Acta Ecologica Sinica 35 (2015) 59–64

Contents lists available at ScienceDirect

Acta Ecologica Sinica

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

Test the relative importance of biotic and abiotic factors on species distribution – A case study in the Yellow River Delta

Song Chuangye [a], Ren Hongxu [a], Huang Chong [b,*]

[a] State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing 100093, China
[b] State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Nature Resources Research, Chinese Academy of Sciences, Beijing 100101, China

ARTICLE INFO

Article history:
Received 16 June 2014
Revised 3 March 2015
Accepted 1 April 2015
Available online

Keywords:
Yellow River Delta
Receiver operating characteristic curve
Biotic interaction
Explained deviances

ABSTRACT

In researches of species distribution model, there are still controversies about the role of biotic and abiotic factors at large spatial scale. To better understand factors controlling species distribution pattern, in this research, we tested: (1) whether incorporating co-occurring species as biotic factors could improve the performance species distribution model; (2) which factor is more important: biotic or abiotic; (3) whether biotic factors are independent of abiotic factors. We fitted generalized additive models for 6 target species by using three different sets of predictive variables: abiotic (ABIOT), biotic (BIOT), and the combination of both sets (FULL). Soil salt content, soil organic matter content and altitude were used as abiotic factors, and the coverage of the co-occurring species was used as biotic factors. Models were evaluated using two approaches: (1) explained deviance (D^2); (2) five-fold cross-validation of receiver operating characteristic curve (ROC). Contribution of each predictive variable was assessed by calculating the average change in residual deviance when dropping each predictive variable from the final fitted regression model. To test the relative importance of biotic and abiotic factors, we used variance partitioning to estimate the proportions of the variance explained by biotic and abiotic factors, jointly and independently. The result showed that: (1) the D^2 and AUC of FULL model were significantly higher than ABIOT and BIOT models, and this indicated that the explanatory and predictive power of the fitted generalized additive model was greatly improved by including co-occurring species as biotic factors; (2) dropping biotic factors from the fitted model caused obvious change in residual deviance, especially the dominant species (this implied that biotic factors have important influences on species distribution, and dominant species exert more influences on species distribution than companion species); (3) variance partitioning found that the joint contribution of biotic and abiotic factors to the explained deviance was relatively small (1~4%), compared with the individual contribution of abiotic and biotic factors set (9–19%, 15–28% respectively). This proved that biotic factors were largely independent of abiotic factors.

1. Introduction

Species distribution models (SDMs) relate present species distribution records to predictive variables to assess factors that potentially control and predict species distribution [1–4]. In early studies, abiotic factors (such as climate, topography, soil and so on) were used as predictive variables to project species distribution [5–8]. However, it was often questioned for biotic interactions were not taken into account within those models [9–12]. This is because biotic interactions (such as competition, mutualism, amensalism or commensalism) also have important implications for predicting species distribution [12–14]. Excluding the direct effects of biotic interactions on species distributions might lead to the low explanatory and predictive power of SDMs [15].

Many researches have proven that biotic interactions have certain influences on species distributions. However, the relative importance of abiotic and biotic factors remains unclear [12]. There still existed a variety of opinions on the relative importance of abiotic and biotic factors. Some argued that biotic factors play a minor role in determining the species distribution patterns at macro ecological scale [16–18]. Others expect them to be significant at local to regional scale [13,14,19–24]. However, some others held the view that species distribution patterns are strongly influenced by biotic interactions at macro ecological scale [25–29]. Therefore, more researches needed to test the relative importance of biotic and abiotic factors.

As biotic factors have certain influences on species distribution, it is necessary to incorporate them into SDMs. The next issue is how to incorporate biotic interactions into the SDMs. Because biotic interactions are very complex, it is difficult to quantify and

* Corresponding author. State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Nature Resources Research, Chinese Academy of Sciences, Beijing 100101, China. Tel.: + 01062836633; fax: + 01062836633.
E-mail address: huanchongigsnrr@gmail.com (H. Chong).

http://dx.doi.org/10.1016/j.chnaes.2015.04.007
1872-2032/

incorporate them into SDMs. Nowadays, the popular approach is "using the co-occurring species of the target species as biotic factors in the SDMs" [30,31]. Some studies proved the effects of this approach [12,30,32]. However, some studies insisted that the inclusion of co-occurring species may not represent biotic interactions. Instead, it may reflect unmeasured or incompletely measured environmental deviance, especially the micro-environment which cannot be captured at a large scale [12,33,34]. It remains a controversial topic until now.

To better understand factors controlling species distribution pattern and improve the performance of SDMs, more researches are required to investigate the role of biotic and abiotic factors in determining species distribution patterns. In this research, we mainly focus on three issues: (1) Could the inclusion of co-occurring species as biotic factors alongside abiotic factors improve the performance of SDMs; (2) What is the relative importance of abiotic and biotic predictors; (3) Is the contribution of biotic factors independent of abiotic factors? We expected that our research could provide some references for the prediction of species distribution.

