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Master Thesis

Mapping tree species suitability based on fuzzy set theory

submitted by

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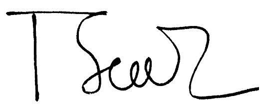
Affidavit

I hereby declare that I am the sole author of this work. No assistance other than that which is permitted has been used. Ideas and quotes taken directly or indirectly from other sources are identified as such. This written work has not yet been submitted in any part.

Vienna, April 11, 2022



Son Tran Thanh

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From this thesis, I have gained new experience in the field of decision support system. I got to know the ways to develop and evaluate models. I also had a chance to improve my knowledge with MATLAB. These skills will be valuable for my future career. I hope that the results of my thesis will contribute to forest science and support managers in decision making and addressing forest-related issues.

Finally, I would like to thank my family for loving and standing by my side. Without them I wouldn't have been able to pass this challenge.

Summary

Tree species choice plays an important role in sustainable forest management. Several approaches have been studied to match the best tree species with given site conditions. However, the need for the current study has arisen due to the lack of crisp data and the difference in expert perspectives. Fuzzy logic controller is an appropriate solution to address these limitations as it could combine quantitative and qualitative approaches. The system utilizes rules instead of algorithms to model expert knowledge with crisp data.

The objectives of this thesis were (1) Developing the conceptual frame for a Tree Species Suitability model, (2) Implementing the model within the MATLAB environment, and (3) Evaluating the model with data from the federal province of Styria, Austria.

The environmental factors were divided into three groups including temperature regime, nutrient supply and water supply. Each group was modeled by Mamdani fuzzy logic controllers to formulate Temperature Suitability Index, Nutrient Suitability Index and Water Suitability Index. Eventually, these indices were aggregated and compared by two methods, namely Gamma operator and Minimum operator. For the model evaluation, 30 sites along different ecological gradients were selected in Styria, Austria (FORSITE project) to analyze model behavior for *Picea abies*, *Abies alba*, *Fagus sylvatica* and *Quercus robur*.

Overall, the species suitability model behavior met the expectations regarding the estimated suitability indices for individual species along the gradients as well as regards the relative performance of the analyzed tree species. However, model outputs along the input gradients were partly found to be inconsistent with the given input data because of (1) the Center of Gravity defuzzification method, (2) the overlap of the output fuzzy sets, (3) the Maximum aggregation method of the output fuzzy sets, and (4) the rule base. Gamma operator produced smoother output data than Minimum operator. Results of the model showed that *Picea abies* and *Abies alba* are suitable to grow from high to medium elevations while *Fagus sylvatica* and *Quercus robur* are appropriate to plant in medium and low altitudes. The Tree Species Suitability model is a promising tool to support managers in tree species selection.

Kurzfassung

Die Baumartenwahl ist eine der langfristig wirkenden Entscheidungen im Rahmen nachhaltiger Waldbewirtschaftung. Unterschiedliche Ansätze wurden vorgeschlagen bzw. sind in Verwendung, um die Eignung einer Baumart für einen bestimmten Standort zu beurteilen. Die gegenständliche Arbeit fokussiert auf das weitgehende Fehlen von quantitativen Daten und die unscharfe und zum Teil unterschiedliche Meinung von Experten. Fuzzy Logic Ansätze werden in diesem Kontext als ein möglicher methodischer Ansatz gesehen. Die Ziele der vorliegenden Arbeit sind: (i) die Entwicklung des konzeptionellen Rahmens für ein Baumarteneignungsmodell, (ii) die Implementierung des Modells mit MATLAB, und (iii) Die vorläufige Evaluierung des Models mit Daten aus dem FORSITE Projekt aus der Steiermark, Österreich.

Standortsmerkmale wurden in das Temperaturregime, die Nährstoff- und die Wasserversorgung strukturiert. Jede Merkmalsgruppe wurde als Mamdani Kontrolleinheit modelliert. Als Ergebnis jeder Einheit ergibt sich jeweils ein Eignungsindex, die drei Indices werden dann in einem weiteren Schritt zu einer Gesamteignung aggregiert. Für die Aggregation wurden sowohl ein Gamma-Operator als auch ein Minimum-Operator verwendet.

Das Modellverhalten wurde anhand von 30 Standorten in der Steiermark aus dem FORSITE Projekt evaluiert. Dazu wurden Eignungswerte für Picea abies, Abies alba, Fagus sylvatica und Quercus robur berechnet und vergleichend analysiert. Insgesamt entsprach das Modellverhalten entlang der ökologischen Gradienten den Erwartungen, sowohl absolut als auch in Bezug auf das relative Verhalten der Baumarteneignungswerte. Es wurde allerdings festgestellt, dass teilweise die Relationen von Input zu Output nicht konsistent waren. Gründe waren (i) die Center of Gravity Defuzzifizierungsmethode (COG), (ii) die Überlappungsbereiche von Fuzzy Sets, (iii) die Maximum-Aggregierungsmethode für Output-Fuzzy Sets, und (iv) die Regelbasis. Der Gamma-Operator produzierte gleichmäßigere Outputs im Vergleich zum Minimum-Operator. Die Resultate zeigten, dass Picea abies und Abies alba von Hochlagenstandorten bis in mittlere Höhenlagen sehr gut geeignet sind, während Fagus sylvatica und Quercus robur in mittleren und tiefer gelegenen Höhenlagen gute Eignungswerte aufwiesen. Das vorgestellte Baumarteneignungsmodell erwies sich als vielversprechends Tool um die Baumartenwahl zu unterstützen.

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Abbreviations

GDD: Growing Degree Days

WF: Winter Frost

LVP: Length of Vegetation Period

LF: Last Frost

SD: Soil Depth

ST: Soil Type

BSP: Base Saturation Percentage

CF: Coarse Fraction

SMI: Soil Moisture Index

GW: Ground Water

ZAMG: Zentralanstalt für Meteorologie und Geodynamik

FAO: Food and Agriculture Organization of the United Nations

SAM: Soil Adsorption Matrix

TSI: Temperature Suitability Index

NSI: Nutrient Suitability Index

WSI: Water Suitability Index

TSSI: Tree Species Suitability Index

OL: Overlap percentage

1 Introduction

Forests play a vital role in providing long-term ecosystem services, combating rural poverty, and ensuring food security. Due to human overpopulation and increasing demand for foods and lands, forests have been extremely degraded for decades (FAO, 2015). Annually, 13 million hectares are deforested which devastatingly affects the world's biodiversity (Bremer et al., 2010). Land use and land use change activities cause soil compaction, forest fragmentation, loss of endemic species and their habitat, among others (Noss and Copperrider, 1994). To address these issues, sustainable use, management, and restoration of forest ecosystems have been considered as priorities of the Sustainable Development Goals (FAO, 2018).

The suitable choice of tree species is a key element in sustainable forest management and forest restoration due to its positive effects on productivity, ecosystem services, tree survival rate and investment costs. Climate change has added to the complexity of decisions about tree species composition in forest management. Several approaches have been studied about tree species selection. Garcia et al. (2013) conducted simulations that included climate change scenarios to assess the survival capacity of tree species. Rollan et al. (2018) devised a planning tool that combines tree species selection with the plantation schedule, while considering the maximization of carbon sequestration and income generation. Conway and Vander Vecht (2015) employed surveys and interviews to explore tree selection criteria of actors who plant and supply urban trees. Villacís et al. (2016) generated a list of recommended tree species by evaluating the performance of saplings, such as sapling survival, causes of mortality, increment of sapling height and diameter, and effects of plants on soil properties. Another approach basing on species distribution was developed to assess tree species suitability. It assumes the absolute frequency of species presence as a direct indicator of habitat suitability (Braunisch et al., 2008). Based on this theory, Gastón et al. (2014) evaluated the species suitability through species distribution model and compared results with expert experience.

In general, these previous approaches could be classified into two categories including qualitative and quantitative. The qualitative approach mainly focuses on empirical analysis and expert recommendation method. This could lead to subjectivity and ambiguity in decision making due to the differences of expert perspectives and experience. The uncertainty factors are not thoroughly weighed and criteria for tree suitability are not unified

(Xu et al., 2018). For example, a bias may be introduced by human promotion of certain tree species because of their economic superiority. The conceptual inconsistency may increase if such models are extrapolated into novel climatic conditions. By contrast, quantitative approach considers the collection and analysis of data. Numerous experiments have been conducted to study the growth and habit of the tree species (Xu et al., 2018). However, these experiments require more time, manpower, materials, and financial resources. Thus, the insufficiency of data is conspicuously a limitation in this approach. Besides, the changing of environment due to climate change led to the uncertainty of these previous methods. For instance, the scarcity of optimal habitat forces most of the individuals to live in suboptimal conditions, increasing uncertainty to select relevant tree species based on species distribution (Braunisch et al., 2008).

Another approach in tree species selection has been studied, namely the fundamental niche approach. The fundamental niche is considered as a set of environmental conditions and resources that allow a given species to survive and reproduce without being affected by biotic factors (Varghese et al., 2010). In other words, the fundamental niche of a species is specified by its physiological range of tolerance to environmental factors (Kearney, 2004). The fundamental niche is a relevant approach in tree species selection because it allows managers to define the best species for current site conditions and climate change scenario. To employ this approach, forest managers usually try to match physiological requirements of tree species with suitable bioclimatic and chemo-physical site conditions (Lexer et al., 2000). However, as discussed above, there are two main problems involved in solving this task including knowledge uncertainty and data uncertainty. Site related information in the literature is primarily based on the experts' own experiences and qualitative knowledge (Sjöman et al., 2018), which is always subject to uncertainty (Niamir et al., 2019). Furthermore, a lack of quantitative data on site parameters leads to ambiguity of selecting suitable tree species (Lexer et al., 2000). An inability to apply fundamental niche knowledge on species selection could limit the scenario analysis application in tree species selection.

The development of fuzzy logic theory offers a potential solution to address the limitation of qualitative and quantitative manners as it is a combination of these two approaches. Fuzzy logic has emerged since Lofti Zadeh published the paper "Fuzzy Sets" in 1965. A fuzzy set expresses the relationship between an uncertain quantity x and a membership function μ, which belongs to interval [0,1] (Nasr, 2012). It is employed to handle the concept of partial truth, where the true value may range between "completely true" and "completely false". In contrast to classical sets, fuzzy sets thus provide a convenient way of defining memberships more general than a simple Boolean true or false approach. Fuzzy logic is much closer in spirit to human thinking and natural language comparing to the traditional logical systems (Lee, 1990). The advantage of this approach is to mathematically represent uncertainty and vagueness and to provide formalized tools for dealing with the imprecision intrinsic to many problems. Fuzzy logic is powerful due to the ability of transferring into algorithm a completely unstructured set of heuristics expressed by linguistic variables (Mamdani, 1999). Fuzzy logic has been applied to develop fuzzy inference systems, which formalize the mapping from given inputs to outputs. Several types of fuzzy inference system (FIS) have been proposed by researchers (Nasr et al., 2012). Two most common used inference systems are Mamdani fuzzy control (Mamdani and Assilian, 1975) and Takagi–Sugeno fuzzy control (Takagi and Sugeno, 1985).

During the past years, fuzzy inference systems have found numerous applications in the forestry sector. Toledo-Castro et al. (2018) developed a forest fire controller based on fuzzy logic which analyses environmental information to estimate the existence of forest fire risks, and to detect the occurrence of fire outbreaks over different forest areas. A fuzzy inference model was developed by Wu et al. (2019) to assess soil quality and map land use types with appropriate soil quality grades. Mendoza and Prabhu (2004) defined criteria and indicators as instrument to assess sustainable forest management based on fuzzy logic methods. Riedler et al. (2002) integrated soil and site variables into a fuzzy logic-based model and proposed a set of rules to predict forest soil degradation. In Lexer and Hönninger (2001), fuzzy inference was used to model the effect of site nutrient status on tree growth in a hybrid forest dynamics model. Joss et al. (2008) applied a fuzzy inference modeling approach to evaluate land suitability for afforestation of hybrid poplar (Populus spp.) across the Prairie Provinces of Canada. These previous studies are premise for the application of fuzzy logic in fundamental niche of the tree species.

2 Objectives

The main aim of this study is to develop a Tree Species Suitability model based on fuzzy set theory. The model approach will be demonstrated by example of four selected European tree species. To achieve this overall aim, several technical objectives must be accomplished:

(i) Developing the conceptual frame for a Tree Species Suitability model.

(ii) Implementing the model within the MATLAB environment.

(iii) Evaluating the model with data from the federal province of Styria, Austria.

3 Materials and methods

3.1 Mamdani fuzzy control approach

According to Keshwani et al. (2008), the Mamdani scheme is a type of fuzzy relational model which is based on if-then rules. It is also called a linguistic model because both the antecedent and the consequent are fuzzy propositions (Babuska, 1998). Mamdani fuzzy model is the most applied fuzzy methodology due to its popularity and easy application (Nasr, 2012). Mamdani systems are suitable to expert system applications where the rules are developed from human expert knowledge because they have more intuitive and easier to understand rule bases. Due to these advantages, the Mamdani fuzzy inference system has been selected in this study.

In general, the Mamdani fuzzy inference system contains of four parts: fuzzification, fuzzy rule base (knowledge base), fuzzy inference engine and defuzzification (see Figure 1).

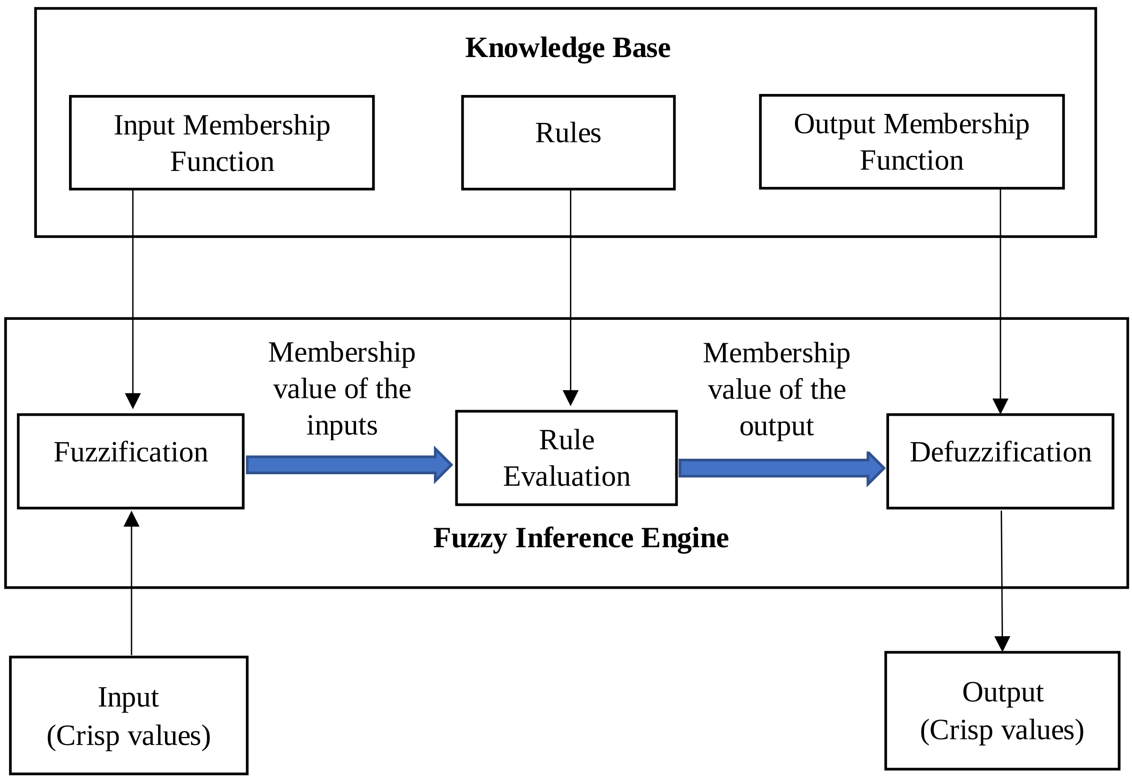

Figure 1: Mamdani Inference System

3.1.1 Fuzzification

Fuzzification is the process of transforming a crisp expression into fuzzy sets using membership functions (see Figure 2). A fuzzy set maps a natural base variable into a term of a linguistic variable via a membership function and admits the possibility of partial membership in it. Linguistic variables were defined as variables whose values are words or sentences. For instance, temperature can be a linguistic variable if its values are linguistic rather than numerical, i.e., hot, warm, cool, cold instead of 30, 20, 10, 0 degree Celsius. Mathematically, the fuzzy set A can be represented as a set of ordered pairs (Ocampo-Duque et al., 2006) (Eq. 1)

$$A = \{x, \mu_A(x) \mid x \in U\} \qquad (1)$$

Where $\mu A(x)$ is the membership function of x in A and U is a universe of discourse. If $\mu A(x) = 1$, x is totally in A. If $\mu A(x) = 0$, x is not in A. If $0 < \mu_A(x) < 1$, *x* is partly in A.

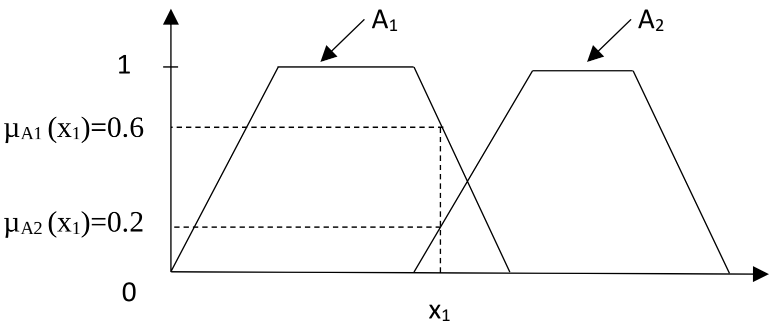

Figure 2: Fuzzification method

The shape of a membership function can vary depending on the application. There are some common types of membership functions such as Triangle, Trapezoidal, Sigmoidal, Generalized bell and Gaussian. Trapezoidal membership function (see Figure 3) is frequently suggested for an efficient computation (Zimmermann, 1996). Mathematically, fuzzy membership values are computed through following equation (2):

$$\mu_{A(x)} = \max(\min(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}), 0) \qquad (2)$$

Where the parameters are defined by a lower limit a, an upper limit d, a lower support limit b, and an upper support limit c, and a < b < c < d. Trapezoidal membership function was selected in this study.

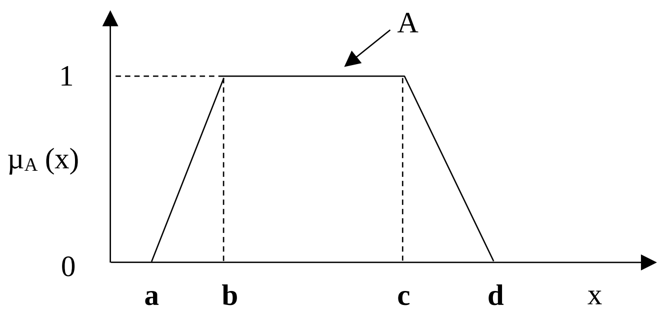

Figure 3: Trapezoidal membership function

3.1.2 Fuzzy rule base

In knowledge-based systems, fuzzy rules with the form of If-Then (conditional propositional forms) are utilized to illustrate the relation between input and output linguistic variables (Nasr, 2012). A single fuzzy if-then rule is formed by If x is A, then y is B, where A and B are linguistic variables determined by fuzzy sets on the ranges (universes of discourse) X and Y, respectively. The If-part of the rule "x is A" is the antecedent or premise, while the Then-part of the rule "y is B" is the consequent or conclusion. Fuzzy set theory contains a group of mathematical set operations, including union (OR) and intersection (AND) (Mamdani, 1975) for combining factors in a multicriteria evaluation (Reynolds et al., 2000). Components of the antecedent part are aggregated by fuzzy operators to compute the rule strength which represents the antecedent. If two fuzzy sets A and A1 are defined on the universe X, for a given element x belonging to X, the following operations can be carried out:

Intersection (AND): $\mu_{A \cap A1}(x) = \min(\mu_A(x), \mu_{A1}(x))$ (3)

Union (OR): $\mu_{A \cup A1}(x) = \max(\mu_A(x), \mu_{A1}(x))$ (4)

Where $\mu_{A \cap A1}$ is aggregation of the antecedent; μ_A and μ_{A1} are monocausal factors. An example of the fuzzy rule is given below:

- *If Growing Degree Day is Very low AND Winter Frost is Very cold AND Length of Vegetation Period is Very short AND Last Frost is Very early then Temperature Suitability is Unsuitable*

In which, Growing Degree Day, Winter Frost, Length of Vegetation Period and Last Frost are input variables. Temperature Suitability is the output variable. Very low, Very cold, Very short, Very early and Unsuitable are terms of linguistic variables. AND is the fuzzy operator.

3.1.3 Fuzzy inference engine

A fuzzy inference engine combines fuzzy if-then rules, using fuzzy reasoning methods to link inputs and outputs (Eyoh et al., 2013). There are many methods for the fuzzy inference engine in which the max–min and max–product methods are the two most used techniques (Akgun et al., 2012). Max-min method was selected for this study and implemented as follows (see Figure 4):

- Step 1: Input membership values are aggregated using fuzzy operators to compute a rule strength. The rule strength is a single membership value which represents the antecedent. A common operator is the minimum operator.
- Step 2: The implication method is applied for all rules to find the relation between the antecedent and the consequent. The consequent as fuzzy sets are truncated to the degree specified by the antecedent following the minimum operator (Izquierdo et al., 2017):

$$\mu_{Ri}\ (y) = \min\left[\mu_{Ai}\ (x), \mu_{Bi}\ (y)\right],\ i = 1,2,\ldots,n \quad (5)$$

Where μ_{Ri} (y) is the relation's membership degree of rule ''i'' according to ''x'' and ''y'' inputs, μ_{Ai} (x) and μ_{Bi} (y) are the membership degrees of ''x'' and ''y'' inputs respectively, ''n'' is the number of rules.

- Step 3: Aggregation method is implemented to combine all truncated output fuzzy sets into a final fuzzy set using the following maximum operator (Izquierdo et al., 2017):

$$\mu_{\tilde{B}}\ (y) = \max[\mu_{Ri}\ (y)],\ i = 1,2,\ldots,n \quad (6)$$

Where $\mu_{\tilde{B}}$ (y) is the aggregated fuzzy set of the consequent, μ_{Ri} (y) is the membership degree of rule ''i'', ''n'' is the number of rules.

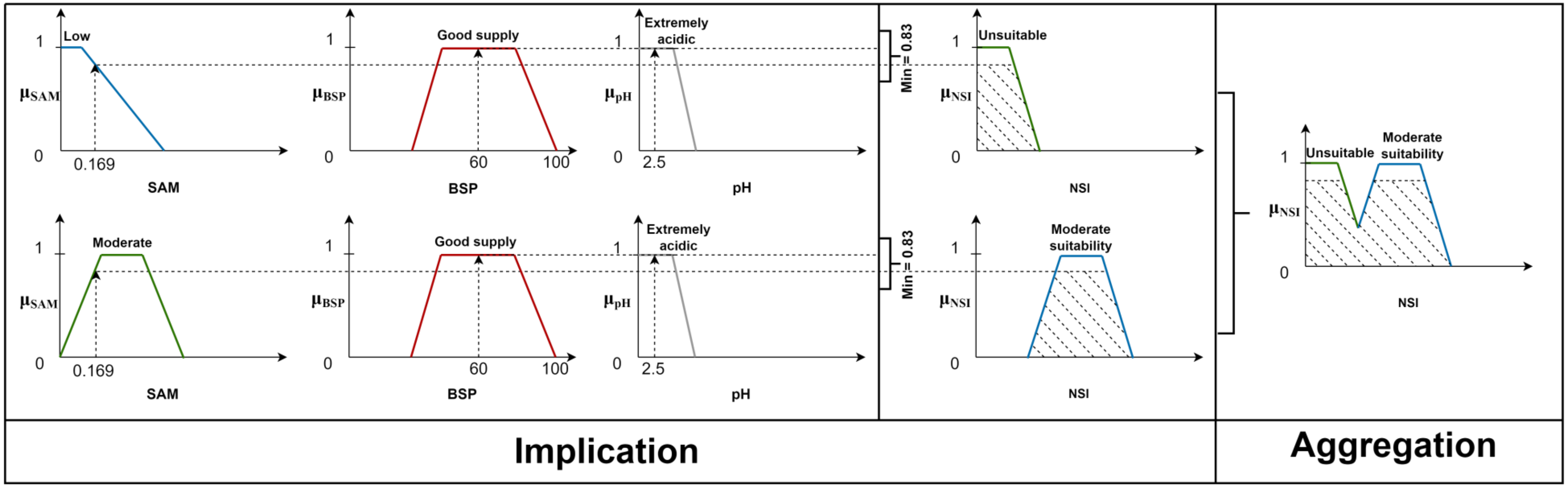

Figure 4: Implication and aggregation in Mamdani fuzzy control (SAM: Soil Adsorption Matrix, BSP: Base Saturation Percentage, NSI: Nutrient Suitability Index), two rule bases are processed: *"IF SAM is Low AND BSP is Good supply AND pH is Extremely acidic THEN NSI is Unsuitable"* and *"IF SAM us Moderate AND BSP is Good supply AND pH is Extremely acidic THEN NSI is Moderate suitability"*

3.1.4 Defuzzification

Defuzzification is the process of mapping from a space of inferred fuzzy control actions to a space of non-fuzzy control actions. The purpose of defuzzification is producing a crisp value that best represent for the possibility distribution of the inferred fuzzy control action (Lee, 1990). There are some common defuzzification methods including Mean of Maximum, Center of Gravity, Bisector, Middle of Maximum, Smallest of Maximum and Largest of Maximum. Center of Gravity method was selected for defuzzification process due to its higher consistency compared to other methods (Husain et al., 2017). A crisp value is computed depending on the center of gravity of the overall output fuzzy set (see Figure 5), which is mathematically represented by the following equation:

$$x^* = \frac{\sum_{i=1}^{n} x_i.\mu(x_i)}{\sum_{i=1}^{n} \mu(x_i)} \qquad (7)$$

Where $\mu(x_i)$ is the membership value for point x_i in the universe of discourse, n represents the number of elements in the fuzzy set.

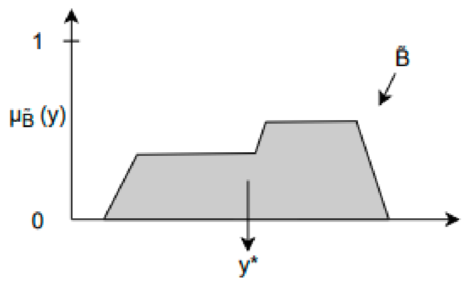

Figure 5: Center of Gravity defuzzification method

3.2 Structure of the Tree Species Suitability model

The Tree Species Suitability model was built for four species (*Picea abies*, *Abies alba*, *Fagus sylvatica*, *Quercus robur*) based on the Mamdani fuzzy control approach (see Figure 6).

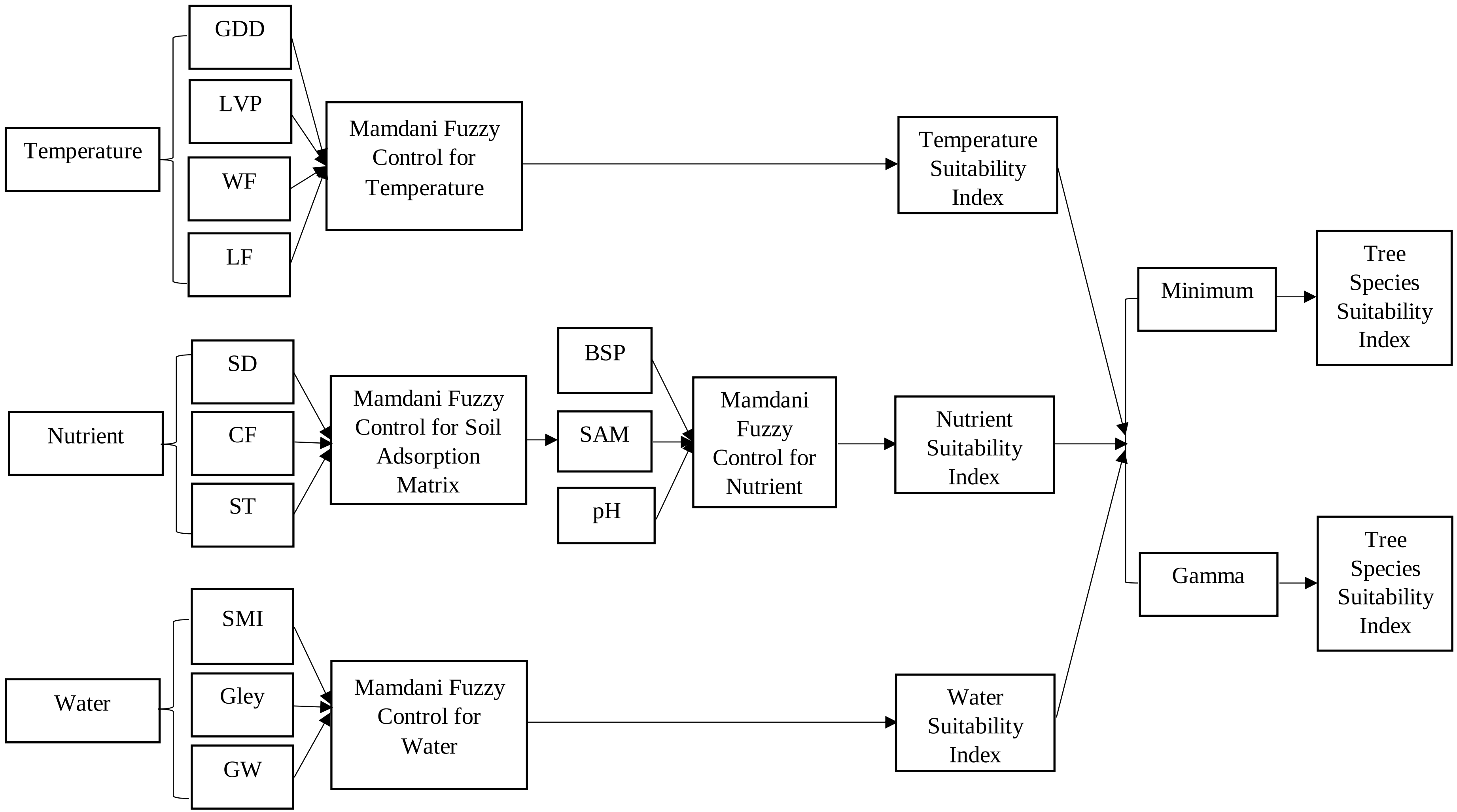

Figure 6: Tree Species Suitability model

To model the eco-physiological suitability of tree species, the site parameters were structured into three factor groups: temperature regime, nutrient supply, and water supply. The fuzzy sets and rule base were constructed based on (1) data of the FORSITE project and (2) expert knowledge.

The temperature part consisted of four variables including Growing Degree Days (GDD), Winter Frost (WF), Length of Vegetation Period (LVP) and Last Frost (LF). These parameters were modelled in a Mamdani Fuzzy Control unit to generate the Temperature Suitability Index.

To reduce the complexity of nutrient part which contained five variables, a hierarchical approach was employed. First, Soil Depth (SD), Coarse Fraction (CF) and Soil Type (ST) were processed in a Mamdani Fuzzy Control unit to define the Soil Adsorption Matrix (SAM). The variable SAM was then combined with Base Saturation Percentage (BSP) and pH in a second Mamdani Fuzzy Control unit to determine the final Nutrient Suitability Index.

The water group contained three variables including Soil Moisture Index (SMI), Gley and Ground Water (GW), which were performed in a Mamdani Fuzzy Control unit to formulate the Water Suitability Index.

Finally, two approaches were implemented to model the combined effect of temperature regime, nutrient supply, and water supply on tree species, namely the Gamma operator and Minimum operator. The Gamma operator is an algebraic product of the two fuzzy operators (fuzzy Sum and fuzzy Product), which are both raised to the power of gamma. The generalized function is as follows (Giesecke et al., 2009):

$$\mu_{A\gamma B\gamma C} = (\mu_A \cdot \mu_B \cdot \mu_C)^{(1-\gamma)} \cdot (1-(1-\mu_A)\cdot(1-\mu_B)\cdot(1-\mu_C))^{\gamma}, \gamma \in [0,1] \quad (8)$$

Where $\mu_{A\gamma B\gamma C}$ is the aggregate environmental response; μ_A, μ_B and μ_C are monocausal responses. According to Lexer and Hönninger (2001), this is a flexible operator which can handle compensating effects depending on the value of the gamma coefficient. When the specific γ is 1, no compensation is expected between the input variables and if γ is 0, full compensation is provided. Values in between permit combination of these two extremes.

The second method is Minimum operator, which was utilized, for instance, by Botkin et al. (1972) and Kienast (1987) based on the Liebig's law of the minimum to aggregate the environmental response from various monocausal responses:

$$\mu_{A\cap B\cap C} = \min(\mu_A, \mu_B, \mu_C) \qquad (9)$$

Where $\mu_{A\cap B\cap C}$ is the aggregate environmental response; μ_A, μ_B and μ_C are monocausal responses.

