AGROCIENCIA URUGUAY

Agrociencia Uruguay 2026 | Volume 30 | Number NE1 | Article e1642
DOI: 10.31285/AGRO.30.1642
ISSN 2730-5066

Investigaciones en pecán en Sudamérica

Edaphoclimatic Zoning for Pecan Trees in Southern Brazil

Filippini-Alba, J. M. [1]; Wrege, M. S. [2]; Martins, C. R. [1]

[1]*Empresa Brasileira de Pesquisa Agropecuária (Embrapa), Embrapa Clima Temperado, Pelotas, RS, Brasil*

[2]*Empresa Brasileira de Pesquisa Agropecuária (Embrapa), Embrapa Florestas, Colombo, PR, Brasil*

Abstract

Edaphoclimatic zoning for walnut trees is a modeling of climate and soil properties for favorable planting conditions. The evaluated areas as Preferential class, Recommended class and Few Recommended, fertility-only restricted class occupied 236 ha or 0.04% of total territory, 49,207 ha or 8.5%, and 146,074 ha or 12.7%, respectively. That is almost 120 times the planting area of pecan orchards, with 1,652 hectares. Thus, there is a significant potential for pecan production in the region. Rio Grande do Sul is the most favored state with 42,832 ha of recommended areas, for varieties of 200-300 chilling hours or 300-500 chilling hours, followed by Parana and Santa Catarina states, both with 1,056 ha. While Parana concentrates 1,045 ha as recommended aptitude for varieties of 300-500 chilling hours, Santa Catarina has a somewhat more balanced distribution. These states have more areas of "Few Recommended, fertility-only restricted" class, whose aptitude is adequate in all properties as recommended class, except for fertility, which is a property easy to adjust at field, incorporating inputs. Southern Brazil region covers 576,257 km^2, 35% correspond to Preferential, Recommended and Few Recommended areas, 61.5% of territory is related to not recommended or restricted areas, 3% represent body waters, and 0.5% are urban areas.

Keywords: climate, production, soil, walnut, zone

Editor

María Cristina Soldati
Instituto Nacional de Tecnología Agropecuaria (INTA). Buenos Aires, Argentina

Received *19 Dec 2024*
Accepted *13 Feb 2025*
Published *13 Feb 2026*

Correspondence

Jose M. Filippini-Alba
jose.filippini@gmail.com

CC BY

Filippini-Alba, J. M., Wrege, M. S., & Martins, C. R. (2026). Edaphoclimatic zoning for pecan trees in southern Brazil. *Agrociencia Uruguay, 30*(NE1), Article e1642.
https://doi.org/10.31285/AGRO.30.1642

Zonificación edafoclimática para nogales de pecán en el sur de Brasil

Resumen

La zonificación edafoclimática para cultivo de nogal-pecán es en realidad un modelo para condiciones de suelo y clima favorables al cultivo de la especie. Las áreas evaluadas como Preferencial, Recomendada y Poco Recomendada con restricción solamente por fertilidad ocuparon 236 ha o 0,04% del territorio, 49207 ha o 8,5% y 146074 ha o 12,7%, respectivamente, lo que representa casi 120 veces el área total de frutales de pecán, de 1652 ha. Por lo tanto, existe un gran potencial para el cultivo de nogales en la región. Río Grande del Sur es el estado más favorecido con 42832 ha de áreas recomendadas, principalmente para variedades de 200-300 horas de frío, o 300-500 horas de frío, seguidos por Paraná y Santa Catalina, con 1056 ha cada uno. Mientras Paraná concentra 1045 ha de la clase recomendada para 300-500 horas de frío, Santa Catalina posee una distribución más balanceada. En Santa Catalina y Paraná hay escases de áreas preferenciales y recomendadas, pero crece la ocupación de la clase «Poco recomendada con restricción solamente por fertilidad», cuya aptitud es adecuada en todas las propiedades del suelo, con la excepción de la fertilidad, que es fácilmente corregida en campo por adición de fertilizante. La región sur de Brasil cubre 576257 km^2, de los que 35% corresponden a áreas preferenciales a poco recomendadas para cultivo de pecán, 61,5% son áreas no recomendadas o restrictas, 3% son cuerpos de agua y 0,5% son áreas urbanas.

