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Scientific Article

Biotic homogenization in the availability of ornamental seeds of the native flora in Chile

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Abstract

Biotic homogenization is a global phenomenon, mainly in urban areas where exotic species are dominant, contributing to the loss of native biodiversity. Gardening native flora to promote local biodiversity is becoming a conservation practice in urban settings. Therefore, in this study, we analyzed the representation of the Chilean native flora in the Chilean and international ornamental flower seed market to know which native plant seeds are sold. We found that native seed are absent in the local market and that the totality of seed supply in the market corresponds to species of exotic origin, mainly from the Palearctic region (43%). However, surprisingly, many Chilean flower seeds are traded in the international market (approximately 6% of the total Chilean flora). This lack of availability of native seeds for local consumers constitutes a bottleneck for ecological restoration initiatives. It is consistent with the greater abundance of exotic species in urban green areas and supports the hypothesis of biocultural homogenization.
Keywords: biocultural homogenization, exotic species, gardening, nursery, seed marketing.

Resumo

Homogeneização biótica na disponibilidade de sementes ornamentais da flora nativa no Chile

A homogeneização biótica é um fenómeno global, principalmente em áreas urbanas onde as espécies exóticas são dominantes, contribuindo para a perda da biodiversidade nativa Uso da flora nativa na jardinagem para promover a biodiversidade local está se tornando uma prática de conservação em ambientes urbanos. Portanto, neste estudo, analisarmos a representação da flora nativa chilena no mercado chileno e internacional de sementes de flores ornamentais para saber quais sementes de plantas nativas são vendidas. Descobrimos que as sementes nativas estão ausentes no mercado local e que a totalidade da oferta de sementes no mercado corresponde a espécies de origem exótica, principalmente da região do Palearctic (43%). Contudo, surpreendentemente, muitas sementes de flores chilenas são comercializadas no mercado internacional (aproximadamente 6% do total da flora chilena). Esta falta de disponibilidade de sementes nativas para os consumidores locais constitui um gargalo para as iniciativas de restauração ecológica. Este fato é consistente com a maior abundância de espécies exóticas em áreas verdes urbanas e apoia a hipótese de homogeneização biocultural.
Palavras-chave: homogeneização biocultural, espécies exóticas, jardinagem, mercado de sementes, viveiro.

Introduction

Biotic homogenization is a global phenomenon, mainly in urban areas where exotic species are dominant at the expense of native species, contributing to the loss of native biodiversity (McKinney, 2006). This phenomenon is particularly relevant since today, 56% of the population lives in cities (The World Bank, 2022), and this trend is expected to continue, especially in Latin American countries rich in biodiversity, which have the highest percentage of urban population in the world (Rozzi, 2015). However, urban green spaces and residential gardens may be an essential reservoir of native biodiversity in an urbanized world (Goddard et al., 2010). Thus, in these green spaces, local seeds mixes can be an effective method for improving the biodiversity of plants or higher-level trophic organisms, such as native pollinators (Braman et al., 2002; Harmon-Threatt and Hendrix, 2015; Baldock et al., 2019).

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The native flora of Chile consists of 4,655 species, of which almost half (n = 2,145) are endemic (Rodríguez et al., 2018). A recent revision of the useful native plants of Chile estimated that at least 300 species have ornamental uses, and 417 native species have been recommended as having the potential for ornamental use (Díaz-Forestier et al., 2019). Moreover, León-Lobos and Rosas (2010) estimated that 586 native species are sold as seedlings or seeds outside Chile in the international market. Many of these species have been traditionally used ornamentally in foreign countries, mainly in the United Kingdom, the United States of America, Japan and Holland (Gardner, 2001; Teillier, 2008).

Despite their benefits and international interest, native species are rare in Chilean nurseries (León-Lobos and Rosas, 2010) and Chilean urban green spaces (Figueroa et al., 2018, Varas et al., 2020), with exotic species predominating over native ones (Rozzi et al., 2003; Santilli et al., 2018; Varas et al., 2020). This substitution and uniformity of local biota diminish people's in-person encounters with local biodiversity, promoting biocultural homogenization related to the process of "extinction of experience" (Soga and Gaston, 2016).

Research on urban flora has focused mainly on analyzing the flora's diversity, ecological interactions, and landscape attributes and has rarely considered the availability or supply of seeds in the retail market, which could be a relevant constraint to its ornamental application. However, in recent decades, both, the increase in specialized stores and the sale of seeds in retail stores, in addition to a higher interest in gardening, have increased the availability and demand for seeds for their use in private and public gardens or even in agricultural areas to improve the landscape and to promote local biodiversity. For example, the use of floral band to attract pollinators implemented in Santiago urban parks (El Mercurio, 2022) and in rural areas (Muñoz et al., 2021a).

Therefore, this study aims to evaluate the representation of Chilean flora in the ornamental seed market in Chile to implement conservation practices. Our specific questions are: i) which native plant seeds are sold in the Chilean market? and ii) which native plant seeds are sold in the international market?

Material and Methods

In 2020, we reviewed the catalogs of the leading retail companies in the gardening market in Chile, which represent 90% of the official Chilean market retail companies, in addition to widely distributed in the country, small gardening dealers' companies (Table 1) to determine the seed species that are formally sold. We reviewed information only from formal markets, understanding that there is an informal market, often not legal and that it lacks adequate traceability of the origin of the seeds. The identified species were classified according to their taxonomy, origin and biogeographical region of origin (*sensu* Wallace, 1876), commercial name and commercial company.

Table 1. Retail companies in the gardening market in Chile, where we looked for seed species that are formally commercialized. It is important to note that some websites informally sell seeds of many native species or offer them to promote native flora for gardening. However, because of the informal nature of this market, there are no reliable data available, and they were not considered in this study.

Companies	Type of companies
Easy	Retail
Jumbo	Retail
Sodimac	Retail
Wallmart (Lider)	Retail
Anasac	Specialized store for gardening/agricultural supplies
Copeval	Specialized store for agricultural supplies

With regard to the international market, we reviewed the 5th (2002) and 8th (2012) editions of the "Seed search" catalog, which contains the last updated record of all the seed species (with their scientific name) and companies that sell seeds formally in the international market. The taxonomy of the species was updated according to the vascular plants of Chile catalog by Rodríguez et al. (2018). The species were organized according to their taxonomy, commercial company and country.

Results

Thirty-eight exotic species, comprising 19 families and 35 genera are currently sold in the Chilean ornamental seed market (Table 2).

Table 2. Species available in current Chilean seed market for gardens.

