Acta Oecologica 85 (2017) 141–149

Contents lists available at ScienceDirect

Acta Oecologica

journal homepage: www.elsevier.com/locate/actoec

Modeling impacts of human footprint and soil variability on the potential distribution of invasive plant species in different biomes

Ji-Zhong Wan[a,b], Chun-Jing Wang[b], Fei-Hai Yu[a,*]

[a] Zhejiang Provincial Key Laboratory of Plant Evolutionary Ecology and Conservation, Taizhou University, Taizhou 318000, Zhejiang Province, China
[b] School of Nature Conservation, Beijing Forestry University, Beijing 100083, China

ARTICLE INFO

Keywords:
Alien invasive plant
Biome
China
Human influence
Species distribution modeling
Soil variables

ABSTRACT

Human footprint and soil variability may be important in shaping the spread of invasive plant species (IPS). However, until now, there is little knowledge on how human footprint and soil variability affect the potential distribution of IPS in different biomes. We used Maxent modeling to project the potential distribution of 29 IPS with wide distributions and long introduction histories in China based on various combinations of climatic correlates, soil characteristics and human footprint. Then, we evaluated the relative importance of each type of environmental variables (climate, soil and human footprint) as well as the difference in range and similarity of the potential distribution of IPS between different biomes. Human footprint and soil variables contributed to the prediction of the potential distribution of IPS, and different types of biomes had varying responses and degrees of impacts from the tested variables. Human footprint and soil variability had the highest tendency to increase the potential distribution of IPS in Montane Grasslands and Shrublands. We propose to integrate the assessment in impacts of human footprint and soil variability on the potential distribution of IPS in different biomes into the prevention and control of plant invasion.

1. Introduction

Plant invasion is a large threat to global biodiversity (Gurevitch and Padilla, 2004; Hejda et al., 2009; Vilà et al., 2011; Bellard et al., 2013). Invasive plant species (IPS) can invade their non-native ranges, and decrease the habitable space of native plant species (Hejda et al., 2009; Vilà et al., 2011; Pyšek et al., 2012). Invasion biologists have conventionally developed some risk assessment tools such as species distribution models (SDMs) to evaluate the invasion risk of IPS based on significant abiotic and biotic factors influencing the potential distribution of IPS (Thuiller et al., 2005; Foxcroft et al., 2010; Xu and Qiang, 2011; Spear et al., 2013; Donoghue and Edwards, 2014; Ray et al., 2016). Human footprint is the combination of human activities that affect the nature directly or indirectly (Gallardo et al., 2014). It is an environmental variable that may contribute to the distribution of IPS by increasing reproductive opportunities through gardening, forestry and transportation in new areas (Beans et al., 2012; Donaldson et al., 2014; Gallardo et al., 2014). Furthermore, soil factors may also play an important role in the spread of IPS. For instance, the spread of IPS occurs more frequently than expected and causes greater damage in the soil conditions of high resource biomes such as tropical and sub-tropical grasslands and forests (Foxcroft et al., 2010; Donoghue and Edwards, 2014; Joshi et al., 2015; Ray et al., 2016).

A biome is a large community of plant and faunal species that have common characteristics due to similar conditions (i.e. climate), and usually found at a large geographical scale (Olson et al., 2001). Different biomes may provide habitats that favor the expansion of IPS at varying degrees (Thuiller et al., 2005; Petitpierre et al., 2012; Faulkner et al., 2014; Wan et al., 2016; Wang et al., 2017). Some studies have developed the model-based methods to evaluate the potential distribution of IPS in the invaded regions based on different biomes worldwide (e.g. Thuiller et al., 2005; Bellard et al., 2013; Donoghue and Edwards, 2014; Wan et al., 2017). For instance, biological conservationists have developed valuable biosecurity tools for the invasion of IPS based on the potential distributions and biomes using SDMs (Donaldson et al., 2014; Faulkner et al., 2014). However, these studies may misestimate the potential distribution of IPS in the invaded ranges by using only climatic variables. This is because climate alone cannot thoroughly explain the potential distribution of IPS in the invaded ranges (Beans et al., 2012; Bellard et al., 2013; Merow et al., 2013; Radosavljevic and Anderson, 2014), and other environmental variables such as human footprint and soil characteristics may also play an important role (Beans et al., 2012; Zhang et al., 2014). Furthermore, strategies for preventing and controlling IPS may be derived from the

* Corresponding author.
E-mail address: feihaiyu@126.com (F.-H. Yu).

http://dx.doi.org/10.1016/j.actao.2017.10.008
Received 8 September 2016; Received in revised form 6 October 2017; Accepted 17 October 2017

relationships between human footprint, soil characteristics and the distribution of IPS in different biomes (Thuiller et al., 2005; Keeley, 2006; Faulkner et al., 2014). Hence, an understanding of effects of such variables on the potential distribution of IPS in different biomes is important, but still poorly explored. We hypothesize that human footprint and soil variability have varying degrees of impacts on the potential distribution of IPS among different biomes.

To explore the relationships among human footprint, soil variability, biomes and the distribution of IPS, we modeled the distribution of different IPS that are widely distributed and also have long introduction histories in China. Specifically, we addressed the following questions: 1) Can combined human footprint and soil variables have large contribution to the potential distribution of IPS? 2) Are there any differences in the impacts of human footprint and soil variables on the potential distribution of IPS among various biomes?

2. Materials and methods

2.1. Study area

The study region was the mainland China, which has a total land area of 9.6×10^6 km^2 with higher altitudes in the west compared to the eastern regions. Mountains, plateaus and hills cover about 67% of the land area, while basins and plains make up around 33%. Climatic conditions in the mainland are mainly continental monsoons, and vary considerably (Domrös and Peng, 2012). There are seven main biomes, including grasslands, shrublands and forests (Fig. 1; Olson et al., 2001). The maps of the biomes used were downloaded from www.worldwildlife.org.

