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An Annotated Checklist to Vascular Flora of the Ica Region, Peru—with notes on endemic species, habitat, climate and agrobiodiversity

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Abstract

The ephemeral and fragmented nature of plant communities in the desert region of Ica, Peru have contributed to the poor documentation of its flora. This study provides the first comprehensive checklist and analysis of the vascular plants and habitats of the region, based on over 1800 herbarium collections, site-specific vegetation surveys and monitoring (2001–2017). Here, we report 501 taxa belonging to 283 genera in 68 families, with an outstanding number of taxa (297) representing new records for the region; over 10% of the flora (52 taxa) is categorised as threatened (CR, EN, VU). Asteraceae is the largest family in the checklist, followed by Poaceae, Fabaceae and Solanaceae. The highest species richness is found in quebradas and huaycos (170 taxa), followed by lomas (137 taxa) and huertas (115). Of the lomas taxa, 28% are assessed nationally as threatened, and 95 taxa (68%) are endemic to Peru. Across all habitats five species are restricted to the Ica region (*Cleistocactus clavispinus, Haageocereus icensis, Onoseris humboldtiana, Nolana willeana, Tecoma fulva* subsp. *guarume*). *Nolana willeana*, not collected since 1956, was rediscovered in 2006. We provide insights into habitat and taxonomic delimitation of enigmatic species in the following genera: *Bulnesia*, *Capparis*, *Eremocharis*, *Hoffmannseggia*, *Leptoglossis*, *Lomanthus Maytenus*, *Poissonia* and *Weberbauerella*, among others. We support the reinstatement of *Prosopis limensis* as a valid species and provide information for its identification in the field. Analysis of *Inga feuillei* as an ancient domestication vital to agriculture, is provided, and we report an additional 127 cultivated species associated with traditional agriculture, assessing origins and conservation priority. We present climatic and geological observations for the region with spatial and ENSO-related research from data, plots and transects. A vegetation map and niche model are provided. Threatened lomas species are detailed to support conservation and policy. To aid identification we provide photographs of 155 plant species and all key habitats. The sustainable wellbeing of the Ica region depends on concerted collaboration to monitor, conserve and restore native plants wisely for the natural resources they provide to people and agriculture.

Key words: Agrobiodiversity, cacti, desert flora, dry forest, El Niño, fog ecosystem, grasses, habitat restoration, huarango, hyperaridity, *Tillandsia*

Introduction

At the south-western extension of South America is the arid desert region of Ica. The region is important for modern export agriculture and widely known for its pre-Columbian archaeology, but is poorly known botanically. This desert region is part of the Peruvian south coast and an extension of the Chilean Atacama Desert, while also being part of the Peru–Chile coastal desert biome that includes the Sechura Desert and equatorial Pacific seasonal dry forests of northern Peru and south-west Ecuador.

Around 60% of Ica's 21,327 km^2 appears as hyperarid desert with wide expanses of exposed geomorphology. This landscape is framed by a backdrop of Andean valleys (*quebradas*) and traversed by fertile river valleys and fog sustained ecosystems (*lomas*), that have all provided critical ecosystem services to humans over several millennia (see Weberbauer 1945, Ferreyra 1961, 1983, Whaley *et al.* 2010, 2011, Beresford-Jones 2009ab, 2015, 2018). Around 8000 km^2 (ca. 38% of the land area) is largely devoid of vascular plants, albeit replete with unstudied biotic crusts and isolated lichen-bearing outcrops. The desert matrix is interspersed by highly ephemeral vegetation zones that are rarely recorded during decadal events. Habitats are very restricted in area; perennial herbaceous lomas, for example, occupies <1% (0.94%) of the area of Ica. Most of the botanical diversity is confined towards Ica's eastern Andean flanks and western coastal hills (*ibid.*). This includes a 260 km north–south swathe of dry valleys, outwash bajadas and Andean pre-cordillera valleys (hereafter 'quebradas'), that terminate (in Chincha province) at elevations of around 4400 m in the Andean headwaters and *puna* (upland pasture over ca. 3300 m. elev.). To the west, plant diversity and vegetation are largely restricted to lomas ecosystems, river mouths and the estuaries of Ríos Chincha, Grande, Ica and Pisco, together with the degraded saltmarshes (*humedales*) of Agua Santa, Caucato, Pisco and Santa Rosa. Between these areas, dry forest relicts and riparian ecosystems merge, with ephemeral outwash streams braiding across bajadas. Called *huaycos* locally, these streams only flow for a few days per year (flash flood), supporting unique plant assemblages. Some huaycos only become active every seven to ten years, after extreme rainfall events during the phases of the El Niño–Southern Oscillation (ENSO), when dry river channels can transform into raging torrents, bringing a regenerative pulse to the desert (Young & León 2009, Whaley *et al.* 2010a).

Regional floristic associations are wide and include species from arid Pacific coastal areas, as well as disjunctions from the dry valleys of Argentina and Bolivia, and the deserts of south-west USA and Mexico, including the Mojave and Sonoran (Raven 1963, Solbrig 1972, 1976, López 2003, Simpson *et al*. 2005), as well as Galapagos (Svenson 1946) with other widespread generic affinities in the arid Neotropics (Sarmiento 1975).

The ephemeral and disparate nature of vegetation occurrence, tied to wider climatic oscillations of ENSO, have limited the appearance of plants and opportunities for collection (Dillon *et al.* 1989, 2003, Whaley *et al.* 2010ab). In elevated areas, vegetation is sustained by fog that is concentrated by topography and proximity to the sea. These unique habitats are known as 'lomas' in Peru and Chile and found along the coastal desert from 5°S in the north of Peru, to 30°S in northern Chile (Ferreyra 1953, 1961, 1977, 1993, Rundel 1978, Pefaur 1982, Dillon & Rundel 1990, Rundel *et al.* 1991, Dillon 2005, Zegarra 2006). A few upland Andean species, that also occur in Ica, have been reported in floristic studies from Ayacucho (Roque & Ramírez 2008) and Huancavelica (Rondinel *et al.* 2004), which are Andean regions of Ica's catchment.

History of land use and protection

The combination of Andean water, biodiversity, high insolation rates and fertile soils, with intrinsic lack of disease, has meant that Ica has seen a long history of human settlement and ecosystem alteration (see Rowe 1969, Beresford-Jones 2009a, 2015). This degradative process is largely uncatalogued and today, most native vegetation in the lower valleys has been converted to agriculture and urban development. The abandoned agricultural terraces of the Andean valleys are testament to a diminishing water supply from upland deforestation, overgrazing and climate change. Despite being famous for viticulture, including 'Pisco' distillation, vines only occupied 6% of the cultivated area in 1956, while 82% of the cultivated valley was dedicated to growing cotton (Smith 1960, Peloso 1999). Today, cotton has been supplanted by an industrial export sector producing table grapes, citrus, asparagus and avocado, with a recent boom in chicken farms for domestic consumption. According to Clark (1942), the impenetrable forests of Ica, described by Vasquez de Espinosa in 1628, were converted to fuel as a precursor to agriculture. Over the last 50 years, most of the remaining forest relicts have been cut illegally to produce charcoal, despite national and international efforts to conserve germplasm and promote their restoration and cultural reintegration (Whaley *et al.* 2010ab).

Motivated by exceptional marine diversity, two protected areas have been established in Ica: the Reserva Nacional de Paracas (335,000 ha (117,250 ha terrestrial)) established in 1975, and the Reserva Nacional San Fernando (154,716 ha (111,998 ha terrestrial)) established in 2011. Both are managed by Servicio Nacional de Áreas Naturales Protegidas por el Estado (SERNANP). Species and habitat data presented here were provided in georeferenced format to SERNANP to support restricted-access zonification of critical lomas habitat and establish permanent plots.

Sporadically, the region is impacted by large earthquakes and by El Niño-related flood or precipitation events, resulting in huge fluvial impacts (Keefer & Moseley 2003, Eichler & Londoño 2013b). These events have punctuated human settlement in the region. Archaeology suggests that deforestation allowed violent El Niño floods to destroy agricultural infrastructure, ultimately causing a collapse of pre-Columbian Nasca culture (see Beresford-Jones *et al.* 2009a, 2011ab); a process perhaps exacerbated by climate change (Eitel *et al.* 2005).

The desert context and climate

The Ica region is at the western elbow of an 'arid diagonal' region that traverses the South American continent (Fig. 1). This vast region of South America includes the southern Chaco, the Andean dry valleys, the Atacama Desert and the coastal desert region of Chile and Peru. Towards the equator, weakened South Pacific trade winds allow the Inter-Tropical Convergence Zone (ITCZ) to traverse the Andes, carrying tropical humid air to the coast of Ecuador (Rossel & Cadier 2009) and truncating aridity. The aridity is well defined by <600 mm of annual precipitation, with much of the area receiving <200 mm/yr. Ica lies in mid-section of the hyperarid coastal belt (Peru and Chile), extending for 3000 km and including 1500 km of the Atacama Desert, which receives <20 mm/yr of rainfall.

Although punctuated by transient fluctuations in climate, including ENSO cycles and Quaternary deglaciations, components of the flora of Ica have had deep time aridity in which to evolve. Evidence suggests that although the ENSO developed its intensity relatively recently, during the Holocene, arid conditions are thought to have prevailed at least since the late Eocene, with the onset of hyperaridity by the middle of the Miocene—some 15 million years ago (Alpers & Brimhall 1988, Böhlke *et al.* 1997, McKay *et al.* 2003). Hyperaridity seems to have intensified ca. 12 million years ago as the Andes grew in height (Mujica *et al.* 2015). In northern Chile, Dunai *et al.* (2005) state that over the last 25 million years, "only exceptional global climatic disturbances have permitted humidity transfer across the Andes into this driest of regions". According to Hartley *et al.* (2005), geological evidence suggests that the Atacama Desert is the oldest in the world, with arid conditions prevailing for around 150 million years.

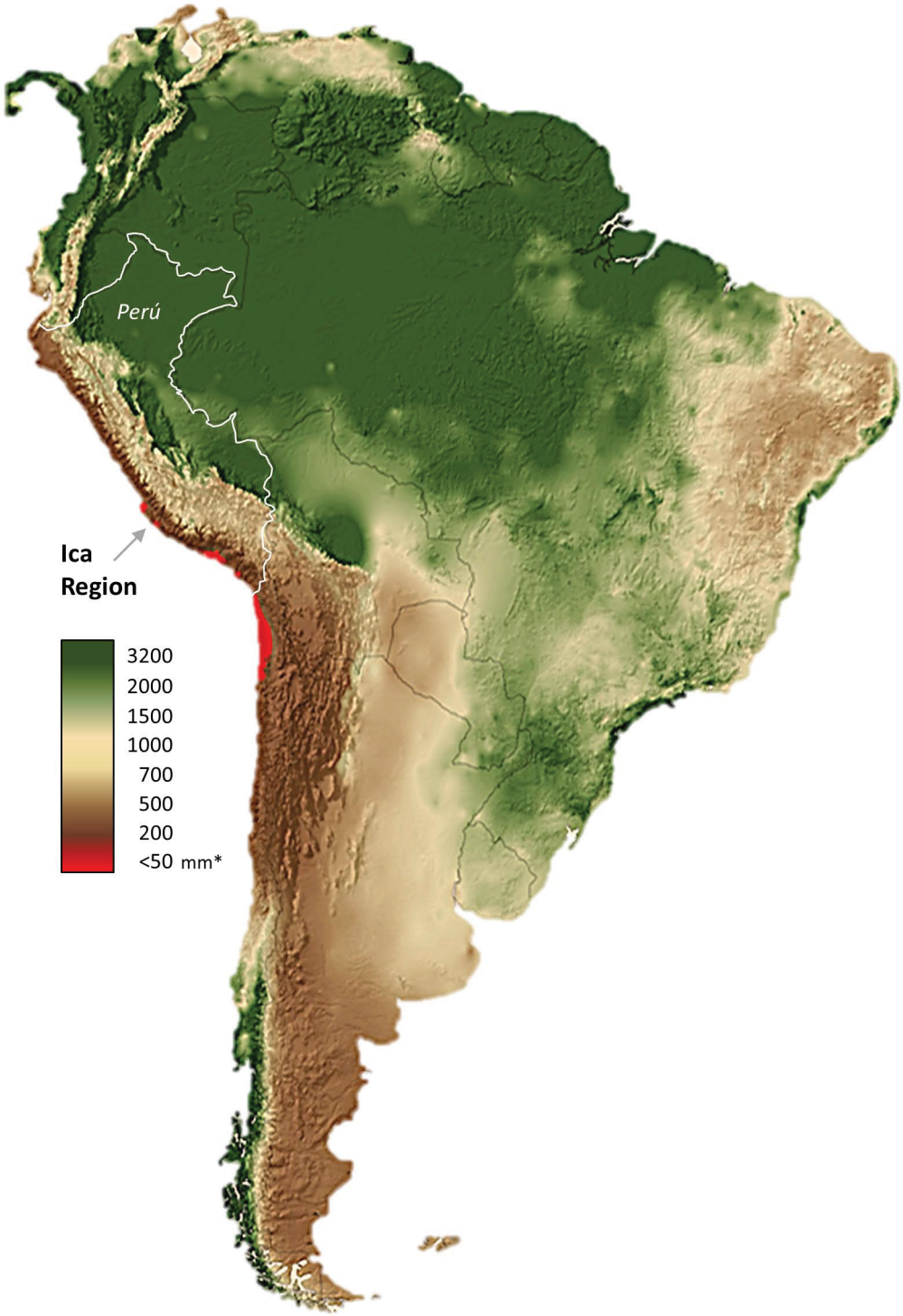

FIGURE 1. South American Rainfall, showing: the 'arid diagonal' and SW elbow position of Ica. Approximate annual average precipitation levels as follows: solid green (2000–3400 mm), light green (1200–2000 mm), cream (600–1200 mm), light brown (400–600mm), mid-brown (<400 mm), dark brown (<200 mm), red (virtually no recorded rainfall). The coast of Peru and Chile receive moisture in areas of fog production and interception, this is largely unrecorded or quantified. (illustration: with thanks to Justin Moat)

Several key factors impede rainfall: moisture from the easterly trade winds is blocked by the Andes to create a rain shadow; the Humboldt current system (or Peru Current) suppresses evaporation and rainfall; air pressure is stabilised by the semi-permanent subtropical anticyclone in the south-east Pacific Ocean; and onshore winds from the

diurnal temperature differential push aridity inland (see Villagrán & Hinojosa 1997, Houston & Hartley 2003, Dunai *et al.* 2005, Hartley *et al.* 2005). However, with the onset of ENSO, increased sea surface temperatures can produce devastating flash flooding, but with few quantitative records and often in single catchments along the Pacific coast (Houston 2006, Bozkurt *et al.* 2016), these remain largely undocumented. ENSO cycles appear to be highly sensitive to climatic forcing, variability (Liu *et al.* 2014, Emile-Geay *et al.* 2016) and climate change (Latif *et al.* 2015).

While the climate of the Ica region is classed as hyperarid (with reported average annual precipitation of 3 mm/yr (ONERN 1971, SENAMHI 2007)), and undoutbtedly very dry, little data is available, especially for ENSO rainfall and humidity. The red zone (Fig. 1) shows an area of virtually no recorded annual rainfall (<10 mm/yr). However, in February 2007 and January–March 2017, for example, heavy cloudbursts of rainfall caused flood ponds to form in Ica (pers. obsv.). As rainfall is so infrequent in Ica, meteorological stations are not set up to measure precipitation, thus the region's perceived level of aridity is somewhat deceptive, at least during ENSO cycles. These stations also fail to record the horizontal moisture input from fog.

Peruvian and Chilean coastal desert vegetation receives much of its moisture input from fog, derived from the Pacific Ocean (see Dillon *et al.* 2003, Whaley *et al.* 2010a, Beresford-Jones *et al.* 2015). From late May to January, the fog season brings lomas vegetation to life on coastal hills and western-most Andean flanks. Adding to the moisture budget are nocturnal ground dews and fogs; these are still poorly understood but are partially determined by latitude and wind speed (see Oka & Ogawa 1984ab). Sporadically from December to April, coastal rivers flow with a large influx of Amazon-derived moisture. This water input changed over the Quaternary period, under influence from shifts of the ITCZ (Bekaddour *et al.* 2014), leaving ancient and recharged aquifers and water tables.

Climate in Ica

Central valley climate. (Ocucaje station-47255188 SENAMHI at 324 m elev. (Fig. 2)) Summer (December–April) daytime temperature rises quickly to over 30˚C; peaking around 37˚C, with nocturnal temperatures not dropping below 15˚C. June–August is the coolest period, June being the coldest month with a 6–8˚C minimum. The maximum temperature recorded in Santiago, Ica (409 m) was 44.8˚C (13:40 23/03/08), with daily temperatures often exceeding 40˚C (12:00–14:30) from December–March (2007–2008) (see Fig. 2.). The Ica valley (ca. 340 m elev.) climate at comparable elevation is cooler than the valleys towards the south. Relative humidity (RH) is generally low throughout the year, with a peak in June–October, when >70% RH is maintained, correlating with the lowest temperatures and the lomas fog season.

Lomas climate. A climatic proxy for lomas is San de Juan de Marcona (station-000729 SENAMHI at 32 m elev., no RH available), where the temperature remains above 12˚C in winter months and rarely exceeds 30˚C in summer (1972, Fig. 2). This lomas environment is cool compared to that of inland valleys, as the onshore breeze is sea-cooled, moderating temperature and humidity. Climate monitoring dataloggers were positioned alongside vegetation in Lomas San Fernando (in collaboration with SERNANP)—see results and phenology (Fig. 6).

Quebrada climate. The temperature of quebradas is regulated by: (i) warm convection winds; (ii) radiant heat from rocks, raising night temperatures; and (iii) morning 'canyon' shade. We can infer an average annual cooling lapse rate of around 6.5˚C per 1000 m rise in elevation. This is corroborated by comparing the February temperature range in Ocucaje (station-47255188 SENAMHI at 324 m elev., 15–35˚C (Fig. 2)) to that of Huancano (station-000639 at 1019 m elev., 17–30˚C) and San Juan de Yanac (station-156113 at 2502 m elev., 10–19˚C). This shows a lapse rate of around 7.4˚C with 1000 m rise in elevation. During much of the year, daily temperature ranges tend to *decrease* with an increase in elevation from 300 to 2500 m (~20˚C at 310 m, ~13˚C at 1020 m, ~9˚C at 2500 m).

Sea temperature. The coastal climate of Peru is maritime and driven by sea temperature and shifts in position of the coastal currents, the effects of which hold sway over productivity and phenology of vegetation. The sea surface temperature (SST) inshore ranges from ca. 16˚C in winter to a maximum of ca. 22˚C during summer (Penven *et al.* 2005). The southerly cold coastal water has less seasonal variance (in the range of ca. 14–19˚C), but river-water mixing periodically raises the temperature by a degree or two (Swartzman *et al.* 2008). During the 'exceptionally strong' ENSO of 1997–1998, SST peaked +6.89˚C over the average, with the central coast temperatures rising to 25.5˚C (Tarazona *et al.* 1999, 2007). Despite inter-decadal SST variability, the Humboldt current appears to have undergone a significant cooling trend (ca. 0.3–0.4˚C/decade) over the latter half of the 20th c. (1860–2000), attributed to stronger upwelling with increased wind, and Antarctic melting due to climate change (Gutiérrez *et al.* 2011).

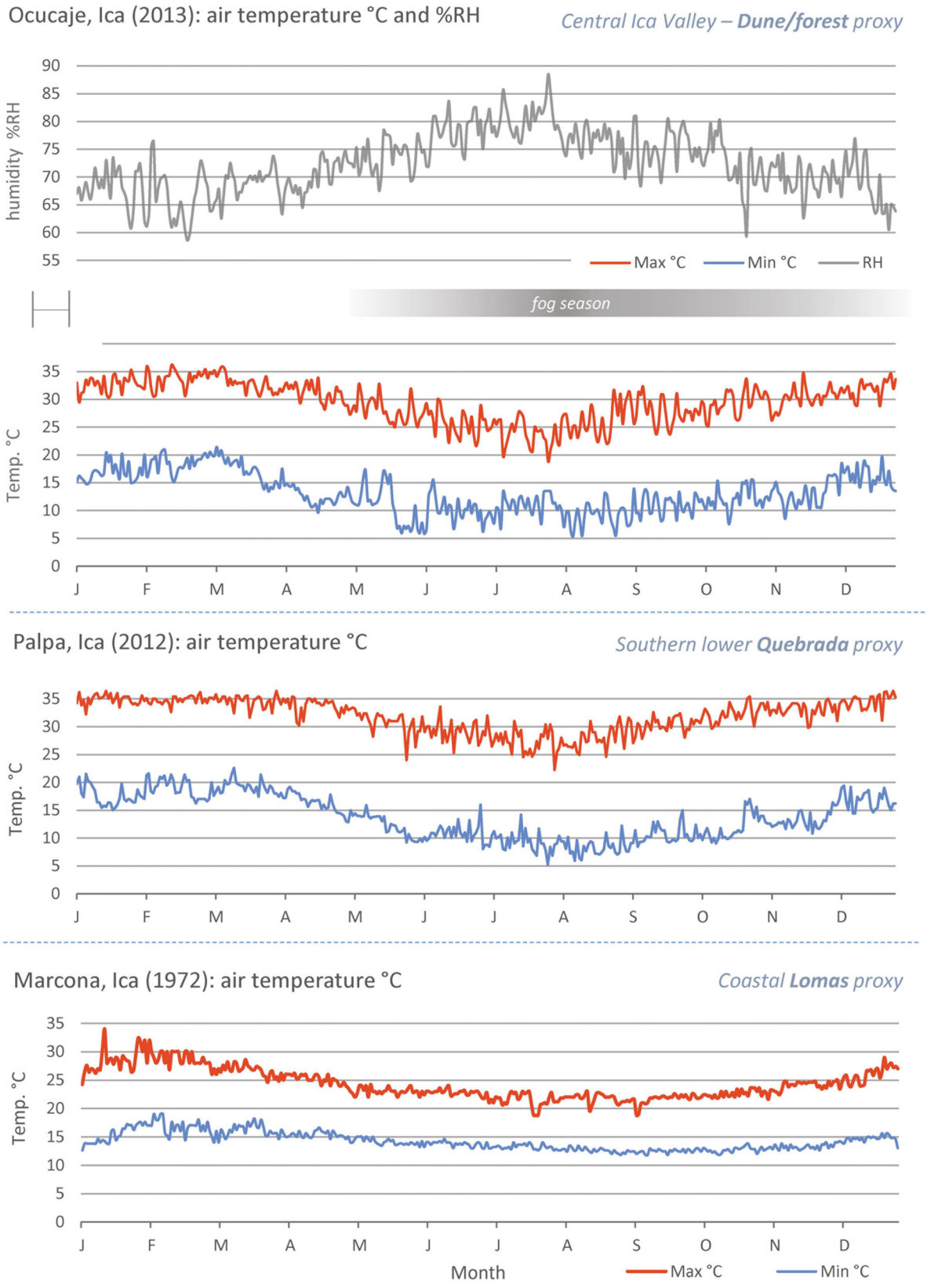

FIGURE 2. Climate of Ica. Showing (top): minimum (blue) and maximum (red) annual temperature (˚C) and average annual RH% in Ocucaje (Río Ica central valley), and (below): annual temperature in Palpa (lower quebrada) and Marcona (coastal). (illustration: OW)

Fog. Although few quantitative data are available, advection fog (less orographic) is the principle source of water for most of the non-riverine habitats. Fog contributes an average of 10 L/m^2/day during the fog season (Semenzato 1995). According to Whaley *et al.* (2011), the quantity of fog captured in June by a *Prosopis* tree (3 m high × 4 m wide canopy) was 7–9 L/night (from dune margins of Ica valley ca. 423 m elev.), revealing a significant seasonal moisture input to forests. In lomas few data are available. However, in Andean flank lomas of Chincha, Ica (600–700 m elev., 17 km from coast) 1–4 L/m^2/day of fog water was collected during peak season (June–November) (Asociación Zabalketa 2014). This is comparable to northern Chile, where fog water data were recorded at two elevations (1997–2004 Proyecto Fondecyt, in Pinto 2005); during peak season (June–October) at Huantajaya (1000 m elev. 12 km from coast) 1.5–3 L/m^2/day was collected, and at Alto Patache (850 m elev. 3 km from coast) 9–22 L/m^2/day was collected. From these levels it can be calculated that dense lomas vegetation might intercept fog, to drip at an equivalent to annual rainfall of 60–240 mm/yr. In certain topographical optima, these figures may double; more research is needed in this area.

Geology and substrate of plant communities

Marine-origin sedimentary uplift. Ica occupies a westerly geographical position on the Nazca plate, uplifted by the Pacific plate subduction, resulting in a topography that begins offshore and rises continuously from 6500 m beneath the sea to over 5000 m elev. in the Andean cordillera (Wipf *et al.* 2008). The area is one of extreme seismic activity where rapid Tertiary uplift of marine sediments has formed a wide coastal plain, dominated by the Tablazo de Ica (ca. 450–600 m elev.). The Tablazo includes weathered landscape features such as yardangs and fluvial sediment feeds, creating large dune fields (Thomas 2011); coastal marine terraces record Quaternary sea level fluctuations (Hsu 1992). The arid zone uplift between river systems is known as the 'Pisco formation', and appears never to have supported vegetation. Here, strata is found bearing the fossils of small whales, giant sharks and penguins (such as *Icadyptes salasi*, ca. 36 Ma (Clarke *et al.* 2007), found near to where threatened Humboldt penguins (*Spheniscus humboldti*) can be seen today). The uplift effectively blocks the Río Ica, diverting it south and creating a wide valley with a series of eastern ephemeral streams (huaycos) that arise from minor Andean catchments (Whaley *et al.* 2010ab) (Fig. 3 map). High levels of salinity produce marginal halophytic vegetation including: *Atriplex* spp., *Distichlis spicata* (L.) Greene, *Prosopis limensis* Benth., together with introduced *Geoffroea decorticans* (Hook. & Arn.) Burkart, and *Tamarix aphylla* (L.) H.Karst., a highly invasive species in Ica.

Coastal ridge. Elevated to around 990 m west of Río Ica and 1720 m west of Nazca, is a coastal ridge split by two river valleys and aeolian deflation (Fig. 3 map). The underlying basement rock is composed of Precambrian gneiss with Lower Palaeozoic granite, overlain with Upper Jurassic to Lower Cretaceous volcanic and sedimentary rock. During the Late Cretaceous to Early Tertiary periods, this rock was uplifted to form the narrow ridge on the outer plate shelf (Kulm *et al.* 1982 in Di Celma *et al.* 2016) with volcano-sedimentary rocks and magnetite orebodies at the boundary-parallel (Chen *et al.* 2010). This complex ridge formation allows classes of lomas vegetation to thrive through variable fog interception. Holocene sea level fluctuations may have influenced the extent and distribution of some lomas vegetation (Beresford-Jones *et al.* 2015). Further inland, beyond the frontal ridge, Tertiary uplift and aeolian sands provide substrates for *Tillandsia* lomas assemblages, while igneous outcrops form plant refugia.

Rocky outcrops. These rocks have some of the earliest origins, being composed of Precambrian gneiss, Lower Palaeozoic granites with Upper Jurassic to Lower Cretaceous volcanic rocks. They appear as intrusions, in the coastal lomas and pre-cordillera (Di Celma *et al.* 2016). These highly weathered and fissured outcrops protrude above the surrounding landscape and trap moisture as 'smooth rock refugia' (*sensu* Danin 1999) where fog and dew collect, supporting concentrations of rare endemic plant species in small relictual populations. Outcrops are also rich in uncatalogued lichens and other poikilohydric species.

Aeolian sands. Sand is transported by strong winds from coastal sediment feeds to supply a number of large barchan, ridge and terminal dune systems (Hesse 2009). Extensive dune systems are found south of the Pisco valley (ca. 380 km^2) and west of the Ica valley (ca. 640 km^2). They extend into the city of Ica (Cerro Saraja) and Guadalupe and Santiago districts; reaching the pre-cordillera and edges of outwash bajadas (Pampa de Yauca) and Andean foothills. Dunes are truncated at rivers (Usaca, Copara dunes, Nazca) and form large terminal dunes inland (Pampa Blanca, Palpa and Cerro Blanco, Nazca). Valley margin dunes most commonly support *Prosopis limensis* Benth., *Pluchea chingoyo* (Kunth) DC., *Scutia spicata* (Humb. & Bonpl. ex Willd.) Weberb. and *Vallesia glabra* (Cav.) Link (Whaley *et al.* 2010). Cerro Blanco is unique, located to host both Andean xeric slope species, such as the endemic *Orthopterygium huaucui* (A.Gray) Hemsl., and disjunctive coastal lomas species such as *Weberbauerella raimondiana* Ferreyra and *Tiquilia ferreyrae* (I.M.Johnst.) A.T.Richardson (León *et al.* 1997). These dune systems are distinct from the phytogenic mounds or coppice dunes, commonly forming around plants in exposed or deforested areas in Ica.

Prosopis limensis (Fig. 12) grows vegetatively through and over sand dunes, with buried branches developing roots seasonally to absorb fog drip (Whaley *et al.* 2010a). Mature trees on dune tops can be observed to be connected to 'mother trees' at the dune base (*ibid.*). The same trees in fog streams can be colonised by epiphytic *Tillandsia purpurea* Ruiz & Pav. and *Tillandsia capillaris* Ruiz & Pav., although this occurrence is in decline.

The development of large dune systems in Ica appears to be a relatively recent phenomenon of the Late Pleistocene. Dunas de Pampa Blanca is believed to have risen over the last 70,000 years and continued building into the Holocene (see Newell & Boyd 1955, Hesse 2009ab, Londoño *et al.* 2012). One plausible explanation is an increasing intensity of aeolian transport with post-glacial deposits, aridity and convective winds.

Andean substrates. Andean valleys (quebradas and outwashes) provide the widest range of substrates, varying from sheer slopes of Cretaceous volcanic rock (Atherton & Aguirre 1992) to weathered colluvium and alluvial silts. As rivers and ephemeral streams merge with the coastal plain, fresh water, leaches the salinity from the marine uplift, and alluvial clay (*yapana*) is deposited over floodplains and in small basins. Since the development of agriculture in this area, the water is distributed via a system of irrigation canals (*acequias*). Today, agriculture and deforestation have transformed the process of episodic sedimentation and pedogenesis (Beresford-Jones *et al.* 2009). The quebrada bajadas provide for species absent from sand and silt deposits of the lower valley (Whaley *et al.* 2010ab); most cactus diversity is restricted to colluvial deposits within these igneous rock substrates, the lowest elevation species being *Armatocereus procerus* Rauh & Backeb. at ca. 550 m elev. Huaycos support perennial species such as: *Bulnesia retama* (Gillies ex Hook. & Arn.) Griseb., *Hoffmannseggia viscosa* Hook. & Arn. (Fig. 11), *Galvezia fruticosa* J.F.Gmel. and *Trixis cacalioides* (Kunth) D.Don. Marginal sections of quebradas provide fractured rock, scree and gravel substrates for woody species such as *Maytenus octogona* and *Tecoma fulva* subsp. *guarume* (DC.) J.R.I.Wood (*ibid.*). The lower valley riparian species restricted to river margins, irrigation canals and floodplain include the widespread *Baccharis salicifolia* (Ruiz & Pav.) Pers., *Salix humboldtiana* Willd. and *Tessaria integrifolia* Ruiz & Pav. (*ibid.*).

Flora of Ica and coastal desert background

The flora of Peru has around 19,745 taxa, of which 28% are endemic (Brako & Zarucchi 1993, León *et al.* 2006). Diversity is greatest in the Andes–Amazonia Centre of Biodiversity (see Rafiqpoor *et al.* 2005), and consequently where most floristic studies have focused. Like much of the arid coastal belt in Peru, the Ica region has been little studied and no annotated checklist is available for its flora.

Plant collectors on the coastal desert

The most notable early collectors on the desert coast of Peru were the Spanish duo Hipólito Ruiz López and José Antonio Pavón Jiménez, collecting from 1778 to 1788 during the 'Expedición Botánica al Virreinato del Perú'. Later, the British collector Hugh Cuming travelled by ship from Chile to collect plants (and sea shells) from the coast of Peru in 1829. Significantly, Cuming collected the type specimens of *Prosopis limensis* (*Cuming 974*, from *Lima et Peruvia Septentrionalis*, dated 1831). Although his specimen sheets rarely record locality, he may have stopped briefly in Ica having visited Ilo (Moquegua) and Cerro Azul (Cañete, Lima) (Dance 1980). The British botanist Richard Spruce arrived on the Peruvian desert coast to recover his poor health, having travelled from Ecuador to Piura in 1862 during a large El Niño event. Spruce was perhaps the first botanist to collect and research dry forest and *algarrobo* (*Prosopis* sp.) in northern Peru (Hemming 2015). Antonio Raimondi collected plants in Arequipa and briefly in Ica in 1863 (Raimondi 1929). The German-born Augusto Weberbauer spent much of his working life in Peru as a botanist, leaving an important herbarium collection with type specimens (*Herbario MOL Augusto Weberbauer*). Weberbauer collected and surveyed lomas species in Ica in 1901, while travelling to Arequipa (1902). He returned to collect plants in Ica (Ayacucho, Huancavelica and Junín) in 1910, and along the coast in 1925. In 1946, at the age of 75, he again returned to Ica, collecting along the coast to Lomas of Chala (Arequipa) on one of his last collecting trips (Weberbauer 1911, 1945). In Ica, Weberbauer collected specimens from: lomas of Bahía San Juan, San Nicolás, Independencia (Morro Quemado), Paracas—localities which were challenging to reach; also Ríos Ica, Pisco, Blanco and Ingenio; and quebradas of Nazca, Palpa, Ingenio, Huayurí and Río Grande. The North American botanist Francis Macbride collected in the lomas of Lima (1921–1922) (Dillon *et al.* 2012) but it is uncertain if he reached Ica. Several other herbarium vouchers reveal the travels of: Robert Murphy in 1919 and 1920; Dora Stafford 1933, 1934 and 1937 (Stafford 1939); and Paul Hutchinson in 1957 and 1964, collecting in Arequipa and Ica. The great Peruvian botanist Ramón Ferreyra (USM) collected most prolifically in Ica during 1946, 1947, 1949, 1950, 1957, 1959 and 1977, and Emma Cerrate in 1951. Passing collectors in Ica also included Alwyn Gentry in 1978 and 1988, the Argentine collector Armando Hunziker in 1981, Walter Lewis (Missouri Botanical Garden) and Walter Till (University of Vienna) in 1982.

Ica has also attracted cacti specialists such as the German botanist Werner Rauh in 1958, who collected in coastal Peru many times from 1954 to 1988 (Koch *et al.* 2013), as well as Backeberg in the 1960s, Ritter in 1970s and Ostolaza in 1998. Notably, Robert Cushman Murphy, an ornithologist from the American Museum of Natural History, is the only person to have systematically collected plants from Peru's 'guano islands' (September 1919 to February 1920), including the islands of Ica, namely Isla La Vieja (also known as Isla Independencia) and Isla Sangayán (or San Gallán) near Paracas, Pisco (Johnston 1931).

The first published lists of the flora of Ica began with the cursory government assessment (ONERN 1971ab). Ramón Ferreyra published species of relict dry forest and Lomas Marcona in Ica, before progressing to lomas of Arequipa (Atiquipa, Camaná, Chala, Islay, Jahuay, Méjia, Mollendo, Ocoña) (Ferreyra 1953, 1983). Studies of smaller geographic units in Ica were published as flora of: guano islands (Johnston 1931), riparian forest (Velásquez 1995), the Ica valley (Roque & Cano 1999) and Cerro Blanco, Nazca (León *et al.* 1997). Most recently, Whaley *et al.* (2010b) published an illustrated guide for the plants and vegetation of Ica (*Plantas y Vegetación de Ica, Perú*), which includes the principle vegetation types and species as an educational resource for conservation and restoration. A precursory analysis of Ica's flora and vegetation was also published (Whaley *et al.* 2010a), and a checklist for Peruvian lomas formations has been compiled (Dillon *et al.* 2012).

Other studies of arid southern Peru and Chile

Floristic studies for the south coast are published for Arequipa (Galán De Mera 2009, Montesinos-Tubée *et al.* 2015), Moquegua (Arakaki & Cano 2003, Montesinos-Tubée 2015 (Andean)), Tacna (Ferreyra 1962, Dillon 1997ab, Galán De Mera *et al.* 1997, 2001, Dillon *et al.* 2007, 2012), and Ayacucho (Roque & Ramírez 2008). Also relevant are studies of northern Chile, Arica and Tarapacá regions (Pinto & Luebert 2009); Pan de Azúcar National Park, Antofagasta (Rundel *et al.* 1996); and Parque Nacional Llullaillaco in the Chilean altiplano of Antofagasta region (Kalin-Arroyo *et al.* 1998). Ecological and phytogeographical studies have also focused on studying the Peru–Chile desert (Rundel *et al.* 1991, Dillon *et al.* 2003, Dillon *et al.* 2009, Galán De Mera 2009) and ENSO phenomena (Dillon & Rundel 1989, Ferreyra 1993, Manrique *et al.* 2010).

Few comprehensive vouchered checklists are available for coastal regions or reserves in arid desert regions of southern Peru and northern Chile. Table 1 provides a summary of checklists.

TABLE 1. Summary of floristic checklists for south coastal Peru and northern Chile.

	Area	Reference	Region	Elevation (m)	N° taxa	N° endemics
PERU	Lachay National Reserve, Chancay, Lima	Cano *et al.* (1999)	coastal	150–786	146	11 (8%)
	Ica Valley, Ica	Roque & Cano (1999)	coastal	250–1150	142	6 (7%)
	San Fernando National Reserve, Ica	Cano *et al.* (2005)	coastal	9–1780	87	24 (27%)
	San Fernando National Reserve, Ica	Arana *et al.* (2010)	coastal	200–1000	80	19 (24%)
	Río Acarí, Caravelí, Arequipa,	Montesinos & Mondragón (2013, 2016)	coastal	100–700	133	7 (7%)
	Peruvian coast and lomas	Dillon *et al.* (2011)	coastal	<1000	847	199 (24%)
	Lomas Yuta, Arequipa	Quipuscoa *et al.* (2016)	coastal	50–1000	183	37 (20%)
	Region of Tacna	León *et al.* (2004)	coastal, Andean	0–4700	708	92 (13%)
CHILE	Pan de Azúcar National Reserve, Antofagasta / Atacama	Rundel *et al.* (1996)	coastal	155	207	6 (3%)
	Arica and Tarapacá	Pinto & Luebert (2009)	coastal	50–1000	156	—

The unique hyperarid environment of the Ica region, has allowed excellent preservation of plant remains for archaeobotanical studies, providing insight into historical ecology alongside the sequence and effects of ENSO cycles and anthropogenic change (Rowe 1969, Roque *et al.* 2003, Cook and Parrish 2005, Piacenza 2005, Beresford-Jones *et al.* 2009ab, 2011ab, 2015, Cadwallader *et al.* 2012, Carmichael *et al.* 2014).

Publication aims and contents

The lack of a comprehensive checklist in the Ica region hampers the prioritisation of on-going conservation efforts and the implementation of management and research. The aim of this checklist, therefore, is to support further research and actions towards conservation and habitat restoration. Georeferenced duplicated herbarium vouchers serve as a reference baseline collection for this work. Here, we provide: i) a comprehensive checklist of vascular plants of the Ica region with information on distribution, life form, habitat, conservation status and endemism; ii) a preliminary list of nationally assessed or classified endangered species in lomas formations; iii) insight into agricultural biodiversity and genetic resources; iv) spatial information related to conservation designation and habitat restoration; vi) a vegetation map. We highlight habitats where further botanical research and ecological studies are needed.

Methods

The checklist

The checklist was assembled from a total of ca. 1800 plant specimens (3–6 duplicates) collected during a series of conservation, mapping, sustainable use and restoration projects. Among these projects are: bioarchaeological studies 2001–2002 (Cambridge University); the UK Darwin Initiative project 'Habitat restoration and sustainable management of southern Peruvian dry forest' (Royal Botanic Gardens, Kew (RBGK)); Trees for Cities 2005–2009; restoration, agrobiodiversity and lomas studies 2011–2013 (RBGK); and Sainsbury's project 'Sustaining agriculture and biodiversity of Ica' 2014–2017 (RBGK). Studies were conducted in collaboration with Universidad La Agraria, La Molina (MOL); Universidad San Luis Gonzaga de Ica (UNICA); SERNANP; Servicio Nacional Forestal y de Fauna Silvestre (SERFOR)—preceded by Instituto Nacional de Recursos Naturales (INRENA); Gobierno Regional de Ica. Supporting partners included: Agrícola Chapi, Agrokasa, Asociación para la Niñez y su Ambiente (ANIA), Barfoots, Sainsbury's, Samaca and Seatrade.

Collection localities were confined to the Ica region (21,328 km^2) extending up to the border with Arequipa, Ayacucho and Huancavelica regions at Ica's southern and eastern extension (Fig. 3 map). Standard protocols for plant collection were used; georeferenced locality, date, plant description and habitat, associated taxa, phenology and, where possible, ecological information about threats, pollination and dispersal, were recorded. From 2012, the smartphone mapping application Locus Pro™ was also used for plant collections, vegetation surveys and transects. This application proved an invaluable tool when combined with Google Earth, allowing georeferenced collection and photographs of species and habitat to be linked to a unique site or plot. Maps and processed predictive niche model projections and satellite imagery (including SPOT 1–7) were pre-loaded into Locus Pro™ to allow the niche model location of isolated and ephemeral populations.

Considerations for species conservation were of paramount importance. If a species was extremely rare in a locality, it was not collected. Over the research period, we were able to return to the same localities and collect specimens when seasonal or ENSO conditions induced flowering and proliferation. Off-road vehicles were driven only on official existing tracks and all transects and collection surveys were conducted on foot. Specimens were identified by the authors using available taxonomic revisions, monographs and floras, and by comparison with specialist-identified herbarium collections at E, HUSA, K, MOL (Forestal and Weberbauer), SGO, USM and WU. Family specialists at Kew were consulted (especially Gwilym Lewis, Nicolas Hind and Steve Renvoize, who provided continual support). Verification of species names and authors was based on the International Plant Names Index (IPNI, www.ipni.org), the Peru Checklist available on TROPICOS (www.tropicos.org) and The Plant List (www.theplantlist.org), together with recent taxonomic revisions and specialist recognition. Herbarium specimens were deposited in national (MOL, USM) and international (K, E) herbaria. All herbarium collections were databased and analysed in a spreadsheet to form the basis of the accompanying checklist (Appendix 1).

The checklist follows the Angiosperm Phylogeny III (2009) classification of families, while ferns and their allies follow Christenhusz and Chase (2014). The list is arranged by ferns and fern allies, then angiosperms. Within each group, taxa are arranged alphabetically by family and within families, then alphabetically by genus and species. Each taxon is arranged by: scientific name, growth form, habitat, lomas occurrence, species origin, conservation status, new records, elevation and selected vouchers. The growth form, habitat, lomas specificity and elevation were determined by *in situ* observations together with herbarium label information. Regional origin of species was taken from Brako and Zarucchi (1993) and *Flora of Peru* (Macbride 1936–1960). Conservation status of taxa follows IUCN threat categories (IUCN 2001), national assessments by Decreto Supremo 043–2006–AG (2006), García (2006), León *et*

al. (2006), Ostolaza (2003) and Särkinen *et al.* (2015). A taxon was considered as a new record to the Ica region if it was not reported by Brako and Zarucchi (1993), León *et al.* (2006), the Andean Botanical Information System (www.sacha.org), or any other published work citing voucher specimens from Ica. Preliminary conservation assessments were checked using field knowledge of threats; localities were further assessed using GeoCAT (http://geocat.kew.org/) (Bachman *et al.* 2011) and GBIF (http://www.gbif.org). All taxa in the checklist are documented with voucher specimens and standard herbarium acronyms (Thiers 2017). Occasionally some species (cacti) were recorded without herbarium vouchers; in these cases, literature citations or photographs are cited.

