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Letter to the editor Open Access

Does high vegetation coverage equal high giant panda density?

DEAR EDITOR,

The giant panda (*Ailuropoda melanoleuca*) is a unique forest-dwelling species endemic to China. Previous studies have suggested that giant pandas are heavily reliant on old-growth forests with high vegetation coverage. As such, management has primarily focused on improving vegetation coverage in the potential range of giant pandas to increase the availability of suitable habitat. However, it remains unclear whether high vegetation coverage itself results in higher giant panda density. Here, we analyzed changes in vegetation coverage from 2001 to 2011 as well as the occurrence of wild giant pandas in five mountain areas. Results showed that the proportion of high vegetation coverage has increased across the regions. However, contrary to the prevailing view, for regions with high-risk subpopulations (n<15 individuals), those with a high proportion of vegetation coverage also had some of the lowest panda densities. Thus, to promote population growth and conservation, additional research is needed to re-evaluate the hypothesis that giant pandas rely on dense vegetation.

Giant pandas mainly occur in dense forests, with bamboo understories providing their primary food (Lai et al., 2020). Loss of these habitats due to anthropogenic disturbance (e.g., livestock grazing, logging, road construction) and natural factors (e.g., earthquakes, mudslides) (State Forestry Administration, 2015) is a significant threat to the species (Wei et al., 2018a). The Chinese government has initiated a series of measures to promote the protection of giant panda habitat, including the development of nature reserves and the implementation of various projects, e.g., Grain-to-Green Program and Natural Forest Conversion Program. These conservation actions aim to prevent further shrinkage of panda habitat, accelerate the restoration of vegetation, and increase the number of pandas (Li et al., 2021). Plant growth also has an important impact on the seasonal activity of pandas by moderating local microclimate factors (Tuanmu et al., 2013), such as temperature and humidity (Boone et al., 2006). Giant pandas tend to migrate to lower altitudes in winter and to higher altitudes in summer to maintain an optimum temperature (Zhang & Hu, 2000). In addition to seasonal movement, during the breeding season, pandas tend to choose warmer and drier breeding dens as protection against adverse weather (Wei et al., 2019). Thus, panda survival and reproduction are closely related to the climatic conditions of their habitats.

Vegetation is often used to estimate habitat suitability and vegetation preference of giant pandas (Qi et al., 2012). Studies have shown that giant pandas tend to prefer primary forests with mixed coniferous and broad-leaved assemblages (Zhang & Hu, 2000). However, with the dramatic increase in human disturbance over the past several decades, many pandas have had to rely on secondary forests (Wei et al., 2018b) or even sparse forests where bamboo still grows well enough to support their daily requirements (Hull et al., 2016). Complicating the long-term conservation of giant pandas is the potential impact of climate change on their already disturbed habitats. Dynamic changes in habitat suitability under various climate scenarios suggest several likely challenges, including bamboo shortages, additional habitat loss, and population dispersal (Zang et al., 2020). However, whether high vegetation coverage and local climate factors support dense populations of giant pandas is uncertain.

To verify whether areas with high vegetation coverage contain relatively high densities of giant pandas, we studied five mountain regions (Minshan Mountains: MS; Qionglaishan Mountains: QLS; Daxiangling Mountains: DXL; Xiaoxiangling Mountain: XXL; Liangshan Mountains: LS; E101°51′–105°27′, N28°12′–33°34′) within the distribution range of giant pandas (total area 2 027.2 million km^2) (Figure 1A), together with panda occurrence data, climate data (precipitation and temperature), and vegetation coverage data. Information on