3.2.1 Temperature Suitability Index

Growing Degree Days (GDD) is an indicator for estimating the growth and development of plants during the growing season. GDD is based on the concept that development only occurs if the temperature exceeds minimum development thresholds or base temperature. According to McMaster et al. (1997), the formula to calculate GDD is:

$$\mathrm{GDD} = \frac{\mathrm{T_{Max}} + \mathrm{T_{Min}}}{2} - \mathrm{T_{Base}} \qquad (10)$$

Where $\mathrm{T_{Max}}$ is the daily maximum air temperature, $\mathrm{T_{Min}}$ is the daily minimum air temperature, and T_{Base} is the temperature below which plant growth is zero. $\mathrm{T_{Base}}$ differs among tree species, growth stage and possibly cultivars (Wang, 1960). Here $\mathrm{T_{Base}}$ was fixed at 5°C.

Winter Frost (WF) is considered as a major environmental factor which limits the productivity and distribution of plants (Larcher et al., 1981). Subsequent cell damages to species could be occurred if temperatures fall below WF's threshold (Larcher, 1995). Species are most vulnerable to frost and morality during the regeneration stage (Murray et al., 1994). Frost in growing season can destroy buds, terminal twigs, or the entire plant (Nitschke et al., 2008). Net photosynthesis and stomatal conductance rates are decreased by frost (Rahimi et al., 2007). The most affected organelle during frost-days is chloroplast

(Kratsch and Wise, 2000). During freezing, cells are dehydrated, and the membrane is destabilized, which are the key processes leading to frost damage (Pearce, 2001). In addition, frost-damaged trees are more susceptible to disease and insects (Dale et al., 2001; Murray et al., 1994). Frost events are assumed to occur when temperatures fall below 0 ºC. Minimum temperature thresholds are utilized to determine the appearance of winter frosts (Lexer et al., 2000).

Length of Vegetation Period (LVP) is usually defined as the part of the year where the daily average temperature exceeds a certain limit. It is the rhythmically repeating part of the year in which a plant actively grows and develops. The temperature limit is commonly between +3°C and +5°C depending on the type of plant. LVP is determined by calculating the number of days between the first 5-day period with average temperatures above 5°C (leaf-on date) and the first 5-day period with temperatures below 5°C (leaf-off date) (Buitenwerf et al., 2015). LVP is an important determinant of plant growth and distribution. Changes in the LVP might have both positive and negative effects on the yield of the forest. In principle, longer vegetation period could indicate increased productivity and new planting opportunities in forest setting. However, a longer vegetation period could also disrupt the function and structure of a region's ecosystems and encourage invasive species or weed growth.

Last Frost (LF) refers to the average final spring frost in a specific growing location. This date and temperature vary between locations and elevations. The last spring frost occurs at the beginning of the growing season, which damages seedlings, young plants, and flowering-stage trees (Vestal, 1971). LF in the spring causes variety of damages to fruits, depending on its growing stage (Tait and Zheng, 2003). Understanding LF date would support managers to select suitable time and species for plantation.

3.2.2 Nutrient Suitability Index

Soil Depth (SD) refers to the thickness of the soil materials. It determines rooting, moisture and nutrient storage, mineral reserves, anchorage, and a variety of factors that influence plant growth or land suitability for any intended usage (Yost et al., 2020). Although most plant roots are in the upper one meter of soil, certain plants may reach depths of up to 18 m (Nepstad et al., 1994), which are important for soil water extraction, reducing nutrient loss, and soil carbon sequestration (Maeght et al., 2013). Deeper soils supply more nutrients and water for plants than shallower soils in general (Rajakaruna et al., 2019). Soil depth also affects soil processes, soil properties, and microbial communities (Goebes et al., 2019).

Coarse Fraction (CF) refers to fraction of the solid particle in soil with grain size larger than 2 mm. According to Donald (2007), Coarse Fraction is an important site factor to be considered due to its large occupation of space in soil with less contribution of porosity (water and/or air storage) and chemical reactivity (sorption and/or nutrient storage). As a result, coarse fraction limits the available soil volume to hold water and the capacity of a given volume of soil to retain nutrients.

Soil Type is a significant abiotic factor which would fluent growth of the plants by changing the function of plant roots and soil borne microbes (Sripontan et al., 2014). According to Dan et al. (2017), the relative growth rate, the elongation rate, leaf production rate and the root to shoot ratio were impacted by soil type and water level.

Base Saturation Percentage (BSP) illustrates the proportion of the Cation-Exchange Capacity (CEC) occupied by the basic cations Calcium, Magnesium and Potassium and Natrium (Havlin, 2005). It is also considered as a dynamic soil feature influenced by climatic, geochemical, and environmental conditions (Osman, 2012). BSP plays an important role in soil taxonomic classification, soil fertility (Rawal et al., 2019) and was included as an indication of soil quality among numerous soil chemical properties (Soil Survey Staff, 2004). Increase in BSP could enhance the availability of Ca^{2+}, Mg^{2+}, and K^{+} for plants (Havlin, 2005). Conversely, low base saturation is an ordinary cause of nutrient deficiencies, soil acidification, alterations in soil biota, and general degradation of soil health (Ouimet et al., 1996). Suitable measurement and consideration of the BSP could prevent nutrient deficiencies in plants (Rawal et al., 2019).

The soil pH value is a measure of soil acidity or alkalinity, which ranges from 0 to 14. Neutral soils have pH a of 6.5-7.5, acid soils have a pH $\leq$ 6.5 and basic soils have a soil pH $\geq$ 7.5. Soil pH is described as a key variable due to its significant influences on soil biological, chemical, and physical properties and processes affecting plant growth as well as biomass yield (Minasny et al., 2016; Gentili et al., 2018). For instance, most micronutrients are more accessible to tree species in acid soils than in neutral-alkaline soils, promoting plant development (Lončarić et al., 2008). However, if the concentration is excessively high, some of these micronutrients have contribution to generating reactive oxygen species, causing substantial cellular damage (Morgan et al., 2013). Contrariwise, despite macronutrients is increased in alkaline soils, the availability of phosphorus and micronutrient is decreased which could negatively affect plant growth (Gentili et al., 2018). Soils with high concentrations of available nutrients commonly have a pH of 6.0-7.0 (Williston and LaFayette, 1978).

3.2.3 Water Suitability Index

Soil Moisture Index (SMI) is defined as the percentage of actual (AET) to potential evapotranspiration (PET) at a site (Lexer et al., 2000). According to Steiner (1998), SMI could be utilized to determine the drought tolerance of a species because the higher the species demands, the higher its sensitivity to water deficit.

$$\mathrm{SMI} = 1 - \left(\frac{\mathrm{AET}}{\mathrm{PET}}\right) \qquad (11)$$

Gley (or gleyed) soils are soils developed under conditions of poor drainage, resulting in a typical grey/blue soil colouring and in reduction of iron and other elements. Two main types of gley soil were considered as environmental factors for this study including (1) Surface water gleys (Gley) where water saturating the soil comes from surface drainage and (2) Ground water gleys (GW) where saturation is due to fluctuating groundwater levels. Surface water gleys and ground water gleys could limit the root penetration of the tree in soil, which leads to poor nutrients absorption. Besides, these soils are aerated and therefore the respiration of the tree roots is reduced due to a limited access to oxygen. Consequently, the roots may die under such conditions or tolerate to a certain degree.

3.3 Model evaluation

3.3.1 Site and climate data

Climate data

Climate refers to temperature, humidity, daylight, and wind conditions of a specific region. Climate variables have a significant impact on all stages and processes of the plant growth.

Therefore, collecting and evaluating climate data could provide significant information for tree species selection, which reduces time, efforts and finance.

For evaluation of the Tree Species Suitability model, climate data was taken from a network of weather stations from the Central Institute of Meteorology and Geodynamic in Vienna (ZAMG). The climate data for all the necessary climate variables for the analyses were taken from the climate data records a 30-year period from 1989 to 2018. These variables include information of Growing Degree Days, Winter Frost, Length of Vegetation Period and Last Frost.

Site data

According to Leitgeb and Reiter (2009), beside of climatic conditions determined largely by precipitation and temperature, the physical and chemical soil conditions also play a critical role for tree species suitability. In this analysis of limiting factors of tree species, data on nutrient and water groups were collected from FORSITE project. FORSITE is a forestry project leaded by the Institute of Silviculture – University of Natural Resources and Life Sciences under the sponsorship of Office of the Styrian Provincial Government. The aim of the FORSITE project is to generate comprehensive data on geology, soil, water, heat, and nutrient balance of forest locations for the entire forest area in Styria, Austria.

Data were collected and analyzed in the soil laboratories of the Austrian Research Centre for Forests (BWF) regarding soil physical and chemical parameters. Additional analyzes of soil hydrological parameters were carried out to estimate water storage capacity of the soils.

3.3.2 Evaluation experiments

3.3.2.1 The maximum and minimum values of output variables in Tree Species Suitability model

The maximum and minimum values of Tree Species Suitability represent for the best and the worst scenarios of site condition for tree species. In Tree Species Suitability model, the range of output variables (Soil Adsorption Matrix, Temperature Suitability Index, Nutrient Suitability Index, Water Suitability Index and Tree Species Suitability Index) were designed from 0 to 1. Thus, the lowest value and highest value of these outputs were expected to be 0 and 1, respectively. If the actual maximum and minimum Suitability values that the model can produce are different from 0 and 1, then the model has inconsistent behavior. In this section, an experiment was conducted to calculate the actual maximum and minimum Suitability values of the Tree Species Suitability model. Results were compared with the maximum and minimum values of initial design. From that, sources of inconsistency and model behavior were described.

To define the maximum value which the model can produce, optimum values of environmental variables were selected to present the best site conditions for tree species. On the contrary, poorest values were utilized to calculate the minimum Tree Species Suitability Index. Detail about the input data could be found in Table 1.

Table 1: The environmental factors of European tree species in best and worst scenarios

Scenario	Species	GDD	WF	LVP	LF	SD	CF	ST	BSP	pH	SMI	Gley	GW
Best	Picea abies	800	-20	250	100	100	5	3	50	5	0	0	0
	Abies alba	1900	2	250	100	100	5	3	50	5	0	0	0
	Fagus sylvatica	1900	2	250	100	100	5	3	50	5	0	0	0
	Quercus robur	1900	2	250	100	100	5	3	50	6	0	0	0
Worst	Picea abies	0	-20	100	100	5	5	1	100	2.5	0	2	0
	Abies alba	0	-20	100	100	5	5	1	100	2.5	0.4	0	0
	Fagus sylvatica	0	-20	100	100	5	5	1	4	2.5	0	2	1
	Quercus robur	0	-20	100	100	5	5	1	4	2.5	0.4	0	0

3.3.2.2 The effects of overlap of input fuzzy sets on Tree Species Suitability Index

The overlap of fuzzy sets is a characteristic of fuzzy logic model. Overlap denotes uncertainty in participation of members of one set to other set. It is fundamental that an element of a fuzzy set is also an element of some other fuzzy sets with some degree of membership. When the membership functions of a fuzzy controller have overlap, the system obtains a smooth and continuous control signal near the boundaries of the membership functions. However, it is necessary to understand how different overlap percentages of input fuzzy sets affects model results. For this purpose, an experiment was employed in the Nutrient Suitability model of *Picea abies*. The “Moderate” and “Good” fuzzy sets of Soil Adsorption Matrix variable (SAM) were selected for the analysis. Given A_1, A_2, A_3, A_4 and B_1, B_2, B_3, B_4 as parameters to define “Moderate” and “Good” fuzzy sets, respectively (see Figure 7).

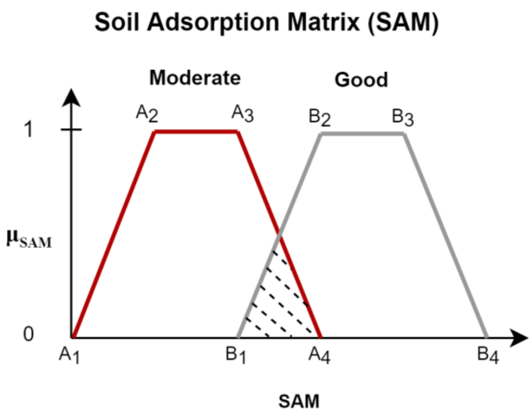

Figure 7: The overlap of input fuzzy sets in Soil Adsorption Matrix

The overlap percentage is calculated as follows:

$$\mathrm{OL}\ (\%) = \frac{\mathrm{B_1A_4}}{\mathrm{A_1B_4}} \cdot 100 \qquad (12)$$

Where $\mathrm{B_1A_4}$ is length of overlapping area, $\mathrm{A_1B_4}$ is total length of two fuzzy sets. The experiment was conducted in the following way: the overlap percentage (OL) was varied in

5 levels (10%, 20%, 30%, 40% and 50%) while keeping SAM constant at 0.45, 0.5 and 0.55 (middle and two border points of the overlapping area). BSP and pH were remained unchanged at optimum value (BSP = 60, pH = 2.5) to prevent their influence on Nutrient Suitability Index (NSI). The aggregation method of consequence part and defuzzification method were constant as initial design. This allowed analyzing how changing in OL could affect NSI. Data of membership functions for different OL were summarized in Table 2.

Table 2: The membership functions of Soil Adsorption Matrix at different overlap percentages

OL (%)	B_1A_4	A_1	A_2	A_3	A_4	B_1	B_2	B_3	B_4
10	0.1	0	0.2	0.4	0.55	0.45	0.6	0.8	1
20	0.2	0	0.2	0.4	0.6	0.4	0.6	0.8	1
30	0.3	0	0.2	0.4	0.65	0.35	0.6	0.8	1
40	0.4	0	0.2	0.4	0.7	0.3	0.6	0.8	1
50	0.5	0	0.2	0.4	0.75	0.25	0.6	0.8	1

3.3.2.3 The effects of overlap of output fuzzy sets on Tree Species Suitability Index

Similar to input variables of the Tree Species Suitability model, the output variables were designed with overlapping areas between fuzzy sets. It is assumed that the overlap of output fuzzy sets leads to inconsistent result of Tree Species Suitability Index because the lower membership values of the overlapping area are ignored in aggregation step. This could lead to the case that different rule bases produce the same output value. To test this assumption, an experiment was employed with Nutrient Suitability models of *Picea abies* and *Abies alba*. Three overlapping output fuzzy sets were analyzed including “Moderate suitability”, “Good suitability” and “Very good suitability”. Data for input variables (SAM, BSP and pH) was selected to match the chosen output fuzzy sets. Given A_1, A_2, A_3, A_4; B_1, B_2, B_3, B_4 and C_1, C_2, C_3, C_4 as parameters to define “Moderate suitability”, “Good suitability” and “Very good suitability” output fuzzy sets (see Figure 8).

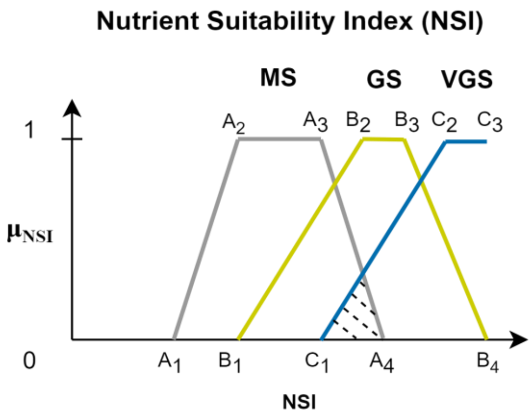

Figure 8: The overlap of fuzzy sets in Nutrient Suitability Index (MS: Moderate Suitability, GS: Good Suitability, VGS: Very Good Suitability)

The overlapping area between three fuzzy sets is calculated as follows:

$$\mathrm{OL}\ (\%) = \frac{\mathrm{C_1A_4}}{\mathrm{A_1B_4}} \cdot 100 \qquad (13)$$

Where $\mathrm{C_1A_4}$ is length of overlapping area and $\mathrm{A_1B_4}$ is total length of three fuzzy sets. The experiment was conducted as follows: the overlapping area were varied in 3 levels (0%, 20%, and 40%) while keeping all input variables constant (SAM = 0.831, BSP = 95, pH = 3.5). With these given inputs, *Picea abies* and *Abies alba* produced different rule bases. Thus, the output values (NSI) for two species were expected to be different. By comparing NSI of two species, the assumption would be explained. The membership functions of fuzzy sets were summarized in Table 3.

Table 3: Membership functions of analyzed fuzzy sets in different overlap percentages

OL (%)	C_1A_4	A_1	A_2	A_3	A_4	B_1	B_2	B_3	B_4	C_1	C_2	C_3	C_4
0	0	0.25	0.4	0.6	0.7	0.4	0.7	0.8	1	0.7	0.9	1	Inf
20	0.15	0.25	0.4	0.6	0.775	0.4	0.7	0.8	1	0.625	0.9	1	Inf
40	0.3	0.25	0.4	0.6	0.85	0.4	0.7	0.8	1	0.55	0.9	1	Inf

3.3.2.4 The effects of aggregation method of output fuzzy sets on Tree Species Suitability Index

As described in section 3.1, output fuzzy sets of all single rule bases will be aggregated by Maximum operator into a final fuzzy set before defuzzification. This aggregation method was assumed to cause inconsistency behavior for Tree Species Suitability model because it only considers highest membership values in the overlapping area. As a result, the contribution of lower membership values is ignored, and the output will be inconsistent with the inputs. To test this hypothesis, an experiment was conducted with Nutrient Suitability models of *Picea abies* and *Abies alba*. The input variables were remained unchanged (SAM = 0.831, BSP = 95, pH = 3.5) while varying two aggregation methods (Maximum and Bounded sum). Defuzzification method was constant with Center of Gravity. According to Mizumoto et al. (1981), the Bounded sum of fuzzy set R1 and fuzzy set R2 is defined as:

$$\mu_{R1} \oplus \mu_{R2} = \min(\mu_{R1} + \mu_{R2}, 1) \qquad (14)$$

Where μ_{R1} and μ_{R2} are the membership values of fuzzy sets R1 and R2, respectively. With given input variables, rule bases for *Picea abies* and *Abies alba* were different. Thus, it is expected that the Nutrient Suitability Index of these two species will be different. If two species have the same outcome, the model will be inconsistent, and the hypothesis will be proven.

3.3.2.5 The discontinuous response of the Tree Species Suitability model

The discontinuous response of Tree Species Suitability model is assumed to occur when two different input fuzzy sets of a variable produce the same output fuzzy set. It leads to the inconsistent behavior of the Tree Species Suitability model. To test this hypothesis, an experiment was employed with Soil Adsorption Matrix model. Soil Depth and Soil Type were remained unchanged at 100 cm and clay soils, respectively while varying Coarse Fraction (CF) from 10% to 20%. By this way, two different rules were processed as:

- Rule 80: *IF SD is very deep AND CF is very low AND ST is clay soils then SAM is very good.*

- Rule 85: *IF SD is very deep AND CF is low AND ST is clay soils then SAM is very good*.

Two input fuzzy sets of CF (Very low and Low) produced the same output fuzzy set (Very good). By analyzing the outcome of SAM, the hypothesis would be tested.

3.3.2.6 Species suitability response along gradients

The aim of this section is to analyze how Tree Species Suitability Index of European tree species responds along different gradients. 30 sample plots were selected for 10 different altitudes in Styria, Austria. The environmental variables were extracted for calculating Tree Species Suitability Index of four European tree species (see Table 4). Results of the Maximum and Gamma functions were compared to define a better method.

Table 4: Environmental factors of the sample plots in Styria

Plot	Elevation (m)	GDD	WF	LVP	LF	SD	CF	ST	BSP	pH	SMI	GW	Gley
1	1880	636	-7.7	125	162	50	77.6	2.0	55.6	4.7	0.0	0	0
2	1880	636	-7.7	125	162	50	78.0	2.0	5.0	3.5	0.2	0	0
3	1880	636	-7.7	125	162	100	10.0	2.0	55.0	4.7	0.0	0	0
4	1750	753	-7.3	142	151	80	65.3	4.0	4.8	3.8	0.0	0	0
5	1750	753	-7.3	142	151	100	10.0	2.0	55.6	4.7	0.0	0	0
6	1750	753	-7.3	142	151	80	65.0	4.0	4.8	3.7	0.2	0	0
7	1580	897	-7.2	156	142	80	69.2	2.0	6.3	3.7	0.0	0	0
8	1580	897	-7.2	156	142	100	10.0	2.0	55.6	4.7	0.0	0	0
9	1580	897	-7.2	156	142	80	69.2	2.0	6.3	3.7	0.2	0	0
10	1402	1083	-5.2	172	135	70	70.2	3.0	98.7	6.6	0.0	0	0
11	1402	1083	-5.2	172	135	100	10.0	3.0	55.0	4.5	0.0	0	0
12	1402	1083	-5.2	172	135	70	70.2	3.0	5.0	3.5	0.2	0	0
13	1165	1259	-6.4	185	122	80	32.8	3.0	93.8	6.0	0.1	0	0
14	1165	1259	-6.4	185	122	100	10.0	3.0	55.0	4.5	0.1	0	0
15	1165	1259	-6.4	185	122	80	33.0	3.0	5.0	3.5	0.2	0	0
16	895	1460	-5.9	193	123	80	27.5	3.0	12.0	3.9	0.0	0	0
17	895	1460	-5.9	193	123	100	10.0	3.0	55.0	4.5	0.0	0	0
18	895	1460	-5.9	193	123	80	27.5	3.0	12.0	3.9	0.2	0	0
19	880	1655	-4.7	203	108	100	24.0	2.0	42.3	4.2	0.0	0	0
20	880	1655	-4.7	203	108	50	60.0	2.0	5.0	3.5	0.0	0	0
21	880	1655	-4.7	203	108	50	60.0	2.0	42.3	4.2	0.2	0	0
22	680	1886	-5.8	217	115	80	25.7	2.0	38.8	4.2	0.1	0	0
23	680	1886	-5.8	217	115	50	70.0	2.0	5.0	3.5	0.1	0	0
24	680	1886	-5.8	217	115	50	70.0	2.0	38.8	4.2	0.2	0	0
25	520	2152	-3.7	229	100	100	10.5	1.0	14.3	3.7	0.1	0	1
26	520	2152	-3.7	229	100	100	10.5	1.0	55.0	4.5	0.1	0	1
27	520	2152	-3.7	229	100	50	60.0	1.0	14.3	3.7	0.2	0	1
28	310	2351	-4.0	238	102	100	0.0	4.0	89.0	5.2	0.1	0	1
29	310	2351	-4.0	238	102	100	0.0	4.0	5.0	3.5	0.1	0	1
30	310	2351	-4.0	238	102	50	50.0	4.0	89.0	5.2	0.2	0	1

4 Results

4.1 The Tree Species Suitability model

4.1.1 Membership functions and linguistic terms of the Tree Species Suitability model

<u>Temperature</u>

The linguistic terms and membership functions were defined for each of temperature's variables depended on expert knowledge, and available data from FORSITE project. The number of linguistic terms is corresponded to the number of membership functions. Growing Degree Days was described by five linguistic terms including Very low, Low, Moderate, High, and Very high in the range from 0 to 3000. Four linguistic terms particularly Very cold, Cold, Cool and Mild were selected to illustrate Winter Frost within interval [-20, 0] C^o. Similarly, Length of Vegetable Period were varied from 100 to 250 days with six linguistics terms (Very short, Short, Moderately short, Moderately long, Long, and Very long). Five terms were employed for Last Frost (Very early, Early, Moderately late, Late and Very late). The Temperature Suitability Index consisted of five terms namely Unsuitable, Low suitability, Moderate suitability, Good suitability, and Very good suitability, ranging from 0 to 1. The details about linguistic terms and membership functions of the temperature variables can be found in Table 5 and Figure 9.

Table 5: Membership functions and linguistic terms of the Temperature Suitability model

	Variables	Linguistic Term	Lower limit a (0)	Lower support limit b (1)	Upper support limit c (1)	Upper limit d (0)
Input	Growing Degree Days	Very low	Inf	Inf	200	500
		Low	0	400	600	800
		Moderate	500	800	1200	1800
		High	800	1600	2000	2500
		Very high	2000	2500	3000	Inf
	Winter Frost	Very cold	Inf	-20	-15	-7
		Cold	-20	-12	-10	-2
		Cool	-10	-7	-5	0
		Mild	-7	-2	0	Inf
	Length of Vegetation Period	Very short	Inf	100	120	140
		Short	100	130	150	170
		Moderately short	120	160	170	200
		Moderately long	140	180	190	220
		Long	160	200	220	250
		Very long	180	230	250	Inf
	Last Frost	Very early	Inf	100	110	140
		Early	100	120	140	160
		Moderately late	120	150	160	180
		Late	140	170	180	200
		Very late	160	190	200	Inf
Output	Temperature Suitability Index	Unsuitable	Inf	0	0.15	0.3
		Low suitability	0	0.2	0.3	0.5
		Moderate suitability	0.25	0.4	0.6	0.75
		Good suitability	0.4	0.7	0.8	1
		Very good suitability	0.6	0.9	1	Inf

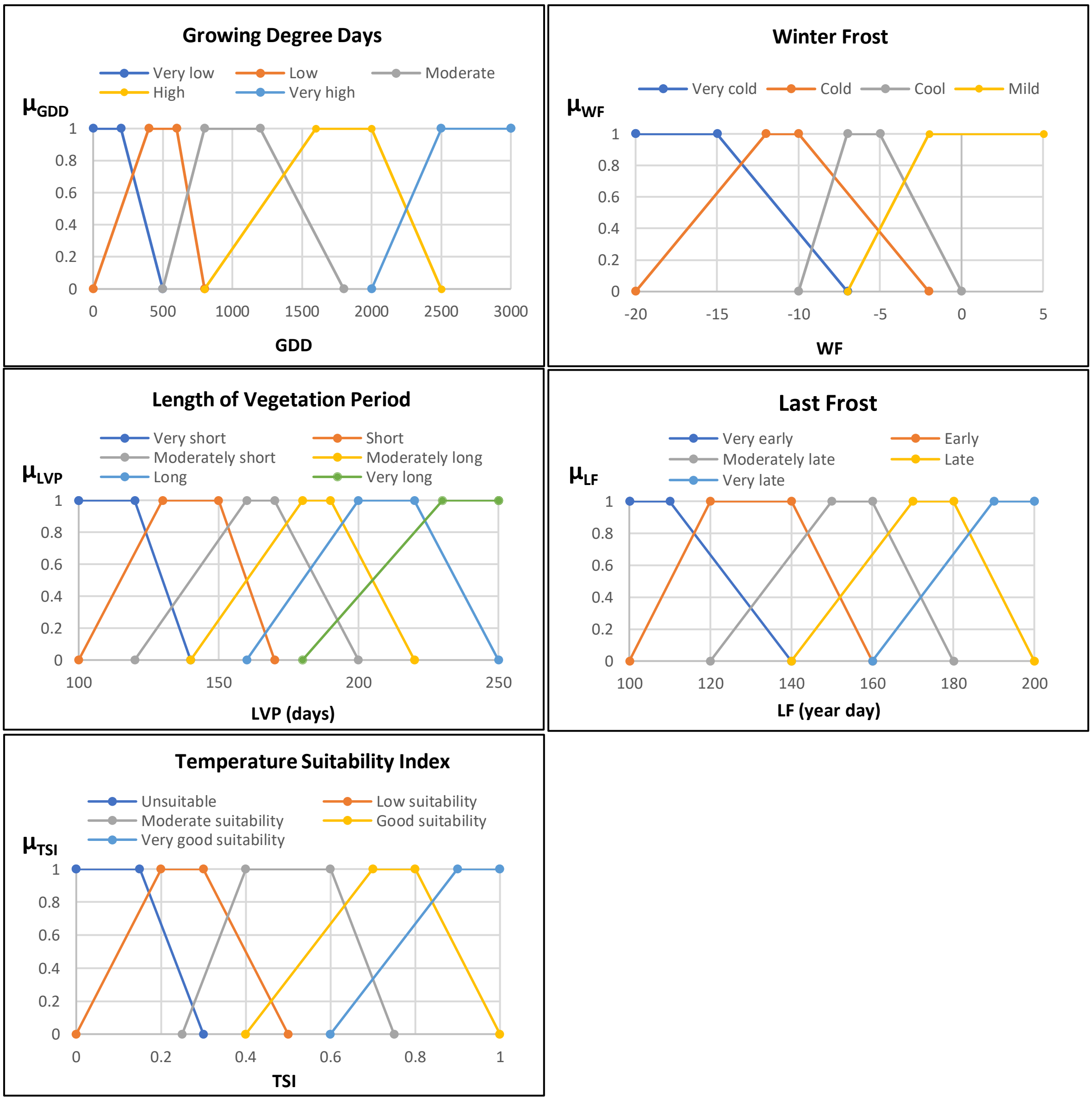

Figure 9: Membership functions of the Temperature Suitability model

Nutrients

The linguistic terms and parameters to build membership functions of the Soil Adsorption Matrix model are presented in Table 6, and Figure 10. Five linguistic terms namely Very shallow, Shallow, Moderately deep, Deep, and Very deep were defined for Soil Depth from 10 to 100 cm. Coarse Fraction contained five terms including Very low, Low, Moderately high, High and Very high, corresponding to the range of 0-100 %. Soil Type consisted of four terms (Sandy soils, Loamy sand, Loamy soils, Clay soils), and were defined as singleton fuzzy sets. Soil Adsorption Matrix (SAM) was described by four terms (Low, Moderate, Good, Very good) in the range between 0 and 1.

Table 6: Membership functions and linguistic terms of the Soil Adsorption Matrix

	Variables	Linguistic Term	Lower limit a (0)	Lower support limit b (1)	Upper support limit c (1)	Upper limit d (0)
Input	Soil Depth	Very shallow	Inf	Inf	10	30
		Shallow	15	20	30	50
		Moderately deep	30	40	60	80
		Deep	60	70	80	100
		Very deep	80	90	100	Inf
	Coarse Fraction	Very low	Inf	0	10	30
		Low	10	20	30	50
		Moderately high	30	40	50	70
		High	50	60	70	90
		Very high	70	80	100	Inf
	Soil Type	Sandy soils	1	1	1	1
		Loamy sands	2	2	2	2
		Loamy soils	3	3	3	3
		Clay soils	4	4	4	4
Output	Soil Adsorption Matrix	Low	Inf	0	0.1	0.5
		Moderate	0	0.2	0.4	0.6
		Good	0.4	0.6	0.8	1
		Very good	0.5	0.9	1	Inf

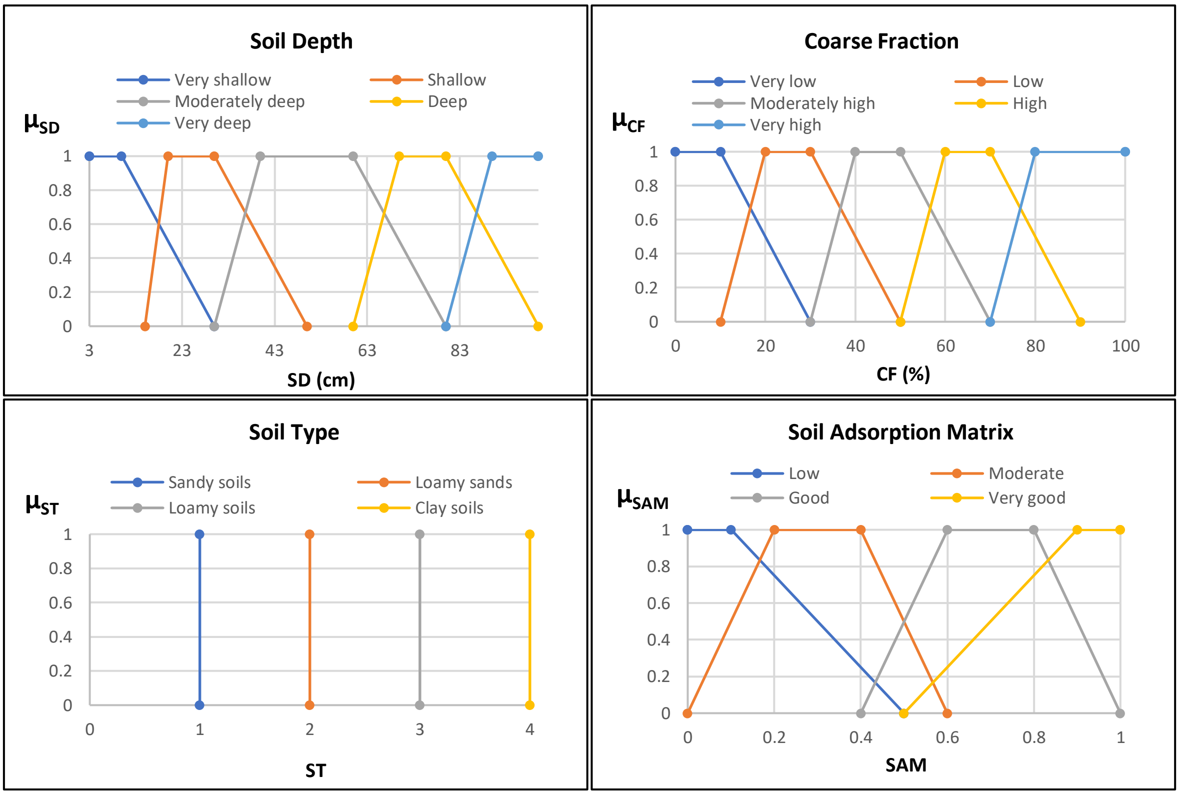

Figure 10: Membership functions of the Soil Adsorption Matrix

SAM was combined with Base Saturation Percentage (BSP) and pH in the Nutrient Suitability model. The linguistic terms and parameters to construct the model are summarized in Table 7 and Figure 11. BPS contains four terms including Low & unbalanced, Good supply, Moderately good supply, and Low supply. pH was described by four terms, namely Extremely acidic, Very acidic, Moderately acidic, Weak acidic/Weak alkaline, respectively. Finally, Nutrient Suitability Index was ranked from 0 to 1 with five terms (Unsuitable, Low suitability, Moderate suitability, Good suitability, Very good suitability).