Palabras clave: clima, producción, suelo, nuez, zona

Zoneamento edafoclimático para nogueira-pecan no Sul do Brasil

Resumo

O zoneamento edafoclimático trata-se de uma modelagem para condições de clima e solo favoráveis ao cultivo da espécie. As áreas avaliadas como Preferencial, Recomendável e Pouco Recomendável com restrição somente por fertilidade ocuparam 236 ha ou 0,04% de território, 49207 ha ou 8,5% e 146074 ha ou 12,7%, respectivamente, o que representa quase 120 vezes a área total dos pomares plantados de nogueira, de 1652 ha. Assim, existe grande potencial para o cultivo de Nogueira-pecan na região. Rio Grande do Sul é o estado mais favorecido com 42832 ha de áreas recomendadas, principalmente para variedades de 200-300 horas de frio ou 300-500 horas de frio, seguido por Paraná y Santa Catarina com 1056 ha cada um, coincidentemente. Enquanto Paraná concentra 1045 ha da classe recomendada para 300-500 horas de frio, Santa Catarina possui distribuição mais balanceada. Nos estados de Santa Catarina e Paraná há poucas áreas preferenciais e recomendadas, porém existe abundancia da classe “Pouco recomendada com restrição somente por fertilidade”, cuja atitude agrícola adequa-se a todas as propriedades do solo, com a exceção da fertilidade, que pode ser facilmente corregida no campo por adição de fertilizante. A região Sul do Brasil cobre 576257 km^2, sendo 35% relativos a áreas preferenciais a pouco recomendadas para cultivo de pecan; 61,5% são áreas não recomendadas o restritas, 3% correspondem a corpos d’água e 0,5% são áreas urbanas.

Palavras-chave: clima, produção, solo, noz, zona

1. Introduction

Although the pecan planted area is concentrated around its region of origin, that is, United States and Mexico, its cultivation and production has expanded in several parts of the world (Martins, Hoffmann, et al., 2023), such as Brazil, Uruguay, Argentina, Chile, Peru, South Africa, Australia (Oliveira et al., 2023), and, recently, China. Based on information from the International Nut and Dried Fruit Council Foundation, global pecan production has been growing over the years. Production was close to 68 thousand tons in 2004, reaching more than 154 thousand tons in 2022, what represents an increase of almost 100% (International Nut and Dried Fruit Council, 2023; Martins et al., 2019).

As the fifth largest production of pecan in the world, Brazilian production reached 6,127 tons with 4,634 cultivated hectares in 2022 (Instituto Brasileiro de Geografia e Estatística [IBGE], n.d.b), depending basically on four

states, Rio Grande do Sul, the main producer, Paraná and Santa Catarina, with lower production, and São Paulo, with minimum contribution (Figure 1). In Brazil, the estimated pecan planted area is around 10-12 ha, with most of the orchards being at a juvenile stage (Martins, Barreto, et al., 2023). Pecan production has become increasingly important, especially in the southern region of the country, with tradition and favorable climatic conditions for fruit-culture. In the 2022/2023 harvest, the state of Rio Grande do Sul produced more than 4.2 thousand tons of pecan nuts, representing a significant increase in production compared to previous years (Instituto Brasileiro de Pecanicultura, 2022).

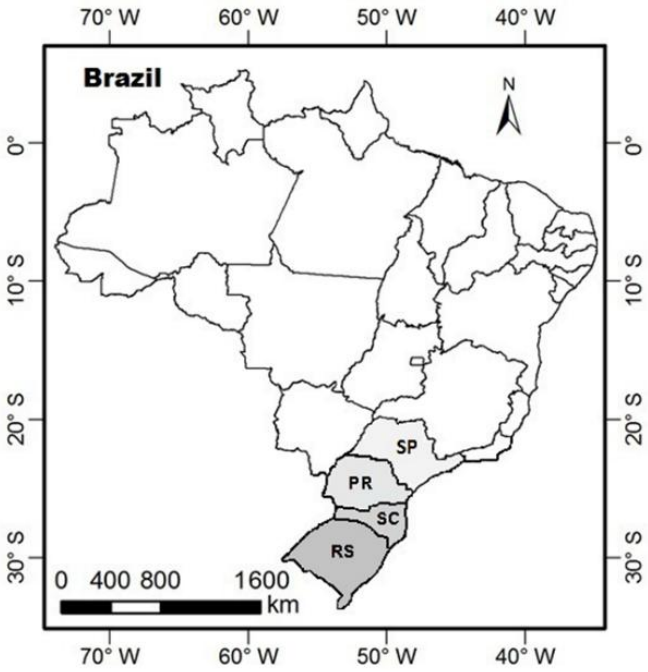

Figure 1. Location of the three Brazilian states with significant production of pecan nuts: Parana – PR, Santa Catarina – SC, and Rio Grande do Sul – RS

