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# 1 Pre-assessments of plant conservation status in islands: 2 the case of French Overseas Territories

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54 that were used to conduct this study.

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## 62 **Abstract**

63 Assessment methods have been developed to estimate a preliminary conservation status for  
64 species and subsequently to facilitate the building of Red Lists. Such pre-assessment methods  
65 could be particularly useful in the French Overseas Territories (FOTs) where Red Lists tend  
66 to be out-dated or absent and where a high number of endemic species face detrimental  
67 anthropogenic pressures. We first aimed to conduct a preliminary assessment (hereafter, pre-  
68 assessment) of the conservation status of endemic plants from Guadeloupe, Martinique,  
69 Réunion, Mayotte, French sub-Antarctic islands, New Caledonia, and Scattered Islands. We  
70 then compared the various methods used in conducting the pre-assessment and discussed  
71 ways to adapt these methods to small territories. We compiled occurrence data of endemic  
72 species identified thanks to a previous taxonomic work and pre-assessed their conservation  
73 status under Red List criteria A and B and the use of a Random Forest algorithm. We then  
74 measured the accuracy, specificity, and sensitivity of each method based on existing Red  
75 Lists. The Random Forest algorithm and a method based on range-size performed best at  
76 correctly attributing conservation status. Using these pre-assessment methods, we estimated  
77 that up to 60% of the endemic flora of the FOTs is potentially threatened. Range restriction  
78 but also anthropogenic pressures were key factors that explained these risks. Pre-assessment  
79 methods are useful tools to get a first measure of species conservation status. These methods  
80 should be adapted to the territories considered and their conservation issues in order to reach a  
81 good performance.

82 **Keywords:** Red List, pre-assessments, islands, tracheophytes, French overseas territories,  
83 endemics

84

## 85 **1. Introduction**

86 Plants are the dominant kingdom in terms of Earth biomass, representing around 82% (c.a.  
87 450Gt), and represent around 370 000 species (Bar-On et al. 2018; Roskov et al. 2019,  
88 Freiberg et al. 2020). Plants are essential to the functioning of ecosystems and provide  
89 invaluable services to humanity. Yet, almost 22% of vascular plants may be threatened with  
90 extinction, although only 14% of them have had their conservation status assessed at the  
91 global scale (Brummitt et al. 2015; IUCN Red List version 2022-2). The conservation status  
92 of species is essential for the prioritization of conservation actions and one of the tools  
93 designed for this purpose is the Red List of threatened species of the International Union for  
94 Conservation of Nature (IUCN) (Mace et al. 2008). The IUCN Red List is the world's most  
95 commonly used system for gauging the extinction risk faced by species. It is based on criteria

96 and data to assess for each species: i. a population decline (criterion A); ii. a reduced range  
97 (criterion B); iii. a small population and decline (criterion C); iv. a very small population  
98 (criterion D); and/or v. a quantitative analysis of the risk of extinction (criterion E) (IUCN  
99 2012). These criteria are used to assign a threat category to each species. The Red List allows  
100 to consistently document the conservation status of species, to identify areas in need of special  
101 protection, to support conservation actions and policies, and to monitor the changing state of  
102 biodiversity on Earth (Rodrigues et al. 2006).

103 Assessing the conservation status of a species is a time-consuming and costly process that  
104 requires extensive studies on the taxonomy and chorology of species, monitoring the changes  
105 of populations and threats in a territory, mobilizing and training a large number of experts,  
106 conducting dedicated workshops, processing data and publishing results, among other tasks  
107 (UICN France 2018). It therefore proves impractical to assess and regularly update the status  
108 of every plant species on the planet, especially as new species are described every day (on  
109 average 2 400 annually in the last 10 years [IPNI 2021]). In addition, existing plant  
110 assessments have not accumulated on the Red List in a systematic way due to different types  
111 of biases. For example, more attention is paid to plant species expected to be threatened, so  
112 that species that may be secure are under-evaluated (Bachman et al. 2019). To overcome these  
113 difficulties, methods and tools for preliminary conservation assessments (hereafter, pre-  
114 assessments) have been developed to support and speed up the evaluation of the conservation  
115 status of species while following standards close to those used in the Red List framework (e.g.  
116 Stévant et al. 2019; Bachman et al. 2020). Although an assessment following Red List  
117 standards is necessary to know the genuine conservation status of a species as defined by the  
118 IUCN, such pre-assessment methods have been used for comprehensive analyses of potential  
119 extinction risks of the flora of Puerto Rico (Miller et al. 2012), Hawaii (Krupnick et al. 2009),  
120 the Lesser Antilles (Carrington et al. 2017), and Greece (Kougioumoutzis et al. 2021).

121 Automatic pre-assessment methods have therefore a high potential to assist Red List  
122 assessments (Cazalis et al. 2022).

123 In this study we focus on selected French overseas territories (FOTs) and aim to pre-assess the  
124 conservation status of their endemic flora. According to existing regional Red Lists (New  
125 Caledonia, French Polynesia, Guadeloupe, Martinique, Réunion, Mayotte), more than half of  
126 the seed plants endemic to the FOTs could be threatened with extinction, of which nearly 1/3  
127 have been assessed as critically endangered (Véron et al. 2021). This figure remains high in  
128 ferns and lycophytes since 37% of endemic species are threatened with extinction (Véron et  
129 al. 2021). However, there is still a large number of species whose conservation status is  
130 unknown or out-of-date and no longer corresponds to the current conservation status of the  
131 taxon. The stakes are high since nearly 4 000 species of tracheophytes are endemic to the  
132 FOTs (Véron et al. 2021), of which 10 are part of biodiversity hotspots (Myers et al. 2000). In  
133 these territories, plant taxa face a vast array of threats, such as deforestation, invasive species,  
134 changes in land use, fires, tourism, mining activities or climate change (e.g. UICN France et  
135 al. 2014, Meyer et al. 2021). With the exception of French Guiana and Adélie Land, FOTs are  
136 islands, and species found in insular territories are likely more vulnerable to anthropogenic  
137 pressures than continental species (Russell and Kueffer 2019). Thus, the proportion of  
138 threatened endemic plants is higher in the FOTs than in metropolitan France and even higher  
139 than on a global scale (Nic Lughadha et al. 2020; Véron et al. 2021).

140 The application of pre-assessment methods to the endemic flora of the FOTs is an important  
141 contribution to conservation actions in these territories. These pre-assessments compile  
142 baseline data for future actions and these new data could support future Red Lists. The  
143 numerous botanical field collecting campaigns carried out for several centuries in the overseas  
144 territories, the study of herbaria specimens and their digitization, the existence of national and

145 regional taxonomic repositories, recent inventories and participatory sciences are all assets  
146 allowing for the analysis of these pre-evaluations. The detailed knowledge of the flora of  
147 certain, but not all, territories and the existence of recent Red Lists (e.g. New Caledonia)  
148 make it possible to test the performance of these methods and their bias in order to improve  
149 upon them. Knowledge of island characteristics, biogeography, environmental pressures,  
150 collecting efforts, conservation issues and available floristic data in the overseas territories  
151 means that factors that have not yet been taken into account can be tested to analyze the  
152 performance of pre-assessments methods globally. The objectives of this study are therefore  
153 to:

- 154 1) Pre-assess the conservation status of the endemic flora of selected FOTs, in  
155 particular for Not Evaluated species;
- 156 2) Compare the performance of four assessment methods to correctly predict IUCN  
157 Red List conservation status while considering factors absent from previous  
158 studies;

159

## 160 **2. Method**

### 161 2.1. Compiling and cleaning data

162 The first step of this study was to compile occurrence data of strict endemic and regional  
163 endemic plant species (see definition in Supplementary Information 1) of Réunion, Mayotte,  
164 Guadeloupe, Martinique, Scattered Islands, French sub-Antarctic Islands and New Caledonia.  
165 We focused on these FOTs due to conservation issues for endemic plants and data availability  
166 (Supplementary Information 1). To select endemic species we used the French national  
167 taxonomic repository TAXREF (Gargominy et al. 2021) and a recent checklist of the FOTs

168 endemic plants (Véron et al. 2021). Only species records within the geographic boundary of  
169 the FOTs were used in the analysis. The main data sources included local inventory datasets  
170 (e.g. <https://mascarine.cbnm.org/>; Carrington et al. 2018), the National inventory of natural  
171 heritage – the official data source of French National Red Lists - (INPN; MNHN and OFB  
172 2021), the Global Biodiversity Information Facility (GBIF), the collections of the Paris  
173 herbarium (P) along with the ones of the FOTs herbaria (e.g., GUAD, MTK, REU, MAO,  
174 NOU) and other international herbaria (e.g., K, MO, G) (all data sources are in Table 1). In  
175 total we compiled occurrence records for 3 545 taxa, i.e. 89% of endemic tracheophytes in the  
176 FOTs (Véron et al. 2021). Some studies proposed to use only data freely available on the web  
177 (GBIF, BIEN etc.), yet this would lead to inaccurate results for the FOTs because they are  
178 incomplete and/or not precise enough (all specimen data are not in GBIF, many sensitive data  
179 have had their coordinates approximated etc.).