Table 7: Membership functions and linguistic terms of the Nutrient Suitability model

	Variables	Linguistic Term	Lower limit a (0)	Lower support limit b (1)	Upper support limit c (1)	Upper limit d (0)
Input	Soil Adsorption Matrix	Low	Inf	0	0.1	0.5
		Moderate	0	0.2	0.4	0.6
		Good	0.4	0.6	0.8	1
		Very good	0.5	0.9	1	Inf
	Base Saturation Percentage	Low & unbalanced	80	90	100	Inf
		Good supply	30	45	80	100
		Moderately good supply	5	15	35	50
		Low supply	Inf	0	5	15
	pH	Extremely acidic	Inf	Inf	3,0	3,5
		Very acidic	3,0	3,5	4,0	4,5
		Moderately acidic	3,5	4,5	5,0	5,5
		Weak acidic/weak alkaline	5,0	6,0	Inf	Inf
Output	Nutrient Suitability Index	Unsuitable	Inf	0	0.15	0.3
		Low suitability	0	0.2	0.3	0.5
		Moderate suitability	0.25	0.4	0.6	0.75
		Good suitability	0.4	0.7	0.8	1
		Very good suitability	0.6	0.9	1	Inf

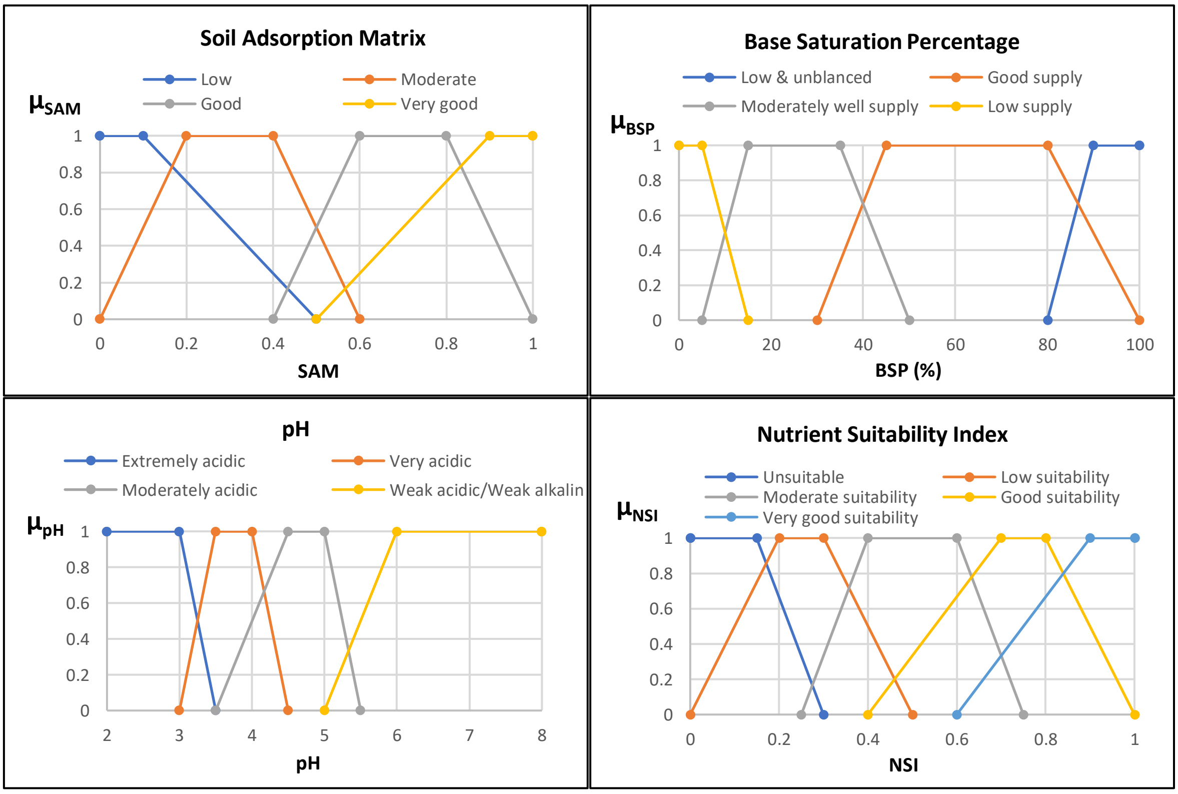

Figure 11: Membership functions of the Nutrient Suitability model

Water

The membership functions and linguistic terms of the Water Suitability model were presented in Table 8 and Figure 12. The crisp value's range of Soil Moisture Index was defined from 0 to 1 with four linguistic terms (Good water supply, Moderate water supply, Limited water supply and Very limited water supply). Gley was described by three terms including No gley, Weak gley soil and Strong gley soil. Similarly, three linguistic terms were developed for Ground water (GW) namely No ground water, Ground water weak and Ground water strong. Gley and GW were illustrated by singleton fuzzy sets. Eventually, the linguistic terms of the Water Suitability Index were Unsuitable, Low suitability, Moderate suitability, Good suitability, and Very good suitability, ranking from 0 to 1.

Table 8: Membership functions and linguistic terms of the Water Suitability model

	Variables	**Linguistic Term**	**Lower limit a (0)**	**Lower support limit b (1)**	**Upper support limit c (1)**	**Upper limit d (0)**
Input	Soil Moisture Index	Good water supply	Inf	Inf	0.05	0.15
		Moderate water supply	0	0.1	0.15	0.2
		Limited water supply	0.15	0.25	0.3	0.4
		Very limited water supply	0.25	0.35	Inf	Inf
	Gley	No gley	1	1	1	1
		Weak gley soil	2	2	2	2
		Strong gley soil	3	3	3	3
	Ground Water	No ground water	1	1	1	1
		Ground water weak	2	2	2	2
		Ground water strong	3	3	3	3
Output	Water Suitability Index	Unsuitable	Inf	0	0.15	0.3
		Low suitability	0	0.2	0.3	0.5
		Moderate suitability	0.25	0.4	0.6	0.75
		Good suitability	0.4	0.7	0.8	1
		Very good suitability	0.6	0.9	1	Inf

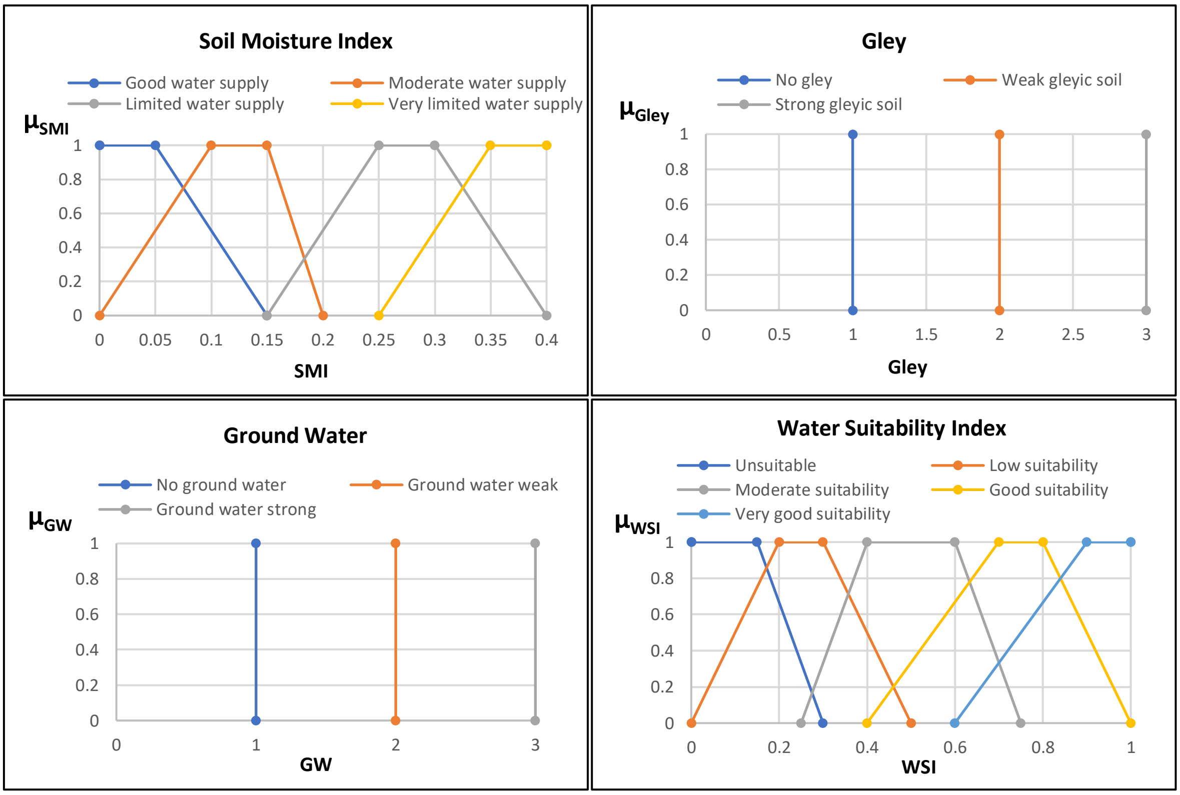

Figure 12: Membership functions of the Water Suitability model

4.1.2 Rules of the Tree Species Suitability model

For the construction of the Tree Species Suitability model, total 800 rules were developed for each tree species on the basic of available datasets and expert knowledges. In this model, the number of rules depend on the number of input variables and membership functions (MFs). If the number of MFs for each input variable is k and the number of input variables is n, then the total rule of the model is defined as:

$$R(\text{rule}) = k(x_1)k(x_2)\ldots k(x_n) \quad (15)$$

Therefore, since the Temperature Suitability model consisted of 4 input variables in which each variable contained from 4 to 6 MFs, the implemented rules for this model equal 600 (5x4x6x5). The number of MFs for Temperature Suitability Index (output variable) was 5. It should be noticed that if the input variable has more MFs than output variable, then two different rules can produce the same output fuzzy set. Thus, two different fuzzy sets of

Length of Vegetation Period can produce the same fuzzy set of Temperature Suitability Index. An example rule of the Temperature Suitability model is:

- *If GDD is Very low AND WF is Very cold AND LVP is Very short AND LF is Very early then SUI is Unsuitable.*

The Soil Adsorption Matrix (SAM) model consisted of three input variables in which Soil Depth and Soil Type contained 5 MFs, and Coarse Fraction had 4 MFs. SAM (output variable) was constructed with 4 MFs. Thus, 100 rules (5x5x4) were produced for the SAM model. Nutrient Suitability model had 3 input variables in which each variable included 4 MFs. The Nutrient Suitability Index (output variable) contained 4 MFs. As a result, 64 rules (4x4x4) were employed for this model. Examples of rules for Soil Adsorption Matrix and Nutrient Suitability models are given below:

- *If SD is Very shallow AND CF is Very low AND ST is Sandy soils then SAM is Low.*

- *If SAM is Very good AND BSP is Moderately good supply AND pH is Moderately acidic then SUI is Very good.*

Water Suitability model consisted of 4 MFs in Soil Moisture Index, 3 MFs in Ground Water and 3 MFs in Gley. The Water Suitability Index (output variable) contained 4 MFs. Therefore, 36 rules (4x3x3) were developed. An example of rule for this model is presented below:

- *If SMI is Good water supply AND GW is No ground water AND Gley is No gley then SUI is Very good suitability.*

The entire rules of the Tree Species Suitability model were detailed in annex.

4.2 Model evaluation

4.2.1 The maximum and minimum values of output variables in Tree Species Suitability model

Table 9 illustrates the minimum and maximum values of four output variables including Temperature Suitability Index (TSI), Soil Adsorption Matrix (SAM), Nutrient Suitability Index (NSI) and Water Suitability Index (WSI). Results shows that the highest and lowest results of SAM were 0.831 and 0.169, respectively. Maximum and minimum values of TSI were even for four European tree species (0.863 and 0.114). The minimum NSI of *Picea* *abies* was higher comparing to other species (0.25 vs 0.119) while the maximum value was even (0.863). The minimum WSI of *Quercus robur* was larger than that of remained species (0.25 vs 0.114). There was no difference in maximum WSI among species.

Table 9: The minimum and maximum values of output variables in Tree Species Suitability model

Value	Species	SAM	TSI	NSI	WSI
Max	Picea abies	0.831	0.863	0.863	0.863
	Abies alba	0.831	0.863	0.863	0.863
	Fagus sylvatica	0.831	0.863	0.863	0.863
	Quercus robur	0.831	0.863	0.863	0.863
Min	Picea abies	0.169	0.114	0.25	0.114
	Abies alba	0.169	0.114	0.119	0.114
	Fagus sylvatica	0.169	0.114	0.119	0.114
	Quercus robur	0.169	0.114	0.119	0.25

The minimum NSI of *Picea abies* and the minimum WSI of *Quercus robur* were higher than results of other species due to the difference in rule base. In the “worst” scenario, *Picea abies* produced “Low suitability” fuzzy set while *Abies alba, Fagus sylvatica* and *Quercus robur* had “Unsuitable suitability” fuzzy set. Similarly, the poorest fuzzy set for *Quercus robur* was “Low suitability”, which is slightly higher than “Unsuitable suitability” fuzzy set of other species.

All Mamdani fuzzy controls of the Tree Species Suitability model could not produce optimum output values (0 and 1) as initial design. The reason for this problem was Center of Gravity (COG) defuzzification method (see Figure 13). The COG method calculated a crisp value corresponding to a center point of the output fuzzy set. Consequently, the actual maximum Suitability Index was always lower than the desired maximum value of the fuzzy set (underestimated). By contrast, the actual minimum Suitability Index was higher than the desired minimum value of the fuzzy set (overestimated).

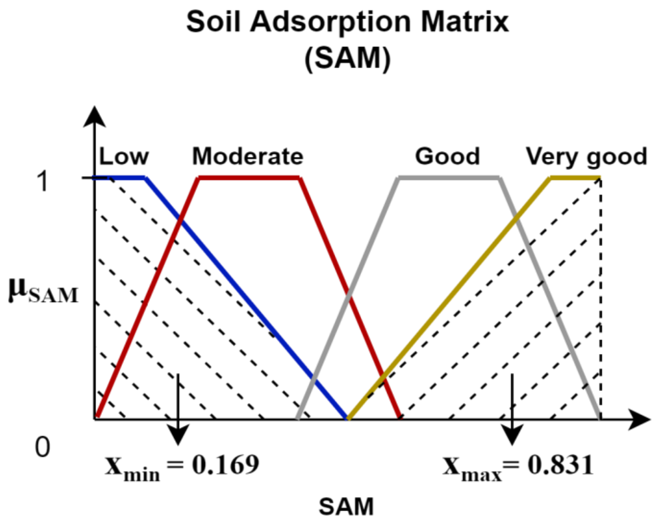

Figure 13: Effect of Center of Gravity defuzzification method on output value

The minimum NSI of all species were higher than minimum TSI and minimum WSI. The reason for this difference was illustrated in Figure 14 with result of minimum NSI for *Abies alba*.

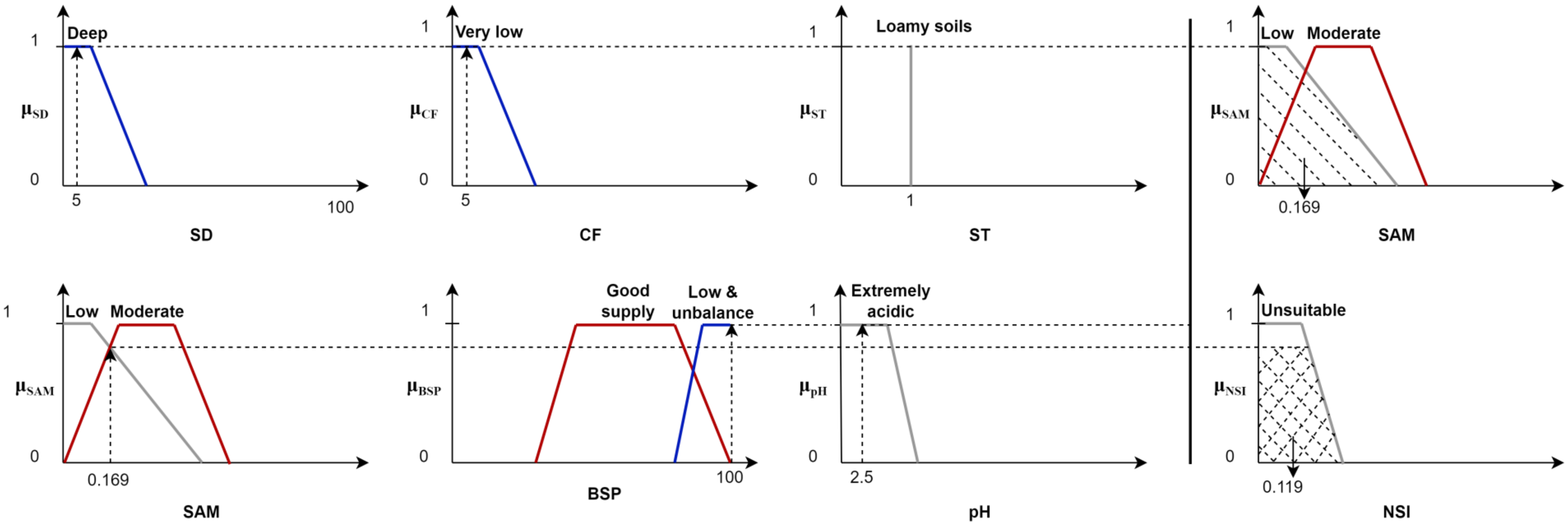

Figure 14: The impact of Center of Gravity defuzzification method on Nutrient Suitability model

With given input data, the model produced following rule bases:

(1) If *SD is very shallow* AND *CF is very low* AND *ST is sandy soils* then *SAM is low* (Rule 1 of SAM model).

(2) If *SAM is low* AND *BSP is low & unbalanced* AND *pH is extremely acidic* then *NSI is unsuitable* (Rule 1 of NSI model).

(3) If *SAM is moderate* AND *BSP is low & unbalanced* AND *pH is extremely acidic* then *NSI is unsuitable* (Rule 17 of NSI model).

It is conspicuous that the Soil Adsorption Matrix model only produced a "Low" output fuzzy set, which resulted in SAM of 0.169. However, when the same value of SAM was utilized as an input for Nutrient Suitability model, it was belonged to two input fuzzy sets (Low and Moderate). This difference was consequence of the Center of Gravity defuzzification method. COG tended to find a line which divides the aggregated fuzzy set into two equal masses. Therefore, SAM could not reach extreme value (0) of the output range even with the "worst" site condition. The overestimate of SAM led to its additional input fuzzy set in Nutrient Suitability model (Moderate), resulting in two "Unsuitable" output fuzzy sets (two sets were overlapped in black checkered area). Consequently, NSI was overestimated (0.119).

The type of membership function is an important factor which affects the crisp value. Different shape of fuzzy sets led to the difference in maximum and minimum values of SAM comparing to TSI, NSI and WSI. The maximum and minimum values of 1 and 0 can only be obtained if the output fuzzy set is singleton.

4.2.2 The effects of overlap of input fuzzy sets on Tree Species Suitability Index

The results of Nutrient Suitability Index (NSI) at different overlap percentages (OL) are illustrated in Table 10 and Figure 15. As OL increased, NSI increased gradually from 0.462 to 0.568 at Soil Adsorption Matrix (SAM) of 0.45. Contrariwise, decrease trends of NSI were occurred at SAM of 0.5 and 0.55 (from 0.621 to 0.616 and from 0.69 to 0.637, correspondingly).

Table 10: Nutrient Suitability Index of *Picea abies* at different overlap percentages of input fuzzy sets

SAM	OL (%)	NSI
0.45	10	0.462
	20	0.527
	30	0.550
	40	0.561
	50	0.568
0.5	10	0.621
	20	0.619
	30	0.618
	40	0.617
	50	0.616
0.55	10	0.690
	20	0.673
	30	0.653
	40	0.643
	50	0.637

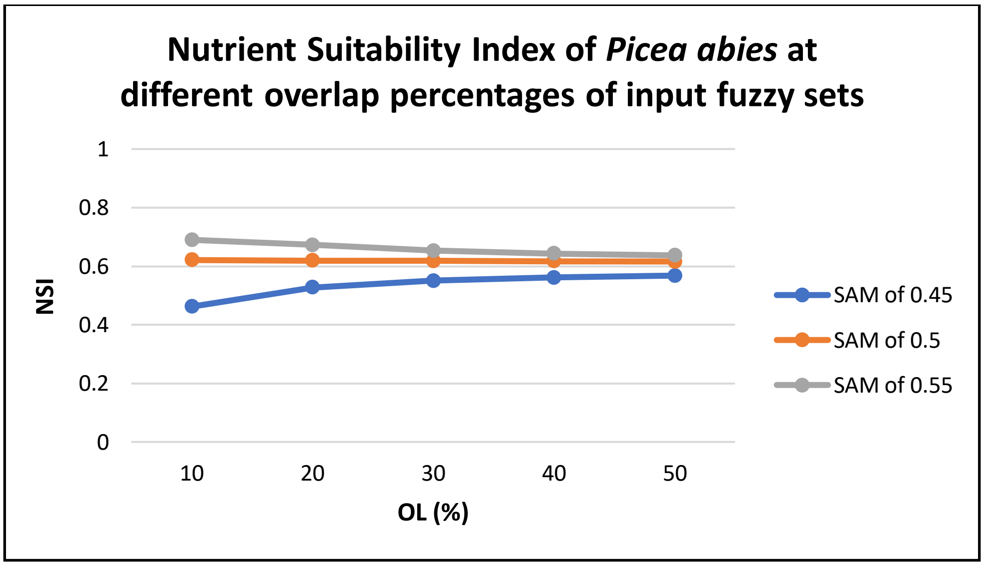

Figure 15: Nutrient Suitability Index of *Picea abies* at different overlap percentages of input fuzzy sets

It is obvious that the increment of OL increased membership function value of SAM (μ_{SAM}) in both "Moderate" and "Good" fuzzy sets (see Figure 16). This led to the rise in output fuzzy sets of NSI. However, since the rise of output fuzzy set both increased and decreased NSI (increased at SAM of 0.45 while decreased at SAM of 0.5 and 0.55), it is necessary to evaluate other factors which affect the final output value.

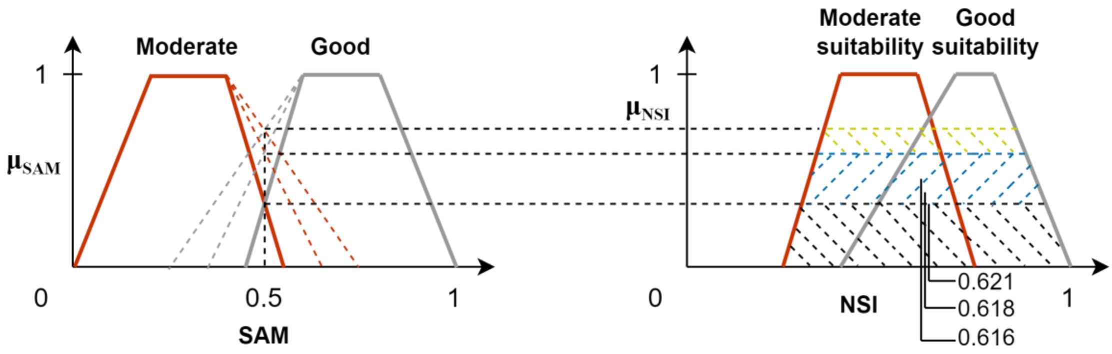

Figure 16: Nutrient Suitability Index of *Picea abies* at different overlap percentages (OL = 10%, 30%, 50%; SAM = 0.5). OL at 20% and 40% were ignored for better visualization

The shape of the output fuzzy set affected NSI (see Figure 16). In this case, "Moderate suitability" and "Good suitability" output fuzzy sets had different shape. Since defuzzification value always stays in the line that divides aggregated output fuzzy set into two equal masses, it will behave depending on the shape of the fuzzy set. Thus, as OL increased, NSI can either increased or decreased or stable. The stable case will occur if "Moderate suitability" and "Good suitability" output fuzzy sets are symmetric, and their membership values are equal.

The position of input value in overlapping area also affected NSI (see Figure 17). Three different input values of SAM (0.45, 0.5, 0.55) led to three different aggregated output fuzzy sets. As OL increased, NSI behaved differently for each case.

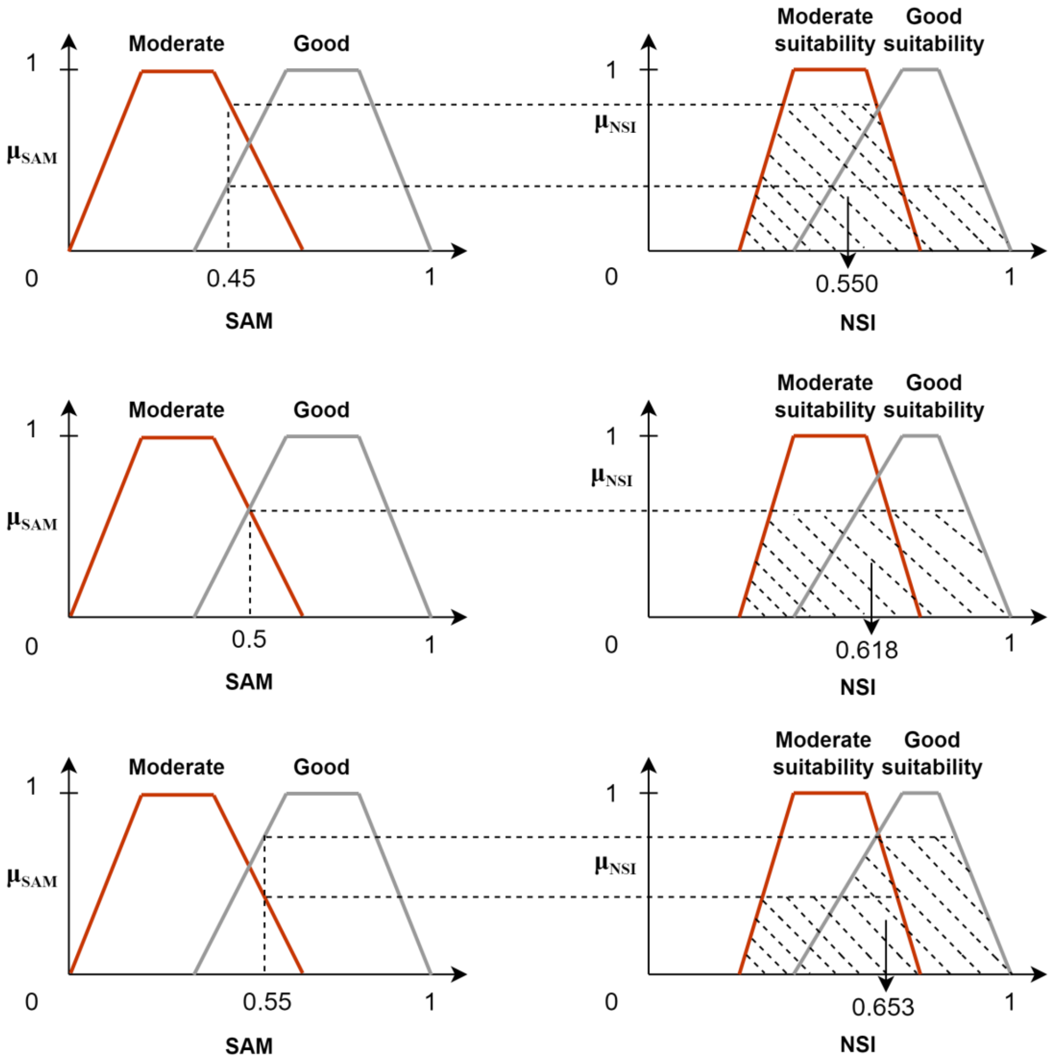

Figure 17: Nutrient Suitability Index of different Soil Adsorption Matrix at 30% of overlap

4.2.3 The effects of overlap of the output fuzzy sets to Tree Species Suitability Index

The Nutrient Suitability Index (NSI) of *Picea abies* and *Albies alba* at different overlap percentages (OL) of output fuzzy sets were presented in Table 11. Two species had even NSI at 20% and 40% OL while the difference occurred at 0% OL.

Table 11: Nutrient Suitability Index of *Picea abies* and *Abies alba* at different overlap percentages

OL (%)	NSI	
	Picea abies	***Abies alba***
0	0562	0.558
20	0.568	0.568
40	0.575	0.575

For given input data, four rules were processed including rule 34, rule 46, rule 50 and rule 62 (Annex). The output fuzzy set for each rule and their aggregation could be observed through an example of 20% OL (see Figure 18).

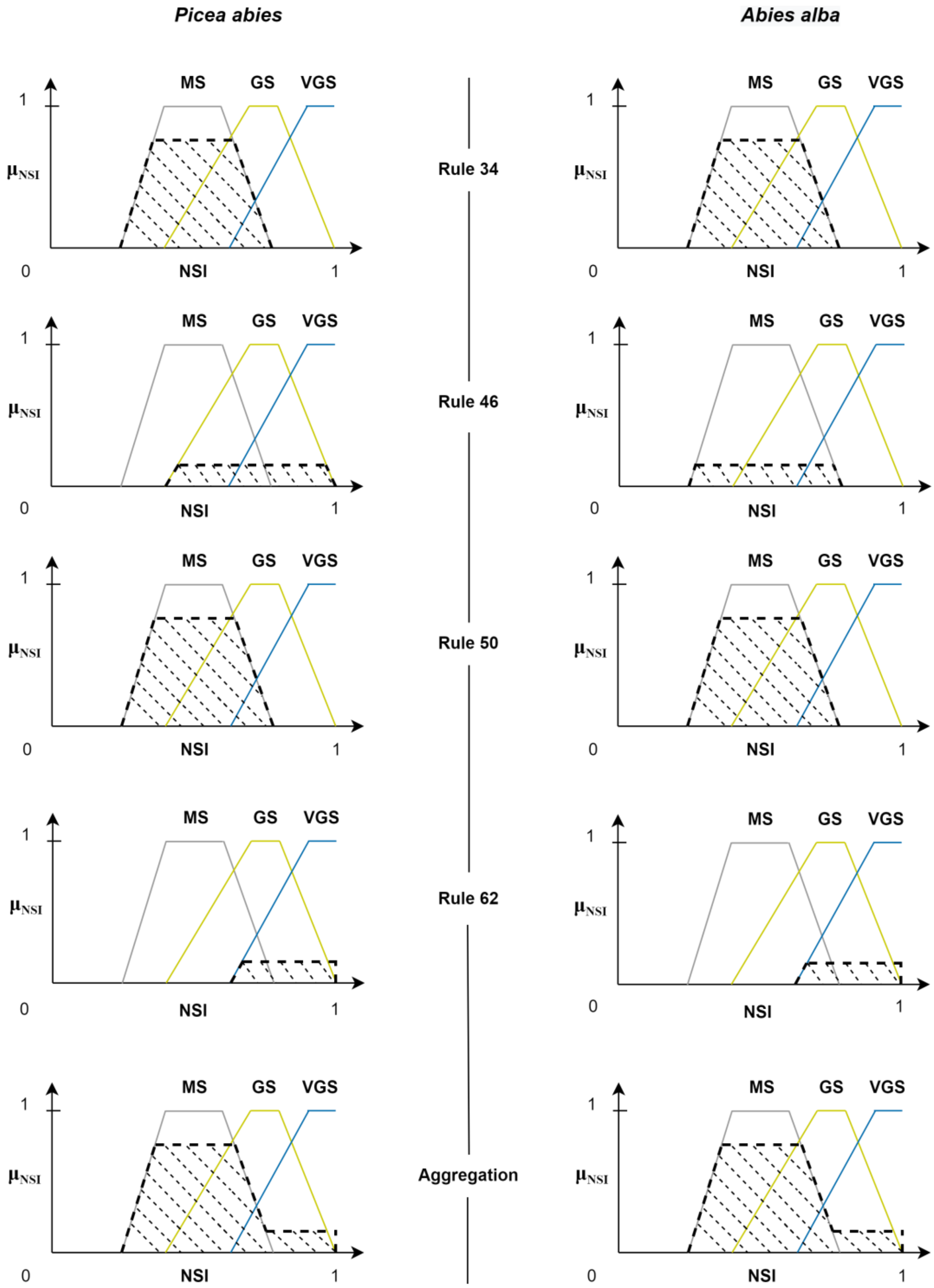

Figure 18: Output fuzzy sets of *Picea abies* and *Abies alba* at 20% overlap

In this case, two species had the same output fuzzy sets for rule 34, rule 50 and rule 62. The difference occurred in rule 46. *Picea abies* had "Good suitability" set while result for *Abies* *alba* was “Moderate suiability” set. In spite of this difference, the final aggregated output fuzzy sets of two species was even. The reason for this phenomenen was the overlap between three output fuzzy sets, in which the “Good suitability” set was occupied by “Moderate suitability” set and “Very good suitability” set. Consequently, a haft fuzzy area of “Good suitability” set of *Picea abies* in rule 46 was overlaped by “Moderate suitability” sets in rule 34 and rule 50 while the other half was overlap by “Very good suitability” set of rule 62. Similarly, the “Moderate suitability” set of *Abies alba* in rule 46 was overlaped by “Moderate suitability” sets in rule 34 and rule 50. Since the model used Maximum aggregation method, the fuzzy sets of two species in rule 46 were removed, resulting in the same final aggregated fuzzy sets.