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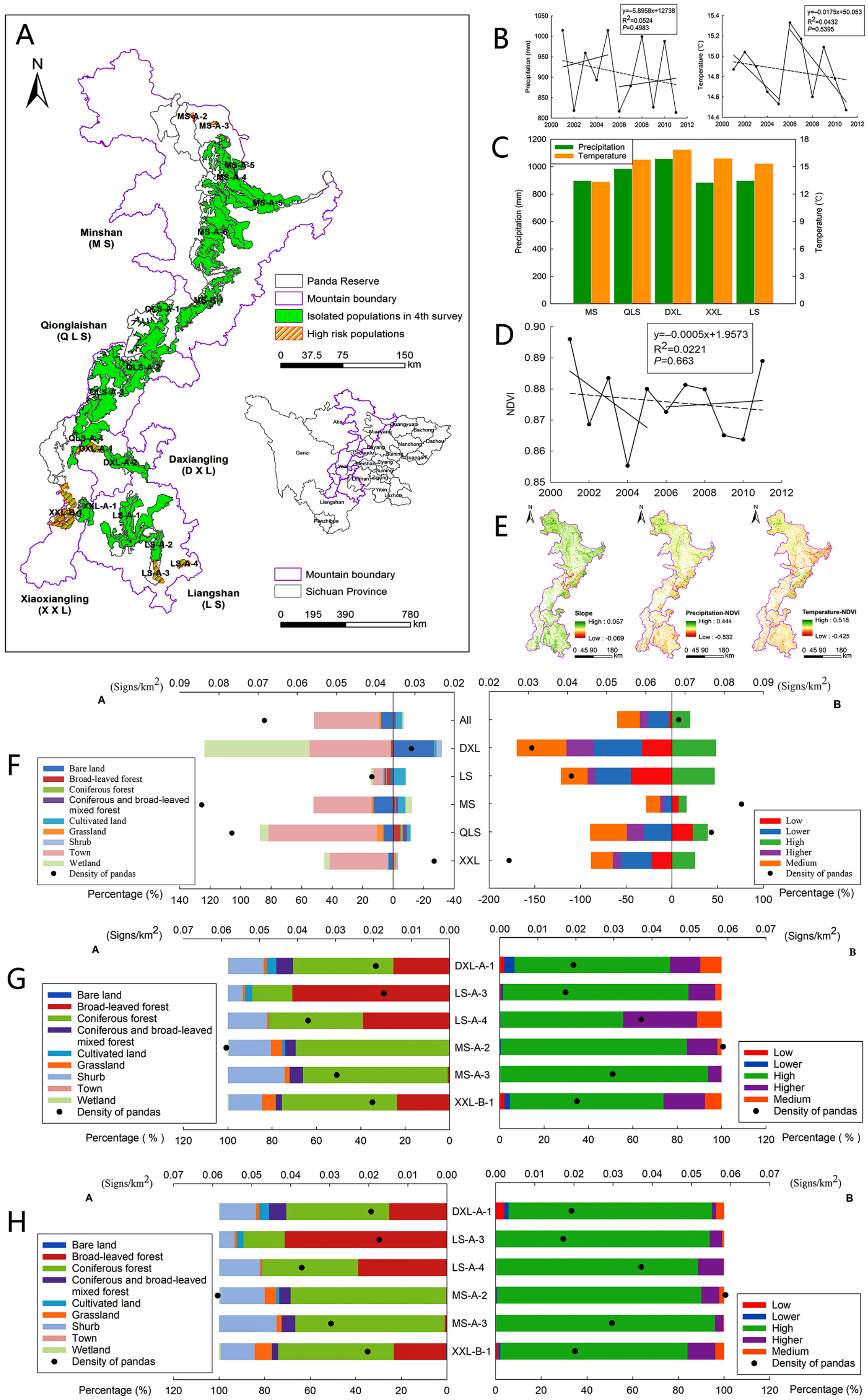
A
N
MS-A-2
MS-A-3
MS-A-5
MS-A-4
MS-A-1
MS-A-6
Minshan
(M S)
Panda Reserve
Mountain boundary
Isolated populations in 4th survey
High risk populations
0 37.5 75 150
km
Qionglaishan
(Q L S)
QLS-A-1
QLS-A-2
QLS-A-3
QLS-A-4
DXL-A-1
DXL-A-2
Daxiangling
(D X L)
XXL-B-1
XXL-A-1
LS-A-1
LS-A-2
LS-A-3
LS-A-4
Xiaoxiangling
(X X L)
Liangshan
(L S)
Mountain boundary
Sichuan Province
0 195 390 780
km
B
Precipitation (mm)
Temperature (℃)
C
Precipitation
Temperature
Precipitation (mm)
Temperature (℃)
MS
QLS
DXL
XXL
LS
D
y=−0.0005x+1.9573
R2=0.0221
P=0.663
NDVI
E
Slope
Precipitation-NDVI
Temperature-NDVI
F
(Signs/km2)
A
B
All
DXL
LS
MS
QLS
XXL
Bare land
Broad-leaved forest
Coniferous forest
Coniferous and broad-leaved mixed forest
Cultivated land
Grassland
Shrub
Town
Wetland
Density of pandas
Low
Lower
High
Higher
Medium
Density of pandas
Percentage (%)
G
(Signs/km2)
A
B
DXL-A-1
LS-A-3
LS-A-4
MS-A-2
MS-A-3
XXL-B-1
Bare land
Broad-leaved forest
Coniferous forest
Coniferous and broad-leaved mixed forest
Cultivated land
Grassland
Shurb
Town
Wetland
Density of pandas
Low
Lower
High
Higher
Medium
Density of pandas
Percentage (%)
H
(Signs/km2)
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DXL-A-1
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LS-A-4
MS-A-2
MS-A-3
XXL-B-1
Bare land
Broad-leaved forest
Coniferous forest
Coniferous and broad-leaved mixed forest
Cultivated land
Grassland
Shurb
Town
Wetland
Density of pandas
Low
Lower
High
Higher
Medium
Density of pandas
Percentage (%)

