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# Preliminary global assessment of biodiversity consequences of sea level rise mediated by climate change

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41 *Running Title:* Biodiversity consequences of sea level rise  
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## 43 **Preliminary global assessment of biodiversity consequences** 44 **of sea level rise mediated by climate change**

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49 **Abstract** Considerable attention has focused on the climatic effects of global climate change on  
50 biodiversity, but few analyses and no broad assessments have evaluated the effects of sea level  
51 rise on biodiversity. Taking advantage of new maps of marine intrusion under scenarios of 1 m  
52 and 6 m sea level rise, we calculated areal losses for all ecoregions globally, with areal losses for  
53 particular ecoregions ranging from nil to complete. Marine intrusion is a global phenomenon, but  
54 is most prominent in Southeast Asia and nearby islands, eastern North America, northeastern  
55 South America, and western Alaska. Making assumptions regarding responses to reduced  
56 distributional area by species endemic to ecoregions, we estimated likely numbers of extinction  
57 caused by sea level rise, and found that marine-intrusion-caused extinctions of narrow endemics  
58 is most prominent in northeastern South America, although anticipated extinctions in smaller  
59 numbers are scattered worldwide. This assessment serves as a complement to recent estimates of  
60 losses owing to changing climatic conditions, considering a dimension of biodiversity  
61 consequences of climate change that has not previously been taken into account.

62

63 **Keywords** climate change, sea-level change, marine intrusion, biodiversity, ecoregions,  
64 endemic species, extinction

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## 67 **Introduction**

68 Considerable attention has focused on the biodiversity consequences of global climate change  
69 (Peters and Darling 1985; Dobson et al. 1989; Lovejoy and Hannah 2005). In particular,  
70 attention has focused on direct effects of changes in climatic conditions on species' ability to  
71 persist in a region—if climate changes sufficiently that persistence is not possible, then either  
72 movement to track appropriate conditions or extirpation are the only alternatives (Holt 1990).

73 The dimensions of biodiversity loss due to climate change are being outlined to varying degrees  
74 of confidence, by both empirical observations of climate change effects (Parmesan 1996; Visser  
75 et al. 1998; Parmesan et al. 1999; Pounds et al. 1999; Parmesan and Yohe 2003) and predictions  
76 from ecological niche models based on general circulation model (GCM) outputs (Erasmus et al.  
77 2002; Peterson et al. 2002; Thomas et al. 2004a; Araújo et al. 2005; Peterson et al. 2005; Anciães  
78 and Peterson 2006), although the interpretation of model results in terms of extinction rates can  
79 be complex (Buckley and Roughgarden 2004; Thuiller et al. 2004; Lewis 2006).

80 Another important dimension of climate change, however, is that of sea-level rise. The  
81 factors contributing to this phenomenon are clearly complex, and future projections can vary  
82 quite dramatically; still, best (though perhaps conservative) estimates are on the order of 0.5-1.0  
83 m (Carter et al. 2007), while others consider the complexity of the projections (Oerlemans et al.  
84 2005), with some estimates much higher (Bindschadler 1998; Thomas et al. 2004b; Rignot and  
85 Kanagaratnam 2006). Curiously, although considerable reflection and analysis has focused on

86 this theme on the human and economic side (Titus 1990; Mimura 1999; Hitz and Smith 2004;  
87 Bosello et al. 2007), few analyses have addressed the biodiversity consequences of sea-level  
88 change: a few papers have addressed ecosystem adaptation to rising sea-level (McKee et al.  
89 2007), one has analyzed the likely effects on a single endangered species (LaFever et al. 2007),  
90 and a few analyses have been developed regarding particular regions or affected taxa (Daniels et  
91 al. 1993; Galbraith et al. 2002; Gopal and Chauhan 2006).

92 To date, nonetheless, no global assessment has been developed. Such is the purpose of  
93 this contribution: to offer a first-pass global assessment of sea-level rise impacts on biodiversity.  
94 We caution at the outset that our inferences are limited by several factors—imprecise estimates  
95 of sea-level rise, difficulties in scenario-building at <1 m sea-level rise, and lack of high-  
96 resolution data on biodiversity distributions globally. Still, if proper precautions and caveats are  
97 considered, a first-order estimate is worth exploring, if only to assess the relative importance of  
98 sea-level changes as an additional threat to global biodiversity.

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100

## 101 **Methods**

### 102 Sea-level rise scenarios and inundation delineation

103 Sea level rise over the past century has resulted largely from thermal expansion of the ocean,  
104 melting of mountain glaciers, and accelerated discharge of glacial ice from the ice sheets to the  
105 ocean (Dyurgerov and Meier 1997). Among these factors, ice sheet melt has potential for  
106 substantial global impacts. The Greenland Ice Sheet contains a volume of water equivalent to 6  
107 m of sea level rise, and the West Antarctic Ice Sheet, an unstable ice sheet grounded well below  
108 sea level, contains a volume of water equivalent to 5 m of sea level rise (Bindschadler, 1998).

109 Both are currently showing rapid increases in mass loss that will significantly increase sea level  
110 if such losses continue (Thomas et al., 2004; Rignot and Kanagaratam 2006). Shepherd and  
111 Wingham (2007) summarized the recent sea level contributions from the Greenland and  
112 Antarctic Ice Sheets, showing a modest but growing component of the current rate of sea level  
113 rise. Otto-Bliesner et al. (2006) indicate that warming and melting of the Greenland Ice Sheet  
114 and other circum-Arctic ice fields likely contributed 2.2-3.4 m of sea level rise during the Last  
115 Interglaciation. Overpeck et al. (2006) also indicate that the rate of future melting and related sea  
116 level rise could be faster than widely thought and estimate sea level rise from melting of polar  
117 ice sheets may reach 4 to >6 m similar to those of 130,000-127,000 yr ago by the year 2100. In  
118 addition, actual flooding process involves levels of high water that can be several meters above  
119 mean sea level (Marbaix and Nicholis, 2007). Considering the sea level rises reported in the  
120 literature and the effects of tidal and storm surge, potential inundation areas were delineated in  
121 this study with two scenarios bracketing the likely range of sea level rises of 1 and 6 m; the  
122 vertical resolution of the global digital elevation model prohibits calculations of <1 m.

123 Geographical information systems (GIS) has been used in several previous studies to  
124 delineate potentially inundated areas resulting from projected sea level rises (Dasgupta et al.  
125 2007; LaFever et al. 2007). In these analyses, inundation areas are identified if their elevation is  
126 below a projected sea level rise. Although the method is simple, it has two shortcomings. First,  
127 water connectivity is not considered when inundation areas are delineated. Some areas, though  
128 their elevation is below a projected sea level rise, should not be inundated if terrain barriers exist  
129 between the ocean and the areas. Second, some areas with elevations below the projected sea  
130 level rise are already inland water bodies, and therefore should not be included in calculations of

131 newly inundated areas. Given these two shortcomings, simple GIS methods likely overpredict  
132 potential inundation areas.

133         A new and more robust GIS analysis method developed by Li et al. (In press) was used in  
134 this study to overcome the above shortcomings. In the method, cells below a projected sea level  
135 rise are initially flagged. From the flagged cells, only those with connectivity to the ocean are  
136 selected. The selected cells are then checked to see whether or not they are part of existing inland  
137 water bodies. Only those cells that connect to the ocean and are not presently inland water are  
138 designated as inundation cells. The method was implemented as several steps in a GIS raster  
139 analysis framework. Details of the method are referred to Li et al. (In press).

140

141 Ecoregion areal loss estimates

142 The Terrestrial Ecoregions GIS Database and the Terrestrial Ecoregions Base Global Dataset  
143 (Olson et al. 2001) were the source of geospatial data showing the global extent of ecoregions, as  
144 well as providing data on numbers of endemic species in each ecoregion. Of the many variables  
145 calculated and summarized for each of the 827 terrestrial ecoregions by Olson et al. (2001), we  
146 used values for strict endemic species and near endemic species (summed across all terrestrial  
147 vertebrate classes) in this analysis. We converted the vector-format terrestrial ecoregions  
148 coverage into a grid, and estimated ecoregion areal loss resulting from marine intrusion by  
149 overlaying it with the 1 m and 6 m inundation grids generated with the above GIS method and  
150 performing raster map algebra. Each grid was projected to a global equal area projection  
151 (Mollweide) at a 1000 m resolution.

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154 Extinction estimates

155 The areal reductions of ecoregions can be used to estimate biodiversity losses under certain sets  
156 of assumptions—specifically, that species will respond to area available and habitable in certain,  
157 predictable ways (MacArthur and Wilson 1967). The relationship between numbers of species  
158 present and area under consideration (species-area relationship, or SAR) has been used  
159 extensively for estimates of likely future extinctions in numerous situations (Brooks et al. 1997;  
160 Brooks et al. 2002), although not without controversy (see Results and Discussion). In its  
161 simplest form, the SAR is a steady-state relationship between number of species ( $S$ ) and area ( $A$ )  
162 often, although not always (Tjørve 2003) of the form,  $S = cA^z$ , where  $c$  and  $z$  are constants  
163 estimated from the data.

164 In applications to calculating species' losses owing to areal reductions, if the present  
165 number of species  $S_{now}$  is existing in an area  $A_{now}$ , which is reduced to  $A_{future}$ , and if  $c$  and  $z$   
166 remain constant (assumed), then the number of species will eventually decrease to a new steady  
167 state  $S_{future} = S_{now} (A_{future} / A_{now})^z$  (May and Stumpf 2000; Pimm and Raven 2000). In the present  
168 analyses, we calculated  $A_{future}$  and  $A_{now}$  as detailed above, and  $S_{now}$  was taken as the sum of strict  
169 endemics and near endemics from the Terrestrial Ecoregions Base Global Dataset (Olson et al.  
170 2001). Estimating the constant  $c$  is unnecessary for calculating species' losses via area reduction.  
171 We estimated  $z$  in two different ways: (1) as the overall SAR across all ecoregions globally, and  
172 (2) SARs for 3 latitudinal bands (polar,  $>50^\circ\text{N}$  and  $>50^\circ\text{S}$ ; temperate,  $23\text{-}50^\circ\text{N}$  and  $23\text{-}50^\circ\text{S}$ ;  
173 tropical,  $23^\circ\text{S}$  to  $23^\circ\text{N}$ ). We calculated  $S_{future}$  for each ecosystem under the general  $z$  and the  
174 latitude-specific  $z$ , and estimated confidence intervals for each  $S_{future}$  calculation based on  $z \pm (2 \times$   
175 standard error). We opted not to use Kinzig & Harte's (2000) corrections for endemism for  
176 reasons treated in Results and Discussion.