Pecan nuts' health benefits incremented the interest and the expansion of cultivation in Brazil (Oliveira et al., 2023). Furthermore, the consolidation of walnut exports, together with the emergence of new agro-industries, the development of the machinery and equipment sector, as well as the generation of technologies and the advancement of scientific technical knowledge have structured the Brazilian production chain. However, its productivity is still very low (Martins, Barreto, et al., 2023), and advances in qualified cultivation in terms of production, fruit quality and financial profitability depend on appropriate climatic and soil conditions.

The pecan tree originates from Northern Mexico and Mississippi region, US (Texas and Georgia), with occurrence of dry climate, temperate climate and subtropical climate. Subtropical climate and temperate climate, in lesser extent, occur in the south of Brazil, a region similar to the US state of Georgia. Thus, zoning appears as an essential necessity for new territories. The objective of this article is to discuss the edaphoclimatic zoning of southern Brazil region for pecan cultivation. Probably, considerations can extend to other kind of nuts, mainly from a pedologic point of view.

The main productive pole in southern Brazil locates in the southern half of Rio Grande do Sul state, integrating the municipalities of Santa Maria, São Sepé, Cachoeira do Sul, Encruzilhada do Sul, Rio Pardo and Pantano Grande, with about 22 walnuts as total. Anyway, little municipalities with some walnuts spread by Santa Catarina state and southern half of Parana state. Climatic condition is unfavorable at northern half of Parana state due to absence of chilling hours.

2. Materials and Methods

The edaphic and climate zoning is an instrument of territorial planning, what discriminates areas with similar climate and soil conditions for pecan cultivation (Filippini Alba et al., 2020). Methodology of zoning usually considers the integration of several digital levels of information through a geographic information system (GIS) as soil digital map, digital elevation model and climatic map, usually including humidity condition, medium temperature or chilling hours. Cartographic features as territorial limits, hydrography or the road network extracted from a specific database (IBGE, n.d.a) complete the information. Brazil provides continuous monitoring for scales 1:1,000,000 and 1:250,000. The former is the preferential scale for national objectives and the latter allows a better detailing.

Embrapa Solos made available the soil map of Parana state and Santa Catarina state in 1:250,000 scale. The soil map of Rio Grande do Sul state was prepared by cooperation project between the Embrapa Temperate Climate and the Federal University of Rio Grande do Sul. Map of declivity derived from the digital elevation model (Instituto Nacional de Pesquisas Espaciais, 2008) allowed discriminating areas with declivity greater than 45%, that is, unsuitable for agriculture. Criteria used for soil zoning parameters (Table 1) were based on logical concepts and production experience (Filippini Alba et al., 2020). Producers confirmed these criteria through a formulary exposed during a technical event. Pecan tree grows best in deep, permeable and well-drained soils, with a medium texture, that is, sandy-clay texture, rich in nutrients and with a neutral to alkaline pH (Rovani, 2016).

Table 1. Criteria for definition of edaphic aptitude for pecan cultivation in southern Brazil

Edaphic parameters	Aptitude classes			
	P	R	FR	NR
Effective depth	Greater than 100 cm	100-50 cm	Lesser than 50 cm	
Drainage	Strong, accentuated or good	Moderate	Imperfect or excessive	Bad or very bad
Texture	Medium or clayey	Very clayey	Clayey 2:1 or silty	Loamy or organic sand
Declivity	0-13%	13-20%	20-45%	Greater than 45%
Stoniness or rockiness	0-3%	3-15%	15-50%	Greater than 50%
Fertility	Eutrophic or dystrophic with high activity clay	Dystrophic or dystrophic with low activity clay	Alitic or Aluminum	Presence of salts

P = Preferential; R = Recommended; FR = Few Recommended; NR = Not Recommended.