Common names

For the purposes of this checklist, we do not include all known common names; they can be found in Whaley *et al.* (2010b). We recognise that only 31 species in Ica have common names with ancient pre-Columbian Quechua or Aymara origins (see Soukup 1970, Sejuro 1990). We have sought to resuscitate and distinguish these names so that the wealth of accumulated ethnographic information held by older generations in rural communities can be best recorded. For this reason, we urge researchers to record common names that are falling into decline as rural communities become urbanised.

Monitoring and survey

Checklist vouchers are the result of monitoring to assess: (i) regional plant diversity, conservation priorities and distribution; (ii) habitat restoration; (iii) natural regeneration, disease and phenology post seasonal/ENSO flooding; and (iv) agrobiodiversity and cultivated species. Monitoring was carried out every 1–2 months in our project Ica valley restoration sites, including the local communities of San Pedro and Huarangal, and farm sites: Chapi (Fundo Don Ernesto), Agrokasa (Fundo La Catalina) and Chanca (Fundo La Portada). Quebradas and river valleys of the region were also targeted, including repeated monitoring of *Prosopis* die-back in Río Poroma, Nazca and other sites. Permanent plots were set up in the Lomas San Fernando and Lomas Amara using the following methodology. Plots were randomly selected from stratified vegetation bands (delimited by topography and elevation). Eight plots were located along two 8–9 km transects (Fig. 4), running inland from the coast in a north-easterly direction. Each plot measured 10 × 10 m and was temporarily sub-divided into four (using 8 mm white rope). From the central axis the orientation of the plot was aligned using a calibrated digital compass. Each plot's southern margin was orientated perpendicular to the south (and the prevailing wind). Corner points were established clockwise: NE (45°), SE (135°), SW (225°), NW (315°). Borders and corners were delimited temporarily with the rope and small flags (70 cm bamboo cane), used only for the purpose of demarcation during monitoring. The centre point and corners were marked accurately with GPS positioning using Locus Pro™ linked to a bluetooth Garmin GLO™ (±1 m accuracy). The centre point was marked using a 20 cm steel bar, hammered to ca. 10 cm below ground level and capped with a small protective cement disc. Points were marked with small pebbles for ease of relocation but avoiding attention disturbance. All plant species were collected in the elevation band (<30 m distant) around the plot. Within the plot, the number of individuals, size and percentage cover for each species were recorded, together with details of phenology. Minimal movement was made inside and around the plot to avoid compaction and disturbance. Of the four subdivisions, two were dedicated 'non-step' for comparison. All the plots were photographed from each corner with drone imaging overflights. The numbers of *Bostryx* spp. snail shells (dead or alive) were recorded within each plot quadrant as indicative of productivity and ENSO-related events. Other ecological notes were recorded, such as pollinators and birds observed, mammal scat and evidence of other fauna. The plot transects are presented here, along with the taxa and phenology recorded. Quantitative comparative analyses will be published after re-monitoring. Lomas Amara and San Fernando were monitored, with herbarium vouchers made, on nine occasions for several days at a time. Lomas Marcona and Morro Quemado were collected and surveyed less intensively, with three collecting trips made to each. Using calibrated dataloggers (Gemini Tinytag™), climatic observations were recorded in a number of locations including herein: Ica central valley (2007–2008) and lomas San Fernando (2013–2015) (Fig. 2, 6).

Climate niche analysis

A basic predictive climatic niche map was produced using georeferenced collection localities (herbarium vouchers) within the region, to gain an understanding of climatic affinities and species distribution. Predictions exploited potential occurrence for both submontane vegetation types using the Maxent model and the Bioclim data set (Phillips *et al.* 2004). This was used to highlight areas of Ica's (coastal arid) climatic niche, both in and outside the region. The environmental variable that contributed most to the model was BIO19 (Precipitation of Coldest Quarter) with some contribution from BIO14 (Precipitation of Driest Month).

Maximum entropy is used to predict species distributions from the probability estimates from point occurrence data based on a set of environmental constraints. It can also be used, as here, to predict the distribution of particular vegetation types by combining occurrence data for key indicator species of the vegetation type. Maxent software version 3.3.3e was used for this study, with 18 environmental layers from Bioclim (Hijmans *et al.* 2005) and spatial point data for the Ica collections below 1400 m, including those presented in this paper (representing the coastal arid vegetation ecotypes and aggregated bioclimatic zones). The model produced is a crude estimate of the probability of each georeferenced pixel having a similar niche (or climatic envelope) to the vegetation and species defined by the collection localities in Ica. The values range from 0 to 1, where 0 is the lowest probability and 1 highest.

Agrobiodiversity

A checklist of cultivated plants for the Ica region is presented in Appendix 2. This list was compiled following surveys made of 63 traditional *huertas* (smallholdings or seasonally flooded orchard plots) in the Ica region. These are located, approximately north to south, as follows: Sunampe, Chincha Valley, San José de Los Molinos, Salas Guadalupe, La Tinguiña, San Juan Bautista, Los Aquijes, Pachacútec, Pueblo Nuevo, Ocucaje, Subtanjalla, Santiago, Tate, Pampahuasi, Yauca del Rosario, Tingué and Huarangal. Additional surveys included huertas of the Nazca watersheds including: Pampa La Joya, Poroma, Vista Alegre, Valle Las Trancas, as well as small isolated huertas throughout Ica's watersheds. Prior informed consent and authorisation were obtained from smallholders for the surveys.

Information on the uses of plants was documented from landowners in the huertas during identification. An inventory of the plants cultivated was compiled, including all species of fruit trees and useful herbaceous plants. At the same time, wild species that may have established themselves naturally and were retained by the landowners, were also noted. Plants in huerta margins (ditches, irrigation canals) and their associated flora and fauna species were also registered. All data and survey information form part of a 'Red de Huertas' (huerta network) scheme (Sainsbury's project 2014–2017) which seeks to monitor change in traditional farming in order to protect and restore agrobiodiversity for ecosystem services and livelihoods into the future.

Results

1. The checklist

1.1. Floristic diversity

A total of 501 taxa are documented for the Ica region, representing 68 families and 283 genera (Appendix 1). An additional 45 species (Appendix 2) are excluded from the floristic analysis because they are largely cultivated or confined to traditional agricultural systems. Of the species identified, Eudicots represent the majority of species (79%), followed by Monocots (20%), Gymnosperms (0.5%) and Pteridophytes (0.5%) respectively (Table 2). Of these, 89% (447) are identified to species and 11% to genus level—several of which may represent new taxa.

TABLE 2. Diversity of families, genera and taxa recorded.

	Families	Genera	Taxa
Eudicots	56	227	396
Monocots	9	53	101
Gymnosperms	1	1	2
Pteridophytes	2	2	2
Totals	68	283	501

The most representative plant families (Table 3) are: Asteraceae (14.4%), Poaceae (14%), Fabaceae (9.4%), Solanaceae (9.4%), Malvaceae (5.2%), Cactaceae (4.6%), Amaranthaceae (3.6%), Boraginaceae (3.6%), Cyperaceae (2.4%), Convolvulaceae (2.2%), Bromeliaceae (2%) and Verbenaceae (2%). The remainder of families have less than ten species each (27.2%) (Table 3).

TABLE 3. Families richest in number of taxa and genera for the Ica region.

Family	Genera	Taxa
Asteraceae	43	72
Poaceae	39	70
Fabaceae	27	47
Solanaceae	14	47
Malvaceae	17	26
Cactaceae	14	23
Amaranthaceae	6	18
Boraginaceae	6	18
Cyperaceae	6	12
Convolvulaceae	5	11
Bromeliaceae	1	10
Verbenaceae	7	10
Euphorbiaceae	4	9
Apiaceae	4	8
Brassicaceae	5	8
Plantaginaceae	4	8
Caryophyllaceae	4	7
Lamiaceae	5	6
Nyctaginaceae	2	5
Oxalidaceae	1	5
Others	69	81

1.2. New records

Our results represent a significant contribution to the flora of Ica with a total of 297 new taxon records (59%) for the region. The most important families for new records are: Poaceae (48 taxa), Asteraceae (47 taxa), Fabaceae (27 taxa), Solanaceae (27 taxa), Cactaceae (14 taxa) and Malvaceae (13 taxa). The genera with the highest number of new records (four taxa or more) are, in descending order: *Solanum*, *Eragrostis*, *Paspalum*, *Senecio*, *Nolana*, *Euphorbia*, *Haagocereus*, *Cyperus*, *Dalea*, *Tillandsia*, *Boerhavia* and *Oxalis* (Table 4).

TABLE 4. Genera with highest number of new records for the Ica region.

Family	Genera	N° taxa
Solanaceae	*Solanum*	13
Poaceae	*Eragrostis*	6
Poaceae	*Paspalum*	6
Asteraceae	*Senecio*	5
Solanaceae	*Nolana*	5
Euphorbiaceae	*Euphorbia*	5
Cactaceae	*Haagocereus*	4
Cyperaceae	*Cyperus*	4
Fabaceae	*Dalea*	4
Bromeliaceae	*Tillandsia*	4
Nyctaginaceae	*Boerhavia*	4
Oxalidaceae	*Oxalis*	4

New families recorded for the region are: Campanulaceae, Caprifoliaceae, Clusiaceae, Crassulaceae, Equisetaceae, Krameriaceae, Linaceae, Lythraceae, Orchidaceae, Plumbaginaceae, Polemoniaceae, Primulaceae, Rubiaceae, Salviniaceae, Sapindaceae, Schoepfiaceae (Santalaceae) and Urticaceae.

1.3. Growth forms

Although it appears that the majority of the flora of Ica is composed of herbaceous plants, many have typical desert adaptations. The Eudicots often re-sprout from woody stems or root crowns and, when able to reach maturity in protected areas, can develop as small shrubs. Monocots are often long-lived geophytes sprouting from bulbs, stolons or tubers. In Ica, 77% of species are herbs (annual, biannual and perennial); shrubs represent 9%; trees represent 6%; cacti represent around 5%; with 2% being epiphytes (arboreal, arenic and lithophytic); and 1% climbers.

TABLE 5. Number and percentage of species according to growth form.

Growth form	N° taxa	% Flora of Ica
Herbs*	384	77%
Shrubs	46	9%
Trees	31	6%
Cacti	23	5%
Epiphytes	11	2%
Climbers	6	1%
Total	501	100%

**including a number of woody perennials*

1.4. Habitats

The dry forest and riparian relicts of Ica have relatively low plant diversity, with about 40 characteristic species centred around keystone trees (see above). This forest habitat is nonetheless, fundamentally important to the ecology, biodiversity and culture of the region, and as such, is described elsewhere (see Velásquez 1995, Roque & Cano 1999, Beresford-Jones *et al*. 2009ab, 2011; Whaley *et al*. 2010ab). Therefore, the principle forest species of conservation importance are elucidated in the checklist, whilst here, we focus on the other habitats and sites of plant diversity.

The most species-diverse habitats with approximate numbers of taxa are listed below (using local terms, with other known terms in brackets) (see Fig. 3 map, Table 6). Some species share different habitats, while lomas species are mostly confined to lomas. **(i)** 170 taxa—***quebradas*** (Andean dry valleys, pre-cordillera, *esteparia*) and ***huaycos*** (arroyo, bajada, ephemeral stream, outwash, wadi); **(ii)** 137 taxa—***lomas*** (herbaceous lomas, fog ecosystems, fog meadows, coastal cordillera); **(iii)** 115 taxa—***huertas*** (*chacra*, forest gardens, including acequias) and sunken irrigated fields (*hoyadas* or *pozas*); **(iv)** 65 taxa—***riparian*** (ribereño (alongside the rivers <50 m) with the wider term 'riparian oasis'); **(v)** 40 taxa—***dry forest*** relicts (bosque seco, monte, huarangal); **(vi)** 25 taxa– ***marsh*** (humedales, *puquio,* oases, estuaries, saltmarsh, bogs, springs); **(vii)** 20 taxa—***Andean*** (sierra, upland, alpine), these are typical higher elevation Andean species, found growing in lower elevation Ica; **(viii)** 20 taxa—***cactus scrub*** (matorral, dry monte with columnar cacti); **(ix)** 10 taxa—***Tillandsiales*** (*Tillandsia* lomas, achupallas, clavelines); **(x)** 10 taxa—***xerophytic scrub*** (steep rocky quebrada slopes), this class is rather indistinct with ENSO-related ephemerals (see discussion); **(xi)** 5 taxa—***Prosopis dunes*** (*huarangales,* bosque de dunas).

A distinguishing feature of the xerophytic scrub class is that they occur on hyperarid rocky slopes (with scree), out of reach of perennial or fluvial water. They are not lomas habitat and with few species of cacti. Indicator species include *Cnidoscolus pavonianus* (Müll.Arg.) Fern.Casas, *Melocactus peruvianus* Vaupel, *Orthopterygium huaucui* (A.Gray) Hemsl (upper slope), with *Bulnesia retama* (lower slope). Very rarely at decadal intervals, they receive rainfall to germinate perennials and produce a flush of episodic annuals.

FIGURE 3. Vegetation map of Ica. Showing: key vegetation types, national reserve (R.N.) protected areas, lomas, *Prosopis* forest relicts (low density), ancient *Prosopis* tree sites, collection localities, major rivers and towns. (illustration: OW with thanks to Justin Moat).

TABLE 6. Species richness per vegetation type.

Vegetation type	N° species
Quebradas and huaycos	170
Lomas	137
Huertas	115
Riparian	65
Dry forest	40
Marsh (humedale and puquio)	25
Andean *	20
Cactus scrub	20
Tillandsiales	10
Xerophytic scrub	10
Prosopis dunes	5

**Andean species found in lower elevation Ica*

1.5. Endemism and conservation value

Of the 501 taxa registered for the Ica region, at least 414 are native to Peru, with 97 (19%) being endemic to Peru. Around 50 (10%) appear to be introduced. 37 taxa (7%) were identified to genus level only. It is thought that the total number of native species will reach over 450 taxa. Table 7 summarises the number of endemic, native and introduced species per group. Of the 501 taxa, the conservation status of 128 species (26%) has been assessed nationally and internationally (Appendix 1), of which 58 (12%) have an assessment as endangered (VU, EN, CR); 11 of these are assessed as critically endangered.

TABLE 7. Number and percentage of endemic, native and introduced species recorded.

	Endemic to Peru	Native species	Introduced species	Unidentified species (genera only)
Pteridophytes	-	2	-	-
Eudicots	88	338	28	29
Monocots	9	72	22	8
Gymnosperms	-	2	0	-
Totals	**97** (19%)	**414** (62%)	**50** (11%)	**37** (7%)

TABLE 8. Number of endemic species per family recorded for the Ica region.

Family	N° endemic taxa
Solanaceae	17
Cactaceae	16
Asteraceae	14
Fabaceae	8
Poaceae	4
Apiaceae	3
Boraginaceae	3
Bromeliaceae	3
Caryophyllaceae	3
Others (19 families)	24
Total	**95**
Percentage endemism	**19%**

The percentage of endemic species per habitat was calculated for: cactus scrub, xerophytic slopes, lomas, quebrada and huayco, Andean, dry forest and huertas (Table 9), as a measurement of habitat uniqueness.

TABLE 9. Percentage of endemic species per habitat, for the Ica region.

Habitat	%
Cactus scrub	70%
Xerophytic slopes	42%
Lomas	38%
Quebradas and huaycos	34%
Andean	24%
Dry forest	13%
Huertas	4%

2. Lomas - species surveys

Of the 501 taxa registered and identified for the Ica region, 137 taxa occur in lomas ecosystems. Of these taxa, 37 (28%) are assessed as endangered (VU, EN, CR) with a risk of extinction in the wild. We identified 78 species in Lomas Amara and Ullujaya (LA), 68 species in Lomas San Fernando (LSF), 23 species in Lomas Marcona (LM) and 21 species in Lomas Morro Quemado (LMQ). Although the LA and LSF taxa were nearly all identified, 11 taxa in LMQ and 4 taxa in LMQ, remain at generic level, until we complete determinations (then being 32 LMQ and 27 LM). As outlined above, herbarium voucher collection was more intensive in Lomas Amara and San Fernando, than in Lomas Marcona and Morro Quemado.

2.1. Lomas Amara and Ullujaya

Of the 78 taxa documented, 66 (85%) are identified to species level and 12 (15%) to genus level only. A total of 61 taxa (78%) are herbs, 11 (14%) shrubs, two cacti and four epiphytes. A total of 38% taxa are endemic to Peru. A total of 27 (35%) have conservation assessments (Table 10), with 28% assessed as threatened (CR, EN, VU).

TABLE 10. Species with extinction risk assessments in Lomas Amara and Ullujaya.

Family	Species	Growth form	Conservation status
Amaranthaceae	*Atriplex rotundifolia* Dombey ex Moq.	shrub	[1]LC
Asteraceae	*Ambrosia dentata* (Cabrera) M.O.Dillon	shrub	[1]CR B1ab(iii), [4]CR
Asteraceae	*Lomanthus icaensis* (H.Beltrán & A.Galán) B.Nord.	herb	[1]CR B1a
Asteraceae	*Lomanthus okopanus* (Cabrera) B.Nord.	herb	[1]CR B1ab(iii), [4]CR
Boraginaceae	*Tiquilia ferreyrae* (I.M.Johnst.) A.T.Richardson	herb	[1]DD
Brassicaceae	*Dictyophragmus* aff. *lactucoides* (Förther & Weigend) Al-Shehbaz	herb	[1]CR B1a
Bromeliaceae	*Tillandsia landbeckii* Phil.	epiphyte	[3]VU
Cactaceae	*Haageocereus acranthus* (Vaupel) Backeb.	cactus	[2]LC
Cactaceae	*Haageocereus tenuis* F.Ritter	cactus	[2]CR B1ab(iii,v)+ 2ab(iii,v), [4]CR, [5]CR
Caryophyllaceae	*Drymaria paposana* Phil. var. *serrulata* J.A.Duke	herb	[1]VU B1ab(iii)
Ephedraceae	*Ephedra americana* Humb. & Bonpl. ex Willd.	shrub	[2]LC, [4]NT
Ephedraceae	*Ephedra rupestris* Benth.	shrub	[2]LC, [4]CR
Fabaceae	*Dalea smithii* (J.F.Macbr.) J.F.Macbr.	shrub	[1]LC
Fabaceae	*Hoffmannseggia miranda* Sandwith	herb	[1]EN B1ab(iii)
Fabaceae	*Poissonia weberbaueri* (Harms) Lavin	shrub	[1]EN B1a

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TABLE 10. (Continued)

Family	Species	Growth form	Conservation status
Geraniaceae	*Geranium limae* R.Knuth	herb	[1]VU B1ab(iii)
Krameriaceae	*Krameria lappacea* (Dombey) Burdet & B.B.Simpson	shrub	[4]EN
Malvaceae	*Palaua trisepala* Hochr.	herb	[1]EN B1a
Poaceae	*Jarava pachypus* Pilg.	herb	[1]VU B1ab(iii)
Schoepfiaceae	*Quinchamalium lomae* Pilg.	herb	[1]EN B1a
Solanaceae	*Leptoglossis lomana* (Diels) Hunz.	herb	[1]EN B1ab(iii)
Solanaceae	*Nicotiana paniculata* L.	herb	[1]LC
Solanaceae	*Nolana pallida* I.M.Johnst.	herb	[1]VU B1ab(iii)
Solanaceae	*Nolana pilosa* I.M.Johnst.	herb	[1]VU B1ab(iii)
Solanaceae	*Nolana tovariana* Ferreyra	herb	[1]EN B1a
Solanaceae	*Nolana willeana* Ferreyra	herb	[1]CR B1ab(iii)
Solanaceae	*Solanum edmonstonei* Hook.f.	herb	[2]DD, [6]VU (B1,2a)

[1]León *et al.* 2006, [2]IUCN, [3]Betancur & García 2006, [4]MINAG (2006) DS 043-2006-AG, [5]Ostolaza 2003, [6]Särkinen *et al.* 2015.

2.2. Lomas de Marcona

Of the 23 taxa registered, 20 (87%) are identified to species level and three (13%) to genus only. A total of 14 (61%) taxa are endemic to Peru, and three of these taxa are identified only to genus. Of the taxa registered, 17 (74%) are herbs, four (17%) are shrubs, with one cactus species and one epiphyte. A total of 12 (52%) hold conservation assessments (Table 11), with 39% presently assessed as threatened (CR, EN, VU).

TABLE 11. Species with extinction risk assessments in Lomas Marcona.

Family	Species	Growth form	Conservation status
Asteraceae	*Ambrosia dentata* (Cabrera) M.O.Dillon	shrub	[1]CR B1ab(iii), [4]CR
Amaranthaceae	*Atriplex rotundifolia* Dombey ex Moq.	shrub	[1]LC
Boraginaceae	*Tiquilia ferreyrae* (I.M.Johnst.) A.T.Richardson	herb	[1]DD
Brassicaceae	*Dictyophragmus* aff. *lactucoides* (Förther & Weigend) Al-Shehbaz	herb	[1]CR B1a
Bromeliaceae	*Tillandsia marconae* W.Till & Vitek	epiphyte	[3]EN
Cactaceae	*Corryocactus brachypetalus* (Vaupel) Britton & Rose	cactus	[2]EN
Fabaceae	*Weberbauerella raimondiana* Ferreyra	herb	[1]EN B1ab(iii), [4]CR
Malvaceae	*Palaua trisepala* Hochr.	herb	[1]EN B1a
Schoepfiaceae	*Quinchamalium lomae* Pilg.	herb	[1]EN B1a
Solanaceae	*Nolana pallidula* I.M.Johnst.	herb	[1]VU B1ab(iii)
Solanaceae	*Nolana spathulata* Ruiz & Pav.	herb	[1]NT
Solanaceae	*Nolana tomentella* Ferreyra	herb	[1]EN B1a

[1]León *et al.* 2006, [2]IUCN, [3]Betancur & García 2006, [4]MINAG (2006) DS 043-2006-AG

2.3. Lomas de Morro Quemado

Of the 21 taxa documented, 17 (81%) are identified to species, four (19%) to genus only. A total of five (24%) taxa are endemic to Peru, 11 (52%) are native and one introduced (*Sonchus oleraceus* (L.) L.). Of the taxa registered, 18 (86%) are herbs and three (14%) are shrubs. A total of five have been assessed for extinction risk (Table 12) and are presently assessed as threatened (CR, EN, VU).

TABLE 12. Species with extinction risk assessments in Lomas de Morro Quemado.

Family	Species	Growth form	Conservation status
Asteraceae	*Ambrosia dentata* (Cabrera) M.O.Dillon	shrub	[1]CR B1ab(iii), [4]CR
Ephedraceae	*Ephedra americana* Humb. & Bonpl. ex Willd.	shrub	[2]LC, [4]NT
Geraniaceae	*Geranium limae* R.Knuth	herb	[1]VU B1ab(iii)
Schoepfiaceae	*Quinchamalium lomae* Pilg.	herb	[1]EN B1a
Solanaceae	*Solanum edmonstonei* Hook.f.	herb	[2]DD, [6]VU (B1,2a)

[1]León *et al.* 2006, [2]IUCN, [4]MINAG (2006) DS 043-2006-AG, [6]Särkinen *et al.* 2015.

2.4. Lomas San Fernando

Of the 68 taxa documented, 63 (89%) are identified to species level and eight to genus only. A total of 29 (41%) taxa are endemic to Peru with one introduced (*Sonchus oleraceus*). Of the taxa registered, 52 (73%) are herbs, eight are epiphytic, six shrubs and five cacti. Of the 29 endemic taxa, *Onoseris humboltiana* is the only narrow endemic we have recorded that is restricted solely to Lomas San Fernando (see Appendix 1 checklist, Fig. 9). A total of 32 taxa (45%) have had their extinction risk assessed (Table 13) with 31% presently assessed as threatened (CR, EN, VU).

TABLE 13. Species with extinction risk assessments in Lomas San Fernando.

Family	Species	Growth form	Conservation status
Amaranthaceae	*Alternanthera albotomentosa* Suess. var. *albotomentosa*	herb	[1]NT
Amaranthaceae	*Atriplex rotundifolia* Dombey ex Moq.	shrub	[1]LC
Apiaceae	*Domeykoa saniculifolia* Mathias & Constance	herb	[1]EN B1ab(iii)
Apiaceae	*Eremocharis piscoensis* Mathias & Constance	herb	[1]EN B1ab(iii)
Asteraceae	*Ambrosia dentata* (Cabrera) M.O.Dillon	shrub	[1]CR B1ab(iii), [4]CR
Asteraceae	*Onoseris humboldtiana* Ferreyra		[1]DD
Asteraceae	*Senecio calcicola* Meyen & Walp.	herb	[4]CR
Brassicaceae	*Dictyophragmus englerianus* (Muschl.) O.E.Schulz	herb	[1]EN B2c(i,ii)
Bromeliaceae	*Tillandsia marconae* W.Till & Vitek	epiphyte	[3]EN
Bromeliaceae	*Tillandsia paleacea* C.Presl	epiphyte	[3]DD
Bromeliaceae	*Tillandsia recurvata* (L.) L.	epiphyte	[3]LC
Cactaceae	*Cumulopuntia sphaerica* (C.F.Först.) E.F.Anderson	cactus	[2]LC, [5]EN
Cactaceae	*Cylindropuntia tunicata* (Lehm.) F.M.Knuth	cactus	[2]LC
Cactaceae	*Eriosyce islayensis* (C.F.Först.) Katt.	cactus	[1]LC, [2]NT
Cactaceae	*Haageocereus decumbens* (Vaupel) Backeb.	cactus	[2]LC
Cactaceae	*Haageocereus tenuis* F.Ritter	cactus	[2]CR B1ab(iii,v)+ 2ab(iii,v), [4]CR, [5]CR
Caryophyllaceae	*Spergularia congestifolia* I.M.Johnst.	herb	[1]EN B1a
Ephedraceae	*Ephedra americana* Humb. & Bonpl. ex Willd.	shrub	[2]LC, [4]NT
Fabaceae	*Poissonia weberbaueri* (Harms) Lavin	shrub	[1]EN B1a
Fabaceae	*Weberbauerella brongniartioides* Ulbr.	shrub	[1]EN B1ab(iii), [4]CR
Fabaceae	*Weberbauerella raimondiana* Ferreyra	herb	[1]EN B1ab(iii), [4]CR
Krameriaceae	*Krameria lappacea* (Dombey) Burdet & B.B.Simpson	shrub	[4]EN
Malvaceae	*Cristaria multifida* Cav.	herb	[1]VU B1ab(iii)
Malvaceae	*Palaua trisepala* Hochr.	herb	[1]EN B1a
Oxalidaceae	*Oxalis lomana* Diels.	herb	[1]NT
Solanaceae	*Leptoglossis ferreyraei* Hunz. & Subils	herb	[1]EN B1ab(iii)
Solanaceae	*Nolana pallida* I.M.Johnst.	herb	[1]VU B1ab(iii)
Solanaceae	*Nolana pilosa* I.M.Johnst.	herb	[1]VU B1ab(iii)
Solanaceae	*Nolana plicata* I.M.Johnst.	herb	[1]VU B1ab(iii)
Solanaceae	*Nolana thinophila* I.M.Johnst.	herb	[1]VU B1ab(iii)
Solanaceae	*Nolana tovariana* Ferreyra	herb	[1]EN B1a
Solanaceae	*Solanum edmonstonei* Hook.f.	herb	[2]DD, [6]VU (B1,2a)

[1]León *et al.* 2006, [2]IUCN, [3]Betancur & García 2006, [4]MINAG DS 043-2006-AG, [5]Ostolaza 2003, [6]Särkinen *et al.* 2015.

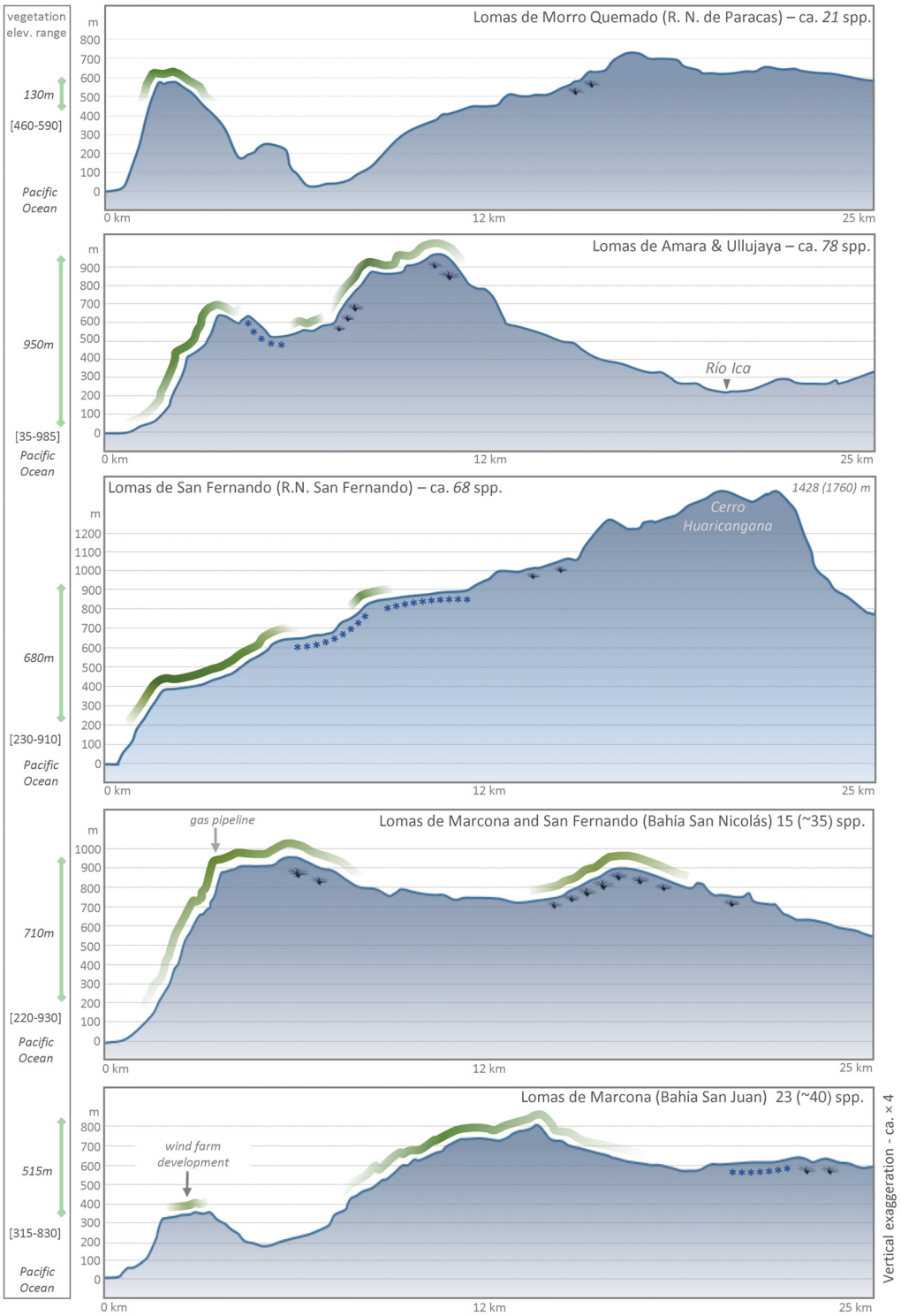


FIGURE 4. Vegetation survey transects of coastal lomas of Ica. Vegetation survey transects (25 km), run perpendicular westwards from Pacific Ocean (from prevailing wind), towards Andes. The green floating contour band indicates vegetation presence, with tone density, indicating approximate species richness. The starting point of each transect was as follows: **LMQ** (Lomas Morro Quemado)—14˚21’38.21”S / 76˚7’14.46”W, **LA** (Lomas Amara, Ullujaya)—14˚45’55.13”S / 75˚45’21.87”W, **LSF** (Lomas de San Fernando)—15˚9’3.87”S / 75˚18’50.03”W, **LM** (Lomas Marcona) (BSN)—15˚12’1.20”S / 75˚14’4.94”W, **LM** (BSJ)—15˚25’42.20”S / 75˚4’48.97”W. The plant symbol indicates vegetation predominated by *Tillandsia* species; asterisks (⁎⁎⁎) indicate areas of highly ephemeral vegetation with *Nolana* spp. seed and responsive to freak rainfall during ENSO cycles. The number of taxa collected (and identified) for each lomas is indicated after its name, with approximate expected number of species for Lomas Marcona (with restricted access due to mining operations). Names and development infrastructure are indicated. Column (left) indicates the elevational range of lomas vegetation. (illustration: OW).

3. Lomas - vegetation surveys

3.1. Lomas types

By conducting a series of transects (Fig. 4), we were able to ascertain the spatial distribution and classes of lomas vegetation along 25 km inland trajectories. Lomas habitats in Ica (see Fig. 3 map) can be divided into three classes for both coastal and Andean topography (Table 14). The criterion for classes are: Herbaceous—characterised by the presence of perennial woody species, Tillandsiales—characterised by dominance of *Tillandsia* species in ridge clump formations, and Ephemeral lomas—characterised by annual species appearing after sporadic periods of ENSO rainfall.

TABLE 14. Classes of Lomas vegetation in Ica.

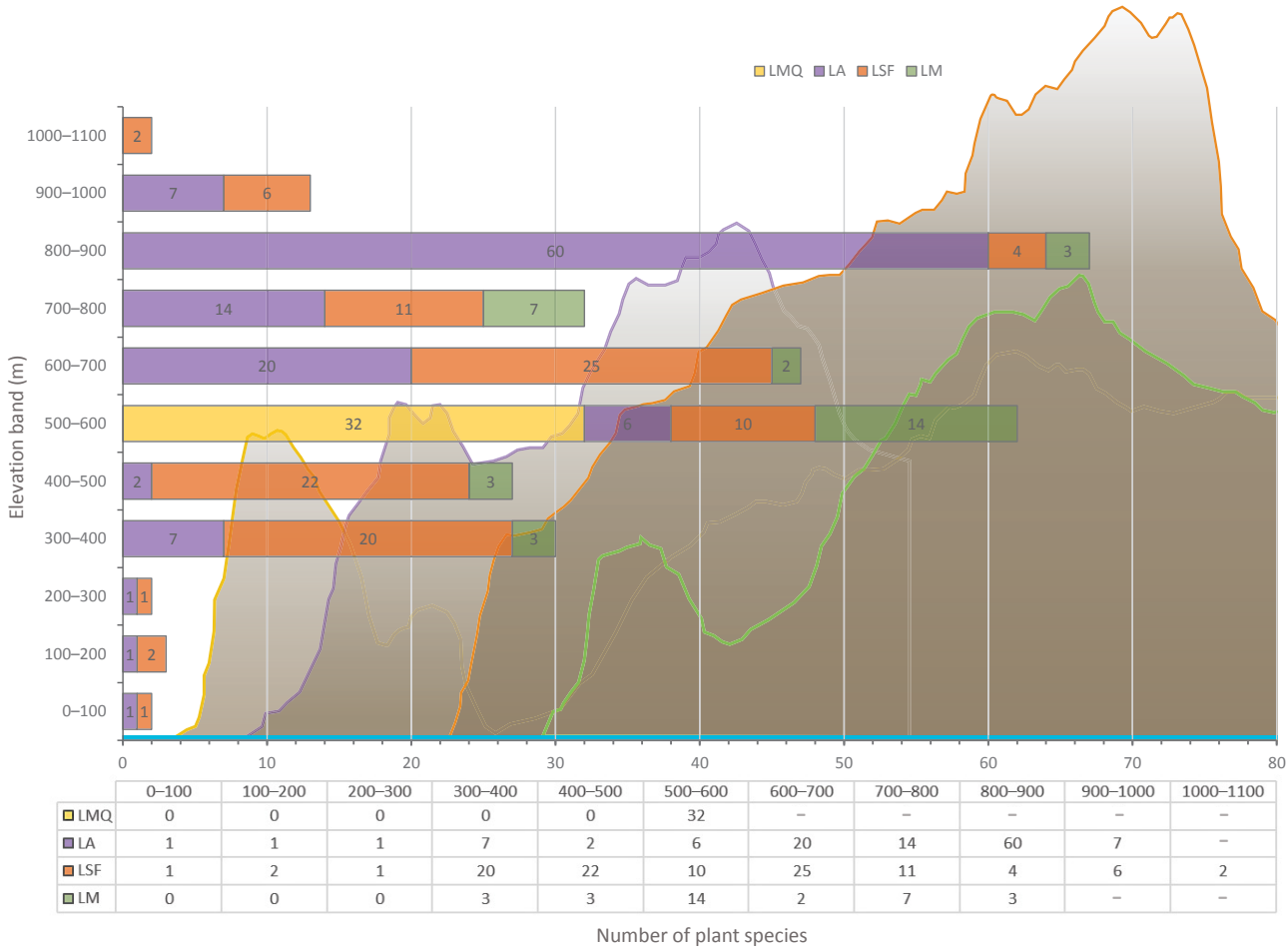
Class		Distance inland (ca. km)	Location, elevation	Characterised by
Herbaceous	Coastal lomas	0.5–12	Coastal western-facing hills (80–950 m)	perennial woody species
Ephemeral / EN sporadic	Coastal lomas	0.2–12	Coastal hills / inclines, elevated plains (50–950 m)	sporadic ephemerophyte species
Tillandsiales	Coastal lomas	7–24	Coastal hills / inclines (450–1100 m)	perennial *Tillandsia* spp.
Herbaceous	Andean lomas	14–38	Andean western-facing slopes (500–1700 m)	perennial woody species
Ephemeral / ENSO sporadic	Andean lomas	14–38	Andean western-facing slopes (500–1700 m)	sporadic ephemerophyte species (among cactus scrub)
Tillandsiales	Andean lomas	14–27	Andean western-facing slopes (350–1000 m)	perennial *Tillandsia* spp.

In Ica, coastal lomas vegetation rarely occurs at elevations above 1100 m. Only Lomas San Fernando exceeds this elevation (with an inclined plateau from 920 m rising to Cerro Huaricangana at 1790 m) where *Tillandsia latifolia* occurs. The occurrence of lomas vegetation was observed to be intrinsically related to fog formation (or stratus clouds), topography and aspect (see Oka & Ogawa 1984ab), together with other interrelated factors including humidity, dew point, wind speed, sea temperature, atmospheric pressure and marine-generated aerosols. These factors contribute to determining the development of herbaceous and *Tillandsia* coastal lomas. Hence, individual lomas formations support distinct vegetation according to topography, elevation and distance from the sea (see Figs. 4, 5), although edaphic limitations remain.

3.2. Lomas topography and appearance

The transect surveys ascertained that the frontal coastal topography restricts the extent of fog penetration and hence inland lomas (see Fig. 4 and 5). Biodiversity is concentrated at elevational bands specific to each lomas. Lomas de Morro Quemado vegetation, for example, is densely concentrated at 500–550 m elev. due to a vertiginous cliff generating rapid uplift of inshore wind, concentrating orographic fog on its southern side (see Fig. 5). Distance from the shoreline is also a key factor; likewise, the distance from the fog-generating cold currents (SST) is another, albeit less discernible, factor. Herbaceous lomas occurs as its highest biomass and diversity at 400–700 m elev. in Lomas San Fernando (see Fig. 5), then declining rapidly inland up to 900 m elev. where expanses of desert pavements appear with isolated clumps of *Haageocereus* spp. and *Eriosyce islayensis* cacti (ca. 20–100 m apart). Using random test pits across this area (680–900 m elev.), we found the ubiquitous presence of dead root matrices. This discovery was corroborated by local fisherman recounting how vegetation had appeared after El Niño rainfall, during the very strong ENSO events of 1982–1983 and 1997–1998. We classed these expanses as 'highly ephemeral lomas' ecosystems (see Figs. 3 & 9 in Beresford-Jones *et al.* 2015). These ephemeral lomas are also characterised by the presence of surface 'desert pavement' layers of *Nolana* seed and other annuals. *Nolana* spp. were only observed germinating seasonally in small numbers where clumps stabilised by cactus (*Haageocereus* spp.), as phytogenic mound communities, are able capture the fog drifting across flat pampas. The rocky frontal cliff in Lomas Amara provides rock refugia (230–580 m elev.) for plant communities, with the majority of species concentrated from 630 to 880 m elev. (see Fig. 5). On rocky lomas peaks, wind vortices concentrate fog to sustain lichen-rich outcrops of herbaceous lomas at 890–930 m elev. In a few extremely rare locations at 550 m elev., on loose powdery substrates (a desert loess with a thin crust or pavement), microclimatic conditions permit the formation of monotypic lichen meadows where no vascular plants are found. This phenomenon is encountered widely in the Namib Desert but is extremely rare in Peru. These 'meadows'

are largely composed of fruticose lichens including the bright orange *Teloschistes peruensis* (Ach.) J.W.Thomson, and where Ramalinaceae and Teloschistaceae appear to dominate (see Rundel 1978, Thomson & Iltis 1968). This is the first record of the species in Peru since its description from Camaná in 1968 (Thomson & Iltis 1968) (pers. comm. Ester Gaya, Reinaldo Vargas, Peter Nelson and Daniel Stanton).



	0–100	100–200	200–300	300–400	400–500	500–600	600–700	700–800	800–900	900–1000	1000–1100
LMQ	0	0	0	0	0	32	–	–	–	–	–
LA	1	1	1	7	2	6	20	14	60	7	–
LSF	1	2	1	20	22	10	25	11	4	6	2
LM	0	0	0	3	3	14	2	7	3	–	–

FIGURE 5. Number of taxa within elevational (100 m) contour belts in lomas of Ica (arranged north to south). **LMQ** (Lomas Morro Quemado) 21 identified species (32 total); **LA** (Lomas Amara and Ullujaya) 78 species; **LSF** (Lomas de San Fernando) 68 species; **LM** (Lomas de Marcona) 23 species. The sum of species in all four lomas within each belt is shown on *x* axis. Note this is *not* related to biomass (e.g. *Tillandsia* are low diversity with high biomass) and several taxa occur in more than one band. Some error exists due to collection bias. The lomas profiles are a scaled representation with vertical exaggeration ca. × 8 (see Fig. 4), outline colour corresponds with lomas representation in horizontal column. (illustration: OW).

3.3. Tillandsia lomas

The transect of Lomas de Marcona (the southern section—can also be referred to as Lomas San Fernando) was dominated by *Tillandsia* species, especially *T. latifolia* (with mixed stands of *T. marconae* and *T. purpurea* at mid-altitude) found at around 700 m elev. with marginal stands extending to 1180 m elev. and 21 km inland. Here, the elevation of frontal lomas blocks and deflects fog, restricting herbaceous lomas development. *Tillandsia latifolia* and *Tillandsia* spp. were also found dead and decaying over large swathes of several hundred hectares. It is unclear why this is happening; it may be related to natural shifts of dune topography or the influence of climate change on fog development, or equally related to a change in fog composition due to adjacent mining activities (Warhurst 1999). All transects and surveys revealed that herbaceous coastal lomas, rarely occurs more than 12 km inland (Fig. 4), but small isolated populations of *Tillandsia latifolia* and foliose lichens are found on the elevated yardang ridges, 18 km inland. The biggest *Tillandsia* formations in Ica occur inland on the Andean foothills, north-east of Pisco (22 km inland, 500 m elev.) and at Chincha (14 km inland, 280 m elev.). These extend up to around 900 m elev. and 28–30 km inland, and are composed of *T. latifolia*, *T. paleacea* and *T. purpurea*. Here, *T. paleacea* grows in uniform crescent formations and differs from the dune formations of *T. latifolia* (see Hesse 2014). This extensive unprotected area of *Tillandsia* vegetation, is sustained by inland penetration of marine-generated fog and the absence of blocking coastal

ridges. Sandy substrates unusually also support *Tillandsia* in these areas, alongside quebrada species at the rocky margins, including: *Alternanthera pubiflora* (Benth.) Kuntze, *Atriplex rotundifolia* Dombey ex Moq, *Hoffmannseggia viscosa* Hook. & Arn., *Nolana* spp., *Solanum chilense* Dunal, *Tarasa operculata* (Cav.) Krapov., and the cacti *Eriosyce islayensis* (C.F.Först.) Katt., *Haageocereus acranthus* (Vaupel) Backeb. and *Mila caespitosa* Britton & Rose.

