

MSC RESEARCH PROJECT REPORT

BIOLOGY, LEIDEN UNIVERSITY

Sustainability of Wild Plant Extraction on the Dutch Caribbean Island Sint Eustatius

Chantal Posthouwer, 0914703

22 March 2016

MSc specialization: Biology: Evolution, Biodiversity and Conservation

Start date: 14 September 2015/End date: 18 April 2016, 30 EC

Format of report: Economic Botany

Supervisor and contact person

Prof. dr. T. R. van Andel

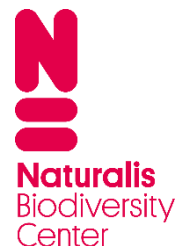
Naturalis Biodiversity Center

Darwinweg 2, 2333 CR Leiden

The Netherlands



Universiteit
Leiden



1 <H1> Sustainability of Wild Plant Extraction on the 2 Dutch Caribbean Island Sint Eustatius.

3 C. Posthouwer ^a

4 ^a Naturalis Biodiversity Center, Leiden University, Darwinweg 4, P.O. Box 9517, 2300 RA Leiden, The Netherlands

5 <H2> Abstract

6 An often overlooked mechanism driving local extinction or scarcity of species is the selective
7 plant extraction by humans. Not much scientific attention has been paid to selective plant
8 harvesting and the use of plants by inhabitants of the former Dutch Antilles. The aim of this
9 study was to make a rapid sustainability assessment of wild plant harvesting on Sint Eustatius.
10 A quantitative plot inventory was done to gather abundancy data on plants in the wild, and 31
11 interviews were conducted to collect information on local names, plant uses, preparation
12 methods and harvesting locations. In total, 181 plant species belonging to 63 different plant
13 families were mentioned as useful by the inhabitants of Sint Eustatius. Of these species, 66
14 were harvested exclusively from wild sources. Several wild species were cultivated in
15 gardens. We found four wild-harvested species (*Melocactus intortus*, *Nectandra coriacea*,
16 *Pilosocereus royenii* and *Chiococca alba*) that may encounter sustainability problems in the
17 future, or might experience them already. From our study we can conclude that for the
18 majority of useful species on Sint Eustatius, plant extraction does not form an immediate
19 threat to their survival.

20

21 Keywords: Ethnobotany, Sint Eustatius, biodiversity, sustainable harvest, conservation

22

23 <H2> 1. Introduction

24 Roughly five percent of the earth's land surface is represented by islands, but their plant
25 endemics comprise about one-fourth of all existent terrestrial plant species (Bramwell &
26 Caujapé-Castells 2011). Together, the Caribbean islands form one of the 25 biodiversity
27 hotspots, meaning it is an area with prodigious concentrations of endemic species, undergoing
28 extreme loss of habitat (Myers et al. 2000). Around 12,000 vascular plant species occur on
29 these islands, of which 7,000 are endemic, while of the original primary vegetation only
30 11.3% remains. The endemic species on islands comprise 2.3% of all global plant species
31 (Myers et al. 2000). Island endemic plants are much more vulnerable to environmental
32 changes in comparison with non-endemic species, due to their usually small population sizes
33 and ranges and generally low genetic diversity (Bramwell & Caujapé-Castells 2011).

34 Recently, 617 vascular plant species were reported for the Dutch Caribbean island Sint
35 Eustatius, of which some were only collected under cultivation. The list of plants excludes
36 strictly ornamental plants that rarely escape from cultivation (Axelrod 2016). There are two
37 endemic species known for the island *Ipomoea sphenophylla* Urb. (Rojer 1997; Axelrod
38 2016) and the recently discovered *Gonolobus aloiensis* Krings & F. S. Axelrod (Krings &
39 Axelrod 2013). In addition, 11 of the vascular plant species that were reported are endemic to
40 the Lesser Antilles (Axelrod 2016). The biodiversity of Sint Eustatius has been greatly
41 disturbed by activities related to agriculture and cattle breeding in the past. At present, the
42 destruction of habitat by industrial development, tourism, pollution and roaming cattle are the
43 most important threats to the biodiversity (Rojer 1997). However, an often overlooked
44 mechanism driving local extinction or scarcity of species is the selective plant extraction by
45 humans (Levis et al. 2012). Not much attention has been paid to plant harvesting by humans
46 and little recent scientific research exist on the use of plants by the inhabitants of the former
47 Dutch Antilles. A biodiversity inventory has been done on the island by STENAPA (Rojer

48 1997), but the latest study on domesticated and useful plants of the Dutch Antilles was done
49 in 1954 (Arnoldo 1954). The last published inventory of medicinal plants stems from 1907
50 (Boldingh 1907). An unpublished list of useful plants was compiled by STENAPA (Stenapa
51 2013), but no research has been done on the sustainability of the harvest of wild useful plants
52 on the island. In order to assess the balance between the gains and losses of plant biodiversity,
53 we need to understand the selective plant extraction by humans. To find out if there are any
54 useful wild plants at risk for overharvesting caused by the selective plant extraction by
55 humans, a sustainability assessment of wild plant harvesting on Sint Eustatius needs to be
56 made. The results of this study can provide useful information for the preservation of local
57 biodiversity; as a base for the conservation and sustainable management of wild useful plants
58 and/or to improve existing management plans. It can also be used to inform local people,
59 tourists and policymakers on the value and vulnerability of the island's plant biodiversity.

60

61 <H3> *Sustainable plant harvesting*

62 In order to make a rapid assessment of the sustainability of wild plant extraction, it is
63 important to define the word sustainable. According to the Oxford Dictionary the definition of
64 sustainable is "Conserving an ecological balance by avoiding depletion of natural resources"
65 (www.oxforddictionaries.com). Another definition of sustainable is given by Peters (1996,
66 82): "From an ecological or management perspective, a truly sustainable system for exploiting
67 non-timber resources is one in which fruits, nuts, latexes, gums and other plant products can
68 be harvested indefinitely from a limited area of forest with negligible impact on the structure
69 and function of the plant populations being exploited". Whether the harvest of a plant species
70 is sustainable or not depends on several factors. For example, the plant part that is harvested
71 can determine the survival of individual plants after harvesting (Van Andel & Havinga 2008,
72 Schmidt et al. 2011). The removal of wood, roots, whole plants or the cutting of bark when

73 ring-barking takes place, will lead to the death of a plant in most cases (Cunningham 1993).
74 The harvest of leaves, fruits or seeds is deemed to be less damaging (Van Andel & Havinga
75 2008), with the exception of intensive pruning, which can affect reproductive performance
76 (Peters 1996; Gaoue and Ticktin 2007). Other important factors for sustainable harvesting are
77 the vegetation type from where plants are collected, their abundance and growth rate. Plants
78 are especially susceptible for overharvesting when they are slow-growing primary forest
79 species that occur in low densities (Peters 1996) or when they are harvested from vulnerable
80 vegetation types such as national parks. Plant species that are harvested from disturbed areas
81 and open, weedy vegetation are less likely to encounter sustainability problems (Van Andel &
82 Havinga 2008). The harvest of cultivated or domesticated plants can be considered
83 sustainable, since they depend on humans for their reproduction. Species that are endemic to
84 Sint Eustatius or to a few Caribbean islands are more likely to encounter sustainability
85 problems, as they have a very narrow distribution. The harvest of plants listed on the
86 International Union for Conservation of Nature Red List (www.iucnredlist.org) and the
87 Convention on International Trade of Endangered Species list (www.checklist.cites.org) is
88 considered to be not sustainable in any case.