Nº	Family	Specie
1	Acanthaceae	*Thunbergia alata*
2	Aizoaceae	*Mesembryanthemum criniflorum*
3	Asteraceae	*Callistephus chinensis*
4	Asteraceae	*Chamaemelum nobile*
5	Asteraceae	*Cosmos bipinnatus*
6	Asteraceae	*Dahlia* sp.
7	Asteraceae	*Dimorphoteca aurantiaca*
8	Asteraceae	*Helianthus annuus*
9	Asteraceae	*Leucanthemum maximum*
10	Asteraceae	*Osteospermum fruticosum*
11	Asteraceae	*Tagetes erecta*
12	Asteraceae	*Tagetes patula*
13	Asteraceae	*Tanacetum coccineum*
14	Asteraceae	*Zinnia elegans*
15	Asteraceae	*Xerochrysum bracteatum*
16	Brassicaceae	*Aubrieta deltoidea*
17	Brassicaceae	*Lobularia maritima*
18	Brassicaceae	*Matthiola incana*
19	Carophyllaceae	*Dianthus barbatus*
20	Carophyllaceae	*Dianthus caryophyllus*
21	Carophyllaceae	*Gypsophila paniculata*
22	Convolvulaceae	*Convolvulus tricolor*
23	Convolvulaceae	*Ipomea purpurea*
24	Fabaceae	*Lupinus polyphyllus*
25	Lamiaceae	*Lavandula officinalis*
26	Nyctaginaceae	*Mirabilis jalapa*
27	Papaveraceae	*Eschscholzia californica*
28	Plumbaginaceae	*Limonium sinuatum*
29	Polemoniaceae	*Phlox drummondii*
30	Portulacaceae	*Portulaca grandiflora*
31	Primulaceae	*Primula vulgaris*
32	Ranunculaceae	*Aquilegia* sp.
33	Ranunculaceae	*Aquilegia vulgaris*
34	Ranunculaceae	*Delphinium gracile*
35	Scrophulariaceae	*Antirrhinum majus*
36	Solanaceae	*Petunia hybrida*
37	Tropaeolaceae	*Tropaeolum majus*
38	Violaceae	*Viola odorata*

Among these species, the most frequent biogeographic origin was the Palearctic (43%; n = 18, Figure 1), for example, *Primula acaulis* L. (Primulaceae). In contrast, Oriental and Australasian biogeographic origins were represented by only *Callistephus chinensis* (L.) Nees, 1832 and *Xerochrysum bracteatum* (Vent.) Tzvelev, 1990 (both Asteraceae), respectively.

It was found that the families and genera of the exotic seeds sold in Chile are highly represented in the Chilean flora; 90% (n=19) and 51.4% (n=35) of the families and genera respectively (Figure 2a).

According to the international market, 290 Chilean species are formally sold in the seed market, including 73 families, 155 genera, 160 native and 130 endemic species (Tables 3 and 4).

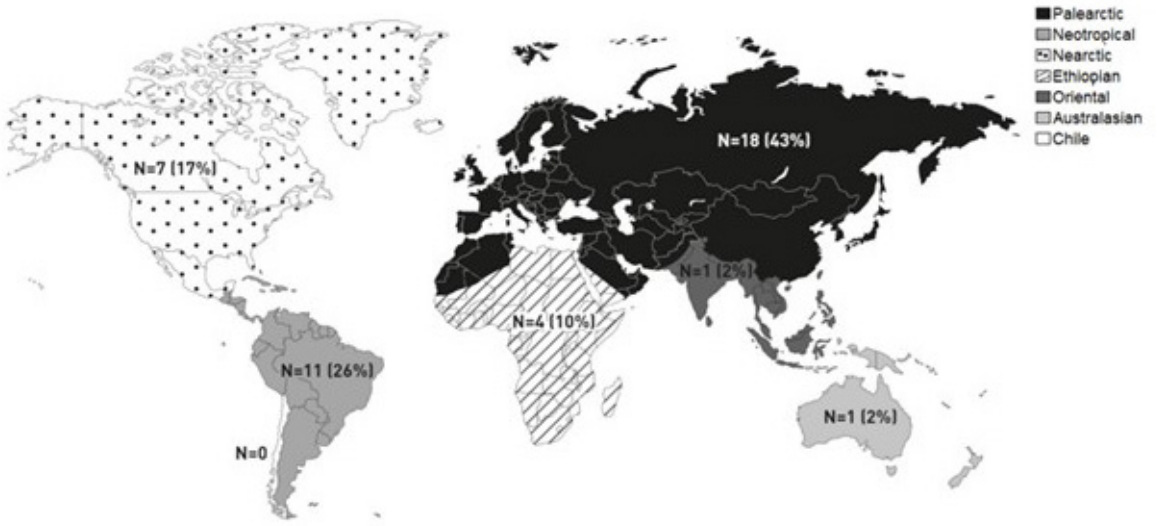

Figure 1. Number of ornamental species seeds sold in the Chilean market by biogeographic origin. Chile is in white color for comparison purposes. In parentheses, the proportion of the total sold seeds.

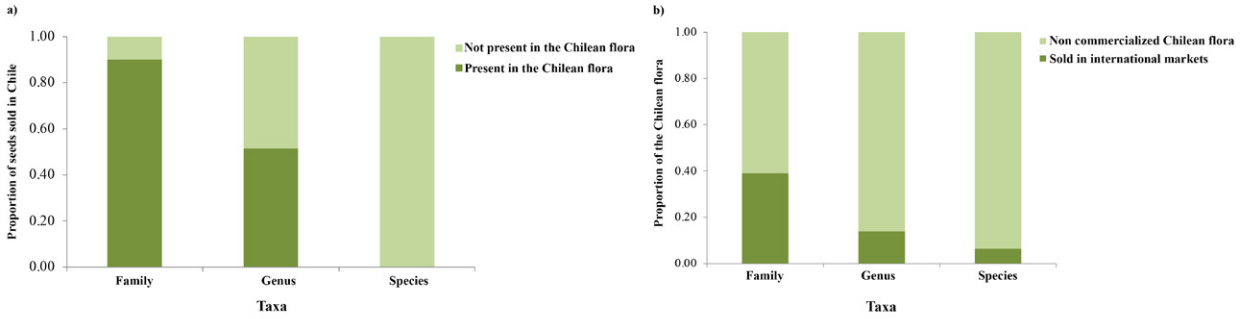

Figure 2. Proportion of different taxa of ornamental species sold as seeds: a) In the Chilean local market and b) native Chilean species sold in the international market.

Table 3. Chilean species commercialized at international seed market.