3.4. Lomas climate

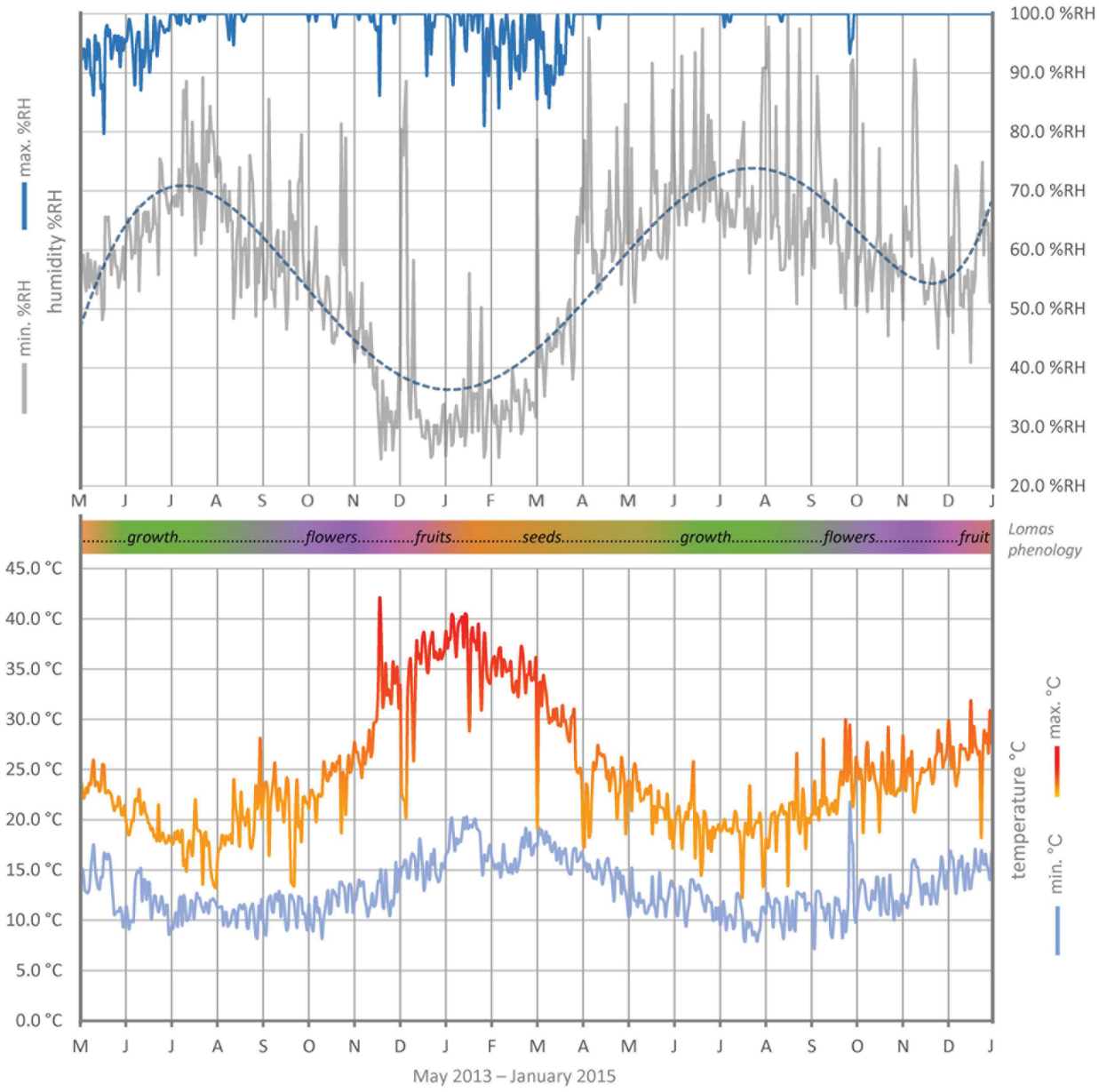


FIGURE 6. Climate of lomas. Data derived from calibrated datalogger readings from herbaceous lomas vegetation (May 2013—January 2015) at 435 m elev. in Lomas San Fernando, showing: Annual maximum and minimum relative humidity (%RH) and temperature (˚C). The temperature spike (red) is thought to be anomalous and associated with the year prior to ENSO. The phenology is indicative and derived from monitoring and collection vouchers. (illustration: OW).

A calibrated datalogger was installed in lomas vegetation (435 m elev.) and set to record ambient climate at 50 cm above ground, on a linear dune in LSF. Running successfully only from May 2013 to January 2015, we recorded an atypical (prior to ENSO), poorly defined fog season from May to November, with a dry season from December to April

(Fig. 6). Relative humidity reached over 90% RH every day throughout the year, except in the peak dry season from February to March (2014). We recorded a constant annual minimum nocturnal temperature range that did not drop below 7.5˚C. During the summer months (January–April), minimum nocturnal temperature remained above 15˚C. Maximum winter temperatures rarely exceed 25˚C until October. However, during the summer 2013–2014 (November–March), a maximum diurnal temperature of over 35˚C was recorded, reaching a peak of 42˚C (Fig. 6). In 2014, LSF failed to develop, with most plants remaining in a dormant and/or senescent state. This appears to be a regular mode of LSF, related to the temperature of ocean currents and the circulation of counter-currents within Bahía San Fernando (Fig. 3). However, 2014 was atypical prior to the 2014–2016 El Niño. During seven years of fieldwork, we observed only a single year of full flowering of herbaceous lomas in LSF, during 2012. The lomas flowered only moderately in 2000 and in 2010. As these were La Niña years (weak–strong), we tentatively suggest that LSF could be highly responsive to La Niña (cooler) conditions. Local fisherman (pers. comm.) suggest that the lack of lomas development is not a recent phenomenon attributable solely to climate change. They also recount that during the exceptional 1997–1998 ENSO event, LSF developed 'knee-high' flowering meadows across the wide areas described above.

4. Agrobiodiversity and traditional farming

In the Ica valley the cultivated area is about 65,000 ha (including groundwater irrigation), of this, around 70% is turned over to industrial export agriculture and around 5 % remains as huertas. Traditional farming in Ica is largely conducted in irrigated sunken fields known as huertas and/or chacras, in the valley floodplain. After exceptional El Niño flooding, more extensive areas of marginal land (held by *comunidades campesinas* or privately) can also be irrigated for single cropping of maize, chickpeas, pumpkin or beans. This spontaneous farming is rarely witnessed and only during some El Niño events, but bajadas and valley shoulder margins retain a relictual matrix of irrigation canals and raised border fields—some with pre-Columbian origin. In Ica, as in other arid coastal valleys, the huerta depends on seasonal river water for productivity, is usually <2 ha and located alongside dwellings for production of crops for domestic consumption. Huertas have a range of permanent fruit trees around which seasonal crops and herbs are produced for food, medicine and some ornamental purposes. The chacra is usually larger (<5 ha) and can be an extension of the huerta, or equally at some distance from houses and owners. Both are irrigated by flooding when water is abundant and/or through furrow channels (*surcos*) when limited. The chacra may be open or bordered with native trees and acequias. Following seasonal inundation, the chacra is dedicated to production of crops such as beans, maize, pumpkin, cotton, sweet potato and (historically) peanuts, and can include smaller 'pan llevar' crops for the house.

For the purposes of the map (Fig. 3), we do not highlight huertas (or chacras) in the 'cultivated' classification as they are relatively small and currently merge into large expanses of industrial agriculture. Huertas are nearly always confined to the reach of irrigation canals, whereas industrialised agriculture uses pumped groundwater (and some seasonal filtered river water) for crop export production and is able to occupy valley margins (Fig. 3). Some smallholder farmers with economic resources may purchase pumped groundwater by the hour, or establish their own wells for pumping in years when the river water fails. Following the *Reforma Agraria* (1969), a few rural communities manage to maintain the large diesel pumps (including Perkins diesel) installed by the previous hacienda owners. In the Río Pisco and parts of Río Grande, with perennial river flow, river irrigation and shallow wells are used more extensively for crops destined for domestic use and limited export. Throughout the Ica region, many huertas have pre-Columbian origins and are flooded via complex acequias systems, such as La Achirana (del Inca) that, despite its name, has pre-Columbian roots (Ore 2005).

A total of 127 cultivated species, were recorded in 63 huertas (Appendix 2); of these, 79 (69%) species were introduced and 48 (38%) are native. Around 44 native species have been long cultivated in Peru, while around 30 species (24%) have been cultivated since pre-Columbian times, as evidenced by bioarchaeological studies cited. Some of these species represent genotypes of high conservation importance adapted to Ica's soil and climate. Trees represent 39% of cultivated species, shrubs 14%, herbs 45% and cactus 2% (Table 15). Three of the introduced species are highly damaging invasives, namely, *Acacia karroo* (used for spiny barrier fencing), *Ricinus communis* (a relic of the castor oil industry) and *Tamarix aphylla*, the latter two having already invaded large areas of the Ica region (Whaley *et al.* 2010ab).

The top twenty predominant species found in huertas are shown in Table 16. Notably, mango (*Mangifera indica* L.) with over ten varieties, was found in 90% of huertas. Distinct varieties of pacay (*Inga feuillei* DC) (see checklist) were found in 62%. Given the introduction of grapes (*Vitis vinifera* L.) during the 16th c. for production of Pisco and wine, and today's industrial table-grape production, their presence in 78% of the huertas sampled is unsurprising.

TABLE 15. Summary analysis of cultivated species found in huertas surveyed in Ica.

Huerta species	N° species	%
Total number of cultivated species	127	–
Introduced to Peru	79	69%
Native to Peru	48	38%
Present in pre-Columbian huertas	30	24%
Crop habit type		
Tree	49	39%
Shrub	18	14%
Herb	57	54%
Cactus	3	2%

TABLE 16. Huerta species with the highest frequency of occurrence in 63 huertas surveyed.

Huerta species	Common name	Frequency	%	Origin*
Mangifera indica L.	mango	57	90	OW
Vitis vinifera L.	uva	49	78	OW
Persea americana Mill.	palta	44	70	MCA
Musa × *paradisiaca* L.	plátano	43	68	OW
Inga feuillei DC.	pacay	39	62	P
Citrus limon (L.) Osbeck	limon	38	60	OW
Carya illinoinensis (Wangenh.) K.Koch	pecano	36	57	NA
Citrus sinensis (L.) Osbeck	naranja	33	52	OW
Carica papaya L.	papaya	32	51	MCA
Spondias purpurea L.	ciruela, jocote	31	49	MCA
Punica granatum L.	granada	28	44	OW
Annona cherimola Mill.	chirimoya	22	35	P
Ficus carica L.	higo	22	35	OW
Opuntia ficus-indica (L.) Mill.	tuna	21	33	MCA
Annona muricata L.	guanábana	20	32	P
Manihot esculenta Crantz	yuca	18	29	P (Brazil)
Cajanus cajan (L.) Millsp.	frejol palo	17	27	OW
Citrus reticulata Blanco	mandarina	17	27	OW
Ipomoea batatas (L.) Lam.	camote	17	27	P
Phoenix dactylifera L.	dátil	15	23	OW

**OW: Old World, MCA: Mexico and Central America, P: Peru, NA: North America*

We also recorded the following native tree species: *Annona cherimola* Miller, *Annona muricata* L., *Bixa orellana* L., *Bunchosia armeniaca* (Cav.) DC., *Piper aduncum* L., *Pouteria lucuma* (Ruiz & Pav.) Kuntze, *Psidium guajava* L., *Sapindus saponaria* L., *Tara spinosa*. Alongside irrigation canals, traditionally grown starchy tubers were found: *Canna indica* L., *Ipomoea batatas* (L.) Lam., *Manihot esculenta* Crantz. All these species are in declining use due to the urbanisation and removal of irrigation canals.

The ancient pre-Columbian introduction, avocado (*Persea americana* Mill.) (see Galindo-Tovar *et al.* 2008), was found in 70% of huertas. We also found Mexican or Central American species including: *Spondias purpurea* L. (49% of huertas) and *Opuntia ficus-indica* (L.) Mill. (33%) and very rarely, *Casimiroa edulis* La Llave (1%). From the Old World (Asia and Africa), we commonly found *Cajanus cajan* (L.) Millsp., *Jatropha curcas* L., *Mangifera indica* L.,

Melia azedarach L. (supposedly introduced to produce insecticides during the colonial period), *Musa* × *paradisiaca* L., *Phoenix dactylifera* L., *Punica granatum* L. and *Tamarindus indica* L., most of which provide vital nutritional and medicinal resources.

The North American *Carya illinoinensis* (Wangenh.) K.Koch has become a highly successful introduction to Peru, and today Ica produces the majority of the Peruvian pecan nut. The pecan was introduced to Peru in the 1920s with genetically variable grafts from the US planted in Estación Experimental Agrícola de La Molina. Most of these plants died, but some re-sprouted from roots and by 1965, were productive. From these, the varieties 'Stuart' and 'Mahan' were selected. Central arid Ica was found to be ideal for Mahan, while Stuart thrived in the cooler north of Ica (pers. comm. Klaus Bederski).

Notably, over 161 non-cultivated plants are also found in huertas and used in traditional agriculture. Of these, 114 taxa (71%) are native and/or endemic to Peru.

Discussion

1. The checklist

Floristic diversity and distribution

Published floristic checklists for the Ica region enumerate around 142 plant taxa (Roque & Cano 1999, Cano *et al*. 2005, Arana *et al*. 2010). Our results increase the total number of recorded vascular plant species in the Ica region to 501 (with 95 endemics), the details of which are provided in the checklist, with current information regarding their taxonomy, distribution, habitat and conservation status (Appendix 1). This study highlights the floristic importance of the region, with the first comprehensive species list detailing their habitats and individual lomas assemblages. The number of species is comparable to that of other arid south coast regions (see Table 1), but these are usually without vouchers and include high elevation species outside the confines of Ica, constraining useful comparison.

It is notable that Andean quebradas have higher species diversity than lomas (Table 6) but are subject to least research, and that the highest percentage of endemism per habitat (Table 9) is found cactus scrub, whereas lomas supports the highest number of endemic species.

Tree species

The Ica region is home to surprisingly few tree species. This is especially noticeable when compared to the seasonal dry forest of northern Peru. Ica has around 30 native tree or large shrub species—6% of the total flora (Table 5). Tree diversity is consistent with the hyperarid coasts of southern Peru and Chile (7°–30°S). Arid conditions prevent easy inward migration and colonisation, while many shrubs and trees have evolved episodic reproductive systems connected to ENSO cycles (see Squeo *et al*. 2007). With only rare flooding and no significant rainfall, physical size and reproductive opportunities are constrained. Woody desert plants tend to be long-lived species, requiring less frequent establishment events (Schaffer & Gadgil 1975 in Arroyo *et al.* 1988), but also making them highly vulnerable to degradation. Key species such as *Prosopis limensis* in Ica, may be able to live for well over 1000 years (see Fig. 12) (Beresford-Jones *et al*. 2009a, Whaley *et al.* 2010a). Trees in Ica survive a tenuous existence, where fuel and cultivatable land have been in short supply for millennia. In the checklist, we highlight five tree species of conservation priority: *Bulnesia retama* (Gillies ex Hook. & Arn.) Griseb, *Capparis avicennifolia* Kunth, *Inga feuillei* DC., *Maytenus octogona* (L'Hér.) DC., and *Prosopis limensis* Benth.

Key Plant families

The most species-rich families in the region (Table 3) are: Asteraceae, Poaceae, Fabaceae, Solanaceae, Malvaceae (not discussed here) and Cactaceae. Endemism is highest in Solanaceae (17%), with specialised lomas and quebrada species. Cactaceae also share a high endemism with 16% of taxa. Both families are often dependent on animals for seed dispersal; conversely, Asteraceae has a disproportionally low number of endemic taxa (14%) with the majority of species producing vagile wind-blown seed.

Asteraceae (Compositae) are the second most diverse family within the Peruvian flora (Beltrán *et al*. 2006). To the west of the Andes, on the coast, puna and western slope ecosystems, this is the most species-rich family (Cano *et al*. 1999, 2010, 2011, Gonzáles 2015, 2016). Our study places Asteraceae as the richest plant family in the Ica region (14% of Ica's flora). The family is in great need of taxonomic revision in Peru, with 24% of the Ica region's taxa presenting identification problems to specialists, including the genera: *Grindelia*, *Jungia*, *Senecio* and *Viguiera.*

Importantly in Ica, a region dependent on agriculture, a handful of Asteraceae species perform critical ecosystem services in riparian habitat (see Table 6). The multi-stemmed woody shrubs *Baccharis salicifolia* (Ruiz & Pav.) Pers. and *Tessaria integrifolia* Ruiz & Pav. play an essential role in controlling erosion by protecting riparian borders and regulating streamflow. They also serve as a principle nectar source for native insects and honey production (Whaley *et al.* 2010, 2011), especially following the collapse of *Prosopis* nectar with forest die-back in the region (Whaley 2009, 2010a, Baena *et al.* 2017). Their mobile wind-blown seeds can rapidly colonise saline seeps and riverbanks after flooding, but increasingly have to compete with *Tamarix aphylla*. Yetman & Van Devender (2002) record *B. salicifolia* being used for arrows and soap by the Mayo indigenous people in the Sonoran Desert, while Felger & Moser (1985) document its use by the Seri people for making beads from the stems and using the leaves for medicinal tea, dieting, contraception and a remedy for headaches. These valuable proxy ethnographical records in North America indicate the huge loss of pre-Columbian ethnobotanical knowledge following the Hispanic conquest; little such knowledge is found in Ica today. The two woody perennial shrubs *Trixis cacalioides* (Kunth) D.Don and *Encelia canescens* Lam. play similar roles in erosion control along ephemeral streams, across Andean outwashes and in quebradas. *T. cacalioides* grows on the arid coast of Peru and western Argentina. *E. canescens* is confined to the coast of Peru and northern Chile. They provide essential habitat of 'nectar corridors' for migrating pollinators and dispersers. Around 120 species of Hymenoptera have been recorded on these species in Ica, along with Lycaenidae and Hesperiidae butterflies. The corridors also represent excellent habitat for reptiles (*Dicrodon heterolepis*, *Microlophus peruvianus* and *Pseudalsophis elegans*), Andean fox (*Lycalopex culpaeus*) and the South American gray fox (*Lycalopex griseus*) (Sainsbury's Project 2014–2017, Ormeño *et al.* 2017). These species are inherently adapted to desert vegetation corridors and episodic existence.

The very rare lomas endemics, *Encelia* aff. *pilosiflora* S.F.Blake, *Lomanthus icaensis* (H.Beltrán & A.Galán) B.Nord. and *Onoseris humboldtiana* Ferreyra (Fig. 9), are discussed in the checklist (Appendix 1).

Poaceae (Gramineae) in Peru, are represented by about 750 species and 157 genera (Tovar 1993, Brako & Zarucchi 1993, Ulloa *et al*. 2004). The present study reports 70 species in 39 genera for the Ica region, constituting around 14% of regional flora with 4% endemism. The high proportion of pantropical grasses (31%) in the present checklist is a testament to the human footprint of colonial farming and the migration of people and livestock through the region. Poaceae in Ica are disregarded, reduced to small pockets that are often impacted more through burning than overgrazing. Their present scarcity is indicative of the reduction in superficial soil moisture and changes to flood irrigation (see Ore 2005). Prior to groundwater pumping for industrialised agriculture, land around Ica had much more surface water; grass covered significant areas of field, river and acequia margins up to the 1980s. Grassy banks and field margins were rarely burnt, as they are today, due to their importance for forage (that included leguminous weeds) especially for horses (pers. comm. Consuelo Borda, Félix Quinteros, Livia Cruz). The presence of native and endemic C4 grasses in the Ica region, such as *Jarava pachypus* Pilg (La Torre *et al.* 2006), suggests that prior to the Holocene, when water tables were higher and paleofauna herbivory present, Ica's forests were probably more savannah-like. During the later Holocene, with the expansion of pre-Columbian settlements and the hunting of herbivores, such as the white-tailed deer (*Odocoileus virginianus*) and guanaco (*Lama guanicoe cacsilensis* (Cadwallader *et al*. 2012)), this savannah may have converted to floodplain closed forest, which was subsequently deforested during the late Nasca culture period (see Beresford-Jones *et al.* 2009). Native and endemic grasses found in Ica today are relictual, declining and in urgent need of conservation, and include: *Aristida chiclayensis* Tovar., *Jarava pachypus* Pilg., *Paspalum haenkeanum* J.Presl., *Pennisetum annuum* Mez., and the Peru/northern Chile endemic *Rostraria trachyantha* (Phil.); these are discussed in the checklist (Appendix 1) along with the unusual Amazon disjunct *Guadua superba* Huber.

Fabaceae (Leguminosae) in Peru are represented by ca. 1000 species (145 genera, 234 endemics) (Brako & Zarucchi 1993, Ulloa *et al*. 2004, Baldeón *et al*. 2006). The present study reports 47 species in 27 genera for the Ica region, constituting 9.4% of regional flora. The genera *Astragalus*, *Calliandra* and *Hoffmannseggia* include taxa which have proved challenging to identify in Ica and may represent new species. *Hoffmannseggia* species are seasonally iconic to Ica's ephemeral and lomas habitats (see Fig. 11 and Appendix 3). The ecological importance of several legumes in Ica, especially *Prosopis limensis*, *Acacia macracantha* and *Inga feuillei*, has been discussed elsewhere (see for example Beresford-Jones *et al.* 2009a, Whaley *el al*. 2010a), and further taxonomical detail and ecology of these are also covered in the checklist. The useful tree *Geoffroea decorticans* (Hook. & Arn.) Burkart, found in the Pisco valley, is a noteworthy disjunction from northern Chile. The species is only found in plantation or agricultural hedges in Ica, and is absent from natural habitat. We therefore suggest that this represents a 19th c. introduction from Chile through the port of Pisco. *Parkinsonia aculeata* L. is widely distributed in Ica but appears be a long-established introduction from Mexico or Central America. Although its origin remains uncertain, there is good evidence of its presence in Peru for at least 250 years (Hughes *et al.* 2003). Today *P. aculeata* is widely distributed and ecologically

integrated; in rare sites it is found alongside its native sister species, *Parkinsonia praecox* (Ruiz & Pav.) Hawkins. In Ica, *P. praecox*, having been eradicated from low-lying areas, is today restricted to bajadas and quebrada shoulders. Whaley *et al.* (2010a) recorded the presence for the first time in Peru of *Parkinsonia* × *carterae* Hawkins—a thornless hybrid of *P. aculeata* and *P. praecox.*

In the checklist (Appendix 1), we provide a discussion of the taxonomy and ecology of the emblematic huarango of Ica (*Prosopis limensis*) and pacay (*Inga feuillei*). There is also an analysis of *Hoffmannseggia* species (Fig. 11) and the rare endemics *Poissonia weberbaueri* (Harms) Lavin. and *Weberbauerella* species.

Solanaceae is among the most diverse families in the Peruvian flora, with about 600 species in 42 genera (Brako and Zarucchi 1993). A total of 208 species are recognised as Peruvian endemics (Knapp *et al*. 2006). The genus *Solanum* itself is the most species-rich in Peru, with 253 native species (Särkinen *et al.* 2015). The present study reports 47 Solanaceae species in 14 genera for the Ica region, constituting 9.4% of regional flora and representing the fourth most diverse family. In the Ica region, the two most species-rich genera are *Solanum* (16 species) and *Nolana* (13 species). The majority of *Nolana* species (ca. 11) are confined to lomas fog ecosystems, with only two species, *Nolana chancoana* M.O.Dillon & Quip. and *Nolana humifusa* (Gouan) I.M.Johnst., found typically in quebrada outwashes after flooding. Five species of Solanaceae are found as shrubs or small trees, namely: *Cestrum auriculatum* L'Hér., *Dunalia spinosa* (Meyen) Dammer (Andean), *Grabowskia boerhaaviifolia* (L.f.) Schltdl., *Lycium americanum* Jacq. and *Nicotiana glauca* Graham. Collectively, these are an essential source of nectar for a wide range of pollinating insects and four hummingbird species (*Amazilia amazilia*, *Myrtis fanny*, *Rhodopis vesper* and *Thaumastura cora*). *G. boerhaaviifolia* and *L. americanum*, while being highly threatened by development, also have superb microclimatic properties for habitat restoration and provide excellent habitat for biodiversity and livelihood resources for beekeepers.

In the checklist (Appendix 1), we discuss: *Solanum pimpinellifolium* L., the endemic *Leptoglossis ferreyraei* Hunz. & Subils., *L. lomana* (Diels) Hunz. and *Solanum edmonstonei* Hook.f. The Peru/northern Chile endemic *Nolana adansonii* (Roem. & Schult.) I.M.Johnst., and Ica endemic *Nolana willeana* Ferreyra, are also covered.

Cactaceae diversity and endemism in Peru is of the world's highest (Taylor & Zappi 2004, Ortega-Baes & Godínez-Alvarez 2006), with over 250 species and 199 endemics (Arakaki *et al*. 2006), representing around 15% of the world's species. According to Brako and Zarucchi (1993), 11 species are recorded for Ica. The present study reports 23 species for the Ica region, constituting 4.6% of regional flora and the sixth most diverse family. Cactus species in Ica are distributed over a wide elevation range from 300 to 4000 m (*ibid*., Ostolaza 1998, 2016, Brako & Zarucchi 1993). Their occurrence is confined to quebradas and outwash bajadas over 530 m elev. and to sea-cooled frontal rocks and lomas. There are no naturally occurring cacti in the lower valleys or floodplains, although three species introduced to Ica are found cultivated in huertas: ayrampu (*Tunilla soehrensii* (Britton & Rose) D.R.Hunt & Iliff), San Pedro cactus (*Echinopsis pachanoi* (Britton & Rose) Friedrich & G.D.Rowley) and tuna (*Opuntia ficus-indica* (L.) Mill.). We recorded a range of animals responsible for cactus flower pollination, such as the oasis hummingbird (*Rhodopis vesper*), and bees and wasps such as *Agapostemon nasutus* and *Polistes peruvianus*. The long-tailed mockingbird (*Mimus longicaudatus*) and Andean fox (*Lycalopex culpaeus*) also play key roles in seed dispersal for several species.

Cacti species are strikingly delimited by elevation in Ica; studies suggests this distribution is strongly correlated to seed germination temperature requirements. Germination for cactus seed is usually in the temperature range 17–34˚C and frequently 15–20˚C, while germination is low above 30˚C (see Rojas-Aréchiga & Vázquez-Yanes 2000, RBGK Seed Information Database (SID) 2017). In the lower (450 m elev.) Ica valley, summer daytime temperatures remain over 32˚C (Fig. 2) and hot for most native species germination. The cooler quebrada habitat supports the majority of cactus species; here, weathered igneous substrate gravels and moisture also support biological crusts that likely perform an important role for cactus seed establishment (see Rivera-Aguilar *et al.* 2005). Following the El Niño of 1997–1998, we recorded the flood deposition of live pieces of broken cacti (*Armatocereus procerus*, *Haageocereus* spp. and *Melocactus peruvianus*) in the lower valley at ca. 430 m elev., Pampa de Yauca (see Fig. 3 map); tellingly these failed to sprout.

Few historical accounts of cacti are available for the Ica region, an exception being those of the German botanist Friedrich Ritter (1898–1989) and the Dutch botanist Albert Buining (1901–1976). Ritter, renowned worldwide for his work on South American Cactaceae, emigrated to South America in 1952 and settled in Arica, Chile. Many new species were published by Ritter in the journal of the German Cactus Society during the 1960s (Staples 2013). During January and February 1969, Ritter and Buining undertook a two-month trip through Chile and Peru, travelling in Peru through Tacna, Moquegua, Arequipa, Puno, Cusco, Ocoña, Atico, Chala, Nazca, Ica, Pisco Valley and valleys north to Lima (Eggli *et al.* 1995, Buining 1972ab). In Ica, they describe leaving the lower valley and climbing up the quebrada towards the Andes from Nazca: "Initially it was very, very dry, but higher, rising along dangerously narrow kinds of roads, we came from a bright sunny area, here we found *Weberbauerocereus rauhii* Backeb., *Loxanthocereus*

clavispinus Rauh & Backeb. (see Fig. 10) and *Loxanthocereus hystrix* Rauh & Backeb. at about 1800 m of elevation. Here finding *Browningia candelaris* (Meyen) Britton & Rose, perhaps a form or variety" (Buining 1972b). The latter may in fact have been *Browningia candelaris* subsp. *icaensis* (F.Ritter) D.R.Hunt. Today, the populations of iconic *B. candelaris* are severely depleted in Ica due to its uses as a construction material, for machete practice and as animal forage during severe droughts. In 2017, we surveyed the same transect carried out by Ritter and Buining and, although many were isolated and rare, found almost all of the species recorded in 1972.

In the checklist (Appendix 1), we discuss two possible Ica endemics: *Cleistocactus clavispinus* (Rauh & Backeb.) Ostolaza (syn. *Loxanthocereus clavispinus*) and *Haageocereus icensis* Backeb. ex F.Ritter. Although CITES restrictions limited our cacti voucher collection, most of the species were recorded by the authors during vegetation surveys with georeferenced photography, and others were cited from Arakaki *et al.* (2006). Considerable fieldwork remains to be carried out in to order establish species occurrence and distribution. Table 17 provides a summary of the distribution of cacti by elevational range and habitat.

TABLE 17. Cactus species assemblages and approximate elevational range.

Elevation (m)	Landscape	Cacti species
300–950	coastal lomas, Tillandsiales and foothills	*Corryocactus brachypetalus* (Vaupel) Britton & Rose, *Cumulopuntia sphaerica* (C.F.Först.) E.F.Anderson, *Cylindropuntia tunicata* (Lehm.) F.M.Knuth, *Eriosyce islayensis* (C.F.Först.) Katt., *Haageocereus decumbens* (Vaupel) Backeb., *Mila caespitosa* Britton & Rose.
550–1500	Andean outwashes and quebradas	*Armatocereus procerus* Rauh & Backeb., *Cleistocactus clavispinus* (Rauh & Backeb.) Ostolaza (syn. *Loxanthocereus*), *Cleistocactus sextonianus* (Backeb.) D.R.Hunt, *Cumulopuntia sphaerica*, *Haageocereus* spp. (including: *Haageocereus acranthus* (Vaupel) Backeb. subsp. *acranthus*, *Haageocereus acranthus* (Vaupel) Backeb. subsp. *backebergii* N.Calderón, *Haageocereus pseudomelanostele* (Werderm. & Backeb.) Backeb. subsp. *turbidus* (Rauh & Backeb.) Ostolaza, *Melocactus peruvianus* Vaupel., *Neoraimondia arequipensis* Backeb.
1500–2000	quebradas and Andean western dry slopes	*Armatocereus matucanensis* Backeb., *Browningia candelaris* (Meyen) Britton & Rose, *Cumulopuntia sphaerica*, *Haageocereus pseudomelanostele* subsp. *turbidus*, *Loxanthocereus deserticola* F.Ritter, *Weberbauerocereus rauhii* Backeb.
2000–4000	Andean sierra and puna	*Austrocylindropuntia subulata* (Muehlenpf.) Backeb., *Corryocactus brevistylus* subsp. *puquiensis* (Rauh & Backeb.) Ostolaza, *Loxanthocereus hystrix* Rauh & Backeb. (all reported in Nazca), *Matucana haynei* (Otto ex Salm-Dyck) Britton & Rose (reported in Pisco) and *Oreocereus hendriksenianus* Backeb. (reported in Nazca and Chincha)

Climatic niche connections

Peru

The predictive climatic niche model (Fig. 8) was used to produce a basic map to visualise the extent of Ica's climatic envelop (red/orange/yellow). Red is most representative of Ica's bioclimatic conditions—delimited by collection localities. This predicts an arid climatic niche distributed along the Andean pre-cordillera as far as the central coast. This niche is beyond the reach of central coast winter fogs (and temperature inversion) and outside the Andean rainfall zone. Lima and the central coast are too humid for Ica's arid-loving species, falling outside Ica's climatic niche. *Prosopis limensis* does not naturally occur in this region, for example. The arid climatic isthmus (east of the coastal humid belt), suggests a dispersal route through lower dry quebradas. The arid niche prevails again on north coast Peru, where a high correlation in La Libertad (Pacasmayo) is centred around a relict *Prosopis* forest (Bosque El Cañoncillo) that has close floristic affinities with the Ica region (Fig. 8). The regions of Lambayeque and Piura, parts of Tumbes and the south-west Ecuador border, share a similar climatic niche corresponding with the 'Tumbesian' flora dry forest and its arid gradient southwards. Here, floristic affinities with Ica include the shrub and tree species: *Acacia macracantha*, *Capparis avicennifolia*, *Grabowskia boerhaaviifolia*, *Maytenus octogona*, *Neoraimondia arequipensis*, *Parkinsonia praecox*, *Prosopis* sp., *Scutia spicata* and *Vallesia glabra.*

Broader arid connections

Ica shares floristic affinities through the South American 'arid diagonal', including tree genera *Acacia*, *Bulnesia*, *Capparis*, *Parkinsonia*, *Prosopis* and *Scutia*, while specific affinities are found in seasonal dry forests of coastal Ecuador/northern Peru, inter-Andean valleys of Peru, Central America/Caribbean and Bolivia/Argentina (see Linares-

Palomino *et al.* 2003, 2005). The Chilean north-west hyperarid zone shares climatic similarities to that of Ica, where *Prosopis* are often the only tree species. In Chile, the hyperaridity extends far into the Andes and south to Antofagasta, including the area of Pampa Tamarugal, home to tree species *Prosopis tamarugo* Phil., *Prosopis chilensis* and *Prosopis strombulifera*. Similarly, San Pedro de Atacama (2410 m elev.) in the Andes, is home to *Prosopis alba* varieties with pre-Columbian origins (see McRostie 2014). Although northern Chile is drier than Ica, the model niche (Fig. 8) includes northern Chile where riparian valleys support *A. macracantha* forest relicts, much as in Ica (see Aronson 1990). More significantly, the eastern dry valley biome of Argentina and Bolivia is shown, and where, surprisingly, there are closer floral affinities to Ica, than to much of coastal Chile. Perhaps arid climate and unimodal southerly winds play a limiting role in dispersal whilst human migration plays a role.

The model is precise enough to match distribution of disjunctive species *Bulnesia retama* and of *Poissonia heterantha* east of the Andean cordillera. Molecular analysis reveals *P. heterantha* to be closely related to *Poissonia weberbaueri* (Pennington *et al.* 2011) found in Ica. An evolutionary rates analysis, suggests the separation of *P. weberbaueri* from *P. heterantha* around at 14 million years ago (Pennington *et al.* 2011), correlating with the uplift of the Bolivian Andes and induced aridity through climatic barriers (Rohrmann *et al.* 2016). Although the *Bulnesia retama* disjunction in Ica (see Solbrig 1972) (Fig. 8), maybe an exceptional dispersal event, it may also be evidence of ancient connectivity to the area of Argentine Monte Desert—the centre of *B. retama* distribution. The Andean orogeny and Chilean hyperaridity through the Miocene (Mujica *et al.* 2015) could have displaced *Bulnesia*. Chilean aridity is a barrier to north–south distributions of Chilean and Peruvian species (Müller 1985b, Galán de Mera *et al.* 1997, Manrique *et al.* 2014). Other woody species of Ica that have trans-Andean distributions in Argentina, Bolivia and Paraguay, include *Krameria lappacea*, *Lycium americanum*, *Parkinsonia praecox* and *Trixis cacalioides*; all have wider distributions than *B. retama*. In Ica, *B. retama* is an extremophile adapted to hyperarid environments, able to survive decadal droughts, among rocks with temperatures spiking well over 40˚C. The species is evolutionarily the most advanced of the genus (Crisci *et al.* 1979) and may represent a paleophyte bastion that has survived the Miocene transition to hyperaridity.

Range contraction and dispersal

Species disjunction and isolated populations in Ica, are suggestive of long-range dispersal whilst at the same time endemism, suggests a history of range contraction and fragmentation. Were habitats split by the Andean orogeny and compounded by the loss of megafauna dispersal agents in the Quaternary for example? We can speculate that plant populations contracted with climate change, leaving species restricted to a single fog-bathed hilltop or damp quebrada niche. The Chilean coastal desert forest refugium, Bosque de Fray Jorge, offers insight: evergreen rainforest was fragmented dramatically during a transition to aridity in the Pleistocene glacial periods. Fray Jorge persists as an 'island' on small hilltops where coastal fogs replace the rainfall, supporting the same species found thousands of kilometres south (see Villagrán & Hinojosa 1997, Villagrán *et al.* 2004, Squeo 2016). The discovery of new, closely related species in Ica, in disparate quebrada and lomas, may also provide evidence that contraction and separation are part of an on-going process. The vast and variable perturbations of ENSO over the Pliocene (Tindall *et al.* 2016) and the Holocene (Carré *et al.* 2014) may represent a driver. Extreme rainfall pulses occurring once every 500 years or so (*ibid*.), would have temporarily connected species and populations across ecological and physical barriers, before the hyperarid desert between habitats returned.

2. Lomas vegetation

Lomas endemism, connectivity and threat

According to Müller (1985) and Dillon *et al.* (1991), Peruvian lomas has around 42% overall plant endemism; with 62% endemism for southern Peru and 22% for central Peru formations. We found that the lomas of Ica supports 27% of the regional flora, with 39% of total species numbers endemic to Peru. However, the four individual lomas of Ica have <1% endemism per lomas (e.g. 0.7% for Lomas Amara, 0.8% for Lomas San Fernando)—these are the lomas-specific endemics, unique to distinct lomas landscape units (fog 'islands' in arid isolation). Therefore, for the purposes of conservation, the lomas of Ica appear to have (or have had) ecological connectivity for the dispersal of species and should be considered as a single interconnected system. The lomas of Ica are a national priority for conservation, with 27% of species classified as threatened Peru endemics on the national red list (León *et al*. 2006), the IUCN *Red List of Threatened Species* and others. However, the region is not considered a conservation priority presently (Rodríguez & Young 2000); this is a situation we hope to help to redress. Although the lomas units are separated by arid desert

expanses, they do not exist in genetic isolation. During fieldwork we recorded the movement of guanaco (*Lama guanicoe cacsilensis* Lönnberg 1913) (Fig. 7), Andean fox (*Lycalopex culpaeus* Molina 1782) and the South American gray fox (*Lycalopex griseus* Gray 1837) (Conservamos Ica-CÓNICA 2017), between Lomas Amara, Marcona and San Fernando. These species are rare and threatened today but were once common and key to plant dispersal.

Tillandsia lomas delimitation

Tillandsia and herbaceous lomas rarely overlap to form significant ecotones between one another; they occupy climatically and edaphically distinct landscape units (Figs. 3, 4). Elevation and aspect determine the temperature inversion and wind speeds that concentrate fog with resultant vegetation. We observed this limit at ca. 930 m elev. for herbaceous lomas, although it is more variable for *Tillandsia* lomas according to the species and latitude. Growing at ca. 1150 m elev., *Tillandsia latifolia* holds the upper altitudinal limit for the genus in the coastal lomas of Ica, thriving in the most xeric environment. In Chile and Peru, Dillon *et al*. (1991, 2011) and Pinto (2005) found herbaceous lomas vegetation had an elevation threshold around 900–1200 m. It appears that *Tillandsia* lomas in Chile occurs at higher elevations than in Peru. Oka & Ogawa (1984a) suggest a latitudinal correlation between *Tillandsia* lomas occurrence and elevation, where altitudinal limits increase southwards. From 8–19°S, *Tillandsia* lomas distribution increases with altitude; as such at 9–13°S (Lima being 12°S), occurring at 80–500 m elev. Southwards, in northern Chile (18–20°S), *Tillandsia* lomas occurs at 1000–1300 m elev. More recently, *Tillandsia virescens* Ruiz & Pav. was recorded growing at 3800 m elev. in Arica (18°S) and Iquique (19°S) (Pinto 2005). Rutllant *et al*. (2003) suggest that this may be a response to the marine air layer, diurnal solar heating and circulation affecting the heights of the thermal inversion air base.

Tillandsia lomas species (arenic and lithophytic) have radical adaptations, including roots with a loss of absorbing function. The short finger-like roots are exclusively for anchorage; the micro-morphology (and possibly exudates) contribute to their adhering function (Brighigna *et al.* 1990). We observed how 'arenic' *Tillandsia* species retain dead structures (including roots), anchoring themselves in precise localities to occupy sandy and free-draining 'sweet spots', where fog moisture can be intercepted but is not retained in the soil. Moisture would rot the anchoring structure, allowing the wind to blow plants out of fog interception. This explains how *Tillandsia* cannot thrive within herbaceous lomas that is characterised by seasonal soil moisture retention. Aeolian sand is the principle substrate for *Tillandsia* arenic species in Ica, these are: *Tillandsia landbeckii* Phil., *T. latifolia*, *T. marconae* W.Till & Vitek., *T. paleacea* C.Presl. and *T. purpurea.* These species are found on dune margins of the pre-cordillera and on dry secondary ridge lomas (see Fig. 3 map). *Tillandsia* lomas in Ica constitutes the largest area of lowland vegetation, outside cultivated areas (1500 km^2), covering an area (south of the Río Pisco) of ca. 693 km^2.

Lomas and ENSO cycles

During ENSO cycles, lomas vegetation communities can change radically, with greater productivity and altered species composition (Dillon & Rundel 1989, Dillon *et al*. 2003, Tovar *et al*. 2018). Surveys of the lomas in Ica documented both permanent and ephemeral (episodic) vegetation. Fog-sustained vegetation with woody perennials was concentrated on ridge and incline belts. However, inland, lomas niches (described above) occur as outlying 'atolls' in expanses of arid desert exposure. And these desert exposures were found to support highly ephemeral lomas vegetation, that is rarely seen or documented. Aside from the physical evidence for this occurrence (described above), it was also noted by groups of local fishermen. Local commercial fishermen use rocky lomas shores and inlets to fish and harvest shellfish, and are obliged to traverse lomas on rough tracks. As such, they are some of the few to see lomas on a monthly basis throughout ENSO cycles; furthermore, they have visual recollections of El Niño of 1982–1983 and 1997–1998.

After nearly two decades of collection and survey, we offer the following observations about the characteristics of the lomas of Ica:

(i) El Niño rainfall in lomas is an unpredictable, localised event that may occur over one lomas area and not necessarily another adjacent. Rainfall in coastal lomas is not a widespread condition of either El Niño or La Niña phases of ENSO, and, is not necessarily exclusive to an ENSO cycle (although this might be an artefact of climate change).

(ii) Rare episodic rainfall events occur in lomas every 5–15 years (some of which correspond to ENSO), of sufficient intensity to cause surface pooling, run-off and soil saturation. In certain elevated areas, this triggers proliferation of episodic/ephemerophtye species, leading to high productivity over large areas (see Whitford 2002, Beresford-Jones *et al.* 2015). Increased productivity can trigger *Bostryx* snail (see Ramírez *et al.* 2003) and other animal populations to boom. These areas typically have relatively poor fog inception and are devoid of vegetation in normal years. Ephemerophtye species in Ica include *Nolana pallida*, *Nolana tovariana* Ferreyra, *Leptoglossis lomana* and *Palaua* spp., together with grasses *Jarava pachypus* and *Cenchrus* aff. *echinatus*. The seeds of some *Nolana*

species can be found at high densities; in one permanent plot (10 × 10 m) we recorded 960–9100 seeds per m^2 of *Nolana* (*Nolana* aff. *pallida*, *Nolana* aff. *tovariana*).

(iii) Plant diversity does not increase significantly after El Niño rainfall, but community structure, productivity and dominance are altered. Perennial lomas species do not benefit reproductively from El Niño rainfall, but from cooler and foggier La Niña episodes (see Beresford-Jones *et al.* 2015). In addition, temperature spikes prior to ENSO events that are not followed by rainfall, can be a factor causing perennial lomas vegetation to remain dormant or senescent throughout the year (seen in LSF 2013–2015).

Coastal and Andean lomas

The region of Ica includes both coastal and Andean lomas, that share attributes of seasonal fog-induced vegetation, but with notably distinct perennial and annual assemblages. We have described coastal lomas in some detail, but our studies of Andean lomas are incomplete. Andean lomas occurs on arid upland western-facing frontal crests, inclines and saddles, where seasonal fog produces characteristic lomas species. At 800–1750 m elev., these areas are somewhat above coastal hyperaridity and below most seasonal Andean rain. Outside the fog season, these areas appear variously as arid and rocky, or as biological crust-covered loess with disparate perennial xerophytes, including quebrada species such as columnar cacti, as well as *Cnidoscolus pavonianus* (Müll.Arg.) Fern.Casas, *Melocactus peruvianus* Vaupel and *Orthopterygium huaucui* (A.Gray) Hemsl., that do not occur in the coastal lomas. The delimitation of these areas is unclear during ENSO rainfall, as seen in 2017, where ephemeral 'meadows' of Andean species turned the western cordillera green. We observed this phenomenon during La Niña 1998–1999 and El Niño/La Niña 2006–2008. Andean slope lomas is difficult to access and requires systematic collection during ENSO cycles. We provide characterisations below.

