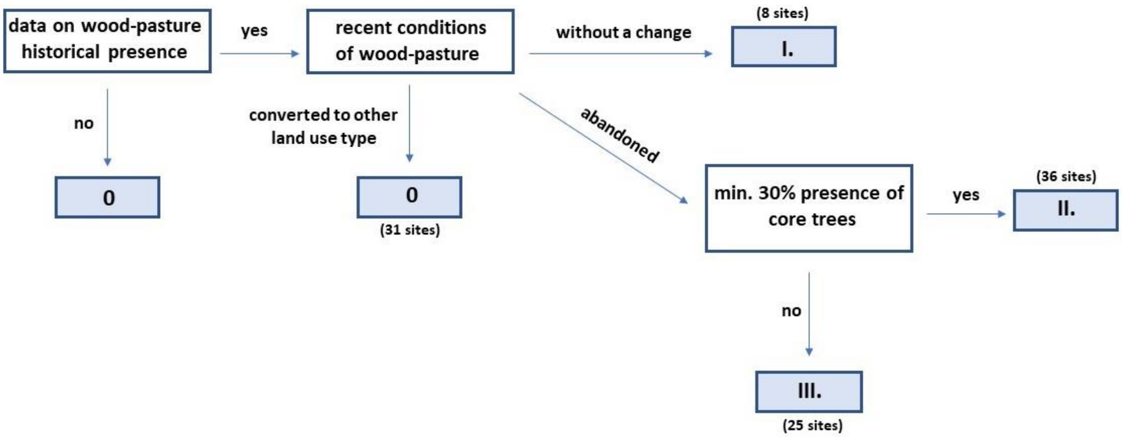

Figure 6. Decision tree classifier based on the potential for restoration of historical wood pasture. The potential for restoration decreases from the category I to III, and 0 refers to zero potential. Numbers in brackets represent the number of localities within each category identified in our research.

4. Discussion

4.1. Historical Distribution and Recent Decline of Wood Pastures

The presence of wood pastures as a specific form of a seminatural habitat depends on direct and active management, which has been widely used in Europe since the Middle Ages [11]. The increasing demand for food and infrastructural, urban, and industrial development put significant and contrasting pressure on open landscapes [50] and resulted in consequent and contrasting land-use changes in the form of active management cessation, land abandonment, or land-use intensification [20]. Within the complex and geographically specific process, the split of previously combined agricultural and forestry land uses was especially strengthened and played its role during the 20th century. Single-purpose-oriented management resulted in the development of separate organizations focused solely on forestry or agriculture. The tendency to isolate grazing of stock from the forested area is closely related to the rise of industrial forestry and is still a prevalent legislative paradigm in most European countries including Slovakia [51] and has an enormous impact across Europe [52].

Moreover, the politically driven process of collectivization in Eastern Europe [52] was very successful in interrupting and transforming the traditional relation of rural communities to common land. During the transition to a large-scale production scheme in the late 1950s, the Slovak rural landscape underwent a massive development of unification. Long-established land organization and management were pursued mainly in localities with less favorable environmental and agricultural conditions. Unlike arable land, the wood pastures were sidelined from any form of management for several decades, transforming the land into low-productive forests. As a result, a large majority of wood pasture and other grazed habitats identified in the study area from 1950s are currently overgrown or have vanished completely.

The shift of the social paradigm toward traditional land organization also had negative repercussions for wood pastures, turning them into an obsolete component set aside at the outskirts of the landscape and out of sight. In this way, wood pastures, once a crucial and vital part of the rural landscape, became virtually extinct in Central Europe [12,22].

In the first half of the 20th century, there were virtually hundreds of localities of open-canopy habitats with sparse tree and shrub formations used for grazing of various intensity across Slovakia [22]. They ranged from seminatural grazing sites on steep limestone slopes and subalpine and mountain grazing sites with dispersed conifers to precisely spatially delimitated wood-pasture localities in low elevations, with well-established boundaries, and a multipurpose component of veteran oak trees, the latter being the main topic in our paper.

We thoroughly analyzed this metaset of grazing habitats within the two respective regions and selected altogether 100 localities, based on the precise revision of characteristic features as wood pastures sensu stricto. All other ecosystems, which did not match the selected attributes essential for wood-pasture identification, were excluded; nevertheless, they represent an impressive set of seminatural grazing habitats that underwent a similar trajectory of abandonment and encroachment. Due to the abandonment and cessation of the traditional management based particularly on the grazing of large herbivores, virtually all wood pastures identified in our study gradually lost their former open characteristics, a development path recorded for several European countries [21]. Within the study area, only eight localities persisted and maintained their original structure; 61 areas were heavily overgrown because of abandonment.