Nº	Family	Specie	Origin
1	Aextoxicaceae	*Aextoxicon punctatum*	Native
2	Aizoaceae	*Tetragonia tetragonoides*	Native
3	Alstroemeriaceae	*Alstroemeria aurea*	Native
4	Alstroemeriaceae	*Alstroemeria hookeri*	Endemic
5	Alstroemeriaceae	*Alstroemeria magnifica*	Endemic
6	Alstroemeriaceae	*Alstroemeria umbellata*	Endemic
7	Alstroemeriaceae	*Alstroemeria pulchra*	Endemic
8	Alstroemeriaceae	*Alstroemeria andina*	Endemic
9	Alstroemeriaceae	*Alstroemeria ligtu*	Endemic
10	Alstroemeriaceae	*Alstroemeria kingii*	Endemic
11	Alstroemeriaceae	*Alstroemeria exerens*	Endemic
12	Alstroemeriaceae	*Alstroemeria pallida*	Endemic
13	Alstroemeriaceae	*Alstroemeria angustifolia*	Endemic
14	Alstroemeriaceae	*Alstroemeria pelegrina*	Endemic
15	Alstroemeriaceae	*Alstroemeria garaventae*	Endemic
16	Alstroemeriaceae	*Alstroemeria graminea*	Endemic

Table 3. Continuation

17	Alstroemeriaceae	*Alstroemeria diluta*	Endemic
18	Alstroemeriaceae	*Alstroemeria schizanthoides*	Endemic
19	Alstroemeriaceae	*Bomarea salsilla*	Native
20	Alstroemeriaceae	*Leontochir ovallei*	Endemic
21	Amaryllidaceae	*Latace andina*	Native
22	Amaryllidaceae	*Myostemma bagnoldii*	Endemic
23	Amaryllidaceae	*Myostemma montana*	Endemic
24	Amaryllidaceae	*Nothoscordum gracile*	Native
25	Amaryllidaceae	*Rhodolirium chilense*	Endemic
26	Amaryllidaceae	*Rhodolirium montanum*	Native
27	Anacardiaceae	*Schinus areira*	Native
28	Anacardiaceae	*Schinus latifolius*	Endemic
29	Anacardiaceae	*Schinus polygamus*	Native
30	Apiaceae	*Azorella madreporica*	Native
31	Apiaceae	*Bolax gummifera*	Native
32	Apiaceae	*Centella asiatica*	Native
33	Apiaceae	*Osmorhiza chilensis*	Native
34	Apiaceae	*Sanicula crassicaulis*	Native
35	Araucariaceae	*Araucaria araucana*	Native
36	Arecaceae	*Jubaea chilensis*	Endemic
37	Asteraceae	*Bidens pilosa*	Native
38	Asteraceae	*Conyza bonariensis*	Native
39	Asteraceae	*Erigeron andicola*	Native
40	Asteraceae	*Madia sativa*	Native
41	Asteraceae	*Mutisia ilicifolia*	Endemic
42	Asteraceae	*Mutisia oligodon*	Native
43	Asteraceae	*Mutisia latifolia*	Endemic
44	Asteraceae	*Mutisia decurrens*	Native
45	Asteraceae	*Mutisia spinosa*	Endemic
46	Asteraceae	*Nassauvia lagascae*	Native
47	Asteraceae	*Nassauvia revoluta*	Native
48	Asteraceae	*Tagetes minuta*	Native
49	Asteraceae	*Verbesina encelioides*	Endemic
50	Berberidaceae	*Berberis darwinii*	Native
51	Berberidaceae	*Berberis microphylla*	Native
52	Berberidaceae	*Berberis trigona*	Native
53	Berberidaceae	*Berberis montana*	Native
54	Berberidaceae	*Berberis congestiflora*	Endemic
55	Bignoniaceae	*Argylia adscendens*	Endemic
56	Bignoniaceae	*Eccremocarpus scaber*	Native
57	Boraginaceae	*Cordia decandra*	Endemic
58	Brassicaceae	*Schizopetalon walkeri*	Endemic
59	Bromeliaceae	*Fascicularia bicolor*	Endemic
60	Bromeliaceae	*Puya chilensis*	Endemic
61	Bromeliaceae	*Puya alpestris*	Endemic
62	Bromeliaceae	*Puya berteroniana*	Endemic
63	Bromeliaceae	*Puya coerulea*	Endemic

Table 3. Continuation

64	Cactaceae	*Austrocactus patagonicus*	Native
65	Cactaceae	*Austrocedrus chilensis*	Native
66	Cactaceae	*Browningia candelaris*	Native
67	Cactaceae	*Copiapoa humilis*	Endemic
68	Cactaceae	*Copiapoa marginata*	Endemic
69	Cactaceae	*Copiapoa coquimbana*	Endemic
70	Cactaceae	*Copiapoa hypogaea*	Endemic
71	Cactaceae	*Copiapoa calderana*	Endemic
72	Cactaceae	*Copiapoa cinerea*	Endemic
73	Cactaceae	*Copiapoa echinoides*	Endemic
74	Cactaceae	*Copiapoa cinerascens*	Endemic
75	Cactaceae	*Copiapoa grandiflora*	Endemic
76	Cactaceae	*Corryocactus brevistylus*	Native
77	Cactaceae	*Cumulopuntia echinacea*	Native
78	Cactaceae	*Echinopsis chiloensis*	Endemic
79	Cactaceae	*Eriosyce curvispina*	Endemic
80	Cactaceae	*Eriosyce subgibbosa*	Endemic
81	Cactaceae	*Eriosyce taltalensis*	Endemic
82	Cactaceae	*Eriosyce napina*	Endemic
83	Cactaceae	*Eriosyce paucicostata*	Endemic
84	Cactaceae	*Eriosyce heinrichiana*	Endemic
85	Cactaceae	*Eriosyce villosa*	Endemic
86	Cactaceae	*Eriosyce aurata*	Endemic
87	Cactaceae	*Eriosyce chilensis*	Endemic
88	Cactaceae	*Eriosyce senilis*	Endemic
89	Cactaceae	*Eriosyce sociabilis*	Endemic
90	Cactaceae	*Eriosyce islayensis*	Native
91	Cactaceae	*Eriosyce eriosyzoides*	Endemic
92	Cactaceae	*Eriosyce simulans*	Endemic
93	Cactaceae	*Eriosyce confinis*	Endemic
94	Cactaceae	*Eriosyce crispa*	Endemic
95	Cactaceae	*Eriosyce iquiquensis*	Endemic
96	Cactaceae	*Eriosyce engleri*	Endemic
97	Cactaceae	*Eriosyce odieri*	Endemic
98	Cactaceae	*Eriosyce rodentiophila*	Endemic
99	Cactaceae	*Eriosyce esmeraldana*	Endemic
100	Cactaceae	*Eriosyce aspillagae*	Endemic
101	Cactaceae	*Eriosyce recondita*	Endemic
102	Cactaceae	*Eulychnia acida*	Endemic
103	Cactaceae	*Eulychnia castanea*	Endemic
104	Cactaceae	*Haageocereus australis*	Native
105	Cactaceae	*Maihuenia poeppigii*	Native
106	Cactaceae	*Maihuenia patagonica*	Native
107	Cactaceae	*Maihueniopsis glomerata*	Native
108	Cactaceae	*Maihueniopsis nigrispina*	Native
109	Cactaceae	*Oreocereus leucotrichus*	Native
110	Calceolariaceae	*Calceolaria biflora*	Native