Coastal lomas receives seasonal fog, dews and episodic rain, but the annual moisture budget is small and woody species remain diminutive with specialist adaptations. The soil moisture decreases with depth, and species are not deep rooted. Geophytes produce storage organs, for example *Alstroemeria* spp., *Pyrolirion albicans* Herb., *Solanum montanum* L. and *Weberbauerella raimondiana*. Woody lomas shrubs in this habitat include: *Ambrosia dentata*, *Atriplex rotundifolia*, *Croton alnifolius* Lam., *Ephedra americana* and *Krameria lappacea*; as well as cacti *Haageocereus* spp. and *Eriosyce islayensis*. There are no trees. Rocky outcrops allow rare plant communities to persist in marginal areas. These species communities include: endemic woody plants *Calliandra* aff. *taxifolia* (Kunth) Benth. and *Lomanthus icaensis*; grasses such as *Jarava pachypus*; and a range of endemic annuals such as *Astragalus triflorus* (DC.) A.Gray, and *Hoffmannseggia miranda* (Fig 11). Above the lomas shoreline, granite outcrops support tenuous populations of *Nolana adansonii*. *Eriosyce islayensis* is found growing at lomas extremes: close to the sea, rooted in fractured rocks, and in arid elevated lomas. The Andean pre-cordillera apices of outcrops support *Tillandsia latifolia* phenotypes, some of which conform best to *Tillandsia murorum* Mez. (pers. comm. Walter Till).

Andean lomas, outside Ica, by contrast, include trees that are sustained by light seasonal rains as well as site-specific heavy fogs and groundwater. As a consequence, the lomas of Atiquipa is able to support large trees and shrubs not found in Ica's coastal lomas. Tree species here include: *Acacia macracantha*, *Carica candicans* A.Gray, *Citharexylum flexuosum* (Ruiz & Pav.) D.Don, *Duranta armata* Moldenke, *Myrcianthes ferreyrae* (McVaugh) McVaugh (CR), and *Tara spinosa* (see Ramírez *et al.* 2012, Cordero *et al.* 2017). Here, *Tara* (*Caesalpinia*) *spinosa* appears to be a pre-Columbian introduction (Balaguer *et al.* 2011). The Lomas de Lachay (11°21'34"S / 77°22'1"W) is also distinctive with relictual wooded areas that include *Acacia macracantha*, *Carica candicans* and *Tara spinosa*, but also *Schinus molle*, *Acnistus arborescens* Schltdl. and the iconic *Capparidastrum petiolare* (Kunth) Hutch. (*Capparis prisca* J.F.Macbr) (Cano *et al.* 1999). Lachay's plants are sustained by heavy fogs and light rains annually, able to maintain plant productivity throughout the summer following El Niño (Cano *et al.* 1999). After two years, the lomas reverts to its normal annual composition (Tovar *et al.* 2017). Although both Lomas Atiquipa and Lachay have been significantly altered since pre-Columbian times (Balaguer *et al*. 2011, Beresford-Jones *et al*. 2015), the presence of trees here contrasts to their complete absence in Ica's coastal lomas.

Lomas historical ecology and moisture

Some degree of anthropogenic and climatic alteration of Ica's lomas plant composition is certain (Beresford-Jones *et al*. 2015); the degree of alteration, however, is uncertain. The desiccation process and positive feedback, that ensues with the deforestation/vegetation of lomas plants, sees the failure of fog interception and consequential lack of moisture collection (*ibid*. Moutarde 2007). Existing species composition and vegetation structure suggest that Ica's coastal lomas occupy an ancient climatic niche that has never supported the establishment of large trees, at least not during the Quaternary (see Beresford-Jones *et al.* 2015), and this is supported by limited palynological study (Moutarde & Huamán 2006 unpublished) that warrants further research.

Decadal rainfall

In March 2017, exceptional ENSO flooding and rainfall in Ica enabled the observation of the natural regeneration of woody plants in quebradas and bajadas. The woody shrubs flowering included *Atriplex rotundifolia*, *Bulnesia retama*, *Lycium americanum* and *Presliophytum incanum* (Graham) Weigend; these were, in turn, surrounded by a 'flowering desert' (rarely observed in Peru), composed of small herbaceous ephemeral plants forming mixed carpets of *Allionia incarnata* L., *Encelia canescens* Lam., *Hoffmannseggia viscosa* Hook. & Arn., *Lepidium pubescens* Desv. and *Tiquilia dichotoma* (Ruiz & Pav.) Pers., as well as the grass *Aristida adscensionis* L. (pers. comm. Emilio Mitacc, Christian Padilla, Hudson Yonjoy and Darwin Garcia).

3. Forest conservation and restoration

The *Prosopis*-dominated forests of Ica have had a long history of deforestation (Walton 2009, Whaley *et al* 2010a, Beresford-Jones *et al.* 2009a, 2011b). With few exceptions, desert forests are inherently fragile with scarce opportunities to replace them, but on the arid Pacific coast, El Niño flooding *is* that opportunity. Paradoxically, with El Niño flooding perhaps set to become more frequent (Cai *et al.* 2014, Milly *et al.* 2002), Ica's forest could be rebuilt from its relicts. However, time is running out to find climate change-resistant seed. In 2016, the magnificent 'Huarango Milenario' from Huayurí near Palpa (14°31'48.83"S / 75°16'59.66"W), the oldest veteran tree in Ica thought to be several thousand years old, lost its last few leaves and died. In the same year, the last riparian dry forest relict of Usaca, with its huge ancestral tree, was destroyed by a deliberate forest fire (14°50'7.81"S / 75°11'50.71"W) (see Appendix 4, Figure F5) (SERFOR 2016). Since the start of this study in 2001, entire huarango forests have been burnt for charcoal (14°48'33.11"S / 75°12'43.15"W), and other areas have been choked by the introduced invasive *Tamarix aphylla* (14°26'14.76"S / 75°39'34.32"W). We estimate that ca. 1200 ha of riparian land is subject to *T. aphylla* invasion. In addition, over 350 km of invasive non-native *Acacia karroo* hedges have been planted, and ephemeral streams colonised by the invasive *Ricinus communis*. The new regional strategy for forest conservation and restoration (not yet publicly available), and existing restoration, biodiversity protection and climate change strategies (GORE 2014, MINAM 2014), must be used to lobby for funding the removal of invasive species, rebuilding habitat and resilience into remaining forest relicts and veteran trees.

Aside from the implementation of lowland dry forest restoration, in order to improve catchment hydrology, water supply and biological resources, the Ica region needs to address the deforestation of its upper watersheds (including that within Huancavelica and Ayacucho). Centuries of fuel extraction, followed by overgrazing during regeneration, has left only pockets of natural vegetation. The Incas appeared to understand the need to restore native forests (Chepstow-Lusty & Jonsson 2000). Given experiences in Ecuador and worldwide with introduced conifer plantations impacting fragile habitats (see Middendorp *et al.* 2016), the planting of non-native pines in Ica's arid Andean catchment (see García Bendezú 2018) needs careful consideration. Watershed restoration requires a science-based evaluation of the most appropriate native combinations of species (see Beechie *et al.* 2013), where historical ecology and projected climatic change models will indicate the most viable option for both people and ecosystem.

4. Guanaco and lomas 'flagship' species conservation in Ica

Of the lomas plants in Ica, 38% are endemic to Peru; 28% of these are threatened with extinction, according to national and international assessments. This is greater than the world level of 20% threatened, and more than double the national levels of 10.6% threatened (Brummitt *et al.* 2015). It is vital that in-country conservation assessments are not used in isolation; the internationally recognised IUCN *Red List* is fundamental to guiding conservation priorities and policy internationally.

Conservation of the lomas ecosystem in Ica—representing only 3% (ca. 665 km^2) of the region (21,327 km^2)—could protect most of the endangered plant species and 27% of the flora; most of these are native, with over a third endemic to Peru. Presently, less than one third of Ica's lomas area is protected (RN San Fernando and Paracas). Largely aimed at marine diversity conservation, these two areas protect around 10% of the plant species in Ica. The Chincha and Andean slope *Tillandsia* and lomas, quebradas, forest relicts, Lomas de Marcona (with type localities), Lomas Amara and Ullujaya, Lomas of Cerrro Blanco are all completely unprotected. Large infrastructure projects in Ica threaten species and their fragile habitats at all levels, including re-routing the Pan-American highway, gas pipelines (that transverse lomas), wind farms, afforestation and mining. The important lomas 'flagship' species for Ica is the Peruvian south coast guanaco (Fig. 7), a wild camelid subspecies—*Lama guanicoe cacsilensis* (Lönnberg 1913) (Wheeler *et al.* 1992, Wheeler 1995, González *et al.* 2006, Marin *et al.* 2012) that on the coast depends on lomas vegetation. The

FIGURE 7. The Guanaco and Andean Condor 'flagship' species for Ica with LSF logo. Flagship animals and plant dispersal agents photographed in Lomas San Fernando / Marcona: top and centre right: rare images of Peruvian south coast guanaco subspecies (*Lama guanicoe cacsilensis* Lönnberg 1913), browsing on the inflorescences of *Tillandsia latifolia* (photos: Alfonso Orellana, 15 May 2016); centre left: Andean Fox (*Lycalopex culpaeus* Molina, 1782) (OW); bottom left: Andean condor (*Vultur gryphus* Linnaeus 1758) (photo Justin Moat); bottom right: logo of Reserva Nacional San Fernando (RNSF) with condor and guanaco. RNSF is the most significant coastal habitat for the threatened Andean condor in Peru, a species once frequent on the south coast of Peru (see Murphy 1925), where they depend on carrion from breeding sea mammals (Stucchi 2009, Vásquez 2015).

guanaco has been declared critically endangered in Peru (DS N° 004-2014-MINAGRI), with <3000 individuals in the whole country (Wheeler *et al.* 2006). According to the IUCN, '*Lama guanicoe cacsilensis* will become extinct in Peru within 30 years at current hunting and mortality rates' (Baldi *et al*. 2016). Conservation priority action is desperately needed to prevent the extinction of this species in Ica (Sisniegas & Jiménez 2008), where recently only four individuals were recorded in Lomas de Marcona and San Fernando (Castillo-Doloriert *et al.* 2016) (Fig. 7). Disturbance and off-road activities such as the Dakar Rally may have fatal effects, especially when they occur during guanaco reproduction periods. The only hope is to restrict and buffer access to lomas, with the establishment of protected Andes-to-coast corridors (see León *et al.* 1997). The Peruvian south coast guanaco is fundamentally important for Ica's lomas ecology (Whaley *et al*. 2010a) (Fig. 7) and is key to sustaining Peruvian camelid farming, being the origin of domesticated camelids upon which the Inca empire relied (Wheeler *et al*. 1992, Kadwell *et al*. 2001, Marin *et al.* 2012). Lomas conservation can help protect this patrimonial species, which in turn performs an essential role in seed dispersal and

maintenance of habitat. Conservation of lomas also maintains ecosystem services such as fisheries (valued at 1.328 million USD in RNSF), by protecting rocky spawning grounds (Carrasco *et al.* 2012). Our research outputs included the provision of detailed maps to SERNANP, who successfully restrict access to the most species-rich and fragile areas of Lomas San Fernando. This is increasingly necessary as the introduction of alien pathogens is one of the most underestimated causes of human-mediated environmental degradation (Anderson *et al.* 2004, Dunn & Hatcher 2015).

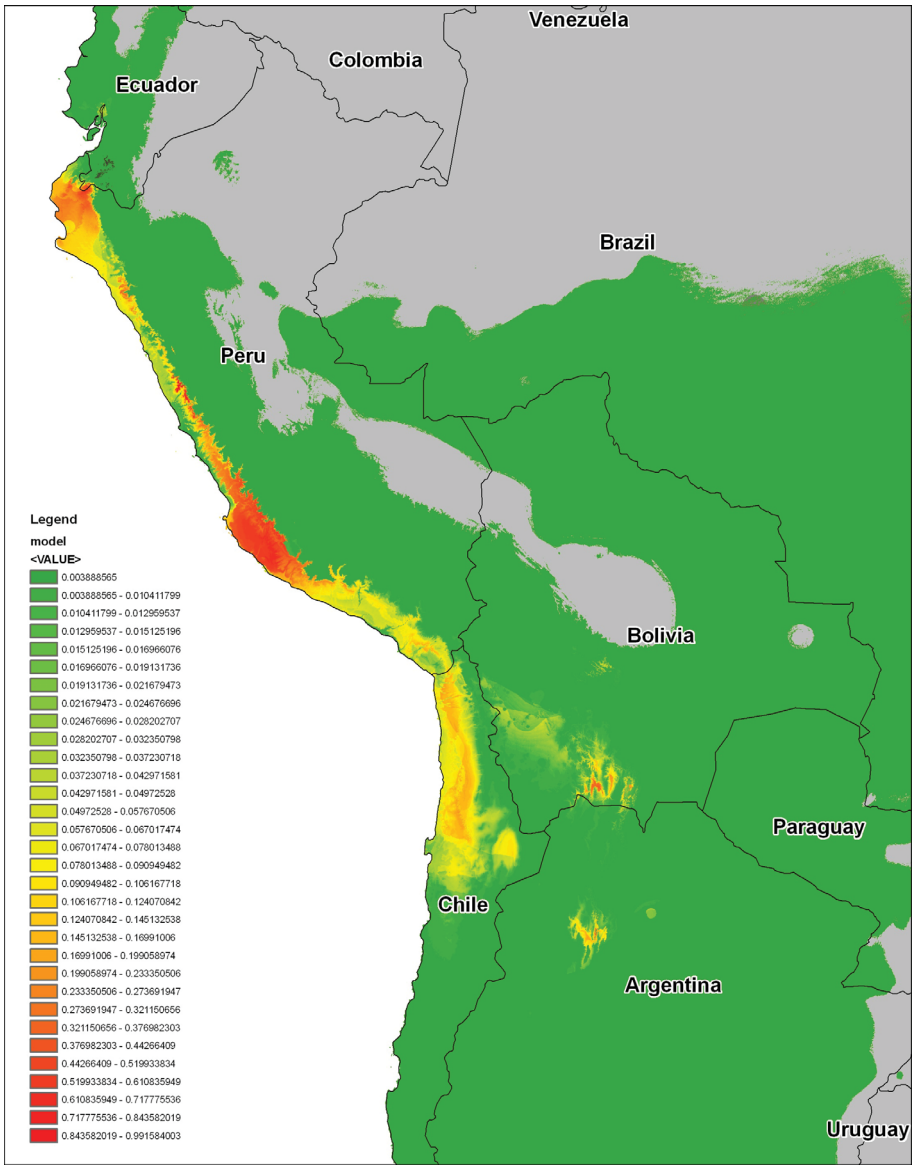


FIGURE 8. Predictive model for Ica's climate - showing the occurrence of similarity to the climatic niche of Ica throughout eastern South America (Peru, Chile, Bolivia, Argentina), as defined by the authors georeferenced plant collections including those of Appendix 1. Where closest to 1 (red) is most representative. The model highlights contiguous and disjunctive species niches, including most significantly, niches in eastern Andes (Bolivia and Argentina) and dry forest of northern Peru, in Lambayeque and Piura. (illustration: thanks to Justin Moat).

5. Agrobiodiversity in huertas

Excavation of pre-Columbian Nasca culture midden and settlement sites (including Paracas, Ica-Chincha), provides an inferred historical record of huerta species over several thousand years (see Parrish 2003, Roque *et al.* 2003, Cook & Parrish 2005, Beresford-Jones *et al.* 2009, 2011, García 2012, Piacenza 2016, Tantaleán *et al*. 2016) (see Appendix 2). Of the species grown (ca. 3000–650 BP), 24% of species are still cultivated in Ica according to our analysis of 63 extant huertas (Table 15). Most of these species (excepting *Zea mays* L.) are in declining use, while others are no longer found in cultivation, such as *Campomanesia lineatifolia* Ruiz & Pav., *Erythroxylum coca* Lam., *Lagenaria siceraria*

(Molina) Standl. and *Pachyrhizus tuberosus* (Lam.) Spreng. (although it is possible that *E. coca* and *P. tuberosus* were Andean imports). In addition, several species widely grown for millennia are now rarely cultivated (<1% of huertas), including: *Arachis hypogaea* L. (maní), *Bunchosia armeniaca* (Cav.) DC. (ciruela del fraile), *Gossypium barbadense* L. (algodón nativo) and *Sapindus saponaria* L. (boliche). Several species stand out as being in continuous cultivation over at least two millennia and are still common in huertas today: *Cucurbita maxima* (zapallo, pumpkin), *Inga feuillei* DC. (pacay), *Phaseolus lunatus* L. (pallar), *Prosopis limensis* Benth. (huarango) and *Zea mays* (maize). Despite continuous cultivation of early Mesoamerican introductions such as maize, other multi-use Central American species are rare or absent in Ica's archaeological sites, these include: *Annona muricata* L. (guanábana) (perhaps confused with *Annona cherimola* Miller), *Casimiroa edulis* La Llave, *Leucaena leucocephala* (Lam.) de Wit, *Persea americana* Mill. (avocado, palta) and *Spondias purpurea* L. Mill (ciruela). These species, however, are found in Ica huertas today, apparently spreading from northern Peru or as colonial introductions. The avocado is a pre-Columbian introduction following domestication in Mesoamerica. De la Vega (1605) states that at the time of the Spanish arrival in Peru, avocado was only recently in cultivation (Galindo-Tovar *et al.* 2008). Archaeological evidence suggests that the species was present much earlier on the Peruvian coast (ca. 1500 BC) but is a late introduction to Ica (*ibid*.).

Rivera *et al.* (2013) report that *Phoenix dactylifera* L. (date palm) was established in Peru by 1580, having been introduced to Spain in 961 AD by Islamic Moors (Harvey 1992). The species is found growing throughout Ica today. In 1653, Padre Bernabé Cobo, the Spanish Jesuit, wrote: "In other hot and dry valleys of these (coastal) plains, the fruits ripen perfectly, as dates are in all the valleys of the province of Ica (which belong to the archbishop of Lima), particularly in Nazca and Pisco." (*ibid*.). The early presence of *P. dactylifera* in Peru, indicates its nutritional and cultural importance to the Moorish conqueror—the date is used as a food to break Ramadan. The species is highly salt tolerant (Barrow 1998) and thus, at times, is the only species present in deforested hypersaline soils in the Ica and Pisco valleys, where it may have considerable germplasm value as a cultivar. Likewise, the high number of mango varieties in Ica is indicative of their early introduction to Peru, perhaps via Brazil during the 16th c. (Smith *et al*. 1992). The Ica region, similar to other areas of ancient agricultural development, represents a reservoir of genetic variation no longer found in the wild. Research in Central America, for instance, suggests that domesticated *Spondias purpurea* has unique alleles confined only to cultivation, that are extinct in the wild through loss of their original dry forest (Miller & Schall 2005).

Pillars of agricultural sustainability

Sustaining Ica's traditional huerta system over centuries has rested on integration of native multi-use species: *Acacia macracantha* and *Prosopis limensis* (Fig. 12) (Whaley *et al.* 2010, Beresford-Jones *et al.* 2009a). Both trees provide more than physical protection: intensive selection in the genetic isolation of Ica's riparian oasis huertas, has resulted in landraces of huge natural resource value (see Alexander *et al.* 2016). These species are found in Ica as thornless varieties and are still used to improve soil fertility through the incorporation of leaf litter. *A. macracantha* is almost unique on the coast of Peru for its ability to survive repeated firewood coppicing, providing highly palatable fodder at the same time (Whaley *et al.* 2010a). The huarango (*Prosopis limensis*) (see checklist, Appendix 1) is a multi-purpose super-food, fodder and timber tree, while being an important nitrogen fixer, highly tolerant of salinity (Felker & Clark 1980, Felker *et al*. 1981, Pasiecznik*, et al.* 2001). It has been used for at least 8000 years in Peru (Beresford-Jones *et al*. 2009, 2015). Other species also appear to have specialist adaptations: rhizosphere research of the medical and nectar-rich *Tara spinosa* has revealed six root symbiont *Ensifer* rhizobia with high genetic variability (Cordero *et al.* 2016). We find these species grown together in huertas, often alongside *Inga feuillei* (see checklist, Appendix 1). Accordingly, this suite of tree species appears to have sustained soil fertility and productivity in huertas of Ica over millennia, providing essential resources to people and biodiversity.

The availability of artificial fertilisers, together with the recent *Prosopis* die-back (Whaley *et al*. 2010a, Baena *et al.* 2017) have resulted in declining use of these trees (excepting *T. spinosa* which has been successfully industrialised in Ica). Widespread deforestation of *P. limensis* for charcoal has pushed regional government legislation to protect the 'huarango tree for public benefit and conservation' (Ordenanza Regional No 0009-2007-GORE-ICA, 2007). Whilst, the 'Festival de Huarango' initiated in 2006, was declared an official date in the civic calendar by the regional government in 2017, and now provides reason for hope with an annual focus for education and cultural celebration around Ica's unique desert ecosystem and species.

Huerta biodiversity and conservation

The traditional huertas of Ica are vital habitat for native biodiversity (Pecho *et al.* 2010, Whaley *et al.* 2010ab). Desert ecosystems with high human population pressure, are pushed beyond sustainable resource thresholds for fuelwood and agriculture. As such, with most of the forest removed, the survival of animals and plants in Ica is now reliant

upon traditional agricultural ecosystems. We found 115 non-cultivated plant species in traditional huertas (see Table 6). Birds also rely on huertas and forest restoration (Conservamos Ica-CÓNICA 2017), including the endemic black-necked woodpecker (*Colaptes atricollis* (Malherbe 1850)) and slender-billed finch (*Xenospingus concolor* (d'Orbigny & Lafresnaye 1837)) (González & Torre-Cuadros 2001, Pecho *et al.* 2010). Huertas provide refuge for native rare and declining plant species including: *Galvezia fruticosa, Indigofera truxillensis*, *Tecoma fulva* subsp. *guarume* and *Waltheria ovata*, which in turn, provide for native pollinators. Huertas are key to pollinator survival, during a one-year monthly survey of traditional huertas around industrial agriculture, 36 native pollinating species of Hymenoptera were recorded on *W. ovata*, 17 species on *Sidastrum paniculatum* (L.) Fryxell and 11 species on *Inga feuillei*—the key pollinator sustaining plant species amongst 17 other native plants (Lara *et al.* 2017). The same study, recorded a peak of activity and species (11 am to 12 pm) to guide badly timed insecticide applications killing pollinators. As a conservation strategy, huertas and agrobiodiversity can be protected by planting native threatened and useful plants in and around schools though a 'conservation through use' strategy of school propagation and cultural integration. Likewise, with the support of agricultural partners, forests can be demonstrably restored (see Whaley *et al.* 2010a, Conservamos Ica-CÓNICA 2016).

Conclusion

The ephemeral and dispersed nature of plants in the Ica region have impeded their documentation. Our finding of 297 new records, is an indication of the pressing need for further botanical research in arid Peru. With over 500 species (and an additional 127 cultivated species), the region supports a substantial proportion of the plant diversity on the Peruvian coast. We are in the process of describing several new species, while others are poorly known and remain unnamed despite the best efforts of specialists. Algae (see Dawson *et al.* 1964), moss, lichen, fungi, crusts and microbial symbionts of Ica remain unstudied. Although we have provided what we hope is an informative picture of most habitats, studies of western Andean lomas and quebrada following sporadic and ENSO related rains, are wanting. As such, we expect the total regional flora to reach somewhere between 550–650 vascular plant species. Future studies should direct efforts to areas for which no site-based floristic studies have been published, such as the humedales of Pisco. The highest species richness is found in quebradas and huaycos, yet there are no ecological studies of these ecosystems when they become most productive. Furthermore, these habitats form river catchments that provide the critical ecosystem services to agriculture and human settlement, including water. The maintenance of ecosystem services will depend on the restoration of native vegetation. The story of agriculture and human migration in Ica is both ancient and current, with intense competition for space and natural resources, the use of land is often reckless. Agriculture needs to restore the ecosystem and traditional farms around it, in order to sustain itself and its workforce. Today in Ica, school children are learning that native plants, traditional agricultural practice and crops can be conserved though and by schools, and that this makes for a brighter happier future.

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APPENDIX 1. THE CHECKLIST

Format of checklist

The checklist contains 501 vascular plant taxa of the Ica region, Peru. It is arranged by ferns and fern allies, and angiosperms, following the classifications of families from Christenhusz and Chase (2014), and the Angiosperm Phylogeny III (2009). Within each group, taxa are arranged alphabetically by family, and within families; alphabetically by genus and species. Each taxon is arranged by: scientific name, growth form, habitat, specific lomas occurrence (if found), species origin, conservation status, new records for Ica, elevation (derived from herbarium vouchers cited, fieldwork, taxonomic literature) and selected vouchers (vouchers cited are collections held at K, MOL, USM) otherwise records of species noted by Arakaki *et al.* (2006) and Whaley *et al*. (2010), photographic records noted by * (including locality). Selected vouchers are collected solely by Oliver Whaley prefixed—OW; Alfonso Orellana—AO; Octavio Pecho—OP, with team collection codes: Darwin Project Peru—DPP; Kew Project Peru—KPP. Conservation status references are indicated as follows: [1]León *et al* 2006, [2]IUCN, [3]Betancur & García 2006, [4]Decreto Supremo 043-2006-AG, [5]Ostolaza 2003, [6]Sarkinen *et al.* 2015 and [7]Hernández & García 2006.

Endemic species and species of conservation priority are discussed with illustrations provided, these include: *Aa weddelliana*, *Bulnesia retama*, *Capparis avicennifolia*, *Cleistocactus clavispinus*, *Eremocharis* spp., *Hoffmannseggia* spp., *Inga feuillei*, *Maytenus octogona*, *Poissonia weberbaueri*, *Prosopis limensis*, *Solanum edmonstonei, Tecoma fulva* subsp. *guarume* and *Weberbauerella* spp..

Photographs of 155 plant species (all taken in Ica) can be found arranged alphabetically in Appendix 3, and habitats of the Ica Region, arranged from Andes to Pacific Ocean, can be found in Appendix 4.

LYCOPODIOPHYTA

EQUISETACEAE

Equisetum giganteum L. *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 500. *Vouchers*: AO 057.

SALVINIACEAE

Azolla filiculoides Lam. *Growth form*: herb. *Habitat*: marsh and puquio. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 440–515. *Vouchers*: Whaley *et al.* (2010).

POLYPODIOPHYTA

EPHEDRACEAE

Ephedra americana Humb. & Bonpl. ex Willd. *Growth form*: shrub. *Habitat*: lomas, xerophytic scrub. *Lomas*: Lomas Amara and Ullujaya, Lomas Morro Quemado, Lomas San Fernando. *Origin*: Native. *Conservation status*: [2]LC, [4]NT. New record for Ica. *Elevation* (m): 500–1700. *Vouchers*: AO 134, 185, DPP 156, 259, KPP 034, OW 1656.

Ephedra rupestris Benth. *Growth form*: shrub. *Habitat*: lomas, quebrada and huayco, xerophytic scrub. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: [2]LC, [4]CR. New record for Ica. *Elevation* (m): 830–3310. *Vouchers*: DPP 197, 370, 422.

ANGIOSPERMS

ACANTHACEAE

Dicliptera porphyrea Lindau. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]EN B1ab(iii). New record for Ica. *Elevation* (m): 810. *Vouchers*: DPP 402.

Dicliptera tomentosa (Vahl) Nees. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1660–2110. *Vouchers*: AO 052, DPP 258.

Ruellia floribunda Hook. *Growth form*: herb. *Habitat*: dry forest. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 270–1480. *Vouchers*: AO 131, DPP 002, 015, 275.

AIZOACEAE

Sesuvium portulacastrum (L.) L. *Growth form*: herb. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 5–560. *Vouchers*: AO 074, OW 054, 1652.

Tetragonia microcarpa Phil. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 670. *Vouchers*: OW 1654.

Trianthema portulacastrum L. *Growth form*: herb. *Habitat*: riparian, huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 390–470. *Vouchers*: DPP 025, 034, 056.

ALSTROEMERIACEAE

Alstroemeria* aff. *violacea Phil. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara y Ullujaya, Lomas Morro Quemado. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 540–870. *Vouchers*: AO 167, 174, 177, DPP 190, 361, KPP 106, 110, OW 1662, 1677.

***Alstroemeria* sp.** *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Marcona. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 540. *Vouchers*: AO 221, 222, 228.

AMARANTHACEAE

Alternanthera albotomentosa Suess. **var. *albotomentosa***. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]NT. New record for Ica. *Elevation* (m): 370–470. *Vouchers*: DPP 036, KPP 83.

Alternanthera halimifolia (Lam.) Standl. ex Pitier. *Growth form*: herb. *Habitat*: riparian, huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410–950. *Vouchers*: DPP 109, 305, 322, 489, OW 049, 077.

Alternanthera pubiflora (Benth.) Kuntze. *Growth form*: herb. *Habitat*: quebrada and huayco, lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 580–840. *Vouchers*: AO 232, DPP 123, 339, OW 1544.

***Alternanthera* sp**. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: Lomas Amara and Ullujaya. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 820–840. *Vouchers*: DPP 187, KPP 100.

Amaranthus hybridus L. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 470. *Vouchers*: DPP 044.

Amaranthus spinosus L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 405–440. *Vouchers*: DPP 058, 214, 328, OW 038.

Amaranthus urceolatus Benth. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 480. *Vouchers*: DPP 458.

Atriplex peruviana Moq. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 470. *Vouchers*: DPP 053.

Atriplex rotundifolia Dombey ex Moq. *Growth form*: shrub. *Habitat*: dry forest, quebrada and huayco, xerophytic scrub. *Lomas*: Lomas Amara and Ullujaya, Lomas Marcona, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]LC. *Elevation* (m): 450–830. *Vouchers*: AO 212, DPP 84, 105, 169, 347, 406, KPP 11, 31.

***Atriplex* sp.** *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 260. *Vouchers*: DPP 52, 401.

Chenopodium album L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. *Elevation* (m): 400–915. *Vouchers*: AO 396, DPP 208.

Chenopodium ambrosioides L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native, cultivated. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 405–415. *Vouchers*: DPP 149, 329, OW 100, 102.

Chenopodium murale L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. *Elevation* (m): 415–910. *Vouchers*: DPP 325, 487.

Chenopodium pallidicaule Aellen. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 470. *Vouchers*: DPP 35.

Chenopodium petiolare Kunth. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Marcona, Lomas Morro Quemado. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 540–830. *Vouchers*: AO 186, DPP 351.

Chenopodium quinoa Willd. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native, cultivated. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 400. *Vouchers*: DPP 143.

Sarcocornia fruticosa (L.) A.J.Scott. *Growth form*: herb. *Habitat*: coastal. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 6. *Vouchers*: AO 73.

Suaeda foliosa Moq. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Marcona, Lomas Morro Quemado, Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 460–840. *Vouchers*: AO 178, 218, DPP 189, KPP 42.

AMARYLLIDACEAE

Clinanthus incarnum (Kraenzl.) Meerow. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]EN B1ab(iii). New record for Ica. *Elevation* (m): no data. *Vouchers*: Mendivil *et al.* 083 (USM).

Pyrolirion albicans Herb. *Growth form*: herb. *Habitat*: lomas, quebrada and huayco. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 630–840. *Vouchers*: DPP 360, OW 1726.

ANACARDIACEAE

Orthopterygium huaucui (A.Gray) Hemsl. *Growth form*: tree. *Habitat*: xerophytic scrub. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]EN B2b(v). *Elevation* (m): 960. *Vouchers*: DPP 447.

Schinus molle L. *Growth form*: tree. *Habitat*: Andean, dry forest, huerta, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 370–1410. *Vouchers*: AO 7, 30, DPP 230, 291, 450, OW 07.

APIACEAE

Cyclospermum laciniatum (DC.) Constance. *Growth form*: herb. *Habitat*: huerta, lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 590–835. *Vouchers*: AO 183, DPP 178, 354.

Cyclospermum leptophyllum (Pers.) Sprague. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 40. *Vouchers*: DPP 492.

Daucus montanus Humb. & Bonpl. ex Schult. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Morro Quemado. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 500–550. *Vouchers*: AO 184, 197.

Domeykoa amplexicaulis Mathias & Constance. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 655. *Vouchers*: OW 1730.

Domeykoa saniculifolia Mathias & Constance. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]EN B1ab(iii). *Elevation* (m): 380. *Vouchers*: OW 1685.

Eremocharis hutchisonii Mathias & Constance. *Growth form*: shrub. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]EN B1a. Likely new record for Ica. *Elevation* (m): 1550–1680. *Vouchers*: AO 066, DPP 265.

Note:—*Eremocharis* is a small South American genus comprising nine species associated with Andean and lomas habitats. Of the eight Peruvian endemics: *Eremocharis longiramea* I.M.Johnst. is found in northern regions Ancash, Cajamarca, La Libertad, Lambayeque, Lima and Piura (350–2600 m); *E. tripartita* (H.Wolff) Mathias & Constance from mountains of Cajamarca (2000–3300 m); *E. triradiata* I.M.Johnst. from dry slopes of Río Urubamba, Cuzco (2000–3000 m); *E. integrifolia* Mathias & Constance from type locality in Matucana, Lima (2400 m); *E. piscoensis* Mathias & Constance from a few localities in Andean quebrada and lomas Arequipa, Huancavelica, Ica (550–2000 m); *E. confinis* I.M.Johnst. from Tacna (1950–2900 m). Both *E. hutchisonii* and *E. ferreyrae* Mathias & Constance are solely known in Arequipa from their type locality in Chala (3300 m) and Lomas Atiquipa (5–200 m). The only Chilean species, *E. fruticosa* Phil., is endemic to the northern regions of Antofagasta and Atacama.

Eremocharis hutchisonii appears to be endemic to dry valleys and upper quebradas of the border region of Ica and Arequipa. It was discovered in the Atico watershed by Paul Hutchison in 1957, on the Puquio to Chala road (3300 m elev.), 'hanging from cliff, rare and growing to 70 cm' (*Hutchison 1277*, holo UC!; iso E!, F!, K!, G!, GH!, M!, MICH!, MO!, S!, US!, USM!). According to León and Monsavle (2006), the shrub is known from two localities and has not been seen since 1978. We collected *Eremocharis* aff. *hutchisonii* in September 2007 near Ronquillo, Lucanas, in Ica near the Ayacucho border (1673 m). It is rare with only a few large individuals seen. It is confined to damp pockets within ephemeral runnel streams on dry slopes, in association with *Acacia macracantha*, *Cestrum auriculatum* L'Hér., *Neoraimondia arequipensis*, *Tarasa operculata* and *Trixis cacalioides*. The species grows as an open ramified shrub 1–2 m high, with yellowish and bluish-green stems, exhibiting small yellow-green flowers (3–4 mm) in umbellets 10–15 mm across. In the mature plant, the small pinnatisect leaves appear bifid or trifid, reduced or absent on the upper stems. The plant and dry fruits are aromatic. In their description of *E. hutchisonii*, Mathias & Constance (1962) define the species with 8–20 flowers with purple-brownish petals. Notably the type collection (*Hutchison 1277*) records on the label, 'Petals pale purple, bases darker and striated'. However, our collection exhibits 5–10 yellow-green flowers. Additional fieldwork and taxonomic studies are needed for a better understanding of *E. hutchisonii* species delimitation. The species is likely to be episodic and found during ENSO cycles—the year of its discovery (1957) was a strong El Niño (NOAA 2017). The species is inherently vulnerable, as it depends on dry streams presently impacted by illegal mining and road development. Fires are frequently lit to improve grazing around water holes. Climate change is resulting in more extreme flash flooding, liable to wash away populations. The species has been assessed as Endangered (EN B1a) (León & Monsavle 2006).

Eremocharis piscoensis Mathias & Constance. *Growth form*: shrub or herb. *Habitat*: lomas, quebrada and huayco. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]EN B1ab(iii). *Elevation* (m): 590. *Vouchers*: KPP 030, OW 1760, Rahn 170 (USM).

Note:—*E. piscoensis* was first described in 1962, from the collection *Rauh & Hirsch P 400* (type UC!) of 'Pisco Valley, 1000–2000 m, 10-03-1954'. The species is restricted to coastal and Andean lomas between Ica and Arequipa. According to Mathias and Constance (1962), its key characters are its linear or filiform leaves, elongate leaf divisions, purplish-brown petals (rarely yellow), although sometimes resembling *E. longiramea*. We recorded *Eremocharis* aff. *piscoensis* growing as a flush of young plants in Lomas San Fernando (905 m elev.), 5–10 cm high with glabrous, distinctly bluish-green succulent deeply pinnatisect leaves. The umbel is composed of 2–3 compacted umbellets with 8–10 yellow-green flowers. The whole plant is aromatic and flavoursome. Although our collections have affinities with the original description and holotype of *Eremocharis piscoensis*, it may well prove to be new. Unlike the type specimen collected in the Andes of Pisco, our collections were made from frontal lomas, and associated with *Argylia radiata*, *Atriplex rotundifolia*, *Cenchrus echinatus* and *Palaua* spp. *E. piscoensis* is only known from a narrow distribution and likely to appear only after exceptional or ENSO related rainfall—the year of its discovery (1954) was a weak El Niño year (NOAA). León and Monsavle (2006) assessed the species as Endangered (EN B1a(iii)).

APOCYNACEAE

Sarcostemma clausum (Jacq.) Schult. *Growth form*: herb. *Habitat*: dry forest. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410–450. *Vouchers*: DPP 147, 199.

Vallesia glabra (Cav.) Link. *Growth form*: tree. *Habitat*: dry forest. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. *Elevation* (m): 320–980. *Vouchers*: AO 008, 16, DPP 001, 288, 294, OW 022, 1901.

ASPARAGACEAE

Oziroe biflora (Ruiz & Pav.) Speta. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 470. *Vouchers*: KPP 044.

ASTERACEAE

Acanthospermum hispidum DC. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 400–450. *Vouchers*: DPP 059, 215, 320.

Ageratum conyzoides L**.** *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 415. *Vouchers*: DPP 323.

Ambrosia artemisiifolia L. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 410. *Vouchers*: DPP 63.

Ambrosia artemisioides Meyen & Walp. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 480. *Vouchers*: DPP 89.

Ambrosia dentata (Cabrera) M.O.Dillon. *Growth form*: shrub. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Marcona, Lomas Morro Quemado, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]CR B1ab(iii), [4]CR. New record for Ica. *Elevation* (m): 450–840. *Vouchers*: AO 199, 229, DPP 167, 343, KPP 029, 041, 098, OW 1705.

Ambrosia peruviana Willd. *Growth form*: herb. *Habitat*: dry forest, huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 450. *Vouchers*: DPP 534, 567.

Baccharis **aff.** ***phylicoides*** Kunth. *Growth form*: shrub. *Habitat*: dry forest. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3160. *Vouchers*: DPP 420.

Baccharis salicifolia (Ruiz & Pav.) Pers. *Growth form*: shrub. *Habitat*: dry forest, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 400–930. *Vouchers*: DPP 028, 451, OW 063, 02101.

Baccharis **sp.** *Growth form*: shrub. *Habitat*: dry forest. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 3310. *Vouchers*: DPP 423.

Bidens pilosa L. *Growth form*: herb. *Habitat*: dry forest, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 450. *Vouchers*: DPP 529.

Bidens triplinervia Kunth. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 405–1670. *Vouchers*: DPP 060, 087, 250, 293.

Centaurea **sp.** *Growth form*: herb. *Habitat*: Andean. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 3100. *Vouchers*: DPP 507.

Conyza bonariensis (L.) Cronquist. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 470–780. *Vouchers*: DPP 040, 101.

Conyza coronopifolia Kunth. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3300. *Vouchers*: DPP 435.

Cotula australis (Sieber ex Spreng.) Hook.f. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3235. *Vouchers*: DPP 509.

Eclipta prostrata (L.) L. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410. *Vouchers*: DPP 145.

Encelia* aff. *pilosiflora S.F.Blake. *Growth form*: herb. *Habitat*: huerta, lomas, riparian. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 835. *Vouchers*: DPP 363.

Note:—This Peruvian endemic was described by Blake in 1917 from the type specimen *Mathews 1014* (K!), collected in the 'Tablada of Lurin' near Lima. A hundred years later, the area around Lurin and Barranco is covered by housing development, with the species probably being extinct in its type locality. The species was cited in Brako & Zarucchi (1993) as an endemic shrub restricted only to the coastal lomas of Arequipa and Lima. It was also mentioned in Beltrán *et al.* (2006), although without a conservation category or citation of herbarium vouchers. The only other historical collection known is *Weberbauer 1658* (B†) from the 'mountains of Barranco near Lima' collected in 1902, and according to Brako and Zarucchi (1993) the collection of *Macbride 5955* (F). Our collection of *Encelia* aff. *pilosiflora* from Lomas Amara superficially resembles the variable *Encelia canescens* Lam., but is distinct in having particularly large deltoid leaves with most of the plant covered in a velvety pubescence.

Encelia canescens Lam. *Growth form*: shrub. *Habitat*: huerta, lomas, riparian. *Lomas*: Lomas Marcona, Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410–1120. *Vouchers*: AO 001, 028, 088, 092, DPP 067, 079, 106, 283, 560, KPP 7, OW 1699.

Enydra fluctuans Lour. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 40. *Vouchers*: DPP 481.

Erigeron leptorhizon DC. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Morro Quemado. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 595. *Vouchers*: AO 201.

***Erigeron* sp**. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Morro Quemado. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 575–595. *Vouchers*: AO 104, 200.

Flaveria bidentis (L.) Kuntze. *Growth form*: herb. *Habitat*: dry forest, huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 405–910. *Vouchers*: DPP 211, 217, OW 052.

Galinsoga parviflora Cav. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410. *Vouchers*: DPP 95.

Galinsoga quadriradiata Ruiz & Pav. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410–415. *Vouchers*: DPP 94, 310.

Gamochaeta purpurea (L.) Cabrera. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 270. *Vouchers*: DPP 11.

Gnaphalium* aff. *lacteum Meyen & Walp. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3305. *Vouchers*: DPP 433.

Gnaphalium cheiranthifolium Bertero ex Lam. *Growth form*: herb. *Habitat*: Andean. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 915. *Vouchers*: DPP 289.

Grindelia* aff. *tarapacana Phil. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 820. *Vouchers*: DPP 399.

Grindelia glutinosa (Cav.) Mart. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 818–3150. *Vouchers*: DPP 125, 412.

***Grindelia* sp**. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 3150. *Vouchers*: DPP 419.

Helenium aromaticum (Hook.) L.H.Bailey. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 590–1280. *Vouchers*: AO 062, 086, DPP 222.

Heterosperma* aff. *diversifolium Kunth. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1635. *Vouchers*: DPP 235.

Heterosperma diversifolium Kunth. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 710. *Vouchers*: KPP 062.

Heterosperma ovatifolium Cav. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 415. *Vouchers*: DPP 312.

Hypochaeris echegarayi Hieron. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3305. *Vouchers*: DPP 424.

Jaegeria hirta (Lag.) Less. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3230. *Vouchers*: DPP 502.

Jungia pauciflora Rusby **subsp. *amplistipula*** (Cerrate) Harling. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]LC. New record for Ica. *Elevation* (m): 3305. *Vouchers*: DPP 429.

***Jungia* sp**. *Growth form*: shrub. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 1550. *Vouchers*: AO 065.

Laennecia* aff. *gnaphalioides (Kunth) Cass. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 830. *Vouchers*: DPP 136.

Lomanthus icaensis (H.Beltrán & A.Galán) B.Nord. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: [1]CR B1a. New record for Ica. *Elevation* (m): 670–820. *Vouchers*: KPP 099, OW 1655.

