

**USE OF ECOLOGICAL CHARACTERISTIC OF SOIL FOR MAKING THE
SUITABILITY MAPS FOR GROWTH AND CULTIVATION OF SPECIES OF THE
GENUS *VACCINIUM* USING GIS TOOLS**

Esad BUKALO, Damir BEHLULOVIC, Ahmedin SALCINOVIC, Marijana TOMIC*

Federal institute for agropedology. Bosnia and Herzegovina
(Corresponding author: zapsa@pkpa.com.ba)

Abstract

Basis for understanding the spatial distribution of specific plant species is in the knowledge of the specific pedoclimatic and orographic demands certain plants.

In this paper authors prepared suitability map for the growth and cultivation of species of the genus *Vaccinium* in the Canton Srednja Bosna using GIS tools. In paper, as the major limitations for growth and cultivation species of the genus *Vaccinium*, it's used pH value of the soil (source: Basic Soil Map of Bosnia and Herzegovina (BiH), 1:50 000), elevation and aspect (source: DTM of BiH). Map as the end result allows the user to get answers to questions related to the cultivation of and growth of species of the genus *Vaccinium* in the Canton Srednja Bosna.

Keywords: analysis, GIS, limiting factors, *Vaccinium*

Introduction

Plant species, of the genus *Vaccinium*, originating from the eastern part of North America where they were transferred to Europe. A typical representative of the genus *Vaccinium* species is blueberry (*Vaccinium myrtillus* L.) and Northern highbush blueberry (*Vaccinium corymbosum* L.) which are the focus of research to create distribution maps and benefits from the exploitation of natural populations and breeding in Central Bosnia Canton. Blueberries from natural populations (*Vaccinium myrtillus* L.) grow in continental areas in mixed and coniferous forests on acid soil. Optimally grows at an altitude of 800-1200 m above sea level. Often grow in such numbers that fully covers the populated area. Important plant species as growing in poor soil that enriched with humus. From the surface of the soil is much branched subshrub, tall and up to 40 cm. The branches are green and sharp edges. The leaves are finely toothed and leathery, egg-shaped, the edge finely serrated toothed, and in their axillary, from May to June to develop a greenish pink bell-shaped flowers. Individual flowers are placed in the armpit leaf and they are oval shape. In their place in July dark blue berries are maturing that in the upper end ends with circular hollow. Berries are fine pungent odor similar to the smell of fresh wood. Fresh berries are sour - sweet taste, while the dry slightly bitter. The juice berries is dark blue, almost black. Blueberry fruit we collect when they fully mature. They are dried at a temperature of 40 – 50 °C. Its cultivation and increased production gains in importance in recent years thanks to its rich composition, antioxidant, so besides the food, vitamin and cosmetic industry is also interested in this type of healing fruit.

Northern highbush blueberry (*Vaccinium corymbosum* L.) was introduced in the flora of Bosnia and Herzegovina due to import seedlings and start cultivating blueberries. However, both abroad and in our country, began with the breeding of new varieties. They are mostly of American origin and enriched by the so-called. "High shrub" blueberry (which at the peak of the shoot or branch educated offspring by which are extended in height). These types of blueberries do not spread the rhizomes that it makes ordinary blueberries (*Vaccinium myrtillus* L.). These crossbred varieties are characterized by autogamy so it is essential carry out the planting with at least two varieties to increase yield (planting two rows of each variety). In Central Bosnia Canton blueberry

(*Vaccinium myrtillus* L.) and Northern highbush blueberry (*Vaccinium corimbosum* L.) significantly represented in the municipalities: Fojnica, Kiseljak, Kreševo, Travnik, Gornji Vakuf, Donji Vakuf, Jajce and Bugojno. In these areas blueberry has economic importance, given that the export-oriented and highly profitable medicinal plant species. However, natural resources blueberries are not evenly distributed and vary spatially. For this reason it is spatially oriented information base for management of natural resources, in these exact research resource blueberries from natural populations.

