The coastal tussac (*Poa flabellata*) grasslands of the Falkland Islands are a critical seabird breeding habitat, but have been drastically reduced by grazing and erosion. Meanwhile, the sensitivity of seabirds and tussac to climate change is unknown, due to a lack of long-term records in the South Atlantic. Our 14,000-year multi-proxy record reveals an ecosystem state shift following seabird establishment 5,000 years ago, as marine-derived nutrients from guano facilitated tussac establishment, peat productivity, and increased fire. Seabird arrival coincided with regional cooling, suggesting the Falkland Islands are a cold-climate refugium. Conservation efforts focusing on tussac restoration should include this terrestrial-marine linkage, though a warming Southern Ocean calls into question the long-term viability of the Falkland Islands as habitat for low-latitude seabirds.