89

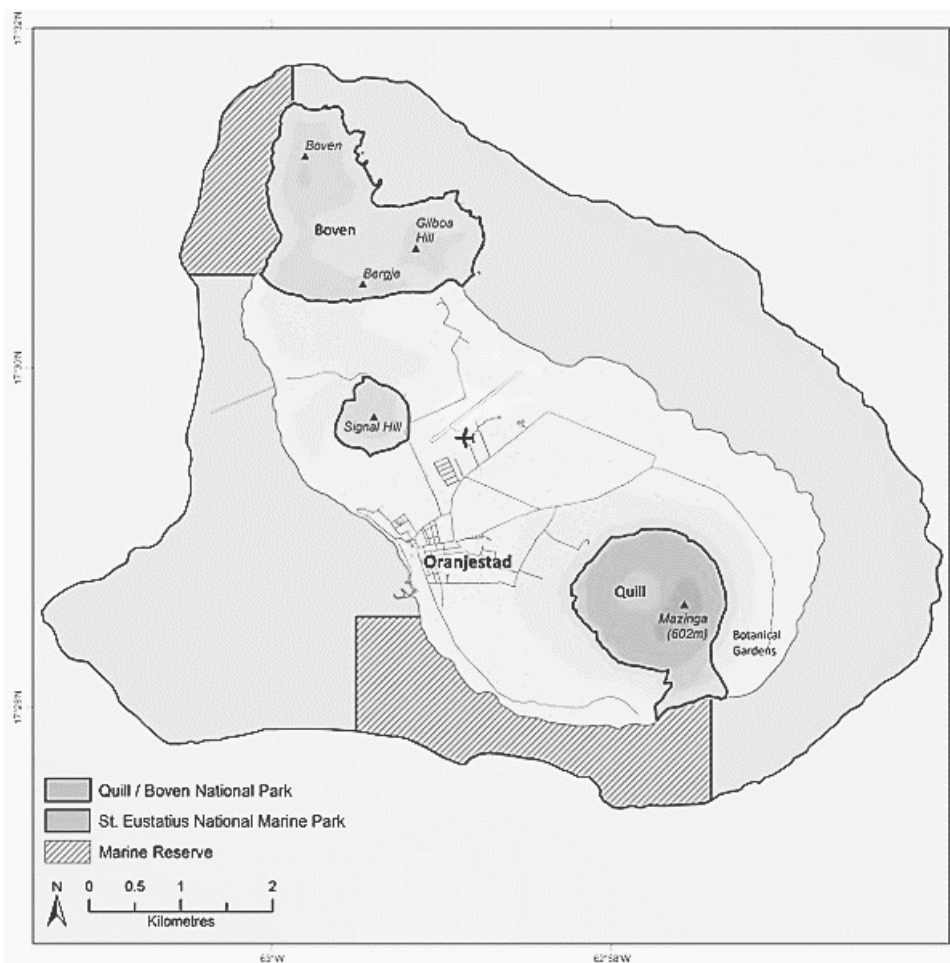
90 <H3> *Research questions and aim of study*

91 To make a rapid sustainability assessment of wild plant harvesting on Sint Eustatius, we need
92 to answer the following research questions: 1) What wild plant species are mentioned as
93 useful plants by the inhabitants of Sint Eustatius?; 2) Are there species mentioned that are
94 listed on the Convention on International Trade of Endangered Species (CITES) Appendices or on
95 the Red List of Threatened Species of the International Union for Conservation of Nature
96 (IUCN)?; 3) How are these plants harvested?; 4) Are useful plants harvested from vulnerable
97 vegetation types?; 5) How abundant are these plants in their natural habitat?

98 <H2> 2. Methods

99 <H3> 2.1. Study area

100 Fieldwork was conducted on Sint Eustatius, a Dutch Caribbean island with a surface area of
 101 21 km². Sint Eustatius is of volcanic origin and can roughly be divided into three different
 102 landscapes: the Mountains (or Boven) in the northwest, occupied for a large part by an oil
 103 transshipment company, the Cultuurvlakte in the flat centre; and the south-eastern part with the
 104 Quill volcano (Rojer 1997). A little more than a quarter of the island's land area is
 105 internationally recognized as a national park (www.statiapark.org^a). Figure 1 shows the
 106 protected areas of Sint Eustatius. On 31 December 2014, Sint Eustatius held a population of
 107 almost 3,900 people (www.statline.cbs.nl).



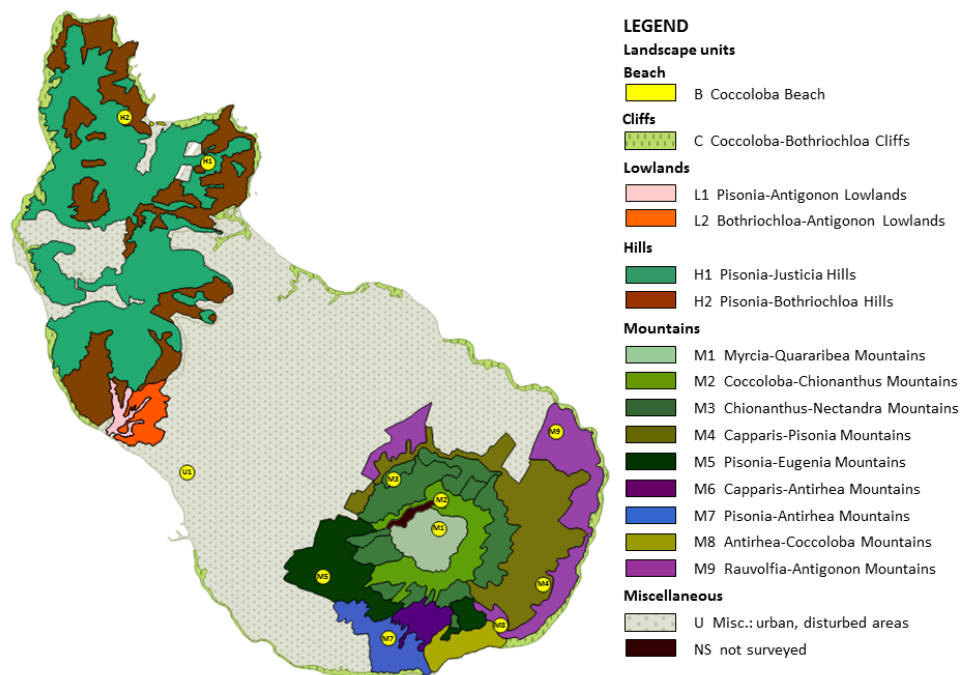
108

109 Figure 1. Map of Sint Eustatius showing its protected areas (Adapted from

110 www.dcnanature.org)

111 <H3> 2.2. *Fieldwork – Quantitative plot inventory*

112 Fieldwork was carried out between 3 October and 16 November. In the first two weeks on
113 Sint Eustatius, a quantitative plot inventory was conducted as part of the course Tropical
114 Biodiversity and Field Methods given at Leiden University (www.studiegids.leidenuniv.nl).
115 To obtain abundance data of higher plant species in several vegetation types, 11 plots of 25 x
116 25 m in different vegetation types were surveyed. In each plot, all trees and lianas with a
117 diameter at breast height (DBH) of ≥ 10 cm were counted. We also estimated their height and
118 measured their diameter. Inside the plot, a smaller area of 5 x 5 m was marked in which all
119 shrubs, lianas and tree saplings higher than 1.5 m with a DBH < 10 cm were counted. In
120 addition, an area of 1 x 1 m was marked inside each plot, where we counted all seedlings and
121 herbs <1.50 m. Plants were collected by using standard botanical methods (Martin 2004) for
122 later identification, excluding CITES-listed species (see
123 <https://www.cites.org/eng/app/appendices.php>), which were identified by means of
124 photographs. Plot locations were chosen randomly and cover 11 different vegetation types
125 present on the island. A map showing plot locations and vegetation types is shown in Figure
126 2. A more detailed description of the plot inventory, including exact plot coordinates and
127 explanations of the vegetation codes will be published by Van Andel et al. (2016).