Within Slovakia, as an example of what happened in most of Eastern Europe, the forest cover has continuously increased from 33.8% in 1920, to 35.1% in 1945 [53], and to the recent share of 41.3% [54]. The encroachment of wood pasture and other seminatural grazing habitats and their overall decline plays a partial role in the forest expansion, reported by several European countries [12,21,55,56], where the lack of management has caused important environmental concerns. This fact together with the EU afforestation program caused an increase in unmanaged forests across the EU [52] that are used to fulfil the Kyoto Protocol commitments, but the lack of management caused relevant wildfires and forest destruction also associated with extreme weather events, such as strong winds.

The intensification of agricultural use associated, among others, with the CAP payments, often associated with the conversion of wood pastures to other types of land cover, also had a largely detrimental effect on wood pastures [20], resulting, in Slovakia's case, in around 31% of the historical localities being lost irreversibly due to the conversion into arable land, meadow, or even urbanized area.

The collapse of this traditional land-use form had a consequence from both an agricultural and a natural perspective. The concept of wood pasture incorporated a multipurpose land-use form, which provided a set of productive, regulating, and even cultural services within a well-balanced grazing site, and there was no need for excessive energetic inputs. With their ability to integrate grazing activities with a sustainable timber harvest and produce hay and fodder and various other products and services in one place, wood pastures were highly functional man-made ecosystems paralleling nowadays the concepts of sustainable land-use forms [22]. The presence of large veteran trees with an open canopy and sufficient spacing was crucial for maintaining rich communities of shade-intolerant specialist species, confined to both the grazed understory and a diverse supply of sun-exposed deadwood habitats, such as tree cavities [57]. The process of abandonment resulted in consecutive overgrowing and the loss of an open microclimate, which was a critical condition for original communities [58]. It may be challenging to maintain even the rudiments of the original assemblages in the closed-canopy forest that replaced these habitats within their historical range [59]. At the same time, the effective restoration of wood pasture may play an important role in tackling the biodiversity decline reported from rural areas in Europe [60].

4.2. Wood-Pasture Restoration Potential

Only half of the overgrown wood pastures had core veteran trees preserved, representing a crucial element for wood-pasture restoration. In the former untreated wood pastures, large veteran trees were more common compared to other actively managed ecosystems, including forests [18,61]. This is probably because trees growing in pastures have several functions other than just wood, and trees can provide these functions even when they grow older [62,63]. Despite the undoubtful and diverse functions and services such trees provide, attitudes and behaviors toward large old trees can be very contrasting [64]. Even nowadays, core veteran trees are occasionally removed from wood pastures due to their decreasing commercial value, CAP tree limitations [65] related to old age, and stem malformations related to previous coppicing or pollarding [66,67]. Retaining a viable population of veteran trees may hence be challenging, even under conditions of active management.

A big challenge for the restoration of abandoned and/or overgrown wood pastures is the re-establishment of complex active management allowing the provision of the former benefits. This can be achieved when overgrown areas are cleared, grazing regime is re-introduced, and, at the same time, vital core trees are present and retained [68] thereby notably increasing the number of ecosystem services these areas deliver [11]. Because the restoration of veteran core trees is technically ineffective after their removal, those sites with a persistent population of core trees, even if heavily overgrown, should be identified and prioritized in the restoration effort.

Initial interventions can largely determine the outcome of the restoration process [69]. In many cases, scrub clearing and core tree retention can interfere and steer grazing management, critical for the long-term maintenance of the understory structure and overall open nature of the locality [50,70,71]. Pulsative human land use through rotating management systems and techniques, widespread cattle grazing, bush cutting, or hay production, together with the high recovery possibility of trees and shrubs, makes an ever-changing landscape pattern [72]. The steric asynchronization of the process triggers the soft landscape pattern to shift with all the participating structural vegetation types [73], which furthermore triggers and maintains the recovery of biodiversity and regulatory services within the locality under restoration [36].