177

178 **Results and Discussion**

179 Areal loss estimates globally were 0.7% of global land area under 1 m of sea level rise, and 1.5%  
180 of global land area under 6 m of sea level rise . Proportional losses in ecoregions ranged from  
181 very low to complete (100%) under both scenarios of sea-level rise, although the higher nature of  
182 loss estimates under the 6 m scenario is clear, with most affected ecoregions concentrated in  
183 Southeast Asia and associated islands, northeastern South America, eastern North America, and  
184 western Alaska (Fig. 1). Even under a 1 m sea-level rise scenario, 21 ecoregions are expected to  
185 lose >50% of their land area, which include 8 mangrove-dominated ecoregions, lowland forest  
186 and scrub on 8 islands or island groups, plus 5 low-lying continental areas (Peninsular Malaysian  
187 peat swamp forests, Orinoco Delta swamp forests, Marajó varzea, Orinoco wetlands, and  
188 Esperance mallee; see summary in Appendix). As such, sea-level rise manifested as marine  
189 intrusions is expected to have significant effects on terrestrial ecoregions (Figs. 2 and 3).

190 Areal loss estimates for ecoregions can be translated into estimates of extinctions of  
191 endemic and near-endemic taxa. Kinzig and Harte (2000) proposed methods to estimate the  
192 fraction of a biota that would be strictly endemic to the lost area. In general, their methods give  
193 smaller predictions than those obtained by application of the conventional SAR. However, their  
194 methods assume that the shapes of the reduced areas are in a certain sense “well-behaved.” In  
195 particular, they present as an example of poorly-behaved areas long and narrow strips, which is  
196 exactly the type of shape that sea-level rise causes. Besides, their methods require that the  
197 reduced area is  $\geq 50\%$  of the original area, a condition not fulfilled in most of the ecoregions  
198 analyzed herein.



199 For the global SAR fitting,  $z$  was estimated at  $0.124 \pm 0.015$  s.e., although the overall fit  
200 was not particularly tight ( $R^2 = 0.15$ ,  $N = 827$ ). Of a present standing set of 18,628 endemic or  
201 near-endemic species in single ecoregions, this single SAR parameterization yielded a calculated  
202 loss of 117 (confidence interval 89-144) species for the 1 m sea-level rise scenario, and 221  
203 (169-272) species for the 6 m scenario.

204 Splitting SAR regressions into polar, temperate, and tropical subsets, important regional  
205 differences were observed. The slope of the SAR ( $z$ ) was highest in tropical regions ( $z = 0.199 \pm$   
206  $0.013$ ), intermediate in temperate regions ( $z = 0.152 \pm 0.018$ ), and lowest in polar regions ( $z =$   
207  $0.067 \pm 0.038$ ). The scatter around these relationships was also reduced ( $R^2 = 0.45$ ,  $N = 391$ ;  $R^2 =$   
208  $0.24$ ,  $N = 334$ ;  $R^2 = 0.04$ ,  $N = 102$ ; respectively), suggesting that latitudinal effects explain part  
209 of the variation in the overall SAR (see also Drakare et al. 2006). These SAR differences  
210 translated into different rates of estimated species loss also: 0 of 35 polar species under both  
211 scenarios; 10 (8-13) and 30 (23-37) out of 3117 species under the 1 m and 6 m scenarios in  
212 temperate regions, respectively; and 170 (149-191) and 307 (269-344) out of 15,476 species  
213 under the 1 m and 6 m scenarios in tropical regions, respectively. Overall, then, with the region-  
214 specific  $z$  estimates, global species losses sum to 181 (157-204) species under the 1 m scenario  
215 and 337 (292-381) species under the 6 m scenario, out of 18,628 current species.

216 The use of SARs for estimating future extinctions has been criticized on a number of  
217 grounds (Drakare et al. 2006; Lewis 2006). (i) The value of  $z$  is sometimes taken as a given from  
218 other studies, rather than fitted from the data; in this study, we calculated  $z$  directly from  
219 ecoregion species richness data, and thus custom-fit the SAR to the data at hand. (ii) The value  
220 of  $z$  is not solely dependent on area, but is also affected by latitude, taxonomic considerations,  
221 and other factors; we developed region-specific calculations that yielded dramatically different

222 values of  $z$ ; it was not feasible to take other considerations (e.g., taxon) into account. (iv) SAR  
223 parameter values may change at different scales, which means that use of the simple equation  
224  $S_{future} = S_{now} (A_{future} / A_{now})^z$  may be flawed, since it is based on constant parameter values across  
225 many scales. This criticism is important, as it affects every attempt to use SARs over spatial  
226 scales spanning several orders of magnitude, and particularly at small areas, where SAR  
227 behavior may become erratic (Lomolino 2000 ). However, as our dataset has >98% of ecoregions  
228 polygons >10 km<sup>2</sup>, so the “small island” effect is probably not important. Finally (iv), simple  
229 deforestation may not be a good surrogate for area loss, since deforested regions often still  
230 maintain a matrix of habitats, some of which may remain habitable; in our case, area loss is  
231 measured directly, without surrogates, so our analyses are less subject to this concern.

232         However, even with sea level rise, ecoregions may shrink or disappear, but also may  
233 invade inland, effectively dispersing and transforming adjacent areas. For example, in regions  
234 with shallow slopes, conditions suitable for mangrove growth may develop as inland areas  
235 become new shorelines, thus compensating to some degree the losses. To address this  
236 consideration, detailed modeling of how the process of sea intrusion creates new conditions as it  
237 proceeds, and how ecosystems may or may not invade inland. We have not as-yet attempted such  
238 steps, so our results must be considered as preliminary. An additional frustration is that the SAR-  
239 based approach only estimates numbers of species likely to be lost, but does not inform regarding  
240 *which* species are likely to be lost. Hence, overall, we consider our SAR application to assessing  
241 species losses resulting from marine intrusion avoids many (if not all) of the common pitfalls  
242 reported in the literature. Still, we point out that caution is warranted in interpreting these first  
243 explorations of extinction consequences of marine intrusion.

244 In sum, we present a first-pass global summary of likely biodiversity consequences of  
245 sea-level rise and marine intrusion caused by climate change. The most realistic scenario of the  
246 two we explored for sea-level rise is 1 m, although the 6 m scenario is not outside of the range of  
247 possibilities if uncertainties regarding the effects of glacial calving and ice-sheet loss turn out to  
248 be worse than expected (Bindschadler 1998; Thomas et al. 2004b; Rignot and Kanagaratnam  
249 2006). The losses estimated herein, interestingly, would be largely complementary to those  
250 species lost based on *climate* change per se (i.e., climatic conditions becoming unsuitable for the  
251 species), which have been explored in many recent publications (Peterson 2003; Thomas et al.  
252 2004a; Thuiller et al. 2005; Araújo and Rahbek 2006; Thuiller et al. 2006). Moreover, our  
253 analyses do not take into account second-order effects on biodiversity caused by humans affected  
254 by rising sea levels, such as migrations and land use shifts which may cause yet more negative  
255 effects on natural systems.

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## Figure Legends

Fig. 1. Global summary of percent areal reduction across global ecoregions under a scenario of 6

m of sea-level rise (lightest pink = 0-5% loss, middle pink = 5-10% loss, strong pink = 10-15% loss, red = 15-20% loss, dark red 20-50% loss, dark red-brown = >50% loss).

Inset shows frequency distribution of areal losses under 1 m and 6 m scenarios of sea level rise.

Fig. 2. Left: Areal losses to ecoregions resulting from 1 m and 6 m sea level rise for portions of

southeastern United States, Central America, the Caribbean, and northern South America.

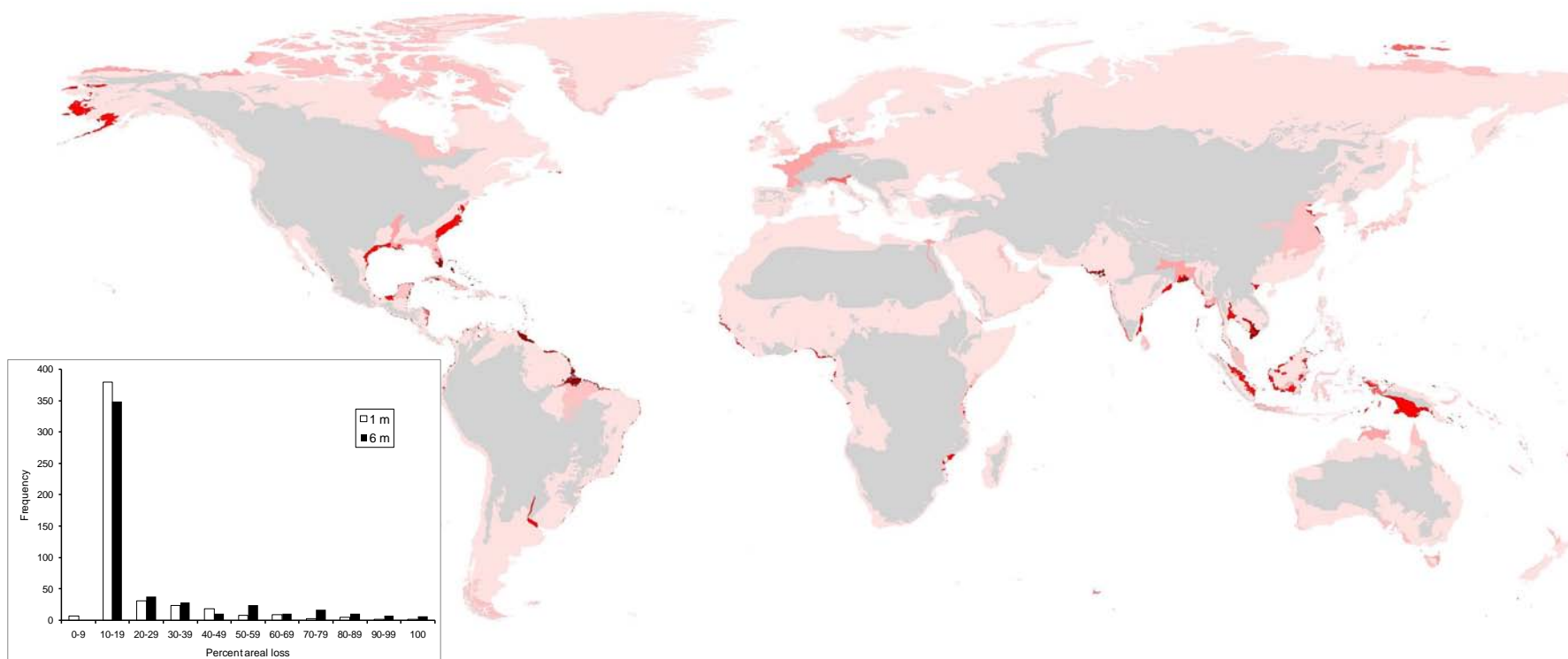
Ecoregions in this area predicted to suffer the greatest impacts include South Florida rocklands, Everglades, Piura mangroves, Para mangroves, Usumacinta mangroves, and Cuban mangroves. Right: Detail of the region surrounding the mouth of the Amazon