180 Within these compiled datasets (one for each territory), a comparison was made between the  
181 names of the species and the French national taxonomic repository TAXREF (Gargominy et  
182 al. 2021). The spelling of the names of the taxa present in these datasets was compared to the  
183 names present in TAXREF and corrected when necessary. Only taxa considered endemic or  
184 subendemic in TAXREF and in the Endemia repository for New-Caledonia were kept. The  
185 names in the datasets that are considered synonyms in TAXREF were changed to their  
186 accepted names. We kept occurrences at the species and infra-specific levels because: *i.* data  
187 often allow the identification of taxa below the species level, *ii.* Red Lists can accommodate  
188 infra-specific taxa, *iii.* many taxa are endemic at the infra-specific but not the specific level  
189 (see Supplementary Information 2 for results of a complementary analysis at the specific  
190 level). It was also necessary to filter the data by removing duplicate occurrences, and by  
191 removing or correcting erroneous coordinates (especially occurrences in the sea or at the  
192 center of the territory).

193 Many occurrences had locality information but were not georeferenced. However, pre-  
194 assessments of IUCN status mostly require spatial coordinates for each collected specimen.  
195 When necessary, we therefore created locality indexes (i.e. we attributed spatial coordinates to  
196 locality names found on herbarium labels) mainly with the help of botanical experts of the  
197 FOTs who have a comprehensive knowledge of these islands and their botanical collections.  
198 This made it possible to *post-facto* assign longitude, latitude, and uncertainties on the  
199 coordinates for places in Martinique, Guadeloupe, Réunion, New Caledonia, and the French  
200 sub-Antarctic Islands. Walker et al. (2022) showed that minimal data-cleaning performed well  
201 in the context of automated assessments and that excluding uncertain data would considerably  
202 reduce the coverage of automatic assessments. Thus, we preferred to keep most of uncertain  
203 data, although we excluded the ones that mentioned a locality that was too vague (e.g.  
204 “Guadeloupe”). Moreover, we estimated whether coordinate uncertainty was higher or lower  
205 than 2 km, which is the size of the grid cell recommended to estimate species Area of  
206 Occupancy (IUCN 2012). We then ran an analysis on the influence of uncertain coordinates  
207 on our results (see section 2.3 and Supplementary Information 2). However, we acknowledge  
208 that coordinates and uncertainties estimations were often subjective. In total we compiled ca.  
209 255 000 georeferenced occurrences of FOTs endemic taxa. Regarding the Scattered Islands  
210 we directly extracted range distribution data from Hivert et al. (2018) who estimated species  
211 conservation status based on criteria that were adapted from the Red List criteria due to the  
212 very small size of the territory and conservation management purposes.

## 213 2.2.Preliminary Conservation Assessments (objective 1)

214 Pre-assessments are conducted with available data and aim to overcome the difficulty (or  
215 impossibility) to exactly reproduce the IUCN approach and standards automatically. To allow  
216 approaching the potential threats status of species, these methods sometimes deviate from

217 IUCN criteria and sub-criteria, but instead use variables related to extinction risks which  
218 make them highly performant (e.g. Stévant et al. 2019, see also Discussion). Here, we used  
219 four successful methods developed in the literature to assign pre-assessment conservation  
220 statuses to endemic tracheophytes of the FOTs (Fig. 1). We adapted these methods to each  
221 territory according to its geographic characteristics and data availability (table 1).

222 i) Criterion B, considering jointly criteria B1a, B2a, B1b, B2b

223 • Criteria B1a and B2a

224 This method calculates the Area Of Occupancy (AOO), Extent Of Occurrence (EOO) and the  
225 number of locations for each species based on georeferenced data (IUCN 2012). The EOO  
226 provides information on the overall geographical distribution while the AOO provides  
227 information on the area occupied by a species (see detailed definition in IUCN 2012). A  
228 location is "a particular area from the ecological and geographical point of view in which a  
229 single threatening event can rapidly affect all individuals of the taxon present". AOO, EOO  
230 and number of locations allows pre-assessment using criteria B1a and B2a according to  
231 Dauby et al. (2017). We used the R package "ConR" and the default options of the  
232 "IUCN.eval" function, although sometimes adapted to the geographical characteristics of the  
233 territory (Table 1). Thus, the AOO was calculated using a 2km\*2km grid whose origin varies  
234 over a given number of iterations and we retained the minimum value of the AOO over all  
235 iterations (see other methods in Moat et al. (2018)). For a trade-off between efficiency and  
236 speed, we chose to vary the grid origin 20 times. For the identification of locations, and due to  
237 the difficulty of complying with the definition stated above using automatic methods, a  
238 location was defined as a 10km\*10km or 5km\*5km grid cell encompassing the largest  
239 possible number of occurrences (Table 1). Nevertheless, we performed a sensitivity analysis  
240 to estimate the influence of grid size on our results (Supplementary Information 2). We did

241 not assess fragmentation as no methods exist to automatically do so. The thresholds of EOO,  
242 AOO and number of locations used to pre-assess the category of a taxon were generally those  
243 defined by the IUCN (IUCN 2012), except for very small islands. Indeed, IUCN thresholds to  
244 assess extinction risk assessments do not always comply with management objectives in very  
245 small territories and it is therefore not recommended to use the IUCN standards there. New  
246 thresholds were therefore defined for the Scattered islands, Crozet, Saint-Paul and Amsterdam  
247 (islands of the French sub-Antarctic islands) at both local/single island and regional scales  
248 following Hivert et al. (2018) (Supplementary Information 3). These adaptations do not allow  
249 measuring a genuine IUCN conservation status but they are useful for conservation  
250 management issues in small territories.

251 • Criteria B1b and B2b

252 This method is adapted from Carrington et al. (2017) and aims to pre-assess a continuing  
253 population decline, i.e. criteria B1b and B2b. It is used to estimate a decline in one of the  
254 following elements relative to a reference year:

- 255 - the AOO of a taxon estimated using the ConR package (Dauby et al. 2017);
- 256 - habitat quality by assessing the proportion of occurrence of a taxon outside any  
257 protected areas (as defined in [protectedplanet.net](http://protectedplanet.net) and assuming that protected  
258 areas prevent population declines). A potential decline is estimated for this  
259 criterion when half of the occurrences are outside the protected areas;
- 260 - the number of locations (Dauby et al. 2017);
- 261 - the proportion of yearly observations for a taxon. We chose to estimate the  
262 changes of the proportion of individuals rather than the number of individuals in  
263 order to roughly take into account sampling differences between years.

264

265 However, we acknowledge the difficulty of estimating a continuous decline using automatic  
266 methods, the often 'opportunistic' data available, and the differences in sampling in time and  
267 space (see below how this limitation was taken into account in the analysis of method  
268 performance). We chose 2010 as the reference year assuming that this conforms to the IUCN  
269 recommendations to estimate a continuous decline (IUCN 2012) and that a 10 year period  
270 should ideally be used to estimate the state of a species (UICN France 2018). Yet, as the  
271 IUCN guidelines do not recommend a specific threshold to estimate a continuous decline, we  
272 also conducted additional analyses by choosing the reference year as the median year of  
273 collection for each territory (Supplementary Information 2). Finally, the reference year does  
274 not influence the binary classification of species as “threatened” or “non-threatened” (see  
275 below).

276 The joint analysis of the pre-assessments of sub-criteria B1a, B2a, B1b, B2b, i.e. based on  
277 AOO, EOO, number of locations and population decline, makes it possible to estimate  
278 criterion B following the IUCN analysis grid (see IUCN 2012) and attribute a status Critically  
279 Endangered (CR), Endangered (EN), Vulnerable (VU) or Near-Threatened or Least-Concern  
280 (NT or LC) to species. The expertise of experienced botanists is indispensable to estimate  
281 sub-criterion c) [extreme fluctuations] and, to our knowledge, it is not assessable using  
282 automatic methods, so it was not considered in this study.

## 283 ii) Criterion A

284 The purpose of this method is to estimate the decline of a population based on the proportion  
285 of the AOO of each species that intersects a degraded area (Stévant et al. 2019). Indeed, the  
286 decline of a population can be inferred from habitat losses according to the IUCN (IUCN  
287 2012). We identified degraded areas based on land cover data (e.g. Bossard et al. 2000),  
288 evolution of land cover (Bossard et al. 2000) and on pressure maps specific to each territory  
289 (e.g. loss of forest cover, fire frequency, invasive species) (Table 1). A raster map combining

290 all these degraded areas was built for each territory and was used to calculate a potential  
291 decline in the AOO as defined by Stévant et al. (2019). Following Stévant et al. (2019)  
292 method, a species is pre-assessed CR, EN or VU if more than 80%, 70% or 50% of its AOO  
293 intersects degraded areas, respectively.