Table 3. Continuation

111	Calceolariaceae	*Calceolaria tripartita*	Native
112	Calceolariaceae	*Calceolaria alba*	Endemic
113	Calceolariaceae	*Calceolaria pinifolia*	Native
114	Calceolariaceae	*Calceolaria integrifolia*	Native
115	Calceolariaceae	*Calceolaria lanigera*	Endemic
116	Calceolariaceae	*Calceolaria corymbosa*	Native
117	Calceolariaceae	*Calceolaria polifolia*	Endemic
118	Calceolariaceae	*Calceolaria arachnoidea*	Endemic
119	Calceolariaceae	*Calceolaria tenella*	Native
120	Calceolariaceae	*Calceolaria uniflora*	Native
121	Calceolariaceae	*Jovellana violacea*	Endemic
122	Calceolariaceae	*Jovellana punctata*	Endemic
123	Campanulaceae	*Lobelia tupa*	Endemic
124	Campanulaceae	*Lobelia excelsa*	Endemic
125	Campanulaceae	*Lobelia polyphylla*	Endemic
126	Campanulaceae	*Lobelia bridgesii*	Endemic
127	Cardiopteridaceae	*Citronella mucronata*	Endemic
128	Celastraceae	*Maytenus boaria*	Native
129	Chenopodiaceae	*Chenopodium quinoa*	Native
130	Chenopodiaceae	*Dysphania ambrosioides*	Native
131	Columelliaceae	*Desfontainia fulgens*	Native
132	Convolvulaceae	*Ipomoea pes-caprae*	Native
133	Cunoniaceae	*Eucryphia glutinosa*	Endemic
134	Cunoniaceae	*Eucryphia cordifolia*	Native
135	Cyperaceae	*Cyperus eragrostis*	Native
136	Cyperaceae	*Cyperus reflexus*	Native
137	Cyperaceae	*Eleocharis macrostachya*	Native
138	Cyperaceae	*Schoenoplectus americanus*	Native
139	Cyperaceae	*Schoenoplectus pungens*	Native
140	Davalliaceae	*Davallia solida*	Native
141	Dryopteridaceae	*Rumohra adiantiformis*	Native
142	Elaeocarpaceae	*Crinodendron hookerianum*	Endemic
143	Elaeocarpaceae	*Crinodendron patagua*	Endemic
144	Ephedraceae	*Ephedra chilensis*	Native
145	Ephedraceae	*Ephedra trifurcata*	Endemic
146	Fabaceae	*Acacia caven*	Native
147	Fabaceae	*Astragalus trifoliatus*	Endemic
148	Fabaceae	*Caesalpinia gilliesii*	Native
149	Fabaceae	*Caesalpinia spinosa*	Native
150	Fabaceae	*Geoffroea decorticans*	Native
151	Fabaceae	*Lathyrus nervosus*	Native
152	Fabaceae	*Lathyrus hookeri*	Native
153	Fabaceae	*Lathyrus pubescens*	Native
154	Fabaceae	*Lupinus microcarpus*	Native
155	Fabaceae	*Otholobium glandulosum*	Native
156	Fabaceae	*Prosopis chilensis*	Native
157	Fabaceae	*Prosopis tamarugo*	Endemic
158	Fabaceae	*Senna candolleana*	Endemic

Table 3. Continuation

159	Fabaceae	*Sophora macrocarpa*	Endemic
160	Fabaceae	*Sophora cassioides*	Endemic
161	Francoaceae	*Balbisia peduncularis*	Native
162	Geraniaceae	*Geranium sessiliflorum*	Native
163	Gesneriaceae	*Mitraria coccinea*	Native
164	Grossulariaceae	*Ribes magellanicum*	Native
165	Gunneraceae	*Gunnera tinctoria*	Native
166	Iridaceae	*Herbertia lahue*	Native
167	Iridaceae	*Olsynium frigidum*	Native
168	Iridaceae	*Olsynium junceum*	Endemic
169	Iridaceae	*Sisyrinchium striatum*	Native
170	Iridaceae	*Sisyrinchium patagonicum*	Native
171	Iridaceae	*Sisyrinchium cuspidatum*	Native
172	Juncaceae	*Juncus effusus*	Native
173	Juncaceae	*Juncus tenuis*	Native
174	Juncaceae	*Juncus balticus*	Native
175	Juncaceae	*Juncus kraussii*	Native
176	Lamiaceae	*Lepechinia chilensis*	Endemic
177	Lardizabalaceae	*Lardizabala biternata*	Endemic
178	Lauraceae	*Beilschmiedia berteroana*	Endemic
179	Lauraceae	*Beilschmiedia miersii*	Endemic
180	Lauraceae	*Cryptocarya alba*	Endemic
181	Loasaceae	*Blumenbachia prietea*	Native
182	Loasaceae	*Caiophora coronata*	Native
183	Malvaceae	*Thespesia populnea*	Native
184	Monimiaceae	*Laurelia sempervirens*	Endemic
185	Monimiaceae	*Peumus boldus*	Endemic
186	Montiaceae	*Calandrinia ciliata*	Native
187	Montiaceae	*Calandrinia caespitosa*	Endemic
188	Montiaceae	*Calandrinia affinis*	Native
189	Montiaceae	*Cistanthe grandiflora*	Endemic
190	Montiaceae	*Cistanthe longiscapa*	Endemic
191	Montiaceae	*Montiopsis umbellata*	Native
192	Montiaceae	*Montiopsis sericea*	Endemic
193	Myrtaceae	*Luma apiculata*	Native
194	Myrtaceae	*Luma chequen*	Endemic
195	Myrtaceae	*Ugni molinae*	Native
196	Nothofagaceae	*Nothofagus antarctica*	Native
197	Nothofagaceae	*Nothofagus obliqua*	Native
198	Nothofagaceae	*Nothofagus dombeyi*	Native
199	Nothofagaceae	*Nothofagus alpina*	Native
200	Nothofagaceae	*Nothofagus glauca*	Endemic
201	Nothofagaceae	*Nothofagus pumilio*	Native
202	Onagraceae	*Clarkia tenella*	Native
203	Onagraceae	*Fuchsia magellanica*	Native
204	Onagraceae	*Oenothera stricta*	Native
205	Onagraceae	*Oenothera acaulis*	Endemic
206	Onagraceae	*Oenothera odorata*	Native