128

129 Figure 2. Map of Sint Eustatius showing plot locations and different vegetation types. Map
 130 made by Jeremy Miller (Naturalis Biodiversity Center), based on the vegetation map of De
 131 Freitas et al. (2012).

132

133 <H3> 2.3. Fieldwork - Interviews

134 An interview was prepared with questions related to wild plant harvesting (Appendix I) and a
 135 list of key informants was compiled, based on suggestions by staff members of STENAPA
 136 and islanders themselves. After the quantitative vegetation study and becoming acquainted
 137 with most wild plant species on the island, interviews were conducted. The interviews were
 138 conducted together with Thomas Verheijden (Verheijden et al. 2016). We started by asking
 139 what local people knew about the use of wild plants on the island, local names, uses, where
 140 they were harvested, how they were prepared, how often they were used and whether they
 141 were difficult to find. We continued by asking the respondents if they knew other people that
 142 used plants. In this way we tried to cover wild plant use by using a representative sample of
 143 key persons on the island by means of snowball sampling. All plants mentioned during

144 interviews were collected and processed into herbarium vouchers and shipped to the
145 herbarium of Naturalis Biodiversity Center (L) in the Netherlands for further identification.
146 Additional information on the use of plants was obtained during the plot inventory, from an
147 unpublished list of STENAPA (Stenapa 2013) and from the Statia Cookbook (Gilmore et al.
148 2007).

149

150 <H3> 2.4. Data analysis

151 The herbarium vouchers processed in the field were identified in the Naturalis Herbarium (L)
152 by using literature (Arnoldo 1954; Boldingh 1907; Boldingh 1913; Hawthorne et al. 2004;
153 Van Proosdij 2001; Stoffers 1962-1984) and comparing them to earlier collected herbarium
154 specimens from the Caribbean region. All scientific names were checked with The Plant List
155 (see www.theplantlist.org). After identification, the sustainability of the harvest of wild plants
156 was assessed. To select species with possible sustainability problems, we produced a list of all
157 harvested plant species on the island. From this comprehensive list, we removed all species
158 that were either domesticated or cultivated. From the list with exclusively wild-harvested
159 plants we removed all plants that were weedy or abundant in disturbed vegetation types. This
160 was determined by means of literature (Hammerton & Fournet 1991; Van der Burg et al.
161 2012; Wiersema & Léon 2013) and own observations in the field. Further, we extracted the
162 plant species that occurred only in the protected areas and calculated their abundance figures
163 by using species abundance data obtained during our plot inventory. After calculating the
164 abundance figures of risk species, and taking our own field observations into consideration,
165 the species were separated into two categories: rare and abundant. Based on the plant parts
166 harvested and harvesting methods, we also determined whether or not the harvesting was
167 possibly destructive. Finally, we came up with a shortlist of wild-harvested plants that may
168 encounter sustainability problems in the future. Plants that occurred on the CITES appendices

169 or on the IUCN Red List of Threatened Species were also short-listed and their abundance
170 figures were calculated.

171
172 The importance of wild-harvested plant species to the local inhabitants was calculated as
173 number of use reports and citation frequency. The number of use reports is calculated as all
174 applications and/or preparations for one species. For example, the root of *Chiococca alba* is
175 used as a male aphrodisiac, it can be soaked in rum or boiled with green peas. It is also used
176 as an ingredient for health tonics, which are good for men. Therefore, the number of use
177 reports for this species is three. The citation frequency is calculated by counting the number
178 of interviews where the species is mentioned. The use of *C. alba*, for example, was mentioned
179 by seven different informants; therefore, the citation frequency of this species is seven. The
180 citation frequency including other sources is also calculated.

181

182 <H3> 2.5. Ethics

183 During this research, we followed the Code of Ethics of the International Society of
184 Ethnobiology (www.ethnobiology.net). We explained the nature of our research to all
185 informants before starting the interview and recorded their oral consent on a tape recorder.
186 We also asked permission to tape the interview and when the informants did not give their
187 permission we respected their decision and stopped recording. All informants received a small
188 financial compensation for their participation in this study.

189

190 <H2> 3. Results

191 <H3> 3.1 Floristic diversity

192 In total we conducted 31 interviews (18 males and 12 females, mean age \pm 59 years) of which
193 one interview was with a group. During our interviews, a total of 181 plant species were

194 mentioned as useful. These plants belonged to 63 different families. Of these plants we were
 195 able to identify 171 to species level, seven to genus level and one only to family level. We
 196 were unable to collect two species. These plants were excluded from most of our analyses due
 197 to a lack of information. The plants that we were unable to identify were sent for DNA
 198 analysis, but these results will be published elsewhere. A complete list with all useful plant
 199 species, scientific and local names and their uses, can be found in Appendix II.

200

201 Table 1 shows, the most important wild-harvested plant species, based on their citation
 202 frequency and number of use reports.

203

204 Table. 1. Most important wild-harvested plant species to the local inhabitants.

Species	Citation frequency (including other sources*)	Use reports	Abundanc y Category
<i>Jatropha gossypifolia</i>	18	13	Abundant
<i>Senna occidentalis</i>	17	8	Abundant
<i>Hymenaea courbaril</i>	16	1	Rare
<i>Lantana camara</i>	12	5	Abundant
<i>Croton flavens</i>	10	10	Abundant
<i>Phyllanthus amarus</i>	10	9	Abundant
<i>Lantana involucrata</i>	10	3	Abundant
<i>Bursera simaruba</i>	9 (10 ¹)	5	Abundant
<i>Opuntia dillenii</i>	7 (10 ²)	2	Rare
<i>Datura inoxia</i>	9	1	Abundant
<i>Antigonon leptopus</i>	8 (9 ¹)	6	Abundant
<i>Solanum bahamense</i>	8	5	Abundant
<i>Momordica charantia</i>	7 (8 ¹)	8	Abundant
<i>Catharanthus roseus</i>	7 (8 ³)	4	Abundant

205 * Other sources: ¹ Stenapa 2013; ² W. Hellebrand, pers. comm.; ³ Anonymous informant, pers.

206 comm.; Gilmore et al. 2007; ³ W. Hellebrand, pers. comm.

207 <H3> 3.2. CITES or IUCN listed species

208 In Table 2, wild-harvested species from Sint Eustatius that are on the CITES Appendices are
 209 listed. Five useful Cactaceae species were listed on CITES Appendix II, and none of them
 210 were found to be abundant during our plot inventory. Individuals of *Opuntia ficus-indica* were
 211 harvested from wild sources as well as from cultivated sources. Apart from the cacti, one
 212 Euphorbiaceae species, *Euphorbia lactea*, was listed on CITES Appendix II. Cultivated
 213 varieties are not included in these lists. On Sint Eustatius, however, *E. lactea* is a non-
 214 indigenous ornamental (Debrot & Boman 2012) that has escaped from cultivation and is very
 215 abundant. The harvest of this plant can therefore be considered sustainable. The harvest of the
 216 five species belonging to the Cactaceae family, however, needs attention, as all species are
 217 considered rare on the island. Especially *O. dillenii* needs to be monitored, since it ranked in
 218 the top five plants with the highest citation frequency (see Table 1).