294           iii)     Criteria A, B

295 This third methodological approach attributes a conservation status corresponding to the most  
296 threatened status between criterion A and criterion B. Used jointly, criteria A and B are  
297 similar to the PACA method of Stévant et al. (2019), with the difference that the potential  
298 decline of a population (criteria B1b and B2b) is estimated differently: by the presence in a  
299 degraded habitat according to Stévant et al. (2019), by the comparison to a reference year in  
300 our study. Yet, the former option was tested in Supplementary Information 2. In addition,  
301 when we did not observe any decline for a taxon but the ConR algorithm (criterion B1a and  
302 B2a) classified the species in a threat category based on the EOO, the AOO and the number of  
303 locations, we followed the method of Stévant et al. (2019) and defined the categories "likely  
304 rare" (CR or EN according to ConR but without observed decline) and "potentially rare" (VU  
305 according to ConR but without observed decline). The classification "likely rare" is analogous  
306 to the VU category under criterion D2 (i.e. restricted area of occupancy or number of  
307 locations with a plausible future threat that could drive the taxon to CR or EX in a very short  
308 time). Conversely, a taxon pre-assessed LC or NT based on its AOO or EOO but facing a  
309 decline was classified as "LC or NT, potential decline".

310

311           iv)     Random Forest (Breiman 2001) – no defined criteria

312 Random Forest is a machine learning method particularly suitable for pre-assessments of  
313 extinction risks (Bland et al. 2015; Pelletier et al. 2018; Walker et al. 2022). Here we used the

314 "Random Forest" algorithm to classify endemic plants in a conservation status category, the  
315 predictors being the variables used for criteria B (AOO, EOO, number of locations, decline in  
316 one of the variables indicated in point *i.*, proportion of occurrence within a protected area) and  
317 A (proportion of the AOO degraded for each pressure taken individually and for all pressure  
318 layers combined). We also estimated the importance of these variables on IUCN Red List  
319 statuses by calculating the Importance of Gini according to the Random Forest algorithm  
320 (Supplementary Information 4; Breiman 2001). The model parameters for each territory were  
321 adjusted to achieve the best possible performance. The model was trained and evaluated  
322 across the entire dataset of taxa having an IUCN status (excluding Data Deficient [DD] and  
323 Not Evaluated [NE] taxa), as recommended by Walker et al. (2022) whose results "favor  
324 using all assessed species" for training, "even when well-designed sub-samples are available".  
325 We then used the classification trees generated in order to estimate a pre-status for DD and  
326 NE taxa.

327 We also explored another machine learning method, the neural network approach from (Zizka  
328 et al. 2020), using similar predictors (Supplementary Information 2).

329

330 Pre-assessments were performed with the R software (R Core Team 2020) and scripts are  
331 available online at [https://github.com/arthur-b-1303/Projet\\_Fentom](https://github.com/arthur-b-1303/Projet_Fentom)

332 **Table 1:** Data used for each territory. Criterion B parameters vary between territories in order to reach the best performance possible for this  
 333 pre-assessment method. CLC=Corinne Land Cover (Bossard et al. 2000)

	<b>Main sources of species records</b>	<b>Number of occurrence records compiled</b>	<b>Median age of records</b>	<b>Pre-assessed endemic species</b>	<b>Anthropogenic pressures (criterion A)</b>	<b>Criterion B parameters</b>
<b>New Caledonia</b>	Endemia and RLA Flore NC 2019; ERMINES project (for ultramafic substrates); Herbaria P and NOU; Other international herbaria; INPN; GBIF	126 329 records including 121 657 georeferenced	1978	2 591 (out of 2 758 endemic species)	Urban and agricultural environments (Gouvernement de la Nouvelle-Calédonie 2014); Loss of forest cover (Hansen et al. 2013); Fires (OEIL 2021); Active mines (Gouvernement de la Nouvelle-Calédonie 2014)	AOO, EOO according to recommendations of (IUCN 2012)  Number of locations = 10km*10km square grid
<b>Réunion</b>	Mascarine; Herbarium REU; Herbarium P; INPN; GBIF	102 406 records including 102 208 georeferenced	2010	413 (out of 489 endemic species)	Urban and agricultural environments (Bossard et al. 2000); Land use change 2012-2018 (Bossard et al. 2000); loss of forest cover (Hansen et al. 2013); invasive species (Fenouillas et al. 2021)	AOO, EOO (IUCN 2012)  Number of locations = 10km*10km square grid
<b>Mayotte</b>	Mascarine; Herbarium MAO; Herbarium P; INPN; GBIF	7 178 records including 7	2012	117 (out of 124 endemic)	Urban and agricultural	AOO [EOO not considered] (IUCN

		088 georeferenced		species)	environments (Bossard et al. 2000); Land use change 2012-2018 (Bossard et al. 2000); loss of forest cover (Hansen et al. 2013)	2012) Number of locations = 5km*5km square grid
<b>Martinique</b>	CBN Martinique; Herbarium MTK; Herbarium P; Dataset in Carrington et al. (2017); INPN; GBIF	4 514 records including 3640 georeferenced	1945	183 (out of 221 endemic species)	Urban and agricultural environments (Bossard et al. 2000); Land use change 2012-2018 (Bossard et al. 2000); loss of forest cover (Hansen et al. 2013)	AOO, EOO (IUCN 2012) Number of locations = 10km*10km square grid
<b>Guadeloupe</b>	Gwada Botanica ( <a href="https://www.gwadabotanica.fr/">https://www.gwadabotanica.fr/</a> ); Herbarium GUAD; Herbarium P; Dataset in Carrington et al. (2017); INPN; GBIF	8 551 records including 7 985 georeferenced	1981	187 (out of 206 endemic species)	Urban and agricultural environments (Bossard et al. 2000); Land use change 2012-2018 (Bossard et al. 2000); loss of forest cover (Hansen et al. 2013)	AOO, EOO (IUCN 2012) Number of locations = 5km*5km square grid
<b>French sub- Antarctic islands (Kerguelen, Crozet, Saint- Paul,</b>	National Nature Reserve of the French sub-Antarctic Islands; Project IPEV 136 Subanteco; GBIF; Herbarium P.	12 652 records of which 12 372 geolocated	2017	16 (out of 15 endemic species + 2 patrimonial species)	Not assessed	<u>Kerguelen</u> : AOO, EOO (IUCN 2012)  Number of locations = 10km*10km square

Amsterdam)						<p>grid</p> <p><u>Saint Paul, Amsterdam, Crozet</u>          AOO, 100m*100m square grid, Number of locations = 100m*100m square grid.</p> <p>CR = <math>\leq 0.5\%</math> of grid cells; EN = <math>\leq 3.5\%</math>; VU = <math>\leq 7.5\%</math></p>
Scattered Islands (Europa, Glorioso, Juan de Nova, Tromelin)	Conservatoire Botanique National Mascarin (Hivert et al. 2018)	Hivert et al. (2018)	Hivert et al. (2018)	38 (out of 38 endemic species)	Not assessed	<p>AOO, 100m*100m square grid. CR = <math>\leq 0,35</math> to <math>0,96\%</math> of grid cells; EN = <math>\leq 2,88</math> to <math>3,5\%</math>; VU = <math>\leq 6,73</math> to <math>7,48\%</math>.</p> <p>Besides , different thresholds are used to estimate extinction risks at local and regional scales (see Hivert et al. 2018)</p> <p>Number of locations = number of islands</p>

334 \* Occurrence records include preserved specimens, living specimens, observations, photographs, and material samples