The technology intended for the management of spatially oriented data, is GIS (geographic information system). Using GIS technology aims to better and more efficient decision-making in creation of natural resource management and protection of resources, above all, forests, biodiversity and land as a significant resource for sustainable development. Practical application of GIS begins with inventarisation habitats, which includes a variety of procedures, which ultimately results in a single list of all the habitats, distribution of certain plant species in a certain area (municipality, canton or wide area). Inventory of habitat is one of the first and initial steps for all future actions and it is implemented by the relevant phytocenological principles, a detailed list of the distribution and abundance. Often underestimate what it takes to set up a GIS. Unlike office software such as Word, which simply allows you to get started, GIS software is a "semi-prepared". It is necessary to complete and fill out the data could be used. This is because each GIS must be adapted to the specific needs that will be used. Therefore it is necessary to program which data should be able to relate. Then the data is collected and entered into the system. Later this data is updated regularly. Depending on the purpose of GIS, it requires skills and very often, a lot of time. Implementation of GIS should be viewed as a project with clearly defined goals and stages. It is a complex process that can be accomplished only by the principle - step by step. Implementations of GIS include not only the technical aspects. As most often leads to changes in operating procedures, usually requires adjustment of the organizational structure. In certain cases are needed to adapt the legal framework. Finally, the successful implementation of a GIS is often necessary to change the mindset. Any person who makes decisions and who wants start the project of GIS implementation must be aware of the social, organizational and legal changes that accompany the introduction of new technology and, therefore, positively support the process of professional change management.

This paper addresses all the necessary aspects of the application of GIS tools in the case of ordinary blueberries (*Vaccinium myrtillus* L.) and Northern highbush blueberry (*Vaccinium corimbosum* L.).

The main objective of this paper is to determine the habitat distribution of blueberries in Central Bosnia Canton. The next step is to create a map of distribution using GIS tools. Map aims to answer the question "where a habitat for blueberries is and what are the conditions for its distribution and abundance? "i.e. what is the spatial distribution of habitats, which are soil management and pedological aspects (primarily pH, altitude etc.) typical for the habitat of blueberries in Central Bosnia Canton? In the map data is inserted from the field work about distribution of blueberries, then marking the protected areas or specific characteristics, monitoring changes in the habitat over time. Regardless of the actions and habitat mapping techniques and methods of Remote Sensing (preparation and analysis of satellite imagery and aerial photogrammetry) it's always necessary to carry out the field research, and therefore this is an on-going process. For starting position abundance and distribution of blueberries and sustainability of this medicinal plant species, the goal is to establish exactly the maximum annual allowable amount of exploitation "quota" to be the Forest Management Company of Central Bosnia Canton to respect and implement in the general production practice.

Materials and methods

GIS analysis was performed in the software package ArcGIS Desktop, ESRI. Most analyses involving geomorphology, namely relief facilities require the use of digital terrain model (DTM). DTM represents a set of points on the surface of the Earth, whose spatial coordinates x , y , z are stored on the carrier suitable for further computer processing. As such it is defined as a mathematical model of the Earth's physical surface presented discrete sizes, stored on data storage media. To create a DTM have been used vectorized contour lines and elevation points from 1:25,000 scale topographic maps. In this paper we prepare suitability map for the growth and cultivation of ordinary blueberries (*Vaccinium myrtillus L.*) and Northern highbush blueberry (*Vaccinium corimbosum L.*) in Central Bosnia Canton using GIS tools. In this paper as limiting factors for the growth and cultivation of blueberries we considered pH value of the land (source: Basic Soil Map of Bosnia and Herzegovina, 1:50 000) and elevation (source: DTM BiH).

Habitat mapping was carried out as follows:

- *Geographically (the study of specific areas of distribution of ordinary blueberries and Northern highbush blueberry)*
- *Thematically (mapped are only certain types of habitat - habitat blueberries).*
- *Geographical and thematic (mapped are only certain types of habitats in a particular geographic limited area).*

Map the habitats in nature meant identifying and locating habitats. Periodic repetition of the habitat mapping was done for reasons of monitoring changes in habitat.

Before access to mapping and monitoring abundance and distribution of blueberries determine the important parameters:

- Revealed changes that are occurring on the site, in order to be able to assess the level of vulnerability of blueberries (unsustainable exploitation, wrong tools for exploitation, the exploitation and so on).
- Specifies the methods to ensure the value of the data, how to apply the method of habitat mapping.
- Conducted a consultative process (including the names of evaluators to assess the distribution and abundance of blueberries).

Results and discussion

Processes endangering certain plant species, therefore blueberries, natural and anthropogenic factors, and induced changes in the population, are mainly continuous. This continuous process of crossing certain economically important medicinal plants in endangered, rare, risky or protected category in the wider manufacturing practices are seen as more or less empirically. Sustainability of blueberries from natural populations and determining the maximum annual amount allowed for exploitation "quota" was carried out precisely in the two-year studies (2011 and 2012) in the Central Bosnia Canton.