Table 3. Continuation

207	Orobanchaceae	*Euphrasia cockayniana*	Endemic
208	Oxalidaceae	*Oxalis valdiviensis*	Native
209	Oxalidaceae	*Oxalis megalorrhiza*	Native
210	Papaveraceae	*Argemone hunnemannii*	Native
211	Passifloraceae	*Malesherbia humilis*	Endemic
212	Passifloraceae	*Malesherbia linearifolia*	Endemic
213	Passifloraceae	*Malesherbia lirana*	Endemic
214	Passifloraceae	*Passiflora foetida*	Native
215	Philesiaceae	*Lapageria rosea*	Endemic
216	Phrymaceae	*Erythranthe lutea*	Native
217	Phrymaceae	*Erythranthe cuprea*	Native
218	Plantaginaceae	*Hebe elliptica*	Native
219	Plantaginaceae	*Hebe salicifolia*	Native
220	Plantaginaceae	*Ourisia microphylla*	Native
221	Plantaginaceae	*Plantago maritima*	Native
222	Plumbaginaceae	*Armeria maritima*	Native
223	Poaceae	*Avenella flexuosa*	Native
224	Poaceae	*Bromus catharticus*	Native
225	Poaceae	*Carex trifida*	Native
226	Poaceae	*Cortaderia selloana*	Native
227	Poaceae	*Danthonia californica*	Native
228	Poaceae	*Deschampsia caespitosa*	Native
229	Poaceae	*Deschampsia elongata*	Native
230	Poaceae	*Elymus magellanicus*	Native
231	Poaceae	*Hordeum brachyatherum*	Endemic
232	Poaceae	*Imperata condensata*	Native
233	Poaceae	*Paspalum dilatatum*	Native
234	Poaceae	*Phleum alpinum*	Native
235	Poaceae	*Poa secunda*	Native
236	Podocarpaceae	*Podocarpus saligna*	Endemic
237	Podocarpaceae	*Prumnopitys andina*	Native
238	Polemoniaceae	*Collomia biflora*	Native
239	Polygonaceae	*Rumex magellanicus*	Native
240	Portulacaceae	*Portulaca philippii*	Native
241	Primulaceae	*Primula magellanica*	Native
242	Primulaceae	*Samolus repens*	Native
243	Proteaceae	*Embothrium coccineum*	Native
244	Proteaceae	*Gevuina avellana*	Native
245	Proteaceae	*Lomatia ferruginea*	Native
246	Proteaceae	*Lomatia hirsuta*	Native
247	Proteaceae	*Lomatia dentata*	Endemic
248	Quillajaceae	*Quillaja saponaria*	Native
249	Ranunculaceae	*Anemone multifida*	Native
250	Ranunculaceae	*Ranunculus sericocephalus*	Native
251	Rhamnaceae	*Colletia hystrix*	Native
252	Rosaceae	*Acaena magellanica*	Native
253	Rosaceae	*Acaena ovalifolia*	Native
254	Rosaceae	*Acaena sericea*	Native

Table 3. Continuation

255	Rosaceae	*Acaena caespitosa*	Native
256	Rosaceae	*Acaena pinnatifida*	Native
257	Rosaceae	*Acaena splendens*	Native
258	Rosaceae	*Geum magellanicum*	Native
259	Rosaceae	*Geum quellyon*	Endemic
260	Rosaceae	*Kageneckia angustifolia*	Endemic
261	Rosaceae	*Kageneckia oblonga*	Endemic
262	Salicaceae	*Azara integrifolia*	Endemic
263	Salicaceae	*Azara petiolaris*	Endemic
264	Scrophulariaceae	*Alonsoa meridionalis*	Native
265	Scrophulariaceae	*Buddleja globosa*	Native
266	Solanaceae	*Nicandra physalodes*	Native
267	Solanaceae	*Nicotiana glauca*	Native
268	Solanaceae	*Nolana paradoxa*	Endemic
269	Solanaceae	*Salpiglossis sinuata*	Native
270	Solanaceae	*Schizanthus hookeri*	Native
271	Solanaceae	*Schizanthus grahamii*	Endemic
272	Solanaceae	*Solanum sisymbriifolium*	Native
273	Solanaceae	*Solanum pinnatum*	Endemic
274	Tecophilaeaceae	*Conanthera bifolia*	Endemic
275	Tecophilaeaceae	*Tecophilaea cyanocrocus*	Endemic
276	Tropaeolaceae	*Tropaeolum polyphyllum*	Native
277	Tropaeolaceae	*Tropaeolum speciosum*	Endemic
278	Tropaeolaceae	*Tropaeolum azureum*	Endemic
279	Tropaeolaceae	*Tropaeolum tricolor*	Endemic
280	Tropaeolaceae	*Tropaeolum ciliatum*	Endemic
281	Tropaeolaceae	*Tropaeolum incisum*	Native
282	Tropaeolaceae	*Tropaeolum sessilifolium*	Endemic
283	Tropaeolaceae	*Tropaeolum brachyceras*	Endemic
284	Verbenaceae	*Rhaphithamnus spinosus*	Native
285	Verbenaceae	*Verbena bonariensis*	Native
286	Violaceae	*Viola atropurpurea*	Native
287	Violaceae	*Viola cotyledon*	Native
288	Violaceae	*Viola volcanica*	Endemic
289	Violaceae	*Viola glacialis*	Endemic
290	Winteraceae	*Drimys winteri*	Endemic

Table 4. Numbers of taxa and endemism per taxonomic family of the Chilean flora and its representation in internationally seeds market. Data of native flora from Rodríguez et al., (2018).

Taxonomic family	Number of taxa in Chile	Proportion of endemic taxa	Proportion of internationally commercialized taxa	Proportion of endemic taxa commercialized internationally from the family number of taxa
Aextoxicaceae	1	0.00	1.00	0.00
Aizoaceae	10	0.60	0.10	0.00
Alstroemeriaceae	60	0.85	0.30	0.27
Amaryllidaceae	110	0.85	0.05	0.03
Anacardiaceae	10	0.50	0.30	0.10
Apiaceae	102	0.43	0.05	0.00
Araucariaceae	1	0.00	1.00	0.00
Arecaceae	2	1.00	0.50	0.50
Asteraceae	921	0.44	0.01	0.00
Berberidaceae	19	0.63	0.26	0.05
Bignoniaceae	15	0.60	0.13	0.07
Boraginaceae	87	0.62	0.01	0.01
Brassicaceae	143	0.38	0.01	0.01
Bromeliaceae	29	0.86	0.17	0.17
Cactaceae	127	0.81	0.36	0.27
Calceolariaceae	85	0.74	0.15	0.07
Campanulaceae	17	0.65	0.24	0.24
Cardiopteridaceae	1	1.00	1.00	1.00
Celastraceae	5	0.00	0.20	0.00
Chenopodiaceae	50	0.50	0.04	0.00
Columelliaceae	1	0.00	1.00	0.00
Convolvulaceae	29	0.31	0.03	0.00
Cunoniaceae	4	0.25	0.50	0.25
Cyperaceae	169	0.23	0.03	0.00
Davalliaceae	1	0.00	1.00	0.00
Dryopteridaceae	20	0.45	0.05	0.00
Elaeocarpaceae	3	0.67	0.67	0.67
Ephedraceae	6	0.33	0.33	0.17
Fabaceae	300	0.54	0.05	0.02
Francoaceae	13	0.69	0.08	0.00
Geraniaceae	5	0.20	0.20	0.00
Gesneriaceae	3	0.33	0.33	0.00
Grossulariaceae	9	0.44	0.11	0.00
Gunneraceae	9	0.44	0.11	0.00
Iridaceae	36	0.39	0.17	0.03
Juncaceae	44	0.11	0.09	0.00
Lamiaceae	28	0.64	0.04	0.04
Lardizabalaceae	2	0.50	0.50	0.50
Lauraceae	4	0.75	0.75	0.75
Loasaceae	48	0.48	0.04	0.00

