Scientific Abstract

Spartina alterniflora is a highly invasive plant that has extensively colonized Chinese coastal wetlands, degrading critical habitat for migratory waterbirds. In response, the Chinese government launched the Special Action Plan for *Spartina alterniflora* Prevention and Control (2022–2025), aiming to remove over 90% of the invaded area nationwide. This study quantitatively assessed the effectiveness of this campaign in Dafeng Milu National Nature Reserve (DMNNR), a UNESCO World Heritage site on the Yellow Sea coast, using satellite imagery from Sentinel-2 and a dual-method framework combining Random Forest (RF) classification with *Spartina alterniflora* Index (SAI) threshold extraction. Cloud-free Sentinel-2 scenes from December 2022 and December 2025 were analyzed to map *S. alterniflora* distribution before and after control. A total of 640 reference samples were collected through multi-source image interpretation and split spatially into a western subset for training and eastern subset for independent testing, which were used to train an RF classifier and derive site-specific SAI thresholds ($-0.790 \leq SAI \leq -0.388$). The RF model achieved an overall accuracy of 94.97% on the independent test set. High spatial agreement between the RF-based and SAI-based maps, quantified by the Intersection over Union (IoU = 0.916) validated the SAI approach, which was applied to 2025 imagery for sample-free remnant patch detection. Results show that the invaded area declined from 3,147.86 ha to 22.84 ha, representing a 99.27% removal rate that substantially exceeds the 90% national target. Of the baseline extent, 3,141.92 ha (99.81%) was cleared, with only 5.95 ha persisting and 16.89 ha of new growth detected. Remnant patches exhibited strong spatial clustering (Moran's I = 0.95, $p < 0.001$) in three hotspots along the seaward fringe. The complete disappearance of *S. alterniflora* spectral signatures in SAI and NDVI histograms confirmed large-scale removal attributable to the management. The restoration of over 3,000 ha of tidal flat supports UNESCO conservation objectives and maintains critical foraging habitat for globally threatened shorebirds. The transferable dual-method framework addresses key limitations in post-eradication monitoring where

field access is constrained, providing a practical tool for evaluating control effectiveness across coastal reserves.

Keywords: Geographical Information Science, Remote Sensing, *Spartina alterniflora*, invasive species control, Sentinel-2, coastal wetlands, Random Forest