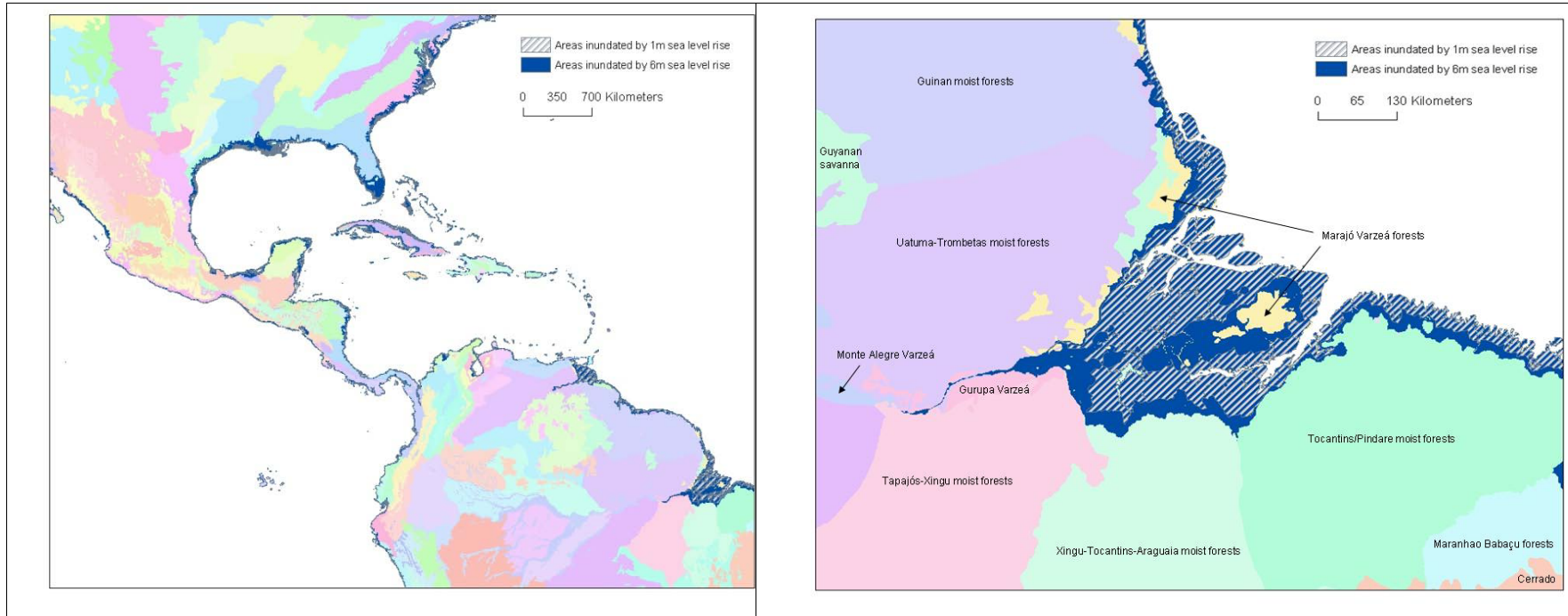
River in South America, showing areal losses for ecosystems resulting from 1 m and 6 m scenarios of sea level rise.

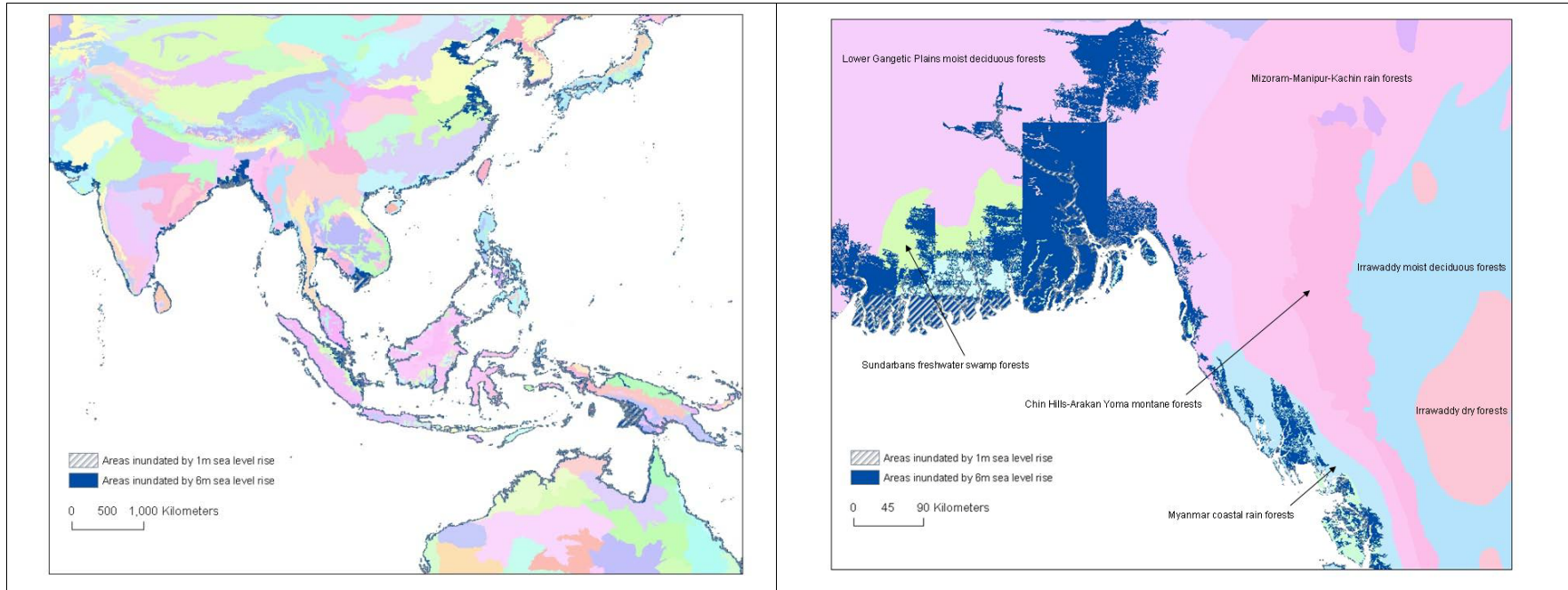
Fig. 3. Left: Areal losses to ecoregions resulting from 1 m and 6 m sea level rise for portions of

Asia and northern Australia. Ecoregions in this area predicted to suffer the greatest impacts include the Central Polynesian tropical moist forests, Indochina mangroves, and the New Guinea mangroves. Right: Detail of the region surrounding the Bay of Bengal,

showing areal losses for ecosystems resulting from 1 m and 6 m scenarios of sea level rise.







## Appendix

Summary of projected effects of sea level rise on global ecoregions (Olson et al. 2001). Ecoregions for which no data on endemism were provided are excluded from this summary. Abbreviation: “end” = endemism.