Based on the objective estimates prevalence and abundance of blueberries from natural populations there are maximum annual amount allowed collecting "quotas" in the municipalities of the Central Bosnia Canton. The definition of "quota" estimate is calculated based on net square and fresh biomass in tons (t). In determining the "quota", acknowledge the fact that the specified maximum annual amount will not threaten the viability of the species.

Table 1. Allowable annual collection "quota" blueberry *V. myrtillus*

Blueberry / Municipality	Bugojno, G. Vakuf,	Busova a, Vitez,	Jajce, Dobreti ,	Kreševo Kiseljak N. Travnik	Travnik
Allowable annual exploitation "quota"	tons / quotas	tons / quotas	tons / quotas	tons / quotas	tons / quotas
Blueberry (<i>V. myrtillus</i>)2011	60	0	20	10	40
Blueberry (<i>V. myrtillus</i>) 2012	40	0	15	8	30

Of the total area of Central Bosnia Canton 318 930 ha on area suitable for growing blueberries, taking into account as a limiting criteria elevation we come to an area of 120 317.65 hectares or 37.73%. (Figure 1. and Table 2.).

Table 2. Suitability of growing blueberries in relation to elevation

Altitudes	Suitability for growing blueberries	Area (ha)	Percentage
from 800 to 1000 m	Suitable for growing blueberries	120317,65	37,73
below 800 and over 1200 m	Unsuitable for growing blueberries	198612,35	62,27
Total		318930,00	100,00

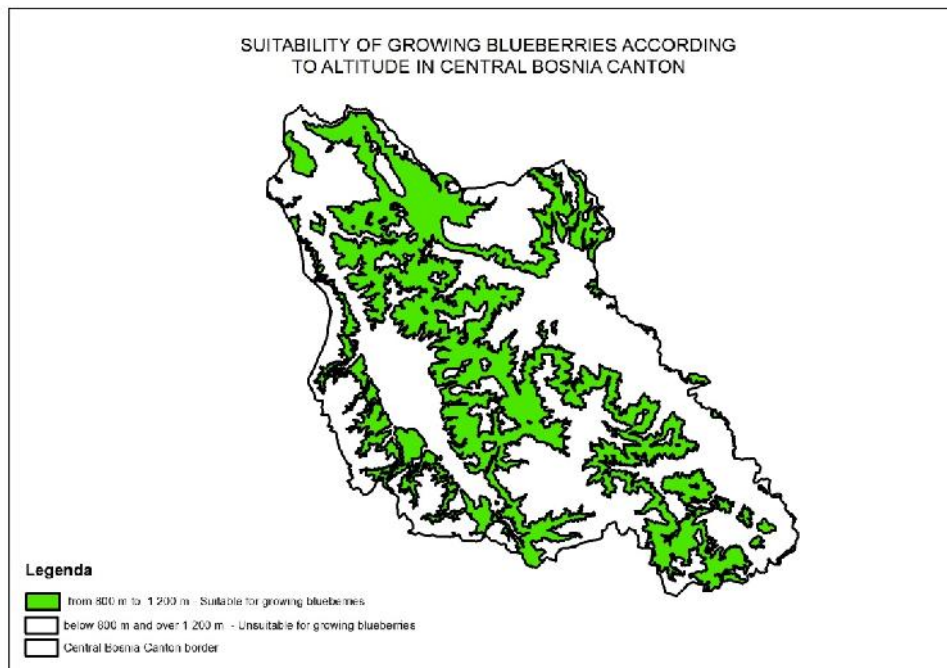


Figure 1. Suitability of growing blueberries according to altitude in Central Bosnia Canton

Taking into account the pH value, as another limiting factor for growing blueberries we come to data on benefits of growing blueberries in an area of 147 136 ha, or 46.13% of the total area of Central Bosnia Canton (Tables 3 and 4 and Figure 2).As a source for obtaining information on soil reaction in H₂O used data from the "Basic Soil Map of Bosnia and Herzegovina of 1:50 000."

