

## Morphological Characteristics of *Nitraria tangutorum* Nebkha Dunes in Different Habitats: Post-print

**Authors:** Wei Yajuan, Wang Ji, Dang Xiaohong, Zhang Yong, Xie Yunhu, Shen Guilu, Ding Yanlong, Wan Fang, Dang Xiaohong

**Date:** 2019-09-09T00:00:00+00:00

### Abstract

Taking the desert-oasis ecotone of Jilantai as the study area, quantitative analysis was conducted on the morphological characteristics of *Nitraria tangutorum* shrub sand dunes, relationships among various morphological parameters, and growth characteristics of *Nitraria tangutorum* shrubs under different habitat conditions. The results show that: With the increase of *Haloxylon ammodendron* forest age (except for pure *Nitraria tangutorum* stands), the variation range of each morphological parameter of *Nitraria tangutorum* shrub sand dunes is relatively large, and they develop toward a prolate spheroid shape, with some evolving toward an asymmetric ‘tadpole-like’ shape. Under four different habitat conditions, the correlation coefficients among various morphological parameters of *Nitraria tangutorum* shrub sand dunes are all above 0.782 ( $P < 0.01$ ), showing significant correlation, which is the result of synergistic development of shrub sand dunes in various habitats. Regression equation analysis was conducted between the long axis and short axis, as well as between horizontal scale and sand dune height of *Nitraria tangutorum* shrub sand dunes in various habitats, showing significant linear relationships ( $R^2 > 0.7217$ ) and power function, quadratic function relationships ( $R^2 > 0.8351$ ) respectively, with all slopes being positive, indicating that shrub sand dunes in all four habitats are in the developmental stage. The height and coverage of *Nitraria tangutorum* shrubs have significant effects on the morphological characteristics of shrub sand dunes; that is, the higher the shrub height and the greater the coverage, the greater the height, base area, and volume of *Nitraria tangutorum* shrub sand dunes.

## Full Text

# Morphological Features of *Nitraria tangutorum* Nebkhas in Different Habitats

**Journal:** Arid Zone Research (ChinaXiv Partner Journal)

**DOI:** 10.13866/j.azr.2019.01.29

**Authors:** WEI Ya-juan<sup>1</sup>, WANG Ji<sup>1,2</sup>, DANG Xiao-hong<sup>1,2</sup>, ZHANG Yong<sup>3</sup>, XIE Yun-hu<sup>1</sup>, SHEN Gui-lu, DING Yan-long<sup>1</sup>, WANG Fang<sup>1</sup>

### **Affiliations:**

<sup>1</sup>College of Desert Control Science and Engineering, Inner Mongolia Agricultural University, Hohhot 010018, Inner Mongolia, China

<sup>2</sup>Inner Mongolia Hangjin Desert Ecosystem Positioning Research Station, Ordos 017400, Inner Mongolia, China

<sup>3</sup>Xilin Gol League Forestry Investigation Designing Institute, Xilinhot 026000, Inner Mongolia, China

Inner Mongolia Lantai Industrial Corporation, Alashan 750336, Inner Mongolia, China

---

## 1.1 Study Area

The study area is located in the Jilantai region of the Ulanbuh Desert, with geographic coordinates of 105°39'40"–105°44'56" E and 39°45'26"–39°46'38" N, at an elevation of 970 m. The region has a temperate continental climate. Meteorological data from 1980–2016 show a mean annual temperature of 8.6°C, with extreme maximum and minimum temperatures of 40.9°C and -31.2°C, respectively. Mean annual precipitation is 121.1 mm, concentrated primarily in July, August, and September (accounting for 135.9 mm). The mean annual wind speed is 3.5 m · s<sup>-1</sup>, with maximum speeds reaching 15 m · s<sup>-1</sup> and prevailing wind directions from NNW to NWW.

The primary vegetation types in the study area include *Tamarix chinensis*, *Populus euphratica*, *Nitraria tangutorum*, *Caragana microphylla*, and *Artemisia* spp. The *Haloxylon ammodendron* plantations were established in the 1980s, with plantation ages ranging from 5 to 15 years. Sample plots were established in plantations of different stand ages, with three replicate plots (50 m × 50 m each) for each age class (5, 10, and 15 years). Within each plot, *Nitraria tangutorum* nebkhas were systematically surveyed.

## 1.2 Methods

For each nebkha, morphological parameters were measured including length (L), width (W), and height (H). The following formulas were used to calculate derived parameters:

$$D = \frac{L + W}{2}$$

$$A = \frac{\pi(L + W)}{4}$$

$$V = \frac{\pi(L \times W \times H)}{6}$$

where D is the mean diameter, A is the basal area, and V is the volume. Correlation analysis and regression modeling were performed to examine relationships among these parameters.

## 2.1 Morphological Characteristics of *Nitraria tangutorum* Nebkhas

The morphological parameters of *N. tangutorum* nebkhas varied significantly across the four different habitats. As the stand age of *H. ammodendron* increased (except in the pure *N. tangutorum* area), nebkha dimensions showed a wider range of variation, with some areas developing into luxuriant thickets.

\*\*\*\* shows the characteristics of *H. ammodendron* plantations with different stand ages. The 15-year plantation had the highest density (975 plants/ha) and tallest shrubs ( $159 \pm 13.23$  cm), while the 5-year plantation showed the lowest values.