Table 4. Continuation

Malvaceae	85	0.46	0.01	0.00
Monimiaceae	3	0.67	0.67	0.67
Montiaceae	57	0.35	0.12	0.07
Myrtaceae	27	0.67	0.11	0.04
Nothofagaceae	11	0.36	0.55	0.09
Onagraceae	37	0.24	0.14	0.03
Orobanchaceae	24	0.54	0.04	0.04
Oxalidaceae	54	0.54	0.04	0.00
Papaveraceae	4	0.50	0.25	0.00
Passifloraceae	26	0.81	0.15	0.12
Philesiaceae	2	0.50	0.50	0.50
Phrymaceae	8	0.50	0.25	0.00
Plantaginaceae	60	0.25	0.07	0.00
Plumbaginaceae	4	0.50	0.25	0.00
Poaceae	411	0.19	0.03	0.00
Podocarpaceae	5	0.20	0.40	0.20
Polemoniaceae	10	0.10	0.10	0.00
Polygonaceae	33	0.67	0.03	0.00
Portulacaceae	1	0.00	1.00	0.00
Primulaceae	10	0.10	0.20	0.00
Proteaceae	6	0.00	0.83	0.00
Quillajaceae	1	0.00	1.00	0.00
Ranunculaceae	41	0.10	0.05	0.00
Rhamnaceae	12	0.58	0.08	0.00
Rosaceae	46	0.30	0.22	0.07
Salicaceae	10	0.60	0.20	0.20
Scrophulariaceae	5	0.40	0.40	0.00
Solanaceae	189	0.52	0.04	0.02
Tecophilaeaceae	10	1.00	0.20	0.20
Tropaeolaceae	26	0.85	0.31	0.23
Verbenaceae	64	0.31	0.03	0.00
Violaceae	78	0.68	0.05	0.03
Winteraceae	4	0.75	0.25	0.25

Approximately 6% of the total native flora is sold in the international seed market (Figure 2b), including less than half of the Chilean plant families (39%). The most common families were Cactaceae (n = 46 species) and Alstroemeriaceae (n = 18 species), and among the genera, *Eriosyce* (n = 23 species) and *Alstroemeria* (n = 16 species) were most frequently found in the international seed market.

Regarding the companies, we found 155 companies from 21 different countries that sell Chilean seed species (Table 5), with England (34%) and the USA (32%) selling the most species of all the companies. None of these companies have businesses or representation in Chile. Most of the Chilean seeds were sold internationally by companies such as B&T World Seeds (n = 117), Chiltern Seeds (n = 90) and Sandeman Seeds (n = 79).

Table 5. International companies that commercialized seeds of native species from Seed search catalogue, 5th (2002) and 8th (2012) editions.

Name	Country	Number of native species commercialized
B&T World Seeds	France	117
Chiltern Seeds	England	90
Sandeman Seeds	France	79
Mesa Garden Seed List	Mexico	47
Cactus Heaven	Malta	32
Plant World	England	31
Doug and Vivi Rowland	England	30
Alplains	USA	30
Succseed Valsangsvagen 24	Sweden	23
Sheffield's Seed	USA	20
Jelitto Perennial Seeds	Germany	19
Coombland gardens Nursey	England	18
Secret Seeds	England	14
J.L. Hudson, Seedsman	USA	13
Impecta Handels	Sweden	12
Thompson & Morgan	England	11
Plants of Distintction Abacus House	England	10
Herbiseed	England	9
Frosty Hollow	USA	9
Seedhunt	USA	9
Sunshine Seeds	Germany	8
Granite Seed	U.S.	8
Austrahort Pty. Ltd.	Australia	7
Abundant Life Seed Foundation	USA	7
Inside Passage	USA	7
Larner Seeds	USA	7
Mistletoe Seed	USA	7
Sun Mountain Native Seed	USA	7
Ellison Horticultural Pty	Australia	6
H.G. Kershaw Pty Ltd	Australia	6
Harvest Seeds	Australia	6
Royston Petrie	Australia	6
Forestart	England	6
Potterton & Martin	England	6
Vreek's Zaden	Holland	6
Freshwater Farms	USA	6
Horizon Herbs	USA	6
Legendary Etchnobotanical Resources	USA	6
Applewood Seed Co.	USA	6

Table 5. Continuation

Andrew Norfield Seeds	Welsh	6
W.E.TH Ingwersen Ltd.	England	5
Exotische Nutz	Germany	5
Carter Seeds	USA	5
Horus Botanicals	USA	5
Ion Exchange	USA	5
Phoenix Seeds	Australia	4
Richters Herbs	Canada	4
Agroforestry Research Trust	England	4
Seeds-by-Size	England	4
CN Seeds	England	4
Emorsgate seed	England	4
Mr. Fothergills Seed	England	4
Jim Almond	England	4
Nicky's Nursery	England	4
Seymour Selected Seeds	England	4
Shivalik Seeds	England	4
JWP Bloemzaden	Holland	4
Reichenbach Seeds	New Zealand	4
Southern Seeds	New Zealand	4
Witton Lane Seeds	Norway	4
Companion Plants	USA	4
E.O.N.S.	USA	4
Glenshirst Cactus Nursery	USA	4
Lawyer Nursery	USA	4
PJT Botanicals	USA	4
Prairie Moon Nursery	USA	4
Fruit Spirit	Australia	3
Ninderthana Seed Service Pyt Ltd.	Australia	3
The Organic Gardering Catalogue	England	3
David Chesire Seeds	England	3
Holly Gate Cactus Nursery	England	3
Fratelli Ignegnoli	Italy	3
Kings Herbs Ltd	New Zealand	3
Nikau Hill	New Zealand	3
Kerrachar	Scotland	3
Wildseed	Tasmania	3
De Giorgi Seed Company	USA	3
F.W. Schumacher	USA	3
Green Dealer	USA	3
Native American Seed	USA	3
Gardens North	Canada	2
Derry Watkins	England	2

Table 5. Continuation

E.W. King & Co. Ltd. Monks Farm	England	2
Graysons Seeds	England	2
Pro-veg Seeds Ltd.	England	2
Salley Garden	England	2
Wallis Seeds	England	2
Golden Cottage Garden Plants	England	2
Drake's Alpines	England	2
Filaree Farm	E.U.	2
Syringa	Germany	2
Gautam Global	India	2
Nestlebrae Exotics	New Zealand	2
Leuthens Frohandel	Norway	2
Access Group	Togo	2
Bluestern Prairie	USA	2
Callahan Seeds	USA	2
Desert Citizens Seed Co.	USA	2
Pinetree Garden Seeds	USA	2
RH Shumway's	USA	2
Rocky Mountain Rare Plants	USA	2
The Thyme Garden	USA	2
Underwood Gardens	USA	2
V&J Seed Farm	USA	2
Western Productions	USA	2
Eden Seeds	Australia	1
Greta's Organic Gardens	Canada	1
Northcott Gardens	Canada	1
Prairie Habitats Inc.	Canada	1
Rawlinson	Canada	1
West Coast Seed	Canada	1
Semences BC	Canada	1
Rainforest Seed	Costa Rica	1
Ball Colegrave Ltd.	England	1
D.T. Brown & Co. Ltd.	England	1
Field House Alpines	England	1
The Cottage Herbery	England	1
Halcycon Seeds	England	1
Seeds of Italy	England	1
Jungle Seeds	England	1
Moles Seeds	England	1
Naturescape	England	1
Range Nurseries	England	1
Suttons Seeds	England	1
Simpson's Seeds	England	1