Continent or region	Ecoregion	Area (km <sup>2</sup> )	% loss (6 m)	% loss (1 m)	Total end	Total strict end	Total near end	Global model (6 m)	Global model (1 m)	Regional model (6 m)	Regional model (1 m)
Africa	Albany thickets	17030	0.57	0.11	13	1	12	13.0	13.0	13.0	13.0
	Angolan Miombo woodlands	661412	0.00	0.00	36	5	31	36.0	36.0	36.0	36.0
	Angolan scarp savanna and woodlands	74530	2.80	1.47	35	5	30	34.9	34.9	34.8	34.9
	Atlantic coastal desert	40006	3.09	0.03	1	0	1	1.0	1.0	1.0	1.0
	Atlantic Equatorial coastal forests	190072	4.80	3.64	47	6	41	46.7	46.8	46.5	46.7
	Central African mangroves	30934	23.81	20.30	5	0	5	4.8	4.9	4.7	4.8
	Cross-Sanaga-Bioko coastal forests	52211	4.28	3.81	52	3	49	51.7	51.8	51.5	51.6
	East African mangroves	16110	41.35	20.58	1	0	1	0.9	1.0	0.9	1.0
	Eritrean coastal desert	4627	19.02	1.17	2	0	2	1.9	2.0	1.9	2.0
	Ethiopian xeric grasslands and shrublands	153342	1.62	0.32	33	2	31	32.9	33.0	32.9	33.0
	Hoby grasslands and shrublands	25600	0.18	0.02	18	5	13	18.0	18.0	18.0	18.0
	Kaokoveld desert	45868	1.37	0.43	38	6	32	37.9	38.0	37.9	38.0
	Knysna-Amatole montane forests	2993	0.80	0.03	22	5	17	22.0	22.0	22.0	22.0
	KwaZulu-Cape coastal forest mosaic	17844	1.08	0.47	31	1	30	31.0	31.0	30.9	31.0
	Lowland fynbos and renosterveld	32865	1.71	0.27	53	4	49	52.9	53.0	52.9	53.0
	Maputaland coastal forest mosaic	30232	3.24	0.36	30	2	28	29.9	30.0	29.8	30.0
	Maputaland-Pondoland bushland and thickets	19534	0.02	0.01	22	1	21	22.0	22.0	22.0	22.0
	Montane fynbos and renosterveld	45849	0.10	0.07	70	12	58	70.0	70.0	70.0	70.0
	Namib desert	81028	1.14	0.37	44	3	41	43.9	44.0	43.9	44.0
	Niger Delta swamp forests	14479	0.61	0.28	5	0	5	5.0	5.0	5.0	5.0
	Nigerian lowland forests	67469	0.77	0.24	10	2	8	10.0	10.0	10.0	10.0

	Nile Delta flooded savanna	51149	10.71	0.35	1	0	1	1.0	1.0	1.0	1.0
	North Saharan steppe and woodlands	1679755	0.19	0.08	6	0	6	6.0	6.0	6.0	6.0
	Northern Zanzibar-Inhambane coastal forest mosaic	112892	6.12	3.59	128	27	101	127.0	127.4	126.4	127.1
	Saharan halophytics	54146	0.62	0.06	1	0	1	1.0	1.0	1.0	1.0
	Sahelian Acacia savanna	3060463	0.03	0.01	42	10	32	42.0	42.0	42.0	42.0
	Somali Acacia-Commiphora bushlands and thickets	1056351	0.08	0.05	133	28	105	133.0	133.0	133.0	133.0
	Somali montane xeric woodlands	62740	0.53	0.11	28	4	24	28.0	28.0	28.0	28.0
	Southern Africa mangroves	1001	10.49	2.20	1	0	1	1.0	1.0	1.0	1.0
	Southern Zanzibar-Inhambane coastal forest mosaic	147227	5.03	2.02	48	7	41	47.7	47.9	47.5	47.8
	Succulent Karoo	102954	0.29	0.11	63	9	54	63.0	63.0	63.0	63.0
	West Sudanian savanna	1642134	0.14	0.08	51	10	41	51.0	51.0	51.0	51.0
	Western Congolian forest-savanna mosaic	414381	0.54	0.11	23	3	20	23.0	23.0	23.0	23.0
	Zambeian coastal flooded savanna	19603	21.87	0.14	4	1	3	3.9	4.0	3.8	4.0
Africa/Europe	Mediterranean acacia-argania dry woodlands and succulent thickets	100308	0.38	0.15	26	6	20	26.0	26.0	26.0	26.0
	Mediterranean conifer and mixed forests	23134	0.93	0.70	3	1	2	3.0	3.0	3.0	3.0
	Mediterranean dry woodlands and steppe	292727	1.01	0.43	3	0	3	3.0	3.0	3.0	3.0
	Mediterranean woodlands and forests	359213	1.43	0.69	18	3	15	18.0	18.0	18.0	18.0
Antarctica	Marielandia Antarctic tundra	1149005	0.51	0.12	0	0	0	0.0	0.0	0.0	0.0
	Maudlandia Antarctic desert	2119791	0.39	0.10	0	0	0	0.0	0.0	0.0	0.0
Asia	Aegean and Western Turkey sclerophyllous and mixed forests	133827	3.35	1.84	13	5	8	12.9	13.0	12.9	13.0
	Anatolian conifer and deciduous mixed forests	86550	0.48	0.39	0	0	0	0.0	0.0	0.0	0.0
	Arabian Desert and East Sahero-Arabian xeric shrublands	1855231	0.12	0.02	3	0	3	3.0	3.0	3.0	3.0
	Arabian Peninsula coastal fog desert	83264	5.45	0.76	5	0	5	5.0	5.0	4.9	5.0
	Baluchistan xeric woodlands	289415	0.09	0.02	15	2	13	15.0	15.0	15.0	15.0
	Bohai Sea saline meadow	11580	41.19	1.47	0	0	0	0.0	0.0	0.0	0.0
	Cardamom Mountains rain forests	44307	0.85	0.27	18	6	12	18.0	18.0	18.0	18.0

Caucasus mixed forests	170708	0.01	0.00	12	5	7	12.0	12.0	12.0	12.0
Central Deccan Plateau dry deciduous forests	240677	0.65	0.16	4	1	3	4.0	4.0	4.0	4.0
Central Indochina dry forests	320854	0.17	0.00	14	3	11	14.0	14.0	14.0	14.0
Central Korean deciduous forests	104749	4.77	0.92	1	0	1	1.0	1.0	1.0	1.0
Changjiang Plain evergreen forests	438855	6.52	0.51	10	0	10	9.9	10.0	9.9	10.0
Chao Phraya freshwater swamp forests	39102	20.32	0.06	11	2	9	10.7	11.0	10.5	11.0
Chao Phraya lowland moist deciduous forests	20517	3.16	0.03	1	0	1	1.0	1.0	1.0	1.0
Cherskii-Kolyma mountain tundra	557883	0.01	0.01	0	0	0	0.0	0.0	0.0	0.0
Chukchi Peninsula tundra	298986	1.40	0.65	0	0	0	0.0	0.0	0.0	0.0
Deccan thorn scrub forests	340967	1.32	0.43	15	3	12	15.0	15.0	15.0	15.0
East Deccan dry-evergreen forests	25583	25.24	8.38	3	0	3	2.9	3.0	2.8	2.9
East Siberian taiga	3908414	0.02	0.02	0	0	0	0.0	0.0	0.0	0.0
Eastern highlands moist deciduous forests	341677	0.92	0.33	6	2	4	6.0	6.0	6.0	6.0
Goadavari-Krishna mangroves	6997	70.60	37.20	11	3	8	9.5	10.4	8.6	10.0
Guinean forest-savanna mosaic	675071	0.51	0.09	47	6	41	47.0	47.0	47.0	47.0
Guinean mangroves	23675	26.99	4.68	1	0	1	1.0	1.0	0.9	1.0
Gulf of Oman desert and semi-desert	62610	3.33	0.59	2	0	2	2.0	2.0	2.0	2.0
Huang He Plain mixed forests	435176	5.21	0.04	2	0	2	2.0	2.0	2.0	2.0
Indochina mangroves	26948	80.00	57.75	8	2	6	6.6	7.2	5.8	6.7
Indus River Delta-Arabian Sea mangroves	5802	45.43	8.10	1	0	1	0.9	1.0	0.9	1.0
Jian Nan subtropical evergreen forests	665300	0.45	0.24	33	7	26	33.0	33.0	33.0	33.0
Kamchatka Mountain tundra and forest tundra	119518	0.76	0.15	0	0	0	0.0	0.0	0.0	0.0
Kamchatka-Kurile meadows and sparse forests	146771	3.83	1.07	0	0	0	0.0	0.0	0.0	0.0
Khathiar-Gir dry deciduous forests	267763	0.47	0.03	2	0	2	2.0	2.0	2.0	2.0
Lesser Sundas deciduous forests	39542	3.82	2.65	46	12	34	45.8	45.8	45.6	45.8
Lower Gangetic Plains moist deciduous forests	254698	11.66	0.30	10	1	9	9.8	10.0	9.8	10.0

Madagascar dry deciduous forests	152452	1.08	0.10	123	26	97	122.8	123.0	122.7	123.0
Madagascar lowland forests	112319	1.57	0.23	313	83	230	312.4	312.9	312.0	312.9
Madagascar mangroves	5192	6.70	1.16	7	0	7	6.9	7.0	6.9	7.0
Madagascar spiny thickets	43477	0.72	0.32	77	17	60	76.9	77.0	76.9	77.0
Madagascar succulent woodlands	79907	0.41	0.01	31	4	27	31.0	31.0	31.0	31.0
Malabar Coast moist forests	35544	15.50	4.14	28	5	23	27.4	27.9	27.1	27.8
Manchurian mixed forests	505177	0.36	0.05	1	0	1	1.0	1.0	1.0	1.0
Mizoram-Manipur-Kachin rain forests	135864	0.00	0.00	23	4	19	23.0	23.0	23.0	23.0
Myanmar Coast mangroves	21410	26.36	4.52	2	0	2	1.9	2.0	1.9	2.0
Myanmar coastal rain forests	66711	10.40	0.60	16	3	13	15.8	16.0	15.7	16.0
North Western Ghats moist deciduous forests	48357	0.16	0.03	19	1	18	19.0	19.0	19.0	19.0
Northeast China Plain deciduous forests	232977	4.00	0.33	6	3	3	6.0	6.0	6.0	6.0
Northeast Siberian coastal tundra	223112	9.52	1.25	0	0	0	0.0	0.0	0.0	0.0
Northeast Siberian taiga	1128358	0.34	0.06	0	0	0	0.0	0.0	0.0	0.0
Northern Vietnam lowland rain forests	22695	4.35	0.36	8	1	7	8.0	8.0	7.9	8.0
Northwest Russian-Novaya Zemlya tundra	284890	2.40	0.76	0	0	0	0.0	0.0	0.0	0.0
Northwestern thorn scrub forests	489387	2.66	0.11	17	4	13	16.9	17.0	16.9	17.0
Okhotsk-Manchurian taiga	402820	0.86	0.19	0	0	0	0.0	0.0	0.0	0.0
Orissa semi-evergreen forests	22366	22.45	10.07	6	0	6	5.8	5.9	5.7	5.9
Peninsular Malaysian peat swamp forests	3669	6.98	74.84	1	0	1	1.0	0.8	1.0	0.8
Peninsular Malaysian rain forests	125637	6.00	0.30	32	7	25	31.8	32.0	31.6	32.0
Persian Gulf desert and semi-desert	72860	7.20	0.00	0	0	0	0.0	0.0	0.0	0.0
Pontic steppe	996270	0.89	0.12	6	2	4	6.0	6.0	6.0	6.0
Rann of Kutch seasonal salt marsh	28072	61.15	1.02	4	0	4	3.6	4.0	3.5	4.0
Red River freshwater swamp forests	10739	40.53	4.63	0	0	0	0.0	0.0	0.0	0.0
Red Sea coastal desert	59493	1.80	0.32	2	1	1	2.0	2.0	2.0	2.0