The effect of overlap in output fuzzy sets on NSI could be futher explained through Figure 19. As a consequence of overlap, *Picea abies* and *Abies alba* also had the same NSI at 40% OL. Conversely, without overlap (0% OL), two species had difference in the red area of the “Good suitability” set, resulting in different NSI.

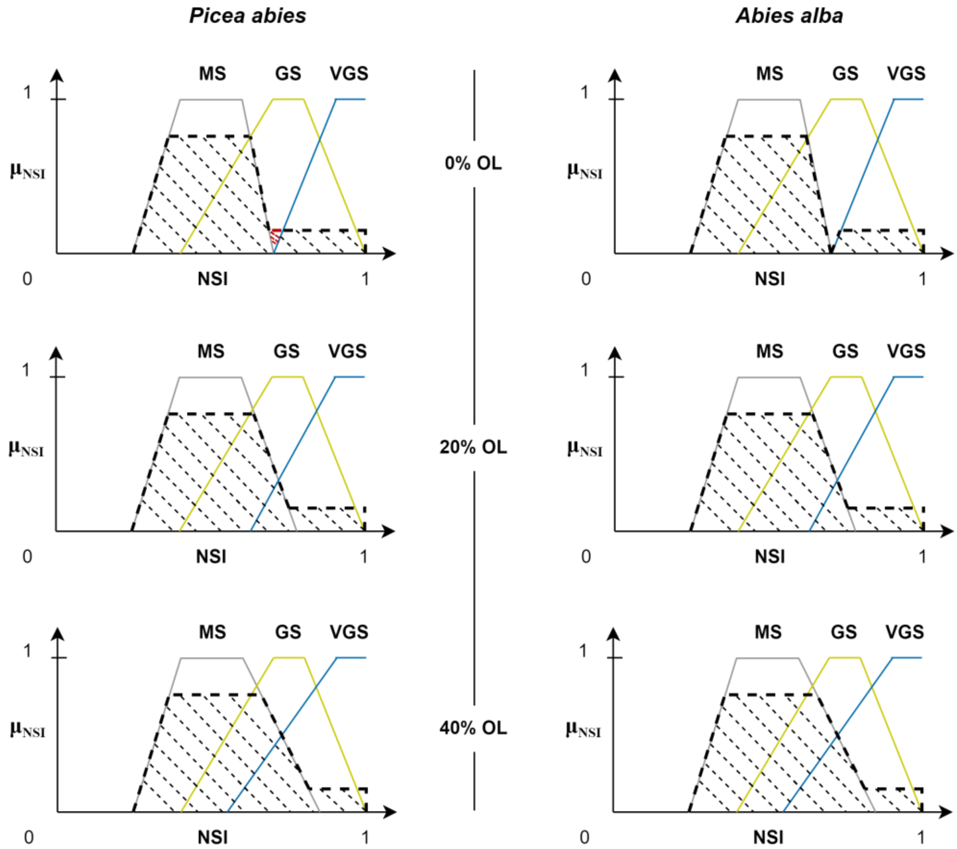

Figure 19: Aggregated output fuzzy set of *Picea abies* and *Abies alba* at different overlap percentages

4.2.4 The effects of aggregation method of output fuzzy sets on the Tree Species Suitability Index

As shown in Table 12, the Nutrient Suitability Index of *Picea abies and Abies alba* were even (0.566) with the Maximum aggregation method. There was a different in the results of two species with Bounded sum approach, in which the NSI of *Picea abies* was slightly higher than that of *Abies alba* (0.567 and 0.535).

Table 12: The Nutrient Suitability Index of *Picea abies* and *Abies alba* in different aggregation methods

Aggregation method	**NSI**	
	Picea abies	***Abies alba***
Maximum	0.566	0.566
Bounded sum	0.567	0.535

The performance of Nutrient Suitability model with Maximum aggregation method is presented in Figure 20. Four rules were processed, including rule 34, rule 46, rule 50 and rule 62 (see annex). Two species had the same output fuzzy sets in rule 34, rule 50 and rule 62. The difference occurred in rule 46, in which *Picea abies* had “Good suitability” set and *Abies alba* had “Moderate suitability” set. However, fuzzy set of rule 46 in both species were overlapped by fuzzy set of other rules. Since Maximum aggregation method only considers highest value, all membership values in rule 46 was ignored in both species. This led to the equal NSI for *Picea abies* and *Abies alba.*

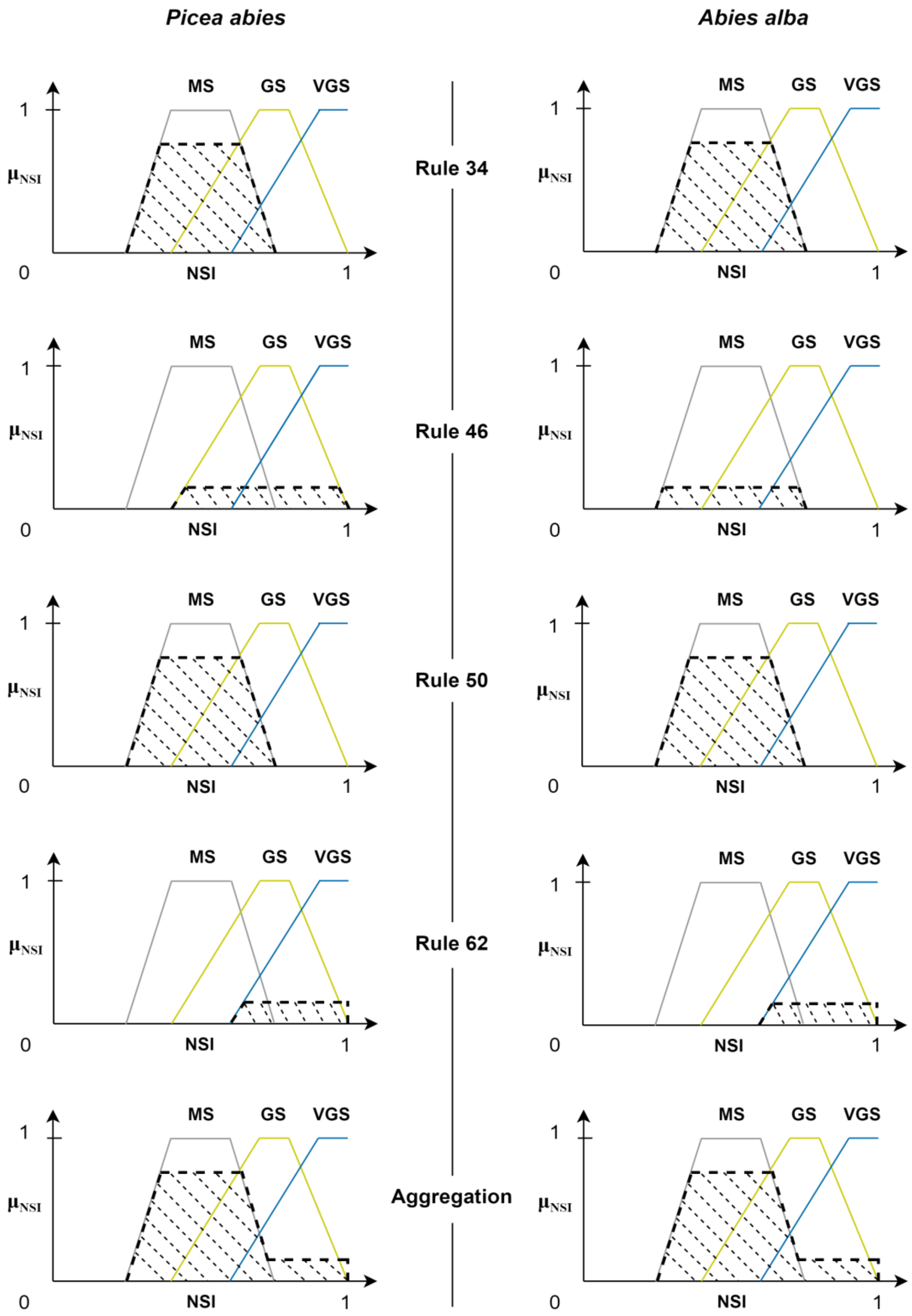

Figure 20: The performance of Maximum aggregation method

Figure 21 illustrated the performance of Nutrient Suitability model with Bounded sum aggregation method. As discussed above, the difference of *Picea abies* and *Abies alba* occurred in rule 46. However, as Bounded sum calculates the sum of membership values, it considers the contribution of lower values in the overlapping area. This led to the difference in final aggregated fuzzy sets between two species. As a result, NSI of *Picea abies* and *Abies alba* were different.

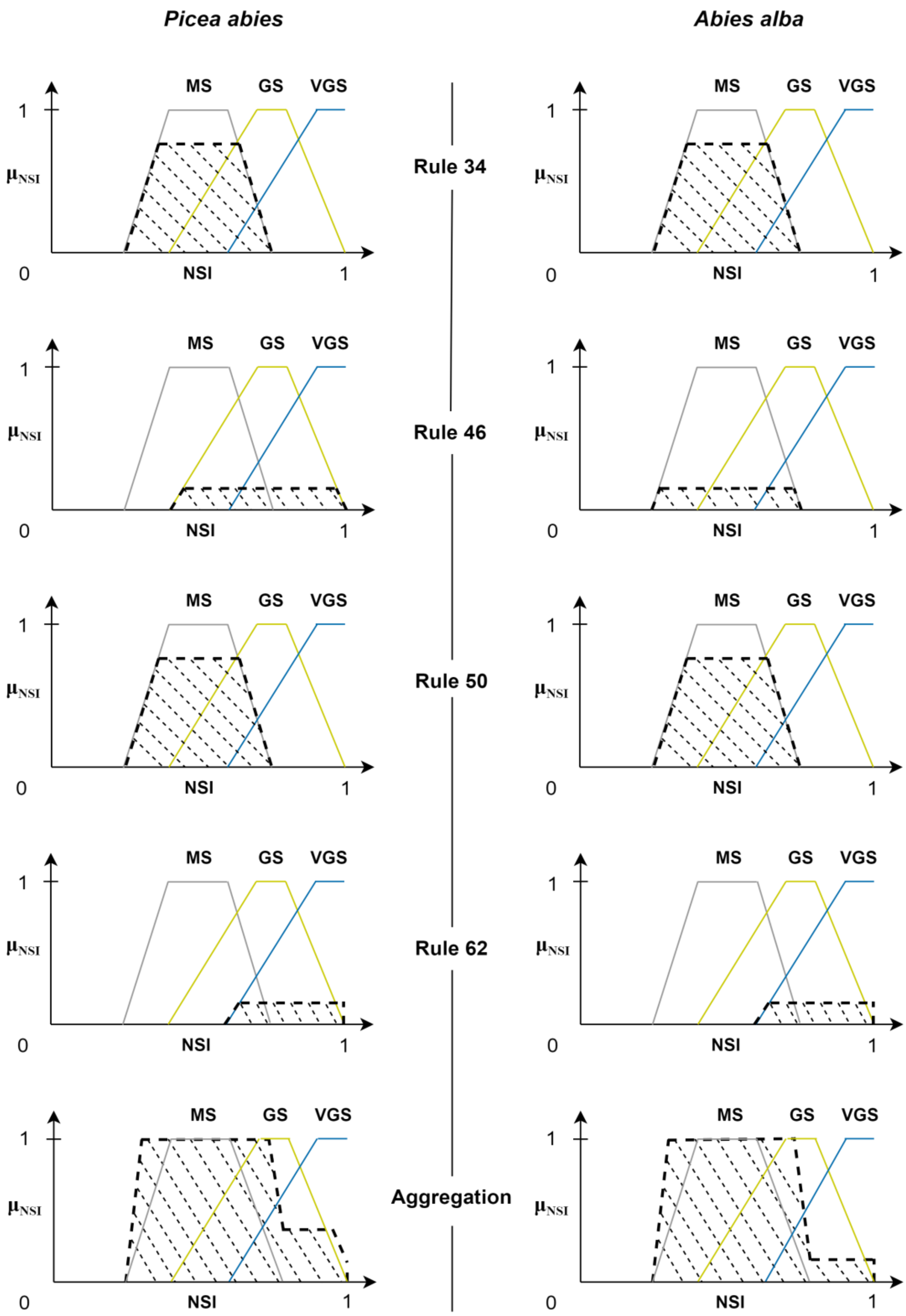

Figure 21: The performance of Bounded sum method

4.2.5 The discontinuous response of Tree Species Suitability model

The results of Soil Adsorption Matrix (SAM) are presented in Table 13 and Figure 22. SAM got the maximum value (0.831) at Coarse Fraction (CF) of 10%. The output values decreased gradually from CF of 11% to 16% and started to increase again until it reached optimum result at CF of 20%. This is an obvious discontinuous response of the model because SAM is expected to decrease following the increment of CF.

Table 13: Soil Adsorption Matrix at different Coarse Fractions

No.	CF (%)	SAM
1	10	0.831
2	11	0.828
3	12	0.826
4	13	0.823
5	14	0.820
6	15	0.817
7	16	0.814
8	17	0.815
9	18	0.820
10	19	0.826
11	20	0.831

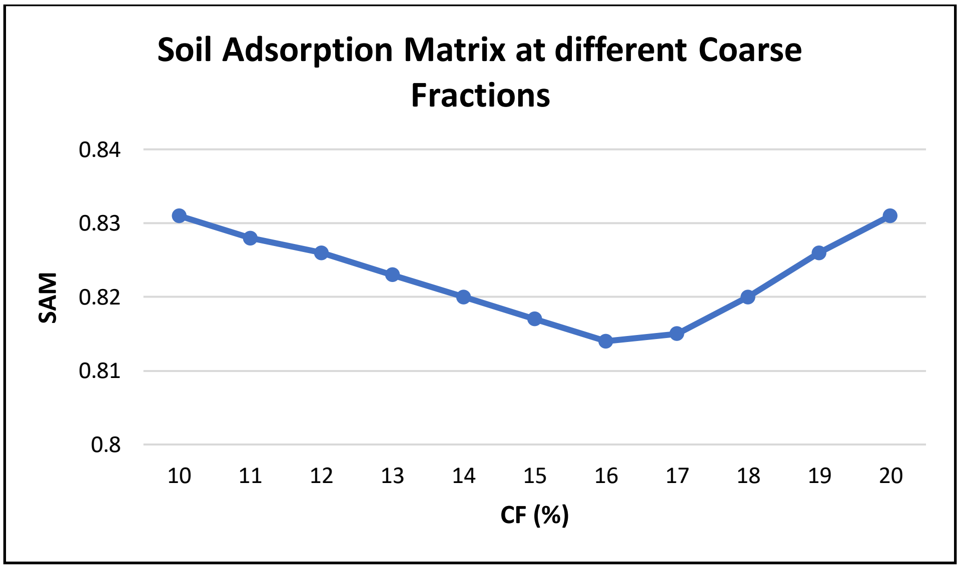

Figure 22: Soil Adsorption Matrix at different Coarse Fractions

The reason for this discontinuous response could be observed through Figure 23. At 12% CF, the model produced two “Very good” output fuzzy sets, which were overlapped (black checkered area). Similarly, at 19% CF, two “Very good” output fuzzy sets were processed and overlapped. As discussed in section 4.2.4, the Maximum aggregation method removes the lower values in the overlapping area. This led to the equal aggregated fuzzy set of SAM at 12% CF and 19% CF regardless their different CF values. Therefore, the discontinuous response of SAM was occurred.

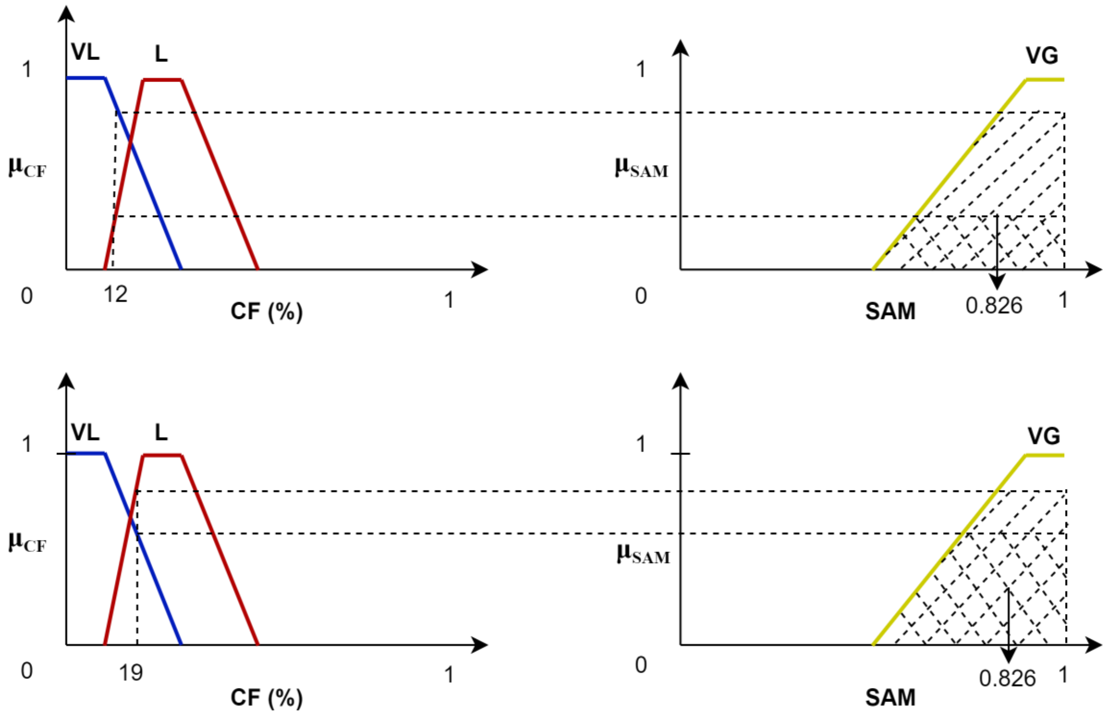

Figure 23: The discontinuous response of Soil Adsorption Matrix (VL: Very low, L: Low, VG: Very good)

4.2.6 Species suitability response along gradients

Figure 24 illustrates the Tree Species Suitability Index (TSSI) of *Picea abies* along different gradients. In general, Minimum approach produced lower TSSI than Gamma approach. Both methods showed quite similar trend of TSSI along different elevations.

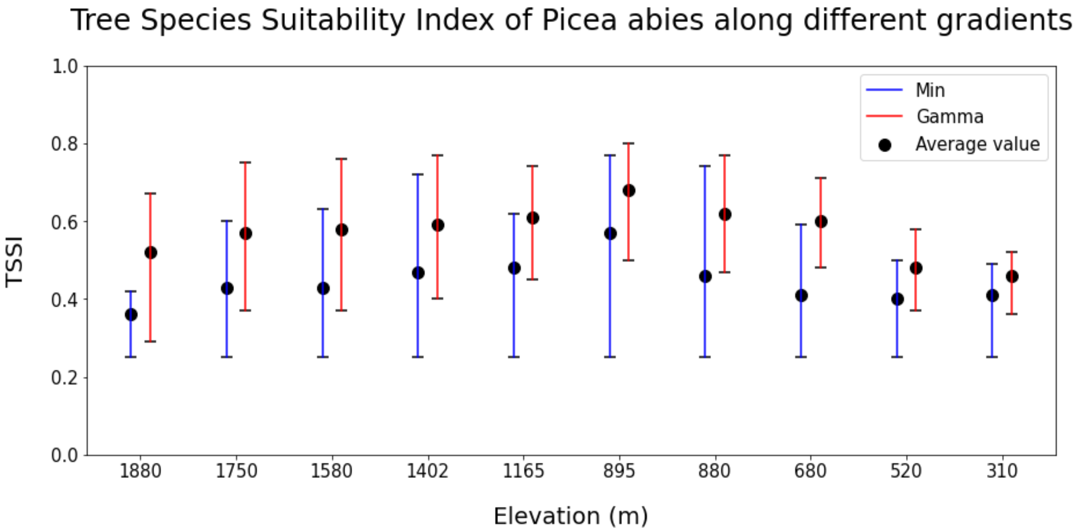

Figure 24: The Tree Species Suitability Index of *Picea abies* along different gradients

The Tree Species Suitability Index (TSSI) of *Abies alba* along different gradients is illustrated in Figure 25. Results indicate that output values of Minimum approach were lower than Gamma approach. Both methods showed similar response curve of TSSI, in which the value reached a peak at elevation of 895 m. The TSSI of different plots at 310 m were the same with Minimum method despite having different soil conditions.

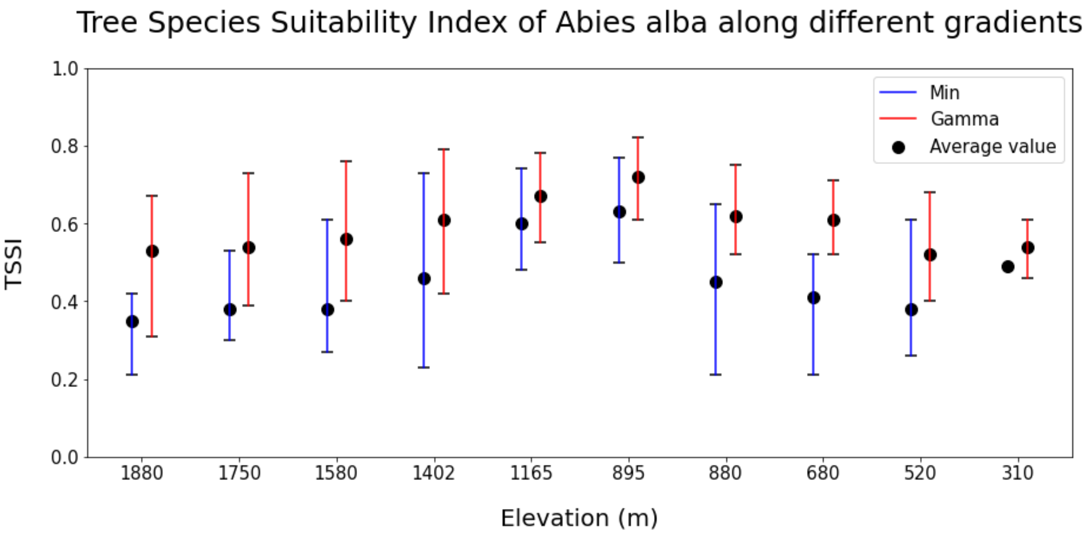

Figure 25: The Tree Species Suitability Index of *Abies alba* along different gradients

Figure 26 presents the Tree Species Suitability Index of *Fagus sylvatica* along different gradients. In general, Gamma method produced higher TSSI than Minimum method. Both approaches showed a similar response curve of TSSI along different gradients. At elevation of 1880 m, there was no variation in TSSI between different plots with Minimum method despite having different soil conditions.

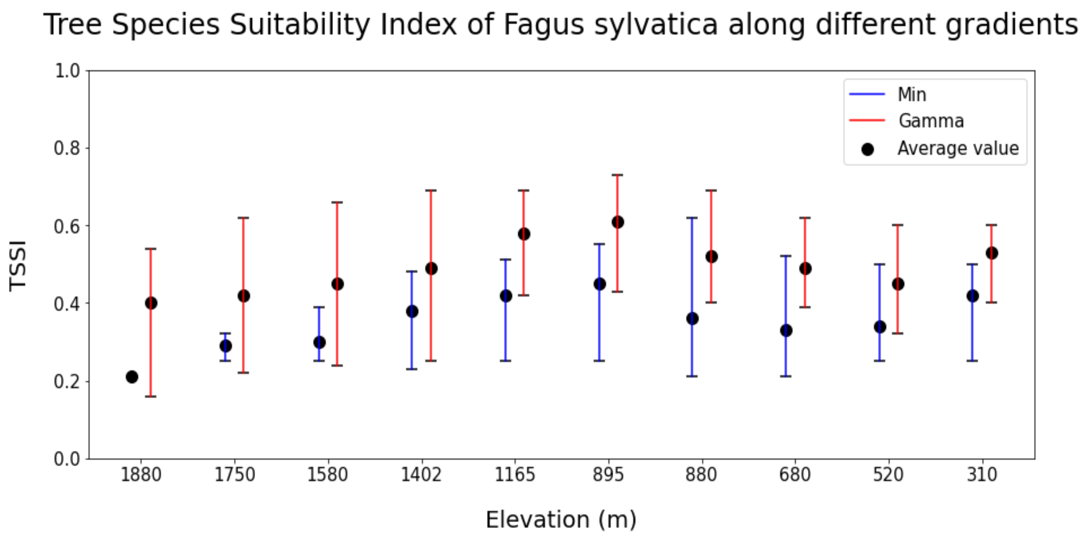

Figure 26: The Tree Species Suitability Index of *Fagus sylvatica* along different gradients

The Tree Species Suitability Index of *Quercus robur* is described in Figure 27. In general, the TSSI of Minimum method is lower than Gamma method. Both methods showed similar trend of TSSI along elevations. It should be noticed that the variation of TSSI at some specific elevations is insignificant or even zero with Minimum approach (1880 m, 1750 m, 1580 m, 1165 m, and 895 m) despite having different soil properties.

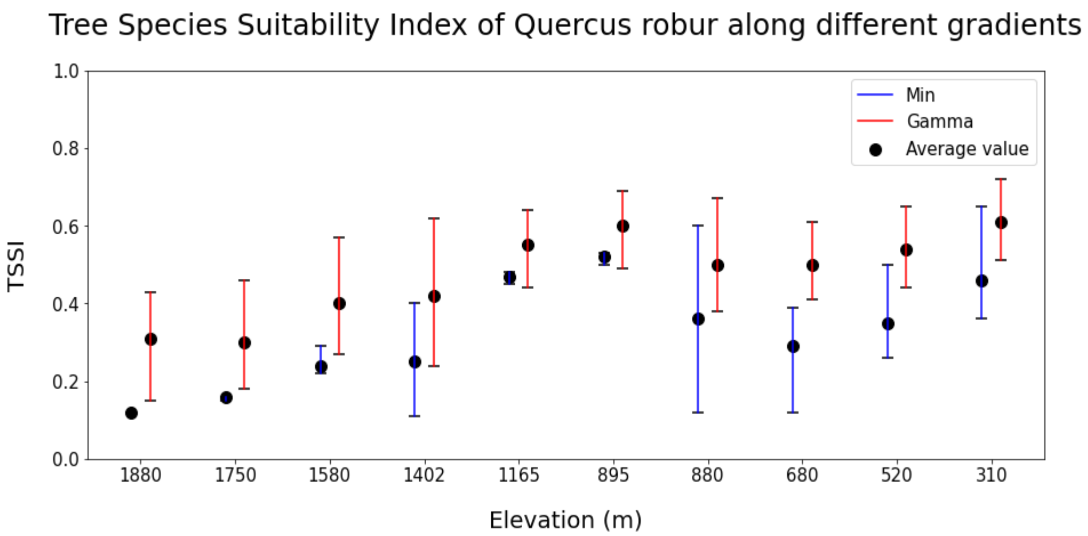

Figure 27: The Tree Species Suitability Index of *Quercus robur* along different gradients

Table 14 presents the maximum difference of Tree Species Suitability Index along altitudes and the maximum difference of Tree Species Suitability Index at the same altitude. Results showed that the variation of TSSI at the same altitude is larger than the variation of TSSI along different altitudes for all species.

Table 14: The maximum difference of Tree Species Suitability Index at the same altitude and along different altitudes

Method	Species	Maximum difference of TSSI along altitudes	Maximum difference of TSSI at the same altitude
Gamma	Picea abies	0.22	0.39
	Abies alba	0.19	0.37
	Fagus sylvatica	0.21	0.44
	Quercus robur	0.31	0.38
Min	Picea abies	0.21	0.52
	Abies alba	0.28	0.5
	Fagus sylvatica	0.24	0.41
	Quercus robur	0.4	0.48

The Tree Species Suitability Index of four European species with Gamma method is presented in Figure 28. In general, *Picea abies* and *Abies alba* had higher TSSI than *Fagus sylvatica* and *Quercus robur*. The TSSI of *Picea abies* and *Abies alba* were higher in the high and medium elevations (1880 m – 895 m) . *Fagus sylvatica* and *Quercus robur* had higher TSSI in medium and low elevations (895 m – 310 m). All species reached a peak at medium altitude (895 m).

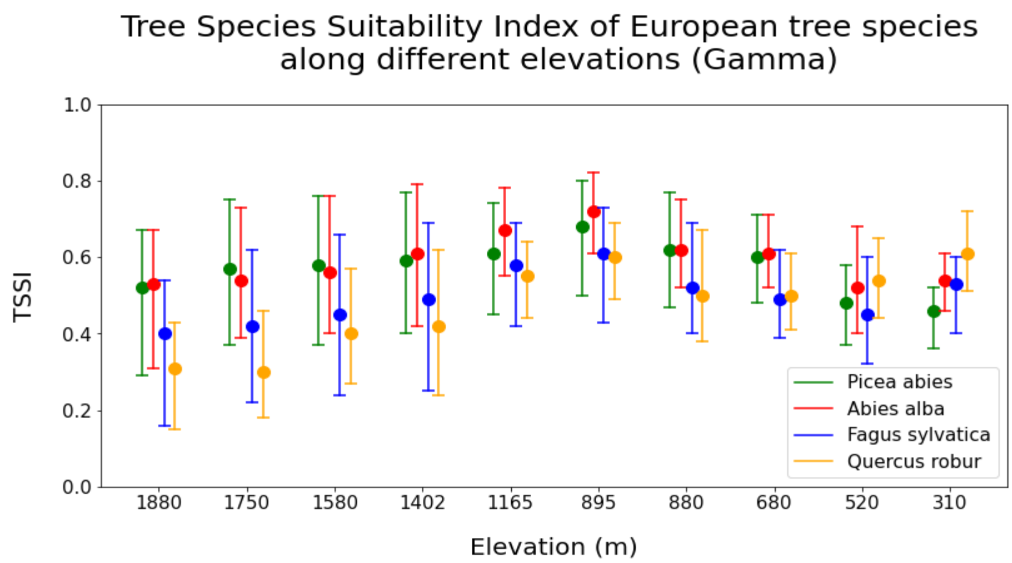

Figure 28: The Tree Species Suitability Index of European tree species along different elevations with Gamma method (the dots represent for the average value)

5 Discussions and conclusion

Proceeding from the consideration that there are limitations in both qualitative and quantitative approaches of tree species selection, the thesis aims to develop a Tree Species Suitability model based on fuzzy-logic theory. Mamdani fuzzy inference systems were applied to link environmental factors with Tree Species Suitability Index. The model consisted of four sub-models including Temperature Suitability, Soil Adsorption Matrix, Nutrient Suitability and Water Suitability. The input variables were processed to generate Temperature Suitability Index, Nutrient Suitability Index and Water Suitability Index. Finally, these indices were aggregated by Minimum and Gamma operators to produce Tree Species Suitability Index.

Here some selected but crucial methodological assumptions are scrutinized.

First, the study revealed the inconsistent behavior of Tree Species Suitability model to the input variables. The factors that caused this problem were Center of gravity defuzzification method, overlap of output fuzzy sets, Maximum aggregation method, and the rule base. Center of Gravity defuzzification method causes the inconsistent response of the Tree Species Suitability model for the outermost output fuzzy sets. The actual maximum and minimum values which Tree Species Suitability model can produce are in fact the centroid points of the extreme output fuzzy sets. It means two bands of values at the top and the bottom of the output range cannot reach as optimum as initial design unless the output fuzzy sets are singleton. The output value is not guaranteed to fulfil the consequence of an IF-THEN rule to at least the same extent that the input fulfil the antecedent (Izquierdo et al., 2017). This inconsistent behavior is more significant in the hierarchical system which an underestimated/overestimated output of a Mamdani Fuzzy Control unit is utilized as an input for other Mamdani Fuzzy Control unit. An adhoc improvement of the COG method might be accomplished by reducing the width of the extreme output fuzzy sets to bring actual output values closer to the limits of the output range. However, further studies are recommended to evaluate the effects of this approach on the smoothness of the output data.