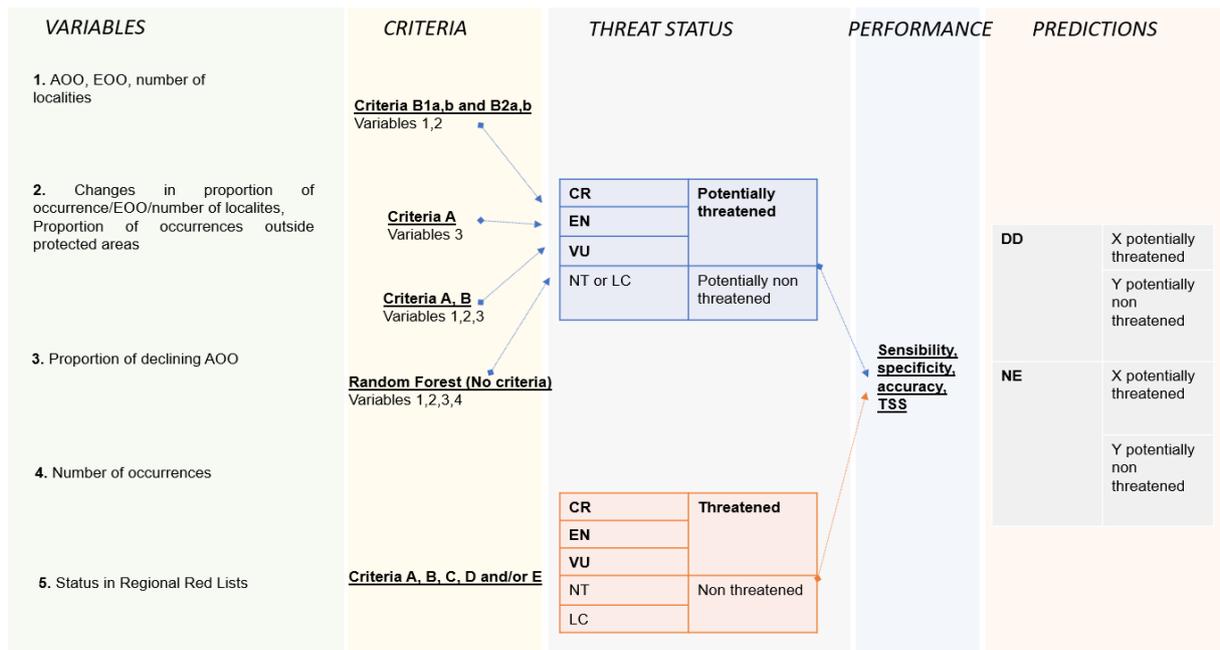
335

336 2.3. Method performance and potential changes in conservation status (objective 2)

337 Following the pre-assessment of conservation statuses, we aimed to test the effectiveness and  
338 limitations of each method (Fig. 1).

339 For each method we compared existing IUCN statuses to the pre-assessed ones. We assessed  
340 each status independently (Supplementary Information 5 and 6) and then classified the species  
341 as potentially threatened (CR, EN, VU) or non-threatened (LC or NT). In addition, we  
342 adopted a precautionary approach and considered 'likely rare' and 'potentially rare' species as  
343 threatened because of the similarity of these categories to the VU status under criterion D2.  
344 We then analyzed the proportion of species that 1) remained threatened after pre-assessments  
345 (sensitivity) and 2) remained non-threatened (specificity) following pre-assessments.  
346 Therefore, DD and NE species were excluded from the calculation of sensitivity and  
347 specificity indices. A high sensitivity indicated that there was a high proportion of species  
348 classified as threatened by the IUCN that were pre-assessed potentially threatened. A high  
349 specificity method indicated that there was a high proportion of species classified as non-  
350 threatened (LC or NT) by the IUCN that were pre-assessed non-threatened.

351 We estimated the accuracy of the pre-assessments, i.e. the proportion of species correctly  
352 assessed, and the True Skill Statistic (TSS) which is equal to "sensitivity + specificity - 1".  
353 TSS scores range from 1 to -1, with 1 indicating a perfect pre-assessment model, while a  
354 value of 0 or lower indicates that pre-assessments are no better than if status had been pre-  
355 assessed randomly. Because of our choice to consider "likely rare" and "potentially rare"  
356 species as threatened, the identification of a decline or not does not influence the performance  
357 of a method.



358  
359 **Fig. 1** Methodological summary of the study

360

### 361 **3. Results**

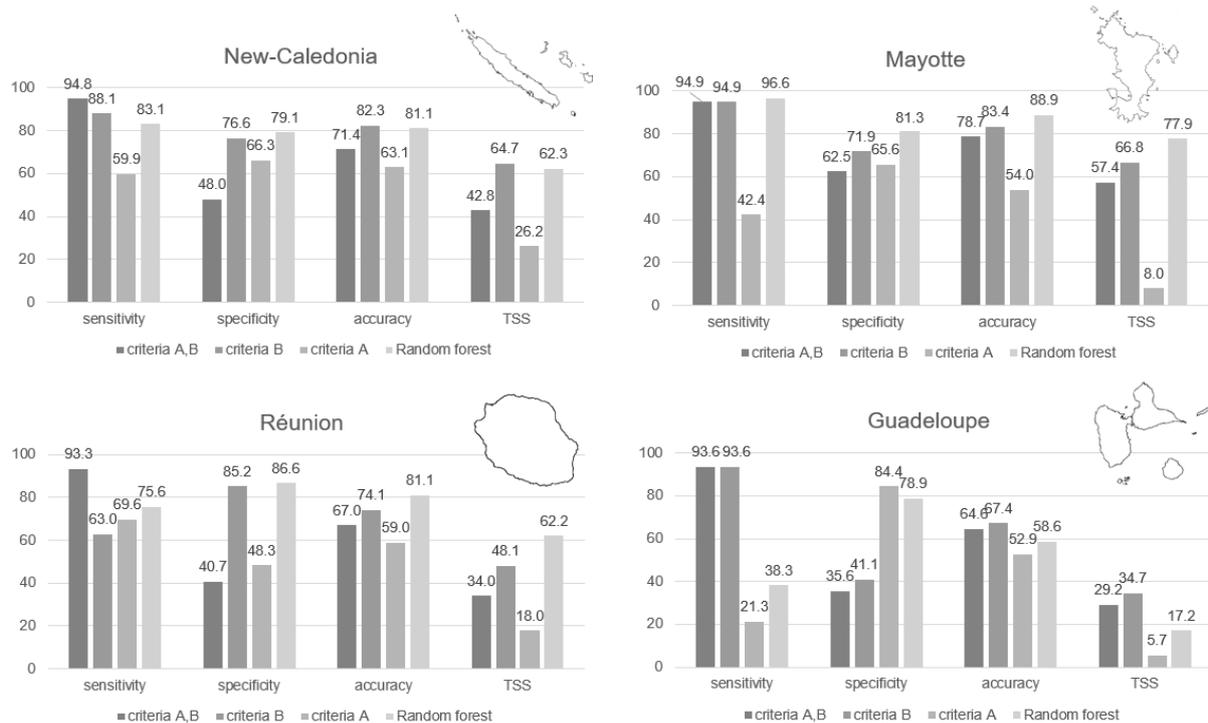
#### 362 3.1. Pre-assessment methods using criterion B and Random Forest performed best

363

364 The pre-assessment method with the best TSS and accuracy was the Random Forest method  
 365 for Réunion, Mayotte, and it also had a good performance in New Caledonia (Fig. 2). It gave  
 366 a sensitivity of 75-96% for these territories and a specificity between 79% and 87% (Fig. 2).  
 367 In contrast, the use of Random Forest for the endemic flora of Guadeloupe had a low  
 368 sensitivity (38.3%) but a high specificity (78.9%). Due to the absence of Red Lists in the  
 369 French sub-Antarctic islands, the low number of endemic species with a conservation status in  
 370 Martinique, and the absence of pressure maps in the Scattered Islands, the Random Forest  
 371 method was not applied for these 3 territories. The other machine learning method we tested  
 372 (Zizka et al. 2020) also performed well but with lower accuracy than Random Forests  
 373 (Supplementary Information 2). Pre-assessment of status using criteria A and B together  
 374 provided the best sensitivity for New Caledonia and Réunion, but the specificity of this  
 375 method was low. As for criterion B used alone, it had the best accuracy and TSS for

376 Guadeloupe and New-Caledonia and a relatively high specificity and sensitivity in the  
377 Scattered Islands (local and regional scales). The high TSS in Guadeloupe was due to high  
378 sensitivity whereas specificity was very low for this territory, i.e. criterion B assigned greater  
379 extinction risks to Guadeloupe's endemic tracheophytes than the assessments in the 2019 Red  
380 List (UICN Comité français et al. 2019). On the other hand, criterion B assigned lower risks  
381 to Réunion endemic taxa compared to the 2013 Red List (UICN France et al. 2013). In order  
382 to improve the performance of methods and take into account the differences in surface area  
383 between territories, different grid cell sizes and thresholds were used for the calculation of the  
384 AOO and the number of locations in Mayotte, the French sub-Antarctic Islands, Guadeloupe,  
385 Martinique and the Scattered Islands (Table 1, Supplementary Information 2). The use of  
386 criterion A alone, obtained with different pressure layers (Table 1), gave the lowest TSS and  
387 accuracy for all the territories.

388 Finally, the number of specimens significantly distinguished LC species, which had a large  
389 number of observations, from threatened categories (CR, EN, VU) which had a low number  
390 of observations, in all territories.