Note:—This narrow endemic perennial herb, restricted to the Peruvian south coast, was recently described under the name of *Senecio icaensis* from the collection *Knud Rahn 104* (USM!), made in 1956 from 'Los Cerrillos near Lomas de Marcona' on the border region of Arequipa and Ica (Beltrán & Galán de Mera 1997). *Senecio icaensis* has recently been separated from *Senecio* and placed under the new genus *Lomanthus* after phylogenetic studies and revision (Nordenstam *et al.* 2009). The species was categorised as Critically Endangered (CR B1a), being only known from the single type locality of *Ferreyra 13445* (USM) dated 1958 (Beltrán *et al*. 2006).

We recorded the species growing in a narrow elevation range (670–820 m elev.) in Lomas Amara, flowering and fruiting in January and November 2013, and sterile in October 2016. These new records extend the species distribution into the Ica region from the Arequipa border. In Lomas Amara and Ullujaya, the species grows to ca. 50–60 cm high, forming a woody root crown with deep roots. It has specific plant community associations on coastal lomas ridges and at the base of large west-facing granite boulders. These act as refugia, providing shelter and garnering humidity from fog condensation and interception. *L. icaensis* grows in association with *Astragalus triflorus*, *Calliandra* aff. *taxifolia, Jarava pachypus*, *Nolana plicata* and *Plantago limensis.* The species is extremely rare, possibly due to its specific

habitat requirements and rarity of refugia features in the landscape. Only four sub-populations are known with less than 30 individuals each. Despite intensive fieldwork in Lomas de San Fernando, the species was not found. Further fieldwork in Lomas de Marcona could well discover additional sub-populations. The species is highly distinctive among other Asteraceae lomas species and can be identified by its coriaceous, unpaired pinnatisect leaves with irregular dentation. These leaves are somewhat glabrous to lightly tormentose above, white densely tomentose beneath, with petioles 60–80 mm long; flowers 10–16 mm wide, with bright saffron-yellow terminal capitula. *Lomanthus icaensis* is distinguished from *Lomanthus okopanus*, as the latter has fewer but larger capitula (>20 mm) and larger petioles (up to 90 mm). The species was assessed as Critically Endangered (CR B1a) by Beltrán *et al*. (2006) under its synonym *Senecio icaensis*.

Lomanthus okopanus (Cabrera) B.Nord. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: [1]CR B1ab(iii), [4]CR. New record for Ica. *Elevation* (m): 830. *Vouchers*: DPP 166.

Mutisia acuminata Ruiz & Pav. *Growth form*: climber. *Habitat*: Andean. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3290. *Vouchers*: DPP 442.

Onoseris humboldtiana Ferreyra. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Endemic (Ica only). *Conservation status*: [1]DD. *Elevation* (m): 630. *Vouchers*: KPP 027.

Note:—The species was described by Ramón Ferreyra in 1959 from the herbarium collection *Ferreyra 13400* (holo USM!, iso G!) from 'Lomas de San Nicolás, al NW de Chala, Provincia Nazca, Setiembre 22, 1958, altitud 500 m', in Ica. The species grows as a woody-stemmed semi-prostrate perennial herb <10 cm high. The lignified caudex rarely spreads more than 20 cm, leaves are simple with grey-white tomentum and crenate undulate rugose margins; flower corolla pale to very pale pink (see Fig. 9). According to Ferreyra (1959), *Onoseris humboldtiana* has solitary head flowers (rarely 2–3 on a single peduncle—which we have not observed). The ray floret corollas are distinctly paler than those of *Onoseris odorata* (D.Don.) Hook. & Arn., which occurs commonly as an annual or biannual of the Ica lomas (and ephemeral outwashes), with pink to mauve ray floret corollas (although they can occasionally be white). In both species, the outer lip of the ray floret corollas have trifid tips to the ray florets, but those of *O. humboldtiana* are acute and with the outer lip of the ray floret corollas being narrow (length = 6–7 times width). In *O. odorata*, the ray florets' outer lips are about twice as wide (length = 2–3 times width) with rounded trifid tips. The floral disc is also distinctive in *O. humboldtiana*, having a smaller disc and apparently brown marginal disc florets buds, whereas in *O. odorata* they are yellow (Fig. 9). Also, in *O. odorata*, the outer lip of the ray floret corolla is clawed, whereas in *O. humboldtiana* it is not. *Onoseris odorata* has lanceolate dentate leaves, tomentose beneath, glabrous or with a sparse tomentum above. *Onoseris humboldtiana* has undulate leaves covered in grey tomentum. As a perennial, only *O. humboldtiana* can be found growing at the end of dry seasons.

The present distribution of *O. humboldtiana* is restricted to Lomas San Fernando. It was found growing in sandy soil at the bottom of small gullies or slacks (600–750 m elev.). The habitat is flanked by linear dunes stabilised by *Atriplex rotundifolia* growing in association with *Ambrosia dentata*, *Nolana pallida*, *Palaua* spp., *Tiquilia ferreyrae*. *O. humboldtiana* also occurs at a lower elevation (160–180 m), in association with colonies of *Argylia radiata* (L.) D.Don. and *Weberbauerella raimondiana*, where it was found flowering with surrounding species in senescence. In Lomas San Fernando *Onoseris humboldtiana* was recorded flowering in October 2012.

The species was assessed as Data Deficient (DD) by Beltrán *et al*. (2006). We have found only two populations (area of occupancy (AOO) <7.5 km^2) of less than 100 individuals restricted to SW facing slopes overlooking the Pacific Ocean. Both populations are highly vulnerable to climate shifts, fungal pathogens, off-road vehicles and illegal collection. It is possible that new populations will be discovered within the range of the species. Here we propose a conservation assessment of Critically Endangered (CR B2ac(iii,iv)).

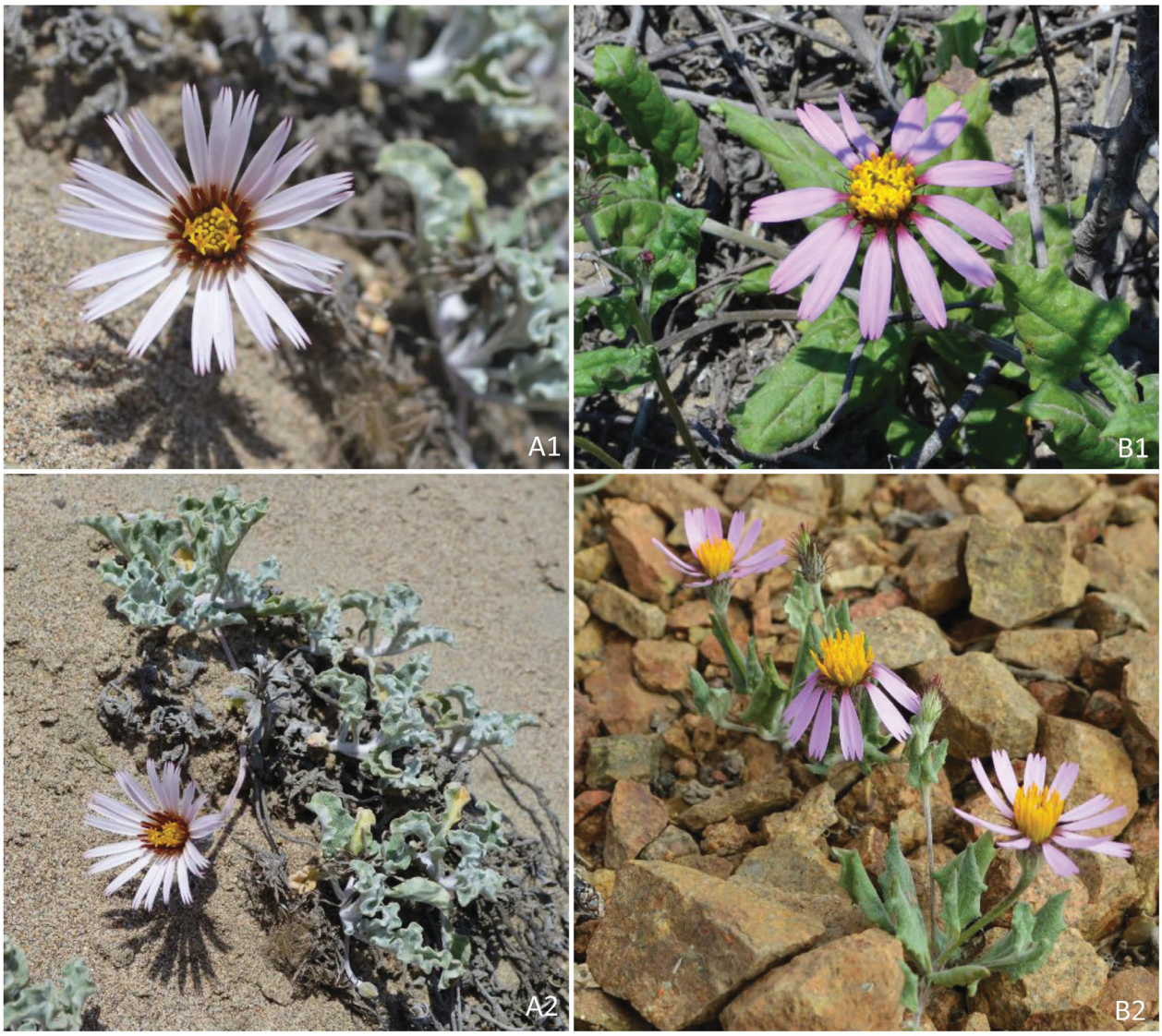

FIGURE 9. Comparison of *Onoseris* (Asteraceae) species in Ica. Showing Ica endemic: *Onoseris humboldtiana* (A1, A2 left) and Peru endemic: *Onoseris odorata* ((B1, B2 right). (photos: OW)

Onoseris odorata (D.Don) Hook. & Arn. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]LC. New record for Ica. *Elevation* (m): 820–1230. *Vouchers*: DPP 277, 394.

***Onoseris* sp**. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 680–720. *Vouchers*: KPP 002, OW 1696, 1723.

Ophryosporus floribundus (DC.) R.M.King & H.Rob. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 820–1670. *Vouchers*: DPP 155, 260, 390.

Ophryosporus origanoides (Meyen & Walp.) Hieron. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3150. *Vouchers*: DPP 418.

Ophryosporus peruvianus (J.F.Gmel.) R.M.King & H.Rob. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 1660. *Vouchers*: DPP 240.

Picrosia longifolia D.Don. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 405–410. *Vouchers*: DPP 057, 096, 488.

Pluchea chingoyo (Kunth) DC. *Growth form*: shrub. *Habitat*: dry forest, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 330–940. *Vouchers*: AO 089, 097, DPP 023, 121, OW 047.

Polyachyrus fuscus (Meyen) Walp. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Morro Quemado. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 550–575. *Vouchers*: AO 169, 191.

***Porophyllum* sp**. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 920. *Vouchers*: DPP 454.

Senecio calcicola Meyen & Walp. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [4]CR. New record for Ica. *Elevation* (m): 700. *Vouchers*: KPP 012.

Senecio flaccidifolius Wedd. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3310. *Vouchers*: DPP 421.

Senecio gracilipes A.Gray. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]EN B1a. New record for Ica. *Elevation* (m): 3300. *Vouchers*: DPP 427.

Senecio lomincola Cabrera. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]NT. *Elevation* (m): 3290. *Vouchers*: DPP 440.

Senecio melanolepis DC. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 840. *Vouchers*: DPP 134.

***Senecio* sp**. *Growth form*: shrub. *Habitat*: lomas. *Lomas*: Lomas Morro Quemado. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 550–560. *Vouchers*: AO 103, 170, 190.

Senecio yurensis Rusby. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [4]CR. New record for Ica. *Elevation* (m): 1670. *Vouchers*: DPP 251.

Sigesbeckia agrestis Poepp. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1660. *Vouchers*: DPP 257.

Sonchus oleraceus (L.) L. *Growth form*: herb. *Habitat*: huerta, lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Morro Quemado, Lomas San Fernando. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 400–830. *Vouchers*: AO 182, KPP 018, DPP 088, 142, 175, 314, 352, 491.

Spilanthes leiocarpa DC. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 560. *Vouchers*: AO 354, DPP 569.

Tagetes gracilis DC. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1650. *Vouchers*: DPP 263.

Tagetes multiflora Kunth. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3230. *Vouchers*: DPP 511.

Tessaria integrifolia Ruiz & Pav. *Growth form*: tree. *Habitat*: riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 420–900. *Vouchers*: AO 003, DPP 029, 378, OW 041, 02501.

Trixis cacalioides (Kunth) D.Don. *Growth form*: shrub. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410–820. *Vouchers*: AO 085, DPP 003, 033, 074, 128, 225.

Verbesina* aff. *mandonii Sch.Bip. Ex B.L.Rob. & Greenm. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1680. *Vouchers*: DPP 267.

Viguiera* aff. *atacamensis Phil. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1110. *Vouchers*: DPP 282.

Villanova oppositifolia (Lag.) S.F.Blake. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 710–1650. *Vouchers*: DPP 237, OW 1690.

Villanova titicacensis (Meyen & Walp.) Walp. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 610. *Vouchers*: KPP 060.

Xanthium spinosum L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 480. *Vouchers*: DPP 471.

Zinnia peruviana (L.) L. *Growth form*: herb. *Habitat*: Andean, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 920. *Vouchers*: DPP 455.

BIGNONIACEAE

Argylia radiata (L.) D.Don. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 360–890. *Vouchers*: KPP 003, 074.

Tecoma fulva (Cav.) G.Don **subsp. *guarume*** (DC.) J.R.I.Wood. *Growth form*: shrub. *Habitat*: dry forest, quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]EN B1ab(iii). New record for Ica. *Elevation* (m): 370–995. *Vouchers*: DPP 037, 069, 078, 201, 220, 226, 551, 519, 527, OW 074, 170, 1701.

Note:—*Tecoma* is a small genus of about 14 species of shrubs and small trees, with a disjunctive distribution in tropical America (12 spp.) and southern Africa (2 spp.). The greatest species number is found in Peru (9 spp.) According to Wood (2008), *Tecoma fulva* is a variable species with a distribution from central Peru to northern Chile and Argentina, but can be distinguished as six subspecies. Gentry (1992) mentioned that *T. arequipensis* is replaced in its north-west distribution limit (around Ica) by *T. guarume*, and that in Ica, *Tecoma guarume* is 'characterised by more membranous leaflets usually with reduced teeth and by having the anthers dispersed around mouth of the corolla tube'—this concurs with our finding. The Peruvian southern Andean species are described as subspecies for the following regions (Wood 2008): *Tecoma fulva* (Cav.) D.Don. subsp. *fulva* (Moquegua, Tacna, N. Chile); subsp. *altoandina* J.R.I.Wood (Huancavelica, Apurimac, N. Bolivia); subsp. *arequipensis* (Sprague) J.R.I.Wood (Arequipa); subsp. *guarume* (A.DC.) J.R.I.Wood (Ica); and subsp. *tanaeciiflora* (Kränzlin) J.R.I.Wood (Arequipa). We collected subsp. *tanaeciiflora* (Kraenzl.) J.R.I.Wood, at the southern border of Ica, near Arequipa (Río Tierra Blanca, Nazca, 915 m). This species has its centre of distribution in Arequipa, 1000—2400 m elev.

Tecoma fulva subsp. *guarume* is known locally as 'cahuato' and is endemic to the Ica region. It can be distinguished from the other subspecies through its pinnate leaves that are obscurely dentate or sub-entire with a winged rachis, instead of having serrate or dentate leaflets. Secondary stems are dark burgundy-red when growing in exposed conditions. The flowers (4–7 cm long) are generally scarlet to deep red outside, orange to yellow inside the corolla, and in certain conditions flowers can be deep orange outside. The anthers are positioned at the mouth of the tube with the stigma emerging ca. 5–8 mm. The dehiscent fruit (6–7 cm long) release an average of 55 winged seeds, adapted for short-range or floodwater dispersal (pers. obsv.). As with other *Tecoma* species, subsp. *guarume* is highly adapted to dry environments. It appears intolerant of saline lowland soils and of coastal air humidity. In the hyperarid south-east of the Ica region, subsp. *guarume* is largely confined to quebrada bottoms and rocky outwashes (378–1440 m) also occurring alongside ephemeral streams in bajadas. It forms dense stands growing up to 4 m wide in dry rocky river margins, typically alongside moraine boulders. When arroyos form alongside mature stands, its huge woody roots, up to 15 cm wide and 10 m deep, can be appreciated. Subsp. *guarume* grows typically in association with shrubs: *Bulnesia retama*, *Galvezia fruticosa*, *Scutia spicata*, *Trixis cacalioides* and the cactus *Neoraimondia arequipensis*.

Subspecies *guarume* could not be better adapted (co-evolved) to hummingbird pollination and is regularly visited by the following species: *Amazilia amazilia* (Lesson 1827), the Peruvian sheartail *Thaumastura cora* (Lesson & Garnot 1827), the purple-collared woodstar *Myrtis fanny* (Lesson 1838) and especially the oasis hummingbird *Rhodopis vesper* (Lesson 1829). The length and curvature of the beak of *Rhodopis vesper* match almost exactly the shape, anther position and length of the corolla of *T. fulva* subsp. *guarume* (pers. obsv.). Hummingbirds are thought to be the evolutionary drivers of flower adaptations of closely related subspecies (Wood 2008). These birds presumably feed on both the nectar and the microscopic insects found inside the flower, as they spend considerable time and energy dedicated to this resource. *Tecoma fulva* subsp. *guarume* has been widely depredated in Ica, with sub-populations eradicated by unregulated urbanisation and development. In addition, the deforestation of quebrada headwaters, together with an increased intensity of flash floods produces down-cutting arroyos which wash away populations. The species is cultivated and has a conservation hedge at the Plant Conservation Centre in Agrícola Chapi, Ica (Conservamosica-CONICA 2017). *Tecoma fulva* subsp. *guarume* is assessed as Endangered (EN B1ab(iii)) by León *et al*. (2006).

Tecoma fulva (Cav.) G.Don **subsp. *tanaeciiflora*** (Kraenzl.) J.R.I.Wood. *Growth form*: shrub. *Habitat*: dry forest, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 930. *Vouchers*: DPP 286.

BORAGINACEAE

Cordia lutea Lam. *Growth form*: tree. *Habitat*: dry forest, huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 530–640. *Vouchers*: AO 091, 368.

Cordia macrocephala (Desv.) Kunth. *Growth form*: shrub. *Habitat*: dry forest. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1660–1700. *Vouchers*: AO 135, DPP 249, 269.

Cryptantha granulosa (Ruiz & Pav.) I.M.Johnst. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 620–670. *Vouchers*: KPP 022, 056.

Cryptantha parviflora (Phil.) Reiche. *Growth form*: herb. *Habitat*: dry forest. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 820–1230. *Vouchers*: DPP 278, 395.

***Cryptantha* sp**. *Growth form*: herb. *Habitat*: dry forest. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): no data. *Vouchers*: OW 1724.

Heliotropium angiospermum Murray. *Growth form*: herb. *Habitat*: dry forest. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 415. *Vouchers*: DPP 321.

Heliotropium arborescens L. *Growth form*: shrub. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 470. *Vouchers*: DPP 411.

Heliotropium curassavicum L. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 30–415. *Vouchers*: DPP 019, 307, 486, OW 019, 1651, 03801.

Heliotropium krauseanum Fedde. *Growth form*: herb. *Habitat*: dry forest, lomas. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 330. *Vouchers*: KPP 053.

***Heliotropium* sp**. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 330–350. *Vouchers*: KPP 052, OW 1737.

Heliotropium toratense I.M.Johnst. *Growth form*: herb. *Habitat*: dry forest. *Lomas*: none. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 925–1630. *Vouchers*: DPP 266, 518.

Pectocarya linearis (Ruiz & Pav.) DC. *Growth form*: herb. *Habitat*: cactus scrub. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1675. *Vouchers*: DPP 264.

Tiquilia dichotoma (Ruiz & Pav.) Pers. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: not assessed. *Elevation* (m): 360–630. *Vouchers*: KPP 028, 073.

Tiquilia ferreyrae (I.M.Johnst.) A.T.Richardson. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Marcona. *Origin*: Endemic. *Conservation status*: [1]DD. *Elevation* (m): 650–810. *Vouchers*: AO 082, OW 1700, 1708.

Tiquilia litoralis (Phil.) A.T.Richardson. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 110–525. *Vouchers*: KPP 035, 092.

Tiquilia paronychioides (Phil.) A.T.Richardson. *Growth form*: herb. *Habitat*: dry forest, huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 270–760. *Vouchers*: AO 046, DPP 008, 297.

***Tiquilia* sp**. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 390–665. *Vouchers*: OW 1669, 1738, 1740.

Nama dichotoma (Ruiz & Pav.) Choisy. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 410. *Vouchers*: DPP 477.

BRASSICACEAE

Capsella bursa-pastoris (L.) Medik. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 475. *Vouchers*: DPP 465, 475.

Dictyophragmus* aff. *lactucoides (Förther & Weigend) Al-Shehbaz. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Marcona. *Origin*: Endemic. *Conservation status*: [1]CR B1a. New record for Ica. *Elevation* (m): 525–715. *Vouchers*: OW 1701, 1754.

Dictyophragmus englerianus (Muschl.) O.E.Schulz. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]EN B2c(i,ii). New record for Ica. *Elevation* (m): 405. *Vouchers*: KPP 049.

Lepidium raimondii O.E.Schulz. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 480. *Vouchers*: DPP 463.

Rorippa nasturtium-aquaticum (L.) Hayek. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1715. *Vouchers*: DPP 272.

Sisymbrium erysimoides Desf. *Growth form*: herb. *Habitat*: quebrada and huayco, riparian. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): no data. *Vouchers*: Cano *et al*. 5910 (USM) & 5922 (USM).

Sisymbrium grayanum Baehni & J.F.Macbr. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1230. *Vouchers*: DPP 280.

Sisymbrium orientale L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1665. *Vouchers*: DPP 248.

BROMELIACEAE

Tillandsia capillaris Ruiz & Pav. *Growth form*: epiphytic. *Habitat*: cactus scrub, lomas, tillandsiales. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 650. *Vouchers*: AO 347.

Tillandsia landbeckii Phil. *Growth form*: epiphytic. *Habitat*: lomas, tillandsiales. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: [3]VU. *Elevation* (m): 835. *Vouchers*: DPP 574.

Tillandsia landbeckii Phil. **subsp. *andina*** W.Till. *Growth form*: epiphytic. *Habitat*: lomas, tillandsiales. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 910. *Vouchers*: KPP 070.

Tillandsia latifolia Meyen **var. *latifolia***. *Growth form*: epiphytic. *Habitat*: cactus scrub, lomas, tillandsiales. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: not assessed. *Elevation* (m): 915. *Vouchers*: KPP 067.

Tillandsia latifolia Meyen **var. *major*** Mez. *Growth form*: epiphytic. *Habitat*: cactus scrub, lomas, tillandsiales. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: [3]NE. New record for Ica. *Elevation* (m): 590–675. *Vouchers*: AO 346.

Tillandsia marconae W.Till & Vitek. *Growth form*: epiphytic. *Habitat*: lomas, tillandsiales. *Lomas*: Lomas Marcona, Lomas San Fernando. *Origin*: Native. *Conservation status*: [3]EN. *Elevation* (m): 850–1050. *Vouchers*: KPP 069, OW 1697.

Tillandsia murorum Mez. *Growth form*: epiphytic. *Habitat*: lomas, tillandsiales. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 470–590. *Vouchers*: AO 079, OW 1676.

Tillandsia paleacea C.Presl. *Growth form*: epiphytic. *Habitat*: lomas, tillandsiales. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: [3]DD. *Elevation* (m): 1050. *Vouchers*: AO 099, Ferreyra 5380 (USM).

Tillandsia purpurea Ruiz & Pav. *Growth form*: epiphytic. *Habitat*: dunes, dry forest, lomas, tillandsiales. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 500–980. *Vouchers*: AO 101, 348, DPP 157, 195, 374, 575, KPP 068, 072, OW 050, 1667, 1711, 1751.

Tillandsia recurvata (L.) L. *Growth form*: epiphytic. *Habitat*: lomas, tillandsiales. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: [3]LC. New record for Ica. *Elevation* (m): 1010. *Vouchers*: Morales & Cuba 928 (USM).

***Tillandsia* sp.** *Growth form*: epiphytic. *Habitat*: lomas, tillandsiales. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 470–915. *Vouchers*: KPP 071, OW 1676.

CACTACEAE

Armatocereus ghiesbreghtii (K.Schum.) F.Ritter. *Growth form*: cactus. *Habitat*: cactus scrub. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]NE. New record for Ica. *Elevation* (m): no data. *Vouchers*: Arakaki *et al*. (2006).

Armatocereus matucanensis Backeb. *Growth form*: cactus. *Habitat*: cactus scrub, quebrada and huayco, xerophytic scrub. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC, [4]NT, [5]VU. New record for Ica. *Elevation* (m): 1420. *Vouchers*: AO 154.

Armatocereus procerus Rauh & Backeb. *Growth form*: cactus. *Habitat*: cactus scrub. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]LC, [2]LC, [5]LC. *Elevation* (m): 780. *Vouchers*: AO 550.

Browningia candelaris (Meyen) Britton & Rose **subsp. *icaensis*** (F.Ritter) D.R.Hunt. *Growth form*: cactus. *Habitat*: cactus scrub, xerophytic scrub. *Lomas*: none. *Origin*: Native. *Conservation status*: [5]VU. *Elevation* (m): 1400. *Vouchers*: AO 161, Hunt (2002).

Cleistocactus acanthurus (Vaupel) D.R.Hunt. *Growth form*: cactus. *Habitat*: cactus scrub. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]EN B1a, [2]NT, [4]EN, [5]EN. *Elevation* (m): no data. *Vouchers*: Arakaki *et al*. (2006).

Cleistocactus clavispinus (Rauh & Backeb.) Ostolaza. *Growth form*: cactus. *Habitat*: cactus scrub. *Lomas*: none. *Origin*: Endemic (Ica only). *Conservation status*: [1]CR B1a, [4]CR. *Elevation* (m): 1000–1500. *Vouchers*: Arakaki *et al*. (2006).

FIGURE 10. Type specimen of Ica endemic cactus *Loxanthocereus clavispinus* Rauh & Backeb., *Rauh K 106* (HEID). (**A, C1, C2**) Image taken by Peter Sack & Christof Nikolaus Schröder. Image © Botanischer Garten Heidelberg und Herbarium (HEID); (**B**) Original image taken by Werner Rauh of his number K 106 (1956) in 1957 or 1958, negative film held at HEID. Image © Nachlass W. Rauh Heidelberg / Archiv W. Barthlott. The image was printed in: Rauh (1958) Beitrag zur Kenntnis der peruanischen Kakteenvegetation p. 304. For additional information on the Werner Rauh Heritage Project, refer to Koch *et al*. (2013).

Note:—First described in 1956 by the German horticulturist Curt Backeberg (1894–1966), under the name *Loxanthocereus clavispinus* Rauh & Backeb. from the collection *Rauh K106* (HEID!) 'Vallis Nazca, 600 m, in locis petrosis' (Fig. 10). The list of diagnoses in *Descriptiones Cactacearum Novarum* by Backeberg (1956) contains the results from two Peruvian fieldtrips (1954 and 1956) of Prof. Dr. Werner Rauh (1913–2000), the cactologist and succulent enthusiast of Heidelberg Botanic Garden (Botanischer Garten Heidelberg). The type material from Rauh's 1956 expedition to Peru (types No. 'K...' [sic]) is deposited in the Heidelberg herbarium, where his original set of herbarium collections is kept. According to Anderson (2001) and Mottram (2014), Backeberg's taxonomic dissertations were not approved by everyone, as he was considered a 'splitter'. However, his legacy is manifold with many detailed observations providing a huge source of potentially useful data. Anderson (2001) describes *C. clavispinus* as a shrubby cactus up to 1 m high, stems 20–80 cm long and 8–10 cm in diameter, with red flowers. The habitat consists of cactus scrub restricted to rocky slopes and dry valleys of the Nazca valley in the Ica region, where it has been recorded at 1000–1500 m elev. (Arakaki *et al.* 2006). Although we could not collect this species, we located the herbarium sheet *Hutchison 1225* labelled '*Loxanthocereus clavispinus* R. & B., topotype, many seen, comparatively monomorphic', in the general collection at K. The specimen was collected in September 1957 from the

Puquio road above Nazca, at 800 m elev. This poorly known cactus appears to be endemic to the upper quebradas of the Ica region alone, with a restricted distribution along the Nazca–Lucanas road at ca. 3000 m elev. This is presumably its only known population with a few individuals (Arakaki *et al*. 2006). Detailed fieldwork is needed in order to establish its full distribution and population size. The location of *Hutchison 1225* (K!), on the Nazca-Puquio road needs further investigation. In this area we recorded *Armatocereus matucanensis*, *Armatocereus procerus*, *Browningia candelaris*, *Cleistocactus* spp., *Cumulopuntia sphaerica*, *Haageocereus* spp., *Melocactus peruvianus*, *Neoraimondia arequipensis* and *Weberbauerocereus rauhii*. Other xerophytic shrubs here include *Cnidoscolus pavonianus* (Müll.Arg.) Fern.Casas and *Orthopterygium huaucui* (with occasional *Tillandsia* spp. growing epiphytically). *Cleistocactus clavispinus* is assessed as Critically Endangered (CR B1a) by Arakaki *et al*. (2006) and is also listed as Critically Endangered (CR) by DS 043-2006-AG. It is listed on Appendix II of CITES (strictly regulates its trade to avoid utilisation incompatible with its survival).

Cleistocactus sextonianus (Backeb.) D.R.Hunt. *Growth form*: cactus. *Habitat*: cactus scrub. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]LC, [2]DD. New record for Ica. *Elevation* (m): no data. *Vouchers*: Arakaki *et al*. (2006).

Corryocactus brachypetalus (Vaupel) Britton & Rose. *Growth form*: cactus. *Habitat*: lomas. *Lomas*: Lomas Marcona. *Origin*: Endemic. *Conservation status*: [1]NE, [2]EN A2ace. New record for Ica. *Elevation* (m): 880. *Vouchers*: OW 1696.

Corryocactus brevistylus (K.Schum. ex Vaupel) Britton & Rose **subsp. *puquiensis*** (Rauh & Backeb.) Ostolaza. *Growth form*: cactus. *Habitat*: Andean. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]NE, [4]VU. New record for Ica. *Elevation* (m): 1600. *Vouchers*: Arakaki *et al*. (2006).

Cumulopuntia sphaerica (C.F.Först.) E.F.Anderson. *Growth form*: cactus. *Habitat*: lomas, quebrada and huayco. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: [2]LC, [5]EN. New record for Ica. *Elevation* (m): 430–455. *Vouchers*: KPP 063, MA1618 (USM).

Cylindropuntia tunicata (Lehm.) F.M.Knuth. *Growth form*: cactus. *Habitat*: cactus scrub, lomas. *Lomas*: Lomas San Fernando. *Origin*: Introduced. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 420–685. *Vouchers*: AO 525.

Eriosyce islayensis (C.F.Först.) Katt. *Growth form*: cactus. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: [1]LC, [2]NT. *Elevation* (m): 505. *Vouchers*: KPP 065, MA1620 (USM).

Haageocereus acranthus (Vaupel) Backeb. *Growth form*: cactus. *Habitat*: cactus scrub, lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 390–1155. *Vouchers*: DPP 281, OW 1749.

Haageocereus decumbens (Vaupel) Backeb. *Growth form*: cactus. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 295–510. *Vouchers*: OW 1687, MA1616 (USM).

Haageocereus icensis Backeb. ex F.Ritter. *Growth form*: cactus. *Habitat*: cactus scrub. *Lomas*: none. *Origin*: Endemic (Ica only). *Conservation status*: not assessed. *Elevation* (m): 0–500. *Vouchers*: Arakaki *et al.* (2006).

Note:—*Haageocereus icensis* was described in 1981 from the collection *Ritter FR146* (iso ZSS) of 'Ica, Canza Mine, 1953' (Calderon *et al*. 2007). The authors added, 'The very poor type specimen and description are not enough evidence to attribute this taxon to any known species of *Haageocereus*' [sic]. Ritter (1981) cites the species as growing with multiple stems up to 2 m long, prostrate or semi-erect. It has 15–18 ribs with whitish-brown areoles 5 mm wide, with around 30 spines and 1–2 central spines 3 cm long. Flowers grow to around 10 cm long with white filaments, petals are white inside and the flowers open at night (as in most species of *Haageocereus* in Ica). The type locality 'Canza Mine' probably refers to the cactus-rich dry quebrada of Cansas just west of Ica, where the lower cactus zone ranges from 700–1200 m. In this quebrada, we registered the following cacti: *Armatocereus procerus*, *Haageocereus* spp., *Melocactus peruvianus*, and *Neoraimondia arequipensis.* These cacti grow disparately among woody shrubs

or small trees, principally: *Bulnesia retama*, *Cnidoscolus pavonianus*, *Galvezia fruticosa*, *Parkinsonia praecox*, and *Presliophytum incanum*. Unfortunately, the quebrada of Cansas has been subject to degradation due to its proximity to the city of Ica and the district of Tinguiña. The valley is now used for dumping building rubbish, especially following the devastating earthquake of 2007, and also has a number of illegal mining operations. Urgent fieldwork is needed to determine the conservation status and presence of *H. icensis* here.

Haageocereus pseudomelanostele (Werderm. & Backeb.) Backeb. **subsp. *turbidus*** (Rauh & Backeb.) Ostolaza. *Growth form*: cactus. *Habitat*: cactus scrub. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [4]EN. New record for Ica. *Elevation* (m): no data. *Vouchers*: Arakaki *et al*. (2006).

Haageocereus tenuis F.Ritter. *Growth form*: cactus. *Habitat*: lomas. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [2]CR B1ab(iii,v)+ B2ab(iii,v), [4]CR, [5]CR. New record for Ica. *Elevation* (m): 370–835. *Vouchers*: DPP 181.

Loxanthocereus deserticola F.Ritter. *Growth form*: cactus. *Habitat*: cactus scrub. *Lomas*: none. *Origin*: Endemic. *Conservation status*: not assessed. *Elevation* (m): no data. *Vouchers*: Arakaki *et al*. (2006).

Melocactus peruvianus Vaupel. *Growth form*: cactus. *Habitat*: cactus scrub, quebrada and huayco, xerophytic scrub. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC, [4]VU, [5]VU. *Elevation* (m): 1420. *Vouchers*: AO 155.

Mila caespitosa Britton & Rose. *Growth form*: cactus. *Habitat*: cactus scrub, tillandsiales, quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]NE, [2]VU A4ac. New record for Ica. *Elevation* (m): 295. *Vouchers*: AO 555.

Neoraimondia arequipensis Backeb. *Growth form*: cactus. *Habitat*: cactus scrub, xerophytic scrub. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [2]LC. *Elevation* (m): 1410–1700. *Vouchers*: AO 133, 156, Arakaki *et al.* (2006).

Tunilla soehrensii (Britton & Rose) D.R.Hunt & Iliff. *Growth form*: cactus. *Habitat*: Andean, huerta. *Lomas*: none. *Origin*: Native, cultivated. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 820. *Vouchers*: AO 301.

Weberbauerocereus rauhii Backeb. *Growth form*: cactus. *Habitat*: Andean, cactus scrub. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]VU B1b(iii)+ C2a(i), [2]LC, [4]VU, [5]VU. *Elevation* (m): 1405. *Vouchers*: AO 158.

CALCEOLARIACEAE

***Calceolaria* sp.1**. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 3155. *Vouchers*: DPP 413.

***Calceolaria* sp.2**. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 3290. *Vouchers*: DPP 438.

***Calceolaria* sp.3**. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 925. *Vouchers*: DPP 517.

Stemotria triandra (Cav.) Govaerts. *Growth form*: herb. *Habitat*: Andean. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]NT. New record for Ica. *Elevation* (m): 3235. *Vouchers*: DPP 445.

CAMPANULACEAE

Lobelia decurrens Cav. *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 480. *Vouchers*: DPP 90.

CAPPARACEAE

Capparis avicennifolia Kunth. *Growth form*: tree. *Habitat*: dry forest. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 370–860. Vouchers: AO 040, 093, DPP 071, 131, 205, 221, 224.

Note:—The native tree *Capparis avicennifolia* (Capparaceae) is rare and highly threatened in Ica. It is restricted to a few outwashes and ephemeral streams of the eastern margins of the Río Ica valley, growing as isolated clumps and individuals in the Pampa de Yauca and Tingué. It is locally known in Ica as 'guayajo or guayabito de los gentiles'. The species occurrence in Ica is a disjunction of some 750 km from its wider distribution in the dry forest of northern Peru (La Libertad, Lambayeque, Piura) and SW Ecuador (Guayas, Manabí), where, although extensively depredated, it is not threatened and widespread. In northern Peru is called 'vichayo'. Kunth (1821) described *C. avicennifolia* from the collection *Humboldt & Bonpland 3722* (holo P!, iso B!) of 'Crescit in litore arenoso Maris Pacifici, inter Cascas et Truxillo Peruvianorum' near Trujillo. The duplicate sent by Humboldt to the German botanist Carl Willdenow (1765–1812) in Berlin is an isotype. Willdenow's collection was purchased by B in 1818, after Willdenow's death. This collection survived the 1943 fires, as it was always kept separately from the main B collection. It is important to note that although Ruiz and Pavón had first collected the species, 'Peruvia ad Ica circuits, et in Huayaquil provincial ad Morro', under the name *C. ovalifolia*, its description and illustration (t.432) remained unpublished until 1954–1958 when volumes IV and V of *Flora Peruiavana et Chilensis* came to be printed. The species was recorded in Ica as 'huayaba del Inga' (Ruiz & Pavón 1958). Flowers of *C. avicennifolia* in Ica show some morphological distinctions from those of northern Peru. In Ica, they are usually covered in dense farinaceous stellate hairs, whereas in northern Peru they tend to be more glabrous. Leaves are variable in both regions, from elliptic to obovate with shallow bifurcate leaf tips. In northern Peru, *C. avicennifolia* typically grows in association with *C. scabrida* and *Prosopis pallida*; in shady conditions it associates with *Vallesia glabra* and in the open with *Cordia lutea*. In Ica, its habitat has experienced complete degradation with original associations lost. We have recorded the species growing in isolation in outwash areas where *Bulnesia retama* and *Galvezia fruticosa* are found. *C. avicennifolia* is very slow growing in Ica, attaining a trunk of only 5 cm width after 25 years (Whaley *et al*. 2010). The species exhibits low seed production and viability; this combined with its use as firewood, account for its locally endangered status. Macbride (1936) recorded the species in Ica growing at the edge of *Prosopis* groves where 'the shrubs occurring on the borders of these groves are the almost leafless *Bulnesia retama* and a *Capparis* with coriaceous leaves closely related to the northern *C. avicennifolia'*.

On the Peruvian coast, *C. scabrida* and *C. avicennifolia* have been discovered to have close relationships with the virtually unknown myxomycetes (plasmodial slime moulds) in their root zone and rhizospheres (Lado *et al.* 2016). *Capparis avicennifolia* is listed as Vulnerable in the 'Resolución Ministerial 505-2016' (MINAGRI 2016). Recently, Cornejo and Iltis (2009) resurrected the genus *Beautempsia* (Capparaceae), an historical name valid under the Botanical code, placing *C. avicennifoli*a as synonym of *Beautempsia avicenniifolia* (Kunth) Gaudich.

CAPRIFOLIACEAE

Sambucus peruviana Kunth. *Growth form*: tree. *Habitat*: Andean, huerta, riparian. *Lomas*: none. *Origin*: Native, cultivated. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 150. *Vouchers*: DPP 549.

CARICACEAE

Carica candicans A.Gray. *Growth form*: tree. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [4]CR. *Elevation* (m): 2540. *Vouchers*: AO 136.

CARYOPHYLLACEAE

Cerastium glomeratum Thuill. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3240. *Vouchers*: DPP 513.

Drymaria paposana Phil. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 835. *Vouchers*: DPP 356.

Drymaria paposana Phil. **var. *serrulata*** J.A.Duke. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: [1]VU B1ab(iii). New record for Ica. *Elevation* (m): 835. *Vouchers*: DPP 194.

***Drymaria* sp.1**. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. Elevation (m): *820. Vouchers*: DPP 396.

Spergularia congestifolia I.M.Johnst. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Morro Quemado. *Origin*: Endemic. *Conservation status*: [1]EN B1a. New record for Ica. *Elevation* (m): 320. *Vouchers*: AO 192.

Spergularia fasiculata Phil. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Marcona. *Origin:* Native. *Conservation status:* not assessed. *Elevation* (m): 580–3235. *Vouchers*: DPP 165, 358, 446.

***Stellaria* sp.** *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 855. *Vouchers*: KPP 105.

CELASTRACEAE

Maytenus octogona (L'Hér.) DC. *Growth form*: tree. *Habitat*: dry forest, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 660–935. *Vouchers*: AO 334, DPP 070, 132, 456.

Note:—The native species *Maytenus octogona* (Celastraceae) was first described by the French botanist Charles Louis L'Héritier de Brutelle (1746–1800) in 1788, under the name of *Celastrus octogonus* from the collection of *Dombey s.n.* (type not located) from 'habitat in Perua'. The species was subsequently reclassified in 1825 under the genus *Maytenus* by the Swiss botanist Augustin Pyramus de Candolle (1778–1841). In 1847, the British botanist Joseph Dalton Hooker (1817–1911) described the same species as *Maytenus obovata*, from a collection of Charles Darwin (*Darwin s.n*., iso at K!) made in 1835 from Chatham Island, Galapagos. *Maytenus octogona* is native to the SW of Ecuador, Galapagos Islands and Peru. On the Peruvian coast it is recorded from regions: Ancash, La Libertad, Lambayeque, Lima, Piura, Tacna and Tumbes. The only historical collections cited for the Peruvian south coast are those mentioned in Macbride's *Flora of Peru* (1951), that are: *Weberbauer 5381*, collected from Mina Santa Ines, Pisco; and *Rusby 2618* from Tacna. After over 15 years of fieldwork, we recorded less than 20 individuals in nine localities in the Ica region (north to south), including: Huarangal (Molletambo), Tierras Blancas, Sol de Oro, Chauchilla, Cerro Puntilla, Copara, Cerro Pucaorjo, Quemazón and Valle Las Trancas. In 2006, we first recorded *M. octogona* in the Quebrada of Río Tingué / Curis near Huarangal, growing as a mature tree to around 6.5 m high, with the largest of five stems measuring a girth of 139 cm (30 cm high). In Tierras Blancas, Nazca, another mature individual measured ca. 5 m high. In all other localities, *M. octogona* was found as a coppiced shrub, up to 2 m high and up to 8 m across. This habit is probably due to its use as firewood and its conversion to coppice. The species has rounded sclerophyllous, semi-succulent, coriaceous leaves (2.5–3 cm wide) that form a deep litter layer under its canopy. This gives the appearance, and sound, of a drift of coins (similar in size to a 1 Sol coin)—perhaps leading to its local Nazca name of 'bacan' (really great). The specific epithet *octogona* is apparently derived from the very slightly obtuse parallel dentation (7–9), each side of the leaf margin, and can display a retuse apex. Mature trunks show a linear, dissected and somewhat reticulated, pattern. The small glabrous stellate flowers (3–4 mm across) are yellow-green and have a fleshy disc. Fruits are exposed from a dehiscent trilocular capsule (7–11 mm wide), bearing one seed per locule. Seeds are covered in a translucent, bright red swollen aril and remain attached, until taken by birds. In Ica, *M. octogona* is confined to the margins of quebradas, alongside seasonal rivers or arroyos, at 660–935 m elev. It is associated with the trees: *Acacia macracantha*, *Capparis avicennifolia*, *Parkinsonia praecox*; and the shrubs: *Bulnesia retama*, *Nicotiana glutinosa* L., *Pluchea chingoyo*, *Scutia spicata*, *Tecoma fulva*; and the cacti: *Armatocereus procerus*, *Cleistocactus acanthurus*, *Haageocereus* spp., and *Neoraimondia arequipensis*.

Maytenus octogona is listed as Near Threatened (NT) in a 'Resolución Ministerial 505-2016' (MINAGRI 2016). The species is extremely rare in Ica and requires urgent conservation actions. It is unlikely to have been a pre-Columbian introduction and appears to be a relict of a previous larger population. Mature trees show low seed production and viability, with drought-induced abortion of fruits. Genetic population studies should be able to guide restoration efforts. The lack of old-growth trees is of great concern; efforts should be taken to conserve the few extant trees.