219

220 Table. 2. Species on the CITES Appendices.

Family	Species	Appendix	Abundance category
Cactaceae	<i>Opuntia dillenii</i>	II	Rare
Cactaceae	<i>Melocactus intortus</i>	II	Rare
Cactaceae	<i>Hylocereus trigonus</i>	II	Rare
Cactaceae	<i>Pilosocereus royenii</i>	II	Rare
Cactaceae	<i>Opuntia ficus-indica</i> *	II	Rare
Euphorbiaceae	<i>Euphorbia lactea</i>	II**	Abundant

221 *Also found cultivated ** Except cultivated varieties

222

223 As shown in Table 3, we found four useful wild-harvested species that are on the IUCN Red
 224 List of Threatened Species. They were categorized as ‘Least Concern’. This means that,
 225 according to IUCN, these plants do not need special attention in terms of conservation.
 226 However, *Hylocereus trigonus* is also on CITES Appendix II and considered rare on Sint

227 Eustatius. In addition, *Hymenaea courbaril* and *Chiococca alba* are both considered rare on
 228 Sint Eustatius and occur only in the National Park. These species do need attention from
 229 conservationists (see Table 4) even though they are categorized as ‘Least Concern’ by IUCN.
 230 *Mimosa pudica* is a weed and considered to be abundant on the island. The harvest of this
 231 species is considered sustainable.

232

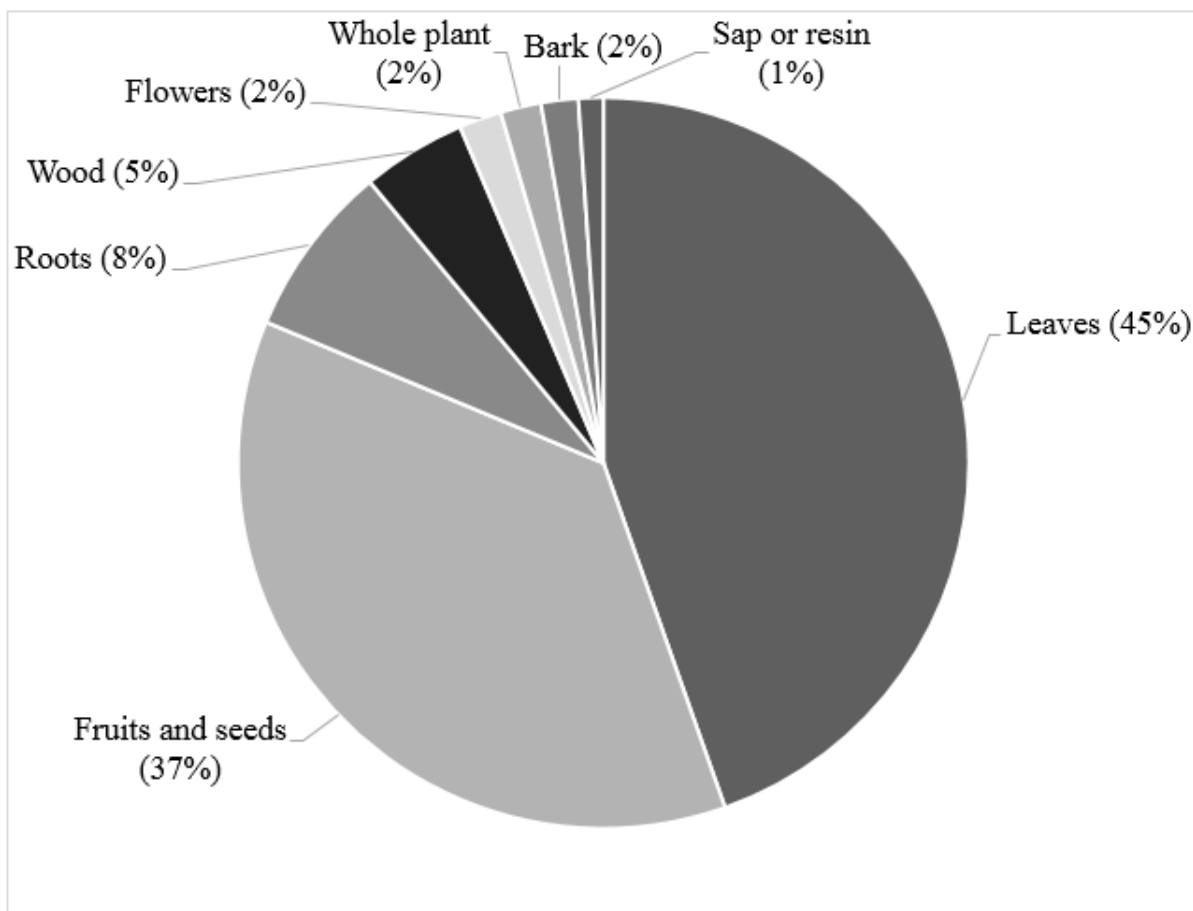
233 Table. 3. Species on the IUCN Red List of Threatened Species.

Family	Species	IUCN status	Abundance category
Cactaceae	<i>Hylocereus trigonus</i>	Least Concern Ver. 3.1	Rare
Fabaceae	<i>Hymenaea courbaril</i>	Least Concern Ver. 3.1	Rare
Fabaceae	<i>Mimosa pudica</i>	Least Concern Ver. 3.1	Abundant
Rubiaceae	<i>Chiococca alba</i>	Least Concern Ver. 3.1	Rare

234

235 <H3> 3.3. Plant parts used

236 Figure 3 shows which plant parts are used by the inhabitants of Sint Eustatius. Leaves are
 237 used almost half of the time, which is sustainable in most cases. Fruits and seeds are the
 238 second most used plant parts. The use of fruits and seeds is also sustainable in general. Roots
 239 come third. Since the plant needs to be uprooted in order to cut them, the harvest of roots is
 240 usually unsustainable.