391 **Fig. 2** Accuracy, TSS, sensitivity and specificity of the four pre-assessment methods for four  
 392 FOTs: Guadeloupe, Mayotte, Réunion, and New Caledonia. Methods are represented from  
 393 dark to light grey: criteria A,B; criteria B; criteria A; Random Forest. For graphical reason the  
 394 TSS score was multiplied by 100. Performance analysis could not be applied to territories  
 395 where no or few endemic taxa were assessed with a IUCN conservation status.  
 396

397

398 3.2 Based on the best performing methods, up to sixty percent of endemic species are  
 399 potentially threatened

400 We used each method in each territory but chose to present results only for the best  
 401 performing ones (all results are in Supplementary Information 5). Using the most appropriate  
 402 pre-assessment method for each territory, 2 135 taxa (60.0%) were found to be threatened  
 403 (Table 2; Supplementary Information 5 and 6). In Réunion and Mayotte, the method with the  
 404 best precision and TSS, i.e. the Random Forest algorithm, indicated that in total 262 taxa  
 405 endemic to these territories would be potentially threatened and 273 would be non-threatened  
 406 (Table 2). Adding the criterion B results obtained in territories where it performed the best  
 407 (New-Caledonia, Guadeloupe), or where the Random Forest algorithm could not be applied  
 408 (Martinique, Scattered islands, French sub-Antarctic islands), we pre-assessed an additional 1  
 409 873 as potentially threatened and 1 147 as non-threatened. However, the number of threatened

410 taxa estimated with criterion B is probably a high estimate due to the low specificity of this  
411 method in Guadeloupe (i.e. many NT or LC species have been pre-assessed as threatened) but  
412 also to the lower specificity of Criterion B in New Caledonia compared to the Random Forest  
413 method. When the Random Forest method, which obtains good precision and TSS in all  
414 territories, is used in New Caledonia and Guadeloupe, the total proportion of threatened  
415 endemic taxa is 56.4%.

	<i>Pre-assessment Method</i>	<i>Spermatophytes</i>		<i>Pteridophytes</i>		<i>All taxa</i>
		<i>Strict endemics</i>	<i>Regional endemics</i>	<i>Strict endemics</i>	<i>Regional endemics</i>	
<b>New-Caledonia</b>	Criterion B	1495 (60.1%)	0	53 (51.9%)	0	1548 (59.7%)
<b>Réunion</b>	Random Forest	119 (49.5%)	45 (35.1%)	5 (26.3%)	12 (46.1%)	181 (43.8%)
<b>Mayotte</b>	Random Forest	41 (75.5%)	38 (62.2%)	1 (100%)	1 (100%)	81 (69.2%)
<b>Guadeloupe</b>	Criterion B	18 (90%)	99 (71.2%)	1 (100%)	24 (88.8%)	142 (75.9%)
<b>Martinique</b>	Criterion B	25 (86.2%)	121 (81.3%)	0	17 (100%)	163 (89.1%)
<b>Scattered Islands</b>	Criterion B, adapted as in [Hivert et al. 2018], local scale)	2 (25%)	15 (39.4%)	0	0	17 (36.9%)
<b>French sub-Antarctic islands</b>	<u>Kerguelen:</u> Criterion B, <u>Crozet:</u> <u>Amsterdam-St Paul:</u> Criterion B adapted as in [Hivert et al. 2018], local scale)	1 (11.1%)	1*(20%)	0	1 (50%)	3 (16.6%)
<b>TOTAL</b>		1701 (59.6%)	319 (62.3%)	60 (48.3%)	55 (73.9%)	2135 (60.0%**)

416 **Table 2:** Number of species pre-assessed as potentially threatened using the "Random Forest"  
417 (Réunion, Mayotte), criterion B (New Caledonia, Martinique, Guadeloupe, Kerguelen),  
418 criteria A+B (Martinique) or criterion B based on Hivert et al. (2018) (Supplementary  
419 Information 3: Scattered Islands, Crozet and Amsterdam-Saint-Paul). Percentages of the total  
420 taxa in these categories are given in parentheses. \**Colobanthus kerguelensis* is potentially VU  
421 in Crozet but LC in Kerguelen.\*\* A few endemic taxa of the Scattered islands and French

422 sub-Antarctic islands were counted several times as they have a conservation status in several  
423 islands of these territories.

424

#### 425 **4. Discussion**

##### 426 4.1. How many endemic species are potentially threatened and why?

427 Using pre-assessment methods with the highest performance for each territory we estimated  
428 that up to 2 135 endemic taxa are potentially threatened and 1 420 are potentially non-  
429 threatened for seven FOTs. The proportion of potentially threatened endemic tracheophytes is  
430 thus 60.0%, which is higher than recent estimates based on published Red Lists (51% for  
431 spermatophytes and 37% for pteridophytes; Véron et al. 2021). Of these, 91 of the 138  
432 previously categorized DD taxa and 1 160 of the 1 745 previously categorized NE taxa are  
433 potentially threatened. This shows that a high proportion of DD species may be potentially  
434 threatened as found in mammals (Bland et al. 2015), reptiles (Bland and Böhm 2016) or  
435 sharks and rays (Walls and Dulvy 2020). However, many taxa have few records, e.g. 443 taxa  
436 have three or fewer records, and further studies, local expertise or inventories would be  
437 necessary to understand whether this represents a genuine extinction risk or a lack of  
438 knowledge. Moreover, it must be considered that not all factors leading to the DD  
439 classification of a taxon can be taken into account by the pre-assessment methods, e.g.  
440 uncertain occurrences, taxonomy, misidentification, nomenclature (e.g. lost or uncertain type  
441 specimen), unknown provenance (Hochkirch et al. 2021). For these reasons we did not define  
442 a DD pre-status category in this study and suggest that further knowledge is necessary for  
443 some taxa assessed as DD in a Red List to evaluate their conservation status. Therefore,  
444 identifying the causes of data-deficiency will facilitate the use of pre-assessment methods to  
445 predict the extinction risk of these species, include them in biodiversity indices and species  
446 conservation status analyses, and avoid unnoticed extinctions (Bland et al. 2017). Besides, we  
447 acknowledge that in New-Caledonia and Guadeloupe the number of potentially threatened

448 taxa may have been over-estimated (the method with the highest accuracy had a relatively low  
449 specificity in these territories, see section 4.3.2), and using a method with a higher specificity  
450 in these territories reduced the proportion of threatened taxa in the FOTs to 56.4%.

451 Based on the methods with the highest accuracy and TSS, Martinique has the highest  
452 proportion of potentially threatened taxa but method performance could not be assessed in this  
453 case and there is a lack of occurrence data for many taxa (pers. comm. G.Viscardi).  
454 Guadeloupe also has a high proportion of potentially threatened endemic tracheophytes,  
455 however risks may have been overestimated in this territory as the specificity of the method is  
456 low. This is likely due to the lack of comprehensive occurrence data for taxa previously  
457 classified as non-threatened and to their natural range-restriction. Excluding Guadeloupe and  
458 Martinique, Mayotte is the territory with the highest proportion of potentially threatened  
459 endemic species due to the narrow range of endemic species there and high levels of threats,  
460 especially agriculture and deforestation. In Réunion, plants occurring in areas with high alien  
461 plant invasion pressure are expected to be at risk (Fenouillas et al. 2021). Pressure from  
462 invasive species is likely a main threat to endemic plants in all FOTs due to competition for  
463 resources (alien plants) and grazing by introduced animals (e.g. cattle, rabbits) (Soubeyran et  
464 al. 2015, but see Caujapé-Castells et al. 2010). Thereby, endemic plants from the Scattered  
465 islands are threatened by invasions (plants, goats), cyclones (for woody species) and the small  
466 size of their populations make them highly vulnerable to extreme climatic events and/or sea  
467 level rise. Yet, reduced human activity, flora monitoring and conservation actions explain  
468 why the proportion of threatened endemic plant species is lower in these islands compared to  
469 other FOTs. In New-Caledonia other important pressures on plant diversity are fires and  
470 mining activities (Meyer et al. 2021). Moreover, it is important to consider the interactions  
471 between these threats, which are expected to have a greater impact than taken individually  
472 (Krupnick 2013; Leclerc et al. 2018; Rojas- Sandoval et al. 2020). For example, in the French

473 sub-Antarctic islands, recent climatic changes, the drop in precipitation, combined with  
474 warmer temperatures, have led to the decline of certain native species, leaving bare soil,  
475 which has benefited the most dispersive invasive species and changed the structure of  
476 communities (Chapuis et al. 2004; Robin et al. 2011).