Table 5. Continuation

Stewarts	England	1
Suffolk Herbs	England	1
Tamar Organics	England	1
Terre de Semences	England	1
Thomas Etty Esq.	England	1
Silk tree	England	1
Unwins Seed Ltd.	England	1
Yellow Flag Wildflowers	England	1
Biosem	E.U.	1
Carl Sperling	Germany	1
Kiepenkerl	Germany	1
Imzaadex Hofstraat	Holland	1
Kumar International	India	1
Agbina	Russia	1
Blackwoods Herbs	South Africa	1
Silverhill Seeds	South Africa	1
Seed Center: Dept Water Affairs & Forestry	South Africa	1
Siam Seeds	Thailand	1
Carmel Valley Seed Co.	USA	1
Edge of the Rockies	USA	1
Heirloom Seeds	USA	1
Inge Hoffman	USA	1
Kester's Wild Game Food Nss Inc	USA	1
Mountain Valley	USA	1
Oregon Exotics	USA	1
Plants of the Southwest	USA	1
Seeds of Change	USA	1
Select Seeds	USA	1
Southwestern Native Seeds	USA	1
Victory Seeds	USA	1

Discussion

The results allow us to see an uneven availability of seeds from native ornamental plants, because native seeds are absent in the formal Chilean seed market, but surprisingly, approximately 6% of Chilean flora are currently sold as seeds in foreign countries. These results are in line with the low representation of native Chilean flora at local plant nurseries, and this trend has not changed in the last decade (León-Lobos and Rosas, 2010). Notably, some endemic and endangered species are commercialized in other countries but not in Chile, such as representatives of the genus *Copiapoa* (Cactaceae), and endemic species such as *Jubaea chilensis* (Arecaceae) and *Peumus boldus* (Monimiaceae). This issue represents an important challenge to valuing these species for gardening in Chile, generate demand, and thus promote the interest of local nurseries (Table 4).

England has the largest number of companies that offer Chilean native seeds (n=52) because British interest in Chilean species date from the early years of the 19th century (Maxwell and Gardner, 1997; Teillier, 2008). Outside Chile, Cactaceae is the most sold family, and half of these seeds belong to the genus *Eriosyce*, with almost

all species endemic to Chile (22 out of 23 - Table 3). This family has desirable ornamental traits for gardening worldwide (Nobel, 2002) and has attracted great interest in terms of private collections. Interest that should increase due to its low water requirements and future climate change scenarios. However, many of these species are currently threatened by illegal harvest. Therefore, it is urgent to establish a formal market for properly collected and cultivated seeds and plants, allowing their origins to be traced, especially because there is an informal seed market.

The existence of a formal market helps to reduce illegal trade in species and to comply with the standards of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Therefore, further studies should aim to quantify these informal markets, particularly foreign markets, to estimate the unregulated leakage of genetic material since Chile is a signatory to CITES and the Convention on Biological Diversity.

The availability and access of native seeds and flora has implications for *ex situ* biodiversity conservation. It enables their use in local ecological restoration programs, in ecological intensification such as cover crops in agricultural areas, and in urban green areas (Harmon-Threatt and Hendrix, 2015; León-Lobos et al., 2020). For example, in many times, the re-establishment of native plant species is hindered by the lack of availability of a suitable soil seed bank or nearby source area for re-colonization. Therefore, the availability of native seeds is a key to ensuring successful restoration (Elzenga et al., 2019). Recent research highlights the use of native flowering shrubs to promote beneficial insects in commercial crops, which result in an increase of crop productivity (Muñoz et al., 2021a, 2021b).

However, there is limited availability of native plants in commercial nurseries, that difficult for their implementation in agriculture (Bannister et al., 2018). In this context, León-Lobos et al. (2020) proposed that the lack of adequate seed supply is a major bottleneck for effective ecosystem restoration in Chile. Additionally, using native seeds for ornamental purposes in urban green areas could increase knowledge and concerns about local biodiversity, affecting awareness and positive attitudes toward their conservation (Parra-Saldívar et al., 2020), in addition to promoting ecological interactions among native species. Biocultural homogenization (Celis-Diez et al., 2017), which involves not only a substitution and uniformity of local biota (biotic homogenization), but also the loss of awareness and willingness to conserve local nature due to the "extinction of experience" or the lack of face-to-face encounters with local biodiversity (Soga and Gaston, 2016), constitute an understudy driver of global change. A possible explanation is the lack of information about seed sourcing, seed quality/availability, processing and storing seeds, dormancy-breaking, and germination (Elzenga et al., 2019; León-Lobos et al., 2020), which limit their propagation and trading.

Conclusions

Native flora has great potential to be incorporated into the formal seed market to help promote local biodiversity, reduce biocultural homogenization and increase awareness and willingness to conserve native flora. The availability of native seeds in the market is regulated by demand. However, to promote their use in gardening and its commercialization, it is necessary to establish incentives through the public and private sector, regulations, research, and outreach projects that increase the value of native flora, particularly locally adapted species, in a climate change scenario. Consequently, we encourage the propagation of native flora to increase its availability in the local market and the exchange of its seeds among gardeners, gardening associations and landscape designers.

Author Contribution

AFR, JLC-D: conceived and designed the research. **AFR**: conducted the observations and acquisition of data. **PD-S, JLC-D**: analysed the data; **PD-S**, **JD-F**, **PL-L**, **JLC-D**: wrote and edited the manuscript.

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References

BALDOCK, K.; GODDARD, M.; HICKS, D.M.; KUNIN, W.; MITSCHUNAS, N.; MORSE, H.; OSGATHORPE, L.M.; POTTS, S.G.; ROBERTSON, K.M.; SCOTT, A.V.; STANICZENKO, P.P.A.; STONE, G.N.; VAUGHAN, I.P.; MEMMOTT, J. A systems approach reveals urban pollinator hotspots and conservation opportunities. **Nature Ecology and Evolution**, v.3, p.363-373, 2019. https://doi.org/10.1038/s41559-018-0769-y

BANNISTER, J.R.; VARGAS-GAETE, R.; OVALLE, J.F.; ACEVEDO, M.; FUENTES-RAMIREZ, A.; DONOSO, P.J.; PROMIS, A.; SMITH-RAMÍREZ, C. Major bottlenecks for the restoration of natural forests in Chile. **Restoration Ecology**, v.26, p.1039-1044, 2018. https://doi.org/10.1111/rec.12880

BRAMAN, S.K.; PENDLEY, A.F.; CORLEY, W. Influence of commercially available wildflower mixes on beneficial arthropod abundance and predation in turfgrass. **Environmental Entomology**, v.31, p.564-572, 2002. https://doi.org/10.1603/0046-225X-31.3.564