The overlap and the Maximum aggregation method of the output fuzzy sets causes inconsistency between the rule base and the Tree Species Suitability Index. As an impact of the Max operator, output fuzzy sets of IF-THEN rules are not guaranteed to be simultaneously satisfied (Izquierdo et al., 2017). Specifically, this method considers just elements of highest membership degrees and ignores lower membership values in the overlapping area. Consequently, a worst-case scenario may happen in which the same Tree Species Suitability indices are obtained despite having different rule bases. This certainly generates uncertainty while attempting to interpret the set of rules or combine expert knowledge in Mamdani fuzzy logic system. To overcome this issue, it is recommended to avoid the overlap of over two output fuzzy sets in the same area. Another solution could be considered is changing aggregation method of the output fuzzy sets to Bounded sum. This approach considers the contribution of the smaller fuzzy set in the overlapping area. Therefore, it provides a fairer treatment for overlapping problem. Further work should be directed at studying the effect of Bounded sum aggregation method on the smoothness of output values.

The rule base is also a cause of the inconsistent behavior in the Tree Species Suitability model. If two different rules are designed to produce the same output fuzzy set, then a discontinuity of the Tree Species Suitability Index will occur. This could lead to the worst situation in which the model produces lower Tree Species Suitability Index despite having better site conditions. To obtain a continuous response curve of the outputs, each input fuzzy set should be linked to a different output fuzzy set. This means that the number of input fuzzy sets and output fuzzy sets should be equal.

The overlap percentage of input fuzzy set and the output fuzzy area has a positive correlation. As the overlap percentage increases, the output value corresponding to each specific input value may increase, decrease, or remain constant, depending on the shape of output fuzzy set and the position of input value in the overlapping area.

Gamma function provides a smoother response curve of the Tree Species Suitability Index than Minimum function. Minimum function only considers the lowest value and ignore the contribution of other variables. Consequently, the final output is only increased if the lowest value is improved. This reduces the smoothness of the output response curve. By contract, Gamma function provides a better compensation among Temperature Suitability Index, Nutrient Suitability Index and Water Suitability Index, and thus generates smoother outputs.

The variation of Tree Species Suitability Index at the same altitude is higher than the one varies along different altitudes. It means that tree species is affected more by soil properties in the small scale than being affected by temperature regime in the large scale. *Picea abies* and *Abies alba* are suitable to live from high to medium elevations. *Fagus sylvatica* and *Quercus robur* are appropriate to grow in medium and low altitudes.

The membership functions and rule bases of the Tree Species Suitability model were built based on expert knowledge, and data of FORSITE project. This could be a source of uncertainty for the model. Due to the limitation of time, the study has not evaluated several potential factors which could influence model performance including type of membership functions and intervals of membership functions. The number of input variables and membership functions could significantly affect computational efficiency of the model in MATLAB environment.

The Tree Species Suitability model was constructed following the fundamental niche approach. Thus, the model ignores other factors which could affect tree species including species competition and presence of insects. Due to the limitation on time and data, the model was only developed for four European tree species. It is recommended to produce Tree Species Suitability model for other valuable species as well.

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Annex

1. Rule bases of the Temperature Suitability model

1.1. Picea abies

No.	IF	AND	AND	AND	THEN
	GDD	WF	LVP	LF	SUI
1	moderate	mild	very short	very early	low
2	moderate	mild	very short	early	low
3	moderate	mild	very short	moderately late	low
4	moderate	mild	very short	late	low
5	moderate	mild	very short	very late	low
6	moderate	very cold	short	very early	moderate
7	moderate	very cold	short	early	moderate
8	moderate	very cold	short	moderately late	moderate
9	moderate	very cold	short	late	moderate
10	moderate	very cold	short	very late	moderate
11	moderate	cold	short	very early	moderate
12	moderate	cold	short	early	moderate
13	moderate	cold	short	moderately late	moderate
14	moderate	cold	short	late	moderate
15	moderate	cold	short	very late	moderate
16	moderate	cool	short	very early	moderate
17	moderate	cool	short	early	moderate
18	moderate	cool	short	moderately late	moderate
19	moderate	cool	short	late	moderate
20	moderate	cool	short	very late	moderate
21	moderate	mild	short	very early	moderate
22	moderate	mild	short	early	moderate
23	moderate	mild	short	moderately late	moderate
24	moderate	mild	short	late	moderate
25	moderate	mild	short	very late	moderate
26	moderate	very cold	moderately short	very early	moderate
27	moderate	very cold	moderately short	early	moderate
28	moderate	very cold	moderately short	moderately late	moderate
29	moderate	very cold	moderately short	late	moderate
30	moderate	very cold	moderately short	very late	moderate
31	moderate	cold	moderately short	very early	good
32	moderate	cold	moderately short	early	good
33	moderate	cold	moderately short	moderately late	good
34	moderate	cold	moderately short	late	good
35	moderate	cold	moderately short	very late	good
36	moderate	cool	moderately short	very early	good
37	moderate	cool	moderately short	early	good

38	moderate	cool	moderately short	moderately late	good
39	moderate	cool	moderately short	late	good
40	moderate	cool	moderately short	very late	good
41	moderate	mild	moderately short	very early	good
42	moderate	mild	moderately short	early	good
43	moderate	mild	moderately short	moderately late	good
44	moderate	mild	moderately short	late	good
45	moderate	mild	moderately short	very late	good
46	moderate	very cold	moderately long	very early	good
47	moderate	very cold	moderately long	early	good
48	moderate	very cold	moderately long	moderately late	good
49	moderate	very cold	moderately long	late	good
50	moderate	very cold	moderately long	very late	good
51	moderate	cold	moderately long	very early	good
52	moderate	cold	moderately long	early	good
53	moderate	cold	moderately long	moderately late	good
54	moderate	cold	moderately long	late	good
55	moderate	cold	moderately long	very late	good
56	moderate	cool	moderately long	very early	good
57	moderate	cool	moderately long	early	good
58	moderate	cool	moderately long	moderately late	good
59	moderate	cool	moderately long	late	good
60	moderate	cool	moderately long	very late	good
61	moderate	mild	moderately long	very early	good
62	moderate	mild	moderately long	early	good
63	moderate	mild	moderately long	moderately late	good
64	moderate	mild	moderately long	late	good
65	moderate	mild	moderately long	very late	good
66	moderate	very cold	long	very early	good
67	moderate	very cold	long	early	good
68	moderate	very cold	long	moderately late	good
69	moderate	very cold	long	late	good
70	moderate	very cold	long	very late	good
71	moderate	cold	long	very early	good
72	moderate	cold	long	early	good
73	moderate	cold	long	moderately late	good
74	moderate	cold	long	late	good
75	moderate	cold	long	very late	good
76	moderate	cool	long	very early	good
77	moderate	cool	long	early	good
78	moderate	cool	long	moderately late	good
79	moderate	cool	long	late	good
80	moderate	cool	long	very late	good
81	moderate	mild	long	very early	good
82	moderate	mild	long	early	good

83	moderate	mild	long	moderately late	good
84	moderate	mild	long	late	good
85	moderate	mild	long	very late	good
86	moderate	very cold	very long	very early	very good
87	moderate	very cold	very long	early	very good
88	moderate	very cold	very long	moderately late	very good
89	moderate	very cold	very long	late	very good
90	moderate	very cold	very long	very late	very good
91	moderate	cold	very long	very early	very good
92	moderate	cold	very long	early	very good
93	moderate	cold	very long	moderately late	very good
94	moderate	cold	very long	late	very good
95	moderate	cold	very long	very late	very good
96	moderate	cool	very long	very early	very good
97	moderate	cool	very long	early	very good
98	moderate	cool	very long	moderately late	very good
99	moderate	cool	very long	late	very good
100	moderate	cool	very long	very late	very good
101	moderate	mild	very long	very early	very good
102	moderate	mild	very long	early	very good
103	moderate	mild	very long	moderately late	very good
104	moderate	mild	very long	late	very good
105	moderate	mild	very long	very late	very good
106	high	very cold	very short	very early	moderate
107	high	very cold	very short	early	moderate
108	high	very cold	very short	moderately late	moderate
109	high	very cold	very short	late	moderate
110	high	very cold	very short	very late	moderate
111	high	cold	very short	very early	moderate
112	high	cold	very short	early	moderate
113	high	cold	very short	moderately late	moderate
114	high	cold	very short	late	moderate
115	high	cold	very short	very late	moderate
116	high	cool	very short	very early	moderate
117	high	cool	very short	early	moderate
118	high	cool	very short	moderately late	moderate
119	high	cool	very short	late	moderate
120	high	cool	very short	very late	moderate
121	high	mild	very short	very early	moderate
122	high	mild	very short	early	moderate
123	high	mild	very short	moderately late	moderate
124	high	mild	very short	late	moderate
125	high	mild	very short	very late	moderate
126	high	very cold	short	very early	good
127	high	very cold	short	early	good

128	high	very cold	short	moderately late	good
129	high	very cold	short	late	good
130	high	very cold	short	very late	good
131	high	cold	short	very early	good
132	high	cold	short	early	good
133	high	cold	short	moderately late	good
134	high	cold	short	late	good
135	high	cold	short	very late	good
136	high	cool	short	very early	good
137	high	cool	short	early	good
138	high	cool	short	moderately late	good
139	high	cool	short	late	good
140	high	cool	short	very late	good
141	high	mild	short	very early	good
142	high	mild	short	early	good
143	high	mild	short	moderately late	good
144	high	mild	short	late	good
145	high	mild	short	very late	good
146	high	very cold	moderately short	very early	very good
147	high	very cold	moderately short	early	very good
148	high	very cold	moderately short	moderately late	very good
149	high	very cold	moderately short	late	very good
150	high	very cold	moderately short	very late	very good
151	high	cold	moderately short	very early	very good
152	high	cold	moderately short	early	very good
153	high	cold	moderately short	moderately late	very good
154	high	cold	moderately short	late	very good
155	high	cold	moderately short	very late	very good
156	high	cool	moderately short	very early	very good
157	high	cool	moderately short	early	very good
158	high	cool	moderately short	moderately late	very good
159	high	cool	moderately short	late	very good
160	high	cool	moderately short	very late	very good
161	high	mild	moderately short	very early	very good
162	high	mild	moderately short	early	very good
163	high	mild	moderately short	moderately late	very good
164	high	mild	moderately short	late	very good
165	high	mild	moderately short	very late	very good
166	high	very cold	moderately long	very early	very good
167	high	very cold	moderately long	early	very good
168	high	very cold	moderately long	moderately late	very good
169	high	very cold	moderately long	late	very good
170	high	very cold	moderately long	very late	very good
171	high	cold	moderately long	very early	very good
172	high	cold	moderately long	early	very good

173	high	cold	moderately long	moderately late	very good
174	high	cold	moderately long	late	very good
175	high	cold	moderately long	very late	very good
176	high	cool	moderately long	very early	very good
177	high	cool	moderately long	early	very good
178	high	cool	moderately long	moderately late	very good
179	high	cool	moderately long	late	very good
180	high	cool	moderately long	very late	very good
181	high	mild	moderately long	very early	very good
182	high	mild	moderately long	early	very good
183	high	mild	moderately long	moderately late	very good
184	high	mild	moderately long	late	very good
185	high	mild	moderately long	very late	very good
186	high	very cold	long	very early	very good
187	high	very cold	long	early	very good
188	high	very cold	long	moderately late	very good
189	high	very cold	long	late	very good
190	high	very cold	long	very late	very good
191	high	cold	long	very early	very good
192	high	cold	long	early	very good
193	high	cold	long	moderately late	very good
194	high	cold	long	late	very good
195	high	cold	long	very late	very good
196	high	cool	long	very early	very good
197	high	cool	long	early	very good
198	high	cool	long	moderately late	very good
199	high	cool	long	late	very good
200	high	cool	long	very late	very good
201	high	mild	long	very early	very good
202	high	mild	long	early	very good
203	high	mild	long	moderately late	very good
204	high	mild	long	late	very good
205	high	mild	long	very late	very good
206	high	very cold	very long	very early	very good
207	high	very cold	very long	early	very good
208	high	very cold	very long	moderately late	very good
209	high	very cold	very long	late	very good
210	high	very cold	very long	very late	very good
211	high	cold	very long	very early	very good
212	high	cold	very long	early	very good
213	high	cold	very long	moderately late	very good
214	high	cold	very long	late	very good
215	high	cold	very long	very late	very good
216	high	cool	very long	very early	very good
217	high	cool	very long	early	very good

218	high	cool	very long	moderately late	very good
219	high	cool	very long	late	very good
220	high	cool	very long	very late	very good
221	high	mild	very long	very early	very good
222	high	mild	very long	early	very good
223	high	mild	very long	moderately late	very good
224	high	mild	very long	late	very good
225	high	mild	very long	very late	very good
226	very high	very cold	very short	very early	moderate
227	very high	very cold	very short	early	moderate
228	very high	very cold	very short	moderately late	moderate
229	very high	very cold	very short	late	moderate
230	very high	very cold	very short	very late	moderate
231	very high	cold	very short	very early	moderate
232	very high	cold	very short	early	moderate
233	very high	cold	very short	moderately late	moderate
234	very high	cold	very short	late	moderate
235	very high	cold	very short	very late	moderate
236	very high	cool	very short	very early	moderate
237	very high	cool	very short	early	moderate
238	very high	cool	very short	moderately late	moderate
239	very high	cool	very short	late	moderate
240	very high	cool	very short	very late	moderate
241	very high	mild	very short	very early	moderate
242	very high	mild	very short	early	moderate
243	very high	mild	very short	moderately late	moderate
244	very high	mild	very short	late	moderate
245	very high	mild	very short	very late	moderate
246	very high	very cold	short	very early	good
247	very high	very cold	short	early	good
248	very high	very cold	short	moderately late	good
249	very high	very cold	short	late	good
250	very high	very cold	short	very late	good
251	very high	cold	short	very early	good
252	very high	cold	short	early	good
253	very high	cold	short	moderately late	good
254	very high	cold	short	late	good
255	very high	cold	short	very late	good
256	very high	cool	short	very early	good
257	very high	cool	short	early	good
258	very high	cool	short	moderately late	good
259	very high	cool	short	late	good
260	very high	cool	short	very late	good
261	very high	mild	short	very early	good
262	very high	mild	short	early	good

263	very high	mild	short	moderately late	good
264	very high	mild	short	late	good
265	very high	mild	short	very late	good
266	very high	very cold	moderately short	very early	good
267	very high	very cold	moderately short	early	good
268	very high	very cold	moderately short	moderately late	good
269	very high	very cold	moderately short	late	good
270	very high	very cold	moderately short	very late	good
271	very high	cold	moderately short	very early	good
272	very high	cold	moderately short	early	good
273	very high	cold	moderately short	moderately late	good
274	very high	cold	moderately short	late	good
275	very high	cold	moderately short	very late	good
276	very high	cool	moderately short	very early	good
277	very high	cool	moderately short	early	good
278	very high	cool	moderately short	moderately late	good
279	very high	cool	moderately short	late	good
280	very high	cool	moderately short	very late	good
281	very high	mild	moderately short	very early	good
282	very high	mild	moderately short	early	good
283	very high	mild	moderately short	moderately late	good
284	very high	mild	moderately short	late	good
285	very high	mild	moderately short	very late	good
286	very high	very cold	moderately long	very early	good
287	very high	very cold	moderately long	early	good
288	very high	very cold	moderately long	moderately late	good
289	very high	very cold	moderately long	late	good
290	very high	very cold	moderately long	very late	good
291	very high	cold	moderately long	very early	good
292	very high	cold	moderately long	early	good
293	very high	cold	moderately long	moderately late	good
294	very high	cold	moderately long	late	good
295	very high	cold	moderately long	very late	good
296	very high	cool	moderately long	very early	good
297	very high	cool	moderately long	early	good
298	very high	cool	moderately long	moderately late	good
299	very high	cool	moderately long	late	good
300	very high	cool	moderately long	very late	good
301	very high	mild	moderately long	very early	good
302	very high	mild	moderately long	early	good
303	very high	mild	moderately long	moderately late	good
304	very high	mild	moderately long	late	good
305	very high	mild	moderately long	very late	good
306	very high	very cold	long	very early	good
307	very high	very cold	long	early	good

308	very high	very cold	long	moderately late	good
309	very high	very cold	long	late	good
310	very high	very cold	long	very late	good
311	very high	cold	long	very early	good
312	very high	cold	long	early	good
313	very high	cold	long	moderately late	good
314	very high	cold	long	late	good
315	very high	cold	long	very late	good
316	very high	cool	long	very early	good
317	very high	cool	long	early	good
318	very high	cool	long	moderately late	good
319	very high	cool	long	late	good
320	very high	cool	long	very late	good
321	very high	mild	long	very early	good
322	very high	mild	long	early	good
323	very high	mild	long	moderately late	good
324	very high	mild	long	late	good
325	very high	mild	long	very late	good
326	very high	very cold	very long	very early	moderate
327	very high	very cold	very long	early	moderate
328	very high	very cold	very long	moderately late	moderate
329	very high	very cold	very long	late	moderate
330	very high	very cold	very long	very late	moderate
331	very high	cold	very long	very early	moderate
332	very high	cold	very long	early	moderate
333	very high	cold	very long	moderately late	moderate
334	very high	cold	very long	late	moderate
335	very high	cold	very long	very late	moderate
336	very high	cool	very long	very early	moderate
337	very high	cool	very long	early	moderate
338	very high	cool	very long	moderately late	moderate
339	very high	cool	very long	late	moderate
340	very high	cool	very long	very late	moderate
341	very high	mild	very long	very early	bad
342	very high	mild	very long	early	bad
343	very high	mild	very long	moderately late	bad
344	very high	mild	very long	late	bad
345	very high	mild	very long	very late	bad
346	moderate	mild	very short	very early	low
347	moderate	mild	very short	early	low
348	moderate	mild	very short	moderately late	low
349	moderate	mild	very short	late	low
350	moderate	mild	very short	very late	low
351	moderate	very cold	short	very early	moderate
352	moderate	very cold	short	early	moderate

353	moderate	very cold	short	moderately late	moderate
354	moderate	very cold	short	late	moderate
355	moderate	very cold	short	very late	moderate
356	moderate	cold	short	very early	moderate
357	moderate	cold	short	early	moderate
358	moderate	cold	short	moderately late	moderate
359	moderate	cold	short	late	moderate
360	moderate	cold	short	very late	moderate
361	moderate	cool	short	very early	moderate
362	moderate	cool	short	early	moderate
363	moderate	cool	short	moderately late	moderate
364	moderate	cool	short	late	moderate
365	moderate	cool	short	very late	moderate
366	moderate	mild	short	very early	moderate
367	moderate	mild	short	early	moderate
368	moderate	mild	short	moderately late	moderate
369	moderate	mild	short	late	moderate
370	moderate	mild	short	very late	moderate
371	moderate	very cold	moderately short	very early	moderate
372	moderate	very cold	moderately short	early	moderate
373	moderate	very cold	moderately short	moderately late	moderate
374	moderate	very cold	moderately short	late	moderate
375	moderate	very cold	moderately short	very late	moderate
376	moderate	cold	moderately short	very early	good
377	moderate	cold	moderately short	early	good
378	moderate	cold	moderately short	moderately late	good
379	moderate	cold	moderately short	late	good
380	moderate	cold	moderately short	very late	good
381	moderate	cool	moderately short	very early	good
382	moderate	cool	moderately short	early	good
383	moderate	cool	moderately short	moderately late	good
384	moderate	cool	moderately short	late	good
385	moderate	cool	moderately short	very late	good
386	moderate	mild	moderately short	very early	good
387	moderate	mild	moderately short	early	good
388	moderate	mild	moderately short	moderately late	good
389	moderate	mild	moderately short	late	good
390	moderate	mild	moderately short	very late	good
391	moderate	very cold	moderately long	very early	good
392	moderate	very cold	moderately long	early	good
393	moderate	very cold	moderately long	moderately late	good
394	moderate	very cold	moderately long	late	good
395	moderate	very cold	moderately long	very late	good
396	moderate	cold	moderately long	very early	good
397	moderate	cold	moderately long	early	good

398	moderate	cold	moderately long	moderately late	good
399	moderate	cold	moderately long	late	good
400	moderate	cold	moderately long	very late	good
401	moderate	cool	moderately long	very early	good
402	moderate	cool	moderately long	early	good
403	moderate	cool	moderately long	moderately late	good
404	moderate	cool	moderately long	late	good
405	moderate	cool	moderately long	very late	good
406	moderate	mild	moderately long	very early	good
407	moderate	mild	moderately long	early	good
408	moderate	mild	moderately long	moderately late	good
409	moderate	mild	moderately long	late	good
410	moderate	mild	moderately long	very late	good
411	moderate	very cold	long	very early	good
412	moderate	very cold	long	early	good
413	moderate	very cold	long	moderately late	good
414	moderate	very cold	long	late	good
415	moderate	very cold	long	very late	good
416	moderate	cold	long	very early	good
417	moderate	cold	long	early	good
418	moderate	cold	long	moderately late	good
419	moderate	cold	long	late	good
420	moderate	cold	long	very late	good
421	moderate	cool	long	very early	good
422	moderate	cool	long	early	good
423	moderate	cool	long	moderately late	good
424	moderate	cool	long	late	good
425	moderate	cool	long	very late	good
426	moderate	mild	long	very early	good
427	moderate	mild	long	early	good
428	moderate	mild	long	moderately late	good
429	moderate	mild	long	late	good
430	moderate	mild	long	very late	good
431	moderate	very cold	very long	very early	very good
432	moderate	very cold	very long	early	very good
433	moderate	very cold	very long	moderately late	very good
434	moderate	very cold	very long	late	very good
435	moderate	very cold	very long	very late	very good
436	moderate	cold	very long	very early	very good
437	moderate	cold	very long	early	very good
438	moderate	cold	very long	moderately late	very good
439	moderate	cold	very long	late	very good
440	moderate	cold	very long	very late	very good
441	moderate	cool	very long	very early	very good
442	moderate	cool	very long	early	very good

443	moderate	cool	very long	moderately late	very good
444	moderate	cool	very long	late	very good
445	moderate	cool	very long	very late	very good
446	moderate	mild	very long	very early	very good
447	moderate	mild	very long	early	very good
448	moderate	mild	very long	moderately late	very good
449	moderate	mild	very long	late	very good
450	moderate	mild	very long	very late	very good
451	high	very cold	very short	very early	moderate
452	high	very cold	very short	early	moderate
453	high	very cold	very short	moderately late	moderate
454	high	very cold	very short	late	moderate
455	high	very cold	very short	very late	moderate
456	high	cold	very short	very early	moderate
457	high	cold	very short	early	moderate
458	high	cold	very short	moderately late	moderate
459	high	cold	very short	late	moderate
460	high	cold	very short	very late	moderate
461	high	cool	very short	very early	moderate
462	high	cool	very short	early	moderate
463	high	cool	very short	moderately late	moderate
464	high	cool	very short	late	moderate
465	high	cool	very short	very late	moderate
466	high	mild	very short	very early	moderate
467	high	mild	very short	early	moderate
468	high	mild	very short	moderately late	moderate
469	high	mild	very short	late	moderate
470	high	mild	very short	very late	moderate
471	high	very cold	short	very early	good
472	high	very cold	short	early	good
473	high	very cold	short	moderately late	good
474	high	very cold	short	late	good
475	high	very cold	short	very late	good
476	high	cold	short	very early	good
477	high	cold	short	early	good
478	high	cold	short	moderately late	good
479	high	cold	short	late	good
480	high	cold	short	very late	good
481	high	cool	short	very early	good
482	high	cool	short	early	good
483	high	cool	short	moderately late	good
484	high	cool	short	late	good
485	high	cool	short	very late	good
486	high	mild	short	very early	good
487	high	mild	short	early	good

488	high	mild	short	moderately late	good
489	high	mild	short	late	good
490	high	mild	short	very late	good
491	high	very cold	moderately short	very early	very good
492	high	very cold	moderately short	early	very good
493	high	very cold	moderately short	moderately late	very good
494	high	very cold	moderately short	late	very good
495	high	very cold	moderately short	very late	very good
496	high	cold	moderately short	very early	very good
497	high	cold	moderately short	early	very good
498	high	cold	moderately short	moderately late	very good
499	high	cold	moderately short	late	very good
500	high	cold	moderately short	very late	very good
501	high	cool	moderately short	very early	very good
502	high	cool	moderately short	early	very good
503	high	cool	moderately short	moderately late	very good
504	high	cool	moderately short	late	very good
505	high	cool	moderately short	very late	very good
506	high	mild	moderately short	very early	very good
507	high	mild	moderately short	early	very good
508	high	mild	moderately short	moderately late	very good
509	high	mild	moderately short	late	very good
510	high	mild	moderately short	very late	very good
511	high	very cold	moderately long	very early	very good
512	high	very cold	moderately long	early	very good
513	high	very cold	moderately long	moderately late	very good
514	high	very cold	moderately long	late	very good
515	high	very cold	moderately long	very late	very good
516	high	cold	moderately long	very early	very good
517	high	cold	moderately long	early	very good
518	high	cold	moderately long	moderately late	very good
519	high	cold	moderately long	late	very good
520	high	cold	moderately long	very late	very good
521	high	cool	moderately long	very early	very good
522	high	cool	moderately long	early	very good
523	high	cool	moderately long	moderately late	very good
524	high	cool	moderately long	late	very good
525	high	cool	moderately long	very late	very good
526	high	mild	moderately long	very early	very good
527	high	mild	moderately long	early	very good
528	high	mild	moderately long	moderately late	very good
529	high	mild	moderately long	late	very good
530	high	mild	moderately long	very late	very good
531	high	very cold	long	very early	very good
532	high	very cold	long	early	very good

533	high	very cold	long	moderately late	very good
534	high	very cold	long	late	very good
535	high	very cold	long	very late	very good
536	high	cold	long	very early	very good
537	high	cold	long	early	very good
538	high	cold	long	moderately late	very good
539	high	cold	long	late	very good
540	high	cold	long	very late	very good
541	high	cool	long	very early	very good
542	high	cool	long	early	very good
543	high	cool	long	moderately late	very good
544	high	cool	long	late	very good
545	high	cool	long	very late	very good
546	high	mild	long	very early	very good
547	high	mild	long	early	very good
548	high	mild	long	moderately late	very good
549	high	mild	long	late	very good
550	high	mild	long	very late	very good
551	high	very cold	very long	very early	very good
552	high	very cold	very long	early	very good
553	high	very cold	very long	moderately late	very good
554	high	very cold	very long	late	very good
555	high	very cold	very long	very late	very good
556	high	cold	very long	very early	very good
557	high	cold	very long	early	very good
558	high	cold	very long	moderately late	very good
559	high	cold	very long	late	very good
560	high	cold	very long	very late	very good
561	high	cool	very long	very early	very good
562	high	cool	very long	early	very good
563	high	cool	very long	moderately late	very good
564	high	cool	very long	late	very good
565	high	cool	very long	very late	very good
566	high	mild	very long	very early	very good
567	high	mild	very long	early	very good
568	high	mild	very long	moderately late	very good
569	high	mild	very long	late	very good
570	high	mild	very long	very late	very good
571	very high	very cold	very short	very early	moderate
572	very high	very cold	very short	early	moderate
573	very high	very cold	very short	moderately late	moderate
574	very high	very cold	very short	late	moderate
575	very high	very cold	very short	very late	moderate
576	very high	cold	very short	very early	moderate
577	very high	cold	very short	early	moderate

578	very high	cold	very short	moderately late	moderate
579	very high	cold	very short	late	moderate
580	very high	cold	very short	very late	moderate
581	very high	cool	very short	very early	moderate
582	very high	cool	very short	early	moderate
583	very high	cool	very short	moderately late	moderate
584	very high	cool	very short	late	moderate
585	very high	cool	very short	very late	moderate
586	very high	mild	very short	very early	moderate
587	very high	mild	very short	early	moderate
588	very high	mild	very short	moderately late	moderate
589	very high	mild	very short	late	moderate
590	very high	mild	very short	very late	moderate
591	very high	very cold	short	very early	good
592	very high	very cold	short	early	good
593	very high	very cold	short	moderately late	good
594	very high	very cold	short	late	good
595	very high	very cold	short	very late	good
596	very high	cold	short	very early	good
597	very high	cold	short	early	good
598	very high	cold	short	moderately late	good
599	very high	cold	short	late	good
600	very high	cold	short	very late	good

1.2. ***Abies alba***

No.	IF	AND	AND	AND	THEN
	GDD	**WF**	**LVP**	**LF**	**SUI**
1	very low	very cold	very short	very early	very low
2	very low	very cold	very short	early	very low
3	very low	very cold	very short	moderately late	very low
4	very low	very cold	very short	late	very low
5	very low	very cold	very short	very late	very low
6	very low	cold	very short	very early	very low
7	very low	cold	very short	early	very low
8	very low	cold	very short	moderately late	very low
9	very low	cold	very short	late	very low
10	very low	cold	very short	very late	very low
11	very low	cool	very short	very early	very low
12	very low	cool	very short	early	very low
13	very low	cool	very short	moderately late	very low
14	very low	cool	very short	late	very low
15	very low	cool	very short	very late	very low
16	very low	mild	very short	very early	very low
17	very low	mild	very short	early	very low
18	very low	mild	very short	moderately late	very low
19	very low	mild	very short	late	very low
20	very low	mild	very short	very late	very low
21	very low	very cold	short	very early	very low
22	very low	very cold	short	early	very low
23	very low	very cold	short	moderately late	very low
24	very low	very cold	short	late	very low
25	very low	very cold	short	very late	very low
26	very low	cold	short	very early	very low
27	very low	cold	short	early	very low
28	very low	cold	short	moderately late	very low
29	very low	cold	short	late	very low
30	very low	cold	short	very late	very low
31	very low	cool	short	very early	very low
32	very low	cool	short	early	very low
33	very low	cool	short	moderately late	very low
34	very low	cool	short	late	very low
35	very low	cool	short	very late	very low
36	very low	mild	short	very early	very low
37	very low	mild	short	early	very low
38	very low	mild	short	moderately late	very low
39	very low	mild	short	late	very low
40	very low	mild	short	very late	very low

41	very low	very cold	moderately short	very early	low
42	very low	very cold	moderately short	early	low
43	very low	very cold	moderately short	moderately late	low
44	very low	very cold	moderately short	late	low
45	very low	very cold	moderately short	very late	low
46	very low	cold	moderately short	very early	low
47	very low	cold	moderately short	early	low
48	very low	cold	moderately short	moderately late	low
49	very low	cold	moderately short	late	low
50	very low	cold	moderately short	very late	low
51	very low	cool	moderately short	very early	low
52	very low	cool	moderately short	early	low
53	very low	cool	moderately short	moderately late	low
54	very low	cool	moderately short	late	low
55	very low	cool	moderately short	very late	low
56	very low	mild	moderately short	very early	low
57	very low	mild	moderately short	early	low
58	very low	mild	moderately short	moderately late	low
59	very low	mild	moderately short	late	low
60	very low	mild	moderately short	very late	low
61	very low	very cold	moderately long	very early	low
62	very low	very cold	moderately long	early	low
63	very low	very cold	moderately long	moderately late	low
64	very low	very cold	moderately long	late	low
65	very low	very cold	moderately long	very late	low
66	very low	cold	moderately long	very early	low
67	very low	cold	moderately long	early	low
68	very low	cold	moderately long	moderately late	low
69	very low	cold	moderately long	late	low
70	very low	cold	moderately long	very late	low
71	very low	cool	moderately long	very early	low
72	very low	cool	moderately long	early	low
73	very low	cool	moderately long	moderately late	low
74	very low	cool	moderately long	late	low
75	very low	cool	moderately long	very late	low
76	very low	mild	moderately long	very early	low
77	very low	mild	moderately long	early	low
78	very low	mild	moderately long	moderately late	low
79	very low	mild	moderately long	late	low
80	very low	mild	moderately long	very late	low
81	very low	very cold	long	very early	moderate
82	very low	very cold	long	early	moderate
83	very low	very cold	long	moderately late	moderate
84	very low	very cold	long	late	moderate
85	very low	very cold	long	very late	low

86	very low	cold	long	very early	moderate
87	very low	cold	long	early	moderate
88	very low	cold	long	moderately late	moderate
89	very low	cold	long	late	moderate
90	very low	cold	long	very late	moderate
91	very low	cool	long	very early	moderate
92	very low	cool	long	early	moderate
93	very low	cool	long	moderately late	moderate
94	very low	cool	long	late	moderate
95	very low	cool	long	very late	moderate
96	very low	mild	long	very early	moderate
97	very low	mild	long	early	moderate
98	very low	mild	long	moderately late	moderate
99	very low	mild	long	late	moderate
100	very low	mild	long	very late	moderate
101	very low	very cold	very long	very early	moderate
102	very low	very cold	very long	early	moderate
103	very low	very cold	very long	moderately late	moderate
104	very low	very cold	very long	late	moderate
105	very low	very cold	very long	very late	moderate
106	very low	cold	very long	very early	moderate
107	very low	cold	very long	early	moderate
108	very low	cold	very long	moderately late	moderate
109	very low	cold	very long	late	moderate
110	very low	cold	very long	very late	moderate
111	very low	cool	very long	very early	moderate
112	very low	cool	very long	early	moderate
113	very low	cool	very long	moderately late	moderate
114	very low	cool	very long	late	moderate
115	very low	cool	very long	very late	moderate
116	very low	mild	very long	very early	moderate
117	very low	mild	very long	early	moderate
118	very low	mild	very long	moderately late	moderate
119	very low	mild	very long	late	moderate
120	very low	mild	very long	very late	moderate
121	low	very cold	very short	very early	low
122	low	very cold	very short	early	low
123	low	very cold	very short	moderately late	low
124	low	very cold	very short	late	low
125	low	very cold	very short	very late	low
126	low	cold	very short	very early	low
127	low	cold	very short	early	low
128	low	cold	very short	moderately late	low
129	low	cold	very short	late	low
130	low	cold	very short	very late	low