#### 477 4.2. What are the implications of pre-assessments for biodiversity conservation?

478 Pre-assessments are not intended to replace Red Lists, as it is essential to follow the  
479 methodology developed by the IUCN to assess the genuine conservation status of species in a  
480 standardized and reproducible way. In particular, we acknowledge that the variables used do  
481 not rigorously match the criteria of the IUCN Red List, although they try to conform to the  
482 criteria as much as possible and are all related to extinction risks (see 4.3.2). Yet our aim was  
483 to automatically pre-assess the potential extinction risks of species, and many criteria and sub-  
484 criteria are difficult (if not impossible) to evaluate without the knowledge of experts. We see  
485 several benefits of the pre-assessment methods used in this study to assist Red Lists. First,  
486 these methods can help to prioritize first-time assessments (e.g., many taxa in Martinique,  
487 Kerguelen) and re-assessments (e.g., Réunion, Mayotte). Especially, automated methods can  
488 be used during the pre-evaluation step of the IUCN Red List process. They give an indication  
489 of which taxa are most likely to be threatened and which should attract closer attention during  
490 IUCN assessment workshops when resources and time are limited. They also allow the  
491 identification of species which are likely not threatened (Bachman et al. 2020), especially by  
492 using pre-assessment methods with high specificity, and which need less data compared to  
493 threatened species to be published on the Red List (IUCN 2013). This allows the reduction of  
494 resources spent on predicted-to-be non-threatened taxa. Second, the variables used in  
495 automatic pre-assessments can contribute to evaluate the Red List criteria, for example  
496 calculating the proportion of the range size of a taxon that intersects newly degraded areas can  
497 help to estimate a decline in species habitat quality. Third, pre-assessments can help prioritize

498 data collection, for example by identifying data-deficient species that are likely to be  
499 threatened and may require further knowledge to validate their conservation status (Cazalis et  
500 al. 2022). From the uses presented above, pre-assessment methods can support the  
501 development of Red Lists by facilitating the evaluation of the conservation status of more  
502 taxa, allowing one to cover more taxonomic groups, geographical regions and more up to date  
503 assessments. Furthermore, this will support the use of Red Lists as a powerful tool to evaluate  
504 the state of biodiversity, to prioritize species in conservation planning, to support conservation  
505 policies such as the Convention on Biological Diversity and to raise awareness of biodiversity  
506 loss. We therefore agree with Cazalis et al. (2022) who advocated that pre-assessment  
507 methods should be better used in IUCN Red Lists. Yet, as stated above, it is essential to  
508 follow the methodology developed by the IUCN to assess the genuine conservation status of  
509 species and it is not recommended to use pre-assessment methods alone to implement  
510 conservation actions. We therefore believe that the main aim of the pre-assessment methods is  
511 to facilitate the development of Red Lists which will further contribute to conservation actions  
512 and policies. Finally, researchers in biodiversity conservation often need information on  
513 conservation status that are not available yet for many taxonomic groups and geographic  
514 places. Therefore, using automatic methods can help to approach species conservation  
515 statuses with a high confidence and include the results in research studies.

516

#### 517 4.3. Quality and shortcomings of pre-assessment methods and the necessity to adapt them to 518 the studied territory

519

##### 520 4.3.1. Data quality

521 This pre-assessment of the conservation status of the flora of the FOTs benefited from a first  
522 study on the taxonomy and endemic status of tracheophytes and bryophytes, a necessary step  
523 for this new study (Véron et al. 2021). In addition, recent field collections have allowed us to  
524 precisely geolocate endemic species in the FOTs. Yet, there are still taxa with imprecise  
525 coordinates, especially in Mayotte and Guadeloupe, which may require further inventories by  
526 botanical experts. We also compiled herbarium data that can be used to determine the change  
527 of a species' range over time, to guide new collections, to revise taxonomy, to discover new  
528 species or to document extinctions. Information on the rarity or commonness of the taxa is  
529 also sometimes directly written on the herbarium sheet. More importantly, herbarium  
530 specimens allow reproducibility (the base of the scientific method) as only these permanent  
531 collections allow for the reassessment of the identification of taxa at any time from the initial  
532 observation in the field. Herbarium data thus provide a historical context of the floristic  
533 diversity of a territory and its evolution. For example, in Réunion, the use of herbarium data  
534 alone informs us that many collections have been made in places that are now degraded.  
535 Many studies have thus recommended using herbarium data for conservation purposes (Rivers  
536 et al. 2010, Rivers et al. 2011, Nic Lughadha et al. 2019, Albani Rocchetti et al. 2021).

537

#### 538 4.3.2. Performance by criteria, limitations and improvements

539 Criterion B based on AOO, EOO, number of locations, is relatively easy to automatically  
540 measure for pre-assessing IUCN conservation status (e.g. Dauby et al. 2017; Moat 2017). The  
541 size of a species' range is strongly correlated with its extinction status (Bland et al. 2015), and  
542 we have shown the importance of range and population structure variables on the  
543 classification of species into one of the Red List threat categories (Supplementary Information  
544 4). We acknowledge that rarity and conservation status are two different concepts, as a  
545 narrow-range species may have stable populations and be secure while a widespread species

546 could be threatened on a high proportion of its range and at risk of extinction. Yet, narrow  
547 range-size is an important indication of extinction risk. In the “largest and statistically better  
548 supported review of the relation be-  
549 tween traits and extinction risk to date”, Chichorro et al. (2019) showed that species with  
550 small range and narrow habitat breadth were the most vulnerable to extinctions. Previous pre-  
551 assessments also showed that species pre-assessed with Criterion B-based methods had a high  
552 probability of matching their IUCN Red List status (Nic Lughadha et al. 2019; Zizka et al.  
553 2020). In line with these results, we found that for the majority of territories the simplified use  
554 of criterion B had a high accuracy and TSS, especially in New Caledonia. The high  
555 performance of criterion B and its tight relationship with extinction risk means that species  
556 pre-assessed as potentially threatened require specific attention during IUCN workshops and  
557 that only few of them are expected to be secure in these territories. On the contrary, criterion  
558 B specificity was low in Guadeloupe while sensitivity was high, meaning that pre-assessed  
559 conservation statuses have likely been overestimated. This indicates that it is important to  
560 look at all performance measures to fully assess the reliability of pre-assessment methods.  
561 Interestingly, criterion B was not the most frequently used criterion in existing Red Lists (with  
562 the exception of New Caledonia) which have often used criterion D and sometimes criteria C  
563 and A (Supplementary Information 1). This shows that a simplified version of criterion B  
564 assessment can perform well to assess whether a taxon is potentially threatened or not, even if  
565 it was classified in a Red List based on another criterion. This could be explained by the  
566 expected positive relationship between AOO and the number of individuals (criterion C) and  
567 of the use of AOO in criterion D2. However, Walker et al. (2022)) showed that a simplified  
568 criterion B method may not perform as well in pre-assessing the conservation status of species  
569 previously classified in a Red List based on criterion A.

570 A limitation of this range criterion is, however, that the threshold values of EOO and AOO  
571 defined by the IUCN (2012) are not always adapted to the small size of some territories,  
572 leading to an overestimation of the extinction risk (Martín 2009). The IUCN therefore does  
573 not recommend using the Red List criteria in very small territories. Consequently, for the  
574 Scattered Islands and French sub-Antarctic islands (except Kerguelen), where assessing  
575 conservation status is an important conservation challenge to respond to management  
576 objectives (Hivert et al. 2018, see also Molloy et al. 2002; Martín 2009), it was necessary to  
577 adapt the size of the grids used to calculate the AOO, but also the conservation status  
578 thresholds defined by the IUCN. Such adaptations are not recommended in the IUCN Red  
579 List but in the context of pre-assessments they improve the performance of methods using  
580 criterion B for small territories.

581 Estimations of population decline (here comprising decline in EOO or number of individuals)  
582 are of moderate importance in classifying taxa as threatened. Nevertheless, the observation of  
583 a decrease in the number of occurrences or the range of a species or a low degree of  
584 protection may indicate that special attention should be paid to the conservation status of the  
585 species. Indeed, biodiversity losses cannot only be assessed in terms of extinction, and  
586 population decline is another indicator to analyze the impact of anthropogenic activities (e.g.  
587 Bissessur et al. 2017). This is particularly the case for strict island endemics where there are  
588 no populations outside the territory to replenish the island population. Furthermore, in the  
589 case of regional endemics, this reinforcement may be made difficult by the need to cross the  
590 ocean, which acts as a barrier to dispersal for many species. There are also species for which  
591 there is no estimated decline following the method of Carrington et al. (2017) but for which  
592 the area of occurrence or number of occurrences is very low. These species have been  
593 classified as 'likely rare' or "potentially rare" which can also correspond to a VU status under  
594 criterion D2. These species are not currently endangered but future pressures could strongly

595 impact them and quickly move them to EX, CR or EN. Due to these limitations in estimating  
596 the number of locations and a continuous decline, we acknowledge that some of the species  
597 pre-assessed as potentially threatened under criterion B may not be at risk. However, as this  
598 method has a high accuracy we expect that such species are few and that the criterion B  
599 method remains useful to identify species potentially at risk. Improving on the automatic  
600 measure of the number of locations and population decline is a future challenge in the  
601 development of pre-assessment methods.