CELIS-DIEZ, J.L.; MUÑOZ, C.; ABADES, S.R.; MARQUET, P.A.; ARMESTO, J.J. Biocultural homogenization in urban settings: Public knowledge of birds in city parks of Santiago, Chile. **Sustainability**, v.9, p.485, 2017. https://doi.org/10.3390/su9040485

DÍAZ-FORESTIER, J.; LEÓN-LOBOS, P.; MARTICORENA, A.; CELIS-DIEZ, J.L.; GIOVANNINI, P. Useful native plants of Chile: review and patterns of use. **Economic Botany**, v.73, p.112-126, 2019. https://doi.org/10.1007/s12231-019-09447-2

EL MERCURIO. 2022. Una "autopista" de especies polinizadoras: Vitacura alista su primer corredor biológico. Available at: <https://www.litoralpress.cl/sitio/Prensa_Texto?LPKey=FOBCQKPP4Y4GPAIJO4LNNS3BFW5CBTH3U4WA7XGD4PG354MYCMGQ> Accessed April 5, 2022.

ELZENGA, J.T.M.; BEKKER, R.M.; PRITCHARD, H.W. Maximising the use of native seeds in restoration projects. **Plant Biology**, v.21, p.377-379, 2019. https://doi.org/10.1111/plb.12984

FIGUEROA, J.A.; CASTRO, S.A.; REYES, M.; TEILLIER, S. Urban park area and age determine the richness of native and exotic plants in parks of a Latin American city: Santiago as a case study. **Urban Ecosystems**, v.21, p.645-655, 2018. https://doi.org/10.1007/s11252-018-0743-0

GARDNER, M.F. The potential for Chilean plants in cultivation. **International Plant Propagators' Society**, v.52, p.285-290, 2001.

GODDARD, M.A.; DOUGILL, A.J.; BENTON, T.G. Scaling up from gardens: biodiversity conservation in urban environments. **Trends in Ecology and Evolution**, v.25, p.90-98, 2010. https://doi.org/10.1016/j.tree.2009.07.016

HARMON-THREATT, A.N.; HENDRIX, S.D. Prairie restorations and bees: The potential ability of seed mixes to foster native bee communities. **Basic and Applied Ecology**, v.16, p.64-72, 2015. https://doi.org/10.1016/j.baae.2014.11.001

LEÓN-LOBOS, P.; BUSTAMANTE-SÁNCHEZ, M.A.; NELSON, C.R.; ALARCÓN, D.; HASBÚN, R.; WAY, M.; PRITCHARD, H.; ARMESTO, J.J. Lack of adequate seed supply is a major bottleneck for effective ecosystem restoration in Chile: Friendly amendment to Bannister et al. (2018). **Restoration Ecology**, v.28, n.2, p.277-281, 2020. https://doi.org/10.1111/rec.13113

LEÓN-LOBOS, P.; ROSAS, M. Estimación del comercio internacional de semillas y plantas nativas de Chile. **Tierra Adentro**, v.89, p.26-28, 2010.

MAXWELL, H.; GARDNER, M. The quest for Chilean green treasure: Some notable British collectors before 1940. **The New Plantsman**, v.4, p.196-214, 1997.

MCKINNEY, M. Urbanization as a major cause of biotic homogenization. **Biological Conservation**, v.127, p.247-260, 2006. https://doi.org/10.1016/j.biocon.2005.09.005

MUÑOZ, A.E.; AMOUROUX, P.; ZAVIEZO, T. Native flowering shrubs promote beneficial insects in avocado orchards**. Agricultural and Forest Entomology**, v.23, p.463-472, 2021b. https://doi.org/10.1111/afe.12447

MUÑOZ, A.E.; PLANTEGENEST, M.; AMOUROUX, P.; ZAVIEZO, T. Native flower strips increase visitation by non-bee insects to avocado flowers and promote yield. **Basic and Applied Ecology**, v.56, p.369-378, 2021a. https://doi.org/10.1016/j.baae.2021.08.015

NOBEL, P.S. **Cacti: Biology and uses.** 1st. ed. California: University of California Press, 2002. p.290.

PARRA-SALDÍVAR, A.; ABADES, S.; CELIS-DIEZ, J.L.; GELCICH, S. Exploring perceived well-being from urban parks: insights from a megacity in Latin America. **Sustainability**, v.12, p.1-14, 2020. https://doi.org/10.3390/su12187586

RODRÍGUEZ, R.; MARTICORENA, C.; ALARCÓN, D.; BAEZA, C.; CAVIERES, L.; FINOT, V.L.; FUENTES, N.; KIESSLING, A.; MIHOC, M.; PAUCHARD, A.; RUIZ, E.; SANCHEZ, P.; MARTICORENA, A. Catálogo de las plantas vasculares de Chile. **Gayana Botánica**, v.75, p.1-430, 2018. http://dx.doi.org/10.4067/S0717-66432018000100001

ROZZI, R. Implications of the biocultural ethic for earth stewardship. In: ROZZI, R.; CHAPIN III, F.S.; CALLICOTT, J.B.; PICKETT, S.T.A.; POWER, M.E.; ARMESTO, J.J.; MAY JR., R.H. (Eds.). **Earth stewardship: linking ecology and ethics in theory and practice**. Dordrecht: Springer International Publishing, 2015. p.13-136.

ROZZI, R.; MASSARDO, F.; SILANDER, J.; DOLLENZ, O.; CONNOLLY, B.; ANDERSON, C.; TURNER, N. Árboles nativos y exóticos en las plazas de Magallanes. **Anales del Instituto de la Patagonia**, v.31, p.27-42, 2003.

SANTILLI, L.; CASTRO, S.A.; FIGUEROA, J.; GUERRERO, N.; RAY, C.; ROMERO-MIERES, M.; ROJAS, G.; LAVANDERO, N. Exotic species predominates in the urban woody flora of central Chile. **Gayana Botánica**, v.75, p.568-588, 2018. http://dx.doi.org/10.4067/S0717-66432018000200568

SOGA, M.; GASTON, K.J. Extinction of experience: The loss of human-nature interactions. **Frontiers in Ecology and the Environment**, v.14, p.94-101, 2016. https://doi.org/10.1002/fee.1225

TEILLIER, S. Plantas de Chile en parques y jardines del mundo. **Chloris Chilensis**, v.11, n.2, 2008.

THE WORLD BANK, 2022 Available at: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?order=wbapi_data_value_2012+wbapi_data_value+wbapi_data_value-last&sort=desc. Accessed on: April 05, 2023.

VARAS, P.; DÍAZ-FORESTIER, J.; CELIS-DIEZ, J.L. Homogenización biótica en la flora leñosa de parques urbanos de la región de Valparaíso. **Revista Geográfica de Valparaíso**, v.57, p.60-72, 2020.

WALLACE, A.R. **The geographical distribution of animals**. London: MacMillan, 1876. 503p