131	low	cool	very short	very early	low
132	low	cool	very short	early	low
133	low	cool	very short	moderately late	low
134	low	cool	very short	late	low
135	low	cool	very short	very late	low
136	low	mild	very short	very early	low
137	low	mild	very short	early	low
138	low	mild	very short	moderately late	low
139	low	mild	very short	late	low
140	low	mild	very short	very late	low
141	low	very cold	short	very early	moderate
142	low	very cold	short	early	moderate
143	low	very cold	short	moderately late	moderate
144	low	very cold	short	late	moderate
145	low	very cold	short	very late	moderate
146	low	cold	short	very early	moderate
147	low	cold	short	early	moderate
148	low	cold	short	moderately late	moderate
149	low	cold	short	late	moderate
150	low	cold	short	very late	moderate
151	low	cool	short	very early	moderate
152	low	cool	short	early	moderate
153	low	cool	short	moderately late	moderate
154	low	cool	short	late	moderate
155	low	cool	short	very late	moderate
156	low	mild	short	very early	moderate
157	low	mild	short	early	moderate
158	low	mild	short	moderately late	moderate
159	low	mild	short	late	moderate
160	low	mild	short	very late	moderate
161	low	very cold	moderately short	very early	moderate
162	low	very cold	moderately short	early	moderate
163	low	very cold	moderately short	moderately late	moderate
164	low	very cold	moderately short	late	moderate
165	low	very cold	moderately short	very late	moderate
166	low	cold	moderately short	very early	moderate
167	low	cold	moderately short	early	moderate
168	low	cold	moderately short	moderately late	moderate
169	low	cold	moderately short	late	moderate
170	low	cold	moderately short	very late	moderate
171	low	cool	moderately short	very early	moderate
172	low	cool	moderately short	early	moderate
173	low	cool	moderately short	moderately late	moderate
174	low	cool	moderately short	late	moderate
175	low	cool	moderately short	very late	moderate

176	low	mild	moderately short	very early	moderate
177	low	mild	moderately short	early	moderate
178	low	mild	moderately short	moderately late	moderate
179	low	mild	moderately short	late	moderate
180	low	mild	moderately short	very late	moderate
181	low	very cold	moderately long	very early	moderate
182	low	very cold	moderately long	early	moderate
183	low	very cold	moderately long	moderately late	moderate
184	low	very cold	moderately long	late	moderate
185	low	very cold	moderately long	very late	moderate
186	low	cold	moderately long	very early	moderate
187	low	cold	moderately long	early	moderate
188	low	cold	moderately long	moderately late	moderate
189	low	cold	moderately long	late	moderate
190	low	cold	moderately long	very late	moderate
191	low	cool	moderately long	very early	moderate
192	low	cool	moderately long	early	moderate
193	low	cool	moderately long	moderately late	moderate
194	low	cool	moderately long	late	moderate
195	low	cool	moderately long	very late	moderate
196	low	mild	moderately long	very early	moderate
197	low	mild	moderately long	early	moderate
198	low	mild	moderately long	moderately late	moderate
199	low	mild	moderately long	late	moderate
200	low	mild	moderately long	very late	moderate
201	low	very cold	long	very early	moderate
202	low	very cold	long	early	moderate
203	low	very cold	long	moderately late	moderate
204	low	very cold	long	late	moderate
205	low	very cold	long	very late	moderate
206	low	cold	long	very early	moderate
207	low	cold	long	early	moderate
208	low	cold	long	moderately late	moderate
209	low	cold	long	late	moderate
210	low	cold	long	very late	moderate
211	low	cool	long	very early	moderate
212	low	cool	long	early	moderate
213	low	cool	long	moderately late	moderate
214	low	cool	long	late	moderate
215	low	cool	long	very late	moderate
216	low	mild	long	very early	moderate
217	low	mild	long	early	moderate
218	low	mild	long	moderately late	moderate
219	low	mild	long	late	moderate
220	low	mild	long	very late	moderate

221	low	very cold	very long	very early	good
222	low	very cold	very long	early	good
223	low	very cold	very long	moderately late	good
224	low	very cold	very long	late	moderate
225	low	very cold	very long	very late	moderate
226	low	cold	very long	very early	good
227	low	cold	very long	early	good
228	low	cold	very long	moderately late	good
229	low	cold	very long	late	moderate
230	low	cold	very long	very late	moderate
231	low	cool	very long	very early	good
232	low	cool	very long	early	good
233	low	cool	very long	moderately late	good
234	low	cool	very long	late	moderate
235	low	cool	very long	very late	moderate
236	low	mild	very long	very early	good
237	low	mild	very long	early	good
238	low	mild	very long	moderately late	good
239	low	mild	very long	late	moderate
240	low	mild	very long	very late	moderate
241	moderate	very cold	very short	very early	low
242	moderate	very cold	very short	early	low
243	moderate	very cold	very short	moderately late	low
244	moderate	very cold	very short	late	low
245	moderate	very cold	very short	very late	low
246	moderate	cold	very short	very early	low
247	moderate	cold	very short	early	low
248	moderate	cold	very short	moderately late	low
249	moderate	cold	very short	late	low
250	moderate	cold	very short	very late	low
251	moderate	cool	very short	very early	low
252	moderate	cool	very short	early	low
253	moderate	cool	very short	moderately late	low
254	moderate	cool	very short	late	low
255	moderate	cool	very short	very late	low
256	moderate	mild	very short	very early	low
257	moderate	mild	very short	early	low
258	moderate	mild	very short	moderately late	low
259	moderate	mild	very short	late	low
260	moderate	mild	very short	very late	low
261	moderate	very cold	short	very early	moderate
262	moderate	very cold	short	early	moderate
263	moderate	very cold	short	moderately late	moderate
264	moderate	very cold	short	late	low
265	moderate	very cold	short	very late	low

266	moderate	cold	short	very early	moderate
267	moderate	cold	short	early	moderate
268	moderate	cold	short	moderately late	moderate
269	moderate	cold	short	late	low
270	moderate	cold	short	very late	low
271	moderate	cool	short	very early	moderate
272	moderate	cool	short	early	moderate
273	moderate	cool	short	moderately late	moderate
274	moderate	cool	short	late	low
275	moderate	cool	short	very late	low
276	moderate	mild	short	very early	moderate
277	moderate	mild	short	early	moderate
278	moderate	mild	short	moderately late	moderate
279	moderate	mild	short	late	low
280	moderate	mild	short	very late	low
281	moderate	very cold	moderately short	very early	moderate
282	moderate	very cold	moderately short	early	moderate
283	moderate	very cold	moderately short	moderately late	moderate
284	moderate	very cold	moderately short	late	low
285	moderate	very cold	moderately short	very late	low
286	moderate	cold	moderately short	very early	good
287	moderate	cold	moderately short	early	good
288	moderate	cold	moderately short	moderately late	good
289	moderate	cold	moderately short	late	moderate
290	moderate	cold	moderately short	very late	moderate
291	moderate	cool	moderately short	very early	good
292	moderate	cool	moderately short	early	good
293	moderate	cool	moderately short	moderately late	good
294	moderate	cool	moderately short	late	moderate
295	moderate	cool	moderately short	very late	moderate
296	moderate	mild	moderately short	very early	good
297	moderate	mild	moderately short	early	good
298	moderate	mild	moderately short	moderately late	good
299	moderate	mild	moderately short	late	moderate
300	moderate	mild	moderately short	very late	moderate
301	moderate	very cold	moderately long	very early	good
302	moderate	very cold	moderately long	early	good
303	moderate	very cold	moderately long	moderately late	good
304	moderate	very cold	moderately long	late	moderate
305	moderate	very cold	moderately long	very late	moderate
306	moderate	cold	moderately long	very early	good
307	moderate	cold	moderately long	early	good
308	moderate	cold	moderately long	moderately late	good
309	moderate	cold	moderately long	late	moderate
310	moderate	cold	moderately long	very late	moderate

311	moderate	cool	moderately long	very early	good
312	moderate	cool	moderately long	early	good
313	moderate	cool	moderately long	moderately late	good
314	moderate	cool	moderately long	late	moderate
315	moderate	cool	moderately long	very late	moderate
316	moderate	mild	moderately long	very early	good
317	moderate	mild	moderately long	early	good
318	moderate	mild	moderately long	moderately late	good
319	moderate	mild	moderately long	late	moderate
320	moderate	mild	moderately long	very late	moderate
321	moderate	very cold	long	very early	good
322	moderate	very cold	long	early	good
323	moderate	very cold	long	moderately late	good
324	moderate	very cold	long	late	moderate
325	moderate	very cold	long	very late	moderate
326	moderate	cold	long	very early	good
327	moderate	cold	long	early	good
328	moderate	cold	long	moderately late	good
329	moderate	cold	long	late	moderate
330	moderate	cold	long	very late	moderate
331	moderate	cool	long	very early	good
332	moderate	cool	long	early	good
333	moderate	cool	long	moderately late	good
334	moderate	cool	long	late	moderate
335	moderate	cool	long	very late	moderate
336	moderate	mild	long	very early	good
337	moderate	mild	long	early	good
338	moderate	mild	long	moderately late	good
339	moderate	mild	long	late	moderate
340	moderate	mild	long	very late	moderate
341	moderate	very cold	very long	very early	good
342	moderate	very cold	very long	early	good
343	moderate	very cold	very long	moderately late	good
344	moderate	very cold	very long	late	moderate
345	moderate	very cold	very long	very late	moderate
346	moderate	cold	very long	very early	very good
347	moderate	cold	very long	early	very good
348	moderate	cold	very long	moderately late	very good
349	moderate	cold	very long	late	good
350	moderate	cold	very long	very late	good
351	moderate	cool	very long	very early	very good
352	moderate	cool	very long	early	very good
353	moderate	cool	very long	moderately late	very good
354	moderate	cool	very long	late	good
355	moderate	cool	very long	very late	good

356	moderate	mild	very long	very early	very good
357	moderate	mild	very long	early	very good
358	moderate	mild	very long	moderately late	very good
359	moderate	mild	very long	late	good
360	moderate	mild	very long	very late	good
361	high	very cold	very short	very early	low
362	high	very cold	very short	early	low
363	high	very cold	very short	moderately late	low
364	high	very cold	very short	late	low
365	high	very cold	very short	very late	low
366	high	cold	very short	very early	low
367	high	cold	very short	early	low
368	high	cold	very short	moderately late	low
369	high	cold	very short	late	low
370	high	cold	very short	very late	low
371	high	cool	very short	very early	low
372	high	cool	very short	early	low
373	high	cool	very short	moderately late	low
374	high	cool	very short	late	low
375	high	cool	very short	very late	low
376	high	mild	very short	very early	low
377	high	mild	very short	early	low
378	high	mild	very short	moderately late	low
379	high	mild	very short	late	low
380	high	mild	very short	very late	low
381	high	very cold	short	very early	moderate
382	high	very cold	short	early	moderate
383	high	very cold	short	moderately late	moderate
384	high	very cold	short	late	low
385	high	very cold	short	very late	low
386	high	cold	short	very early	moderate
387	high	cold	short	early	moderate
388	high	cold	short	moderately late	moderate
389	high	cold	short	late	low
390	high	cold	short	very late	low
391	high	cool	short	very early	moderate
392	high	cool	short	early	moderate
393	high	cool	short	moderately late	moderate
394	high	cool	short	late	low
395	high	cool	short	very late	low
396	high	mild	short	very early	moderate
397	high	mild	short	early	moderate
398	high	mild	short	moderately late	moderate
399	high	mild	short	late	low
400	high	mild	short	very late	low

401	high	very cold	moderately short	very early	good
402	high	very cold	moderately short	early	good
403	high	very cold	moderately short	moderately late	good
404	high	very cold	moderately short	late	moderate
405	high	very cold	moderately short	very late	moderate
406	high	cold	moderately short	very early	good
407	high	cold	moderately short	early	good
408	high	cold	moderately short	moderately late	good
409	high	cold	moderately short	late	moderate
410	high	cold	moderately short	very late	moderate
411	high	cool	moderately short	very early	good
412	high	cool	moderately short	early	good
413	high	cool	moderately short	moderately late	good
414	high	cool	moderately short	late	moderate
415	high	cool	moderately short	very late	moderate
416	high	mild	moderately short	very early	good
417	high	mild	moderately short	early	good
418	high	mild	moderately short	moderately late	good
419	high	mild	moderately short	late	moderate
420	high	mild	moderately short	very late	moderate
421	high	very cold	moderately long	very early	very good
422	high	very cold	moderately long	early	very good
423	high	very cold	moderately long	moderately late	very good
424	high	very cold	moderately long	late	good
425	high	very cold	moderately long	very late	good
426	high	cold	moderately long	very early	very good
427	high	cold	moderately long	early	very good
428	high	cold	moderately long	moderately late	very good
429	high	cold	moderately long	late	good
430	high	cold	moderately long	very late	good
431	high	cool	moderately long	very early	very good
432	high	cool	moderately long	early	very good
433	high	cool	moderately long	moderately late	very good
434	high	cool	moderately long	late	good
435	high	cool	moderately long	very late	good
436	high	mild	moderately long	very early	very good
437	high	mild	moderately long	early	very good
438	high	mild	moderately long	moderately late	very good
439	high	mild	moderately long	late	good
440	high	mild	moderately long	very late	good
441	high	very cold	long	very early	very good
442	high	very cold	long	early	very good
443	high	very cold	long	moderately late	very good
444	high	very cold	long	late	good
445	high	very cold	long	very late	good

446	high	cold	long	very early	very good
447	high	cold	long	early	very good
448	high	cold	long	moderately late	very good
449	high	cold	long	late	good
450	high	cold	long	very late	good
451	high	cool	long	very early	very good
452	high	cool	long	early	very good
453	high	cool	long	moderately late	very good
454	high	cool	long	late	good
455	high	cool	long	very late	good
456	high	mild	long	very early	very good
457	high	mild	long	early	very good
458	high	mild	long	moderately late	very good
459	high	mild	long	late	good
460	high	mild	long	very late	good
461	high	very cold	very long	very early	very good
462	high	very cold	very long	early	very good
463	high	very cold	very long	moderately late	very good
464	high	very cold	very long	late	good
465	high	very cold	very long	very late	good
466	high	cold	very long	very early	very good
467	high	cold	very long	early	very good
468	high	cold	very long	moderately late	very good
469	high	cold	very long	late	good
470	high	cold	very long	very late	good
471	high	cool	very long	very early	very good
472	high	cool	very long	early	very good
473	high	cool	very long	moderately late	very good
474	high	cool	very long	late	good
475	high	cool	very long	very late	good
476	high	mild	very long	very early	very good
477	high	mild	very long	early	very good
478	high	mild	very long	moderately late	very good
479	high	mild	very long	late	good
480	high	mild	very long	very late	good
481	very high	very cold	very short	very early	moderate
482	very high	very cold	very short	early	moderate
483	very high	very cold	very short	moderately late	moderate
484	very high	very cold	very short	late	low
485	very high	very cold	very short	very late	low
486	very high	cold	very short	very early	moderate
487	very high	cold	very short	early	moderate
488	very high	cold	very short	moderately late	moderate
489	very high	cold	very short	late	low
490	very high	cold	very short	very late	low

491	very high	cool	very short	very early	moderate
492	very high	cool	very short	early	moderate
493	very high	cool	very short	moderately late	moderate
494	very high	cool	very short	late	low
495	very high	cool	very short	very late	low
496	very high	mild	very short	very early	moderate
497	very high	mild	very short	early	moderate
498	very high	mild	very short	moderately late	moderate
499	very high	mild	very short	late	low
500	very high	mild	very short	very late	low
501	very high	very cold	short	very early	good
502	very high	very cold	short	early	good
503	very high	very cold	short	moderately late	good
504	very high	very cold	short	late	moderate
505	very high	very cold	short	very late	moderate
506	very high	cold	short	very early	good
507	very high	cold	short	early	good
508	very high	cold	short	moderately late	good
509	very high	cold	short	late	moderate
510	very high	cold	short	very late	moderate
511	very high	cool	short	very early	good
512	very high	cool	short	early	good
513	very high	cool	short	moderately late	good
514	very high	cool	short	late	moderate
515	very high	cool	short	very late	moderate
516	very high	mild	short	very early	good
517	very high	mild	short	early	good
518	very high	mild	short	moderately late	good
519	very high	mild	short	late	moderate
520	very high	mild	short	very late	moderate
521	very high	very cold	moderately short	very early	good
522	very high	very cold	moderately short	early	good
523	very high	very cold	moderately short	moderately late	good
524	very high	very cold	moderately short	late	moderate
525	very high	very cold	moderately short	very late	moderate
526	very high	cold	moderately short	very early	good
527	very high	cold	moderately short	early	good
528	very high	cold	moderately short	moderately late	good
529	very high	cold	moderately short	late	moderate
530	very high	cold	moderately short	very late	moderate
531	very high	cool	moderately short	very early	good
532	very high	cool	moderately short	early	good
533	very high	cool	moderately short	moderately late	good
534	very high	cool	moderately short	late	moderate
535	very high	cool	moderately short	very late	moderate

536	very high	mild	moderately short	very early	good
537	very high	mild	moderately short	early	good
538	very high	mild	moderately short	moderately late	good
539	very high	mild	moderately short	late	moderate
540	very high	mild	moderately short	very late	moderate
541	very high	very cold	moderately long	very early	good
542	very high	very cold	moderately long	early	good
543	very high	very cold	moderately long	moderately late	good
544	very high	very cold	moderately long	late	moderate
545	very high	very cold	moderately long	very late	moderate
546	very high	cold	moderately long	very early	good
547	very high	cold	moderately long	early	good
548	very high	cold	moderately long	moderately late	good
549	very high	cold	moderately long	late	moderate
550	very high	cold	moderately long	very late	moderate
551	very high	cool	moderately long	very early	good
552	very high	cool	moderately long	early	good
553	very high	cool	moderately long	moderately late	good
554	very high	cool	moderately long	late	moderate
555	very high	cool	moderately long	very late	moderate
556	very high	mild	moderately long	very early	good
557	very high	mild	moderately long	early	good
558	very high	mild	moderately long	moderately late	good
559	very high	mild	moderately long	late	moderate
560	very high	mild	moderately long	very late	moderate
561	very high	very cold	long	very early	good
562	very high	very cold	long	early	good
563	very high	very cold	long	moderately late	good
564	very high	very cold	long	late	moderate
565	very high	very cold	long	very late	moderate
566	very high	cold	long	very early	good
567	very high	cold	long	early	good
568	very high	cold	long	moderately late	good
569	very high	cold	long	late	moderate
570	very high	cold	long	very late	moderate
571	very high	cool	long	very early	good
572	very high	cool	long	early	good
573	very high	cool	long	moderately late	good
574	very high	cool	long	late	moderate
575	very high	cool	long	very late	moderate
576	very high	mild	long	very early	good
577	very high	mild	long	early	good
578	very high	mild	long	moderately late	good
579	very high	mild	long	late	good
580	very high	mild	long	very late	good

581	very high	very cold	very long	very early	moderate
582	very high	very cold	very long	early	moderate
583	very high	very cold	very long	moderately late	moderate
584	very high	very cold	very long	late	low
585	very high	very cold	very long	very late	low
586	very high	cold	very long	very early	moderate
587	very high	cold	very long	early	moderate
588	very high	cold	very long	moderately late	moderate
589	very high	cold	very long	late	low
590	very high	cold	very long	very late	low
591	very high	cool	very long	very early	moderate
592	very high	cool	very long	early	moderate
593	very high	cool	very long	moderately late	moderate
594	very high	cool	very long	late	low
595	very high	cool	very long	very late	low
596	very high	mild	very long	very early	low
597	very high	mild	very long	early	low
598	very high	mild	very long	moderately late	low
599	very high	mild	very long	late	low
600	very high	mild	very long	very late	low

1.3. *Fagus sylvatica*

No.	IF	AND	AND	AND	THEN
	GDD	**WF**	**LVP**	**LF**	**SUI**
1	very low	very cold	very short	very early	very low
2	very low	very cold	very short	early	very low
3	very low	very cold	very short	moderately late	very low
4	very low	very cold	very short	late	very low
5	very low	very cold	very short	very late	very low
6	very low	cold	very short	very early	very low
7	very low	cold	very short	early	very low
8	very low	cold	very short	moderately late	very low
9	very low	cold	very short	late	very low
10	very low	cold	very short	very late	very low
11	very low	cool	very short	very early	very low
12	very low	cool	very short	early	very low
13	very low	cool	very short	moderately late	very low
14	very low	cool	very short	late	very low
15	very low	cool	very short	very late	very low
16	very low	mild	very short	very early	very low
17	very low	mild	very short	early	very low
18	very low	mild	very short	moderately late	very low
19	very low	mild	very short	late	very low
20	very low	mild	very short	very late	very low
21	very low	very cold	short	very early	very low
22	very low	very cold	short	early	very low
23	very low	very cold	short	moderately late	very low
24	very low	very cold	short	late	very low
25	very low	very cold	short	very late	very low
26	very low	cold	short	very early	very low
27	very low	cold	short	early	very low
28	very low	cold	short	moderately late	very low
29	very low	cold	short	late	very low
30	very low	cold	short	very late	very low
31	very low	cool	short	very early	very low
32	very low	cool	short	early	very low
33	very low	cool	short	moderately late	very low
34	very low	cool	short	late	very low
35	very low	cool	short	very late	very low
36	very low	mild	short	very early	very low
37	very low	mild	short	early	very low
38	very low	mild	short	moderately late	very low

39	very low	mild	short	late	very low
40	very low	mild	short	very late	very low
41	very low	very cold	moderately short	very early	very low
42	very low	very cold	moderately short	early	very low
43	very low	very cold	moderately short	moderately late	very low
44	very low	very cold	moderately short	late	very low
45	very low	very cold	moderately short	very late	very low
46	very low	cold	moderately short	very early	very low
47	very low	cold	moderately short	early	very low
48	very low	cold	moderately short	moderately late	very low
49	very low	cold	moderately short	late	very low
50	very low	cold	moderately short	very late	very low
51	very low	cool	moderately short	very early	very low
52	very low	cool	moderately short	early	very low
53	very low	cool	moderately short	moderately late	very low
54	very low	cool	moderately short	late	very low
55	very low	cool	moderately short	very late	very low
56	very low	mild	moderately short	very early	very low
57	very low	mild	moderately short	early	very low
58	very low	mild	moderately short	moderately late	very low
59	very low	mild	moderately short	late	very low
60	very low	mild	moderately short	very late	very low
61	very low	very cold	moderately long	very early	very low
62	very low	very cold	moderately long	early	very low
63	very low	very cold	moderately long	moderately late	very low
64	very low	very cold	moderately long	late	very low
65	very low	very cold	moderately long	very late	very low
66	very low	cold	moderately long	very early	very low
67	very low	cold	moderately long	early	very low
68	very low	cold	moderately long	moderately late	very low
69	very low	cold	moderately long	late	very low
70	very low	cold	moderately long	very late	very low
71	very low	cool	moderately long	very early	very low
72	very low	cool	moderately long	early	very low
73	very low	cool	moderately long	moderately late	very low
74	very low	cool	moderately long	late	very low
75	very low	cool	moderately long	very late	very low
76	very low	mild	moderately long	very early	very low
77	very low	mild	moderately long	early	very low
78	very low	mild	moderately long	moderately late	very low
79	very low	mild	moderately long	late	very low
80	very low	mild	moderately long	very late	very low
81	very low	very cold	long	very early	very low
82	very low	very cold	long	early	very low
83	very low	very cold	long	moderately late	very low

84	very low	very cold	long	late	very low
85	very low	very cold	long	very late	very low
86	very low	cold	long	very early	very low
87	very low	cold	long	early	very low
88	very low	cold	long	moderately late	very low
89	very low	cold	long	late	very low
90	very low	cold	long	very late	very low
91	very low	cool	long	very early	**low**
92	very low	cool	long	early	low
93	very low	cool	long	moderately late	low
94	very low	cool	long	late	low
95	very low	cool	long	very late	low
96	very low	mild	long	very early	low
97	very low	mild	long	early	low
98	very low	mild	long	moderately late	low
99	very low	mild	long	late	low
100	very low	mild	long	very late	low
101	very low	very cold	very long	very early	very low
102	very low	very cold	very long	early	very low
103	very low	very cold	very long	moderately late	very low
104	very low	very cold	very long	late	very low
105	very low	very cold	very long	very late	very low
106	very low	cold	very long	very early	very low
107	very low	cold	very long	early	very low
108	very low	cold	very long	moderately late	very low
109	very low	cold	very long	late	very low
110	very low	cold	very long	very late	very low
111	very low	cool	very long	very early	low
112	very low	cool	very long	early	low
113	very low	cool	very long	moderately late	very low
114	very low	cool	very long	late	very low
115	very low	cool	very long	very late	very low
116	very low	mild	very long	very early	low
117	very low	mild	very long	early	low
118	very low	mild	very long	moderately late	low
119	very low	mild	very long	late	low
120	very low	mild	very long	very late	low
121	low	very cold	very short	very early	very low
122	low	very cold	very short	early	very low
123	low	very cold	very short	moderately late	very low
124	low	very cold	very short	late	very low
125	low	very cold	very short	very late	very low
126	low	cold	very short	very early	very low
127	low	cold	very short	early	very low
128	low	cold	very short	moderately late	very low

129	low	cold	very short	late	very low
130	low	cold	very short	very late	very low
131	low	cool	very short	very early	very low
132	low	cool	very short	early	very low
133	low	cool	very short	moderately late	very low
134	low	cool	very short	late	very low
135	low	cool	very short	very late	very low
136	low	mild	very short	very early	very low
137	low	mild	very short	early	very low
138	low	mild	very short	moderately late	very low
139	low	mild	very short	late	very low
140	low	mild	very short	very late	very low
141	low	very cold	short	very early	very low
142	low	very cold	short	early	very low
143	low	very cold	short	moderately late	very low
144	low	very cold	short	late	very low
145	low	very cold	short	very late	very low
146	low	cold	short	very early	very low
147	low	cold	short	early	very low
148	low	cold	short	moderately late	very low
149	low	cold	short	late	very low
150	low	cold	short	very late	very low
151	low	cool	short	very early	**low**
152	low	cool	short	early	low
153	low	cool	short	moderately late	low
154	low	cool	short	late	low
155	low	cool	short	very late	low
156	low	mild	short	very early	low
157	low	mild	short	early	low
158	low	mild	short	moderately late	low
159	low	mild	short	late	low
160	low	mild	short	very late	low
161	low	very cold	moderately short	very early	low
162	low	very cold	moderately short	early	low
163	low	very cold	moderately short	moderately late	low
164	low	very cold	moderately short	late	low
165	low	very cold	moderately short	very late	low
166	low	cold	moderately short	very early	very low
167	low	cold	moderately short	early	very low
168	low	cold	moderately short	moderately late	very low
169	low	cold	moderately short	late	very low
170	low	cold	moderately short	very late	very low
171	low	cool	moderately short	very early	moderate
172	low	cool	moderately short	early	moderate
173	low	cool	moderately short	moderately late	low

174	low	cool	moderately short	late	low
175	low	cool	moderately short	very late	low
176	low	mild	moderately short	very early	moderate
177	low	mild	moderately short	early	moderate
178	low	mild	moderately short	moderately late	low
179	low	mild	moderately short	late	low
180	low	mild	moderately short	very late	low
181	low	very cold	moderately long	very early	moderate
182	low	very cold	moderately long	early	moderate
183	low	very cold	moderately long	moderately late	low
184	low	very cold	moderately long	late	low
185	low	very cold	moderately long	very late	low
186	low	cold	moderately long	very early	very low
187	low	cold	moderately long	early	very low
188	low	cold	moderately long	moderately late	very low
189	low	cold	moderately long	late	very low
190	low	cold	moderately long	very late	very low
191	low	cool	moderately long	very early	moderate
192	low	cool	moderately long	early	moderate
193	low	cool	moderately long	moderately late	low
194	low	cool	moderately long	late	low
195	low	cool	moderately long	very late	low
196	low	mild	moderately long	very early	moderate
197	low	mild	moderately long	early	moderate
198	low	mild	moderately long	moderately late	low
199	low	mild	moderately long	late	low
200	low	mild	moderately long	very late	low
201	low	very cold	long	very early	low
202	low	very cold	long	early	low
203	low	very cold	long	moderately late	low
204	low	very cold	long	late	low
205	low	very cold	long	very late	low
206	low	cold	long	very early	very low
207	low	cold	long	early	very low
208	low	cold	long	moderately late	very low
209	low	cold	long	late	very low
210	low	cold	long	very late	very low
211	low	cool	long	very early	moderate
212	low	cool	long	early	moderate
213	low	cool	long	moderately late	low
214	low	cool	long	late	low
215	low	cool	long	very late	low
216	low	mild	long	very early	moderate
217	low	mild	long	early	moderate
218	low	mild	long	moderately late	low

219	low	mild	long	late	low
220	low	mild	long	very late	low
221	low	very cold	very long	very early	low
222	low	very cold	very long	early	low
223	low	very cold	very long	moderately late	low
224	low	very cold	very long	late	low
225	low	very cold	very long	very late	low
226	low	cold	very long	very early	very low
227	low	cold	very long	early	very low
228	low	cold	very long	moderately late	very low
229	low	cold	very long	late	very low
230	low	cold	very long	very late	very low
231	low	cool	very long	very early	moderate
232	low	cool	very long	early	moderate
233	low	cool	very long	moderately late	low
234	low	cool	very long	late	low
235	low	cool	very long	very late	low
236	low	mild	very long	very early	moderate
237	low	mild	very long	early	moderate
238	low	mild	very long	moderately late	low
239	low	mild	very long	late	low
240	low	mild	very long	very late	low
241	moderate	very cold	very short	very early	low
242	moderate	very cold	very short	early	low
243	moderate	very cold	very short	moderately late	low
244	moderate	very cold	very short	late	low
245	moderate	very cold	very short	very late	low
246	moderate	cold	very short	very early	very low
247	moderate	cold	very short	early	very low
248	moderate	cold	very short	moderately late	very low
249	moderate	cold	very short	late	very low
250	moderate	cold	very short	very late	very low
251	moderate	cool	very short	very early	low
252	moderate	cool	very short	early	low
253	moderate	cool	very short	moderately late	low
254	moderate	cool	very short	late	low
255	moderate	cool	very short	very late	low
256	moderate	mild	very short	very early	low
257	moderate	mild	very short	early	low
258	moderate	mild	very short	moderately late	low
259	moderate	mild	very short	late	low
260	moderate	mild	very short	very late	low
261	moderate	very cold	short	very early	low
262	moderate	very cold	short	early	low
263	moderate	very cold	short	moderately late	low

264	moderate	very cold	short	late	low
265	moderate	very cold	short	very late	low
266	moderate	cold	short	very early	**very low**
267	moderate	cold	short	early	very low
268	moderate	cold	short	moderately late	very low
269	moderate	cold	short	late	very low
270	moderate	cold	short	very late	very low
271	moderate	cool	short	very early	moderate
272	moderate	cool	short	early	moderate
273	moderate	cool	short	moderately late	low
274	moderate	cool	short	late	low
275	moderate	cool	short	very late	low
276	moderate	mild	short	very early	moderate
277	moderate	mild	short	early	moderate
278	moderate	mild	short	moderately late	low
279	moderate	mild	short	late	low
280	moderate	mild	short	very late	low
281	moderate	very cold	moderately short	very early	low
282	moderate	very cold	moderately short	early	low
283	moderate	very cold	moderately short	moderately late	low
284	moderate	very cold	moderately short	late	low
285	moderate	very cold	moderately short	very late	low
286	moderate	cold	moderately short	very early	very low
287	moderate	cold	moderately short	early	very low
288	moderate	cold	moderately short	moderately late	very low
289	moderate	cold	moderately short	late	very low
290	moderate	cold	moderately short	very late	very low
291	moderate	cool	moderately short	very early	moderate
292	moderate	cool	moderately short	early	moderate
293	moderate	cool	moderately short	moderately late	low
294	moderate	cool	moderately short	late	low
295	moderate	cool	moderately short	very late	low
296	moderate	mild	moderately short	very early	moderate
297	moderate	mild	moderately short	early	moderate
298	moderate	mild	moderately short	moderately late	low
299	moderate	mild	moderately short	late	low
300	moderate	mild	moderately short	very late	low
301	moderate	very cold	moderately long	very early	low
302	moderate	very cold	moderately long	early	low
303	moderate	very cold	moderately long	moderately late	low
304	moderate	very cold	moderately long	late	low
305	moderate	very cold	moderately long	very late	low
306	moderate	cold	moderately long	very early	very low
307	moderate	cold	moderately long	early	very low
308	moderate	cold	moderately long	moderately late	very low