Latosols are soils related to tropical climate, usually deep, clayey soils, predominating mainly in the northern half of Rio Grande do Sul state and, according to several spots, in the Parana state. The climate in the territory of Parana gradually changes from temperate in the southeast to a humid subtropical climate in the west and north sectors. Argisols have similar characteristics with Latosols, but they are more associated to temperate climate, perhaps subtropical condition, predominating in the southern part of Rio Grande do Sul state, oceanic littoral of Santa Catarina and Parana states. Cambisols are usually productive soils with potential restriction due to depth. Neosols are unfit soils when shallow and stony, sometimes sandy (beach areas). Gleisols present frequent inundations, harming agricultural activity.

Climatic zoning included data from 123 meteorological stations, monitoring temperature, humidity and wind speed, and 564 rainfall stations, according to series of 30 years and 10 years, respectively. These stations are located from south of São Paulo state to northern Uruguay, producing consistent climatic data. The annual sum of chilling hours considered the sum of hours with temperature lesser or equal than 7.2 °C. Then, temperature data were adjusted using digital elevation model (Wrege et al., 2011). A regression model is performed by points data, that is, the meteorological stations, so data are adjusted by regression with the digital elevation model, in the way that a map in raster format was produced. Finally, the model discarded areas with relative humidity greater than 82% by means of GIS, due to unsuitability for agriculture (Filippini Alba et al., 2020).

The class "Few Recommended with fertility-only restriction" (FRf) was incorporated to the four classes presented in Table 1. This is a specific class of soil, with all properties recommendable, except Fertility, which is inappropriate. However, adjustment is possible by adding chemical inputs at field.

3. Results

Data mentioned in the precedent paragraphs composed the edaphic zoning and the climatic zoning, in the way that the integration of both themes defines the zoning of climate and soil according to criteria of Table 2. Not recommended soil harms all-weather cultivation. Table 3 summarizes data of occupied areas by the different classes of the zoning for climate and soil from the south region of Brazil.

Rio Grande do Sul state has the greatest potential area for planting pecan (Figure 2), that is, 89,502 km^2 summing up the classes P, R and PRf. Santa Catarina has a little potential area, in the central part mainly (Figure 3). The condition of Paraná improves with almost double of the area available for plantation, that is, 21,059 km^2. The Preferential class is rare, with only 236 km^2, unique condition for Rio Grande do Sul state. Recommended class is 8.5% of total territory, decreasing to the north, probable due to less availability of chilling hours (Figure 4).

Table 2. Diagram illustrating the method of overlapping climatic zoning and edaphic zoning resulting in edaphic-climatic zoning

Climatic Zoning	Edaphic zoning				
	NR	FR	FRf	R	P
NR	NR	NR	NR	NR	NR
<100 ch	NR	FR, <100ch	FRf, <100 ch	R, <100 ch	P, <100 ch
100-200 ch	NR	FR, 100-200ch	FRf, 100-200ch	R, 100-200ch	P,100-200 ch
200-300 ch	NR	FR, 200-300ch	FRf, 200-300ch	R, 200-300 ch	P, 200-300 ch
300-500 ch	NR	FR, 300-500ch	FRf, 300-500ch	R, 300-500ch	P, 300-500 ch
>500 ch	NR	FR, >500ch	FRf, > 500ch	R, > 500ch	P, > 500 ch

P = Preferential; R = Recommended; FR = Few Recommended; FRf = "Few Recommended with fertility-only restriction"; NR = Not Recommended.

Table 3. Area occupied by the classes of the edaphoclimatic zoning for pecan cultivation, by state and total in the southern region of Brazil

EC condition	RS	SC	PR	Total	%
P 300-500 ch, km²	236	0	0	236	0.04
R < 100 ch, km²	0	33	0	33	0.01
R 100-200 ch, km²	6470	263	10	6743	1.2
R 200-300 ch, km²	20432	862	1045	22339	3.9
R 300-500 ch, km²	19501	348	1	19850	3.4
R > 500 ch, km²	5	0	0	5	0.0009
FRf <100 ch, km²	0	328	0	328	0.1
FRf 100-200 ch, km²	199	984	3280	4463	0.8
FRf 200-300 ch, km²	20576	3071	12602	36249	6.3
FRf 300-500 ch, km²	22058	5742	4121	31921	5.5
FRf > 500 ch, km²	25	45	0	70	0.01
FR < 100 ch, km²	0	317	0	317	0.1
FR 100-200 ch, km²	3780	641	16448	20869	3.6
FR 200-300 ch, km²	15998	3466	20770	40234	7.0
FR 300-500 ch, km²	10198	2226	4825	17249	3.0
FR > 500 ch, km²	152	191	0	343	0.1
NR (restricted), km²	147587	76270	130638	280701	62
Water body, km²	13887	478	3259	17625	3.1
Urban, km²	644	80	2164	2887	0.5
P + R + FRf, km²	89502	11676	21059	122237	21.2
P + R + FRf, %	31.8	12.2	10.6	Does not apply	
Totals/state area, km²	281748	95345	199163	576256	100%

P = Preferential; R = Recommended; FRf = "Few Recommended with fertility-only restriction"; FR= Few Recommended; NR = Not Recommended; ch = chilling hours.