Figure 1 Study area, relationship between vegetation coverage and precipitation and temperature, spatiotemporal changes in vegetation coverage, and relationship between panda density and vegetation coverage

A: Study area in Sichuan Province, China (Green areas indicate isolated populations of giant pandas according to the Fourth National Survey on Giant Pandas. Names of isolated populations are in black; high-risk subpopulation (<15 pandas) areas are shaded in yellow). B: Changes in average precipitation (A) and temperature (B) in study area from 2001 to 2011 (Broken line shows change from 2001 to 2011 and dotted line shows trend from 2001 to 2011. Short line on left shows trend from 2001 to 2005 and short line on right shows trend from 2006 to 2011). C: Average precipitation and temperature in different mountain areas from 2001 to 2011. D: Spatial variation in NDVI slope (A) and correlation between vegetation growth and climate factors; (B) precipitation and NDVI; and (C) temperature and NDVI. E: Vegetation change in time-series NDVI from 2001 to 2011 (Broken line shows change from 2001 to 2011 and dotted line shows trend from 2001 to 2011. Short line on left shows trend from 2001 to 2005 and short line on right shows trend from 2006 to 2011). F: Relationship between panda density and change in land use type and panda density and change in vegetation coverage, respectively. Change in proportion of land use type (A) and different classes of vegetation coverage (B) in different mountains from 2001 to 2011 and panda density (top of X-axis). (Note: whole study range). G: Relationship between panda density and land use type and panda density and vegetation coverage in 2011. Proportion of land use type (A), different classes of vegetation coverage (B), and density of high-risk isolated populations (top of X-axis). H: Relationship between panda density and land use type and panda density and vegetation coverage in 2001. Proportion of land use type (A), different classes of vegetation coverage (B), and density of high-risk isolated populations (top of X-axis).

population size and occurrence of giant pandas was obtained from the Fourth National Survey of Giant Pandas (2011). We selected six populations based on their size, including subpopulations with fewer than 15 individuals, as this is the threshold for an extinction risk >50% (State Forestry Administration, 2015). The subpopulations included DXL-A-1, LS-A-3, LS-A-4, MS-A-2, MS-A-3, and XXL-B-1 (Figure 1A). Climate data from 2001 to 2011 were acquired from the China Meteorological Data Sharing Service System (http://data.cma.cn/). The normalized difference vegetation index (NDVI) for vegetation coverage from January 2001 to December 2011 (16-day Global 250 m product, MOD13Q1) was obtained from the United States Geological Survey (USGS, https://earthexplorer.usgs.gov/). Distribution of different vegetation types was obtained from the vegetation map of the study area (scale 1:1 000 000), provided by the Data Sharing Infrastructure of Earth System Science (http://www.geodata.cn). Details of processing methods are available in the Supplementary Materials.

Spatiotemporal variations in the NDVI and climate data (precipitation and temperature) from 2001 to 2011 were analyzed using linear regression, and their relationship was determined using Pearson correlation. Spatiotemporal variations in vegetation coverage were evaluated using the pixel dichotomy model, and the relationship between vegetation coverage and panda density was determined by overlay analysis. Details of analysis methods are available in the Supplementary Materials.