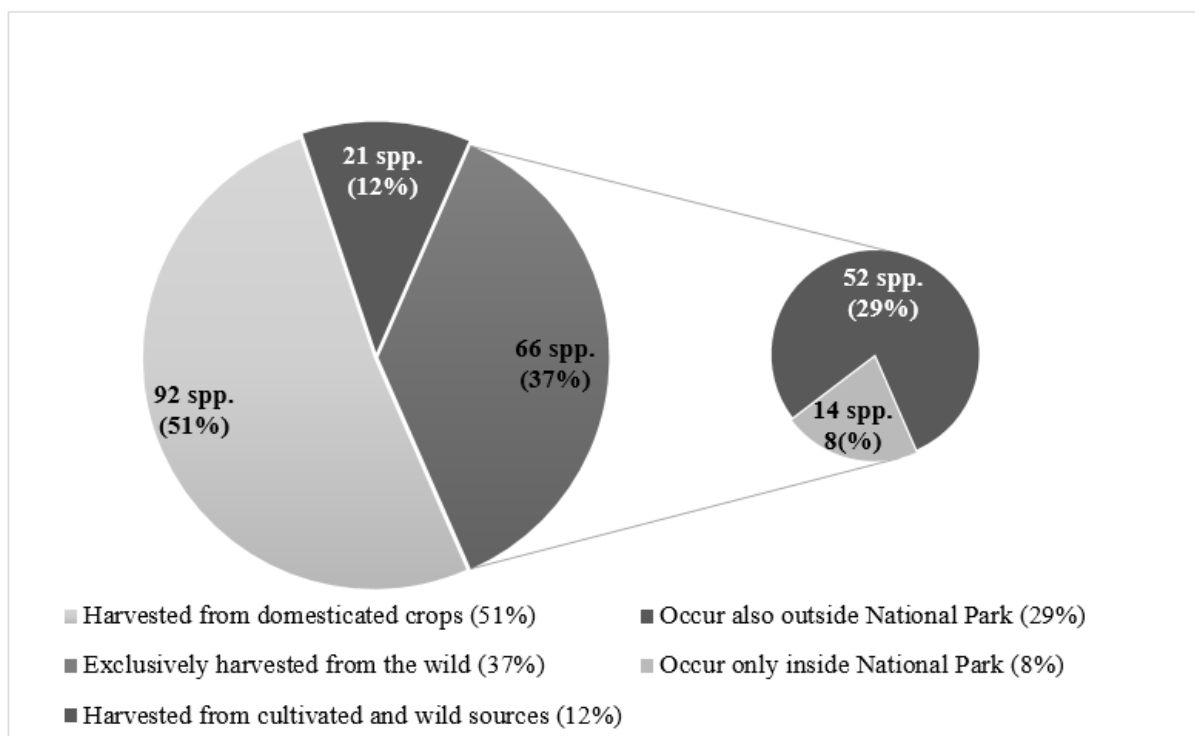
241

242 Figure 3. Percentages of plant parts harvested by the inhabitants of Sint Eustatius.

243

244 <H3> 3.4. Sustainability of wild plant harvesting

245 Figure 4 shows the sources from which useful plants are harvested by the inhabitants of Sint
 246 Eustatius. A little more than half of all useful plants were domesticated species. The other half
 247 were harvested from wild or cultivated sources. In total, only 8% of the total number of useful
 248 species occurred exclusively in protected areas. These are the plant species that need to be
 249 focussed on in further sustainability studies.



250

251 Figure 4. Sources of useful plants.

252

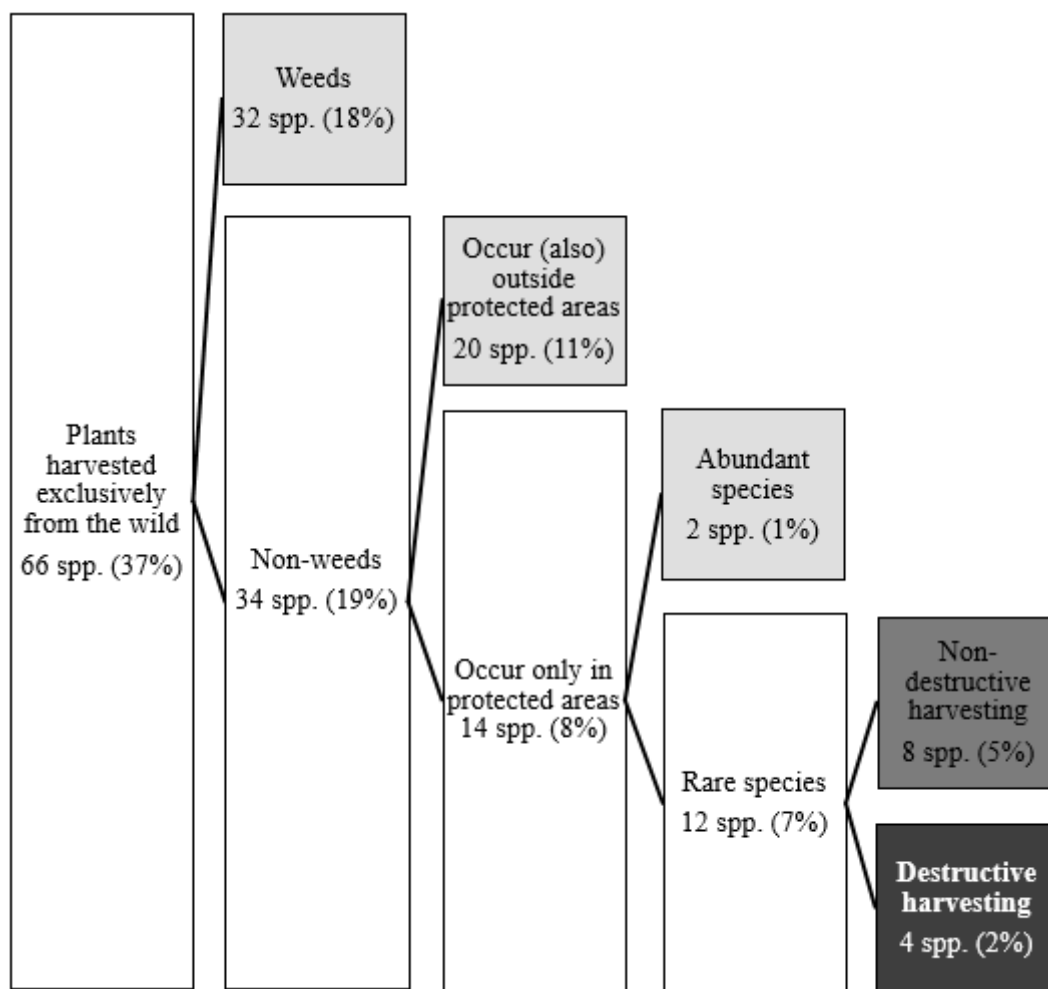
253 Figure 5 shows our sustainability assessment of wild-harvested plants. Almost half of all

254 wild-harvested plants were weeds and were excluded from our analyses. Of all non-weeds, 14

255 species occurred only in the National Park. Of this shortlist of 14 species, less than half were

256 harvested in a way that they may encounter sustainability problems at present or in the future

257 (Table 4). The rare species will be discussed in more detail below.



258

259 Figure 5. Sustainability of wild-harvested plants. Percentages refer to the proportion of this

260 category of the total number of useful plants recorded during this study.

261 Table 4. Rare wild-harvested species of Sint Eustatius.

Species	Plant part harvested	Destructive/ non-destructive	Plot no.
<i>Anthurium grandifolium</i>	Leaves	Destructive	Not in plot
<i>Melocactus intortus</i>	Whole plant; Fruits	Destructive	Not in plot
<i>Nectandra coriacea</i>	Roots	Destructive	Not in plot
<i>Pilosocereus royenii</i>	Whole plant	Destructive	Not in plot
<i>Chiococca alba</i>	Roots	Destructive	Not in plot
<i>Cecropia schreberiana</i>	Leaves; Young shoots	Non-destructive	M1
<i>Eugenia ligustrina</i>	Fruits	Non-destructive	H1
<i>Ficus citrifolia</i>	Roots	Non-destructive	M2; M3; M4
<i>Hylocereus trigonus</i>	Fruits	Non-destructive	Not in plot
<i>Hymenaea courbaril</i>	Fruits	Non-destructive	Not in plot
<i>Tragia volubilis</i>	Leaves	Non-destructive	Not in plot
<i>Varronia nesophila</i>	Leaves	Non-destructive	Not in plot

262
263 *Anthurium grandifolium* was called ‘Monkey tail’ by the local people, because its spike
264 resembles a monkey tail. The leaves of *A. grandifolium* were picked fresh and used in dry
265 periods as fodder. Since the leaves are intensively pruned, the plant is harvested in a destructive
266 way. The plant only occurs on the Quill (Axelrod 2016). No individuals were counted during
267 our plot inventory, so the species is not abundant. However, this plant species was mainly used
268 in the past, so we do not expect immediate sustainability problems for *A. grandifolium*.

269
270 *Melocactus intortus* (‘Pope head’) is listed on CITES appendix II and therefore legally
271 protected. The red fruit is eaten and the inner flesh of the stem is fermented to make an alcoholic
272 drink. Since the plant is harvested in a destructive way, and we did not count any individuals
273 during our plot inventory, it is already rare and may encounter sustainability problems in the
274 future when continuously harvested. The species grows in the Boven area and at Fort de Windt
275 (Boldingh 1909; Axelrod 2016; www.statiapark.org^b).