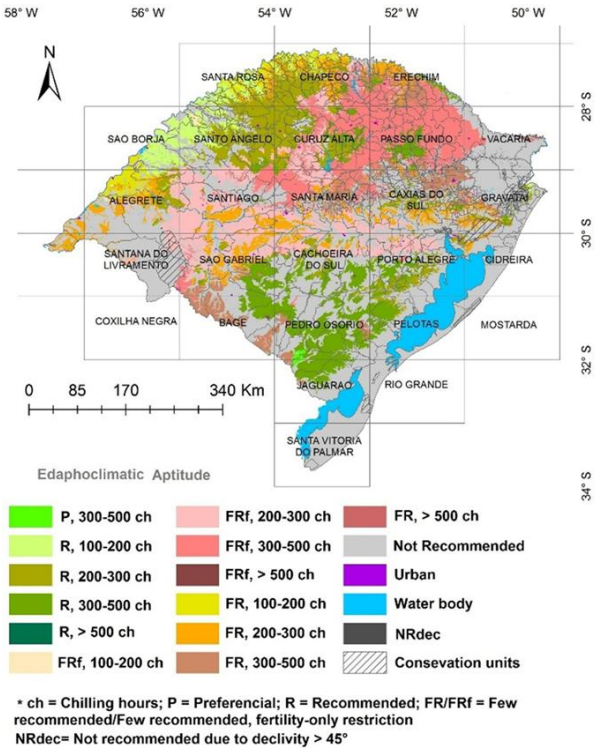

Figure 2. Edaphoclimatic zoning for pecan production in the state of Rio Grande do Sul, Brazil

Cartographic sheets division according to 1:250,000 scale.

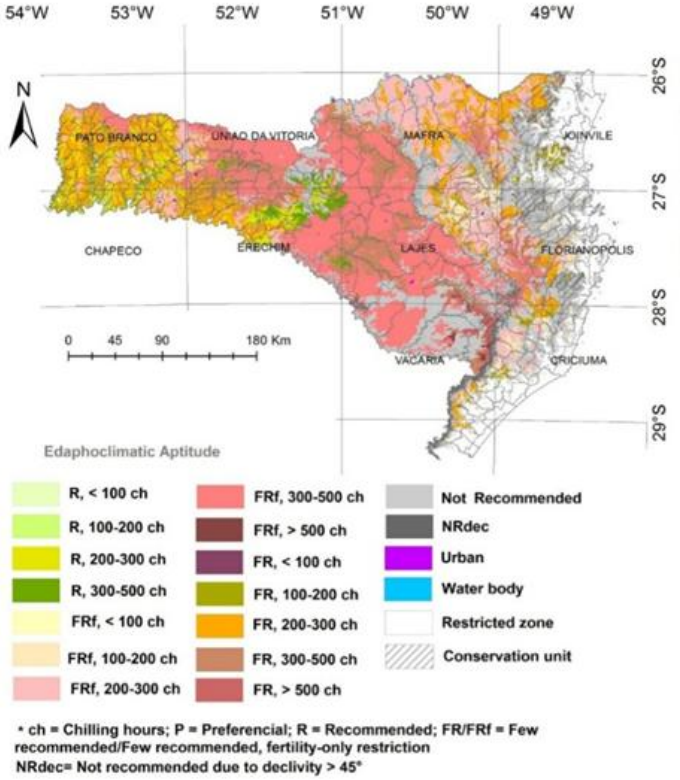

Figure 3. Edaphoclimatic zoning for pecan production in Santa Catarina state, Brazil (left)

Cartographic sheets division according to 1:250,000 scale.

