

## 1. Supplementary material

Table S1. Specific criteria of the Territorial Ecological Management Programs of the Sian Ka'an Biosphere Reserve (POETZCRBSK) regulating the use of the coastal dune.

Criteria	Description	Action
Ah-18	The construction of living places, permanent infrastructure for lodging or services is not allowed in the area between the coast and the watershed of the dune or between the edge of the aquatic system and the limit of distribution of the mangroves.	Partial regulation of the coastal dunes
Ff-5	In the Federal Maritime Terrestrial Zone and within the adjacent 20 meters from the crest of dunes on turtle beaches, only the installation of infrastructure for the management of species is allowed.	
Ff-9	Vehicular traffic on the beach and dunes is prohibited, with the exception of those for marine turtle management programs and the surveillance programs of SEDENA, SEDEMAR and SEMARNAT.	
Ff-12	The transit of horses and any other domestic or domesticated fauna for transportation or recreation on the Sian Ka'an beaches and dunes is prohibited.	
MAE-17	Inside the reserve, the removal of natural vegetation in the coastal dune is not allowed, except for the opening of pedestrian paths less than 1.5 m wide, parallel to the coast, or in a zig zag pattern if they are perpendicular to the coast. Elevated sidewalks are allowed.	
MAE-23	The extraction of mineral resources and the removal of sand from beaches and dunes, as well as the use or exploitation of slabs from the rocky intertidal zone is prohibited.	

Table S2. Ecological Planning Program for the Coastal Zone of the Sian Ka'an Biosphere Reserve (POECZSKBR), general and specific criteria related to coastal dune ecosystem.

Criteria	Description	Acción
Ah-5 to 10	It is allowed the establishment of a single-family house but will depend on the width of the beach fronts of each private property from 50m to 100m, with variable distance in meters (75m2 to 400m2) of constructed area, bathrooms and kitchen. Considering the total area of the property.	Vegetation remotion

<i>MAE-17</i>	On the properties, the removal of natural vegetation in the dune range is not permitted, except for pedestrian paths less than 1.5 m wide, parallel to the coast, or in a zig zag shape if they are perpendicular to the coast. Elevated pathways are permitted.
<i>MAE-19</i>	It is allowed the development of tourist or housing infrastructure in the middle third of the property in a north-south direction, leaving its borders with other properties unbuilt. Preserving the most important elements of the vegetation.
<i>MAE-20</i>	Only the construction surface area and up to 10 m on the perimeter can be completely stripped.
<i>MAE-21</i>	During construction activities, soil can only be removed at the site of the construction..
<i>MAE-4</i>	Only one well will be allowed per property with a single-family home.
<i>Tu-3 to 14</i>	The establishment of a variety of density of hotel-type rooms (0.5 to 0.35) is allowed, but it will depend on the width of the beach fronts of each private property with varied meters (100m <sup>2</sup> to 600m <sup>2</sup> ) and its total surface area.
<i>EI-15</i>	Paving of existing coastal roads is not permitted. The construction of one unpaved access road is permitted every 100 m to private properties, with a maximum width of 4 m. If the roads fall into mangroves, bridges must be made.
<i>EI-20</i>	Private properties and touristic infrastructure will allow access to beaches at least every 1,000 m on average with a minimum width of 2.00 m and a maximum of 3.00 m. In case of construction or similar activities, obstruction of such accesses must be avoided.

Note: Some criteria were summarized, without changing the sense of the regulation.

Table S3. Specific administrative rules established in the Management Program of the Sian Ka'an Biosphere Reserve allowing modification of the coastal dune and its vegetation.

<b>Administrative rule</b>	<b>Description</b>	<b>Action</b>
19 a 24	The establishment of rural housing and residential buildings is allowed depending on the width of the beach fronts of each private property, from 50m to 100m, with various dimensions of permitted constructed area (75m <sup>2</sup> to 400m <sup>2</sup> ).	Removal of vegetation
26	The construction of tourist infrastructure or rural housing is allowed in the middle third of the property in a north-south direction, leaving its adjoining areas with other properties unbuilt.	
27	The construction of an unpaved access road every 100 meters with a maximum width of 4m is allowed.	
28	It is prohibited to have more than one artificial well per single-family home.	

31	A maximum of 20 hotel rooms can be installed in private properties with beachfront length equal to or greater than 600 m.
33 subsection c	The natural vegetation of the dune cord cannot be removed, except for the construction of elevated walkways or the opening of pedestrian paths less than 1.5 meters wide, parallel to the coast, or in a zigzag pattern if they are perpendicular to the coast.
33 subsection e	The land surface of construction- free properties, is to be used exclusively for the conservation of the natural conditions of the site.
33 subsection m	Private properties and touristic developments should allow free access to beaches at least every 1,000 m on average, with paths with a minimum width of 2 m and a maximum of 3 m.

Note: Description of rules was summarized, without changing the original meaning.

Table S4. Authorized permissions for land use change in the northern zone (NZ) and southern zone (SZ) of the Sian Ka'an Biosphere Reserve during 2011-2020, with surface area and type of vegetation affected.

Number	Zone	Vegetation type	Surface (Hc)	Land use	Type of authorization	Month-Year
1	NZ	Pal	0.192	SFH	ETJ	Jun_2011
2	NZ	CD	0.040	SFH	ETJ	Jun_2012
3	NZ	CD	0.046	SFH	DTU-B	Oct_2012
4	NZ	CD	0.022	SFH	ETJ	Dec_2012
5	NZ	CD	0.034	SFH	ETJ	Dec_2012
6	NZ	CD	0.027	SFH	ETJ	Dec_2012
7	NZ	CD	0.020	SFH	ETJ	Oct_2013
8	NZ	CD	0.129	SFH	ETJ	Dec_2013
9	NZ	CD	0.019	SFH	ETJ	Dec_2014
10	NZ	CD	0.133	SFH	DTU-B	May_2014
11	NZ	CD	0.035	SFH	DTU-B	Dec_2014
12	NZ	CD	0.179	SFH	ETJ	Jul_2015
13	<b>SZ</b>	CD	<b>3.155</b>	<b>RV</b>	DTU-B	Sep_2015
14	NZ	CD	0.073	SFH	DTU-B	April_2016
15	NZ	CD	0.099	SFH	DTU-B	April_2016
16	NZ	CD	0.039	SFH	DTU-B	Jun_2016
17	NZ	CD	0.075	SFH	DTU-B	Ago_2016
18	NZ	CD	0.116	SFH	DTU-B	Ago_2016
19	<b>SZ</b>	CD	0.060	SFH	DTU-B	Feb_2017
20	NZ	CD	0.019	SFH	DTU-B	Mar_2017
21	NZ	CD	0.027	SFH	DTU-B	Mar_2017
22	<b>SZ</b>	CD	0.066	SFH	DTU-B	Jun_2017

23	NZ	CD	0.063	SFH	DTU-B	Nov_2017
24	NZ	CD	0.097	SFH	DTU-B	May_2018
25	NZ	CD	0.063	SFH	DTU-B	Dec_2018
26	NZ	CD	0.066	SFH	ETJ	Jul_2019
27	NZ	CD	<b>0.016</b>	SFH	DTU-B	Sep_2019
28	<b>SZ</b>	CD	0.066	SFH	DTU-B	Sep_2020
29	<b>SZ</b>	CD	0.060	SFH	DTU-B	Sep_2020

Abbreviations are as follows: Pal: Palmar; CD: Coastal Dune. SFH: Single Family House; RV: Resort Villas, ETJ: Supporting Technical Studies; DTU-B: Unified Technical Documents modality B.