Based on our results, precipitation and temperature showed decreasing trends from 2001 to 2011, with annual declines of 5.8958 mm and 0.0175 ℃, respectively (Figure 1B). Average maximum precipitation (1 058.27 mm) and average maximum temperature (16.87 ℃) were both in DXL, while average minimum precipitation (848.98 mm) and average minimum temperature (13.35 ℃) were both in MS (Figure 1C). In addition, the NDVI also showed a gradually decreasing trend (0.0005 per year) (Figure 1D). When all sites were combined, there was no correlation between the NDVI and climate variables, but this varied across mountains. For example, NDVI was significantly correlated with precipitation and temperature in DXL, NDVI was significantly correlated with temperature in XXL, and NDVI was weakly correlated with precipitation and temperature in LS, QLS, and MS (Figure 1E).

Our results also showed that the proportion of areas with high vegetation coverage increased overall (42.35% to 50.59%), with the greatest increase in DXL (48.47%) and lowest increase in MS (8.76%, Figure 1F). For the high-risk populations, MS-A-2 showed the highest isolated population density (0.0587 signs/km^2, Figure 1G), with high vegetation coverage of 83.79% and 89.45% in the two survey periods, both dominated by coniferous forest (69.15% and 68.37%, respectively). LS-A-3 showed the smallest isolated population density (0.0173 signs/km^2), with high vegetation coverage of 83.6% and 93.49% in the two survey periods (Figure 1H), both dominated by broad-leaved forest (70.84% and 71.19%, respectively). For the five studied regions, MS had the largest panda population density (0.0844 signs/km^2) and relatively low high vegetation coverage in the two surveys (41.37% and 44.84%, respectively), whereas XXL had the lowest panda population density (0.0251 signs/km^2) and slightly higher high vegetation coverage (45.17% and 56.1%, respectively). Previous studies have assumed that giant pandas prefer habitats with dense vegetation (Zhang & Hu, 2000), and have therefore rarely explored the relationship between giant panda density and high vegetation coverage. Our research provides additional scientific evidence for the formulation of future conservation policies.

Our regression analysis showed that panda distribution was significantly correlated with temperature and precipitation, thus revealing that giant pandas require relatively stable climates, as reported in previous research (Qin, 2020). For example, in DXL, the average annual precipitation and temperature were high but varied substantially, thus showing weak climatic stability based on analysis of variance. In addition, although pandas live in areas with fluctuating temperatures, temperatures in winter can drop to below 20 °C (Zhang & Hu, 2000). Therefore, although high vegetation coverage increased in DXL, its higher temperature and precipitation compared with the other areas may have resulted in lower panda density.

In conclusion, we found that climate is an important factor affecting habitat selection in giant pandas and that high vegetation coverage alone does not equal high density of individuals. These findings are important for conservation planning and reintroduction or corridor construction programs for panda population restoration. However, these results should be considered with the understanding that many factors affect the density and spatial distribution of pandas. Our research only considered vegetation coverage and climate factors, not other factors such as human disturbance. Human disturbance not only affects the spatial distribution and habitat suitability of pandas (Yang et al., 2020), including distributional shifts to higher elevations (Wei et al., 2018b), but can accelerate habitat fragmentation and population shrinkage, potentially impacting genetic disorders and diversity (State Forestry Administration, 2015). Another caveat of this study is that we used a NDVI range from 2001 to 2011. Given the gradual restoration of panda habitat destroyed by earthquakes and the implementation of conservation policies by the government over the last 10 years, further in-depth research on whether the situation has changed is necessary.

SUPPLEMENTARY DATA

Supplementary data to this article can be found online.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

C.L., D.W.Q., and Z.F.X. designed the study. D.W.Q. and Z.F.X. contributed to project/funding administration. Z.Q.B., X.R.L., W.W., J.J.Y., and R.H. participated in data collection and provided logistic support. Q.X., X.D.G., and H.Y. drafted and revised the figures. C.L. drafted the manuscript. C.L., J.R.O., D.W.Q., and Z.F.X. revised the manuscript. All authors read and approved the final version of the manuscript.

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