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Modeling habitat suitability of *Perilla frutescens* with MaxEnt in Uttarakhand—A conservation approach

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ABSTRACT

Prediction of suitable cultivation regions through modeling has evolved as a useful tool for the assessment of habitat suitability and resource conservation to protect medicinal plants. The population of *Perilla frutescens,* one of the therapeutic traditional crop in the Indian Himalayan region has declined over the past few years. This paper reports on potentially suitable cultivation regions for *Perilla* in Uttarakhand using MaxEnt Modeling.

For modeling procedure 35 occurrence records and 14 Worldclim environmental factors as well as aspect, slope, vegetation and elevation data was used. The result showed that precipitation is the key influential factor that affects the distribution of *Perilla*. The highly suitable cultivation regions of *Perilla* are Dehradun, Tehri Garhwal, Uttarkashi, Rudraprayag and Nainital districts of Uttarakhand, India. The statistically significant AUC (area under curve) value (0.915) of ROC (receiver operating characteristic) curve indicated that MaxEnt could be used to predict the potentially suitable cultivation regions of medicinal plants, and the results could pave way for habitat conservation and resource utilization of rare and endangered medicinal plants.

1. Introduction

For decades researchers have focused on plant-environment interactions and their impact on growth of the plants (Elith and Leathwick, 2009; Scheper et al., 2013; Fortunel et al., 2014) that clearly revealed that environmental factors such as temperature, precipitation, humidity and soil not only affect the distribution of medicinal plants but also play an essential role in the formation of their active ingredients (Jochum et al., 2007). Globalization of herbal medicine along with uncontrolled exploitative practices and lack of intensive conservation efforts have pushed many of the medicinal plants to the verge of extinction. Habitat restoration and cultivation would prove to be one of the pragmatic ecological measures for rehabilitation and conservation of medicinal plants. It is essential that the plants are cultivated in appropriate cultivation regions. Merely, growing plants anywhere would only lead to the exploitation of some important medicinal plant species (Barnosky et al., 2011). Therefore, it is imperative to make use of ecological modeling to know the suitable habitat distribution and the environmental factors decisive for both habitat distribution and enhanced formation of active ingredients in medicinal plants.

With the development of statistical modeling and geographic information system (GIS), ecological theories and GIS technique have been widely used in the field of ecology, conservation and utilization (Guisan and Zimmermann, 2000; Warren et al., 2008; Brito et al., 2009). The association among species records at sites and the environmental features of those places are being assessed by species distribution models (SDMs) (Franklin, 2009). The species records are available through field surveys, herbarium and museum databases. The databases utilized by SDMs includes bioclimatic variable, domain, generalized linear model (GLM), multivariate adaptive regression splines (MARS), genetic algorithm for rule-set production (GARP), maximum entropy (MaxEnt) and boosted regression trees.

MaxEnt is relatively a standard model for precisely predicting species distribution (Phillips et al., 2006), that works on the principle of estimating the probability distribution, such as the spatial distribution of a species that is most spread out subject to constraints such as the known observations of the species. MaxEnt uses entropy as the means to generalize specific observations of the presence of a species and does not require or even incorporate absence points within the theoretical framework. Presence points are the global positioning system (GPS) locations of the species and the absence points of a species is not usually recorded. Some of the salient features of MaxEnt model are: it requires presence data only, can use continuous and categorical data both, efficient deterministic algorithms. Further, its output is continuous,

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Fig. 1. Habit of *Perilla frutescens.*