4.3. Environmental Variables of Wood Pastures

The results show that the studied wood pastures were not established randomly, but were rather set within a certain landscape context, characterized by altitude, soil quality, and distance from settlements. These findings further suggest that wood pastures played a significant role in the historical landscape of Slovakia and were clearly distinguished from transitional habitats that might naturally occur at the boundaries of contrasting land-use forms. The most important selective factor from the environmental variables was the altitude. Most of the identified wood pastures were situated in lower altitudes of 210–530 m a.s.l. This exact placement may be driven by the need of a particular tree species that was used within the wood pasture; in our case, the species were predominantly selected oak and hornbeam. These trees are best suited to lower elevations. A wood-pasture study from Southern Transylvania [18] suggests a higher mean elevation (543 m a.s.l.) for this type of wood pasture, but this differentiation is explained by distinct geoecological and climate conditions. A higher elevation is suitable for other tree species, such as beech [62], used also in wood pastures, which prefers more humid and cold microclimates [74].

Silvopastoral ecosystems were not usually established within the most productive soils (see Figures 3 and 4), which were reserved for more intensive land uses, predominantly arable land. Our results suggest that wood pastures were established within less favorable soil conditions and relatively far from the center of the nearest settlement (3200 m), placed within a broad pattern of settlement—arable land—wood-pasture—forest. The role of distance might be thus perceived as a function of manpower, time, and effort needed to be spent within a particular land-use form.

Interestingly, if the quality of soil improved, wood pastures were established farther away than 1300 m from a settlement, within medium and higher quality categories. A study of open-canopy orchard meadows showed a significant decrease within the first 300 m around settlements and a slight increase in areas located further than 1000 m away [61]. The relatively long distance from the settlement is likely one of the drivers of wood-pasture cessation. Wood pastures more frequently persisted in localities close to villages [62] or were even within sight distance [64], probably due to the facilities they need. On the other hand, more distant localities had a higher chance of being abandoned. The subsequent transformation to a more intensive form could have been hindered by a relatively higher cost due to the distance or was not seen as a political priority, due to the remoteness of the area. Therefore, the abandoned wood pastures retained their crucial structural components, allowing for effective restoration, despite undergoing a substantial natural transformation due to the absence of a characteristic disturbance regime [19,21].

We agree that the above-mentioned variables do not fully describe all relations. Certain historical socioeconomical parameters and contexts have not been identified yet. Our results hint to a higher frequency of wood pastures in regions with former Saxon culture and traditions, such as the broad region of historical mining towns in Central Slovakia. Interestingly, the results of Moga [64] connect old oak trees and wood pastures with the Transylvanian Saxons. Whether this was the case in Slovakia remains unclear and requires further research. Nevertheless, it is quite intriguing that such a practice related to the highly effective multipurpose production aspects of wood pasture may have been introduced to our area within the German colonization and consecutive rise of mining activities [75].

5. Conclusions

The evidence is clear. Most of the wood pastures identified in the 1950s across the study area have now been lost or encroached. Only eight wood-pasture localities have been preserved in a similar form in which they were established and managed for decades or even centuries. We place significant hopes for the restoration in 36 overgrown wood-pasture locations where vital core trees have been preserved. Active management based on clearing and grazing can reverse the present unsatisfactory state and allow the provision of former benefits. Analyses of environmental variables have shown that studied wood pastures were not established randomly, but were rather set within a certain landscape context, characterized by elevation, soil quality, and distance from settlements. This knowledge could help in prioritizing locations for the restoration management of abandoned wood pastures from a feasibility point of view and choose those that have the highest potential to be successfully restored.

Wood pastures do not currently represent a transitional habitat between open fields and forests, but rather a distinct and well-established land-use form, and they are associated with high cultural and biodiversity values in Europe. However, due to the lack of active management or historical transformation to different land-use forms, large areas of wood pastures have been lost over the last century. Currently, the rural landscapes in Europe face challenges related to the transformation in a socioeconomic context, biodiversity decline, and climate change—all addressed directly by legislation of the European Green Deal and Common Agricultural Policy. Because wood pastures incorporate aspects of sustainable agriculture, they provide many regulatory, productive, and social services, and at the same, they foster biodiversity and function as a critical refugia for many endangered species, they should play a central role in achieving the goals of nature conservation and reforms addressing the resilience and biodiversity of agricultural landscapes, which unfortunately has not always been the case. New European legislation sets ambitious goals for the restoration of European nature, incorporating complex restoration activities, under the New Restoration Law. We are convinced that the restoration and protection of wood-pasture habitats must play a crucial role in such an effort. This, however, is highly dependent on the precise protection and safeguarding of proper management for existing wood pastures and thorough the identification of historical sites suitable for restoration activities and the re-establishment of important historical know-how for sustainable close-to-nature and future-proof agriculture.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/f14010068/s1, Table S1: Typological and production categories of agriculture soils.

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