276

277 The tree *Nectandra coriacea*, locally called ‘Kakanga root’, grows only on the Quill (Axelrod
278 2016). We observed one of our informants chopping down a sapling, so he could dig up the
279 roots. An extraction of the root is soaked in hot water, and spices or sugar are added to enhance
280 the flavour. This is drunk as a beverage and as a power boost for male stamina. The plant is
281 harvested in a destructive way and we did not count any individuals during our plot inventory.
282 Given its rarity and the popularity of home-made aphrodisiacs on the island, the species may
283 encounter sustainability problems from current harvesting practices.

284

285 *Pilosocereus royenii* (‘Organ pipe cactus’) grows in the Quill area (Axelrod 2016) and is listed
286 on CITES appendix II and legally protected. The stem is soaked in water and drunk to ‘cool the
287 blood’ or used as a shampoo to make dreadlocks grow long. A piece of cactus is cut from the
288 plant and only the inside flesh is used. Since the harvesting method can be destructive and no
289 individuals were counted during the plot inventory, the species may experience sustainability
290 problems now or in the future.

291

292 The liana *Chiococca alba* (also called ‘Kakanga root’ or ‘Buck root’) grows in the Boven and
293 Quill area (Axelrod 2016). The root is soaked in alcohol or boiled with green peanuts and drunk
294 or eaten as a male aphrodisiac and general health tonics. The harvest of the root is not
295 necessarily destructive, since an informant told us that when he digs up the root he only takes
296 a small piece so the plant is able to survive. Even though one person does not harvest it
297 destructively it is possible that other people do. The plant was only locally abundant in the Quill
298 National Park and was not counted during our plot inventory. In addition, *C. alba* is a popular
299 ingredient in aphrodisiacs throughout the Caribbean (Van Andel et al. 2012). For these reasons,
300 the species may encounter sustainability problems in the future.

301

302 The pioneer tree *Cecropia schreberiana*, locally called ‘Trumpet tree’, grows on the floor of
303 the crater in the Quill (Axelrod 2016). A tea is made from the terminal shoots and young leaves
304 and drunk against high blood pressure. Only one individual was counted in plot M1 during the
305 plot inventory. Even though the plant is rare on the island, the harvesting method is non-
306 destructive, and hence we don’t expect immediate sustainability problems. *Cecropia* trees
307 quickly colonize gaps in the rainforest, and a significant amount of this tree can be found along
308 the inaccessible vertical walls of the Quill crater.

309

310 *Eugenia ligustrina* is locally called ‘Blackberry’ and occurs in both the Boven and Quill area
311 (Axelrod 2016). The fruits of this plant are eaten fresh or made into juice. Only one shrub
312 appeared in plot H1 during our plot inventory. The harvesting method is non-destructive, and
313 even though the plant is rare on the island, we do not expect immediate sustainability problems.

314

315 *Ficus citrifolia*, locally called ‘Ficus’, occurs only in the Quill area. The dried aerial roots are
316 used for craft, design and decoration. The species is locally abundant, as only a few individuals
317 were counted during our plot inventory in plot M2, M3 and M4. Even though the species is
318 only locally abundant, it is harvested non-destructively and only mentioned by one informant.
319 For this reason, we do not expect immediate sustainability problems.

320

321 The climbing cactus *Hylocereus trigonus* (local name: ‘Strawberry’ or ‘Dragon fruit’) only
322 occurs in a few patches halfway the Quill volcano and in the Boven area. It is listed on CITES
323 appendix II and legally protected. The fruits are eaten fresh. Since the harvesting method is
324 non-destructive, we do not expect immediate sustainability problems. However, the species is
325 rare on Sint Eustatius and already protected. Therefore, its harvest should be monitored.

326

327 *Hymenaea courbaril* locally called ‘Stinking toe’ is a tree that was only observed occasionally
328 on the lower slopes of the Quill volcano. The pulp from the fruit is eaten raw. During our
329 interviews it appeared that the plant was mainly used in the past and younger people did not
330 like the taste of it. In addition, only the fruits were harvested non-destructively. Even though
331 the tree is rare, we do not expect immediate sustainability problems.

332

333 The vine *Tragia volubilis* (‘Stinging nettle’ or ‘Poison ivy’) occurs in both the Boven and Quill
334 area (Axelrod 2016). The leaves are made into a tea that is drunk to prevent cancer. Even though
335 the plant is rare on Sint Eustatius, the leaves are harvested non-destructively, and thus we do
336 not expect immediate sustainability problems.

337

338 *Varronia nesophila*, locally called ‘Bastard tobacco’ occurs in both the Boven and Quill area
339 (Axelrod 2016). The leaves are made into a tea, which is drunk against a ‘European cold’; a
340 cold that people get when they visit cold countries. Further, the leaves are sometimes smoked
341 as a substitution for marihuana. According to one of the informants, smoking the leaves
342 makes your head spin badly. The harvesting method is non-destructive, and even though the
343 plant is rare on the island, we do not expect immediate sustainability problems.

344

345 <H3> 3.6. *Useful species not harvested on Sint Eustatius.*

346 Not all useful species we heard during our interviews were harvested exclusively on Sint
347 Eustatius. *Hibiscus sabdariffa*, used to make the drink called ‘Sorrel’, is cultivated on Sint
348 Eustatius but the dried calices are also imported from Jamaica. The seaweed *Chrysomenia*
349 *ventricosa*, used to make a drink called ‘Sea moss’, is collected on other islands. The
350 specimen we collected and identified was harvested from Jamaica according to our informant.
351 Another informant told us that he harvests his seaweed from the shallow reefs of St. Kitts. As

352 *C. ventricosa* was not collected on Sint Eustatius, it was not included in our data analyses.
353 Sorrel, however, was included in our data analyses as it was also grown occasionally on Sint
354 Eustatius.

355

356 <H2> 4. Discussion and conclusions

357 <H3> 4.1. Sustainability of wild-harvested plants of Sint Eustatius

358 The aim of this study was to make a rapid sustainability assessment of wild plant harvesting
359 on Sint Eustatius. In total, 181 plant species were mentioned to be useful by the inhabitants of
360 Sint Eustatius. Of these species, 66 were harvested from exclusively wild sources. During our
361 study we found four wild-harvested species (*M. intortus*, *N. coriacea*, *P. royenii* and *C. alba*),
362 that may encounter sustainability problems in the near future and should be priority species
363 for monitoring. We found five species belonging to the Cactaceae family that are all on
364 CITES appendix II, of which three are harvested destructively. As these species are already
365 protected, but still harvested, they should all be monitored. As our study was a rapid
366 sustainability assessment, these data are only an indication for the sustainability of wild plant
367 harvesting on Sint Eustatius. For detailed information on the destructive effects of the harvest
368 of these plants, experimental and quantitative research is needed.

369

370 According to Verheijden et al. (2016), a much higher number of different plant uses was
371 reported in 2015 than was documented in literature on plant use on Sint Eustatius. However,
372 some informants mentioned during the interviews that plant use on Sint Eustatius was
373 decreasing. They indicated that many local people on the island stopped using plants or used
374 less plant species than before. According to them, people on the island were lazy, they did not
375 want to walk up the volcano to harvest plants anymore, and they had money to buy food at the

376 supermarket or go to the doctor when they were ill. In addition, some wild plants, such as
377 *Pimenta racemosa* ('Cinnamon bush'), were found cultivated in gardens, so harvesting from
378 wild sources is not necessary anymore. They also mentioned that the younger generation was
379 not interested in traditional plant use, and thus knowledge on plant use was disappearing.