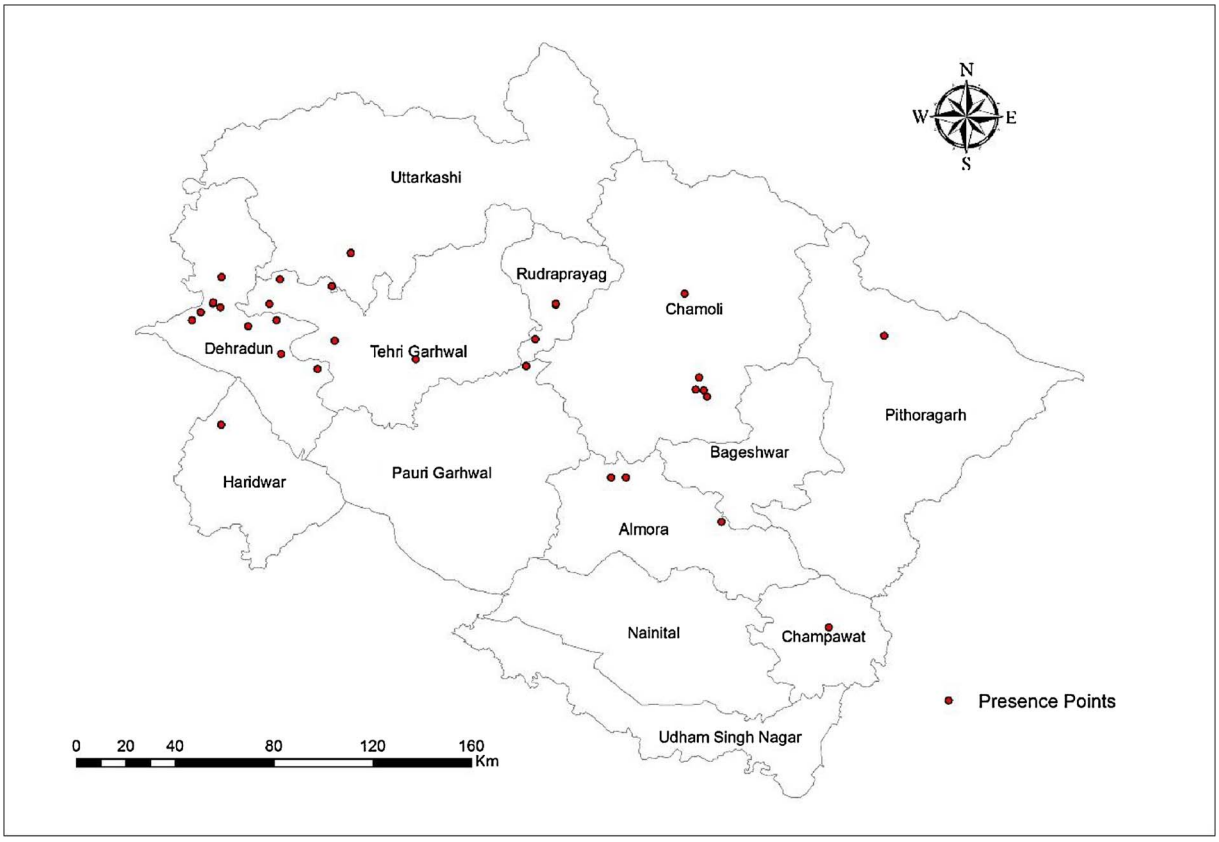

Fig. 2. Presence points of *Perilla frutescens* recorded.

generative approach and works well with limited data as well.

Perilla frutescens, commonly known as Bhanjira, is an annual herb of the family Lamiaceae and a traditional crop of Uttarakhand (Fig. 1). The plant is sporadically cultivated in the Garhwal and Kumaon region of Uttarakhand. The seeds of the plant are used by the local people for making sauce (chutney) and leaves for garnishing. The plant got recognition because of its aromatic and medicinal value. *Perilla* seeds contain saturated (SFAs) and unsaturated (USFAs) fatty acids and is rich in ω-3 fatty acids. Thus, the plant has therapeutic and culinary applications. It is used for curing cold, asthma, abdominal pain, influenza and cancer (Nitta et al., 2003).

With the advancement in cropping system (farming of traditional crops to cash crops), the plant is losing its fate, as the natural distribution of *Perilla* has also been altered and decreased. With the aim of finding new approaches for the habitat conservation and resource utilization of medicinal plants, *Perilla frutescens* was chosen as a representative model species in this study (Fig. 1). The study was structured based on following objectives:

1. Habitat and niche characterization based on field-based studies
2. Identifying the landscape scale environmental correlates through niche model-based study
3. Predicting or identifying the suitable areas for its cultivation and conservation through model-based projections.

2. Material and methods

2.1. Species occurrence data

Sites bearing *Perilla frutescens* were identified using random field surveys at different localities of Uttarakhand. Plant samples were collected and herbarium was prepared and submitted to Botanical Survey of India (BSI), Northern Circle, Dehradun, Uttarakhand for identification and validation. A total of 35 sites having *Perilla* populations were