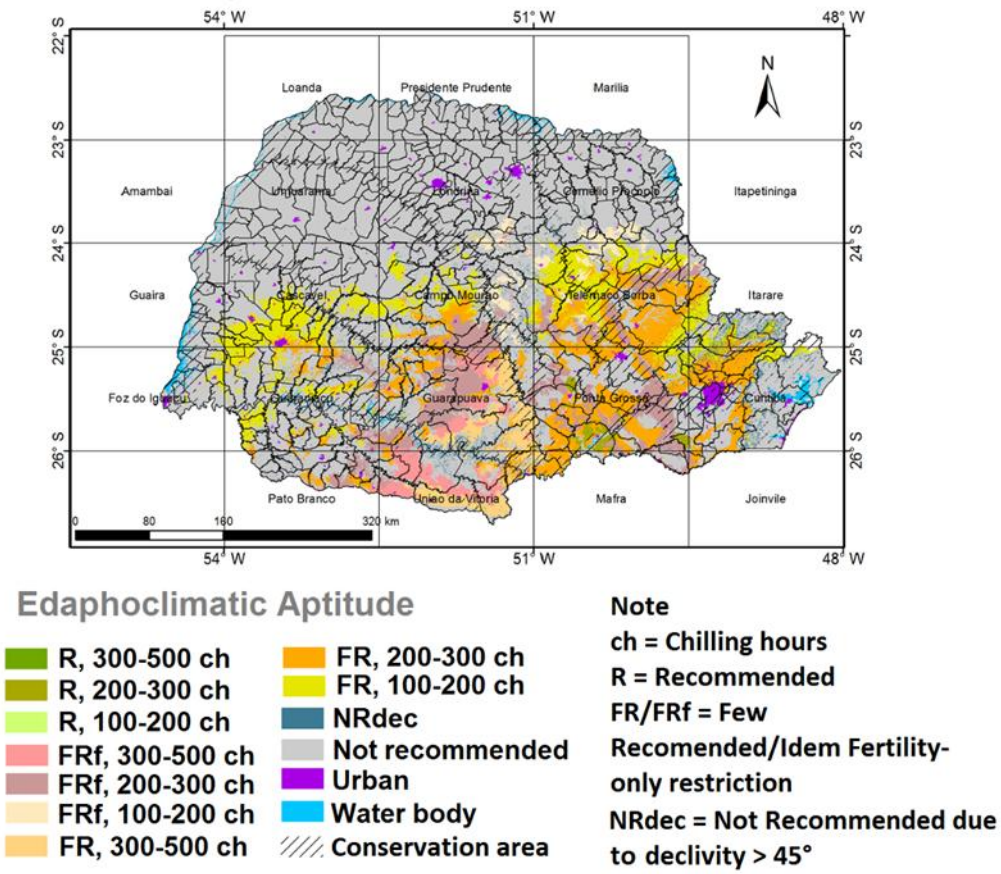

Figure 4. Edaphoclimatic zoning for pecan production in Parana state, Brazil

Cartographic sheets division according to 1:250,000 scale.

4. Discussion

"Not Recommended" class occupies more than 65% together with water bodies and urban complexes. The remaining classes achieve 35% of south Brazilian region, less or equal than 7% each, with emphasis on Few Recommended (FR) or "Few Recommended, fertility-only restriction" (FRf) for varieties of 200-300 chilling hours or 300-500 chilling hours.

According to Wells (2017), "It's really not clear how many chill hours pecans need, probably because there is so much variation from one variety to the next. Desirable, Mahan, Success, and Schley varieties would need 300-500 chill hours, while Stuart reportedly requires from 600-1000 chill hours. In general, pecans do not need many chill hours. At the southern end of its range in Mexico, you can have trees that receive less than 100 chill hours, which still produce nuts."

The Lagoon Mirim region, that is, Jaguarão, Pedro Osório and Porto Alegre sheets, presents a significant potential area for the occurrence of walnut trees, with occurrence of the Preferential class and abundance of the Recommended class for varieties of 300-500 chilling hours (Figure 2). Passo Fundo region (sheet with the same name) decreased the area of this class; however, Recommended classes for less than 300 chilling hours increased its size. "Few Recommended, fertility-only restriction" class occurs significantly as well. Santa Maria sheet showed a more balanced relation between Few Recommended and Recommended classes.

The Atlantic littoral of Santa Catarina is a very preserving area due to intensive tourism. Specially "Few Recommended, fertility-only restriction" class for varieties of 200-300 chilling hours and 300-500 chilling hours occupies an extensive area in the central sector of the state. Recommended class and "Few Recommended, fertility-only restriction" class concentrate in the southern-half of Parana state, surroundings of Garapuava and Pitanga cities or region of Campo Largo, Irati, Ponta Grossa and Telemaco Borba.