Table 3. Suitability of growing blueberries in relation to pH

<i>Soil reaction in H2O</i>	<i>Suitability for growing blueberries</i>	<i>Area (ha)</i>	<i>Percentage</i>
Areas without soil		624,00	0,20
pH less than 4.5	Suitable for growing blueberries	68413,00	21,45
pH 4.5 to 5.5	Suitable for growing blueberries	78723,00	24,68
pH 5,5 to 6,5	Unsuitable for growing blueberries	25778,00	8,08
pH 6,5 to 7,2	Unsuitable for growing blueberries	112436,00	35,25
pH higher than 7.2	Unsuitable for growing blueberries	32956,00	10,33
Total		318930,00	100,00

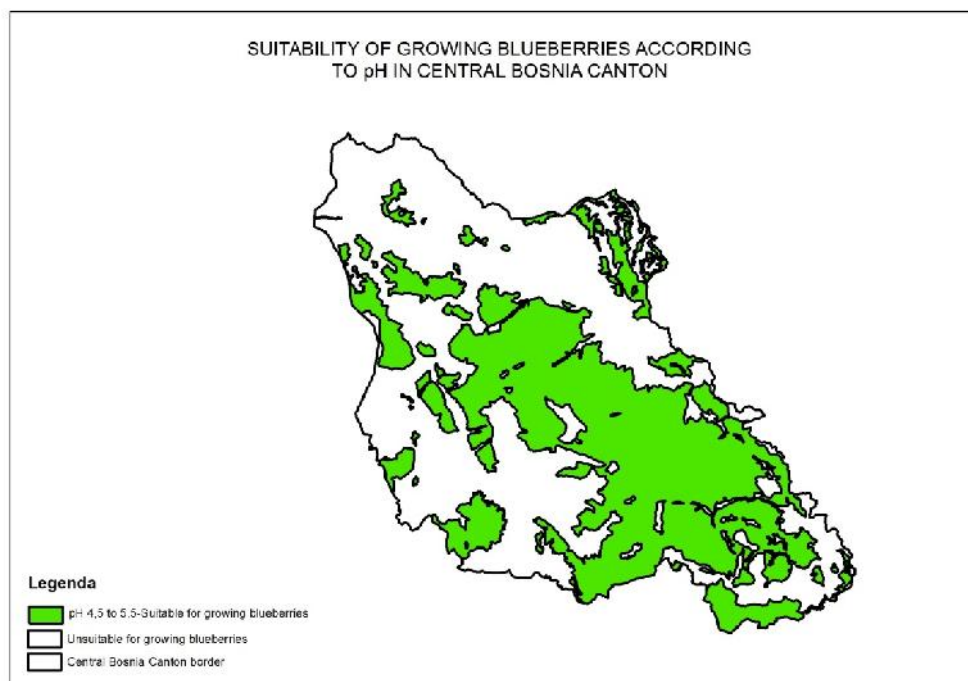


Figure 2. Suitability of growing blueberries according to pH in Central Bosnia Canton

Table 4. Suitability of growing blueberries in relation to pH

<i>Reaction suitable for growing blueberries</i>	<i>Area (ha)</i>	<i>The percentages of the total area of Canton</i>
pH less than 4.5	68413,00	21,45
pH 4,5 to 5,5	78723,00	24,68
Total	147136,00	46,13

By applying tools for the analysis of spatial data available in ArcGIS, and with respect to mentioned limiting factors (altitude and the pH value of the soil), we come the conclusion that the

from total area of Central Bosnia Canton (318,930 ha) only 56.450,00 hectares or 17.70 % of the area suitable for the growth and cultivation of blueberries (Figure 3).