Correlation analysis revealed that all morphological parameters of *N. tangutorum* nebkhas were strongly interrelated. \*\*\*\* presents correlation coefficients for nebkhas across different sample plots. All correlations exceeded 0.782 and were statistically significant ( $P < 0.01$ ), indicating coordinated development of nebkhas across various habitats. The strongest correlations were observed between length and width ( $r > 0.85$  in most cases), and between horizontal dimensions and height ( $r > 0.90$ ).

Regression analysis yielded the following relationships between height (H) and mean diameter (D) for nebkhas in different habitats:

- Habitat 1:  $H = 0.0051D^{2.3673}$ ,  $R^2 = 0.8809$
- Habitat 2:  $H = 0.0601D^2 - 0.9966D + 4.7578$ ,  $R^2 = 0.8484$
- Habitat 3:  $H = 0.0015D^2 + 0.164D - 0.4174$ ,  $R^2 = 0.844$
- Habitat 4:  $H = 0.0407D^2 + 0.033D + 0.1699$ ,  $R^2 = 0.8351$

All regressions were statistically significant ( $P < 0.01$ ), as illustrated in [Figure 3: see original paper], which shows the relationship between nebkha height and horizontal size. The high  $R^2$  values ( $>0.8351$ ) indicate that nebkhas in all habitats are at the developing stage, with height increasing as a power or quadratic function of horizontal dimensions.

## 2.2 Coverage Effects on Nebkha Morphology

[Figure 4: see original paper] shows the coverage of *N. tangutorum* shrubbery in different sample plots. Coverage ranged from 20% to 80%, with 60% being the most common (56.3% of plots). In 15-year-old plantations, coverage typically exceeded 60% [FIGURE:4a, 4b], while in 10-year-old plantations, coverage varied between 20% and 60%. The 5-year-old plantations showed the lowest coverage values, generally below 40% [FIGURE:4c, 4d].

The height and coverage of *N. tangutorum* shrubbery significantly affected nebkha morphology. Taller shrubs with greater coverage produced larger nebkhas with increased height, basal area, and volume. This relationship demonstrates that plant growth parameters directly influence aeolian sediment accumulation patterns.

## 3.1 Discussion

The morphology of nebkhas is closely linked to shrub height and coverage. In arid regions with limited precipitation (121.1 mm annually), wind erosion and deposition processes are strongly mediated by vegetation structure. The study area's wind regime, with mean speeds of  $3.5 \text{ m} \cdot \text{s}^{-1}$  and maximum speeds of  $15 \text{ m} \cdot \text{s}^{-1}$ , creates conditions favorable for nebkha formation around *N. tangutorum* shrubs.

Previous studies have shown similar relationships between shrub morphology and nebkha development. For instance, research in the Hotan River basin reported that *Tamarix* nebkhas reached heights of 1.8–4 m and volumes of 10–15  $\text{m}^3$ , consistent with our findings. The regression models developed here ( $R^2 > 0.8351$ ) confirm that nebkha height scales nonlinearly with horizontal dimensions, reflecting the dynamic balance between sediment supply and vegetation resistance.

The strong correlations among all morphological parameters ( $r > 0.782$ ,  $P < 0.01$ ) indicate that nebkhas develop as integrated geomorphic units rather than assemblages of independent features. This coordinated development suggests that once established, *N. tangutorum* shrubs create self-reinforcing feedbacks: as nebkhas grow taller, they capture more sediment, which further enhances shrub growth and sediment-trapping capacity.

Coverage effects are particularly important. At coverage levels above 60%, nebkhas exhibit more complex morphologies with multiple peaks and steeper slopes, while lower coverage produces simpler, conical forms. This threshold behavior has implications for using *N. tangutorum* in sand stabilization projects, as it suggests a minimum vegetation density is required for effective dune building.

The study demonstrates that in desert-oasis ecotones, the interaction between *H. ammodendron* plantation age and *N. tangutorum* understory vegetation creates a mosaic of nebkha morphologies. Older plantations provide better protection

and resources, enabling *N. tangutorum* to develop larger nebkhas that contribute more substantially to sand fixation and ecosystem engineering.

---

**Abstract:** The morphological features of *Nitraria tangutorum* nebkhas in different habitats in the desert-oasis ecotone in Jilantai were investigated. The relationships among the morphological parameters and the growth of *N. tangutorum* nebkhas were quantitatively analyzed. The results are as follows: The morphological parameters of *N. tangutorum* nebkhas along their long ellipsoidal direction varied in a wide range with the increase of stand age of *Haloxylon ammodendron* (except the *N. tangutorum* area), and the luxuriantly growing thickets evolved in some areas; The correlation coefficients of the morphological parameters of *N. tangutorum* nebkhas in four different habitats were all higher than 0.782 and showed a significant correlation ( $P < 0.01$ ), which was the result of the cooperated development of the nebkhas in various habitats;

The regression equation analysis revealed that there was a significant linear relationship between the length and width ( $R^2 > 0.7217$ ) and a relationship of power function and quadratic function between the horizontal size and height ( $R^2 > 0.8351$ ) of *N. tangutorum* nebkhas in various habitats, which indicated that the *N. tangutorum* nebkhas were all at the developing stage; The height and coverage of *N. tangutorum* shrubbery affected significantly the morphological features of *N. tangutorum* nebkhas, that means the height, basal area and volume of the nebkhas were increased with the increase of plant height and coverage of *N. tangutorum* shrubbery.

**Keywords:** *Nitraria tangutorum*; nebkha; *Haloxylon ammodendron*; morphological feature; desert-oasis ecotone; Jilantai; Ulanbuh Desert

*Note: Figure translations are in progress. See original paper for figures.*

*Source: ChinaXiv – Machine translation. Verify with original.*