	Red Sea Nubo-Sindian tropical desert and semi-desert	653010	0.26	0.03	1	0	1	1.0	1.0	1.0	1.0
	South China-Vietnam subtropical evergreen forests	224929	2.48	0.41	33	6	27	32.9	33.0	32.9	33.0
	South Iran Nubo-Sindian desert and semi-desert	352341	3.21	0.37	5	0	5	5.0	5.0	5.0	5.0
	South Sakhalin-Kurile mixed forests	12556	1.45	0.63	0	0	0	0.0	0.0	0.0	0.0
	South Taiwan monsoon rain forests	2584	8.05	2.79	26	0	26	25.7	25.9	25.6	25.9
	Southeastern Indochina dry evergreen forests	124533	1.08	0.04	7	0	7	7.0	7.0	7.0	7.0
	Southern Korea evergreen forests	14720	9.49	4.12	2	1	1	2.0	2.0	2.0	2.0
	Southern Vietnam lowland dry forests	35082	2.86	1.05	10	1	9	10.0	10.0	9.9	10.0
	Southwestern Arabian foothills savanna	275077	0.00	0.00	8	0	8	8.0	8.0	8.0	8.0
	Sri Lanka dry-zone dry evergreen forests	48526	5.72	1.62	51	10	41	50.6	50.9	50.4	50.8
	Sri Lanka lowland rain forests	12587	3.14	0.75	59	7	52	58.8	58.9	58.6	58.9
	Suiphun-Khanka meadows and forest meadows	33797	0.32	0.04	0	0	0	0.0	0.0	0.0	0.0
	Sundarbans freshwater swamp forests	14607	41.95	1.20	2	0	2	1.9	2.0	1.8	2.0
	Sundarbans mangroves	20455	72.71	23.84	3	0	3	2.6	2.9	2.5	2.9
	Taimyr-Central Siberian tundra	956921	2.35	0.85	0	0	0	0.0	0.0	0.0	0.0
	Taiwan subtropical evergreen forests	33528	4.57	1.42	40	6	34	39.8	39.9	39.7	39.9
	Tigris-Euphrates alluvial salt marsh	35666	1.71	0.68	1	0	1	1.0	1.0	1.0	1.0
	Tonle Sap freshwater swamp forests	26095	44.33	21.16	6	1	5	5.6	5.8	5.3	5.7
	Tonle Sap-Mekong peat swamp forests	29408	58.77	22.93	1	0	1	0.9	1.0	0.8	0.9
	Ussuri broadleaf and mixed forests	197864	0.16	0.05	0	0	0	0.0	0.0	0.0	0.0
	West Siberian taiga	1674101	0.27	0.01	0	0	0	0.0	0.0	0.0	0.0
	Yamal-Gydan tundra	413018	4.52	1.16	0	0	0	0.0	0.0	0.0	0.0
	Yellow Sea saline meadow	5321	53.58	1.82	1	0	1	0.9	1.0	0.9	1.0
Asia/Europe	Euxine-Colchic broadleaf forests	74596	1.44	0.44	2	0	2	2.0	2.0	2.0	2.0
	Crimean Submediterranean forest complex	30240	0.06	0.02	0	0	0	0.0	0.0	0.0	0.0
	Southern Anatolian montane conifer and deciduous forests	76674	0.07	0.05	2	0	2	2.0	2.0	2.0	2.0

Asia/ Europe/North America	Arctic coastal tundra	98272	13.56	7.55	0	0	0	0.0	0.0	0.0	0.0
	Arctic desert	161756	2.44	1.80	0	0	0	0.0	0.0	0.0	0.0
	Arctic foothills tundra	129417	1.27	0.92	0	0	0	0.0	0.0	0.0	0.0
	High Arctic tundra	464713	6.34	4.08	1	0	1	1.0	1.0	1.0	1.0
	Low Arctic tundra	798421	3.64	1.95	0	0	0	0.0	0.0	0.0	0.0
	Middle Arctic tundra	1035068	5.43	3.13	0	0	0	0.0	0.0	0.0	0.0
Asia/North America	Beringia lowland tundra	151223	22.82	9.23	3	0	3	2.9	3.0	2.9	3.0
	Beringia upland tundra	97577	1.91	0.80	3	0	3	3.0	3.0	3.0	3.0
Australia	Arnhem Land tropical savanna	158466	13.06	8.39	49	11	38	48.2	48.5	47.7	48.2
	Biak-Numfoor rain forests	2827	23.03	15.35	28	10	18	27.1	27.4	26.6	27.1
	Brigalow tropical savanna	343173	0.98	0.63	39	7	32	39.0	39.0	38.9	39.0
	Cape York Peninsula tropical savanna	116646	9.67	5.91	72	17	55	71.1	71.5	70.6	71.1
	Carnarvon xeric shrublands	90736	4.83	2.33	38	6	32	37.8	37.9	37.7	37.9
	Carpentaria tropical savanna	360428	4.30	2.14	21	4	17	20.9	20.9	20.8	20.9
	Coolgardie woodlands	137666	0.97	0.38	2	0	2	2.0	2.0	2.0	2.0
	Eastern Australian temperate forests	222501	3.78	2.68	121	39	82	120.4	120.6	120.3	120.5
	Esperance mallee	6526	66.66	50.37	21	4	17	18.3	19.3	17.8	18.9
	Eyre and York mallee	61017	7.24	3.86	12	2	10	11.9	11.9	11.9	11.9
	Jarraah-Karri forest and shrublands	10465	5.69	2.53	15	0	15	14.9	15.0	14.9	14.9
	Kimberly tropical savanna	348683	3.68	2.27	106	31	75	105.5	105.7	105.2	105.5
	Mount Lofty woodlands	23818	1.78	0.88	8	1	7	8.0	8.0	8.0	8.0
	Murray-Darling woodlands and mallee	198388	0.04	0.01	12	1	11	12.0	12.0	12.0	12.0
	Naracoorte woodlands	27579	5.28	2.49	4	0	4	4.0	4.0	4.0	4.0
	Nullarbor Plains xeric shrublands	195721	0.59	0.24	4	1	3	4.0	4.0	4.0	4.0
Pilbara shrublands	179992	1.84	0.99	31	9	22	30.9	31.0	30.9	30.9	
Queensland tropical rain forests	32740	6.20	4.14	123	31	92	122.0	122.4	121.4	122.0	

	Southeast Australia temperate forests	272908	2.24	1.56	34	7	27	33.9	33.9	33.9	33.9
	Southwest Australia savanna	169277	0.73	0.52	41	5	36	41.0	41.0	41.0	41.0
	Southwest Australia woodlands	46160	0.62	0.39	22	1	21	22.0	22.0	22.0	22.0
	Tasmanian Central Highland forests	18694	0.77	0.64	14	1	13	14.0	14.0	14.0	14.0
	Tasmanian temperate forests	18299	13.32	9.55	12	0	12	11.8	11.9	11.7	11.8
	Tasmanian temperate rain forests	31370	6.00	4.65	16	2	14	15.9	15.9	15.8	15.9
	Tirari-Sturt stony desert	377742	0.08	0.04	14	2	12	14.0	14.0	14.0	14.0
	Victoria Plains tropical savanna	226271	0.00	0.03	9	0	9	9.0	9.0	9.0	9.0
Europe	Atlantic mixed forests	399925	9.65	4.17	0	0	0	0.0	0.0	0.0	0.0
	Balkan mixed forests	224882	0.57	0.07	5	0	5	5.0	5.0	5.0	5.0
	Baltic mixed forests	116832	8.14	2.34	0	0	0	0.0	0.0	0.0	0.0
	Caledon conifer forests	22056	0.53	0.36	0	0	0	0.0	0.0	0.0	0.0
	Cantabrian mixed forests	79889	0.78	0.14	6	1	5	6.0	6.0	6.0	6.0
	Celtic broadleaf forests	209601	3.98	2.18	0	0	0	0.0	0.0	0.0	0.0
	Central European mixed forests	732883	0.22	0.04	0	0	0	0.0	0.0	0.0	0.0
	Crete Mediterranean forests	8196	1.84	1.22	4	1	3	4.0	4.0	4.0	4.0
	Cyprus Mediterranean forests	9279	2.94	2.52	13	4	9	13.0	13.0	12.9	12.9
	East European forest steppe	728773	0.00	0.00	1	0	1	1.0	1.0	1.0	1.0
	Eastern Mediterranean conifer-sclerophyllous-broadleaf forests	144130	0.78	0.34	8	3	5	8.0	8.0	8.0	8.0
	English Lowlands beech forests	45710	6.46	3.70	0	0	0	0.0	0.0	0.0	0.0
	Fiordland temperate forests	11050	0.47	0.24	6	1	5	6.0	6.0	6.0	6.0
	Iberian sclerophyllous and semi-deciduous forests	298264	0.06	0.00	3	0	3	3.0	3.0	3.0	3.0
	Illyrian deciduous forests	40685	3.80	0.37	10	1	9	10.0	10.0	9.9	10.0
	Italian sclerophyllous and semi-deciduous forests	102274	2.17	0.20	5	1	4	5.0	5.0	5.0	5.0
	Kola Peninsula tundra	58851	0.88	0.63	0	0	0	0.0	0.0	0.0	0.0
	North Atlantic moist mixed forests	38712	4.84	3.26	0	0	0	0.0	0.0	0.0	0.0