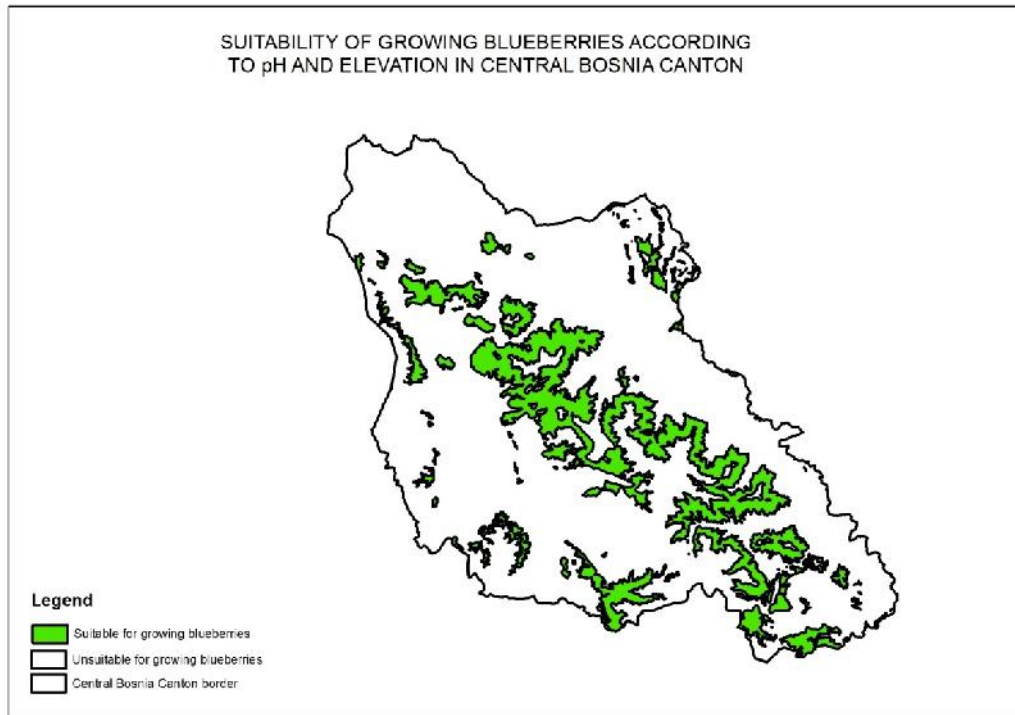


Figure 3. Suitability of growing blueberries according to pH and elevation

Using the method described in this paper Forest Management Company which is responsible for the sustainable management of forest resources in the area of Central Bosnia Canton can make plans for the exploitation of non-wood forest products. From the aspect of agriculture by using this method it is possible to adopt programs and policies for establishing new plantations of Northern highbush blueberry (*Vaccinium corimbosum L.*) with making geographic and alphanumeric databases on individual plantations in a certain area and cadastral parcels. For blueberries from natural populations (*Vaccinium myrtillus*) we highlight areas of distribution according to pH and altitude. The precise study determined the allowed annual exploitation (collection) "quota" to the sustainability of the species.

Conclusion

Based on the two-year study of distribution blueberries (*Vaccinium myrtillis L.*) and the possibility of growing Northern highbush blueberry (*Vaccinium corimbosum L.*), determining the maximum annual amount of exploitation and a number of other issues for the overall MAP (Medicinal and Aromatic Plants) sector, it is necessary to test and enhance the necessary key issues that need to be constantly upgraded (list - inventory, quota system, mapping, training of collectors, the introduction of the best sustainable practices and certification, local brands, etc.).

In the context of exact research can be derived the following conclusions:

- Using the example of blueberries to make mapping and analysis of other habitats of medicinal plants in order to determine the number and distribution, and certainly changes that occur on the site in order to be able to assess the degree of endangerment.
- To use methods for habitat mapping based on maps and aerial images, habitat mapping using grids of point, or by working on permanent plots with suitable equipment.

- For mapping and monitoring of habitat to use digital tools: GPS devices, Internet, GIS, etc. in order to geocode locations, capture additional data, their storage, and analysis of certain plant species, total MAP sector (use of Medicinal and Aromatic Plants).
- According to our research, in the case of blueberries (*Vaccinium myrtillis* L.) and the possibility of growing Northern highbush blueberry (*Vaccinium corimbosum* L.), most effective was digitalization of management of MAP sector, due to the large number and size of existing data it is necessary to use GIS as a tool to support decision-making process and can contribute significantly to the design of administrative and management procedures that are more efficient, transparent and easy to use in a number of activities, therefore in the MAP sector.
- In practical terms, the use of GIS technology contributes to the quality of decision-making with the new capabilities of data analysis, examining the data faster, more efficient communication with municipalities and cantons, handling and analysis of a large number of data, increased efficiency in the public procedures.
- Determining the maximum annual amount of exploitation "quota" in the case of wild blueberries can serve for Forest Management Company of the Central Bosnia Canton (as a model can be unified and to other areas), permitting certain subjects on permitted amounts of collection and inspected to support the sustainability of resources.

Literature

GIS by ESRI Getting Started with ArcGIS™

Agro-Mediterranean Faculty in Mostar (2004) Phytocoenological map of Central Bosnia Canton

Agro-Mediterranean Faculty in Mostar (2009) Inventory of medicinal plants in the FBiH.

Tanovi , N. (2011) Development of herbal sector in FBiH.

Tanovi , N., Sal inovi , A. (2008) Atlas of medicinal plants and mushrooms in BiH.

Behlulovi , D., Sal inovi , A., Tomi , M. (2013) GIS and its role in natural resource management from the aspect of the medicinal plants