380

381 <H3> 4.2. Cactus problem

382 'Miss Blyden', historically known as a specialty of Sint Eustatius, was a popular Christmas
383 drink on the island (Gilmore et al. 2007). The drink was made from the fruits of *Opuntia*
384 *dillenii*. According to the Statia Cookbook, the fruits of *Consolea rubescens* (Salm-Dyck ex
385 DC.) Lem. were also used to make the drink. However, 'Sorrel', a drink made from the
386 calices of *Hibiscus sabdariffa*, is becoming the new Christmas drink of Sint Eustatius.

387 According to one of our informants, the *Opuntia* drink has become rare decades ago because a
388 virus attacked the plants and there are no fruits available on the island anymore. This virus is
389 probably not a virus, but could be the moth *Cactoblastis cactorum*. The larvae of this moth,
390 which was released as a biological pest control on different islands in the Caribbean region,
391 feed on several *Opuntia* species in their native region (Zimmerman et al. 2001). A study on
392 the control and persistence of native *Opuntia* on Nevis and St. Kitts found that *C. cactorum*
393 has been successful in their biological control of weedy *Opuntia* species, but that they did not
394 cause their extinction (Pemberton & Liu 2007). To find out if it was the larvae that caused the
395 decline in the amount of individuals of *Opuntia*, or the harvest of the fruits, more research is
396 needed. In any case, a cultural tradition is disappearing and the cacti should be monitored.

397

398 <H3> 4.3. Possible risks of wild plant harvesting on surrounding islands.

399 From our study we can conclude that the current plant extraction on Sint Eustatius does not
400 form a threat to the great majority of plant species. If wild plant use is indeed disappearing on

401 the island, plant extraction will become even less of a problem on the island. However, there
402 is a lot of traveling between the Caribbean islands. Plants with the same local names as on
403 Sint Eustatius, such as ‘Kakanga root’, ‘White root’ and ‘Mauby’, are used on other
404 Caribbean islands too (Van Andel et al. 2012; www.stcroixsource.com; www.snwmf.com;
405 www.foodandtravel.me). The root of *Chiococca alba* (‘Kakanga root’) is used in Cuba as an
406 aphrodisiac in a drink called ‘Bois Bandé’. If those plants become scarce on other islands,
407 people might look for substitutions on surrounding islands and the Sint Eustatius resources
408 may attract their attention. In that case, future harvesting of wild plants might become a
409 problem.

410

411 <H2> 5. Acknowledgements

412 We are grateful to the Naturalis Biodiversity Center for partly funding the plot inventory and
413 to the foundations Alberta Mennega Stichting and Van Eeden-fonds for providing part of the
414 funding of this research without additional involvement. We would like to thank our
415 informants for giving their time and knowledge for this study, and field guides Ambrosius van
416 Zanten and Celford Gibbs for their help. We would also like to thank Franklin Axelrod of the
417 Puerto Rico herbarium (UPR) for identifying our most difficult plants collected during the
418 plot inventory. Thanks to all other students of the course Tropical Biodiversity and Field
419 Methods and Prof. dr. Tinde van Andel for contributing in collecting and identifying the
420 specimens during the plot inventory. Fieldwork was facilitated by the Caribbean Netherlands
421 Science Institute (CNSI) and Hannah Madden (STENAPA).

<H2> References

- 422 Arnoldo, M. 1954. Gekweekte en Nuttige Planten van de Nederlandse Antillen.
423 Natuurwetenschappelijke Werkgroep Nederlandse Antillen Curacao, Willemstad.
- 424 Axelrod, F.S. 2016. A SYSTEMATIC VADEMECUM TO THE VASCULAR PLANTS OF
425 SINT EUSTATIUS. Manuscript in preparation.
- 426 Boldingh, I. 1907. Lijst van planten, die door de bewoners van de drie Nederlandsche
427 Antillen, St. Eustatius, Saba en St. Martin als geneeskrachtig worden beschouwd. J.H.
428 De Bussy, Amsterdam.
- 429 Boldingh, I. 1909. The flora of the Dutch West Indian islands St. Eustatius, Saba and St.
430 Martin. Brill, Leyden.
- 431 Boldingh, I. 1913. Flora voor de Nederlandsch West-Indische eilanden. De Bussy and KIT,
432 Amsterdam.
- 433 Bramwell, D., Caujapé-Castells, J. 2011. The Biology of Island Floras. Cambridge University
434 Press, Cambridge.
- 435 Cunningham, A.B. 1993. African medicinal plants: setting priorities at the interface between
436 conservation and primary health care. People and Plants working paper 1. UNESCO,
437 Paris.
- 438 De Freitas, J.A., Rojer, A.C., Nijhof, B.S.J., Debrot, A.O. 2012. A landscape ecological
439 vegetation map of Sint Eustatius (Lesser Antilles). IMARES Wageningen UR, Den
440 Helder.

- 441 Debrot, A.O., Boman, E. 2012. The Lesser Antillean Iguana on St. Eustatius: 2012 status
442 update and review of limiting factors. IMARES Wageningen UR, Den Helder.
- 443 Gaoue, O.G., Ticktin, T. 2007. Impacts of bark and foliage harvest on *Khaya senegalensis*
444 (*Meliaceae*) reproductive performance in Benin. *J. Appl. Ecol.* 45, 34–40.
445 doi:10.1111/j.1365-2664.2007.01381.x
- 446 Gilmore, J., Boulton, J., Kennedy, L. & Brown, M. (eds). 2007. *The Statia Cookbook*. St.
447 Eustatius Historical Foundation, Oranjestad.
- 448 Hammerton, J.L., Fournet, J. 1991. *Weeds of the lesser Antilles/Mauvaises herbes des petites*
449 *Antilles*. Institut National de la Recherche Agronomique, Paris.
- 450 Hawthorne, W.D., Jules, D., Marcelle, G. 2004. *Caribbean Spice Island Plants*. Oxford
451 Forestry Institute, Oxford.
- 452 Krings, A., Axelrod, F.S. 2013. *Gonolobus aloiensis* (*Apocynaceae*, *Asclepiadoideae*), a New
453 Species from St. Eustatius. *Syst. Bot.* 38, 1132–1137. doi:10.1600/036364413X674904
- 454 Levis, C., De Souza, P.F., Schiatti, J., Emilio, T., Purri da Veigna Pinto, J.L., Clement, C.R.,
455 Costa, F.R.C. 2012. Historical Human Footprint on Modern Tree Species Composition in
456 the Purus-Madeira Interfluve, Central Amazonia. *PLoS One* 7, e48559.
457 doi:10.1371/journal.pone.0048559
- 458 Martin, G.J. 2004. *Ethnobotany: A Methods Manual*. Earthscan, London.
- 459 Myers, N., Mittermeier, R.A., Mittermeier, C.G., Da Fonseca, G.A.B., Kent, J. 2000.
460 Biodiversity hotspots for conservation priorities. *Nature* 403, 853–8.
461 doi:10.1038/35002501