	Northeastern Spain and Southern France Mediterranean forests	90952	3.73	1.81	6	2	4	6.0	6.0	6.0	6.0
	Po Basin mixed forests	42415	15.46	3.94	1	0	1	1.0	1.0	1.0	1.0
	Sarmatic mixed forests	848072	0.53	0.14	0	0	0	0.0	0.0	0.0	0.0
	Scandinavian and Russian taiga	2161779	0.20	0.08	0	0	0	0.0	0.0	0.0	0.0
	Scandinavian coastal conifer forests	19294	4.76	2.31	0	0	0	0.0	0.0	0.0	0.0
	Scandinavian Montane Birch forest and grasslands	243800	0.59	0.44	0	0	0	0.0	0.0	0.0	0.0
	Southeastern Iberian shrubs and woodlands	2868	3.14	1.01	1	0	1	1.0	1.0	1.0	1.0
	Southwest Iberian Mediterranean sclerophyllous and mixed forests	71272	2.39	0.46	1	0	1	1.0	1.0	1.0	1.0
	Tyrrhenian-Adriatic Sclerophyllous and mixed forests	85226	2.49	0.55	16	3	13	16.0	16.0	15.9	16.0
Islands	Admiralty Islands lowland rain forests	2151	26.78	18.92	24	6	18	23.1	23.4	22.6	23.0
	Aldabra Island xeric scrub	176	10.23	10.23	15	4	11	14.8	14.8	14.7	14.7
	Amsterdam and Saint-Paul Islands temperate grasslands	65	3.08	3.08	0	0	0	0.0	0.0	0.0	0.0
	Andaman Islands rain forests	5700	38.39	29.18	27	10	17	25.4	25.9	24.5	25.2
	Antipodes Subantarctic Islands tundra	891	30.08	25.59	12	4	8	11.5	11.6	11.4	11.5
	Ascension scrub and grasslands	88	18.18	12.50	0	0	0	0.0	0.0	0.0	0.0
	Azores temperate mixed forests	2618	8.40	6.26	3	1	2	3.0	3.0	3.0	3.0
	Bahamian pine mosaic	2092	68.83	13.67	19	3	16	16.4	18.7	15.9	18.6
	Banda Sea Islands moist deciduous forests	7561	41.04	31.56	57	11	46	53.4	54.4	51.3	52.9
	Bermuda subtropical conifer forests	43	37.21	30.23	1	0	1	0.9	1.0	0.9	0.9
	Borneo lowland rain forests	428373	3.59	2.53	36	7	29	35.8	35.9	35.7	35.8
	Borneo montane rain forests	115842	0.00	0.00	39	0	39	39.0	39.0	39.0	39.0
	Borneo peat swamp forests	67737	21.13	15.28	6	0	6	5.8	5.9	5.7	5.8
	Buru rain forests	8655	1.40	0.85	39	6	33	38.9	39.0	38.9	38.9
	Canary Islands dry woodlands and forests	5004	0.06	0.06	25	7	18	25.0	25.0	25.0	25.0
	Cantebury-Otago tussock grasslands	53604	0.88	0.33	5	0	5	5.0	5.0	5.0	5.0
	Cape Verde Islands dry forests	4625	9.25	6.90	33	12	21	32.6	32.7	32.4	32.5

Carolines tropical moist forests	578	21.28	17.65	28	6	22	27.2	27.3	26.7	26.9
Cayos Miskitos-San Andrés and Providencia moist forests	90	21.11	4.44	7	2	5	6.8	7.0	6.7	6.9
Central Polynesian tropical moist forests	621	88.57	83.74	2	1	1	1.5	1.6	1.3	1.4
Chatham Island temperate forests	807	38.17	32.09	0	0	0	0.0	0.0	0.0	0.0
Christmas and Cocos Islands tropical forests	134	8.21	7.46	4	2	2	4.0	4.0	3.9	3.9
Clipperton Island shrub and grasslands	5	100.00	100.00	0	0	0	0.0	0.0	0.0	0.0
Comoros forests	2076	2.31	1.69	44	13	31	43.9	43.9	43.8	43.9
Cook Islands tropical moist forests	206	28.64	23.79	12	4	8	11.5	11.6	11.2	11.4
Cuban cactus scrub	3313	14.97	3.74	35	0	35	34.3	34.8	34.1	34.8
Cuban dry forests	65845	8.88	0.86	41	0	41	40.5	41.0	40.2	40.9
Cuban moist forests	21392	6.79	1.89	47	1	46	46.6	46.9	46.5	46.9
Cuban pine forests	6427	7.76	1.09	38	0	38	37.6	37.9	37.4	37.9
Cuban wetlands	5664	86.58	27.37	43	0	43	33.5	41.3	28.8	40.3
Eastern Java-Bali montane rain forests	15861	0.18	0.14	19	0	19	19.0	19.0	19.0	19.0
Eastern Java-Bali rain forests	54146	7.93	5.07	12	0	12	11.9	11.9	11.8	11.9
Eastern Micronesia tropical moist forests	531	46.89	45.76	5	1	4	4.6	4.6	4.4	4.4
Enriquillo wetlands	628	2.55	0.48	42	0	42	41.9	42.0	41.8	42.0
Faroe Islands boreal grasslands	1456	3.50	2.13	0	0	0	0.0	0.0	0.0	0.0
Fernando de Noronha-Atol das Rocas moist forests	17	52.94	47.06	3	1	2	2.7	2.8	2.6	2.6
Fiji tropical dry forests	6923	11.14	7.67	2	0	2	2.0	2.0	2.0	2.0
Fiji tropical moist forests	11654	9.56	7.53	44	10	34	43.5	43.6	43.1	43.3
Galapagos Galapagos Islands scrubland mosaic	8005	7.66	4.51	71	18	53	70.3	70.6	69.9	70.4
Granitic Seychelles forests	322	19.25	14.29	38	10	28	37.0	37.3	36.4	36.9
Greater Negros-Panay rain forests	35102	5.41	1.65	111	26	85	110.2	110.8	109.8	110.6
Halmahera rain forests	26875	5.91	3.86	64	13	51	63.5	63.7	63.2	63.5
Hawaii tropical dry forests	6658	1.89	0.50	24	0	24	23.9	24.0	23.9	24.0

Hawaii tropical low shrublands	1532	10.05	2.55	13	0	13	12.8	13.0	12.7	12.9
Hawaii tropical moist forests	6735	1.02	0.40	36	5	31	36.0	36.0	35.9	36.0
Hispaniolan dry forests	15527	6.23	2.45	50	0	50	49.6	49.8	49.4	49.8
Hispaniolan moist forests	46006	1.48	0.19	62	5	57	61.9	62.0	61.8	62.0
Hokkaido deciduous forests	25613	3.82	0.52	0	0	0	0.0	0.0	0.0	0.0
Hokkaido montane conifer forests	45823	1.73	0.16	0	0	0	0.0	0.0	0.0	0.0
Honshu alpine conifer forests	11509	0.85	0.46	7	0	7	7.0	7.0	7.0	7.0
Huon Peninsula montane rain forests	16574	1.63	1.16	23	1	22	23.0	23.0	22.9	22.9
Iceland boreal birch forests and alpine tundra	91614	1.92	0.59	0	0	0	0.0	0.0	0.0	0.0
Ile Europa and Bassas da India xeric scrub	3223	26.99	14.74	0	0	0	0.0	0.0	0.0	0.0
Islas Revillagigedo dry forests	218	73.39	73.39	11	3	8	9.3	9.3	8.5	8.5
Jamaican dry forests	2345	4.01	0.38	51	0	51	50.7	51.0	50.6	51.0
Jamaican moist forests	8334	0.44	0.12	56	2	54	56.0	56.0	56.0	56.0
Juan Fernández Islands temperate forests	146	34.25	31.51	8	4	4	7.6	7.6	7.5	7.6
Kermadec Islands subtropical moist forests	35	5.71	5.71	0	0	0	0.0	0.0	0.0	0.0
Leeward Islands moist forests	998	14.13	13.13	23	1	22	22.6	22.6	22.3	22.4
Lesser Antillean dry forests	144	65.97	65.28	14	0	14	12.2	12.3	11.3	11.3
Lord Howe Island subtropical forests	18	61.11	55.56	4	1	3	3.6	3.6	3.5	3.5
Louisiade Archipelago rain forests	1625	43.26	35.38	12	2	10	11.2	11.4	10.7	11.0
Luzon rain forests	95382	3.07	0.70	132	16	116	131.5	131.9	131.2	131.8
Maldives-Lakshadweep-Chagos Archipelago tropical moist forests	297	22.56	21.89	0	0	0	0.0	0.0	0.0	0.0
Marianas tropical dry forests	1039	12.61	0.48	17	3	14	16.7	17.0	16.6	17.0
Marquesas tropical moist forests	1083	17.54	13.11	19	8	11	18.6	18.7	18.3	18.5
Mascarene forests	4932	1.26	0.81	37	13	24	36.9	37.0	36.9	36.9
Mentawai Islands rain forests	6517	16.39	11.92	28	8	20	27.4	27.6	27.0	27.3
Mindanao-Eastern Visayas rain forests	105386	3.43	1.00	129	9	120	128.4	128.8	128.1	128.7