602 The criterion A pre-assessment method makes it possible to estimate the proportion of a  
603 species' distribution area affected by anthropogenic pressures. Yet, it assumes that threats are  
604 uniform across the species range and are fixed in time and space. The strength of the criterion  
605 A assessment according to Stévant et al. (2019) is that it greatly increases the sensitivity of  
606 pre-assessments when combined with criterion B. The joint use of criteria A and B therefore  
607 helps to identify species that are potentially at risk because they are range-restricted and/or  
608 found in a degraded area. In addition, habitat degradation variables are relatively important in  
609 the classification of a taxon in one of the Red List threat categories. The available pressure  
610 maps allow a first assessment of the severity of the threat (Fenouillas et al. 2021), whereas  
611 criterion B focuses on geographical criteria. However, the severity of anthropogenic pressures  
612 could vary greatly depending on the taxa. For example, some species can be found in urban  
613 environments – such as *Clusia major* in Guadeloupe or *Aloe mayottensis* in Mayotte – or in  
614 areas where fires occur (depending on fire intensity). On the contrary, some taxa could also be  
615 threatened despite their expected resilience to the anthropization of habitats (Bissessur et al.  
616 2017) or when they are on the periphery of a degraded area. Here we considered that a taxon  
617 must have been observed within a currently degraded area for it to be potentially impacted,  
618 therefore the conservation status of taxa found close to degraded areas may have been

619 underestimated. In Mayotte, for example, many occurrences are found close to deforested  
620 areas but have not been considered as impacted, which underestimates the risk they face.

621 The Random Forest algorithm provides the best accuracy, specificity and TSS in Réunion and  
622 Mayotte and also performs well in New-Caledonia. With the exception of Guadeloupe, this  
623 method also has a good sensitivity, and is therefore particularly well adapted to the pre-  
624 assessment of NE species. We also tested different parameters of the algorithm in order to  
625 make the method as reliable as possible. One of the difficulties in using classification trees is  
626 the complexity of interpreting the results and the choice of model parameters, although recent  
627 publications have improved our understanding and use of these models in the context of pre-  
628 assessments (Walker et al. 2022). The application of these models also requires that a  
629 conservation assessment has taken place in the past and that enough data are available to train  
630 the model. In addition, we used range, degraded habitat, and protected area variables, but  
631 considering other factors such as climate, habitat, could improve these methods (Walker et al.  
632 2022; but see Bland et al. 2015). In particular, the impact of climate change has not been  
633 considered: while many studies focus on changes in phenology or range, the impacts of  
634 climate change on population survival are still poorly known (Albani Rocchetti et al. 2021).  
635 In small territories, such as the Scattered Islands, sea level rise due to climate change could  
636 lead endemic species to extinction. Besides, future climate modeling can greatly help us  
637 understand how species ranges, and their future conservation statuses, are expected to change  
638 (Dubos et al. 2021).

639

## 640 **5. Conclusion**

641 In this study we showed the value of pre-assessment methods to estimate potential  
642 conservation statuses and support Red Lists. Especially, Random Forest and criterion B pre-

643 assessments methods were generally successful in classifying species as threatened or non-  
644 threatened, with up to 88% accuracy. Therefore, we support the idea that automatic pre-  
645 assessment methods can support IUCN Red Lists to fasten and prioritize assessments by  
646 identifying predicted-to-be threatened taxa. We suggest that the choice of the pre-assessment  
647 method and its parameters should be adapted to the characteristics of each territory and  
648 especially its size in order to fully consider conservation goals and achieve the best possible  
649 performance. For example, changes in pre conservation status thresholds in very small  
650 territories as in the Scattered Islands or some of the French sub-Antarctic islands could help to  
651 better tackle conservation challenges. Based on the best performing pre-assessment method  
652 for each FOT we estimated that up to 60% of tracheophytes endemic to the FOTs could be  
653 threatened. The future assessments using the standardized IUCN Red List methodology could  
654 focus first on the species pre-assessed as threatened in this study. Once the species confirmed  
655 as threatened are identified we recommend that conservation measures be put in place as soon  
656 as possible to protect these threatened species.

657

658

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## 828 *Statements and Declarations*

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831 **Competing interests** The authors have no competing interests to declare that are relevant to  
832 the content of this article.

833 **Data availability** The datasets generated during and/or analysed during the current study are  
834 available from the corresponding author on reasonable request.

835 **Authors' contributions** Simon Véron, Arthur Bernard, Carlos Rodrigues-Vaz, Elise  
836 Lebreton, Serge Muller, Vanessa Invernón, Germinal Rouhan, Olivier Gargominy, Sébastien  
837 Leblond, Marc Pignal, Sandrine Terceirie and Guillaume Gigot contributed to the study  
838 conception and design. Material preparation and data collection were performed by all  
839 authors. Analyses were performed by Simon Véron, Arthur Bernard and Elise Lebreton. The  
840 first draft of the manuscript was written by Simon Véron, Arthur Bernard and Elise Lebreton  
841 and all authors commented on previous versions of the manuscript. All authors read and  
842 approved the final manuscript.

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859 **Figure captions:**

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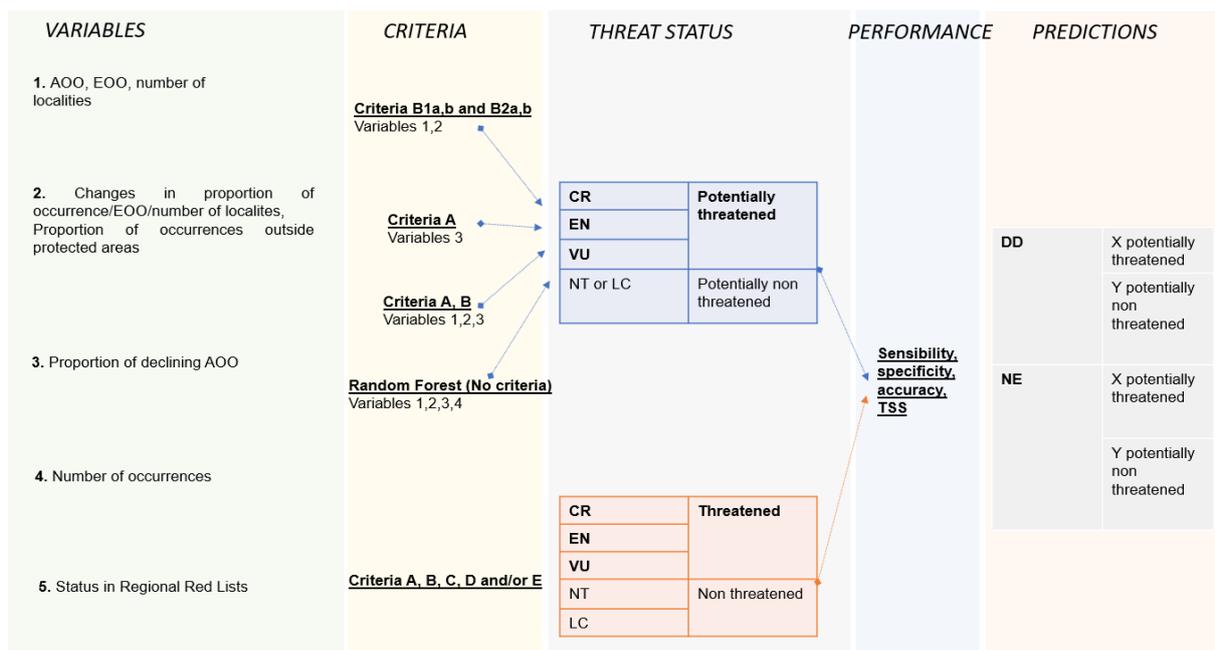
861 **Fig. 1** Methodological summary of the study

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863 **Fig. 2** Accuracy, TSS, sensitivity and specificity of the four pre-assessment methods for four  
864 FOTs: Guadeloupe, Mayotte, Réunion, and New Caledonia. Methods are represented from  
865 dark to light grey: criteria A,B; criteria B; criteria A; Random Forest. For graphical reason the  
866 TSS score was multiplied by 100. Performance analysis could not be applied to territories  
867 where no or few endemic taxa were assessed with a IUCN conservation status.