- 462 Pemberton, R.W., Liu, H. 2007. Control and persistence of native *Opuntia* on Nevis and St.
463 Kitts 50 years after the introduction of *Cactoblastis cactorum*. *Biol. Control* 41, 272–
464 282. doi:10.1016/j.biocontrol.2007.02.002
- 465 Peters, C. 1996. The ecology and management of non-timber resources. World Bank
466 Technical Paper 322, Washington, DC.
- 467 Rojer, A. 1997. Biological Inventory of Sint Eustatius. KNAP project 96-10, Carmabi
468 Foundation.
- 469 Schmidt, I.B., Mandle, L., Ticktin, T., Gaoue, O.G. 2011. What do matrix population models
470 reveal about the sustainability of non-timber forest product harvest? *J. Appl. Ecol.* 48,
471 815–826. doi:10.1111/j.1365-2664.2011.01999.x
- 472 Stenapa. 2013. Unpublished list of useful plants on Sint Eustatius.
- 473 Stoffers, A.L. 1962-1984. Flora of the Netherlands Antilles. *Natuurhistorische Studiekring*
474 *Suriname en de Nederlandse Antillen*, Utrecht.
- 475 Van Andel, T., Havinga, R. 2008. Sustainability aspects of commercial medicinal plant
476 harvesting in Suriname. *For. Ecol. Manage.* 256, 1540–1545.
477 doi:10.1016/j.foreco.2008.06.031
- 478 Van Andel, T., Mitchell, S., Volpato, G., Vandebroek, I., Swier, J., Ruyschaert, S., Rentería
479 Jiménez, C.A., Raes, N. 2012. In search of the perfect aphrodisiac: Parallel use of bitter
480 tonics in West Africa and the Caribbean. *J. Ethnopharmacol.* 143, 840–850.
481 doi:10.1016/j.jep.2012.08.008

- 482 Van Andel, T., Van der Hoorn, B., Stech, M., Bantjes Arostegui, S., Miller, J. 2016. A
483 quantitative assessment of the vegetation types on the island of St. Eustatius, Dutch
484 Caribbean. Manuscript submitted for publication.
- 485 Van der Burg, W.J., De Freitas, J., Debrot, A.O., Lotz, L.A.P. 2012. Naturalised and invasive
486 alien plant species in the Caribbean Netherlands: status, distribution, threats, priorities
487 and recommendations. Imares/Carmabi/PRI, Wageningen.
- 488 Van Proosdij, A.S.J. 2001. Arnoldo's Zakflora. Wat in het wild groeit en bloeit op Aruba,
489 Bonaire en Curacao. Natuurwetenschappelijke studiekering voor het caraïbisch gebied,
490 Amsterdam.
- 491 Verheijden, T.M.S. 2016. Ethnobotanical knowledge loss on the Caribbean island of St.
492 Eustatius. Bachelor's thesis. Naturalis Biodiversity Center, Leiden.
- 493 Wiersema, J.H., León, B. 2013. World Economic Plants: A Standard Reference, Second
494 Edition. CRC Press, Boca Raton.
- 495 www.checklist.cites.org. n.d. Convention on International Trade in Endangered Species of
496 Wild Fauna and Flora.
497 http://checklist.cites.org/#/en/search/country_ids%5B%5D=33&output_layout=alphabetical&level_of_listing=0&show_synonyms=1&show_author=1&show_english=1&show_spanish=1&show_french=1&scientific_name=&page=1&per_page=20 (24-12-15).
- 500 [www.dcnanature.org](http://www.dcnanature.org/st-eustatius-national-marine-park/). 2014. Dutch Caribbean Nature Alliance. [http://www.dcnanature.org/st-](http://www.dcnanature.org/st-eustatius-national-marine-park/)
501 [eustatius-national-marine-park/](http://www.dcnanature.org/st-eustatius-national-marine-park/) (18-1-2016).
- 502 www.ethnobiology.net. 2006. International Society of Ethnobiology Code of Ethics.
503 <http://ethnobiology.net/code-of-ethics/> (18-7-15).

- 504 [www.foodandtravel.me](http://www.foodandtravel.me/kitt-caboodle/). 2015. <http://www.foodandtravel.me/kitt-caboodle/> (7-3-2016).
- 505 www.iucnredlist.org. 2015-4. International Union for the Conservation of Nature Red List of
506 Threatened Species. <http://www.iucnredlist.org/> (24-12-15).
- 507 www.oxforddictionaries.com. n.d.
508 <http://www.oxforddictionaries.com/definition/english/sustainable> (15-2-16).
- 509 www.snwmf.com. 2006. Body is your temple thread.
510 <http://snwmf.com/phorum/read.php?1,81454,107520> (3-7-16).
- 511 www.statiapark.org^a. n.d. Sint Eustatius National Parks.
512 <http://www.statiapark.org/parks/index.html> (18-1-2016).
- 513 www.statiapark.org^b. n.d. Sint Eustatius National Parks.
514 <http://www.statiapark.org/parks/boven/index.html> (15-2-2016)
- 515 www.statline.cbs.nl. 2015. Centraal Bureau voor de Statistiek.
516 <http://statline.cbs.nl/StatWeb/publication/?VW=T&DM=SLNL&PA=80539NED&D1=a>
517 [&D2=a&D3=a&HD=131008-1146&HDR=T&STB=G1,G2](http://statline.cbs.nl/StatWeb/publication/?VW=T&DM=SLNL&PA=80539NED&D1=a&D2=a&D3=a&HD=131008-1146&HDR=T&STB=G1,G2) (24-2-16).
- 518 www.stcroixsource.com. 2004. UVI St. Croix Promotes World Food Day.
519 <http://stcroixsource.com/content/news/local-news/2004/10/17/uvi-st-croix-promotes->
520 [world-food-day](http://stcroixsource.com/content/news/local-news/2004/10/17/uvi-st-croix-promotes-world-food-day) (7-3-2016).
- 521 www.studiegids.leidenuniv.nl. 2015.
522 <https://studiegids.leidenuniv.nl/courses/show/47241/tropical-biology-in-borneo> (14-9-
523 2015)

- 524 Zimmermann, H. G., Moran, V. C., & Hoffmann, J. H. 2001. The Renowned Cactus Moth,
525 *Cactoblastis cactorum* (Lepidoptera: Pyralidae): Its Natural History and Threat to Native
526 *Opuntia* Floras in Mexico and the United States of America. The Florida
527 Entomologist, 84(4), 543–551. <http://doi.org/10.2307/3496386>

<H2> Appendix I – Interview

Date:

Interviewer:

Informant:

Locality:

1. Where were you born?
2. What is your age?
3. Gender:
4. Which ethnicity do you belong to? (Black, white, mixed)
5. Do you collect plants in the bush? (Outside the garden, from Quill? Boven?) *Like wild sage / Kakanga root / Cinnamon bush / Locust, sea grape, cactus*
6. I) Local name II) Plant part III) Preparation, IV) Application (explain illness) V) Where harvested: garden or wild? Wild: Where? VI) If wild, Is it difficult to find? VII) Do you use this wild plant often, how often?
7. If not, do you ask others to bring it to you?
8. Who taught you about bush medicine and plants?
9. Do you know of plants that people used in the past, but not anymore?
I) Local name II) Plant part III) Preparation, IV) Application (explain illness) V) Where harvested: garden or wild? Wild: Where? VI) If wild, Is it difficult to find? VII) Do you use this wild plant often, how often? VIII) Why not used anymore?
10. Do you use, or do you know anyone that uses pope head (show picture of *Melocactus*), Guinea corn (show picture of *Sorghum bicolor*) or *Hymenaea courbaril* (show the fruit)?
11. Do you know if people on the island sell cactuses or orchids?
12. Can you show us your garden? *Collect all plants that are used and we don't know.*

<H2> Appendix II – Species database

The species database will be published online (URL)

<H2> Appendix III – List of figures and tables

<H3> *List of figures*

1. Map of Sint Eustatius showing it's protected areas.
2. Map of Sint Eustatius showing plot locations and different vegetation types.
3. Percentages of plant parts harvested by the inhabitants of Sint Eustatius.
4. Sources of useful plants.
5. Sustainability of wild-harvested plants.

<H3> *List of tables*

1. Most important wild-harvested plant species.
2. Species on the CITES Appendices.
3. Species on the IUCN Red List of Threatened Species.
4. Rare wild-harvested species of Sint Eustatius.