Mindoro rain forests	10115	3.64	1.29	40	2	38	39.8	39.9	39.7	39.9
Nansei Islands subtropical evergreen forests	4094	4.47	2.30	84	33	51	83.5	83.8	83.4	83.7
Nelson Coast temperate forests	14601	0.66	0.51	5	0	5	5.0	5.0	5.0	5.0
New Britain-New Ireland lowland rain forests	35087	8.08	5.26	72	8	64	71.3	71.5	70.8	71.2
New Britain-New Ireland montane rain forests	12133	0.08	0.06	40	2	38	40.0	40.0	40.0	40.0
New Caledonia dry forests	4420	9.86	7.40	28	0	28	27.6	27.7	27.4	27.6
New Caledonia rain forests	14570	6.47	4.47	42	5	37	41.7	41.8	41.4	41.6
New Guinea mangroves	26808	79.43	68.12	11	0	11	9.0	9.5	8.0	8.8
Nicobar Islands rain forests	1688	12.68	10.37	14	1	13	13.8	13.8	13.6	13.7
Nihonkai evergreen forests	21714	9.50	1.46	13	4	9	12.8	13.0	12.8	13.0
Nihonkai montane deciduous forests	82477	1.06	0.36	14	1	13	14.0	14.0	14.0	14.0
North Island temperate forests	84597	1.40	0.55	12	0	12	12.0	12.0	12.0	12.0
Northern New Guinea lowland rain and freshwater swamp forests	135470	4.30	1.98	35	5	30	34.8	34.9	34.7	34.9
Northern New Guinea montane rain forests	23398	0.68	0.09	21	3	18	21.0	21.0	21.0	21.0
Northland temperate kauri forests	29963	5.12	1.79	23	3	20	22.9	22.9	22.8	22.9
Northwestern Hawaii scrub	11	63.64	36.36	8	3	5	7.1	7.6	6.9	7.5
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Novosibirsk Islands arctic desert	37031	18.77	8.34	0	0	0	0.0	0.0	0.0	0.0
Ogasawara subtropical moist forests	94	7.45	4.26	4	2	2	4.0	4.0	4.0	4.0
Palau tropical moist forests	473	32.14	25.58	21	4	17	20.0	20.2	19.4	19.8
Palawan rain forests	14344	5.25	3.02	80	21	59	79.5	79.7	79.1	79.5
Puerto Rican dry forests	1327	11.30	2.71	33	1	32	32.5	32.9	32.2	32.8
Puerto Rican moist forests	7489	5.59	1.08	38	2	36	37.7	37.9	37.6	37.9
Rakiura Island temperate forests	1692	4.43	3.01	5	1	4	5.0	5.0	5.0	5.0
Rapa Nui subtropical broadleaf forests	166	12.05	9.64	0	0	0	0.0	0.0	0.0	0.0
Richmond temperate forests	13268	1.86	0.99	17	3	14	17.0	17.0	17.0	17.0
Sakhalin Island taiga	68903	3.97	1.06	0	0	0	0.0	0.0	0.0	0.0

Samoan tropical moist forests	3110	9.23	6.95	25	6	19	24.7	24.8	24.5	24.6
San Félix-San Ambrosio Islands temperate forests	6	16.67	16.67	0	0	0	0.0	0.0	0.0	0.0
Scotia Sea Islands tundra	8474	4.39	2.38	3	1	2	3.0	3.0	3.0	3.0
Seram rain forests	19455	4.67	3.10	54	12	42	53.7	53.8	53.5	53.7
Society Islands tropical moist forests	1611	7.01	5.09	11	2	9	10.9	10.9	10.8	10.9
Socotra Island xeric shrublands	3799	3.69	1.40	48	18	30	47.8	47.9	47.6	47.9
Solomon Islands rain forests	35902	9.94	6.97	159	45	114	157.0	157.6	155.7	156.7
South China Sea Islands	35	2.86	2.86	0	0	0	0.0	0.0	0.0	0.0
South Island montane grasslands	40009	0.03	0.02	7	1	6	7.0	7.0	7.0	7.0
South Island temperate forests	11706	1.41	0.11	3	0	3	3.0	3.0	3.0	3.0
Southeastern Papuan rain forests	77531	3.80	2.42	72	4	68	71.7	71.8	71.4	71.6
Southern Indian Ocean Islands tundra	8142	19.58	16.76	0	0	0	0.0	0.0	0.0	0.0
Southern New Guinea freshwater swamp forests	100189	40.87	32.47	17	0	17	15.9	16.2	15.3	15.7
Southern New Guinea lowland rain forests	123094	29.44	23.96	18	0	18	17.2	17.4	16.8	17.0
Southwest Borneo freshwater swamp forests	36821	25.85	16.88	1	0	1	1.0	1.0	0.9	1.0
St. Helena scrub and woodlands	127	0.79	0.79	2	1	1	2.0	2.0	2.0	2.0
Sulawesi lowland rain forests	116652	6.60	4.28	127	29	98	125.9	126.3	125.3	125.9
Sulawesi montane rain forests	75909	0.07	0.06	98	21	77	98.0	98.0	98.0	98.0
Sulu Archipelago rain forests	2363	30.77	25.86	33	5	28	31.5	31.8	30.7	31.1
Sumatran freshwater swamp forests	18144	19.39	4.61	0	0	0	0.0	0.0	0.0	0.0
Sumatran lowland rain forests	260064	2.65	1.27	33	3	30	32.9	32.9	32.8	32.9
Sumatran peat swamp forests	87740	43.13	11.04	6	1	5	5.6	5.9	5.4	5.9
Sumba deciduous forests	10796	2.77	1.82	15	3	12	14.9	15.0	14.9	14.9
Sunda Shelf mangroves	37493	76.93	54.86	1	0	1	0.8	0.9	0.7	0.9
Sundaland heath forests	76805	10.65	7.42	2	0	2	2.0	2.0	2.0	2.0
Taiheiyō evergreen forests	138541	6.31	1.25	27	7	20	26.8	27.0	26.7	26.9



	Taiheiyō montane deciduous forests	42047	0.15	0.02	13	0	13	13.0	13.0	13.0	13.0
	Timor and Wetar deciduous forests	33607	3.32	2.26	47	7	40	46.8	46.9	46.7	46.8
	Tongan tropical moist forests	931	56.39	51.34	12	1	11	10.8	11.0	10.2	10.4
	Trans Fly savanna and grasslands	26854	32.58	21.54	11	1	10	10.5	10.7	10.2	10.5
	Trinidad and Tobago moist forests	4759	5.95	3.19	86	1	85	85.3	85.7	85.0	85.4
	Tristan Da Cunha-Gough Islands shrub and grasslands	161	1.86	0.62	7	1	6	7.0	7.0	7.0	7.0
	Trobriand Islands rain forests	4207	23.72	18.75	13	2	11	12.6	12.7	12.3	12.5
	Tuamotu tropical moist forests	920	56.85	55.00	18	6	12	16.2	16.3	15.2	15.4
	Tubuai tropical moist forests	141	17.02	13.48	4	1	3	3.9	3.9	3.9	3.9
	Vanuatu rain forests	13218	12.56	0.00	50	14	36	49.2	50.0	48.7	50.0
	Vogelkop montane rain forests	22033	0.35	41.37	31	4	27	31.0	29.0	31.0	27.9
	Vogelkop-Aru lowland rain forests	77454	17.01	1.40	30	1	29	29.3	29.9	28.9	29.9
	Western Java rain forests	41660	10.71	4.67	14	0	14	13.8	13.9	13.7	13.9
	Western Polynesian tropical moist forests	84	60.71	55.95	0	0	0	0.0	0.0	0.0	0.0
	Windward Islands moist forests	2017	29.35	28.81	44	8	36	42.1	42.2	41.1	41.1
	Wrangel Island arctic desert	7554	4.79	1.51	0	0	0	0.0	0.0	0.0	0.0
	Yap tropical dry forests	97	20.62	4.12	11	2	9	10.7	10.9	10.5	10.9
North America	Alaska Peninsula montane taiga	47871	3.45	2.79	0	0	0	0.0	0.0	0.0	0.0
	Alaska-St. Elias Range tundra	152249	0.10	0.08	0	0	0	0.0	0.0	0.0	0.0
	Aleutian Islands tundra	5499	5.76	5.16	8	3	5	7.9	7.9	8.0	8.0
	Atlantic coastal pine barrens	8975	15.08	1.25	2	1	1	2.0	2.0	2.0	2.0
	Baffin coastal tundra	9110	5.97	4.24	0	0	0	0.0	0.0	0.0	0.0
	Baja California desert	77875	4.24	0.27	95	5	90	94.5	95.0	94.4	95.0
	Belizian pine forests	2829	2.44	0.35	130	0	130	129.6	129.9	129.4	129.9
	Bering tundra	475307	1.54	0.54	0	0	0	0.0	0.0	0.0	0.0
	British Columbia mainland coastal forests	137478	0.63	0.45	0	0	0	0.0	0.0	0.0	0.0

California coastal sage and chaparral	36377	1.40	0.45	35	5	30	34.9	35.0	34.9	35.0
California interior chaparral and woodlands	64665	1.27	0.38	14	3	11	14.0	14.0	14.0	14.0
California montane chaparral and woodlands	20515	0.12	0.03	8	2	6	8.0	8.0	8.0	8.0
Central American Atlantic moist forests	89717	2.59	0.91	174	4	170	173.4	173.8	173.1	173.7
Central American dry forests	68248	2.14	0.36	191	1	190	190.5	190.9	190.2	190.9
Central Pacific coastal forests	73892	1.26	0.32	8	2	6	8.0	8.0	8.0	8.0
Cook Inlet taiga	27893	2.71	1.22	0	0	0	0.0	0.0	0.0	0.0
Costa Rican seasonal moist forests	10712	0.69	0.35	195	0	195	194.8	194.9	194.7	194.9
Davis Highlands tundra	88024	2.40	2.16	0	0	0	0.0	0.0	0.0	0.0
Eastern Canadian forests	487966	2.43	1.59	2	1	1	2.0	2.0	2.0	2.0
Eastern Canadian Shield taiga	755343	1.18	0.77	0	0	0	0.0	0.0	0.0	0.0
Eastern forest-boreal transition	348450	0.00	0.00	0	0	0	0.0	0.0	0.0	0.0
Eastern Great Lakes lowland forests	116727	0.08	0.01	1	0	1	1.0	1.0	1.0	1.0
Everglades	20149	91.21	9.38	2	0	2	1.5	2.0	1.4	2.0
Florida sand pine scrub	3876	21.88	1.39	5	0	5	4.8	5.0	4.8	5.0
Gulf of California xeric scrub	23641	2.15	1.00	119	18	101	118.7	118.9	118.6	118.8
Gulf of St. Lawrence lowland forests	39455	3.74	0.74	0	0	0	0.0	0.0	0.0	0.0
Interior Alaska-Yukon lowland taiga	444388	0.41	0.16	0	0	0	0.0	0.0	0.0	0.0
Jalisco dry forests	26126	2.39	0.57	176	2	174	175.5	175.9	175.2	175.8
Kalaallit Nunaat high arctic tundra	304455	1.54	1.14	0	0	0	0.0	0.0	0.0	0.0
Kalaallit Nunaat low arctic tundra	171449	6.16	5.22	0	0	0	0.0	0.0	0.0	0.0
Middle Atlantic coastal forests	133839	23.86	5.42	3	1	2	2.9	3.0	2.9	3.0
Miskito pine forests	18904	16.30	3.03	128	0	128	125.2	127.5	123.5	127.2
Mississippi lowland forests	112551	13.76	1.83	0	0	0	0.0	0.0	0.0	0.0
New England-Acadian forests	238049	0.62	0.27	1	0	1	1.0	1.0	1.0	1.0
Newfoundland Highland forests	16394	0.29	0.16	0	0	0	0.0	0.0	0.0	0.0