868

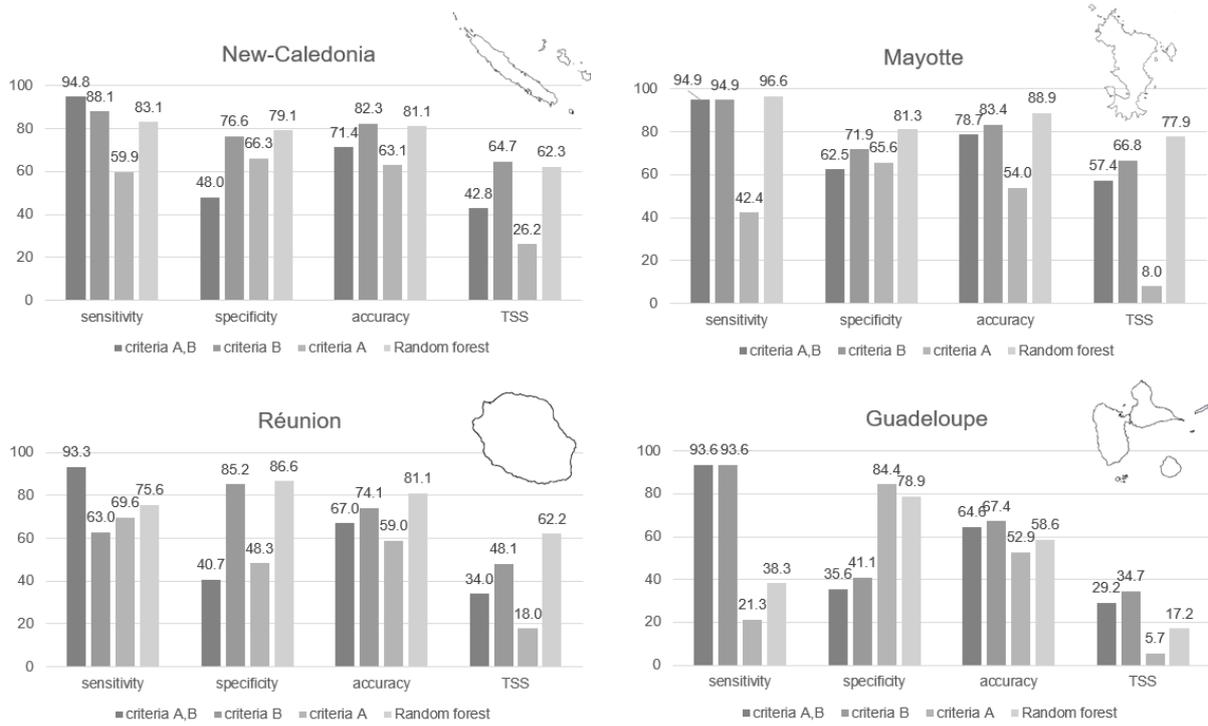
869 **Figures:**



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871 **Fig. 1 (not colored)**

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874 **Fig. 2 (not colored)**

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877 **Tables:**

**Table 1:** Data used for each territory. Criterion B parameters vary between territories in order to reach the best performance possible for this pre-assessment method. CLC=Corinne Land Cover (Bossard et al. 2000)

	<b>Main sources of species records</b>	<b>Number of occurrence records compiled</b>	<b>Median age of records</b>	<b>Pre-assessed endemic species</b>	<b>Anthropogenic pressures (criterion A)</b>	<b>Criterion B parameters</b>
<b>New Caledonia</b>	Endemia and RLA Flore NC 2019; ERMINES project (for ultramafic substrates); Herbaria P and NOU; Other international herbaria; INPN; GBIF	126 329 records of which 121 657 have been georeferenced	1978	2 591 (out of 2 758 endemic species)	Urban and agricultural environments (Gouvernement de la Nouvelle-Calédonie 2014); Loss of forest cover (Hansen et al. 2013); Fires (OEIL 2021); Active mines (Gouvernement de la Nouvelle-Calédonie 2014)	AOO, EOO according to recommendations of (IUCN 2012)  Number of locations = 10km*10km square grid
<b>Réunion</b>	Mascarine; Herbarium REU; Herbarium P; INPN; GBIF	102 406 records of which 102 208 were georeferenced	2010	413 (out of 489 endemic species)	Urban and agricultural environments (Bossard et al. 2000); Land use change 2012-2018 (Bossard et al. 2000); loss of forest cover (Hansen et al. 2013); invasive species (Fenouillas et al. 2021)	AOO, EOO (IUCN 2012)  Number of locations = 10km*10km square grid
<b>Mayotte</b>	Mascarine; Herbarium MAO; Herbarium P; INPN; GBIF	7 178 records of which 7 088 georeferenced	2012	117 (out of 124 endemic species)	Urban and agricultural environments	AOO [EOO not considered] (IUCN 2012)

					(Bossard et al. 2000); Land use change 2012-2018 (Bossard et al. 2000); loss of forest cover (Hansen et al. 2013)	Number of locations = 5km*5km square grid
<b>Martinique</b>	CBN Martinique; Herbarium MTK; Herbarium P; Dataset in Carrington et al. (2017); INPN; GBIF	4 514 records including 3640 georeferenced	1945	183 (out of 221 endemic species)	Urban and agricultural environments (Bossard et al. 2000); Land use change 2012-2018 (Bossard et al. 2000); loss of forest cover (Hansen et al. 2013)	AOO, EOO (IUCN 2012)  Number of locations = 10km*10km square grid
<b>Guadeloupe</b>	Gwada Botanica ( <a href="https://www.gwadabotanica.fr/">https://www.gwadabotanica.fr/</a> ); Herbarium GUAD; Herbarium P; Dataset in Carrington et al. (2017); INPN; GBIF	8 551 records including  7 985 georeferenced	1981	187 (out of 206 endemic species)	Urban and agricultural environments (Bossard et al. 2000); Land use change 2012-2018 (Bossard et al. 2000); loss of forest cover (Hansen et al. 2013)	AOO, EOO (IUCN 2012)  Number of locations = 5km*5km square grid
<b>French sub- Antarctic islands (Kerguelen, Crozet, Saint- Paul,</b>	National Nature Reserve of the French sub-Antarctic Islands; Project IPEV 136 Subanteco; GBIF; Herbarium P.	12 652 records of which 12 372 geolocated	2017	16 (out of 15 endemic species + 2 patrimonial species)	Not assessed	<u>Kerguelen</u> : AOO, EOO (IUCN 2012)  Number of locations = 10km*10km square

Amsterdam)						<p>grid</p> <p><u>Saint Paul, Amsterdam, Crozet</u>          AOO, 100m*100m square grid, Number of locations = 100m*100m square grid.</p> <p>CR = <math>\leq 0.5\%</math> of grid cells; EN = <math>\leq 3.5\%</math>; VU = <math>\leq 7.5\%</math></p>
Scattered Islands (Europa, Glorioso, Juan de Nova, Tromelin)	Conservatoire Botanique National Mascarin (Hivert et al. 2018)	Hivert et al. (2018)	Hivert et al. (2018)	38 (out of 38 endemic species)	Not assessed	<p>AOO, 100m*100m square grid. CR = <math>\leq 0,35</math> to <math>0,96\%</math> of grid cells; EN = <math>\leq 2,88</math> to <math>3,5\%</math>; VU = <math>\leq 6,73</math> to <math>7,48\%</math>.</p> <p>Besides , different thresholds are used to estimate extinction risks at local and regional scales (see Hivert et al. 2018)</p> <p>Number of locations = number of islands</p>

\* Occurrence records include preserved specimens, living specimens, observations, photographs, and material samples

		<i>Spermatophytes</i>		<i>Pteridophytes</i>		
	<i>Pre-assessment Method</i>	<i>Strict endemics</i>	<i>Regional endemics</i>	<i>Strict endemics</i>	<i>Regional endemics</i>	<i>All taxa</i>
<b>New-Caledonia</b>	Criterion B	1495 (60.1%)	0	53 (51.9%)	0	1548 (59.7%)
<b>Réunion</b>	Random Forest	119 (49.5%)	45 (35.1%)	5 (26.3%)	12 (46.1%)	181 (43.8%)
<b>Mayotte</b>	Random Forest	41 (75.5%)	38 (62.2%)	1 (100%)	1 (100%)	81 (69.2%)
<b>Guadeloupe</b>	Criterion B	18 (90%)	99 (71.2%)	1 (100%)	24 (88.8%)	142 (75.9%)
<b>Martinique</b>	Criterion B	25 (86.2%)	121 (81.3%)	0	17 (100%)	163 (89.1%)
<b>Scattered Islands</b>	Criterion B, adapted as in [Hivert et al. 2018], local scale)	2 (25%)	15 (39.4%)	0	0	17 (36.9%)
<b>French sub-Antarctic islands</b>	<u>Kerguelen:</u> Criterion B, <u>Crozet:</u> <u>Amsterdam-St Paul:</u> Criterion B adapted as in [Hivert et al. 2018], local scale)	1 (11.1%)	1*(20%)	0	1 (50%)	3 (16.6%)
<b>TOTAL</b>		1701 (59.6%)	319 (62.3%)	60 (48.3%)	55 (73.9%)	2135 (60.0%**)

**Table 2:** Number of species pre-assessed as potentially threatened using the "Random Forest" (Réunion, Mayotte), criterion B (New Caledonia, Martinique, Guadeloupe, Kerguelen), criteria A+B (Martinique) or criterion B based on Hivert et al. (2018) (Supplementary Information 3: Scattered Islands, Crozet and Amsterdam-Saint-Paul). Percentages of the total taxa in these categories are given in parentheses. \**Colobanthus kerguelensis* is potentially VU in Crozet but LC in Kerguelen.\*\* A few endemic taxa of the Scattered islands and French sub-Antarctic islands were counted several times as they have a conservation status in several islands of these territories.