CLUSCIACEAE

Hypericum silenoides Juss. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Morro Quemado. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 540–550. *Vouchers*: AO 163, 173.

COMMELINACEAE

Commelina diffusa Burm.f. *Growth form*: herb. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. *Elevation* (m): 415–450. *Vouchers*: DPP 303, 535.

Commelina fasciculata Ruiz. & Pav. *Growth form*: herb. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 405. *Vouchers*: DPP 141.

CONVOLVULACEAE

Cuscuta foetida Kunth. *Growth form*: herb / climber. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 420. *Vouchers*: KPP 080.

Evolvulus lanatus Helwig. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 320–830. *Vouchers*: DPP 184, 373, KPP 082, OW 1745.

Ipomoea alba L. *Growth form*: herb. *Habitat*: dry forest. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 445. *Vouchers*: DPP 213, OW 033, 04601.

Ipomoea asarifolia (Desr.) Roem. & Schult. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 420–480. *Vouchers*: OW 457, 571.

Ipomoea carnea Jacq. *Growth form*: shrub. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410. *Vouchers*: AO 541.

Ipomoea dubia Roem. & Schult. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 480. *Vouchers*: DPP 400, 460.

Ipomoea dumetorum Willd. ex Roem. & Schult. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 470. *Vouchers*: DPP 459, OW 1744.

Ipomoea nil (L.) Roth. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): no data. *Vouchers*: Gutte & Muller 8674 (USM).

Ipomoea purpurea (L.) Roth. *Growth form*: climber. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410. *Vouchers*: AO 540.

Jacquemontia unilateralis (Roem. & Schult.) O'Donell. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 330–1400. *Vouchers*: OW 1720, 1721, AO 128.

Merremia aegyptia (L.) Urban. *Growth form*: climber. *Habitat*: huerta, quebrada and huayco, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 360–770. *Vouchers*: Cano *et al*. 5850 (USM), *OW (Pampa de Yauca).

CRASSULACEAE

Crassula connata (Ruiz. & Pav.) A.Berger. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 830. *Vouchers*: OW 1674.

CUCURBITACEAE

Cucumis dipsaceus Ehrenb. ex Spach. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. *Elevation* (m): 750. *Vouchers*: AO 241.

Luffa operculata (L.) Cogn. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 220. *Vouchers*: OW 021.

Momordica balsamina L. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 820. *Vouchers*: DPP 127.

CYPERACEAE

Bolboschoenus maritimus (L.) Palla. *Growth form*: herb. *Habitat*: marsh and puquio. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 210. *Vouchers*: AO 081, OW 016.

Cyperus articulatus L. *Growth form*: herb. *Habitat*: marsh and puquio. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 220. *Vouchers*: OW 085.

Cyperus camphoratus Liebm. *Growth form*: herb. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 270. *Vouchers*: DPP 013.

Cyperus esculentus L. *Growth form*: herb. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 450. *Vouchers*: DPP 537.

Cyperus laevigatus L. *Growth form*: herb. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. *Elevation* (m): 270. *Vouchers*: DPP 018.

Cyperus luzulae (L.) Retz. *Growth form*: herb. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1660. *Vouchers*: DPP 238.

Cyperus odoratus L. *Growth form*: herb. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]DD. New record for Ica. *Elevation* (m): 330. *Vouchers*: OW 1683.

Eleocharis flavescens (Poir.) Urb. *Growth form*: herb. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 5–270. *Vouchers*: AO 075, DPP 009.

Eleocharis geniculata (L.) Roem. & Schult. *Growth form*: herb. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. *Elevation* (m): 280. *Vouchers*: AO 546.

Pycreus niger (Ruiz & Pav.) Cufod. *Growth form*: herb. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 420. *Vouchers*: DPP 306.

Schoenoplectus americanus (Pers.) Volkart ex Schinz & R.Keller. *Growth form*: herb. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. *Elevation* (m): 5. *Vouchers*: AO 077, DPP 376, 558.

***Scirpus* sp.** *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 5. *Vouchers*: AO 076.

EUPHORBIACEAE

Acalypha infesta Poepp. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 405. *Vouchers*: DPP 151.

Cnidoscolus pavonianus (Müll.Arg.) Fern.Casas. *Growth form*: shrub. *Habitat*: quebrada and huayco, xerophytic scrub. *Lomas*: none. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 780. *Vouchers*: AO 262.

Croton alnifolius Lam. *Growth form*: shrub. *Habitat*: quebrada and huayco, xerophytic scrub. *Lomas*: Lomas Marcona, Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 380–1710. *Vouchers*: AO 219, DPP 068, 080, 271, 388, KPP 081, OW 1686.

Croton ruizianus Müll.Arg. *Growth form*: shrub. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 830. *Vouchers*: DPP 364, Roque 418 (USM).

Euphorbia elliptica Lam. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 410–790. *Vouchers*: DPP 117, 332.

Euphorbia hirta L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 790. *Vouchers*: DPP 116.

Euphorbia hypericifolia L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 410–780. *Vouchers*: DPP 103, 330.

Euphorbia hyssopifolia L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 470. *Vouchers*: DPP 092.

Euphorbia serpens Kunth. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 790. *Vouchers*: DPP 115, 385.

FABACEAE

Acacia aroma Hook. & Arn. *Growth form*: tree. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 820–830. *Vouchers*: DPP 130, 203.

Acacia macracantha Willd. *Growth form*: tree. *Habitat*: dry forest. *Lomas*: none. *Origin*: Native. *Conservation status*: [4]NT. *Elevation* (m): 380–920. *Vouchers*: DPP 292, OW 060.

Adesmia muricata (Jacq.) DC. **var. *dentata*** (Lag.) Benth. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 230. *Vouchers*: DPP 159.

Aeschynomene indica L. *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: Introduced. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 730. *Vouchers*: AO 048.

Astragalus triflorus (DC.) A.Gray. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 490–700. *Vouchers*: KPP 038, 055, OW 1665.

Caesalpinia decapetala (Roth) Alston. *Growth form*: tree. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 450. *Vouchers*: DPP 212.

Caesalpinia gilliesii (Hook.) Benth. *Growth form*: tree. *Habitat*: dry forest. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): no data. *Vouchers*: OW 03601.

Calliandra* aff. *taxifolia (Kunth) Benth. *Growth form*: small shrub. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 720. *Vouchers*: OW 1659.

***Calliandra* sp**. *Growth form*: shrub. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 860. *Vouchers*: KPP 109.

Canavalia ensiformis (L.) DC. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 410. *Vouchers*: AO 037.

Coursetia caribaea (Jacq.) Lavin **var. *ochroleuca*** (Jacq.) Lavin. *Growth form*: shrub. *Habitat*: dry forest, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 780–820. *Vouchers*: DPP 099, 204.

Crotalaria incana L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410–610. *Vouchers*: DPP 317, OW 032.

Crotalaria pallida Aiton. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 420. *Vouchers*: DPP 557.

Dalea ayavacensis Kunth. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 480. *Vouchers*: DPP 405, 470.

Dalea cylindrica Hook. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 370–830. *Vouchers*: KPP 086, 101, OW 1657.

Dalea onobrychis DC. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 820–840. *Vouchers*: DPP 346, KPP 102.

Dalea smithii (J.F.Macbr.) J.F.Macbr. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: [1]LC. New record for Ica. *Elevation* (m): 840. *Vouchers*: DPP 193.

***Dalea* sp.** *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 670. *Vouchers*: OW 1732.

Desmanthus virgatus (L.) Willd. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 215. *Vouchers*: DPP 493, OW 031.

Desmodium limense Hook. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1680. *Vouchers*: DPP 274.

Galactia striata (Jacq.) Urb. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 430. *Vouchers*: DPP 547.

Geoffroea decorticans (Hook. & Arn.) Burkart. *Growth form*: tree. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC, [4]VU. New record for Ica. *Elevation* (m): 60–570. *Vouchers*: AO 137, 356, OW 01601.

Hoffmannseggia* aff. *ternata Phil. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 460. *Vouchers*: DPP 407.

Hoffmannseggia arequipensis Ulibarri. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 830–860. *Vouchers*: DPP 372.

Note:—Simpson and Ulibarri (2006) recognise five *Hoffmannseggia* species native to Peru: *Hoffmannseggia arequipensis* and *H. miranda* are Peruvian endemics; *H. glauca* is native to USA, Mexico and S. America; *H. prostrata* DC. is distributed on coastal southern Peru to northern Chile; and *H. viscosa* occurs on the coast of Peru from southern Ecuador to northern Chile. The present study recognises six species native to Peru (*H. ternata* is discussed, together with other *Hoffmannseggia* species, under *H. miranda*). *Hoffmannseggia arequipensis* (Fig. 11) is a small endemic perennial shrub, previously recorded only for coastal Arequipa (Simpson & Ulibarri 2006). The species was described in 1987 from Lomas de Atiquipa (100–200 m elev.), from the collection *Ferreyra 11546* (holo SI, iso USM!, LL) (Ulibarri 1987). Herbarium specimens identified as *Hoffmannseggia* aff. *arequipensis* in the present checklist, are from Lomas Amara (830–860 m elev.), and are associated with small clump islands of vegetation 1–4 m across. The species is not listed under any conservation category by Baldeón *et al*. (2006).

Hoffmannseggia miranda Sandwith. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: [1]EN B1 ab(iii). New record for Ica. *Elevation* (m): 650–830. *Vouchers*: KPP 107, OW 1672, 1727.

Note:—*Hoffmannseggia miranda* is an endemic woody perennial, previously recorded only in Arequipa region (Lomas Mollendo, Lomas Atiquipa) and Moquegua region (Lomas Ilo, Mostacilla, Camaná). According to Baldeón *et al.* (2006), *H. miranda* is endemic to Arequipa and Moquegua, growing at an elevation of 100 m. We found the species in Ica restricted to the western slopes of Lomas Amara (650–860 m elev.). Our collections match the species holotype *Stafford 53* (K!) with respect to habit, stipule morphology and the 3–5 pairs of ovate-obovate leaflets on each pinna. According to Simpson and Ulibarri (2006), the most distinctive feature of the species is the presence of long,

red or purple multicellular trichomes on the claws of the petals. Our collections show dense clusters of wavy yellow trichomes along the petal claw, thus demonstrating variation in trichome colour and form (see Fig. 11). The precise taxonomic position of these collections are pending further study until its phenotypic variability is better understood. The species has been assessed as Endangered (EN B1ab(iii)) by Baldeón *et al.* (2006).

Both Peruvian endemics *H. arequipensis* and *H. miranda* are confined to very localised fog-capturing communities growing as clumps or in rocky refugia among *Quinchamalium lomae*, the succulent *Portulaca pilosissima* Hook. and *Suaeda foliosa*, perennials like *Krameria lappacea*, and the grass *Jarava pachypus*. *Hoffmannseggia prostrata, H.* aff. *ternata* and *H. viscosa* were also found in Ica (Fig. 11) and are largely confined to Andean outwashes, huaycos and quebradas, growing on alluvial soils at 450–1230 m elev. They grow in association with the perennials *Bulnesia retama* and *Galvezia fruticosa*, and post-flooding annuals such as *Ipomoea dumetorum* Willd. ex Roem. & Schult., *Pennisetum* spp. and *Lepidium raimondii*. The less widespread *H.* aff. *ternata* is apparently restricted to alluvial clay deposits (yapana) which dry and crack following huaycos floods. The species has small reddish trichomes on the claws of the petals. Notably, we also collected *H. prostrata* in lomas with hybrid attributes. Molecular studies of Simpson *et al.* (2004, 2005) recognise *H. arequipensis* and *H. miranda* as a species complex. They suggest that *H. prostrata* has the capacity to form hybrids with *H. miranda*, and that future work might show that *H. arequipensis* would be better considered an ecological variant of *H. miranda*. Although Simpson and Ulibarri (2006) treat *H. ternata* as a synonym of *H. viscosa*, the present study recognises these as distinct. The former exhibits smaller leaves and small tubular flowers.

Hoffmannseggia prostrata Lag. ex DC. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 450–830. *Vouchers*: DPP 192, 409, KPP 037.

Hoffmannseggia viscosa Hook. & Arn. *Growth form*: herb or small shrub. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 450–1230. *Vouchers*: AO 044, 261, DPP 051, 085, 100, 279, 408.

Indigofera suffruticosa Mill. *Growth form*: herb or small shrub. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 580. *Vouchers*: AO 276.

Indigofera truxillensis Kunth. *Growth form*: small shrub. *Habitat*: quebrada and huayco, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 790–820. *Vouchers*: DPP 113, 389, OW 011, 04401.

Inga feuillei DC. *Growth form*: tree. *Habitat*: huerta. *Lomas*: none. *Origin*: Native, cultivated. *Conservation status*: not assessed. *Elevation* (m): 420–610. *Vouchers*: AO 287, OW 02201.

Note:—The species was described by De Candolle in 1825 from a cultivated specimen collected by *Feuillée* from a garden or huerta in Lima. *Inga feuillei* was named after its collector, the French priest scientist Louis Éconches Feuillée (1660–1732), who lived in Chile and Peru (1709–1711), writing some of the first accounts of plants (Macbride 1943). In 1845, Bentham named the species as *Inga cumingiana* Benth. from the collection *Cuming 980* (lecto K! designated by Pennington 1997, isolecto GH!, K!) from 'Lima', unaware of its previous description. Macbride (1943) mentions the species as being commonly planted in Lima for shade and harvesting of its pods, and widely known on the coast of Peru as 'pacay' (or pacai). Ruiz and Pavón recorded pacay as 'having a sweet edible pulp, much appreciated by the fairer sex (with) "*real de pacai*" served for entertainment at the holidays' (*ibid*.). The Spanish duo collected the species in Guayaquil in 1828, and in Chancay, Lima, from borders of flooded fields they refer to as 'cocheros'. Since then, the species has been widely collected in Peruvian coastal regions, including Ancash, Ica, La Libertad, Lambayeque, Lima, Piura, Tumbes, as well as the Amazon basin of Ayacucho, Cuzco, Huanuco, Junín and Pasco. Outside Peru, it is known from Bolivia, Colombia and Ecuador. In Ica, as throughout the coast of Peru, the species is confined to gardens and huertas. *Inga feuillei* is found in huertas (north to south) of: Subtanjalla, Guadalupe, San Juan Bautista, Los Aquijes, Tate, Pacacútec, Santiago; and outside the Ica valley, southwards: Santa Cruz, Palpa, Ingenio, Nazca, Vista Alegre, Valle de Las Trancas; as well as small isolated huertas throughout the Nazca watershed (340–620 m elev.). The species was recorded in 62% of 63 huertas surveyed in Ica. The species thrives best along acequias (irrigation canals) where it is planted, but also regenerates as people (especially children) throw the seeds into the acequia (Whaley *et al.* 2010). It is also associated with field margins of *Acacia macracantha* Willd., *Prosopis limensis* Benth., *Schinus molle* L., as well as introduced huerta fruit species (Whaley *et al.* 2010b).

FIGURE 11. *Hoffmannseggia* (Leguminosae) species of Ica. (**A**) *Hoffmannseggia miranda* (lomas rocky substrate); (**B**) *Hoffmannseggia miranda* (lomas sandy substrate); (**C**) *Hoffmannseggia viscosa* (lower valley alluvial silt); (**D**) *Hoffmannseggia viscosa* (lower valley alluvial clay); (**E, F**) *Hoffmannseggia prostrata* (huayco alluvial clay); (**G**) *Hoffmannseggia* aff. *ternata* (lower valley alluvial clay); (**H**) *Hoffmannseggia viscosa* (lower valley alluvial silt) with andrenid bee pollinator. (photos: OW).

Inga feuillei is rather unique in being an Amazon species domesticated and introduced to the coast for multiple purposes (Pennington 1997, Pennington & Fernandes 1998, León 1998, Brack Egg 1999, 2012). The species came into agriculture in Ica around 3000 years ago (García 2012) and was widely integrated by the Nazca and Ica-Chincha cultures during the middle Horizon at Casa Vieja located in Callango (Roque *et al.* 2003, Cook & Parish 2005) and the lower Ica valley (Beresford-Jones *et al.* 2011). The species found its way into Paracas (Nazca culture) around 2400 BP, in Cerro Gentil in the Chincha Valley (Tantaleán *et al.* 2016) and in Paracas Necropolis burials (Towle 1952) ca. 2800 BP. It was also assimilated into agriculture on other sections of the Peruvian coast such as Casma, Lima and Ancash during Moche culture (ca. 1800 BP) (Ugent *et al.* 1986). Extraordinary starch-grain evidence points to the use of *I. feuillei* in Ñanchoc Valley (in northern Peru) as early as 8210 and 6970 BP (Piperno & Dillehay 2008). Another closely related species found in northern Peru is *Inga edulis* (known as 'guaba' or 'pacae soga'), distinguished by a cylindrical linear ridged pod. It is not found in Ica but throughout huertas of the humid tropics of both Central and South America.

Inga feuillei is closely related to *Inga striata* Benth., a species widely distributed around the Amazon basin in Bolivia, Brazil, Colombia, Ecuador and Peru. *Inga feuillei* seems to be a domesticated form of *I. striata* (Reynel & Pennington 1997, Pennington 1997). The key differences being that *Inga feuillei* exhibits a larger flower peduncle, smaller flowers and longer, wider fruits. Furthermore, the foliar nectary of *Inga feuillei* extends as a small tube-like structure (Pennington 1997), although this character is variable in Ica. The domestication of *Inga* remains a mystery; however, molecular analysis has confirmed *Inga feuillei* to be nested within *Inga striata* (Toby Pennington pers. comm.). *Inga feuillei* certainly fits the definition of a domesticated species (see Zeder 2006, Larson *et al.* 2014), and one specifically selected and transported from a wild progenitor.

Today *Inga feuillei* is still cultivated in Ica where, although decreasing, it is the fifth most common huerta tree (Table 16) and greatly appreciated culturally, as the species has served agriculture for thousands of years. Firstly, in the form of human nutrition—when extracted from the pod, the 10–25 seeds (beans) have a fluffy seed coat (sarcotesta) that is edible and sweet. The bean (toxic when raw) appears to have been prepared and consumed in pre-Columbian times (Piperno & Dillehay 2008), although rarely are the beans consumed today. Secondly, the tree provides shade and microclimate, ameliorating the heat and desiccation of the surrounding desert. Thirdly, it provides a useful fuelwood and can be coppiced, producing a leaf and shade mulch. And fourthly, perhaps most importantly, the tree is a drought tolerant nitrogen-fixing soil improver. Trials have shown that *Inga* are some of the most effective nitrogen-fixing legumes known (Pennington & Fernandes 1998). Nitrogen is the most limiting (and limited) nutrient to the growth of plants in desert soils (Fuller 1974). Thus, the assimilation of *I. feuillei* into agriculture on the coast of Peru has been one of necessity, as it compensates for the nitrogen deficit of desert soils not short of phosphorous and potassium. In association with other native drought tolerant nitrogen-fixers, *Acacia macracantha* and *Prosopis limensis*, pre-Columbian cultures were able to sustain soil fertility and agriculture. *I. feuillei* may have been associated with magical life-giving powers, the evidence of which is found in archaeobotanical remains. It was, for example, used extensively in Paracas burials (Tello 1926) and also in the key Nazca ceremonial site of Cahuachi. Orefici and Rojas (2016) state, 'a constant observed in all the graves (at Cahuachi) were pacae (*Inga feuillei*)' [sic.]. Traditional farmers in Ica still use *Inga* for a wide range of nutritional and medicinal uses (Brack Egg 1999, 2012, Whaley *et al.* 2010b). They plant them in and around fields, ploughing the leaves into the soil of sunken fields during the dry months (October to December), before the arrival of water. Perhaps most indicative of its ancient origin and usage in Ica, are the number of varieties that still exist in huertas. We recorded (and propagated) at least eleven distinct varieties, including pacay morado (a rare variety with purple sarcotesta and pod lining), pacay blanco, cinturón, chincano, criollo, rabo de zorro, rosado, sapo norteño, sapito and tablón. Over recent years however, pacay (*I. feuillei*) has been seen as problematic in Ica due to the program of eradication of the fruit fly (including *Ceratitis capitate* (Wiedemann 1824), *Anastrepha* spp., implemented by Servicio Nacional de Sanidad Agraria (SENASA) of Ministerio de Agricultura and Riego), that links the tree as a refuge for the fruit fly pest. There is no scientific literature available for coastal Peru to show a specific link between fruit flies and *Inga*. Two reports found *Anastrepha distincta* to have a non-specific association with *Inga* in Trujillo (Sharp & Picho-Martinez 1990) and Huanuco (Cuculiza & Torres 1975). Fruit flies in Mexico have been reported from native trees species, but with no obligate relationship to *Inga* (Malo *et al.* 1987). Our research found an eradication and spraying program to be causing considerable distress to smallholder families. At the same time, un-composted waste fruit remains unmanaged and is a proven host to fruit fly larvae (Christenson & Foote 1960). *Inga feuillei* was found to be an important refuge for native bees (Lara *et al.* 2017, Sainsbury's Project 2016). The conservation of pacay and their varieties in Ica is a priority to be taken seriously, as this indispensable pre-Columbian resource offers to sustain soil fertility, reducing dependence on fertiliser, while providing income, nutrition and shade to local people.

Lupinus lindleyanus J.Agardh. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 470. *Vouchers*: DPP 520.

Macroptilium lathyroides (L.) Urb. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 920. *Vouchers*: AO 329, DPP 565.

Melilotus indicus (L.) All. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. *Elevation* (m): 420. *Vouchers*: DPP 315, DPP 490, OW 045.

Parkinsonia* × *carterae Hawkins. *Growth form*: tree. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 430–450. *Vouchers*: AO 098, DPP 198.

Parkinsonia aculeata L. *Growth form*: tree. *Habitat*: dry forest, quebrada and huayco. *Lomas*: none. *Origin*: Native, cultivated. *Conservation status*: not assessed. *Elevation* (m): 380–580. *Vouchers*: AO 009, 308, DPP 553, 566, OW 117, 02802.

Parkinsonia praecox (Ruiz & Pav.) Hawkins. *Growth form*: tree. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 380–780. *Vouchers*: AO 027, 031, 038, DPP 031, 110.

Poissonia weberbaueri (Harms) Lavin. *Growth form*: small shrub. *Habitat*: lomas. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]EN B1a. *Elevation* (m): 460–840. *Vouchers*: DPP 375, KPP 001, OW 1670.

Note:—This endemic species was first described in 1908 under the name *Coursetia weberbaueri* Harms, from the collection *Weberbauer 1578* (type B†, fragments at F!, GH!, MO!, NY!) from Mollendo, 'Tambo, prope Mollendo, in arenosis, 200 m in formation Loma' (Engler 1909). The species grows in the region of Arequipa, in Lomas of Atiquipa, Capac, Capace, Jahuay, Ocoña, Puerto Chala and Alto Chira, between 240–600 m. In Ica, we collected the species in both Lomas Amara and San Fernando (460–840 m elev.). The species grows as a small woody shrub up to 35 cm high, and is usually wind-blown into being recumbent, or prostrate and spreading, with swollen 'elbowed' stems up to 80 cm wide. When mature, it forms a large pivotal root that appears like a small trunk above deflated sand. The species flowers between October and March, exhibiting fruits between January and March. Fruits are narrow pods containing 10–12 seeds. When not in flower, its most notable features are its pinnate elliptic leaves (5–8 mm long) folded upwards, that are covered in short tomentose hairs, imparting a whitish blue-green hue to the foliage and new stems. Characteristic yellow-green peduncles rise erect above the foliage. Flowers are an unusual deep scarlet to burgundy colour and when freshly opened, have an elusive orange tinge and yellow-green throat; the banner is slightly recurved with an emarginate apex. The yellow calyx is covered in short glandular hairs.

In Ica, *P. weberbaueri* grows on linear dunes in association with *Ambrosia dentata*, *Ephedra americana*, *Hoffmannseggia* spp., *Nolana pallida*, *Nolana plicata*, *Palaua* spp. and *Tiquilia ferreyrae.* It is extremely tolerant to long periods of desiccation and peak daytime temperatures. Calibrated dataloggers placed alongside the plants, recorded temperature spikes of 42˚C during January 2014 (Fig. 6). During the summer months, the species relies on moisture from nocturnal dews in order to retain small perennial leaves. We recorded *P. weberbaueri* in an outlying sub-population in Lomas San Fernando at 905 m, associated with *Argylia radiata*, *Atriplex rotundifolia*, *Cenchrus echinatus* L. and *Palaua* spp.

Phylogenetic analyses (see Lavin 1988, Lavin *et al.* 2003, Pennington *et al.* 2010, 2011) of Robinioid legumes, placed five species of *Coursetia* into the genus *Poissonia*: i) *Poissonia eriantha* Hauman, from one site east of Apurimac river; ii) *P. heterantha* (Griseb.) Lavin, from Monte vegetation of eastern dry valleys of Argentina and Bolivia; iii) *P. hypoleuca*, from inter-Andean valleys of Argentina, Bolivia and Apurimac valley, Peru; iv) *P. orbicularis*, from Apurimac west of Cuzco, Peru; and v) *P. weberbaueri*, an endemic to coastal lomas of Arequipa and Ica. Surprisingly perhaps, the most geographically distant species, *Poissonia heterantha*, was shown to be most closely related to *P. weberbaueri*.

Our collections of *P. weberbaueri* extend the species' northern distribution. The species is fairly widely scattered within its narrow altitudinal range but limited to a small AOO in lomas. *Poissonia weberbaueri* is assessed as Endangered EN B1a (Baldeón *et al.* 2006).

Prosopis limensis Benth. *Growth form*: tree. *Habitat*: dunes, quebrada and huayco, dry forest, huerta. *Lomas*: none. *Origin*: Endemic. *Conservation status*: not assessed. *Elevation* (m): 120–790. *Vouchers*: AO 018, DPP 118, 227, 228, 563, OW 1678, 1681, 1684.

Note:—The arid coast of SW Ecuador, Peru, and Chile, have several closely related and morphologically similar *Prosopis* tree species. They are often locally called 'algarrobo' after the Spanish-assigned name for carob (*Ceratonia siliqua* L.), to which they are not closely related. However, in Ica, *Prosopis* is called 'huarango'—and is emblematic of the region. Several of these species have been the subject of taxonomic confusion, namely: *Prosopis chilensis* (Molina) Stuntz, *P. juliflora* (Sw.) DC., *P. limensis* Benth. and *P. pallida* (Humb. & Bonpl. ex Willd.) Kunth, and to a lesser extent, *P. alba* Griseb., *P. flexuosa* DC. and *P. laevigata* var. *andicola* Burkart. One problem is that *Prosopis* can undergo interspecific hybridisation (e.g. Hunziker *et al*. 1975). Some species were resolved with Burkart's *Prosopis* monograph (see Burkhart 1976ab) and others assigned as varieties, forms and putative hybrids (see Díaz 1995, 1997, Bessega *et al.* 2000, Pasiecznik *et al*. 2001, Harris *et al.* 2003, Burghardt & Espert 2007). Peruvian botanists (such as Cerrate, Díaz, Ferreyra, Sagástegui and Tovar) continued working on *Prosopis* in order to establish species delimitation, especially of *P. julifolia* and *P. pallida*, following Burkhart (1976). Ramón Ferreyra's herbarium (held at USM) has a large annotated collection in his diligent attempt to resolve *Prosopis* delimitations. *Prosopis julifolia* and *P. pallida* have been treated as a complex by Pasiecznik *et al*. (2001), with additional phylogenetic studies showing *P. juliflora* and *P. pallida* to be distinct with some possible hybridisation (Landeras *et al.* 2006). Burkart (1976) himself, recognised a possible *P. julifolia* × *P. pallida* hybrid near Quevedo, central western Ecuador. According to Burkart, *P. juliflora* does not occur in Peru and is confined to the Caribbean, Colombia, Mexico and Venezuela. Instead he recognised two Peruvian varieties: i) *P. juliflora* var. *inermis* (Kunth) Burkart (thornless with yellow pods) and supposedly a 'version of *P. juliflora*' from SW Ecuador; and ii) *P. juliflora* var. *horrida* (Kunth) Burkart (thorny with brown pods with scattered marginal hairs) from the Bagua Grande and Jaen area of the Amazonas (Burkart 1976, Burkart & Simpson 1977). Both varieties were originally described by Kunth in 1823 as *Prosopis inermis* Kunth, from a collection from 'Regno Peruviano teste Bonpl.' and *Prosopis horrida* from 'fuminis Amazonum, prope litus Oceani Pacifici, in arenosis inter Piura et Lambayeque', respectively. Burkart (1976) also sunk *P. limensis* into synonymy with *P. pallida*, arguing that 'no constant differences were observed between the two'. Both species were described originally from Peru. According to Burkart (1976), the author of *P. limensis*, Bentham (1841), apparently 'neglected to compare it with the much earlier *P. pallida*'. Burkart looked at two Ica specimens (*Ferreyra 2498* at SI!, US! and *Velarde 1537* at LIL†) from the Laguna de Orovilca—a small oasis lake in dune margins of the Ica valley. In describing *P. limensis*, from the collections *Cuming 974* (BM!, E!, GH!, K!) and *Mathews s.n*. (K!), both from 'Lima', Bentham (1841) stated, 'this appears to me to be really distinct from any of the preceding'. He also commented that this group of *Prosopis* are 'very variable, and all (excepting perhaps the *P. limensis*) run much one into the other, that they might possibly be mere varieties of one species'. After years of uncertainty, the taxonomic–numerical studies of Mom *et al*. (2002) and Burghardt *et al.* (2010) suggested *P. pallida* and *P. limensis* as distinct, with possible existence of hybrids. Later phylogenetic studies by Palacios *et al.* (2012) differentiated the three species, *P. julifolia*, *P. limensis* and *P. pallida*, concluding that *P. julifolia* is not found in Peru (but in Colombia and Venezuela including Caribbean coasts), and also recognised *P. limensis* and *P. pallida* as valid species. The present study agrees with the findings of Mom *et al.* (2002) and Palacios *et al.* (2012), supporting the reinstatement of *P. limensis* (the key species in Ica) with *P. pallida* dominating in Tumbes, Piura and Lambayeque. Our fieldwork and collections suggest that small relict populations of *Prosopis* aff. *limensis* are found in coastal Ancash, La Libertad and Lambayeque, and display varying degrees of possible hybridisation with *P. pallida.* After nearly two decades of *Prosopis in situ* observations, we find that flowers, fruit, foliar nectaries and leaflet pubescence are quite variable for the consistent differentiation of *P. limensis* and *P. pallida*. Likewise, the identification of herbarium collections of both species can be confounding, in that key distinguishing characters are only apparent in secondary growth and mature trees. Specimens are frequently made from branch-tip collections with seasonal leaf cohorts, and these immature seasonal flushes are often similar in both species as well as other *Prosopis* in the section. Key field characters to identify *P. limensis* in mature trees are: i) trunk inclined, sinuous or twisted with fissured and exfoliating bark exhibiting superficial and underlying red ochre colour; ii) development of large brachyblasts (swollen woody nodes underlying spent stipule and peduncle 'piles') on secondary branches (see Fig. 12). Characters to separate the species are shown in Table 18.

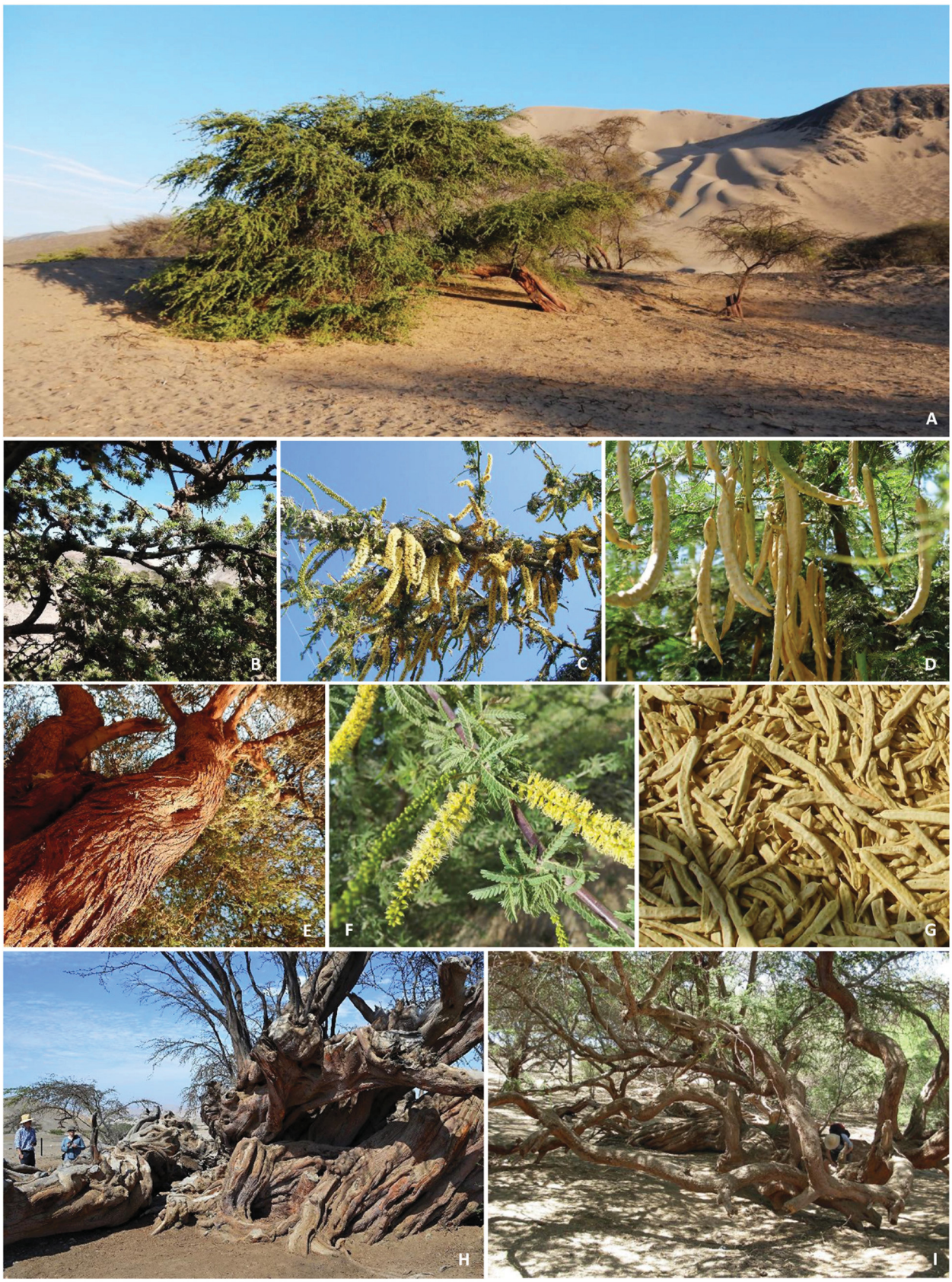

FIGURE 12. Huarango of Ica (*Prosopis limensis* Benth.) showing: (**A**) typical reclining habit in valley margin trees (Copara, Valle Las Trancas, Nazca, Ica); (**B**) characteristic brachyblasts and leaf clumping in mature branches (Mancha verde, Nasca); (**C**) yellow flowers; (**D**) ripe pods noting width (pale yellow, curved and straight); (**E**) fissured reddish trunk; (**F**) flowers, leaf pinna and red stems; (**G**) harvested pods drying; (**H**) the oldest *Prosopis* tree on south coast Peru 'Huarango Milenario' de Huayurí † (died 2016); (**I**) ancient *P. limensis* in Laguna San Pedro Cachiche, Ica. (photos: OW).

TABLE 18. Field characters that separate *P. pallida* from *P. limensis* in mature individuals.

Species	Trunk	Branches, habit	Lateral branches, brachyblasts	Spines (thorns)	Leaflets	Fruit (viable)
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth 'algarrobo'	Erect or slightly inclined, grey surface appearance	Radiating outwards, erect with shallow arch, lower limbs parallel to ground, generally not angular	Brachyblast not developed or absent (at times with short stipular piles <7 mm)	Nodal spine pairs usually present, 1–5 cm, 2.5–5 mm thick at base (conical acute)	Large ± 6–12 mm not overlapping, spaced. Rachis usually straight or slightly curved	Curved or straight, slightly tapered, yellow
Prosopis limensis Benth. 'huarango' (see Fig. 12)	Inclined, recumbent, sinuous or twisted, often deeply notched and fissured, red ochre brown appearance	Irregular radiating and angular, growth inclined towards ground in lower branches, frequently twisting and crooked	Swollen, nodular woody brachyblasts (at times with long stipular piles <12 mm), sometimes bearing resin	Absent (or vestigial <2 mm) in most trees with occasional 'armata' form	Small ± 3–7 mm, often near-touching or overlapping. In drought—spaced narrow but remaining small. Rachis recurved forming clumps that enclose brachyblast	Slightly curved or shallow 'S', margins parallel, cream to pale-yellow (ca. × 1.5–2 width of *P. pallida*)

Human influence. As a principle source of food, forage, fuel and materials (Whaley *et al*. 2010, 2011, Beresford-Jones 2005, 2011b), *Prosopis* has undergone a ca. 10,000-year history of translocation and human selection, through both pre-Columbian and post-colonial eras. Peruvian *Prosopis* species have been introduced worldwide (Shackleton *et al.* 2014), including to Hawaii and Puerto Rico at least a century ago (Gallaher & Merlin 2010, Johnston 1962). In Ica, *P. limensis* is confined to floodplains (with access to ground water) where human settlement and agriculture have dominated the landscape for millennia. People arrived on the coast of Ica some 10,000 years ago and by the time of Nazca culture, were dependent on *Prosopis* pods for food and agriculture (Beresford-Jones *et al.* 2009). *Prosopis* varieties are likely to have formed 'serendipitous backyard hybridisations', as shown by Hughes *et al.* (2007) in *Leucaena*, and were certainly selected to produce landraces. Thus, the morphology of *P. limensis* in Ica (as for *Prosopis* elsewhere) has been driven by human artificial selection over millennia (and prior to human arrival on the coast of Peru (ca. 11,000 BP) by megafauna). *Prosopis limensis* can be distinguished from other *Prosopis* species through two putative domestication traits that can be attributed to selection, with ploidy perhaps also playing a role (Hilu 1993, Harris *et al.* 2003). Firstly, *P. limensis* (in Ica) is virtually thornless; and secondly, clusters of trees (often near archaeological sites) are highly productive, producing thick pale-yellow pods rarely seen in other Peruvian *Prosopis* (see Fig. 12). These traits would have been selected for by earlier peoples as they are today. Selection for thornlessness makes sense in the context of domestication of soft-footed coastal camelids (requiring the high energy protein-rich pods), and the cultural dependence on pods, that are still harvested from under trees, often by barefoot children (Beresford-Jones 2011b, Whaley *et al*. 2010ab). *Prosopis* trees with large spines (often called thorns) are very rare or absent from most populations in Ica. When found, they are locally renowned as 'huarango machos' and reputed to possess harder wood, better for construction. *Prosopis limensis* also provides a vital source of food; spiny and unproductive trees would have been used for timber, with productive, thornless ones nurtured. Thornless, non-browsed *Prosopis* from Peru have already been observed (Lee *et al.* 1992), and we would suggest derive from ancient selected landraces. Cytological insights such as those of Hunziker (1975) are lacking in *Prosopis* of Peru. The relatively small number of base pairs (392 to 490 Mbp) of some New World *Prosopis* genomes, is also intriguing (Doyle & Luckow 2003).

Tracking the type. Hugh Cuming (1791–1865) collected plants on the Peruvian coast in 1829 (Dance 1980), although his specimens can be dated to 1831 or 1832 when accessioned. Although Cuming used the same collection numbers in the Philippines, they are more-or-less sequential and can be tracked from Chile, north along the Peruvian coast. Several of the *P. limensis* syntype specimens (*Cumming 974*) are labelled 'Lima et Peruvia Septentrionalis' (Lima and northern Peru). The type of *Senecio mollendoensis* (*Cuming 944* at K!) was collected in southern Peru (or northern Chile) to where it appears to be a narrow endemic. The type label of *Cuming 944* reads 'Cobija, Iquiqui et

Arica Peruviae meridionalis', thus indicating a huge length of coast (500–700 km) as potential collection localities. Subsequently, he collected *Portulaca pilosissima* Hook (*Cuming 965* at K!) in the 'valley of Canta' Lima; *Philibertia solanoides* Kunth (*Cuming 983* at BM! E! K!*)* in 'Peruvia prope Lima' and *Onoseris cumingii* Hook. & Arn. (*Cuming 995* at E! and K!) around 'Lima' or perhaps south, where this species appears to be endemic. Therefore, although Cuming's localities are hard to pin down, the suggestion here is that the *P. limensis* syntypes were collected near Lima and perhaps towards Canta. Importantly, *Prosopis* species are not naturally distributed on the Peruvian central coast or Lima, as from May to November, the central coast is subject to heavy winter fog. *Prosopis* trees are desert dry forest species and are susceptible to fungal attack and decay of pods and seeds with prolonged humidity. Likewise, there is little bioarchaeological evidence of pre-Colombian *Prosopis* presence or usage, excepting perhaps in Pachacamac, Lurin valley (1410–1476 AD), when perhaps it may have been cultivated (Moutarde 2017) or imported. Today *Prosopis* is not found in forest relicts near Lima (natural forest relicts around Lima are dominated by species such as *Acacia macracantha*, *Cestrum auriculatum*, *Salix humboldtiana* and *Schinus molle*). Pod usage in Lima during pre-Columbian epochs is thought to derive from importation (Whaley *et al.* 2010b, Beresford-Jones 2011b). *Prosopis* trees can be cultivated ornamentally in the drier areas of Lima, towards the pre-cordillera, and are known from a handful of parks in the city. Thus, it seems likely that Cuming collected the *P. limensis* syntypes from trees introduced to Lima; given that some Cuming syntype specimens have short spines, the tree may not be from Ica and is perhaps a hybrid. Certainly, the name *Prosopis limensis* is a misnomer, but it is described by a meticulous botanist, and for the present, is the closest to the huarango (*Prosopis*) of Ica—much to the chagrin of a few.

Conservation. The *Prosopis* of coastal Peru are in unparalleled need of urgent conservation, with systematic seed banking, forest protection and restoration. In Ica, only three forest relicts (of less than 10 ha in total) remain, in Río Grande, Valle Las Trancas and Río Poroma. The last remaining *Prosopis* relicts of significance were destroyed by forest fires in 2008 and 2016 (see discussion: Forest conservation and restoration). *Prosopis* forest die-back has been associated with the ENSO cycle of 1997–1998, and subsequent drought with associated plagues since 2001, specifically: *Melipotis* aff. *indomita* (Walker 1858) (Lepidoptera: Noctuoidea) and *Enallodiplosis discordis* (Gagne, 1994) (Cercidomyiidae) (Whaley 2009, Whaley *et al.* 2010ab); producing over 80% mortality in monitored plots in Ica and Lambayeque (Baena *et al.* 2017).

Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth. *Growth form*: tree. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: [4]VU. *Elevation* (m): 560–790. *Vouchers*: AO 355.

Rhynchosia minima (L.) DC. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. *Elevation* (m): 450. *Vouchers*: DPP 483, 532, 548.

Senna bicapsularis (L.) Roxb. **var. *augusti*** (Harms) H.S.Irwin & Barneby. *Growth form*: shrub. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410. *Vouchers*: DPP 154.

Senna bicapsularis (L.) Roxb. **var. *bicapsularis*** (L.) Roxb. *Growth form*: shrub. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 350. *Vouchers*: DPP 298.

Senna brongniartii (Gaudich.) H.S.Irwin & Barneby. *Growth form*: tree. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 510. *Vouchers*: DPP 004.

Tara spinosa (Molina) Kuntze. *Growth form*: tree. *Habitat*: Andean, huerta, quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: not assessed. *Elevation* (m): 410–1580. *Vouchers*: AO 033, 034, 094.

Vigna luteola (Jacq.) Benth. **var. *angustifolia*** (Engelm. & A.Gray) S.Watson. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 215. *Vouchers*: DPP 484, OW 02.