Northeastern coastal forests	89895	3.23	0.31	0	0	0	0.0	0.0	0.0	0.0
Northern California coastal forests	13292	1.35	0.15	9	2	7	9.0	9.0	9.0	9.0
Northern Canadian Shield taiga	614970	0.01	0.00	0	0	0	0.0	0.0	0.0	0.0
Northern Pacific coastal forests	60613	4.90	3.10	0	0	0	0.0	0.0	0.0	0.0
Northwest Territories taiga	346639	2.21	2.16	0	0	0	0.0	0.0	0.0	0.0
Pacific Coastal Mountain icefields and tundra	107055	0.56	0.34	0	0	0	0.0	0.0	0.0	0.0
Panamanian dry forests	5141	4.20	0.29	144	0	144	143.2	143.9	142.8	143.9
Pantanos de Centla	17209	42.67	9.61	126	0	126	117.6	124.4	112.8	123.5
PetOnPeten-Veracruz moist forests	149472	2.67	0.73	298	17	281	297.0	297.7	296.4	297.6
Puget lowland forests	22551	3.89	0.95	0	0	0	0.0	0.0	0.0	0.0
Queen Charlotte Islands	10001	2.21	1.71	0	0	0	0.0	0.0	0.0	0.0
San Lucan xeric scrub	3902	3.02	1.28	69	0	69	68.7	68.9	68.7	68.9
Sierra de la Laguna dry forests	3994	0.23	0.13	59	1	58	59.0	59.0	59.0	59.0
Sierra de los Tuxtlas	3882	4.56	1.98	157	9	148	156.1	156.6	155.5	156.4
Sierra Madre de Chiapas moist forests	11290	0.25	0.00	196	5	191	195.9	196.0	195.9	196.0
Sinaloan dry forests	77810	2.35	0.12	185	7	178	184.5	185.0	184.3	185.0
Sonoran desert	223498	1.60	0.05	59	6	53	58.9	59.0	58.9	59.0
Sonoran-Sinaloan transition subtropical dry forest	51153	1.82	0.30	0	0	0	0.0	0.0	0.0	0.0
South Avalon-Burin oceanic barrens	2043	22.17	13.12	0	0	0	0.0	0.0	0.0	0.0
South Florida rocklands	2076	96.10	7.76	4	1	3	2.7	4.0	2.4	4.0
Southeastern conifer forests	237108	7.34	0.64	28	8	20	27.7	28.0	27.7	28.0
Southeastern mixed forests	348535	0.35	0.11	9	0	9	9.0	9.0	9.0	9.0
Southern Hudson Bay taiga	374503	6.59	3.16	0	0	0	0.0	0.0	0.0	0.0
Southern Pacific dry forests	42597	2.68	1.77	254	9	245	253.1	253.4	252.6	253.1
Tongat Mountain tundra	32360	0.62	0.47	0	0	0	0.0	0.0	0.0	0.0
Veracruz dry forests	6655	1.98	0.53	112	2	110	111.7	111.9	111.6	111.9

	Veracruz moist forests	69276	1.50	0.78	172	7	165	171.7	171.8	171.6	171.8
	Western Gulf coastal grasslands	80784	43.88	12.27	8	1	7	7.4	7.9	7.3	7.8
	Willamette Valley forests	14881	0.27	1.33	4	2	2	4.0	4.0	4.0	4.0
	Yucatán dry forests	49791	9.46	1.28	138	5	133	136.3	137.8	135.3	137.6
	Yucatán moist forests	69865	8.39	2.14	148	4	144	146.4	147.6	145.4	147.4
South America	Alto Paraná Atlantic forests	485025	0.25	0.15	210	0	210	209.9	210.0	209.9	209.9
	Araya and Paria xeric scrub	5234	5.77	3.65	142	0	142	141.0	141.3	140.3	141.0
	Atacama desert	105425	0.03	0.01	38	1	37	38.0	38.0	38.0	38.0
	Atlantic Coast restingas	7887	45.61	23.39	124	3	121	115.0	120.0	109.8	117.6
	Bahia coastal forests	109935	3.94	2.12	172	6	166	171.1	171.5	170.6	171.3
	Bahia interior forests	230250	0.19	0.09	191	3	188	191.0	191.0	190.9	191.0
	Caatinga	736057	0.37	0.19	138	5	133	137.9	138.0	137.9	137.9
	Catatumbo moist forests	22908	2.72	0.05	188	3	185	187.4	188.0	187.0	188.0
	Chilean matorral	148799	0.24	0.14	90	13	77	90.0	90.0	90.0	90.0
	Chocó-Darién moist forests	73739	4.76	2.16	413	39	374	410.5	411.9	409.0	411.2
	Cordillera La Costa montane forests	14299	0.04	0.01	264	28	236	264.0	264.0	264.0	264.0
	Ecuadorian dry forests	21329	1.37	0.69	120	0	120	119.8	119.9	119.7	119.8
	Espinal	115822	1.32	0.64	50	1	49	49.9	50.0	49.9	50.0
	Guajira-Barranquilla xeric scrub	31699	6.54	2.02	166	1	165	164.6	165.6	163.8	165.3
	Guayaquil flooded grasslands	2936	1.40	0.20	70	0	70	69.9	70.0	69.8	70.0
	Guianan freshwater swamp forests	7769	46.31	17.51	107	0	107	99.1	104.5	94.5	103.0
	Guianan moist forests	513982	2.37	1.02	301	22	279	300.1	300.6	299.6	300.4
	Humid Pampas	241336	3.92	0.06	69	4	65	68.7	69.0	68.6	69.0
	Isthmian-Atlantic moist forests	59026	2.30	0.42	248	7	241	247.3	247.9	246.9	247.8
	Isthmian-Pacific moist forests	29332	3.11	1.42	242	9	233	241.1	241.6	240.5	241.3
	La Costa xeric shrublands	68652	0.47	0.21	172	2	170	171.9	172.0	171.8	171.9

Lara-Falcón dry forests	16991	1.92	0.98	151	1	150	150.6	150.8	150.4	150.7
Llanos	390017	0.72	0.22	203	8	195	202.8	202.9	202.7	202.9
Magdalena-Urabá moist forests	76945	0.73	0.26	210	2	208	209.8	209.9	209.7	209.9
Magellanic subpolar forests	147671	5.85	4.66	51	3	48	50.6	50.7	50.5	50.6
Malpelo Island xeric scrub	10	30.00	20.00	5	2	3	4.8	4.9	4.7	4.8
Maracaibo dry forests	30285	3.04	1.42	163	2	161	162.4	162.7	162.0	162.5
Marajó varzea	88814	78.12	56.54	101	1	100	83.7	91.1	74.6	85.6
Maranhão Babaru forests	142695	2.15	5.59	113	0	113	112.7	112.2	112.5	111.7
Northeastern Brazil restingas	10142	19.70	9.64	107	0	107	104.1	105.7	102.4	104.9
Orinoco Delta swamp forests	28196	69.56	62.80	183	2	181	157.9	161.9	144.4	150.3
Orinoco wetlands	6027	64.13	50.79	143	0	143	125.9	131.0	116.6	124.2
Paraguana xeric scrub	15941	5.66	2.05	156	2	154	154.9	155.6	154.2	155.4
Paraná Parana flooded savanna	38935	34.76	10.74	77	1	76	73.0	75.9	72.1	75.7
Patagonian steppe	488379	0.25	0.00	112	22	90	112.0	112.0	112.0	112.0
Pernambuco coastal forests	17648	4.28	3.51	129	5	124	128.3	128.4	127.9	128.1
Pernambuco interior forests	22731	4.87	2.43	114	0	114	113.3	113.7	112.9	113.4
Sechura desert	185332	2.34	1.66	132	20	112	131.6	131.7	131.4	131.6
Serra do Mar coastal forests	105163	3.60	2.00	217	9	208	216.0	216.5	215.4	216.1
Sin- u Valley dry forests	25113	4.28	0.21	191	6	185	190.0	191.0	189.3	190.9
Tapajós-Xingu moist forests	337258	0.08	0.01	164	1	163	164.0	164.0	164.0	164.0
Tocantins/Pindare moist forests	194130	5.96	1.77	150	1	149	148.9	149.7	148.2	149.5
Tumbes-Piura dry forests	41391	0.82	0.14	150	7	143	149.8	150.0	149.8	150.0
Uatuma-Trombetas moist forests	474271	0.64	0.11	175	0	175	174.9	175.0	174.8	175.0
Uruguayan savanna	356488	1.86	0.58	100	4	96	99.8	99.9	99.7	99.9
Valdivian temperate forests	248645	2.46	1.73	104	18	86	103.7	103.8	103.6	103.7
Venezuelan Andes montane forests	29449	2.40	4.61	296	30	266	295.1	294.3	294.6	293.2

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	Western Ecuador moist forests	34212	1.99	0.04	278	16	262	277.3	278.0	276.9	278.0
	Xingu-Tocantins-Araguaia moist forests	266888	9.89	5.23	155	1	154	153.0	154.0	151.8	153.4
Global	Rock and Ice	11028604	0.03	0.02	0	0	0	0.0	0.0	0.0	0.0

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