309	moderate	cold	moderately long	late	very low
310	moderate	cold	moderately long	very late	very low
311	moderate	cool	moderately long	very early	moderate
312	moderate	cool	moderately long	early	moderate
313	moderate	cool	moderately long	moderately late	low
314	moderate	cool	moderately long	late	low
315	moderate	cool	moderately long	very late	low
316	moderate	mild	moderately long	very early	moderate
317	moderate	mild	moderately long	early	moderate
318	moderate	mild	moderately long	moderately late	low
319	moderate	mild	moderately long	late	low
320	moderate	mild	moderately long	very late	low
321	moderate	very cold	long	very early	low
322	moderate	very cold	long	early	low
323	moderate	very cold	long	moderately late	low
324	moderate	very cold	long	late	low
325	moderate	very cold	long	very late	low
326	moderate	cold	long	very early	very low
327	moderate	cold	long	early	very low
328	moderate	cold	long	moderately late	very low
329	moderate	cold	long	late	very low
330	moderate	cold	long	very late	very low
331	moderate	cool	long	very early	moderate
332	moderate	cool	long	early	moderate
333	moderate	cool	long	moderately late	low
334	moderate	cool	long	late	low
335	moderate	cool	long	very late	low
336	moderate	mild	long	very early	moderate
337	moderate	mild	long	early	moderate
338	moderate	mild	long	moderately late	low
339	moderate	mild	long	late	low
340	moderate	mild	long	very late	low
341	moderate	very cold	very long	very early	low
342	moderate	very cold	very long	early	low
343	moderate	very cold	very long	moderately late	low
344	moderate	very cold	very long	late	low
345	moderate	very cold	very long	very late	low
346	moderate	cold	very long	very early	very low
347	moderate	cold	very long	early	very low
348	moderate	cold	very long	moderately late	very low
349	moderate	cold	very long	late	very low
350	moderate	cold	very long	very late	very low
351	moderate	cool	very long	very early	good
352	moderate	cool	very long	early	good
353	moderate	cool	very long	moderately late	moderate

354	moderate	cool	very long	late	moderate
355	moderate	cool	very long	very late	moderate
356	moderate	mild	very long	very early	good
357	moderate	mild	very long	early	good
358	moderate	mild	very long	moderately late	moderate
359	moderate	mild	very long	late	moderate
360	moderate	mild	very long	very late	moderate
361	high	very cold	very short	very early	low
362	high	very cold	very short	early	low
363	high	very cold	very short	moderately late	low
364	high	very cold	very short	late	low
365	high	very cold	very short	very late	low
366	high	cold	very short	very early	very low
367	high	cold	very short	early	very low
368	high	cold	very short	moderately late	very low
369	high	cold	very short	late	very low
370	high	cold	very short	very late	very low
371	high	cool	very short	very early	low
372	high	cool	very short	early	low
373	high	cool	very short	moderately late	low
374	high	cool	very short	late	low
375	high	cool	very short	very late	low
376	high	mild	very short	very early	low
377	high	mild	very short	early	low
378	high	mild	very short	moderately late	low
379	high	mild	very short	late	low
380	high	mild	very short	very late	low
381	high	very cold	short	very early	low
382	high	very cold	short	early	low
383	high	very cold	short	moderately late	low
384	high	very cold	short	late	low
385	high	very cold	short	very late	low
386	high	cold	short	very early	very low
387	high	cold	short	early	very low
388	high	cold	short	moderately late	very low
389	high	cold	short	late	very low
390	high	cold	short	very late	very low
391	high	cool	short	very early	moderate
392	high	cool	short	early	moderate
393	high	cool	short	moderately late	low
394	high	cool	short	late	low
395	high	cool	short	very late	low
396	high	mild	short	very early	moderate
397	high	mild	short	early	moderate
398	high	mild	short	moderately late	moderate

399	high	mild	short	late	low
400	high	mild	short	very late	low
401	high	very cold	moderately short	very early	low
402	high	very cold	moderately short	early	low
403	high	very cold	moderately short	moderately late	low
404	high	very cold	moderately short	late	low
405	high	very cold	moderately short	very late	low
406	high	cold	moderately short	very early	very low
407	high	cold	moderately short	early	very low
408	high	cold	moderately short	moderately late	very low
409	high	cold	moderately short	late	very low
410	high	cold	moderately short	very late	very low
411	high	cool	moderately short	very early	moderate
412	high	cool	moderately short	early	moderate
413	high	cool	moderately short	moderately late	low
414	high	cool	moderately short	late	low
415	high	cool	moderately short	very late	low
416	high	mild	moderately short	very early	moderate
417	high	mild	moderately short	early	moderate
418	high	mild	moderately short	moderately late	low
419	high	mild	moderately short	late	low
420	high	mild	moderately short	very late	low
421	high	very cold	moderately long	very early	low
422	high	very cold	moderately long	early	low
423	high	very cold	moderately long	moderately late	low
424	high	very cold	moderately long	late	low
425	high	very cold	moderately long	very late	low
426	high	cold	moderately long	very early	very low
427	high	cold	moderately long	early	very low
428	high	cold	moderately long	moderately late	very low
429	high	cold	moderately long	late	very low
430	high	cold	moderately long	very late	very low
431	high	cool	moderately long	very early	very good
432	high	cool	moderately long	early	very good
433	high	cool	moderately long	moderately late	good
434	high	cool	moderately long	late	good
435	high	cool	moderately long	very late	good
436	high	mild	moderately long	very early	very good
437	high	mild	moderately long	early	very good
438	high	mild	moderately long	moderately late	good
439	high	mild	moderately long	late	good
440	high	mild	moderately long	very late	good
441	high	very cold	long	very early	low
442	high	very cold	long	early	low
443	high	very cold	long	moderately late	low

444	high	very cold	long	late	low
445	high	very cold	long	very late	low
446	high	cold	long	very early	very low
447	high	cold	long	early	very low
448	high	cold	long	moderately late	very low
449	high	cold	long	late	very low
450	high	cold	long	very late	very low
451	high	cool	long	very early	very good
452	high	cool	long	early	very good
453	high	cool	long	moderately late	good
454	high	cool	long	late	good
455	high	cool	long	very late	good
456	high	mild	long	very early	very good
457	high	mild	long	early	very good
458	high	mild	long	moderately late	good
459	high	mild	long	late	good
460	high	mild	long	very late	good
461	high	very cold	very long	very early	low
462	high	very cold	very long	early	low
463	high	very cold	very long	moderately late	low
464	high	very cold	very long	late	low
465	high	very cold	very long	very late	low
466	high	cold	very long	very early	very low
467	high	cold	very long	early	very low
468	high	cold	very long	moderately late	very low
469	high	cold	very long	late	very low
470	high	cold	very long	very late	very low
471	high	cool	very long	very early	very good
472	high	cool	very long	early	very good
473	high	cool	very long	moderately late	good
474	high	cool	very long	late	good
475	high	cool	very long	very late	good
476	high	mild	very long	very early	very good
477	high	mild	very long	early	very good
478	high	mild	very long	moderately late	good
479	high	mild	very long	late	good
480	high	mild	very long	very late	good
481	very high	very cold	very short	very early	low
482	very high	very cold	very short	early	low
483	very high	very cold	very short	moderately late	low
484	very high	very cold	very short	late	low
485	very high	very cold	very short	very late	low
486	very high	cold	very short	very early	very low
487	very high	cold	very short	early	very low
488	very high	cold	very short	moderately late	very low

489	very high	cold	very short	late	very low
490	very high	cold	very short	very late	very low
491	very high	cool	very short	very early	low
492	very high	cool	very short	early	low
493	very high	cool	very short	moderately late	low
494	very high	cool	very short	late	low
495	very high	cool	very short	very late	low
496	very high	mild	very short	very early	low
497	very high	mild	very short	early	low
498	very high	mild	very short	moderately late	low
499	very high	mild	very short	late	low
500	very high	mild	very short	very late	low
501	very high	very cold	short	very early	low
502	very high	very cold	short	early	low
503	very high	very cold	short	moderately late	low
504	very high	very cold	short	late	low
505	very high	very cold	short	very late	low
506	very high	cold	short	very early	very low
507	very high	cold	short	early	very low
508	very high	cold	short	moderately late	very low
509	very high	cold	short	late	very low
510	very high	cold	short	very late	very low
511	very high	cool	short	very early	good
512	very high	cool	short	early	good
513	very high	cool	short	moderately late	moderate
514	very high	cool	short	late	moderate
515	very high	cool	short	very late	moderate
516	very high	mild	short	very early	good
517	very high	mild	short	early	good
518	very high	mild	short	moderately late	moderate
519	very high	mild	short	late	moderate
520	very high	mild	short	very late	moderate
521	very high	very cold	moderately short	very early	low
522	very high	very cold	moderately short	early	low
523	very high	very cold	moderately short	moderately late	low
524	very high	very cold	moderately short	late	low
525	very high	very cold	moderately short	very late	low
526	very high	cold	moderately short	very early	very low
527	very high	cold	moderately short	early	very low
528	very high	cold	moderately short	moderately late	very low
529	very high	cold	moderately short	late	very low
530	very high	cold	moderately short	very late	very low
531	very high	cool	moderately short	very early	good
532	very high	cool	moderately short	early	good
533	very high	cool	moderately short	moderately late	moderate

534	very high	cool	moderately short	late	moderate
535	very high	cool	moderately short	very late	moderate
536	very high	mild	moderately short	very early	good
537	very high	mild	moderately short	early	good
538	very high	mild	moderately short	moderately late	moderate
539	very high	mild	moderately short	late	moderate
540	very high	mild	moderately short	very late	moderate
541	very high	very cold	moderately long	very early	low
542	very high	very cold	moderately long	early	low
543	very high	very cold	moderately long	moderately late	low
544	very high	very cold	moderately long	late	low
545	very high	very cold	moderately long	very late	low
546	very high	cold	moderately long	very early	very low
547	very high	cold	moderately long	early	very low
548	very high	cold	moderately long	moderately late	very low
549	very high	cold	moderately long	late	very low
550	very high	cold	moderately long	very late	very low
551	very high	cool	moderately long	very early	very good
552	very high	cool	moderately long	early	very good
553	very high	cool	moderately long	moderately late	good
554	very high	cool	moderately long	late	good
555	very high	cool	moderately long	very late	good
556	very high	mild	moderately long	very early	very good
557	very high	mild	moderately long	early	very good
558	very high	mild	moderately long	moderately late	good
559	very high	mild	moderately long	late	good
560	very high	mild	moderately long	very late	good
561	very high	very cold	long	very early	low
562	very high	very cold	long	early	low
563	very high	very cold	long	moderately late	low
564	very high	very cold	long	late	low
565	very high	very cold	long	very late	low
566	very high	cold	long	very early	very low
567	very high	cold	long	early	very low
568	very high	cold	long	moderately late	very low
569	very high	cold	long	late	very low
570	very high	cold	long	very late	very low
571	very high	cool	long	very early	very good
572	very high	cool	long	early	very good
573	very high	cool	long	moderately late	good
574	very high	cool	long	late	good
575	very high	cool	long	very late	good
576	very high	mild	long	very early	very good
577	very high	mild	long	early	very good
578	very high	mild	long	moderately late	good

579	very high	mild	long	late	good
580	very high	mild	long	very late	good
581	very high	very cold	very long	very early	low
582	very high	very cold	very long	early	low
583	very high	very cold	very long	moderately late	low
584	very high	very cold	very long	late	low
585	very high	very cold	very long	very late	low
586	very high	cold	very long	very early	very low
587	very high	cold	very long	early	very low
588	very high	cold	very long	moderately late	very low
589	very high	cold	very long	late	very low
590	very high	cold	very long	very late	very low
591	very high	cool	very long	very early	good
592	very high	cool	very long	early	good
593	very high	cool	very long	moderately late	moderate
594	very high	cool	very long	late	moderate
595	very high	cool	very long	very late	moderate
596	very high	mild	very long	very early	good
597	very high	mild	very long	early	good
598	very high	mild	very long	moderately late	moderate
599	very high	mild	very long	late	moderate
600	very high	mild	very long	very late	moderate

1.4. *Quercus robur*

No.	IF	AND	AND	AND	THEN
	GDD	WF	LVP	LF	SUI
1	very low	very cold	very short	very early	very low
2	very low	very cold	very short	early	very low
3	very low	very cold	very short	moderately late	very low
4	very low	very cold	very short	late	very low
5	very low	very cold	very short	very late	very low
6	very low	cold	very short	very early	very low
7	very low	cold	very short	early	very low
8	very low	cold	very short	moderately late	very low
9	very low	cold	very short	late	very low
10	very low	cold	very short	very late	very low
11	very low	cool	very short	very early	very low
12	very low	cool	very short	early	very low
13	very low	cool	very short	moderately late	very low
14	very low	cool	very short	late	very low
15	very low	cool	very short	very late	very low
16	very low	mild	very short	very early	very low
17	very low	mild	very short	early	very low
18	very low	mild	very short	moderately late	very low
19	very low	mild	very short	late	very low
20	very low	mild	very short	very late	very low
21	very low	very cold	short	very early	very low
22	very low	very cold	short	early	very low
23	very low	very cold	short	moderately late	very low
24	very low	very cold	short	late	very low
25	very low	very cold	short	very late	very low
26	very low	cold	short	very early	very low
27	very low	cold	short	early	very low
28	very low	cold	short	moderately late	very low
29	very low	cold	short	late	very low
30	very low	cold	short	very late	very low
31	very low	cool	short	very early	very low
32	very low	cool	short	early	very low
33	very low	cool	short	moderately late	very low
34	very low	cool	short	late	very low
35	very low	cool	short	very late	very low
36	very low	mild	short	very early	very low
37	very low	mild	short	early	very low
38	very low	mild	short	moderately late	very low

39	very low	mild	short	late	very low
40	very low	mild	short	very late	very low
41	very low	very cold	moderately short	very early	very low
42	very low	very cold	moderately short	early	very low
43	very low	very cold	moderately short	moderately late	very low
44	very low	very cold	moderately short	late	very low
45	very low	very cold	moderately short	very late	very low
46	very low	cold	moderately short	very early	very low
47	very low	cold	moderately short	early	very low
48	very low	cold	moderately short	moderately late	very low
49	very low	cold	moderately short	late	very low
50	very low	cold	moderately short	very late	very low
51	very low	cool	moderately short	very early	very low
52	very low	cool	moderately short	early	very low
53	very low	cool	moderately short	moderately late	very low
54	very low	cool	moderately short	late	very low
55	very low	cool	moderately short	very late	very low
56	very low	mild	moderately short	very early	very low
57	very low	mild	moderately short	early	very low
58	very low	mild	moderately short	moderately late	very low
59	very low	mild	moderately short	late	very low
60	very low	mild	moderately short	very late	very low
61	very low	very cold	moderately long	very early	very low
62	very low	very cold	moderately long	early	very low
63	very low	very cold	moderately long	moderately late	very low
64	very low	very cold	moderately long	late	very low
65	very low	very cold	moderately long	very late	very low
66	very low	cold	moderately long	very early	very low
67	very low	cold	moderately long	early	very low
68	very low	cold	moderately long	moderately late	very low
69	very low	cold	moderately long	late	very low
70	very low	cold	moderately long	very late	very low
71	very low	cool	moderately long	very early	very low
72	very low	cool	moderately long	early	very low
73	very low	cool	moderately long	moderately late	very low
74	very low	cool	moderately long	late	very low
75	very low	cool	moderately long	very late	very low
76	very low	mild	moderately long	very early	very low
77	very low	mild	moderately long	early	very low
78	very low	mild	moderately long	moderately late	very low
79	very low	mild	moderately long	late	very low
80	very low	mild	moderately long	very late	very low
81	very low	very cold	long	very early	very low
82	very low	very cold	long	early	very low
83	very low	very cold	long	moderately late	very low

84	very low	very cold	long	late	very low
85	very low	very cold	long	very late	very low
86	very low	cold	long	very early	**low**
87	very low	cold	long	early	low
88	very low	cold	long	moderately late	low
89	very low	cold	long	late	low
90	very low	cold	long	very late	low
91	very low	cool	long	very early	low
92	very low	cool	long	early	low
93	very low	cool	long	moderately late	low
94	very low	cool	long	late	low
95	very low	cool	long	very late	low
96	very low	mild	long	very early	low
97	very low	mild	long	early	low
98	very low	mild	long	moderately late	low
99	very low	mild	long	late	low
100	very low	mild	long	very late	low
101	very low	very cold	very long	very early	very low
102	very low	very cold	very long	early	very low
103	very low	very cold	very long	moderately late	very low
104	very low	very cold	very long	late	very low
105	very low	very cold	very long	very late	very low
106	very low	cold	very long	very early	low
107	very low	cold	very long	early	very low
108	very low	cold	very long	moderately late	very low
109	very low	cold	very long	late	very low
110	very low	cold	very long	very late	very low
111	very low	cool	very long	very early	low
112	very low	cool	very long	early	very low
113	very low	cool	very long	moderately late	very low
114	very low	cool	very long	late	very low
115	very low	cool	very long	very late	very low
116	very low	mild	very long	very early	low
117	very low	mild	very long	early	very low
118	very low	mild	very long	moderately late	very low
119	very low	mild	very long	late	very low
120	very low	mild	very long	very late	very low
121	low	very cold	very short	very early	very low
122	low	very cold	very short	early	very low
123	low	very cold	very short	moderately late	very low
124	low	very cold	very short	late	very low
125	low	very cold	very short	very late	very low
126	low	cold	very short	very early	very low
127	low	cold	very short	early	very low
128	low	cold	very short	moderately late	very low

129	low	cold	very short	late	very low
130	low	cold	very short	very late	very low
131	low	cool	very short	very early	very low
132	low	cool	very short	early	very low
133	low	cool	very short	moderately late	very low
134	low	cool	very short	late	very low
135	low	cool	very short	very late	very low
136	low	mild	very short	very early	very low
137	low	mild	very short	early	very low
138	low	mild	very short	moderately late	very low
139	low	mild	very short	late	very low
140	low	mild	very short	very late	very low
141	low	very cold	short	very early	very low
142	low	very cold	short	early	very low
143	low	very cold	short	moderately late	very low
144	low	very cold	short	late	very low
145	low	very cold	short	very late	very low
146	low	cold	short	very early	very low
147	low	cold	short	early	very low
148	low	cold	short	moderately late	very low
149	low	cold	short	late	very low
150	low	cold	short	very late	very low
151	low	cool	short	very early	very low
152	low	cool	short	early	very low
153	low	cool	short	moderately late	very low
154	low	cool	short	late	very low
155	low	cool	short	very late	very low
156	low	mild	short	very early	very low
157	low	mild	short	early	very low
158	low	mild	short	moderately late	very low
159	low	mild	short	late	very low
160	low	mild	short	very late	very low
161	low	very cold	moderately short	very early	very low
162	low	very cold	moderately short	early	very low
163	low	very cold	moderately short	moderately late	very low
164	low	very cold	moderately short	late	very low
165	low	very cold	moderately short	very late	very low
166	low	cold	moderately short	very early	very low
167	low	cold	moderately short	early	very low
168	low	cold	moderately short	moderately late	very low
169	low	cold	moderately short	late	very low
170	low	cold	moderately short	very late	very low
171	low	cool	moderately short	very early	very low
172	low	cool	moderately short	early	very low
173	low	cool	moderately short	moderately late	very low

174	low	cool	moderately short	late	very low
175	low	cool	moderately short	very late	very low
176	low	mild	moderately short	very early	very low
177	low	mild	moderately short	early	very low
178	low	mild	moderately short	moderately late	very low
179	low	mild	moderately short	late	very low
180	low	mild	moderately short	very late	very low
181	low	very cold	moderately long	very early	very low
182	low	very cold	moderately long	early	very low
183	low	very cold	moderately long	moderately late	very low
184	low	very cold	moderately long	late	very low
185	low	very cold	moderately long	very late	very low
186	low	cold	moderately long	very early	very low
187	low	cold	moderately long	early	very low
188	low	cold	moderately long	moderately late	very low
189	low	cold	moderately long	late	very low
190	low	cold	moderately long	very late	very low
191	low	cool	moderately long	very early	very low
192	low	cool	moderately long	early	very low
193	low	cool	moderately long	moderately late	very low
194	low	cool	moderately long	late	very low
195	low	cool	moderately long	very late	very low
196	low	mild	moderately long	very early	very low
197	low	mild	moderately long	early	very low
198	low	mild	moderately long	moderately late	very low
199	low	mild	moderately long	late	very low
200	low	mild	moderately long	very late	very low
201	low	very cold	long	very early	very low
202	low	very cold	long	early	very low
203	low	very cold	long	moderately late	very low
204	low	very cold	long	late	very low
205	low	very cold	long	very late	very low
206	low	cold	long	very early	very low
207	low	cold	long	early	very low
208	low	cold	long	moderately late	very low
209	low	cold	long	late	very low
210	low	cold	long	very late	very low
211	low	cool	long	very early	very low
212	low	cool	long	early	very low
213	low	cool	long	moderately late	very low
214	low	cool	long	late	very low
215	low	cool	long	very late	very low
216	low	mild	long	very early	very low
217	low	mild	long	early	very low
218	low	mild	long	moderately late	very low

219	low	mild	long	late	very low
220	low	mild	long	very late	very low
221	low	very cold	very long	very early	very low
222	low	very cold	very long	early	very low
223	low	very cold	very long	moderately late	very low
224	low	very cold	very long	late	very low
225	low	very cold	very long	very late	very low
226	low	cold	very long	very early	very low
227	low	cold	very long	early	very low
228	low	cold	very long	moderately late	very low
229	low	cold	very long	late	very low
230	low	cold	very long	very late	very low
231	low	cool	very long	very early	very low
232	low	cool	very long	early	very low
233	low	cool	very long	moderately late	very low
234	low	cool	very long	late	very low
235	low	cool	very long	very late	very low
236	low	mild	very long	very early	very low
237	low	mild	very long	early	very low
238	low	mild	very long	moderately late	very low
239	low	mild	very long	late	very low
240	low	mild	very long	very late	very low
241	moderate	very cold	very short	very early	very low
242	moderate	very cold	very short	early	very low
243	moderate	very cold	very short	moderately late	very low
244	moderate	very cold	very short	late	very low
245	moderate	very cold	very short	very late	very low
246	moderate	cold	very short	very early	very low
247	moderate	cold	very short	early	very low
248	moderate	cold	very short	moderately late	very low
249	moderate	cold	very short	late	very low
250	moderate	cold	very short	very late	very low
251	moderate	cool	very short	very early	very low
252	moderate	cool	very short	early	very low
253	moderate	cool	very short	moderately late	very low
254	moderate	cool	very short	late	very low
255	moderate	cool	very short	very late	very low
256	moderate	mild	very short	very early	very low
257	moderate	mild	very short	early	very low
258	moderate	mild	very short	moderately late	very low
259	moderate	mild	very short	late	very low
260	moderate	mild	very short	very late	very low
261	moderate	very cold	short	very early	very low
262	moderate	very cold	short	early	very low
263	moderate	very cold	short	moderately late	very low

264	moderate	very cold	short	late	very low
265	moderate	very cold	short	very late	very low
266	moderate	cold	short	very early	very low
267	moderate	cold	short	early	very low
268	moderate	cold	short	moderately late	very low
269	moderate	cold	short	late	very low
270	moderate	cold	short	very late	very low
271	moderate	cool	short	very early	very low
272	moderate	cool	short	early	very low
273	moderate	cool	short	moderately late	very low
274	moderate	cool	short	late	very low
275	moderate	cool	short	very late	very low
276	moderate	mild	short	very early	very low
277	moderate	mild	short	early	very low
278	moderate	mild	short	moderately late	very low
279	moderate	mild	short	late	very low
280	moderate	mild	short	very late	very low
281	moderate	very cold	moderately short	very early	very low
282	moderate	very cold	moderately short	early	very low
283	moderate	very cold	moderately short	moderately late	very low
284	moderate	very cold	moderately short	late	very low
285	moderate	very cold	moderately short	very late	very low
286	moderate	cold	moderately short	very early	low
287	moderate	cold	moderately short	early	very low
288	moderate	cold	moderately short	moderately late	very low
289	moderate	cold	moderately short	late	very low
290	moderate	cold	moderately short	very late	very low
291	moderate	cool	moderately short	very early	low
292	moderate	cool	moderately short	early	very low
293	moderate	cool	moderately short	moderately late	very low
294	moderate	cool	moderately short	late	very low
295	moderate	cool	moderately short	very late	very low
296	moderate	mild	moderately short	very early	low
297	moderate	mild	moderately short	early	very low
298	moderate	mild	moderately short	moderately late	very low
299	moderate	mild	moderately short	late	very low
300	moderate	mild	moderately short	very late	very low
301	moderate	very cold	moderately long	very early	very low
302	moderate	very cold	moderately long	early	very low
303	moderate	very cold	moderately long	moderately late	very low
304	moderate	very cold	moderately long	late	very low
305	moderate	very cold	moderately long	very late	very low
306	moderate	cold	moderately long	very early	low
307	moderate	cold	moderately long	early	low
308	moderate	cold	moderately long	moderately late	very low

309	moderate	cold	moderately long	late	very low
310	moderate	cold	moderately long	very late	very low
311	moderate	cool	moderately long	very early	moderate
312	moderate	cool	moderately long	early	moderate
313	moderate	cool	moderately long	moderately late	low
314	moderate	cool	moderately long	late	low
315	moderate	cool	moderately long	very late	low
316	moderate	mild	moderately long	very early	moderate
317	moderate	mild	moderately long	early	moderate
318	moderate	mild	moderately long	moderately late	moderate
319	moderate	mild	moderately long	late	low
320	moderate	mild	moderately long	very late	low
321	moderate	very cold	long	very early	very low
322	moderate	very cold	long	early	very low
323	moderate	very cold	long	moderately late	very low
324	moderate	very cold	long	late	very low
325	moderate	very cold	long	very late	very low
326	moderate	cold	long	very early	moderate
327	moderate	cold	long	early	moderate
328	moderate	cold	long	moderately late	low
329	moderate	cold	long	late	low
330	moderate	cold	long	very late	low
331	moderate	cool	long	very early	moderate
332	moderate	cool	long	early	moderate
333	moderate	cool	long	moderately late	moderate
334	moderate	cool	long	late	low
335	moderate	cool	long	very late	low
336	moderate	mild	long	very early	moderate
337	moderate	mild	long	early	moderate
338	moderate	mild	long	moderately late	moderate
339	moderate	mild	long	late	low
340	moderate	mild	long	very late	low
341	moderate	very cold	very long	very early	very low
342	moderate	very cold	very long	early	very low
343	moderate	very cold	very long	moderately late	very low
344	moderate	very cold	very long	late	very low
345	moderate	very cold	very long	very late	very low
346	moderate	cold	very long	very early	moderate
347	moderate	cold	very long	early	moderate
348	moderate	cold	very long	moderately late	moderate
349	moderate	cold	very long	late	low
350	moderate	cold	very long	very late	low
351	moderate	cool	very long	very early	**moderate**
352	moderate	cool	very long	early	moderate
353	moderate	cool	very long	moderately late	moderate

354	moderate	cool	very long	late	low
355	moderate	cool	very long	very late	low
356	moderate	mild	very long	very early	moderate
357	moderate	mild	very long	early	moderate
358	moderate	mild	very long	moderately late	moderate
359	moderate	mild	very long	late	low
360	moderate	mild	very long	very late	low
361	high	very cold	very short	very early	very low
362	high	very cold	very short	early	very low
363	high	very cold	very short	moderately late	very low
364	high	very cold	very short	late	very low
365	high	very cold	very short	very late	very low
366	high	cold	very short	very early	very low
367	high	cold	very short	early	very low
368	high	cold	very short	moderately late	very low
369	high	cold	very short	late	very low
370	high	cold	very short	very late	very low
371	high	cool	very short	very early	very low
372	high	cool	very short	early	very low
373	high	cool	very short	moderately late	very low
374	high	cool	very short	late	very low
375	high	cool	very short	very late	very low
376	high	mild	very short	very early	very low
377	high	mild	very short	early	very low
378	high	mild	very short	moderately late	very low
379	high	mild	very short	late	very low
380	high	mild	very short	very late	very low
381	high	very cold	short	very early	very low
382	high	very cold	short	early	very low
383	high	very cold	short	moderately late	very low
384	high	very cold	short	late	very low
385	high	very cold	short	very late	very low
386	high	cold	short	very early	very low
387	high	cold	short	early	very low
388	high	cold	short	moderately late	very low
389	high	cold	short	late	very low
390	high	cold	short	very late	very low
391	high	cool	short	very early	very low
392	high	cool	short	early	very low
393	high	cool	short	moderately late	very low
394	high	cool	short	late	very low
395	high	cool	short	very late	very low
396	high	mild	short	very early	very low
397	high	mild	short	early	very low
398	high	mild	short	moderately late	very low

399	high	mild	short	late	very low
400	high	mild	short	very late	very low
401	high	very cold	moderately short	very early	very low
402	high	very cold	moderately short	early	very low
403	high	very cold	moderately short	moderately late	very low
404	high	very cold	moderately short	late	very low
405	high	very cold	moderately short	very late	very low
406	high	cold	moderately short	very early	moderate
407	high	cold	moderately short	early	moderate
408	high	cold	moderately short	moderately late	moderate
409	high	cold	moderately short	late	low
410	high	cold	moderately short	very late	low
411	high	cool	moderately short	very early	moderate
412	high	cool	moderately short	early	moderate
413	high	cool	moderately short	moderately late	moderate
414	high	cool	moderately short	late	low
415	high	cool	moderately short	very late	low
416	high	mild	moderately short	very early	moderate
417	high	mild	moderately short	early	moderate
418	high	mild	moderately short	moderately late	moderate
419	high	mild	moderately short	late	low
420	high	mild	moderately short	very late	low
421	high	very cold	moderately long	very early	very low
422	high	very cold	moderately long	early	very low
423	high	very cold	moderately long	moderately late	very low
424	high	very cold	moderately long	late	very low
425	high	very cold	moderately long	very late	very low
426	high	cold	moderately long	very early	moderate
427	high	cold	moderately long	early	moderate
428	high	cold	moderately long	moderately late	moderate
429	high	cold	moderately long	late	low
430	high	cold	moderately long	very late	low
431	high	cool	moderately long	very early	moderate
432	high	cool	moderately long	early	moderate
433	high	cool	moderately long	moderately late	moderate
434	high	cool	moderately long	late	low
435	high	cool	moderately long	very late	low
436	high	mild	moderately long	very early	moderate
437	high	mild	moderately long	early	moderate
438	high	mild	moderately long	moderately late	moderate
439	high	mild	moderately long	late	moderate
440	high	mild	moderately long	very late	low
441	high	very cold	long	very early	very low
442	high	very cold	long	early	very low
443	high	very cold	long	moderately late	very low

444	high	very cold	long	late	very low
445	high	very cold	long	very late	very low
446	high	cold	long	very early	good
447	high	cold	long	early	good
448	high	cold	long	moderately late	good
449	high	cold	long	late	moderate
450	high	cold	long	very late	moderate
451	high	cool	long	very early	good
452	high	cool	long	early	good
453	high	cool	long	moderately late	good
454	high	cool	long	late	moderate
455	high	cool	long	very late	moderate
456	high	mild	long	very early	good
457	high	mild	long	early	good
458	high	mild	long	moderately late	good
459	high	mild	long	late	moderate
460	high	mild	long	very late	moderate
461	high	very cold	very long	very early	very low
462	high	very cold	very long	early	very low
463	high	very cold	very long	moderately late	very low
464	high	very cold	very long	late	very low
465	high	very cold	very long	very late	very low
466	high	cold	very long	very early	very good
467	high	cold	very long	early	very good
468	high	cold	very long	moderately late	very good
469	high	cold	very long	late	good
470	high	cold	very long	very late	good
471	high	cool	very long	very early	very good
472	high	cool	very long	early	very good
473	high	cool	very long	moderately late	very good
474	high	cool	very long	late	good
475	high	cool	very long	very late	good
476	high	mild	very long	very early	very good
477	high	mild	very long	early	very good
478	high	mild	very long	moderately late	very good
479	high	mild	very long	late	good
480	high	mild	very long	very late	good
481	very high	very cold	very short	very early	very low
482	very high	very cold	very short	early	very low
483	very high	very cold	very short	moderately late	very low
484	very high	very cold	very short	late	very low
485	very high	very cold	very short	very late	very low
486	very high	cold	very short	very early	very low
487	very high	cold	very short	early	very low
488	very high	cold	very short	moderately late	very low

