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Effects of introduced species on floristic similarity: Comparing two US states

Hong Qian[a,*], Michael L. McKinney[b], Ingolf Kühn[c]

[a]*Research and Collections Center, Illinois State Museum, 1011 East Ash Street, Springfield, IL 62703, USA*
[b]*Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN 37996, USA*
[c]*Department Community Ecology (BZF), Helmholtz Centre for Environmental Research – UFZ, Theodor-Lieser-Straße 4, 06120 Halle, Germany*

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Abstract

This study aims to examine the effects of introduced species on increasing (homogenizing) or decreasing (differentiating) floristic similarity of plant composition. We calculated the Jaccard index for each pair of counties within two states of USA, California and Florida. We computed the Jaccard index separately for all (native plus exotic) species, for native species, and for exotic species. We further calculated a homogenization index between all species and native species for each pair of counties by subtracting similarity index for native species from that for all species. We correlated the Jaccard and homogenization indices to geographic distance, latitude separation, and longitude separation between pairs of counties and to average human population density and average land area of the two counties. We find a very strong pattern of differentiation for introduced species among nearly all Florida counties. In California, introduced species have a differentiating effect in about half the comparisons. We also find that introduced species tend to have a more homogenizing (or less differentiating) effect with increasing distances between counties. Our results do not show a clear relationship between human population density and the homogenization index.

Zusammenfassung

Das Ziel der vorliegenden Untersuchung ist eine Analyse der Effekte gebietsfremder Arten auf eine zunehmende (d.h. homogenisierende) oder abnehmende (d.h. differenzierende) floristische Ähnlichkeit der Pflanzenartenzusammensetzung. Wir haben den Jaccard-Ähnlichkeitsindex zwischen jedem Paar unterschiedlicher 'counties' (Landkreise) jeweils innerhalb zweier US-Staaten berechnet, nämlich Kalifornien und Florida. Weiterhin haben wir einen "Homogenisierungsindex" zwischen allen und nur den heimischen Pflanzenarten für jedes Paar counties berechnet indem wir den Jaccard-Index der einheimischen von dem aller (einheimischer + gebietsfremder) Arten abgezogen haben. Wir haben den Jaccard-Index und den Homogenisierungsindex mit der geographischen Distanz, der Entfernung über Länge bzw. Breite zwischen dem Mittelpunkt zweier counties sowie der mittleren Bevölkerungsdichte und mittleren Flächengröße der beiden counties korreliert. Wir haben eine deutliche Differenzierung durch die gebietsfremden Arten zwischen fast allen counties in Florida gefunden. In Kalifornien haben die gebietsfremden Arten

*Corresponding author. Tel.: +1 217 7822621; fax: +1 217 7852857.
E-mail address: hqian@museum.state.il.us (H. Qian).

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einen differenzierenden Effekt in ungefähr der Hälfte der Vergleiche. Außerdem haben wir festgestellt, dass gebietsfremde Arten mit zunehmender geographischer Distanz eher eine stärker differenzierende (bzw. weniger homogenisierende) Wirkung zwischen den counties haben. Wir konnten keinen deutlichen Zusammenhang zwischen mittlerer Bevölkerungsdichte und dem Homogenisierungsindex nachweisen.

Keywords: Biological invasions; Biotic differentiation; Biotic homogenization; California; Exotic species; Flora; Florida; Introduced species; Plants

Introduction

The introduction of exotic species into geographical regions where they were historically absent has become a rapidly growing area of investigation (e.g. Guo, Qian, Ricklefs, & Xi, 2006; Kühn, May, Brandl, & Klotz, 2003; McKinney, 2004a, 2004b; Olden, 2006; Rahel, 2000). Once established, many exotic species expand their geographical ranges within the region of introduction, causing an increase in biotic similarity among different areas, a process called biotic homogenization (McKinney, 2004a; Rooney, Wiegmann, Rogers, & Waller, 2004). However, exotic species may also have the opposite effect – biotic differentiation (Olden & Poff, 2003), which would lead to a decrease of biotic similarity among different areas. Homogenization tends to occur where the same introduced species become established in many areas, whereas differentiation tends to occur where different suites of introduced species become established in different areas (Olden & Poff, 2003).

A great number of plant species have been introduced into North America. At a continental scale, 17.4% of the vascular plant species in North America north of Mexico are exotic (Qian & Ricklefs, 2006). At a smaller scale, the proportion of exotic plant species may be much higher. For example, 27% and 32% of the vascular plant species in Illinois (Mohlenbrock, 2002) and Florida (this study), respectively, are exotic. In areas at a further smaller scale such as in Delta Meadows River Park, California, over 50% of the flora can be exotic species (Bowcutt, 1996). Although there are numerous studies examining the effect of exotic species on community similarity, our knowledge of this field remains poor.

In this study, we examine the influence of exotic species on floristic similarity among counties in California and Florida. We chose these two states of the USA as our study areas for two reasons. First, these two states have the largest numbers of exotic plant species in North America (>1000 for each) and are among the states in North America whose county-level floras are well studied and documented (references below). Second, these two states take two different extremes in topographic heterogeneity – very homogeneous in Florida with elevations ranging from 0 to 105 m and very heterogeneous in California with elevations ranging from 0 to 4418 m. Since topographic heterogeneity can influence dispersal of species and hence biotic similarity among localities, the two states provide opportunities to examine the effect of exotic species on floristic similarity in areas with different topographic heterogeneities (e.g. fairly flat vs. highly rugged). Specifically, we wished to determine whether exotic species increased or decreased floristic similarities between counties within each state, how similar the rate of species turnover (i.e. beta diversity) between counties is between exotic and native floras and between the two states for the same type of plant community (i.e. exotic versus native), and whether human population density influenced floristic similarity.

Materials and methods

California is located on the west coast of the USA and it has 58 counties and 403,970 km^2 of land between 32°30′–42°N and 114°8′–124°24′W. Florida is located on the east coast of the USA, and it has 67 counties and 139,852 km^2 of land between 24°30′–31°N and 79°48′–87°38′W.

We obtained species checklists of vascular plants in each county, and native or exotic status of each species in each state from the CalFlora database (http://www.calflora.org) for California and from the Atlas of Florida Vascular Plants database (http://www.plantatlas.usf.edu/) for Florida. A species is considered exotic in a county if it is a non-native species to the state of the county. Distributions of varieties and subspecies were lumped with those of their parent species.

With 58 counties in California and 67 counties in Florida, the numbers of possible pairs of counties are 1653 for California and 2211 for Florida. For each pair of counties within a state, we calculated the Jaccard index of similarity (Legendre & Legendre, 1998): $J = a/(a+b+c)$, where J ranges from 0 (no similarity) to 1 (100% similarity), a is the number of species common to both counties, b is the number of species restricted to one county, and c is the number of species restricted to the other county. We calculated the Jaccard index separately for native species (J_{native}), for exotic species (J_{exotic}), and for native and exotic species (J_{total}).