2.2. Species data

A total of 29 IPS with wide distributions in China were used based on Xu and Qiang (2011). We chose these species based on the following criteria: 1) the species should have had severely invaded mainland China; 2) there were more than 50 occurrence records in invaded regions (i.e. China) to ensure the reliability of logistic SDM, and 3) they should have been introduced to China for more than 100 years (Xu and Qiang, 2011). Thus, the IPS could reach the full invaded ranges (i.e. China) as far as possible. Some IPS have no enough occurrence records in native ranges (the detailed information in Table S1). The occurrence records, especially specimens or recorded sightings, of the 29 IPS were compiled in both native and invaded ranges from a variety of online databases, including Global Biodiversity Information Facility (GBIF; www.gbif.org) and Chinese Virtual Herbarium (CVH; www.cvh.org.cn). We minimized the sample bias of the species occurrence data as follow: all occurrence localities were checked using ArcGlobe 10.2 and ArcGIS 10.2 (Esri; Redlands, CA, USA) to determine whether they were distributed in reasonable ranges based on Xu and Qiang (2011) and the ISSG (Invasive Species Specialist Group; www.issg.org) and obvious errors were removed.

2.3. Environmental variables

Environmental variables such as climate, elevation, soil and human footprint were included as input of SDM (Table S2). Data on the 19 bio-climatic variables and elevation at a 2.5-arc-minute spatial resolution (4.3 km at the equator) were downloaded from the WorldClim database (Hijmans et al., 2005; Table S2). A collinearity test was done among the 19 bio-climatic variables based on Pearson's correlation coefficient to eliminate highly correlated variables from the final modeling procedure (Dormann et al., 2013). We excluded the variables with a cross-correlation coefficient value of > 0.75 or < -0.75 (Zhang et al., 2014; Park and Potter, 2015; Table S3). In this way, we selected finally only six out of the 19 bio-climatic variables. These six bio-climatic variables were related to the potential distribution of Chinese plant species (Zhang et al., 2016). Elevation data were also used because elevation was suggested as an important predictor variable in SDM (Hof et al., 2012). Data on nine soil variables at the 0.5-arc-minute spatial resolution were downloaded from SoilGrids1km (http://soilgrids.org/; detailed information in Table S2). Data of human footprint at the 0.5-arc-minute spatial resolution (1 km at the equator) were obtained from The Global Human Footprint Dataset of the Last of the Wild Project, Version 2, 2005 (LWP-2; HFD; http://sedac.ciesin.columbia.edu/

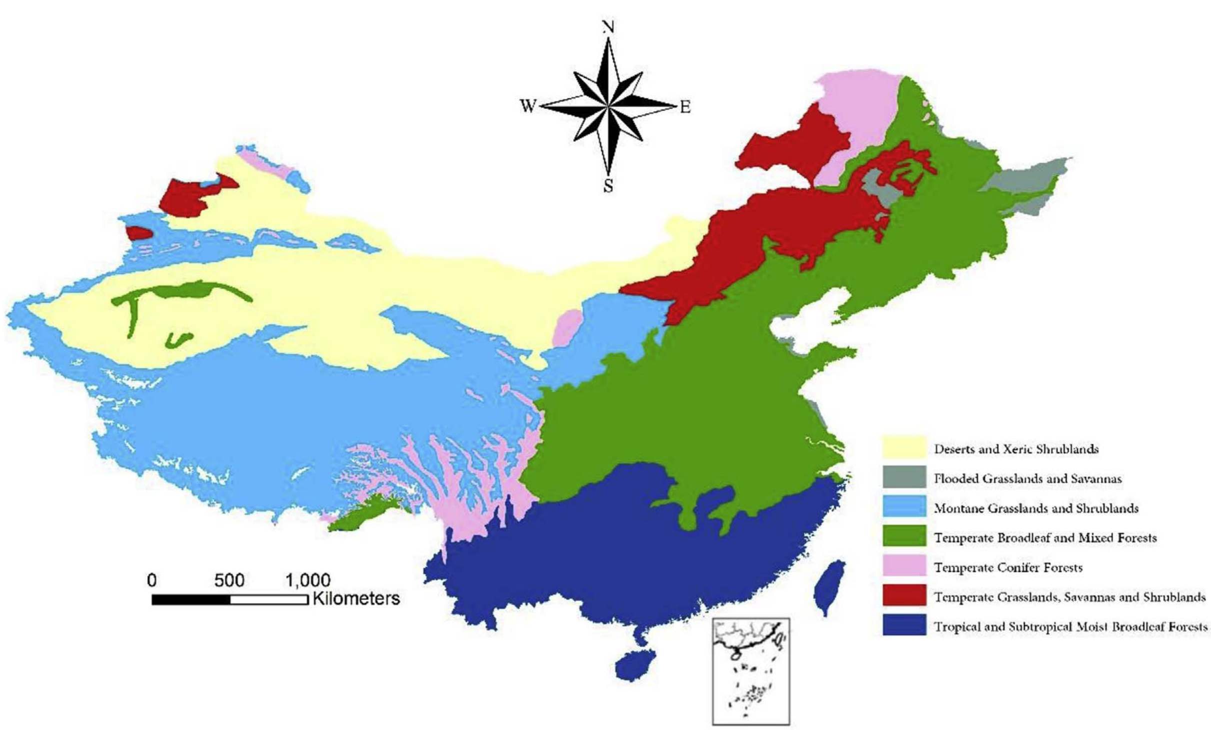

Fig. 1. The study biomes in China (Olson et al., 2001).