489	very high	cold	very short	late	very low
490	very high	cold	very short	very late	very low
491	very high	cool	very short	very early	very low
492	very high	cool	very short	early	very low
493	very high	cool	very short	moderately late	very low
494	very high	cool	very short	late	very low
495	very high	cool	very short	very late	very low
496	very high	mild	very short	very early	very low
497	very high	mild	very short	early	very low
498	very high	mild	very short	moderately late	very low
499	very high	mild	very short	late	very low
500	very high	mild	very short	very late	very low
501	very high	very cold	short	very early	very low
502	very high	very cold	short	early	very low
503	very high	very cold	short	moderately late	very low
504	very high	very cold	short	late	very low
505	very high	very cold	short	very late	very low
506	very high	cold	short	very early	moderate
507	very high	cold	short	early	moderate
508	very high	cold	short	moderately late	moderate
509	very high	cold	short	late	low
510	very high	cold	short	very late	low
511	very high	cool	short	very early	good
512	very high	cool	short	early	good
513	very high	cool	short	moderately late	good
514	very high	cool	short	late	moderate
515	very high	cool	short	very late	moderate
516	very high	mild	short	very early	good
517	very high	mild	short	early	good
518	very high	mild	short	moderately late	good
519	very high	mild	short	late	moderate
520	very high	mild	short	very late	moderate
521	very high	very cold	moderately short	very early	very low
522	very high	very cold	moderately short	early	very low
523	very high	very cold	moderately short	moderately late	very low
524	very high	very cold	moderately short	late	very low
525	very high	very cold	moderately short	very late	very low
526	very high	cold	moderately short	very early	good
527	very high	cold	moderately short	early	good
528	very high	cold	moderately short	moderately late	good
529	very high	cold	moderately short	late	moderate
530	very high	cold	moderately short	very late	moderate
531	very high	cool	moderately short	very early	good
532	very high	cool	moderately short	early	good
533	very high	cool	moderately short	moderately late	good

534	very high	cool	moderately short	late	moderate
535	very high	cool	moderately short	very late	moderate
536	very high	mild	moderately short	very early	good
537	very high	mild	moderately short	early	good
538	very high	mild	moderately short	moderately late	good
539	very high	mild	moderately short	late	moderate
540	very high	mild	moderately short	very late	moderate
541	very high	very cold	moderately long	very early	very low
542	very high	very cold	moderately long	early	very low
543	very high	very cold	moderately long	moderately late	very low
544	very high	very cold	moderately long	late	very low
545	very high	very cold	moderately long	very late	very low
546	very high	cold	moderately long	very early	good
547	very high	cold	moderately long	early	good
548	very high	cold	moderately long	moderately late	good
549	very high	cold	moderately long	late	moderate
550	very high	cold	moderately long	very late	moderate
551	very high	cool	moderately long	very early	good
552	very high	cool	moderately long	early	good
553	very high	cool	moderately long	moderately late	good
554	very high	cool	moderately long	late	moderate
555	very high	cool	moderately long	very late	moderate
556	very high	mild	moderately long	very early	good
557	very high	mild	moderately long	early	good
558	very high	mild	moderately long	moderately late	good
559	very high	mild	moderately long	late	moderate
560	very high	mild	moderately long	very late	moderate
561	very high	very cold	long	very early	very low
562	very high	very cold	long	early	very low
563	very high	very cold	long	moderately late	very low
564	very high	very cold	long	late	very low
565	very high	very cold	long	very late	very low
566	very high	cold	long	very early	very good
567	very high	cold	long	early	very good
568	very high	cold	long	moderately late	very good
569	very high	cold	long	late	good
570	very high	cold	long	very late	good
571	very high	cool	long	very early	very good
572	very high	cool	long	early	very good
573	very high	cool	long	moderately late	very good
574	very high	cool	long	late	good
575	very high	cool	long	very late	good
576	very high	mild	long	very early	very good
577	very high	mild	long	early	very good
578	very high	mild	long	moderately late	very good

579	very high	mild	long	late	good
580	very high	mild	long	very late	good
581	very high	very cold	very long	very early	very low
582	very high	very cold	very long	early	very low
583	very high	very cold	very long	moderately late	very low
584	very high	very cold	very long	late	very low
585	very high	very cold	very long	very late	very low
586	very high	cold	very long	very early	very good
587	very high	cold	very long	early	very good
588	very high	cold	very long	moderately late	very good
589	very high	cold	very long	late	good
590	very high	cold	very long	very late	good
591	very high	cool	very long	very early	very good
592	very high	cool	very long	early	very good
593	very high	cool	very long	moderately late	very good
594	very high	cool	very long	late	good
595	very high	cool	very long	very late	good
596	very high	mild	very long	very early	very good
597	very high	mild	very long	early	very good
598	very high	mild	very long	moderately late	very good
599	very high	mild	very long	late	good
600	very high	mild	very long	very late	good

2. Rule bases for Nutrient Suitability model

2.1. Soil Adsorption Matrix model

No.	IF	AND	AND	THEN
	SD	CF	ST	SAM
1	very shallow	very low	sandy soils	low
2	shallow	very low	sandy soils	low
3	moderately deep	very low	sandy soils	low
4	deep	very low	sandy soils	moderate
5	very deep	very low	sandy soils	moderate
6	very shallow	low	sandy soils	low
7	shallow	low	sandy soils	low
8	moderately deep	low	sandy soils	low
9	deep	low	sandy soils	moderate
10	very deep	low	sandy soils	moderate
11	very shallow	moderately high	sandy soils	low
12	shallow	moderately high	sandy soils	low
13	moderately deep	moderately high	sandy soils	low
14	deep	moderately high	sandy soils	low
15	very deep	moderately high	sandy soils	moderate
16	very shallow	high	sandy soils	low
17	shallow	high	sandy soils	low
18	moderately deep	high	sandy soils	low
19	deep	high	sandy soils	low
20	very deep	high	sandy soils	low
21	very shallow	very high	sandy soils	low
22	shallow	very high	sandy soils	low
23	moderately deep	very high	sandy soils	low
24	deep	very high	sandy soils	low
25	very deep	very high	sandy soils	low
26	very shallow	very low	loamy sands	low
27	shallow	very low	loamy sands	low
28	moderately deep	very low	loamy sands	moderate
29	deep	very low	loamy sands	good
30	very deep	very low	loamy sands	good
31	very shallow	low	loamy sands	low
32	shallow	low	loamy sands	low
33	moderately deep	low	loamy sands	low
34	deep	low	loamy sands	moderate
35	very deep	low	loamy sands	good
36	very shallow	moderately high	loamy sands	low
37	shallow	moderately high	loamy sands	low
38	moderately deep	moderately high	loamy sands	low

39	deep	moderately high	loamy sands	moderate
40	very deep	moderately high	loamy sands	moderate
41	very shallow	high	loamy sands	low
42	shallow	high	loamy sands	low
43	moderately deep	high	loamy sands	low
44	deep	high	loamy sands	low
45	very deep	high	loamy sands	moderate
46	very shallow	very high	loamy sands	low
47	shallow	very high	loamy sands	low
48	moderately deep	very high	loamy sands	low
49	deep	very high	loamy sands	low
50	very deep	very high	loamy sands	moderate
51	very shallow	very low	loamy soils	low
52	shallow	very low	loamy soils	low
53	moderately deep	very low	loamy soils	moderate
54	deep	very low	loamy soils	good
55	very deep	very low	loamy soils	very good
56	very shallow	low	loamy soils	low
57	shallow	low	loamy soils	low
58	moderately deep	low	loamy soils	moderate
59	deep	low	loamy soils	good
60	very deep	low	loamy soils	very good
61	very shallow	moderately high	loamy soils	low
62	shallow	moderately high	loamy soils	low
63	moderately deep	moderately high	loamy soils	moderate
64	deep	moderately high	loamy soils	moderate
65	very deep	moderately high	loamy soils	good
66	very shallow	high	loamy soils	low
67	shallow	high	loamy soils	low
68	moderately deep	high	loamy soils	moderate
69	deep	high	loamy soils	moderate
70	very deep	high	loamy soils	moderate
71	very shallow	very high	loamy soils	low
72	shallow	very high	loamy soils	low
73	moderately deep	very high	loamy soils	low
74	deep	very high	loamy soils	moderate
75	very deep	very high	loamy soils	moderate
76	very shallow	very low	clay soils	low
77	shallow	very low	clay soils	moderate
78	moderately deep	very low	clay soils	moderate
79	deep	very low	clay soils	good
80	very deep	very low	clay soils	very good
81	very shallow	low	clay soils	low
82	shallow	low	clay soils	moderate
83	moderately deep	low	clay soils	moderate

84	deep	low	clay soils	good
85	very deep	low	clay soils	very good
86	very shallow	moderately high	clay soils	low
87	shallow	moderately high	clay soils	moderate
88	moderately deep	moderately high	clay soils	moderate
89	deep	moderately high	clay soils	good
90	very deep	moderately high	clay soils	good
91	very shallow	high	clay soils	low
92	shallow	high	clay soils	low
93	moderately deep	high	clay soils	moderate
94	deep	high	clay soils	moderate
95	very deep	high	clay soils	good
96	very shallow	very high	clay soils	low
97	shallow	very high	clay soils	low
98	moderately deep	very high	clay soils	moderate
99	deep	very high	clay soils	moderate
100	very deep	very high	clay soils	moderate

2.2. Nutrient Suitability model

2.2.1. *Picea abies*

No.	**IF**	**AND**	**AND**	**THEN**
	SAM	**BS**	**pH**	**SUI**
1	low	(low & unbalanced)	extremely acidic	low
2	low	(low & unbalanced)	very acidic	low
3	low	(low & unbalanced)	moderately acidic	low
4	low	(low & unbalanced)	weak acidic / weak alkaline	low
5	low	low supply	extremely acidic	low
6	low	low supply	very acidic	low
7	low	low supply	moderately acidic	low
8	low	low supply	weak acidic / weak alkaline	low
9	low	moderately good supply	extremely acidic	low
10	low	moderately good supply	very acidic	low
11	low	moderately good supply	moderately acidic	low
12	low	moderately good supply	weak acidic / weak alkaline	low
13	low	good supply	extremely acidic	low
14	low	good supply	very acidic	moderate
15	low	good supply	moderately acidic	moderate
16	low	good supply	weak acidic / weak alkaline	moderate
17	moderate	(low & unbalanced)	extremely acidic	low
18	moderate	(low & unbalanced)	very acidic	low
19	moderate	(low & unbalanced)	moderately acidic	low

20	moderate	(low & unbalanced)	weak acidic / weak alkaline	moderate
21	moderate	low supply	extremely acidic	low
22	moderate	low supply	very acidic	moderate
23	moderate	low supply	moderately acidic	moderate
24	moderate	low supply	weak acidic / weak alkaline	moderate
25	moderate	moderately good supply	extremely acidic	low
26	moderate	moderately good supply	very acidic	moderate
27	moderate	moderately good supply	moderately acidic	good
28	moderate	moderately good supply	weak acidic / weak alkaline	good
29	moderate	good supply	extremely acidic	moderate
30	moderate	good supply	very acidic	good
31	moderate	good supply	moderately acidic	very good
32	moderate	good supply	weak acidic / weak alkaline	very good
33	good	(low & unbalanced)	extremely acidic	moderate
34	good	(low & unbalanced)	very acidic	moderate
35	good	(low & unbalanced)	moderately acidic	moderate
36	good	(low & unbalanced)	weak acidic / weak alkaline	moderate
37	good	low supply	extremely acidic	low
38	good	low supply	very acidic	moderate
39	good	low supply	moderately acidic	good
40	good	low supply	weak acidic / weak alkaline	good
41	good	moderately good supply	extremely acidic	moderate
42	good	moderately good supply	very acidic	good
43	good	moderately good supply	moderately acidic	very good
44	good	moderately good supply	weak acidic / weak alkaline	very good
45	good	good supply	extremely acidic	good
46	good	good supply	very acidic	good
47	good	good supply	moderately acidic	very good
48	good	good supply	weak acidic / weak alkaline	very good
49	very good	(low & unbalanced)	extremely acidic	low
50	very good	(low & unbalanced)	very acidic	moderate
51	very good	(low & unbalanced)	moderately acidic	moderate
52	very good	(low & unbalanced)	weak acidic / weak alkaline	moderate
53	very good	low supply	extremely acidic	moderate
54	very good	low supply	very acidic	good
55	very good	low supply	moderately acidic	good
56	very good	low supply	weak acidic / weak alkaline	good
57	very good	moderately good supply	extremely acidic	moderate
58	very good	moderately good supply	very acidic	good
59	very good	moderately good supply	moderately acidic	very good
60	very good	moderately good supply	weak acidic / weak alkaline	very good
61	very good	good supply	extremely acidic	moderate
62	very good	good supply	very acidic	very good
63	very good	good supply	moderately acidic	very good
64	very good	good supply	weak acidic / weak alkaline	very good

2.2.2. *Abies alba*

No.	IF	AND	AND	THEN
	SAM	BS	pH	SUI
1	low	(low & unbalanced)	extremely acidic	unsuitable
2	low	(low & unbalanced)	very acidic	unsuitable
3	low	(low & unbalanced)	moderately acidic	unsuitable
4	low	(low & unbalanced)	weak acidic / weak alkaline	unsuitable
5	low	low supply	extremely acidic	unsuitable
6	low	low supply	very acidic	unsuitable
7	low	low supply	moderately acidic	low
8	low	low supply	weak acidic / weak alkaline	low
9	low	moderately good supply	extremely acidic	unsuitable
10	low	moderately good supply	very acidic	unsuitable
11	low	moderately good supply	moderately acidic	low
12	low	moderately good supply	weak acidic / weak alkaline	low
13	low	good supply	extremely acidic	unsuitable
14	low	good supply	very acidic	unsuitable
15	low	good supply	moderately acidic	moderate
16	low	good supply	weak acidic / weak alkaline	moderate
17	moderate	(low & unbalanced)	extremely acidic	unsuitable
18	moderate	(low & unbalanced)	very acidic	low
19	moderate	(low & unbalanced)	moderately acidic	low
20	moderate	(low & unbalanced)	weak acidic / weak alkaline	moderate
21	moderate	low supply	extremely acidic	unsuitable
22	moderate	low supply	very acidic	low
23	moderate	low supply	moderately acidic	moderate
24	moderate	low supply	weak acidic / weak alkaline	moderate
25	moderate	moderately good supply	extremely acidic	unsuitable
26	moderate	moderately good supply	very acidic	low
27	moderate	moderately good supply	moderately acidic	moderate
28	moderate	moderately good supply	weak acidic / weak alkaline	good
29	moderate	good supply	extremely acidic	low
30	moderate	good supply	very acidic	moderate
31	moderate	good supply	moderately acidic	very good
32	moderate	good supply	weak acidic / weak alkaline	very good
33	good	(low & unbalanced)	extremely acidic	low
34	good	(low & unbalanced)	very acidic	moderate
35	good	(low & unbalanced)	moderately acidic	moderate
36	good	(low & unbalanced)	weak acidic / weak alkaline	moderate
37	good	low supply	extremely acidic	low
38	good	low supply	very acidic	moderate
39	good	low supply	moderately acidic	moderate

40	good	low supply	weak acidic / weak alkaline	moderate
41	good	moderately good supply	extremely acidic	low
42	good	moderately good supply	very acidic	moderate
43	good	moderately good supply	moderately acidic	very good
44	good	moderately good supply	weak acidic / weak alkaline	very good
45	good	good supply	extremely acidic	low
46	good	good supply	very acidic	moderate
47	good	good supply	moderately acidic	very good
48	good	good supply	weak acidic / weak alkaline	very good
49	very good	(low & unbalanced)	extremely acidic	low
50	very good	(low & unbalanced)	very acidic	moderate
51	very good	(low & unbalanced)	moderately acidic	moderate
52	very good	(low & unbalanced)	weak acidic / weak alkaline	moderate
53	very good	low supply	extremely acidic	low
54	very good	low supply	very acidic	moderate
55	very good	low supply	moderately acidic	moderate
56	very good	low supply	weak acidic / weak alkaline	good
57	very good	moderately good supply	extremely acidic	low
58	very good	moderately good supply	very acidic	moderate
59	very good	moderately good supply	moderately acidic	very good
60	very good	moderately good supply	weak acidic / weak alkaline	very good
61	very good	good supply	extremely acidic	low
62	very good	good supply	very acidic	very good
63	very good	good supply	moderately acidic	very good
64	very good	good supply	weak acidic / weak alkaline	very good

2.2.3. *Fagus sylvatica*

No.	**IF**	**AND**	**AND**	**THEN**
	SAM	**BS**	**pH**	**SUI**
1	low	(low & unbalanced)	extremely acidic	unsuitable
2	low	(low & unbalanced)	very acidic	unsuitable
3	low	(low & unbalanced)	moderately acidic	unsuitable
4	low	(low & unbalanced)	weak acidic / weak alkaline	unsuitable
5	low	low supply	extremely acidic	unsuitable
6	low	low supply	very acidic	unsuitable
7	low	low supply	moderately acidic	low
8	low	low supply	weak acidic / weak alkaline	low
9	low	moderately good supply	extremely acidic	unsuitable
10	low	moderately good supply	very acidic	unsuitable
11	low	moderately good supply	moderately acidic	low
12	low	moderately good supply	weak acidic / weak alkaline	low

13	low	good supply	extremely acidic	low
14	low	good supply	very acidic	low
15	low	good supply	moderately acidic	moderate
16	low	good supply	weak acidic / weak alkaline	moderate
17	moderate	(low & unbalanced)	extremely acidic	low
18	moderate	(low & unbalanced)	very acidic	low
19	moderate	(low & unbalanced)	moderately acidic	moderate
20	moderate	(low & unbalanced)	weak acidic / weak alkaline	moderate
21	moderate	low supply	extremely acidic	unsuitable
22	moderate	low supply	very acidic	low
23	moderate	low supply	moderately acidic	moderate
24	moderate	low supply	weak acidic / weak alkaline	moderate
25	moderate	moderately good supply	extremely acidic	unsuitable
26	moderate	moderately good supply	very acidic	low
27	moderate	moderately good supply	moderately acidic	moderate
28	moderate	moderately good supply	weak acidic / weak alkaline	good
29	moderate	good supply	extremely acidic	low
30	moderate	good supply	very acidic	moderate
31	moderate	good supply	moderately acidic	very good
32	moderate	good supply	weak acidic / weak alkaline	very good
33	good	(low & unbalanced)	extremely acidic	low
34	good	(low & unbalanced)	very acidic	moderate
35	good	(low & unbalanced)	moderately acidic	good
36	good	(low & unbalanced)	weak acidic / weak alkaline	good
37	good	low supply	extremely acidic	low
38	good	low supply	very acidic	good
39	good	low supply	moderately acidic	good
40	good	low supply	weak acidic / weak alkaline	good
41	good	moderately good supply	extremely acidic	low
42	good	moderately good supply	very acidic	good
43	good	moderately good supply	moderately acidic	very good
44	good	moderately good supply	weak acidic / weak alkaline	very good
45	good	good supply	extremely acidic	low
46	good	good supply	very acidic	moderate
47	good	good supply	moderately acidic	very good
48	good	good supply	weak acidic / weak alkaline	very good
49	very good	(low & unbalanced)	extremely acidic	low
50	very good	(low & unbalanced)	very acidic	good
51	very good	(low & unbalanced)	moderately acidic	good
52	very good	(low & unbalanced)	weak acidic / weak alkaline	good
53	very good	low supply	extremely acidic	low
54	very good	low supply	very acidic	good
55	very good	low supply	moderately acidic	good
56	very good	low supply	weak acidic / weak alkaline	good
57	very good	moderately good supply	extremely acidic	low

58	very good	moderately good supply	very acidic	moderate
59	very good	moderately good supply	moderately acidic	very good
60	very good	moderately good supply	weak acidic / weak alkaline	very good
61	very good	good supply	extremely acidic	low
62	very good	good supply	very acidic	very good
63	very good	good supply	moderately acidic	very good
64	very good	good supply	weak acidic / weak alkaline	very good

2.3.4. Quercus robur

No.	**IF**	**AND**	**AND**	**THEN**
	SAM	**BS**	**pH**	**SUI**
1	low	(low & unbalanced)	extremely acidic	unsuitable
2	low	(low & unbalanced)	very acidic	unsuitable
3	low	(low & unbalanced)	moderately acidic	unsuitable
4	low	(low & unbalanced)	weak acidic / weak alkaline	unsuitable
5	low	low supply	extremely acidic	unsuitable
6	low	low supply	very acidic	unsuitable
7	low	low supply	moderately acidic	unsuitable
8	low	low supply	weak acidic / weak alkaline	unsuitable
9	low	moderately good supply	extremely acidic	unsuitable
10	low	moderately good supply	very acidic	unsuitable
11	low	moderately good supply	moderately acidic	low
12	low	moderately good supply	weak acidic / weak alkaline	low
13	low	good supply	extremely acidic	unsuitable
14	low	good supply	very acidic	unsuitable
15	low	good supply	moderately acidic	moderate
16	low	good supply	weak acidic / weak alkaline	moderate
17	moderate	(low & unbalanced)	extremely acidic	unsuitable
18	moderate	(low & unbalanced)	very acidic	unsuitable
19	moderate	(low & unbalanced)	moderately acidic	low
20	moderate	(low & unbalanced)	weak acidic / weak alkaline	low
21	moderate	low supply	extremely acidic	unsuitable
22	moderate	low supply	very acidic	unsuitable
23	moderate	low supply	moderately acidic	low
24	moderate	low supply	weak acidic / weak alkaline	moderate
25	moderate	moderately good supply	extremely acidic	unsuitable
26	moderate	moderately good supply	very acidic	low
27	moderate	moderately good supply	moderately acidic	moderate
28	moderate	moderately good supply	weak acidic / weak alkaline	moderate
29	moderate	good supply	extremely acidic	low
30	moderate	good supply	very acidic	moderate

31	moderate	good supply	moderately acidic	moderate
32	moderate	good supply	weak acidic / weak alkaline	moderate
33	good	(low & unbalanced)	extremely acidic	low
34	good	(low & unbalanced)	very acidic	moderate
35	good	(low & unbalanced)	moderately acidic	moderate
36	good	(low & unbalanced)	weak acidic / weak alkaline	moderate
37	good	low supply	extremely acidic	low
38	good	low supply	very acidic	moderate
39	good	low supply	moderately acidic	moderate
40	good	low supply	weak acidic / weak alkaline	moderate
41	good	moderately good supply	extremely acidic	low
42	good	moderately good supply	very acidic	moderate
43	good	moderately good supply	moderately acidic	good
44	good	moderately good supply	weak acidic / weak alkaline	good
45	good	good supply	extremely acidic	low
46	good	good supply	very acidic	moderate
47	good	good supply	moderately acidic	good
48	good	good supply	weak acidic / weak alkaline	very good
49	very good	(low & unbalanced)	extremely acidic	low
50	very good	(low & unbalanced)	very acidic	low
51	very good	(low & unbalanced)	moderately acidic	moderate
52	very good	(low & unbalanced)	weak acidic / weak alkaline	moderate
53	very good	low supply	extremely acidic	low
54	very good	low supply	very acidic	low
55	very good	low supply	moderately acidic	moderate
56	very good	low supply	weak acidic / weak alkaline	moderate
57	very good	moderately good supply	extremely acidic	low
58	very good	moderately good supply	very acidic	moderate
59	very good	moderately good supply	moderately acidic	good
60	very good	moderately good supply	weak acidic / weak alkaline	good
61	very good	good supply	extremely acidic	low
62	very good	good supply	very acidic	good
63	very good	good supply	moderately acidic	very good
64	very good	good supply	weak acidic / weak alkaline	very good

3. Rule bases for Water Suitability model

3.1. *Picea abies*

No.	IF	AND	AND	THEN
	SMI	**GW**	**Gley**	**SUI**
1	good water supply	no ground water	no gley	very good suitability
2	good water supply	no ground water	weak gleyic soil	moderate
3	good water supply	no ground water	strong gleyic soil	unsuitable
4	good water supply	ground water weak	no gley	good suitability
5	good water supply	ground water weak	weak gleyic soil	moderate suitability
6	good water supply	ground water weak	strong gleyic soil	unsuitable
7	good water supply	ground water strong	no gley	low suitability
8	good water supply	ground water strong	weak gleyic soil	low suitability
9	good water supply	ground water strong	strong gleyic soil	unsuitable
10	moderate water supply	no ground water	no gley	moderate suitability
11	moderate water supply	no ground water	weak gleyic soil	moderate suitability
12	moderate water supply	no ground water	strong gleyic soil	unsuitable
13	moderate water supply	ground water weak	no gley	good suitability
14	moderate water supply	ground water weak	weak gleyic soil	moderate suitability
15	moderate water supply	ground water weak	strong gleyic soil	unsuitable
16	moderate water supply	ground water strong	no gley	low suitability
17	moderate water supply	ground water strong	weak gleyic soil	low suitability
18	moderate water supply	ground water strong	strong gleyic soil	unsuitable
19	limited water supply	no ground water	no gley	low suitability
20	limited water supply	no ground water	weak gleyic soil	low suitability
21	limited water supply	no ground water	strong gleyic soil	unsuitable
22	limited water supply	ground water weak	no gley	moderate suitability
23	limited water supply	ground water weak	weak gleyic soil	moderate suitability
24	limited water supply	ground water weak	strong gleyic soil	unsuitable
25	limited water supply	ground water strong	no gley	low suitability
26	limited water supply	ground water strong	weak gleyic soil	low suitability
27	limited water supply	ground water strong	strong gleyic soil	unsuitable
28	very limited water supply	no ground water	no gley	unsuitable
29	very limited water supply	no ground water	weak gleyic soil	unsuitable
30	very limited water supply	no ground water	strong gleyic soil	unsuitable

31	very limited water supply	ground water weak	no gley	low suitability
32	very limited water supply	ground water weak	weak gleyic soil	low suitability
33	very limited water supply	ground water weak	strong gleyic soil	unsuitable
34	very limited water supply	ground water strong	no gley	low suitability
35	very limited water supply	ground water strong	weak gleyic soil	low suitability
36	very limited water supply	ground water strong	strong gleyic soil	unsuitable

3.2. *Abies alba*

No.	IF	AND	AND	THEN
	SMI	**GW**	**Gley**	**SUI**
1	good water supply	no ground water	no gley	very good suitability
2	good water supply	no ground water	weak gleyic soil	very good suitability
3	good water supply	no ground water	strong gleyic soil	good suitability
4	good water supply	ground water weak	no gley	very good suitability
5	good water supply	ground water weak	weak gleyic soil	very good suitability
6	good water supply	ground water weak	strong gleyic soil	good suitability
7	good water supply	ground water strong	no gley	very good suitability
8	good water supply	ground water strong	weak gleyic soil	very good suitability
9	good water supply	ground water strong	strong gleyic soil	good suitability
10	moderate water supply	no ground water	no gley	good suitability
11	moderate water supply	no ground water	weak gleyic soil	good suitability
12	moderate water supply	no ground water	strong gleyic soil	good suitability
13	moderate water supply	ground water weak	no gley	very good suitability
14	moderate water supply	ground water weak	weak gleyic soil	very good suitability
15	moderate water supply	ground water weak	strong gleyic soil	good suitability
16	moderate water supply	ground water strong	no gley	very good suitability
17	moderate water supply	moderate water supply	weak gleyic soil	very good suitability
18	moderate water supply	moderate water supply	strong gleyic soil	good suitability
19	limited water supply	no ground water	no gley	moderate suitability

20	limited water supply	no ground water	weak gleyic soil	moderate suitability
21	limited water supply	no ground water	strong gleyic soil	moderate suitability
22	limited water supply	ground water weak	no gley	good suitability
23	limited water supply	ground water weak	weak gleyic soil	good suitability
24	limited water supply	ground water weak	strong gleyic soil	good suitability
25	limited water supply	ground water strong	no gley	good suitability
26	limited water supply	ground water strong	weak gleyic soil	good suitability
27	limited water supply	ground water strong	strong gleyic soil	good suitability
28	very limited water supply	no ground water	no gley	unsuitable
29	very limited water supply	no ground water	weak gleyic soil	unsuitable
30	very limited water supply	no ground water	strong gleyic soil	unsuitable
31	very limited water supply	ground water weak	no gley	low suitability
32	very limited water supply	ground water weak	weak gleyic soil	low suitability
33	very limited water supply	ground water weak	strong gleyic soil	low suitability
34	very limited water supply	ground water strong	no gley	moderate suitability
35	very limited water supply	ground water strong	weak gleyic soil	moderate suitability
36	very limited water supply	ground water strong	strong gleyic soil	moderate suitability

3.3. *Fagus sylvatica*

No.	IF	AND	AND	THEN
	SMI	**GW**	**Gley**	**SUI**
1	good water supply	no ground water	no gley	very good suitability
2	good water supply	no ground water	weak gleyic soil	moderate suitability
3	good water supply	no ground water	strong gleyic soil	low suitability
4	good water supply	ground water weak	no gley	very good suitability
5	good water supply	ground water weak	weak gleyic soil	moderate suitability
6	good water supply	ground water weak	strong gleyic soil	unsuitable
7	good water supply	ground water strong	no gley	very good suitability
8	good water supply	ground water strong	weak gleyic soil	moderate suitability
9	good water supply	ground water strong	strong gleyic soil	unsuitable
10	moderate water supply	no ground water	no gley	good suitability

11	moderate water supply	no ground water	weak gleyic soil	moderate suitability
12	moderate water supply	no ground water	strong gleyic soil	unsuitable
13	moderate water supply	ground water weak	no gley	very good suitability
14	moderate water supply	ground water weak	weak gleyic soil	moderate suitability
15	moderate water supply	ground water weak	strong gleyic soil	unsuitable
16	moderate water supply	ground water strong	no gley	very good suitability
17	moderate water supply	ground water strong	weak gleyic soil	moderate suitability
18	moderate water supply	ground water strong	strong gleyic soil	unsuitable
19	limited water supply	no ground water	no gley	low suitability
20	limited water supply	no ground water	weak gleyic soil	low suitability
21	limited water supply	no ground water	strong gleyic soil	unsuitable
22	limited water supply	ground water weak	no gley	moderate suitability
23	limited water supply	ground water weak	weak gleyic soil	moderate suitability
24	limited water supply	ground water weak	strong gleyic soil	unsuitable
25	limited water supply	ground water strong	no gley	good suitability
26	limited water supply	ground water strong	weak gleyic soil	moderate suitability
27	limited water supply	ground water strong	strong gleyic soil	unsuitable
28	very limited water supply	no ground water	no gley	unsuitable
29	very limited water supply	no ground water	weak gleyic soil	unsuitable
30	very limited water supply	no ground water	strong gleyic soil	unsuitable
31	very limited water supply	ground water weak	no gley	unsuitable
32	very limited water supply	ground water weak	weak gleyic soil	unsuitable
33	very limited water supply	ground water weak	strong gleyic soil	unsuitable
34	very limited water supply	ground water strong	no gley	moderate suitability
35	very limited water supply	ground water strong	weak gleyic soil	moderate suitability
36	very limited water supply	ground water strong	strong gleyic soil	unsuitable

3.4. Quercus robur

No.	IF	AND	AND	THEN
	SMI	GW	Gley	SUI
1	good water supply	no ground water	no gley	very good suitability
2	good water supply	no ground water	weak gleyic soil	very good suitability
3	good water supply	no ground water	strong gleyic soil	very good suitability
4	good water supply	ground water weak	no gley	very good suitability
5	good water supply	ground water weak	weak gleyic soil	very good suitability
6	good water supply	ground water weak	strong gleyic soil	very good suitability
7	good water supply	ground water strong	no gley	very good suitability
8	good water supply	ground water strong	weak gleyic soil	very good suitability
9	good water supply	ground water strong	strong gleyic soil	very good suitability
10	moderate water supply	no ground water	no gley	good suitability
11	moderate water supply	no ground water	weak gleyic soil	good suitability
12	moderate water supply	no ground water	strong gleyic soil	good suitability
13	moderate water supply	ground water weak	no gley	very good suitability
14	moderate water supply	ground water weak	weak gleyic soil	very good suitability
15	moderate water supply	ground water weak	strong gleyic soil	very good suitability
16	moderate water supply	ground water strong	no gley	very good suitability
17	moderate water supply	ground water strong	weak gleyic soil	very good suitability
18	moderate water supply	ground water strong	strong gleyic soil	very good suitability
19	limited water supply	no ground water	no gley	moderate suitability
20	limited water supply	no ground water	weak gleyic soil	moderate suitability
21	limited water supply	no ground water	strong gleyic soil	moderate suitability
22	limited water supply	ground water weak	no gley	good suitability
23	limited water supply	ground water weak	weak gleyic soil	good suitability
24	limited water supply	ground water weak	strong gleyic soil	good suitability
25	limited water supply	ground water strong	no gley	good suitability
26	limited water supply	ground water strong	weak gleyic soil	good suitability
27	limited water supply	ground water strong	strong gleyic soil	good suitability

28	very limited water supply	no ground water	no gley	low suitability
29	very limited water supply	no ground water	weak gleyic soil	low suitability
30	very limited water supply	no ground water	strong gleyic soil	low suitability
31	very limited water supply	ground water weak	no gley	moderate suitability
32	very limited water supply	ground water weak	weak gleyic soil	moderate suitability
33	very limited water supply	ground water weak	strong gleyic soil	moderate suitability
34	very limited water supply	ground water strong	no gley	good suitability
35	very limited water supply	ground water strong	weak gleyic soil	good suitability
36	very limited water supply	ground water strong	strong gleyic soil	good suitability