Weberbauerella brongniartioides Ulbr. *Growth form*: small shrub. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]EN B1ab(iii), [4]CR. New record for Ica. *Elevation* (m): 905. *Vouchers*: KPP 005, 050, 076, Ferreyra 6458 (K).

Note:—*Weberbauerella brongniartioides* was described by Ulbrich in 1906, from the type specimen *Weberbauer 1513* (holotype B†, neg. 1223 at F!) of 'prope Mollendo, solo arenoso parce plantis compto ad marginem inferiorem formationis, quae Loma dicitur in altitudine 100–200 m' in Arequipa.

According to Baldeón *et al.* (2006), *W. brongniartioides* is an endemic of Arequipa, only growing at 20–300 m

elev. and assessed as Endangered (EN B1ab(iii)). We recorded the species growing as a herb of 5–10 cm high, in Lomas San Fernando at 905 m, associated with *Argylia radiata*, *Atriplex rotundifolia*, *Cenchrus echinatus* L. and species of *Palaua*. It has a restricted distribution in Ica on the frontal lomas. Our collections extend the species distribution into the Ica region—likely to be its northern limit.

Weberbauerella raimondiana Ferreyra. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Marcona, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]EN B1ab(iii), [4]CR. *Elevation* (m): 360–720. *Vouchers*: OW 1698, Ferreyra 2505 (K), Hutchinson 1896 (K).

Note:—The second south coast endemic of the genus is *W. raimondiana*, described by Ferreyra in 1951 from the type specimen *Ferreyra 6498* (holo US!, iso MOL!, US!, USM!) from 'entre Nazca y Chala, Provincia de Caravelí, Noviembre 14, 1949, altura 300–400 metros' in Arequipa. Baldeón *et al.* (2006) cited the species as an endemic subshrub to Arequipa and Ica, associated with fog environments. We recorded the species growing as a herb of 12–35 cm high, in Lomas San Fernando and Marcona (360–720 m elev.). In Lomas San Fernando, it is frequently associated with *Argylia radiata*, *Tiquila dichotoma* (Ruiz & Pav.) Pers., *T. litoralis* (Phil.) A.T.Richardson and *Nolana* spp. The species distribution is highly limited. It grows in linear dunes, occurring in a narrow band where the cusp of the frontal lomas ridge intercepts fog. Here, the exposed position appears to reduce competition and stature of other species, while wind speeds (through upslope compression) concentrate fog and produce cooling.

Both *Weberbauerella* species are woody with bipinnate leaves covered in whitish tormentum. Flowers are dark yellow with distinctive radiating red or brown venation on the banner. Roots have underground storage organs with spheroid stolen. *Weberbauerella brongniartioides* can be distinguished as a more robust plant, growing as a small shrub to 90 cm with larger obovate leaves, whereas is *W. raimondiana* grows low and ground-hugging <25 cm. Both species were categorised under Peruvian law (Decreto Supremo 043-2006-AG) as Critically Endangered. In 2011, SERNANP established the Reserva Nacional San Fernando which protects some of the habitat of these species and part of Lomas San Nicolás (Nazca), provided off-road vehicles continue to be regulated. However, there are unprotected areas between San Nicolás and Lomas Marcona. The main threats are climate change and activities such as the Dakar Rally, off-road motor biking/4x4, unregulated tourism and mining in Marcona. *Weberbauerella raimondiana* has also been assessed as Endangered (EN B1ab(iii)) by Baldeón *et al.* (2006). A third species in the genus was recently described from Chile: *Weberbauerella chilensis* Faúndez & Saldivia (Saldivia & Faúndez 2014).

GERANIACEAE

Erodium cicutarium (L.) L'Hér. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 820–1690. *Vouchers*: DPP 273, 398.

Erodium malacoides (L.) L'Hér. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1670. *Vouchers*: DPP 243.

Geranium limae R.Knuth. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Morro Quemado. *Origin*: Endemic. *Conservation status*: [1]VU B1ab(iii). *Elevation* (m): 560–720. *Vouchers*: AO 193, OW 1658.

KRAMERIACEAE

Krameria lappacea (Dombey) Burdet & B.B.Simpson. *Growth form*: shrub. *Habitat*: lomas. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Native. *Conservation status*: [4]EN. New record for Ica. *Elevation* (m): 370–830. *Vouchers*: DPP 179, 369, KPP 066, 075, 084, 103.

LAMIACEAE

***Salvia* sp**. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Marcona. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 880. *Vouchers*: OW 1695.

Leonotis nepetifolia (L.) R.Br. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. *Elevation* (m): 470–310. *Vouchers*: AO 090, 397, DPP 091.

Marrubium vulgare L. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3150. *Vouchers*: DPP 416.

Minthostachys spicata (Benth.) Epling. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3300. *Vouchers*: DPP 428.

Salvia rhombifolia Ruiz & Pav. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 420. *Vouchers*: AO 542.

Stachys arvensis (L.) L. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. *Elevation* (m): 420. *Vouchers*: DPP 331.

LINACEAE

Linum prostratum Dombey ex Lam. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Morro Quemado. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 550. *Vouchers*: AO 196.

LOASACEAE

Nasa urens (Jacq.) Weigend. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 610–730. *Vouchers*: KPP 058, OW 1671.

Presliophytum incanum (Graham) Weigend. *Growth form*: herb or small shrub. *Habitat*: quebrada and huayco, xerophytic scrub. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]LC. *Elevation* (m): 450–920. *Vouchers*: DPP 140, 207, 231, 449.

LYTHRACEAE

Ammannia latifolia L. *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 270. *Vouchers*: DPP 006.

MALVACEAE

Abutilon grandifolium (Willd.) Sweet. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1660. *Vouchers*: DPP 253.

Acaulimalva oriastrum (Wedd.) Krapov. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3310. *Vouchers*: DPP 426.

Bastardia bivalvis (Cav.) Kunth. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1670. *Vouchers*: DPP 255.

Byttneria cordata Lam. *Growth form*: climber. *Habitat*: dunes. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]LC. *Elevation* (m): 1690. *Vouchers*: DPP 270.

Cristaria aspera Gay **var. *formosula*** (I.M.Johnst.) Muñoz-Schick. *Growth form*: herb. *Habitat*: dry forest, huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 410. *Vouchers*: DPP 474.

Cristaria multifida Cav. *Growth form*: herb. *Habitat*: huerta, lomas. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: [1]VU B1ab(iii). New record for Ica. *Elevation* (m): 520–730. *Vouchers*: KPP 015, 036.

Fuertesimalva peruviana (L.) Fryxell. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 480. *Vouchers*: DPP 462.

Gaya calyptrata (Cav.) Kunth ex K.Schum. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: [1]LC. New record for Ica. *Elevation* (m): 1680. *Vouchers*: DPP 268.

Herissantia crispa (L.) Brizicky. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 770. *Vouchers*: DPP 073.

Malva parviflora L. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 480. *Vouchers*: DPP 086.

Malvastrum tomentosum (L.) S.R.Hill. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 770. *Vouchers*: DPP 072.

Melochia lupulina Sw. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 420. *Vouchers*: DPP 550.

Melochia pyramidata L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 440–820. *Vouchers*: DPP 124, 216.

Palaua* aff. *concinna I.M.Johnst. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 840. *Vouchers*: DPP 337.

Palaua dissecta Benth. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 470–700. *Vouchers*: KPP 016, 043.

Palaua moschata Cav. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 350. *Vouchers*: KPP 087.

Palaua sandemanii (Sandwith) Fryxell. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 710–840. *Vouchers*: DPP 161, 344, KPP 008.

Palaua tomentosa Hochr. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Morro Quemado. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 550. *Vouchers*: AO 166.

Palaua trisepala Hochr. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Marcona, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]EN B1a. *Elevation* (m): 450–840. *Vouchers*: AO 213, DPP 173, KPP 048, OW 1692.

Sida rhombifolia L. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 910. *Vouchers*: AO 399.

Sida spinosa L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410. *Vouchers*: DPP 061.

Sidastrum paniculatum (L.) Fryxell. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 400–910. *Vouchers*: AO 395, DPP 152.

Tarasa operculata (Cav.) Krapov. *Growth form*: herb or small shrub. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 460–1670. *Vouchers*: AO 245, DPP 050, 245.

Urocarpidium mathewsii (Turcz.) Krapov. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 480. *Vouchers*: DPP 093.

Waltheria indica L. *Growth form*: shrub. *Habitat*: dry forest, huerta, quebrada and huayco, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 790. *Vouchers*: DPP 098.

Waltheria ovata Cav. *Growth form*: shrub. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 380–910. *Vouchers*: AO 377, OW 053.

NYCTAGINACEAE

Allionia incarnata L. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 440–480. *Vouchers*: DPP 468, KPP 079.

Boerhavia coccinea Mill. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 410. *Vouchers*: AO 538.

Boerhavia erecta L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 400–780. *Vouchers*: DPP 064, 104, 153.

Boerhavia tuberosa Lam. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 770–830. *Vouchers*: DPP 129, 223, 552.

Boerhavia verbenaceae Killip. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]DD. New record for Ica. *Elevation* (m): 480. *Vouchers*: DPP 404, 469.

ONAGRACEAE

Ludwigia octovalvis (Jacq.) P.H.Raven. *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 450. *Vouchers*: DPP 540.

Oenothera arequipensis Munz & I.M.Johnst. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 480. *Vouchers*: DPP 464.

Oenothera laciniata Hill. *Growth form*: herb. *Habitat*: lomas, marsh and puquio. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 840. *Vouchers*: DPP 177, 362.

Oenothera nocturna Jacq. *Growth form*: herb. *Habitat*: huerta, lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 410. *Vouchers*: DPP 473.

ORCHIDACEAE

Aa* aff. *weddelliana (Rchb.f.) Schltr. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Morro Quemado. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 520–920. *Vouchers*: DPP 353, KPP 096, OW 1709.

Note:—*Aa weddelliana* was first described in 1878 under the name *Altensteinia weddelliana* Rchb.f. from the collection *Mandon 1167* (holo W, iso G!, K!) at 'vicinis Soratae, Paracollo in schistosis, region subalpine 3400 m, Dec 1856–Jan 1857'. The alpine zone above Sorata, near La Paz, lies about 75 km from the Peruvian border, and over 600 km from our coastal collection activities in Ica. The species was apparently first collected in Ica, south of Nazca, in 1957 (*Rahn 198* at USM, cited by Trujillo & Rodríguez 2011). We discovered the terrestrial *Aa* aff. *weddelliana* in Ica in 2007, growing in Lomas Amara and Ullujalla at 834 m elev. (collection cited in Trujillo & Rodríguez 2011). We also registered the plant in 2013, 2014 and 2015 in Lomas Amara and Morro Quemado at 520–920 m elev. The orchid has been reported informally as growing in Cuzco (Revilla *et al.* 2003), although without citing any herbarium specimens. Trujillo and Delgado (2011) also cited the species for Arequipa (Lomas Atiquipa, Los Cerrillos) and Lima (Lomas Lachay). After comparative study of the isotypes of *Aa weddelliana* (held at G! and K!) and our collections in Ica, there are clear distinctions; the type specimen inflorescences, for example, exhibit significantly fewer flowers (23–60 flowers, slightly spaced). By contrast, our Ica herbarium specimens (and *in situ* observations) have 80–140 flowers. These match with *Aa matthewsii* (Rchb.f.) Schltr. *Mathews 677* (held at E! and K!) collected in 'Obrajillo and Tarma—leaves not above ground' (Obrajillo is near Canta, Lima, while Tarma is in the Andes of Junín). The inflorescences of the Ica specimens are arranged on a congested spike with spiral geometry (producing a *Plantago*-like appearance) that match with *Aa matthewsii.* Our specimens are also clearly distinct from the *Aa weddelliana* collections held at SI! (*Johnson 792, Zuloaga 11119, 11726, 13467*) from Jujuy, Argentina, that describe the orchid as a tree epiphyte growing in *Polylepis* and *Podocarpus* forest at 2470–3340 m. The morphological differences and disjunctive distribution between the coastal and Andean populations suggest the coastal taxa as a possible subspecies.

OROBANCHACEAE

***Bartsia* sp.** *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 3300. *Vouchers*: DPP 425.

OXALIDACEAE

Oxalis dombeyi A.St.-Hil. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 890. *Vouchers*: DPP 545.

Oxalis lomana Diel. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]NT. New record for Ica. *Elevation* (m): 620. *Vouchers*: KPP 057.

Oxalis megalorrhiza Jacq. *Growth form*: herb. *Habitat*: lomas. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): no data. *Vouchers*: Ferreyra 14108 (USM).

Oxalis pachyrrhiza Wedd. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 830. *Vouchers*: DPP 164, 180, 357.

***Oxalis* sp**. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Morro Quemado, Lomas San Fernando. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 350–1250. *Vouchers*: AO 045, 059, 084, 187, 210.

PAPAVERACEAE

Argemone subfusiformis G.B.Ownbey. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 410–790. *Vouchers*: DPP 114, 326, 546, OW 029.

Fumaria capreolata L. *Growth form*: herb. *Habitat*: lomas. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 410. *Vouchers*: DPP 304.

PASSIFLORACEAE

Passiflora foetida L. *Growth form*: climber. *Habitat*: dry forest, huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: [7]LC. *Elevation* (m): 420–850. *Vouchers*: AO 152, DPP 133, 570.

PHRYMACEAE

Mimulus glabratus Kunth. *Growth form*: herb. *Habitat*: marsh and puquio. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 510. *Vouchers*: Roque 392 (USM).

PLANTAGINACEAE

Bacopa monnieri (L.) Pennell. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. *Elevation* (m): 270–400. *Vouchers*: DPP 010, 024, 377.

Galvezia eliensii M.O.Dillon & Quip. *Growth form*: shrub. *Habitat*: dry forest. *Lomas*: none. *Origin*: Endemic. *Conservation status*: not assessed. *Elevation* (m): 370–490. *Vouchers*: AO 360, 380.

Galvezia fruticosa J.F.Gmel. *Growth form*: shrub. *Habitat*: dry forest, quebrada and huayco, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 230–810. *Vouchers*: AO 036, 087, 332, DPP 075, 107, 122, 160, OW 076.

Plantago limensis Pers. *Growth form*: herb. *Habitat*: huerta, lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Marcona, Lomas Morro Quemado, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: not assessed. *Elevation* (m): 540–840. *Vouchers*: AO 168, 223, DPP 168, 349, 521, KPP 010, 025.

Plantago major L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. *Elevation* (m): 410. *Vouchers*: DPP 150, 386.

Plantago orbignyana Steinh. ex Decne. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3300. *Vouchers*: DPP 434.

Plantago sericea Ruiz & Pav. **subsp. *sericans*** (Pilg.) Rahn. *Growth form*: herb. *Habitat*: Andean, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3310. *Vouchers*: DPP 432.

Veronica anagallis-aquatica L. *Growth form*: herb. *Habitat*: marsh and puquio. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 400. *Vouchers*: DPP 146, OW 104.

PLUMBAGINACEAE

Plumbago coerulea Kunth. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1660. *Vouchers*: DPP 254.

POACEAE

Anthephora hermaphrodita (L.) Kuntze. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 420. *Vouchers*: OP 88.

Aristida adscensionis L. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 470–820. *Vouchers*: DPP 042, 392.

Aristida chiclayensis Tovar. *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]EN B1a. New record for Ica. *Elevation* (m): 800. *Vouchers*: OP 64.

Note:—An endemic coastal herb assessed as Endangered (EN B1a) and previously known only from the northern Peruvian regions of Cajamarca, La Libertad, Lambayeque and Piura (La Torre *et al.* 2006). Our new records extend the southern distribution of this species to the Ica region. In Peru, the genus *Aristida* comprises 15 species, of which *A. chiclayensis* and the recently discovered *A. pseudochiclayensis* Gut.Peralta & R.Castañeda are endemics (Gutiérrez & Castañeda 2016, Davidse *et al.* 2003, La Torre *et al.* 2006). *Aristida pseudochiclayensis* was described in 2016 from the collection *Castañeda 997* (holo USM!) of 'La Libertad, Virú, Chao, Calipuy'. Both annual endemics are morphologically closely related. *Aristida chiclayensis* has longer arista (27–40 mm), a shorter column (4.5–6 mm) and the apex of the superior glume is bifid; *A. pseudochiclayensis* exhibits a shorter arista (18–20 mm), longer column (7.5–8 mm) and an entire superior glume apex (Gutiérrez & Castañeda 2016). Furthermore, *A. chiclayensis* disarticulates below each fertile floret (Clayton *et al.* 2006).

***Aristida* sp.** *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 930. *Vouchers*: DPP 516.

***Arundo donax* L.** *Growth form*: shrub. *Habitat*: riparian. *Lomas*: none. *Origin*: Introduced. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 340. *Vouchers*: DPP 296, OW 067.

Brachiaria mutica (Forssk.) Stapf. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 420. *Vouchers*: Cano 488 (USM), OP 109.

Bromus catharticus Vahl. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 405. *Vouchers*: OP 53, Ferreyra 11486 (USM).

***Bromus* sp.** *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 730–3230. *Vouchers*: DPP 510, OW 1734.

Cenchrus ciliaris L. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 480. *Vouchers*: DPP 081, 479.

Cenchrus echinatus L. *Growth form*: herb. *Habitat*: lomas, riparian. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 390. *Vouchers*: DPP 452, KPP 051, OW 015.

Cenchrus myosuroides Kunth. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 440. *Vouchers*: DPP 218.

Chloris radiata (L.) Sw. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 215. *Vouchers*: OW 043.

Chloris virgata Sw. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 860–930. *Vouchers*: DPP 515, OW 081.

Chondrosum simplex (Lag.) Kunth. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 500. *Vouchers*: OP 76, OW 1548.

Cynodon dactylon (L.) Pers. *Growth form*: herb. *Habitat*: huerta, marsh and puquio. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. *Elevation* (m): 410–790. *Vouchers*: AO 349, DPP 111, 318, 494, OW 009, 083.

Dactyloctenium aegyptium (L.) Willd. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 420. *Vouchers*: OP 79.

Digitaria sanguinalis (L.) Scop. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 420. *Vouchers*: OP 92.

Distichlis spicata (L.) Greene. *Growth form*: herb. *Habitat*: huerta, marsh and puquio. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 30–570. *Vouchers*: DPP 496, OW 1650.

Echinochloa colona (L.) Link. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: [2]LC. *Elevation* (m): 220–390. *Vouchers*: OP 93, OW 042.

Echinochloa crus-galli (L.) P.Beauv. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 420. *Vouchers*: Cano *et al*. 5989 (USM), OP 94.

Echinochloa crus-pavonis (Kunth) Schult. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 450. *Vouchers*: DPP 530.

***Echinochloa* sp**. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): no data. *Vouchers*: DPP 499, 500.

Eleusine indica (L.) Gaertn. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 215. *Vouchers*: DPP 497, OW 040.

Eragrostis attenuata Hitchc. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 830. *Vouchers*: DPP 196.

Eragrostis cilianensis (All.) Janch. *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 820. *Vouchers*: DPP 393.

Eragrostis ciliaris (L.) R.Br. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 270. *Vouchers*: DPP 007, OW 044.

Eragrostis nigricans (Kunth) Steud. *Growth form*: herb. *Habitat*: quebrada and huayco, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 740. *Vouchers*: OP 69.

Eragrostis peruviana (Jacq.) Trin. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 830. *Vouchers*: DPP 188, 345.

Eragrostis pilosa (L.) P.Beauv. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 215. *Vouchers*: OP 70, OW 039.

Eragrostis weberbaueri Pilg. *Growth form*: herb. *Habitat*: quebrada and huayco, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 480–820. *Vouchers*: DPP 083, 391.

Eriochloa punctata (L.) Desv. ex Ham. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 430. *Vouchers*: OP 96, Roque 124 (USM).

Guadua superba Huber. *Growth form*: shrub. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 410. *Vouchers*: OP 51.

Note:—The genus *Guadua* is endemic to the New World and is one of the most widespread genera of Bambusoideae, occurring from Mexico to Argentina, except Chile (Londoño & Peterson 1991, Tovar 1993). Only five species are recognised for Peru. The disjunctive presence of the perennial *Guadua superba* in Ica is surprising. This tough bamboo-like species is native to the SW Amazon and wet tropics. Its intriguing presence in established stands on the upper valleys of the Ríos Ica and Grande, is most likely to be a human introduction with possible pre-Columbian or colonial origins. In Ica, the species is easily recognisable, with shiny dark green erect stems (culms), growing 2–4 m tall with pale rings at the nodes. Leaf sheaths are glabrous on the surface with hairy outer margin; root thorns can be found at the nodes.

Gynerium sagittatum (Aubl.) P.Beauv. *Growth form*: shrub. *Habitat*: riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 220–390. *Vouchers*: OP 62, OW 010.

Hordeum vulgare L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 460. *Vouchers*: OP 59.

Imperata minutiflora Hack. *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 895. *Vouchers*: OP 111.

Jarava pachypus Pilg. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: [1]VU B1ab(iii). *Elevation* (m): 650–840. *Vouchers*: DPP 182, OW 1728.

Note:—This endemic perennial herb was first described in 1920 under the name of *Stipa pachypus* Pilg. from the collection *Weberbauer 1487* (types G!, S!, US!) from 'Mollendo (Arequipa), auf steinigen, dürftig bewachsenen Sandboden am unteren Rande der Loma-Formation, 20–100 m, August 1902'. It is found in Arequipa and Ica (Brako & Zarucchi 1993) and apparently in Piura (*Peterson & Refulio 15143, 15148* at MO). It was collected from Isla de San Gallán (or Sangayan) in 1919 under its synonym *Stipa distichia* (*Murphy 3478*, holo US!, iso K!). This species is perhaps the only truly endemic grass of lomas formations in the arid south coast of Peru. It is extremely tolerant of stressful conditions. In Ica's lomas, the species acts as a fog garnering 'nurse' plant to other species (see below) in 'micro-island' clump communities. The species could be confused with *Nassella nardoides* (Phil.) Barkworth, although the former is a *puna* species growing at over 4000 m elev., and exhibits larger panicles and a pubescent palea (Tovar 1993). It has been assessed as Vulnerable (VU, B1ab(iii)) (La Torre *et al.* 2006).

Leptochloa fusca (L.) Kunth **subsp. *uninervia*** (J.Presl.) N.Snow. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 470. *Vouchers*: DPP 043, 476, 498, OW 018.

Leptochloa virgata (L.) P.Beauv. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 895. *Vouchers*: OP 85.

Lolium perenne L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 210. *Vouchers*: OP 118.

Muhlenbergia microsperma (DC.) Trin. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 895. *Vouchers*: OP 75.

Paspalidium geminatum (Forssk.) Stapf. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 500. *Vouchers*: Cano 2455 (USM), OP 103.

Paspalum clandestinum Swallen. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 440. *Vouchers*: OP 102.

Paspalum conjugatum P.J.Bergius. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 420. *Vouchers*: OP 97.

Paspalum denticulatum Trin. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 425. *Vouchers*: OP 99.

Paspalum flavum J.Presl. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1660. *Vouchers*: DPP 252.

Paspalum haenkeanum J.Presl. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]LC. *Elevation* (m): 460. *Vouchers*: OP 98, Roque 188 (USM).

Note:—An endemic perennial species originally described in 1830 from the collection *Haenke s.n.* (types HAL!, BM!, BR!, MO!) of 'montanis huanoccensibus Peruviae', meaning mountains of Huanuco. La Torre *et al.* (2006) extended its distribution to Cajamarca, Huanuco, Ica, La Libertad, Lima and Tumbes. This C4 species (La Torre *et al.* 2006) has thick pubescent leaf blades, up to 8.5 cm long and up to 9 mm wide; the inflorescence is composed of racemes with solitary spikelets (Clayton *et al.* 2006). The species is recorded as a weed in traditional agriculture (Sagástegui & Leiva 1993).

Paspalum notatum Flüggé. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 320. *Vouchers*: Cano 2646 (USM), Cano *et al.* 5960 (USM), OP 100.

Paspalum vaginatum Sw. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 500. *Vouchers*: OP 101.

Pennisetum annuum Mez. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]LC. New record for Ica. *Elevation* (m): 1640. *Vouchers*: DPP 232.

Note:—An annual endemic species of Least Concern (LC) (La Torre *et al.* 2006) and described as new to science from the collection *Weberbauer 5354* (types B!, S!) of 'Peru'. The type specimen (at B) was collected in 1910 at 1700–1800 m elev. from 'hills north of Chosica Station, off the Lima–Oroya road'. The species is sporadically distributed along the Pacific Andean slopes of the regions of Cajamarca, La Libertad and Lima, at 650–2000 m elev. Our new record extends its southern distribution to the Ica region. Here, it grows as a herb to 70 cm high at 1640 m elev. in the locality of Ronquillo, near the south-eastern border of Ica. According to Clayton *et al.* (2006), the species has spike-shaped terminal and axillary panicles, a panicle axis with rounded ribs, glabrous, and bearing deciduous spikelets.

Pennisetum clandestinum Hochst. ex Chiov. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 480. *Vouchers*: DPP 082.

Pennisetum purpureum Schumach. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. *Elevation* (m): 470. *Vouchers*: DPP 038.

Pennisetum setaceum (Forssk.) Chiov. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 400. *Vouchers*: OP 105.

Phalaris canariensis L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 390. *Vouchers*: OP 56.

Phragmites australis (Cav.) Trin. ex Steud. *Growth form*: shrub. *Habitat*: marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. *Elevation* (m): 230. *Vouchers*: AO 126.

Poa annua L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 405. *Vouchers*: OP 54, sin coll. 10530 (USM).

Polypogon elongatus Kunth. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1640. *Vouchers*: DPP 233.

Polypogon monspeliensis (L.) Desf. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 210. *Vouchers*: DPP 577.

Polypogon viridis (Gouan) Breistr. *Growth form*: herb. *Habitat*: quebrada and huayco, marsh and puquio. *Lomas*: none. *Origin*: Introduced. *Conservation status*: [2]LC. *Elevation* (m): 1640. *Vouchers*: DPP 234.

Rostraria trachyantha (Phil.) Soreng. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 840. *Vouchers*: DPP 176.

Note:—This annual species appears to be endemic to northern Chile and Peru. It was first described in 1860 under the name *Koeleria trachyantha* Phil., from a collection of *Philippi s.n.* (types SGO!, W!) near Paposo. In Peru, it is found in Ancash, Arequipa, La Libertad, Lambayeque and Lima regions (Brako & Zarucchi 1993) and growing along the Pacific coast on lomas formations (Tovar 1993). Our new record extends its southern distribution to the Ica region, although it was apparently collected in Isla Gallán (or Sangayan) in 1920 (*Murphy 3477*) (Johnston 1931). The species was seen flowering in November at Lomas Amara, growing as a herb to 50 cm high at ca. 840 m elev. It demonstrates an incredible tolerance of aridity.

Setaria parviflora (Poir.) M.Kerguélen. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. New record for Ica. *Elevation* (m): 1660. *Vouchers*: DPP 242.

Setaria verticillata (L.) P.Beauv. *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 220. *Vouchers*: OW 020, 062.

Sorghum bicolor (L.) Moench. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. *Elevation* (m): 215–405. *Vouchers*: OP 113, OW 087.

Sorghum halepense (L.) Pers. *Growth form*: herb. *Habitat*: marsh and puquio, huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. *Elevation* (m): no data. *Vouchers*: DPP 501.

Sporobolus indicus (L.) R.Br. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 400. *Vouchers*: La Torre 762 (USM) & 748 (USM), OP 73.

Sporobolus virginicus (L.) Kunth. *Growth form*: herb. *Habitat*: huerta, marsh and puquio, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 5–570. *Vouchers*: AO 078, DPP 495, OW 079.

***Stipa* sp**. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 840. *Vouchers*: DPP 341.

Tragus berteronianus Schult. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 470. *Vouchers*: DPP 049, 478.

Trichoneura weberbaueri Pilg. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 800. *Vouchers*: OP 121.

***Vulpia* sp**. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 620–840. *Vouchers*: DPP 365, OW 1665.

Zoysia matrella (L.) Merr. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 460. *Vouchers*: OP 87.

POLEMONIACEAE

Cantua candelilla Brand. *Growth form*: shrub. *Habitat*: Andean. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]LC. New record for Ica. *Elevation* (m): 3230. *Vouchers*: DPP 444.

POLYGALACEAE

Pteromonnina pterocarpa (Ruiz & Pav.) B.Eriksen. *Growth form*: herb. *Habitat*: Andean. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 1120. *Vouchers*: DPP 285.

POLYGONACEAE

Polygonum hydropiperoides Michx. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 920. *Vouchers*: AO 398.

PORTULACACEAE

***Calandrinia* sp**. *Growth form*: herb. *Habitat*: Andean, lomas. *Lomas*: Lomas San Fernando. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 690. *Vouchers*: KPP 021.

Cistanthe paniculata (DC.) Carolin ex M.A.Hershkovitz. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 430–890. *Vouchers*: AO 205, DPP 185, 355, KPP 019.

Portulaca pilosissima Hook. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Marcona, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 450–840. *Vouchers*: AO 214, DPP 186, KPP 040.

PRIMULACEAE

Anagallis arvensis L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 910. *Vouchers*: AO 391.

RHAMNACEAE

Colletia spinosissima J.F.Gmel. *Growth form*: shrub or small tree. *Habitat*: Andean. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3150. *Vouchers*: DPP 417.

Scutia spicata (Humb. & Bonpl. ex Willd.) Weberb. *Growth form*: shrub. *Habitat*: dry forest. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. *Elevation* (m): 480–1140. *Vouchers*: AO 023, DPP 119, OW 048, 01801.

RUBIACEAE

Galium arequipicum Dempster. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: [1]EN B1a. New record for Ica. *Elevation* (m): 3230. *Vouchers*: DPP 506.

Spermacoce remota Lam. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 450. *Vouchers*: DPP 539.

SALICACEAE

Salix humboldtiana Willd. *Growth form*: tree. *Habitat*: riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 340–590. *Vouchers*: AO 021, 029, DPP 148, 299, OW 023, 02701.

***Salix* sp**. *Growth form*: tree. *Habitat*: huerta. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 340. *Vouchers*: DPP 300.

SAPINDACEAE

Sapindus saponaria L. *Growth form*: tree. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 600–730. *Vouchers*: AO 039, 309.

SCHOEPFIACEAE

Quinchamalium lomae Pilg. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Marcona, Lomas Morro Quemado. *Origin*: Endemic. *Conservation status*: [1]EN B1a. New record for Ica. *Elevation* (m): 550–840. *Vouchers*: AO 198, 216, DPP 183, 335.

Quinchamalium procumbens Ruiz & Pav. *Growth form*: herb. *Habitat*: Andean. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3230. *Vouchers*: DPP 508.

SCROPHULARIACEAE

Alonsoa meridionalis (L.f.) Kuntze. *Growth form*: herb. *Habitat*: Andean. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1660. *Vouchers*: DPP 239.

Buddleja americana L. *Growth form*: tree. *Habitat*: Andean, huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 405. *Vouchers*: DPP 576.

SOLANACEAE

Browallia americana L. *Growth form*: herb. *Habitat*: Andean, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 410. *Vouchers*: DPP 472.

Cestrum auriculatum L'Hér. *Growth form*: tree. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 440–1030. *Vouchers*: DPP 219, 538.

Datura inoxia Mill. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 480. *Vouchers*: DPP 041, OW 075.

Datura stramonium L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. *Elevation* (m): 400–420. *Vouchers*: DPP 055, 327, OW 056.

Dunalia spinosa (Meyen) Dammer. *Growth form*: shrub. *Habitat*: Andean, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3150. *Vouchers*: DPP 443.

Exodeconus maritimus (Benth.) D'Arcy. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 470–830. *Vouchers*: DPP 138, 467.

Exodeconus prostratus (L'Hér.) Raf. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: [1]LC. New record for Ica. *Elevation* (m): 270. *Vouchers*: DPP 017, 522.

Grabowskia boerhaaviifolia (L.f.) Schltdl. *Growth form*: tree. *Habitat*: dry forest, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 420–760. *Vouchers*: AO 005, 035, DPP 077, OW 1505, 1529.

Leptoglossis ferreyraei Hunz. & Subils. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]EN B1ab(iii). New record for Ica. *Elevation* (m): 590. *Vouchers*: KPP 032.

Note:—The endemic herb *Leptoglossis ferreyraei* was described in 1959 from the collection *Ferreyra 14020* (holo USM! iso CORD) from 'Lomas de Jahuay, entre Nazca y Chala, 300/400 m' in Arequipa. Until now it was thought to be endemic to Arequipa only. It is assessed as Endangered (EN B1ab(iii)) according to Knapp *et al.* (2006). We

recorded the species infrequently, growing as an erect herb of 10–30 cm high, flowering in October 2012 at Lomas San Fernando (590 m elev.) and in November 2006 in Lomas Amara (835 m elev.). The sessile tubular flowers are arranged in contracted cymes (producing around 50 sequential flowers, with between 10 and 40 open at any one time), and with a corolla of around 15 mm long. The flowers have an unusual pale 'glowing' cream-yellow colour, with the corolla tube demarcated by parallel intermittent brown lines that continue on both sides of the corolla as pseudo-venation. These collections extend the species distribution range into the Ica region. According to Hunziker and Subils (1979), *Leptoglossis ferreyraei* can be distinguished from *L. lomana* in that it has basally lignified stems with the basal 'rosette leaves wanting', calyx with branched hairs (mostly dendroid), and sessile or subsessile flowers. Our collections agree with Hunziker & Sublis (1979) in most of these diagnostic characters; however, ours exhibit leaves that form a basal rosette. The original description of *Leptoglossis ferreyraei* was based on three herbarium collections from Arequipa.

Leptoglossis* aff. *lomana (Diels) Hunz. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: [1]EN B1ab(iii). New record for Ica. *Elevation* (m): 830–840. *Vouchers*: DPP 191, KPP 104.

Note:—This species was first described in 1919 under the name of *Leptofeddea lomana* Diels, from the herbarium collection *Weberbauer 1486* (holo B+, iso K!) from 'juxta Mollendo prope regionis lomae marginem inferiorem in arenosis 20–100 m'. Hunziker and Subils (1979) described *Leptoglossis lomana* as a 'tiny ephemerophyte unique to the "lomas" 20 to 500 m alt'. The species is known from the regions of Arequipa, Moquegua and Tacna. In Arequipa, it is found in Lomas Atiquipa, Camaná, Capac, Capace, Jahuay and Ocoña. The species is assessed as Endangered (EN B1ab(iii)) according to Knapp *et al.* (2006). We recorded *Leptoglossis* aff. *lomana* growing as an annual or biannual re-sprouting herb of up to 20 cm high, flowering in January 2013 in Lomas Amara (840 m elev.). It can be found in flushes, as a small emphemerophyte (7–15 cm tall), especially after ENSO related rain and/or heavy fog. These new collections extend the species' northern distribution into the Ica region. According to Hunziker and Sublis (1979) the species can be distinguished as a short-lived tiny herb lacking lignification, its basal leaves forming a rosette at ground level (long petiolate and broad blade), cauline leaves sessile with a linear blade, and calyx pubescent with mainly bifurcate hairs. Our collection resembles *L. lomana* but exhibits long petiolate cauline leaves with a broad blade, and pedunculate flowers.

Lycium americanum Jacq. *Growth form*: shrub. *Habitat*: dry forest, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 420–600. *Vouchers*: AO 004.

Lycopersicon pennellii (Correll) D'Arcy. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 950. *Vouchers*: AO 400.

Nicandra physalodes (L.) Gaertn. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 420. *Vouchers*: DPP 319.

Nicotiana glauca Graham. *Growth form*: shrub or small tree. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 230–450. *Vouchers*: AO 006, DPP 022, 045.

Nicotiana glutinosa L. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 270–1760. *Vouchers*: AO 068, DPP 016, 410.

Nicotiana paniculata L. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic. *Conservation status*: [1]LC. *Elevation* (m): 440–1650. *Vouchers*: DPP 236, OW 1748.

Nolana adansonii (Roem. & Schult.) I.M.Johnst. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 30–70. *Vouchers*: KPP 094, OW 1739.

Note:—*Nolana* is a genus of 89 species, with 44 species in Chile, 40 species in Peru, and one oceanic island endemic (*N. galapagensis* (Christoph.) Johnst.). Only four species have a distribution in both Chile and Peru (Dillon *et al.* 2009). *Nolana adansonii* is a native perennial herb or very small shrub known to grow in the lomas of Arequipa, Moquegua and Tacna regions (Brako and Zarucchi 1993), as well as Tarapaca region in northern Chile (Mesa *et al.* 1998, Muñoz-Schick *et al.* 2001, Zuloaga *et al.* 2008). *Nolana adansonii* was originally described under the name of

Tula adansonii Roem. & Schult., from a collection of *Feuillée s.n*. from 'in rupibus ad mare in Peruvia'. According to Johnston (1936), the type locality corresponds to 'coast just south of Ilo, Peru'. In 1846, Remy described the species as *Sorema cordata* Remy, from a collection of D'Orbigny (type P!) from 'Islay prope Arequipa', although he suggests it being conspecific with the *Feuillée* collections. It is one of the most distinctive *Nolana* species with stipuloid petiole bases, unique in the family (Johnston 1936). The species exhibit unusual glandular succulent (turgid) reniform leaves that tend to cordate when swollen. The campanulate flowers exhibit a very pale purple corolla with dark purple throat and venation inside the tube (see Appendix 3). The anthers are lilac blue producing whitish pollen. The most striking feature is dark brown stems that can appear shiny and black—almost as though enamelled. The whole plant is usually found with a wet appearance, probably due to the hygroscopic effect of sea salt aerosols (and possible exudate). It was actually described as being 'covered with saline oily substance' by Schultes (1819). We observed the species as a halophyte, growing near the shoreline, 20–30 m above sea level at the foot of Lomas Amara and Lomas San Fernando. Here, it is bathed in salt spray transported by onshore winds. It is restricted to rooting in the base of weathered granite boulders that are deeply fissured, channelling fog moisture to a substrate of coarse wind-blown sand and granite flakes. This new collection extends the species' northern distribution range to the Ica region. It is very rare in Ica as it grows in isolated coastal outcrops and small dunes, impacted by rubbish, campsites and off-road vehicles along the coast. The phylogenetic analysis of Dillon *et al.* (2007b) suggests a close relationship between *N. galapagensis* (Christoph.) Johnst. (from six of the Galapagos Islands) and the Peruvian *N. adansonii* and *N. arenicola* I.M.Johnst. (from southern Peru and northern Chile). *Nolana galapagensis* origins are traced to Peruvian taxa with a divergence time of 0.35 Ma (Dillon *et al.* 2009).

Nolana chancoana M.O.Dillon & Quip. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 470. *Vouchers*: DPP 403, 466.

Nolana humifusa (Gouan) I.M.Johnst. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: [1]NT. New record for Ica. *Elevation* (m): 480. *Vouchers*: Mendivil *et al*. 023 (USM, MOL).

Nolana pallida I.M.Johnst. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]VU B1ab(iii). *Elevation* (m): 820–890. *Vouchers*: KPP 004, 097.

Nolana pallidula I.M.Johnst. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Marcona. *Origin*: Endemic. *Conservation status*: [1]VU B1ab(iii). *Elevation* (m): no data. *Vouchers*: Rahn 39 (USM), OW 1756.

Nolana pilosa I.M.Johnst. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]VU B1ab(iii). New record for Ica. *Elevation* (m): 830. *Vouchers*: DPP 172.

Nolana plicata I.M.Johnst. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]VU B1ab(iii). *Elevation* (m): 700. *Vouchers*: KPP 009.

***Nolana* sp.**1. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Marcona, Lomas San Fernando. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 440–780. *Vouchers*: DPP 046, KPP 026, AO 231, OW 1706, 1707.

Nolana spathulata Ruiz & Pav. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Marcona. *Origin*: Endemic. *Conservation status*: [1]NT. *Elevation* (m): 420. *Vouchers*: Ferreyra 13378 (USM).

Nolana thinophila I.M.Johnst. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]VU B1ab(iii). *Elevation* (m): 860. *Vouchers*: KPP 006.

Nolana tomentella Ferreyra. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Marcona. *Origin*: Endemic. *Conservation status*: [1]EN B1a. *Elevation* (m): no data. *Vouchers*: Broggi s.n. (USM).

Nolana tovariana Ferreyra. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [1]EN B1a. New record for Ica. *Elevation* (m): 690–840. *Vouchers*: DPP 174, 350, 359, KPP 014.

Nolana willeana Ferreyra. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Endemic (Ica only). *Conservation status*: [1]CR B1ab(iii). *Elevation* (m): 820–830. *Vouchers*: DPP 162, 336, KPP 095.

Note:—A narrow Peruvian endemic with a highly restricted coastal lomas distribution in the Ica region. It was first described by Ferreyra in 1956 from the collection *Köie s.n.* (holo USM!) of 'Lomas de Amara, cerca de la desembocadura del Río Ica, altitude 700 m'. The species was treated in Ferreyra's 1961 Peruvian *Nolana* revision. According to Knapp *et al.* (2006), the species is only known from its type locality and has not been collected since 1956. We rediscovered the species in September 2006 at ca. 830 m elev., flowering and fruiting in Lomas Amara. Subsequently it was recorded flowering and fruiting in December 2007, January 2013, October 2015, 2016. *Nolana willeana* grows as a perennial woody herb. It usually forms a low opened, structured clump around 20 cm high, at times up to 40 cm and spreading up to 50 cm. The species can easily be distinguished from other *Nolana* species, such as its community associate *N. pallida*, by its succulent oval to obovate leaves covered with a fine whitish tomentum, that impart a pale grey whitish appearance. Flowers are a delicate pale lilac to violet, with a demarcated white centre and tube; the corolla is pleated and chartaceous—blowing and shivering in the wind. The pollen is white and attracts a number of beetles including *Meloidae* species. In the gravelly substrates of the rocky frontal lomas, *N. willeana* leaves are less swollen and half twisted, compared to the ecotypes growing on the secondary lomas ridges, where the sandy substrate develops biotic crusts. The species thrives in herbaceous lomas, often as a structural perennial alongside *Ambrosia dentata*, *Chenopodium petiolare*, *Hoffmannseggia* spp., *Oxalis* spp., *Palaua* spp., *Plantago limensis* and *Spergularia* spp. *Solanum montanum* is commonly found rooted beneath this assemblage, where it presumably benefits from the fog capture. *Nolana willeana* was not observed growing in any strong association with *Tillandsia* lomas (as stated in its original description), but is adaptable enough to grow marginally in a few outlying *Tillandsia* aff. *murorum* populations. It also grows in isolated rocky fog-exposed positions. Its woody stems are used as a sheltering niche with perennial cover for aestivating land snails, including *Bostryx reentsi* (Philippi 1851).

Although its sub-populations appear healthy, the species is very restricted with an AOO of less than 3 km^2 and no designated protection yet. *Nolana willeana* is therefore extremely vulnerable to disturbance, climatic extremes and off-road drivers. The Dakar Rally passed close by in 2011. The species is assessed as Critically Endangered (CR B1ab(iii)) (Knapp *et al.* 2006).

Physalis angulata L. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 390–3230. *Vouchers*: DPP 020, 210, 507, 542.

Physalis peruviana L. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 450. *Vouchers*: DPP 542.

Solanum americanum Mill. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 400–570. *Vouchers*: DPP 027, 048, 097.

Solanum chilense Dunal. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 760–830. *Vouchers*: AO 244, DPP 137.

Solanum corneliomulleri J.F.Macbr. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1660. *Vouchers*: DPP 247.

Solanum corymbosum Jacq. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 800. *Vouchers*: DPP 139.

Solanum edmonstonei Hook.f. *Growth form*: herb or shrub. *Habitat*: quebrada and huayco, lomas. *Lomas*: Lomas Amara and Ullujaya, Lomas Morro Quemado, Lomas San Fernando. *Origin*: Endemic. *Conservation status*: [2]DD, [6]VU (B1,2a). *Elevation* (m): 550–680. *Vouchers*: AO 195, KPP 017, OW 1668.