5. Conclusions

The southern region of Brazil presents an adequate edaphoclimatic condition for pecan production in 35% of its territory, with at least Few Recommended aptitude, what means more than 200 thousand hectares with climatic and edaphic aptitude for the crop. Rio Grande do Sul stands out due to the extension of the territory available for recommended classes and the possibility of different varieties. However, Parana and Santa Catarina have a large area with a "Few Recommended, fertility-only restriction" or Few Recommended condition. Especially the former is an optimum condition, despite the need to add commercial inputs.

Acknowledgements

To the Brazilian Institute of Pecan for the continuous support for the related project.

Transparency of Data

Data not available: The data set that supports the results of this study is not publicly available.

Author contribution statement

	JM Filippini-Alba	MS Wrege	CR Martins
Conceptualization	■	■	■
Formal analysis	■	■	■
Investigation	■		■
Methodology	■	■	■
Project administration	■		
Validation			■
Visualization	■	■	■
Writing – original draft	■		
Writing – review and editing	■	■	■

References

Filippini Alba, J. M., Wrege, M. S., Almeida, I. R., Martins, C. R., Zemnicahak, S., & de Souza, T. G. (2020). *Zoneamento edafoclimático da nogueira-pecã para a região sul do Brasil*. Embrapa.

Instituto Brasileiro de Geografia e Estatística. (n.d.a). *Downloads*. https://downloads.ibge.gov.br

Instituto Brasileiro de Geografia e Estatística. (n.d.b). *Produção de noz*. https://www.ibge.gov.br/explica/producao-agropecuaria/noz/br

Instituto Brasileiro de Pecanicultura. (2022, May 16). *Números da safra, união do setor e conjuntura de mercado pautam abertura da colheita da noz pecan*. https://www.ibpecan.org/post/n%C3%BAmeros-da-safra-uni%C3%A3o-do-setor-e-conjuntura-de-mercado-pautam-abertura-da-colheita-da-noz-pecan

Instituto Nacional de Pesquisas Espaciais. (2008). *TOPODATA: Banco de dados geomorfométricos do Brasil*. http://www.dsr.inpe.br/topodata/index.php

International Nut and Dried Fruit Council. (2023). *Nuts and dried fruits statistical yearbook: 2022/2023*. https://inc.nutfruit.org/wp-content/uploads/2023/05/Statistical-Yearbook-2022-2023.pdf

Martins, C. R., Barreto, C. F., Farias, R. M., Duarte, C. S., Hellwig, C. G., Lima, A. D. V., & Malgarim, M. B. (2023). Quality of pecan grown in orchards with the use of different levels of technology. *Revista Iberoamericana de Tecnología Postcosecha, 24*(1). https://www.redalyc.org/journal/813/81376287006/81376287006.pdf

Martins, C. R., De Marco, R., Farias, R. M., & Malgarim, M. B. (2019). Noz-pecã: Panorama mundial. *Campo & Negócios*, (October), 52–55.

Martins, C. R., Hoffmann, A., Nachtigal, J. C., & Filippini Alba, J. M. (2023). *Panorama da produção, processamento e comercialização de noz-pecan no Sul do Brasil*. Embrapa.

Oliveira, L. O., Santos, D. D., Beise, D. C., Poletto, T., Poletto, I., Muniz, M. F. B., Zeist, J. N. O., Valdir, M., & Stefenon, V. M. (2023). Old but still good: Genetic diversity of ancient pecan genotypes from southern Brazil. *Anais da Academia Brasileira de Ciências*, *95*, e20220885. https://doi.org/10.1590/0001-3765202320220885

Rovani, F. F. M. (2016). *Zoneamento de risco climático para o cultivo da nogueira-pecã (Carya illinoinensis) para o Rio Grande do Sul* (Doctoral dissertation). Universidade Federal de Santa Maria.

Wells, L. (2017). *Warm winter and pecans*. University of Georgia Extension. https://site.extension.uga.edu/pecan/2017/02/warm-winter-and-pecans/

Wrege, M. S., Steinmetz, S., Reisser, C., Jr., & Almeida, I. R. (2011). *Atlas climático da região sul do Brasil: Estados do Paraná, Santa Catarina e Rio Grande do Sul*. Embrapa.