2. Materials and methods

2.1. Study area

The Yellow River Delta (36°55′–38°12′N, 118°07′–119°18′E) was selected as study area. It is located in the Shandong Province of Eastern China, on the south side of the Bohai Sea (Fig. 1). The region is characterized by a temperate, semi-humid continental monsoon climate. The mean annual temperature ranges from 11.5 °C to 12.5 °C, with the warmest monthly temperature of 26.7 °C in July and the coldest of 4.2 °C in January. The mean annual precipitation is 590.9 mm and the mean annual evaporation is 1500 mm. The maximum monthly rainfall is 227 mm in July and the minimum is 1.7 mm in January. The entire area is mainly covered by wet and saline soil. Meadow, especially the halophytic meadow, dominated by Chinese tamarisk (*Tamarix chinensis* Lour.), Seepweed (*Suaeda salsa* (Linn.) Pall.) and reed (*Phragmites australis* (Cavanilles) Trinius ex Steudel), is the typical vegetation in this area.

2.2. Vegetation survey

Part of the vegetation survey data was collected in July and August of 2010 and 2011 by our research group. As the Yellow River Delta is a wetland ecosystem and many regions are covered by water, we set vegetation quadrats along the road and kept them at least 100 m away from the road. A total of 436 quadrats records were collected. The size of a quadrat is 4 m^2 (2 m × 2 m). Variables recorded include height and coverage of all herbal and shrub plants. The coverage was recorded with visual estimation, and geographical coordinates of quadrats were recorded by using a GPS. Among those 436 quadrats, 36 plant species were recorded in total, and the occurrence frequency of each species was calculated. Six species (*Limonium bicolor*, *Aeluropus sinensis*, *Imperata cylindrical*, *T. chinensis*, *S. salsa*, *P. australis*) with high occurrence frequency (>10%) were

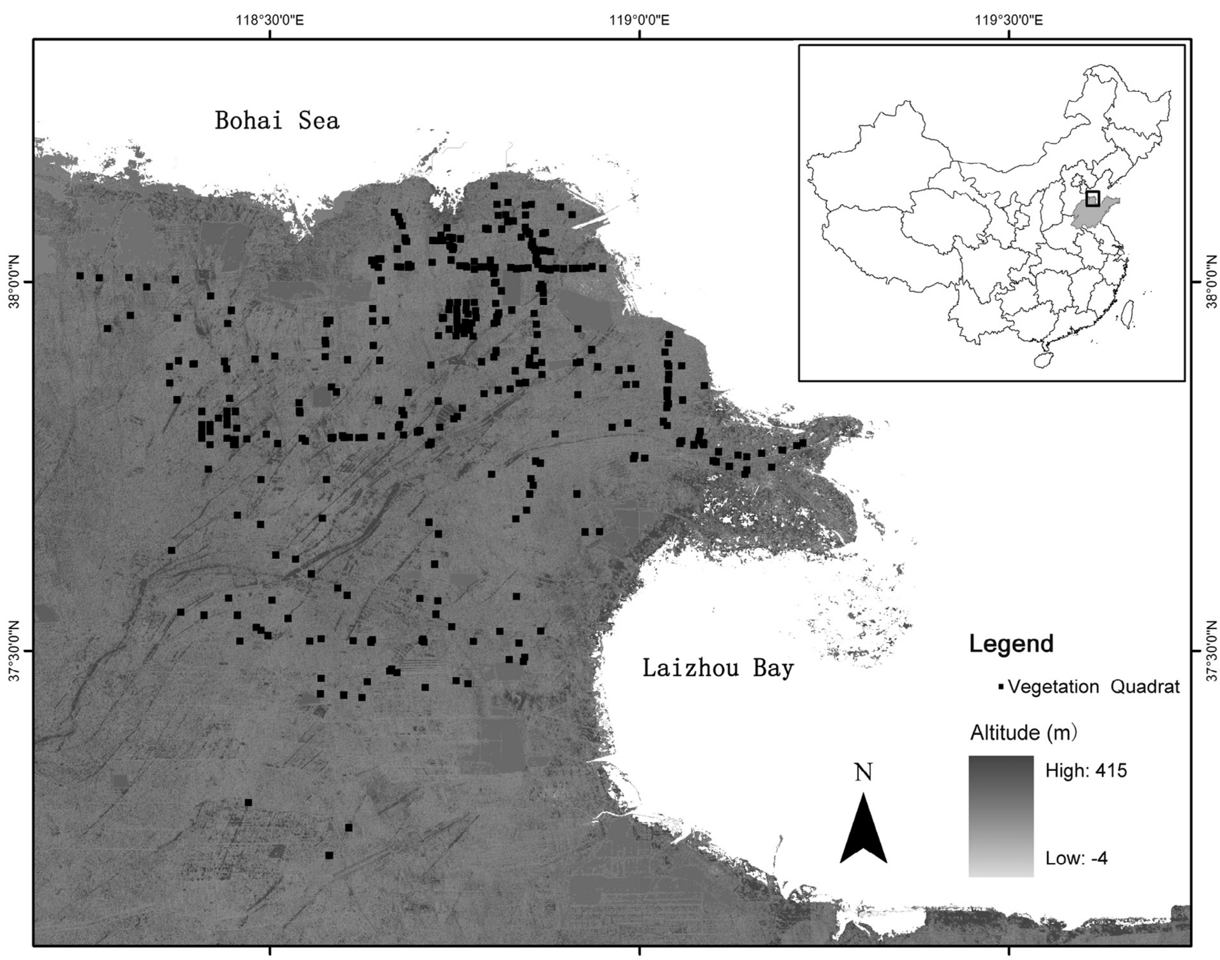

Fig. 1. The location of Yellow River Delta and vegetation quadrats.