Note:—The species was described by Joseph Hooker from a collection of *T. Edmonston s.n.* (lecto K! designated by Bennett 2008, iso CGE, TCD) of 'Charles Island, Galapagos'. *Solanum edmonstonei* was studied in detail by Bennett (2008) in his revision of *Solanum* sect. Regmandra (Solanaceae), where he states that the holotype specimen was probably collected along the coast of Peru (and not Galapagos). He qualifies this by observing that no further specimens have ever been collected from the Galapagos Islands, and presumes Edmonston's collection (HMS Herald

voyage) was mislabelled and/or associated with a previous collection bundle. The account of the voyage of the frigate HMS Herald specifies that the ship docked periodically along the coast of Peru (Seemann 1853 in Bennett 2008) where the young Scottish botanist probably collected the type. When the Herald encountered the Peruvian coast from Chile, the voyage narrative states, 'Although it was the middle of summer, the weather was not hot, the well-known Peruvian mist shrouded the sun, and at times it was even chilly', implying their arrival during a good lomas season. Intriguingly, a small bay called 'Playa Los Ingleses' (beach of the English) is found at the foot of the lomas where we collected *Solanum edmonstonei*. The species is distributed in Arequipa, Ica and Moquegua regions (Sarkinen *et al*. 2015). In Ica, it is restricted to coastal areas and two nearby islands (Isla La Vieja, Sangayan (or San Gallán)), growing on sandy or rocky coastal lomas (300–1080 m elev.) (Bennett 2008). In his revision, Bennett listed *Solanum andersonii* Ochoa, *S. ferreyrae* Ugent and *S. murphyi* I.M.Johnst. as synonyms of *S. edmonstonei*, stating that lack of herbarium material made delimitation problematic. Another allied species is *S. multifidum* Ruiz & Pav., which we recorded rarely in Ica, but is also known in Arequipa and the north central coast. According to Bennett (2008), *S. murphyi* was first described in 1931 by Johnston from the collection *Murphy 3219* (holo BKL!) of 'Peru, Viejas Island'; *S. ferreyrae* was described in 1975 by Ugent from the collection *Ferreyra 1523* (holo US, iso MO, MOL!) of 'Peru, dept. Arequipa, between Nazca and Chala'; and *S. andersonii*, described in 1980 by Ochoa from the collection *Ochoa 13026* (holo personal herb. Ochoa, iso MOL, US) of 'Peru, dept. Ica, Marcona'. Additional field studies are required in order to understand its intraspecific variation and consider species delimitation.

We recorded the species as quite widespread in lomas, adaptable and tenacious, growing: perennially within the lomas; re-sprouting from a dry stem and episodically as an annual; and rarely, as an ephemeral in valley margins. It can form dense perennial clumps, re-sprouting for decades. It rapidly colonises run-off gullies and fog brows in heavy fog seasons, being extraordinarily tolerant of lomas conditions. As such, *S. edmonstonei* is rather unique as a lomas 'interloper'. It is one of only a handful of species, found commonly in sandy herbaceous lomas as well as partitioned in more arid *Tillandsia latifolia* dominated lomas. Most of the plant is succulent and fleshy, often developing distinct dark brown/purple stems. The most notable features are semi-succulent pinnatifid leaves, irregularly lobed (2–5 pairs) with entire margins—at times with secondary lobes. The corolla is pale lilac or purple, on rare occasions white. The calyx can be hairless, unlike the 'Galapagos' type that apparently has glandular hairs outside. The species warrants autecological study, as a wide range of endemic insects (e.g. *Pseudomeloe* beetles) browse on its pollen, leaves and flowers. It is, however, restricted to the intrinsically fragile and limited habitat of lomas in Ica. Sarkinen *et al.* 2015 assessed *S. edmonstonei* as Vulnerable (VU B12a). Earlier, Knapp *et al.* (2007) assessed *Solanum murphyi* as Critically Endangered (CR B1ab(iii)), a species considered by Bennett (2008) a synonym of *S. edmonstonei*.

Solanum ferreyrae Ugent. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara and Ullujaya. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 830. *Vouchers*: DPP 338.

Solanum habrochaites S.Knapp & D.M.Spooner. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 440. *Vouchers*: AO 056.

Solanum lycopersicum L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1250. *Vouchers*: AO 060.

Solanum montanum L. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Amara, Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 450–840. *Vouchers*: DPP 163, 171, 342, KPP 046.

Solanum multifidum Lam. *Growth form*: herb. *Habitat*: lomas. *Lomas*: Lomas Marcona. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): no data. *Vouchers*: Bennett (2008), Cano *et al*. 6125 (USM).

Solanum muricatum Aiton. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 600. *Vouchers*: AO 331.

Solanum nigrum L. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 420. *Vouchers*: DPP 313, 482, OW 014.

Solanum paposanum Phil. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1660. *Vouchers*: DPP 246.

Solanum peruvianum L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 420. *Vouchers*: DPP 324, OW 036.

Solanum pimpinellifolium L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 460–780. *Vouchers*: AO 024, DPP 047, 102.

Note:—Although this species has a widespread scattered distribution along the coast of Peru and northern Chile, it merits attention as a globally important genetic resource. The annual or biannual plant thrives in Ica, following the flooding of fields and valley margins. It is easily recognisable by its small interrupted imparipinnate leaves, bright yellow flowers and its orange-red, edible and delicious tasting fruit. We recorded its natural habitat in Ica as being confined to borders of ephemeral streams and floodplain margins. *Solanum pimpinellifolium* is very closely related to *S. lycopersicum* (the 'tomato') and hybridises freely with it (PBI Solanum Project 2017). *Solanum pimpinellifolium* has a high value for crop improvement as it confers resistance for a range of insect and fungal pests (see for example Ohlson & Foolad 2016). However, the species is experiencing a rapid decline in Ica with genetic variability being eroded rapidly due to hybridisation (*S. lycopersicum* is grown industrially in Ica for tinning and paste); closing of irrigation canals with urban development; industrialisation of agriculture; and road-building which blocks stream water. We suggest the species needs wider recognition in Peru (with specific protection), due to its genetic value worldwide for stress tolerance, as well as for local nutritional, culinary and ecological value. Birds such as *Mimus longicaudatus* (Tschudi 1844) (the long-tailed mockingbird) perform a vital role in its seed dispersal (Tenorio *et al.* 2008).

Solanum **sp.** *Growth form*: herb. *Habitat*: huerta, lomas. *Lomas*: Lomas San Fernando. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 390–880. *Vouchers*: AO 206, DPP 026, KPP 023.

TYPHACEAE

Typha domingensis Pers. *Growth form*: shrub. *Habitat*: marsh and puquio. *Lomas*: none. *Origin*: Native. *Conservation status*: [2]LC. *Elevation* (m): 35. *Vouchers*: DPP 014, 383.

URTICACEAE

Parietaria debilis G.Forst. *Growth form*: herb. *Habitat*: quebrada and huayco, lomas. *Lomas*: Lomas San Fernando. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 590. *Vouchers*: KPP 054.

Urtica urens L. *Growth form*: herb. *Habitat*: huerta, quebrada and huayco. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3150. *Vouchers*: DPP 415.

VERBENACEAE

Aloysia minthiosa Moldenke. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Endemic. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 1660. *Vouchers*: DPP 256.

Junellia juniperina (Lag.) Moldenke. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 3310. *Vouchers*: DPP 414.

Lantana reptans Hayek. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 820. *Vouchers*: DPP 126.

Lantana **sp.** *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 1670. *Vouchers*: DPP 261.

Phyla canescens (Kunth) Greene. *Growth form*: herb. *Habitat*: huerta, riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 390–760. *Vouchers*: DPP 021, 384, OW 046, 056.

Phyla nodiflora (L.) Greene. *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 5. *Vouchers*: AO 080.

Pitraea cuneato-ovata (Cav.) Caro. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 400–450. *Vouchers*: DPP 209, 541, 568.

Verbena hispida Ruiz & Pav. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 840–1660. *Vouchers*: DPP 135, 241.

Verbena litoralis Kunth. *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 270–1660. *Vouchers*: DPP 012, 244, 316.

***Verbena* sp.** *Growth form*: herb. *Habitat*: riparian. *Lomas*: none. *Origin*: unknown. *Conservation status*: not assessed. *Elevation* (m): 3290. *Vouchers*: DPP 441.

ZYGOPHYLLACEAE

Bulnesia retama (Gillies ex Hook. & Arn.) Griseb. *Growth form*: shrub. *Habitat*: quebrada and huayco, xerophytic scrub. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. *Elevation* (m): 380–820. *Vouchers*: AO 015, 042, DPP 032, 202, 290.

Note:— *Bulnesia retama* is a small shrub or tree, that in Peru, is confined solely to the Andean outwash bajadas and lower quebradas in the Ica region. The species occurrence represents a significant 1500 km disjunction from its Argentine distribution. Comparison of Argentine herbarium material (SI!) gave no grounds for distinction between the species. In 1964, it also appears to have been growing in Cañete (Lima Region) at 100 m (*Hutchison & Wright 7115* at MO, UC), although is possibly extinct there today. In 1981, Hunziker collected the species at 600 m elevation in Nazca (*Hunziker 10001, 10004–10007* at MO!), where we also recorded several populations. The species is as yet to be recorded in Arequipa, but it would not be surprising if it was found in the north of this region. In Argentina, the species is found in the hyperarid Monte Desert of the eastern Andes of Catamarca, La Rioja, Mendoza and San Juan. The Monte Desert has climatic conditions similar to Ica—in places hyperarid with <100 mm per year. The disjunctive anomaly was noted by Gentry (1993) where he comments that *B. retama* is 'restricted to the desert washes around Ica' and describes it as 'the only Peruvian *Bulnesia* species; a wand-like shrub with microphyllous leaflets (these deciduous most of the year)'. In Argentina, *B. retama* grows as a small tree to 5 m high, whereas in Peru, the species is found only as a multi-stemmed shrub. This habit is perhaps a result of exploitation of its roots and trunk for firewood over centuries. In 2007, we recorded an individual growing uniquely as a small tree of 3 m high in Río Ingenio, Nazca. In Argentina, the species has been widely exploited for firewood, vineyard posts and industrialised wax production for floor polish during the 20th c. (Dalmasso & Llera 1996).

In Ica, *B. retama* grows between 380–820 m elev., and commonly in unexploited recesses and margins of xeric outwashes and quebradas, south of Río Ica (north to south) including: Cansas, Pampahuasi, Yauca, Tingué, Huarangal, Pampa de Caballo muerto and Huayco Amarillo. It is also found in valleys south of San Cruz including: Santa Cruz, Ingenio, Aja and Pampas de San Jose (the 'Nazca lines'); and the Nazca valleys of Pajonal, Mancha verde, Valle de Las Trancas and Poroma. *Bulnesia retama* establishes itself in ephemeral stream borders growing deep lignified roots. These dry streams may only flow for a few hours per decade. Here, it grows leaflessly with dark green photosynthetic waxy stems, until a flash flood produces a flush of pinnate leaves in small rachis followed by bright yellow stellate flowers, revealing its Zygophyllaceous character. It has elliptic leaflets in 2–3 pairs, 5–15mm long. The winged seeds are dark brown, splitting from the five-winged fruit. Seeds are not conducive to wind dispersal beyond a few metres and appear better adapted to stream or animal dispersal. The species has proven useful in restoration programs to maintain the ecosystem, supporting native bee populations while preventing flash erosion where few other plants can survive (Whaley *et al.* 2010a). In the more elevated parts of its range (>580 m), *B. retama* grows alongside cacti such as *Armatocereus procerus*, *Cleistocactus acanthurus*, *Cumulopuntia sphaerica*, *Haageocereus acranthus*, *Melocactus peruvianus*, *Neoraimondia arequipensis* and other xerophytic plants including *Orthopterygium huaucui*. In lower outwashes, *B. retama* can grow in complete isolation until run-off produces flowering and germination of annuals such as *Allionia incarnata* L. and perennial shrubs such as *Encelia canescens*, *Galvezia fruticosa* and *Trixis cacalioides*. In rare perennially damp conditions, *B. retama* can remain in leaf throughout the year, forming dense stands several metres across. In xeric conditions with wind-blown sand, it establishes phytogenic 'islands'. This clump island habitat is vital to *Microlophus thoracicus* (Tschudi 1845) lizards and the increasingly rare colubrid snake *Pseudalsophis*

elegans (Tschudi 1845). The lizards browse both the leaves and the yellow flowers of *B. retama* and in fact may play a role in their pollination. The snake *Pseudalsophis elegans* has been observed to predate the lizard *Microlophus thoracicus* among the stems of *B. retama*. *Bulnesia retama* clumps also accumulate wind-blown detritus, that today includes plastic and dry organic remains (some with marine origin, see Catenazzi & Donnelly 2007). Flies are attracted to this resource, providing an added protein source for *Microlophus* lizards as well as nocturnal *Phyllodactylus* geckos. *Bulnesia retama* is listed as Data Deficient in the 'Resolución Ministerial 505-2016' (MINAGRI 2016).

Fagonia chilensis Hook. & Arn. *Growth form*: herb. *Habitat*: quebrada and huayco. *Lomas*: none. *Origin*: Native. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 470. *Vouchers*: DPP 054.

Tribulus terrestris L. *Growth form*: herb. *Habitat*: huerta. *Lomas*: none. *Origin*: Introduced. *Conservation status*: not assessed. New record for Ica. *Elevation* (m): 400–780. *Vouchers*: DPP 062, 108.

APPENDIX 2—Cultivated species recorded for the region of Ica (Peru) from 63 huertas. A total of 127 species were recorded. Key: **: found to be highly invasive species in Ica, **Gf**: growth form (**c**: cactus, **h**: herb, **t**: tree, **s**: shrub), **F**: frequency (No. of huertas with the species present). Pre-Columbian origin - publication references as follows: [1]Cook & Parish 2005, [2]Parish 2003, [3]Beresford-Jones *et al*. 2009, [4]Roque *et al*. 2003, [5]Piacereza 2016, [6]Tantaleán *et al*. 2016, [7]García 2012. The following varieties were recorded in Ica, for: [a]*Inga feuillei*: anual, blanco, cinturón, chinchano, criollo, morado, petaca, rabo de zorra, rosado, sapo, tablón; [b]*Malus domestica*: winter, delicia, Israel; [c]*Mangifera indica*: carne, rosado, chato iqueño, papaya, kent; [d]*Musa* × *paradisiaca*: semipalillo, rojo, enano, rosado, biscochito; [e]*Persea americana*: hass, criolla, fuerte; [f]*Vitis vinifera*: quebranta, italia, moscatel, torontel, uvina, albilla, amongst others.

Huerta species	Gf	Common Name	Origin	F	Pre-Columbian cultivated
Acacia karroo Hayne**	t	Aromo, Aromillo	Introduced, cultivated	2	
Acacia macracantha Humb. & Bonpl. ex Willd.	t	Espino	Native, cultivated	5	
Acacia nilotica (L.) Delile	t	Aromo	Introduced, cultivated	1	
Allium cepa L.	h	Cebolla	Introduced, cultivated	2	
Allium fistulosum L.	h	Cebolla china	Introduced, cultivated	9	
Aloe vera L.	h	Sábila	Introduced, cultivated	13	
Annona cherimola Mill.	t	Chirimoya	Native, domesticated	22	x[4]
Annona muricata L.	t	Guanábana	Native, domesticated	20	
Apium graveolens L.	h	Apio	Introduced, cultivated	3	
Arachis hypogaea L.	h	Maní	Native, domesticated	-	x[1,2,4,5,6,7]
Astragalus spp.	h	-	Native, cultivated	-	x[1]
Asparagus officinalis L.	h	Espárrago	Introduced, cultivated	5	
Beta vulgaris L.	h	Betarraga	Introduced, cultivated	3	
Bixa orellana L.	t	Achiote	Native, domesticated	3	x[5]
Brassica oleracea L.	h	Col	Introduced, cultivated	1	
Brassica rapa L.	h	Nabo	Introduced, cultivated	1	
Brugmansia arborea (L.) Steud.	t	Flor campana	Native, cultivated	1	
Bunchosia armeniaca (Cav.) DC.	t	Ciruela del fraile	Native, domesticated	7	x[4,5]
Caesalpinia spinosa (Molina) Kuntze	t	Tara	Native, domesticated	7	
Cajanus cajan (L.) Millsp.	s	Frejol de palo	Introduced, cultivated	17	
Campomanesia lineatifolia Ruiz & Pav.	t	Palillo	Native, cultivated	-	x[5,6]
Canavalia ensiformis (L.) DC.	h	Frejol	Introduced? cultivated	-	x[1,4,5]
Canna indica L.	h	Achira	Native, domesticated	1	x[5]
Capsicum annuum L.	h	Ají rojo	Native, domesticated	-	x[1,4,5,7]
Capsicum baccatum L.	h	Ají cristal / amarillo	Native, domesticated	4	
Capsicum pubescens Ruiz & Pav.	h	Rocoto	Native, domesticated	2	
Carica papaya L.	t	Papaya	Introduced, cultivated	32	
Carya illinoinensis (Wangenh.) K.Koch	t	Pecano	Introduced, cultivated	36	
Casimiroa edulis La Llave	t	Zapote blanco	Introduced, cultivated	1	
Casuarina cunninghamiana Miq.	t	Casuarina	Introduced, cultivated	2	
Ceiba speciosa (A.St.-Hil.) Ravenna	t	Barrigón, palo borracho	Native, cultivated	1	
Chenopodium ambrosioides L.	h	Paico	Native, domesticated	6	
Cicer arietinum L.	h	Garbanzo	Introduced, cultivated	2	
Citrullus lanatus (Thunb.) Matsum. & Nakai	h	Sandía	Introduced, cultivated	5	
Citrus aurantiifolia (Christm.) Swingle	t	Lima	Introduced, cultivated	1	
Citrus limetta Risso	t	Naranja	Introduced, cultivated	1	
Citrus limon (L.) Osbeck	t	Limón	Introduced, cultivated	38	
Citrus paradisi Macfad.	t	Toronja	Introduced, cultivated	3	
Citrus reticulata Blanco	t	Mandarina	Introduced, cultivated	17	
Citrus sinensis (L.) Osbeck	t	Naranja	Introduced, cultivated	33	
Cocos nucifera L.	t	Coco	Introduced, cultivated	2	
Coriandrum sativum L.	h	Culantro	Introduced, cultivated	3	
Crotalaria incana L.	h	Cascabelillo	Native, domesticated	1	
Cucurbita maxima Duchesne	h	Calabaza	Native, domesticated	2	x[1,2,4,5,7]
Cucurbita moschata Duchesne	h	Zapallo, loche	Introduced, cultivated	-	x[5]
Cucurbita pepo L.	h	Zapallo	Introduced, cultivated	5	

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APPENDIX 2. (Continued)

Huerta species	Gf	Common Name	Origin	F	Pre-Columbian cultivated
Cydonia oblonga Mill.	t	Membrillo	Introduced, cultivated	10	
Cymbopogon citratus (DC.) Stapf	h	Hierba luisa	Introduced, cultivated	7	
Cyperus esculentus L.	h	Coquito	Native, cultivated	-	x[5]
Echinopsis pachanoi (Britton & Rose) Friedrich & G.D.Rowley	c	San Pedro	Native, cultivated	-	x[5]
Eriobotrya japonica (Thunb.) Lindl.	t	Níspero japonés	Introduced, cultivated	8	
Erythroxylum coca Lam.	h	Coca	Native, cultivated	-	x[1,2,3]
Eucalyptus camaldulensis Dehnh.	t	Eucalitpo	Introduced, cultivated	7	
Eucalyptus globulus Labill.	t	Eucalipto andino	Introduced, cultivated	5	
Ficus carica L.	t	Higuera	Introduced, cultivated	22	
Foeniculum vulgare Mill.	h	Hinojo	Introduced, cultivated	2	
Fragaria vesca L.	h	Fresa	Introduced, cultivated	1	
Gossypium barbadense L.	s	Algodón nativo	Native, domesticated	4	x[1,2,3,4,5,6,7]
Gossypium hirsutum L.	s	Algodón americano	Introduced, cultivated	1	
Guadua superba Huber	s	Caña guayaquil	Native, domesticated	2	
Inga feuillei DC.	t	Pacay [a]	Native, domesticated	39	x[1,2,3,4,5,6,7]
Ipomoea batatas (L.) Lam.	h	Camote	Native, domesticated	17	x[4,5]
Jatropha curcas L.	s	Piñón	Introduced, cultivated	1	
Lablab aff. *purpureus* (L.) Sweet	s	Zarandaja, lenteja	Introduced, cultivated	3	
Lactuca sativa L.	h	Lechuga	Introduced, cultivated	5	
Lagenaria siceraria (Molina) Standl.	h	Calabaza, mate	Native, domesticated	1	x[1,2,4,5,6]
Lantana camara L.**	s	Lantana	Introduced, cultivated	3	
Laurus nobilis L.	s	Laurel	Introduced, cultivated	1	
Lens esculenta Moench	h	Lenteja	Introduced, cultivated	1	
Leucaena leucocephala (Lam.) de Wit**	t	Leucaena	Introduced, cultivated	2	
Malus domestica Borkh.	t	Manzana (o) [b]	Introduced, cultivated	12	
Mangifera indica L.	t	Mango [c]	Introduced, cultivated	57	
Manihot esculenta Crantz	s	Yuca	Native, domesticated	18	x[4,5,6,7]
Manilkara huberi (Ducke) Standl.	t	Nispero	Introduced, cultivated	1	
Matricaria chamomilla L.	h	Manzanilla	Introduced, cultivated	3	
Medicago sativa L.	h	Alfalfa	Introduced, cultivated	2	
Melia azedarach L.	t	Cinamomo	Introduced, cultivated	3	
Mentha spicata L.	h	Hierbabuena	Introduced, cultivated	7	
Momordica charantia L.	h	Amargo, balsamina	Introduced, cultivated	1	
Morus alba L.	t	Mora	Introduced, cultivated	4	
Morus nigra L.	t	Mora	Introduced, cultivated	2	
Musa × *paradisiaca* L.	s	Plátano [d]	Introduced, cultivated	43	
Nicandra physalodes (L.) Gaertn.	h	Capulí	Native, cultivated	1	
Nicotiana paniculata L.	s	Tabaco silvestre	Native, cultivated	-	x[5]
Ocimum basilicum L.	h	Albahaca	Introduced, cultivated	7	
Olea europaea L.	t	Olivo	Introduced, cultivated	1	
Opuntia ficus-indica (L.) Mill.	c	Tuna	Introduced, domesticated	21	
Origanum vulgare L.	h	Orégano	Introduced, cultivated	3	
Pachyrhizus tuberosus (Lam.) Spreng.	h	Jíquima, chuin	Native, domesticated	-	x[5,7]
Passiflora edulis Sims	h	Maracuya	Native, domesticated	14	
Passiflora ligularis Juss.	h	Granadilla	Native, domesticated	2	
Pelargonium zonale (L.) L'Hér.	s	Geranio	Introduced, cultivated	1	
Persea americana Mill.	t	Palto [e]	Introduced, cultivated	44	
Petroselinum crispum (Mill.) Fuss	h	Perejil	Introduced, cultivated	2	
Phaseolus lunatus L.	h	Pallar	Native, domesticated	14	x[1,2,4,5,6,7]
Phaseolus vulgaris L.	h	Frejol	Native, domesticated	3	x[1,2,4,5,6]
Phoenix dactylifera L.	t	Palmera datilera	Introduced, cultivated	15	
Physalis peruviana L.	h	Capulí, aguaymanto	Native, domesticated	1	
Piper aduncum L.	s	Matico	Native, cultivated	1	
Pisum sativum L.	h	Arverja	Introduced, cultivated	1	
Plantago major L.	h	Llanten	Introduced, cultivated	7	

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APPENDIX 2. (Continued)

Huerta species	Gf	Common Name	Origin	F	Pre-Columbian cultivated
Pluketenia volubilis L.	s	Sacha inchi	Native, domesticated	1	
Pouteria lucuma (Ruiz & Pav.) Kuntze	t	Lúcumo	Native, domesticated	11	x[5]
Prosopis limensis Benth.	t	Huarango	Native, domesticated	8	x[1,2,3,4,5,7]
Prunus persica (L.) Batsch	t	Durazno	Introduced, cultivated	13	
Psidium guajava L.	t	Guayaba	Native, domesticated	3	x[3,5,6]
Punica granatum L.	t	Granado	Introduced, cultivated	28	
Pyrus communis L.	t	Pera	Introduced, cultivated	4	
Raphanus sativus L.	h	Rabanito	Introduced, cultivated	2	
Ricinus communis L.**	s	Higuerilla	Introduced, cultivated	3	
Rosmarinus officinalis L.	s	Romero	Introduced, cultivated	10	
Ruta graveolens L.	h	Ruda	Introduced, cultivated	8	
Saccharum officinarum L.	s	Caña de azúcar	Introduced, cultivated	5	
Sapindus saponaria L.	t	Boliche	Native, cultivated	-	x[4,5]
Schinus molle L.	t	Molle	Native, cultivated	4	
Solanum lycopersicum L.	h	Tomate	Native, domesticated	5	
Solanum pimpinellifolium	h	Tomatillo silvestre	Native, cultivated	-	x[1,2,3]
Solanum tuberosum L.	h	Papa	Native, domesticated	1	x[4]
Spinacia oleracea L.	h	Espinaca	Introduced, cultivated	2	
Spondias purpurea L.	t	Ciruela	Introduced, cultivated	31	
Tagetes minuta L.	h	Huacatay	Native, domesticated	11	
Tamarindus indica L.	t	Tamarindo	Introduced, cultivated	1	
Tamarix aphylla (L.) H.Karst.**	t	Támarix	Introduced, cultivated	1	
Tunilla soehrensii (Britton & Rose) D.R.Hunt & Iliff	c	Ayrampu	Native, cultivated	2	
Verbena litoralis Kunth	h	Verbena	Introduced, cultivated	1	
Vitis vinifera L.	s	Parra, uva [f]	Introduced, cultivated	49	
Zea mays L.	h	Maíz	Introduced, cultivated	14	x[1,2,3,4,5,6,7]

APPENDIX 3. - FLORA

Photographic appendix of 155 images (144 species) of the flora of Ica, arranged alphabetically and taken by the lead author unless otherwise indicated. Photographs of other species in the checklist can also be found published in: Whaley, O.Q., Orellana, A., Pérez, E., Tenorio, M., Quinteros, F., Mendoza, M. & Pecho, O. (2010) *Plantas y Vegetación de Ica, Perú—un recurso para su restauración y conservación.* Royal Botanic Gardens Kew, Lima, Perú, 94 pp. And https://www.kew.org/science/tropamerica/imagedatabas

FIGURE A (Flora of Ica): **1.** *Aa* aff. *weddelliana*, **2.** *Acacia macracantha*, **3.** *Acalypha infesta*, **4.** *Allionia incarnata*, **5.** *Alstroemeria* aff. *violacea*, **6.** *Alternanthera albotomentosa* var. *albotomentosa*, **7.** *Alternanthera pubiflora*, **8.** *Ambrosia dentata*, **9.** *Ammannia latifolia*, **10.** *Argylia radiata*, **11.** *Aristida adscensionis*, **12.** *Armatocereus matucanensis*, **13.** *Armatocereus procerus*, **14.** *Astragalus triflorus*, **15.** *Atriplex rotundifolia*. All photographs © **:** taken by lead author (OW) unless indicated: DT (1); LC (4); EM (7); AO (12, 15).

FIGURE B (Flora of Ica): **1.** *Baccharis salicifolia*, **2.** *Bixa orellana*, **3.** *Boerhavia verbenacea*, **4.** *Bolboschoenus maritimus*, **5.** *Buddleja americana*, **6.** *Bulnesia retama*, **7.** *Browningia candelaris* subsp. *icaensis*, **8.** *Calliandra* aff. *taxifolia*, **9.** *Capparis avicennifolia*, **10.** *Carica candicans*, **11.** *Cenchrus* aff. *echinatus*, **12.** *Chenopodium petiolare*, **13.** *Cistanthe paniculata*, **14.** *Cleistocactus acanthurus*.
Pictures: CP (1); HY (3, 7); AO (8).

FIGURE C (Flora of Ica): **1.** *Cnidoscolus pavonianus*, **2.** *Corryocactus brevistylus*, **3-4.** *Corryocactus brachypetalus*, **5.** *Croton alnifolius*, **6.** *Croton* aff. *ruizianus*, **7.** *Cryptantha granulosa*, **8.** *Cumulopuntia sphaerica*, **9.** *Cylindropuntia tunicata*, **10.** *Dalea cylindrica*, **11.** *Dalea onobrychis*, **12.** *Dalea smithii*, **13.** *Dictyophragmus englerianus*, **14.** *Distichlis spicata*, **15.** *Domeykoa amplexicaulis*.
Pictures: AO (6, 8, 9); JC (11).

FIGURE D (Flora of Ica): **1.** *Domeykoa saniculifolia*, **2-3.** *Encelia canescens*, **4.** *Encelia* aff. *pilosiflora*, **5.** *Ephedra americana*, **6.** *Eremocharis* aff. *piscoensis*, **7.** *Eremocharis hutchisonii*, **8.** *Eriosyce islayensis*, **9.** *Eriosyce* aff. *islayensis*, **10.** *Evolvulus lanatus*, **11.** *Exodeconus prostratus*, **12.** *Fagonia chilensis*, **13.** *Galvezia fruticosa*, **14-15.** *Grabowskia boerhaaviifolia*. Pictures: AO (7); DG (11); MT (15).

FIGURE E (Flora of Ica): **1.** *Grindelia glutinosa*, **2.** *Guadua superba*, **3.** *Haageocereus decumbens*, **4.** *Haageocereus pseudomelanostele*, **5.** *Haageocereus* aff. *tenuis*, **6.** *Heliotropium krauseanum*, **7.** *Indigofera truxillensis*, **8-9.** *Inga feuillei*, **10.** *Ipomoea dubia*, **11.** *Jacquemontia unilateralis*, **12.** *Jarava pachypus*, **13.** *Junellia* aff. *juniperina*, **14.** *Krameria lappacea*, **15.** *Lepidium raimondii*. Pictures: AO (2); OP (8, 12).

FIGURE F (Flora of Ica): **1.** *Leptoglossis ferreyraei*, **2.** *Leptoglossis lomana*, **3.** *Lomanthus icaensis*, **4.** *Loxanthocereus* aff. *hystrix*, **5.** *Lycium americanum*, **6.** *Maytenus octogona*, **7.** *Melocactus peruvianus*, **8.** *Myrcianthes ferreyrae*, **9.** *Nasa urens*, **10.** *Neoraimondia arequipensis*, **11.** *Neoraimondia arequipensis* subsp. *roseiflora*, **12.** *Nicotiana paniculata*, **13.** *Nolana adansonii*, **14.** *Nolana chancoana*, **15.** *Nolana humifusa*. Pictures: AO (4, 10, 15); RS (7), ER (11); DG (14).

FIGURE G (Flora of Ica): **1.** *Nolana pallida*, **2.** *Nolana* aff. *pallida*, **3.** *Nolana pallidula*, **4.** *Nolana spathulata*, **5.** *Nolana thinophila*, **6.** *Nolana tovariana*, **7-8.** *Nolana willeana*, **9-10.** *Orthopterygium huaucui*, **11.** *Oxalis lomana*, **12.** *Oxalis* aff. *pachyrrhiza*, **13.** *Oxalis* sp., **14.** *Oxalis* sp., **15.** *Oziroe biflora*. Pictures: CP (9); HY (14).

FIGURE H (Flora of Ica): **1.** *Palaua moschata*, **2.** *Palaua sandemanii*, **3.** *Palaua trisepala*, **4.** *Paspalum haenkeanum*, **5.** *Passiflora foetida*, **6.** *Plantago* aff. *limensis*, **7.** *Pluchea chingoyo*, **8.** *Poissonia weberbaueri*, **9.** *Polyachyrus* aff. *fuscus*, **10.** *Portulaca pilosissima*, **11.** *Presliophytum incanum*, **12.** *Pyrolirion albicans*, **13-14.** *Quinchamalium lomae*, **15.** *Salicornia fruticosa*. Pictures: CP (1, 9); MT (5); IS (11); AO (15).

FIGURE J (Flora of Ica): **1.** *Scutia spicata*, **2.** *Senecio calcicola*, **3.** *Solanum corymbosum*, **4-5.** *Solanum edmondstonei*, **6-7.** *Solanum montanum*, **8.** *Solanum paposanum*, **9.** *Spergularia congestifolia*, **10.** *Spondias purpurea*, **11.** *Suaeda foliosa*, **12-13.** *Tecoma fulva* subsp. *guarume*, **14.** *Tessaria integrifolia*, **15.** *Tetragonia microcarpa*. Pictures: AO (13); CP (15).

FIGURE K (Flora of Ica): **1.** *Tetragonia vestita*, **2.** *Tillandsia capillaris*, **3-4.** *Tillandsia latifolia*, **5.** *Tillandsia marconae*, **6.** *Tillandsia murorum*, **7.** *Tillandsia* aff. *murorum*, **8.** *Tillandsia paleacea*, **9-10.** *Tillandsia purpurea*, **11.** *Tillandsia recurvata* (*Armatocereus procerus*), **12.** *Tiquilia dichotoma*, **13.** *Tiquilia ferreyrae*, **14.** *Tiquilia paronychioides*, **15.** *Trixis cacalioides*. Pictures: JC (1); DG (2, 8); AO (12, 14).

FIGURE L (Flora of Ica): **1.** *Urocarpidium* sp., **2.** *Villanova oppositifolia*, **3.** *Weberbauerella brongniartioides*, **4.** *Weberbauerella raimondiana*, **5.** *Weberbauerocereus rauhii*, **6.** *Zinnia peruviana*. Pictures: AO (1, 4, 5); JC (2); WT (6).

*All photographs are taken by lead author (Oliver Whaley), unless otherwise indicated, with the photographers initials as follows: Alfonso Orellana (AO), Christian Padilla (CP), Darwin García (DG), Delsy Trujillo (DT), Emilio Mitacc (EM), Erick Ramírez (ER), Hudson Yonjoy (HY), Iomar Santana (IS), Josué Cárdenas (JC), Luis Casma (LC), Marvin Torres (MT), Octavio Pecho (OP), Ronal Sumiano (RS), Willinton Taquiri (WT). Although most photographs are linked to determined specimen voucher, a few are not and remain to be fully identified. For images of *Onoseris* and *Hoffmannseggia* spp., see checklist Appendix 1.

Other photographs of the flora of Ica included in the checklist, can be found published in: Whaley, O.Q., Orellana, A., Pérez, E., Tenorio, M., Quinteros, F., Mendoza, M. & Pecho, O. (2010) *Plantas y Vegetación de Ica, Perú* - un recurso para su restauración y conservación. Royal Botanic Gardens Kew, Lima, Perú, 94 pp. Also at: https://www.kew.org/science/tropamerica/imagedatabase/.

APPENDIX 4. - HABITATS

The principle plant habitats and vegetation types of the Ica region, east to west; from the high Andes to the Pacific seaboard, with: habitat type, characteristic species apparent in the image, approximate location (in Ica, unless indicated), elevation. Photographs© taken by the lead author Oliver Whaley with other photographers otherwise indicated.

FIGURE A. (Habitats: Andean and Quebrada) **1.** Andean upper slopes with 'sanky' cactus (*Corryocactus brevistylus*) (3200 m) – nr. Laramate, Ayacucho towards Ica border; **2.** Xeric vegetation after a wet season with *Orthopterygium huaucui* (3600 m); **3.** Andean quebrada in dry season near Tibillo, Palpa (2500 m); **4.** Quebrada cactus scrub with abandoned pre–Columbian and Inca terraces, with Cacti *Neoraimondia arequipensis* and *Armatocereus procerus*, and riparian *Salix humboldtiana*, *Tessaria integrifolia* – Rio Palpa (1600 m); **5, 6.** Ephemeral streams in mid–quebrada with *Neoraimondia arequipensis*, *Eremocharis* sp. *Presliophytum incanum*, *Tecoma fulva* – Yauca del Rosario, and Sol de Oro, Nasca (1700 m); **7.** Xeric slopes in dry season (1600 m) – quebrada Tingue; **8.** Xeric slope vegetation following ENSO rains (2017) with *Cnidoscolus pavonianus* and *Orthopterygium huaucui* in full leaf – Quebrada Cansas, La Tinguiña (1600 m). Pictures: RS (3), HY (8).

FIGURE B. (Habitats: Quebrada, Cactus slopes, Andean Lomas) **1, 2.** Lower slope bajadas with xerophytic vegetation after freak 2017 ENSO rains with predominance of *Aristida adscensionis* – Quebrada Cansas, La Tinguiña (1400 m); **3.** Xeric slope and loess substrate; ephemeral Andean lomas vegetation with predominance of *Pyrolirion albicans* and *Orthopterygium huaucui* trees – La Cantera, Quebrada Tingue (2200 m); **4.** Herbaceous Andean lomas with *Nasa urens*, *Nolana humifusa* above organic agriculture valley – Huaquina, Topará, Chincha (800 m); **5.** Cactus slopes after freak rain with *Neoraimondia arequipensis* – Quebrada Pampahuasi, Yauca del Rosario (800 m); **6.** Cactus slopes with *Cnidoscolus pavonianus*, *Neoraimondia arequipensis*, *Orthopterygium huaucui*, *Weberbauerocereus rauhii* – Sol de Oro, Nasca (1700 m); **7.** Mid–quebrada with *Acacia macracantha*, *Maytenus octogona*, *Scutia spicata*, *Tecoma fulva* – above Molletambo (1350 m); **8.** Cactus scrub with *Neoraimondia arequipensis* – El Ingenio, Nasca (900 m). Photos: LC (1), HY (2). AO (4, 6), CP (5), ER (8).

FIGURE C. (Habitat: Cactus scrub, huaycos (ephemeral streams), bajada) **1.** Quebrada cactus scrub with *Armatocereus procerus*, *Neoraimondia arequipensis*, *Orthopterygium huaucui* – Cansas, La Tinguiña (1600 m); **2.** Quebrada cactus scrub with *Armatocereus procerus*, *Capparis avicennifolia*, *Neoraimondia arequipensis*, *Scutia spicata* – Huarangal (800 m); **3.** Quebrada after ENSO rains (2017) *Allionia incarnata*, *Armatocereus procerus*, *Prosopis limensis* – Molletambo (950 m); **4.** Huayco with *Bulnesia retama* – Pampas San Antonio; **5.** Arroyo down-cutting quebrada – Huarangal (800 m); **6.** Freak rains (2008) Pampas of Yauca (480 m); **7.** Church of Yauca del Rosario in mid-bajada with ephemeral huaycos with *Capparis avicennifolia*, *Bulnesia retama, Galvezia fruticosa, Prosopis limensis;* **8.** *Capparis avicennifolia* – bajada of Tingue. Pictures: HY (1), JO (3).

FIGURE D. (Habitats: Huayco, riparian, acequia, huerta, industrial agriculture) **1.** Ephemeral stream with *Bulnesia retama*, *Trixis cacalioides* – Pajonal, Nasca (560 m); **2.** Huerta and traditional agriculture with *Inga feuillei*, *Spondias purpurea* – Quebrada Huarangal (750 m); **3.** Quebrada huertas – Huarangal; **4, 5.** Riparian vegetation with *Baccharis salicifolia*, *Cyperus* spp, *Phragmites australis*, *Tessaria integrifolia* – Casa Blanca, Rio Ica (700 m); **6.** Typical acequia in traditional huerta with *Ficus carica*, *Inga feuillei* – Los Aquijes, Ica's central valley (420 m); **7.** Riparian oasis huerta with *Citrus sinensis*, *Phoenix dactylifera*, *Prosopis limensis* – Rio Poroma, Nasca (380 m); **8.** Agroindustrial cultivation of *Asparagus officinalis* and *Vitis vinifera* with marginal dry forest relict dunes of *Prosopis limensis* – Santiago, Ica (390 m).

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FIGURE E. (Habitats: huerta, dry forest oasis relict, outwash fan bajada) **1, 2.** Traditional huertas with *Annona cherimola* 'chirimoya', *Cajanus cajan*, *Carica papaya*, *Carya illinoinensis*, *Inga feuillei*, *Mangifera indica*, *Phaseolus lunatus*, *Persea americana*, *Pouteria lucuma*, among others – Los Aquijes & San Juan Bautista (410 m); **3.** Huerta borders with *Inga feuillei*, *Parkinsonia praecox*, *Pluchea chingoyo*, *Prosopis limensis*, *Tecoma fulva* – Cachiche, Santiago (380 m); **4.** Ancient patrimony 'huarango' *Prosopis limensis* (converted to charcoal) in family huerta – Huarangal, Quebrada Tingué (740 m); **5, 6.** The 'hummingbird' and 'huarango' tree of pre–Columbian Nazca culture – 'Pampa de San Jose 'Nasca lines' (450 m); **7, 8.** Dry relict forests with *Prosopis limensis* and *Acacia macracantha* – Usaca, Nasca (290 m). Pictures: DG (1), LC (2).

FIGURE F. (Habitats: hyperarid desert, dunes, *Tamarix* invasion, riparian, salt marsh) **1.** Tablazo de Ica, tertiary uplift yarding formation – Ocucaje; **2.** Large terminal dune system – Pampa Blanca (530 m); **3.** Invasion of *Tamarix aphylla* with resultant salinization and loss of native plants – Chiquerio, lower Rio Ica (290 m); **4.** Riparian vegetation, *Baccharis lanceolata, Phragmites australis*, *Tessaria integrifolia* – Samaca, lower Rio Ica (210 m); **5.** Dry forest with ancient trees of "huarango" burned in 2016 – Usaca, Nasca (290 m); **6.** Riparian vegetation collecting rubbish thrown into Rio Ica (260 m); **7**, **8.** Saltmarsh coastal wetlands with *Distichlis spicata*, *Eleocharis flavescens*, *Sarcocornia fruticosa*, *Schoenoplectus americanus*, *Sesuvium portulacastrum*, *Typha domingensis* – Caucato, Pisco (10 m), vital habitat for birds such as *Leucophaeus pipixcan*, *Pelecanus thagus, Phalacrocorax brasilianus*. Photos: JM (2), CL (4), AO (5, 8), LC (7).

FIGURE G (Habitats: Tillandsiales, coastal herbaceous lomas): **1.** *Tillandsia* lomas with *T. latifolia*, *T. paleacea*, *T. purpurea* – Quebrada Topará, Chincha (350 m); **2.** Lichen meadow (with *Teloschistes peruensis*) near herbaceous lomas Amara (510 m); **3.** Coastal lomas rock-refugia with lichen in herbaceous lomas – Ullujaya (910 m); **4.** Monitoring of plot in ephemeral lomas (500 m); **5.** Herbaceous lomas of Morro Quemado with *Jarava pachypus*, *Palaua moschata*, *Polyachyrus* sp. – R. N. de Paracas, Pisco (510 m); **6.** Herb Lomas with *Aa weddelliana*, *Ambrosia dentata*, *Oxalis* spp. overlooking the lower desert (700 m); **7.** *Tillandsia purpurea* in *Prosopis limensis* (2008) – marginal dunes of La Angostura (now deforested) (420 m); **8.** *Tillandsia* lomas with *T. landbeckii*, *T. latifolia*, *T. marconae*, *T. purpurea* – R.N. San Fernando, Nasca (860 m). Pictures: HY (1), ML (5), JM (6).

FIGURE H (Coastal lomas, guano Islands, Pacific seaboard): **1–3.** Herbaceous lomas with *Atriplex rotundifolia*, *Nolana* spp., *Solanum edmondstonei*, *Weberbauerella raimondiana* – R.N. San Fernando, Nasca (670 m); **4.** *Tetragonia microcarpa*, *Solanum edmondstonei*, *Tillandsia landbeckii* facing the sea – Lomas Morro Quemado, R. N. Paracas, Pisco (500 m); **5–6.** Island independence (La Vieja) with 'guano birds', lizards and scarce vegetation (*Tillandsia* spp. *Solanum edmonstonei*) – R.N. Paracas, Pisco; **7–8.** Rocky coastal outcrops (with *Nolana adansonii*) and Pacific Ocean seaboard at foot of lomas Amara. Pictures: AO (4), EM (5), CP (6), JM (8).

Photographs are taken lead author (Oliver Whaley) unless otherwise initials as follows: Alfonso Orellana (AO), Christian Padilla (CP), Claudia Luthi (CL), Darwin García (DG), Delsy Trujillo (DT), Emilio Mitacc (EM), Erick Ramírez (ER), Hudson Yonjoy (HY), Jesús Ormeño (JO), Justin Moat (JM), Luis Casma (LC), Mijahel Lara (ML), Ronal Sumiano (RS).