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**TOPOGRAPHIC AND FLORISTIC CHANGE, DRY  
TORTUGAS, FLORIDA, 1904-1977**

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## TOPOGRAPHIC AND FLORISTIC CHANGE, DRY TORTUGAS, FLORIDA, 1904-1977

by D. R. Stoddart<sup>1</sup> and F. R. Fosberg<sup>2</sup>

### ABSTRACT

Topographic and floristic surveys of the Dry Tortugas keys in 1904, 1915 and 1937 have been used in discussions of the changing relationships between area and floristic diversity on small islands over time, and of the processes of colonization and extinction. It is shown that earlier topographic surveys are in general too unreliable to be so used. A list of Dry Tortugas plants, including all published records as well as new collections made in 1962 and 1977, is presented, together with maps of the keys made in 1977. The total flora of about 130 species includes at least 35 native species, including 5 species of sea-grasses and 4 species of mangroves. Introduced species are largely confined to the two largest islands, and the floras of the smaller keys are dominated by a small number of native species.

### INTRODUCTION

The Dry Tortugas Bank (Figure 1) lies at 24°40' N, 82°50' W, 110 km west of Key West, Florida and 165 km north of the nearest point of Cuba. It has a maximum NE-SW dimension of about 18 km, and is 5-8 km wide. As outlined by the 60 ft (18.3 m) isobath, the Bank covers almost exactly 100 sq km. Reef shoals in the centre and eastern part of the Bank rise to less than 6 ft (1.8 m) and have a total area of 245 ha, or only 2.5 per cent of the total Bank area. These shoals have historically supported eleven sand keys, of which three disappeared between 1775 and 1875 and a further three during the present century. The total land area of the eight keys existing in 1900 was about 50 ha; of this, two islands (Loggerhead and Garden Keys) comprised some 70 per cent.

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The reefs and keys of the Dry Tortugas have considerable historical interest. Here Agassiz (1888) first mapped the distribution of coral communities on any extensive reef tract (though his map, showing extensive areas of the now absent *Acropora palmata*, was perhaps somewhat conjectural); here too the presence of the Tortugas Laboratory of the Carnegie Institution led to a long series of research studies published between 1908 and 1942. The reefs have been studied by Vaughan (1914), Brooks (1962) and Jindrich (1972), the latter emphasizing the role of hurricanes in controlling community succession and sediment accumulation. More recently, Shinn et al. (1977) have shown from shallow borings that the topographic highs on the Bank are Holocene reef constructions at least 8 m thick which have accreted at rates of 1.9-4.5 m/1000 yr.

The keys themselves have been the subject of a series of topographic, geological and botanical studies. Detailed accounts of individual islands are available at intervals over more than 70 years, and this presents an opportunity to study changes in a way not possible for most other reef islands in the world. Indeed, Millspaugh (1907, 1911), who published the results of O.E. Lansing's first surveys in 1904, stated that "the principal value of the survey lies ... in the historical record of the present flora". The main studies available are as follows:

1904, March 19-22	O.E. Lansing, Jr., reported by Millspaugh (1907)
1915, July; 1916	H.H.M. Bowman (1918)
1926, June	W.R. Taylor (1926, 1928); algae and sea-grasses
1931, June-July;	G. Tandy, land plants; no publication
1933, August	and collections not seen
1937, 1938	Davis (1940, 1942)
1962, August	F.R. Fosberg
1977, May-June	D.R. Stoddart

The most important of the earlier studies are those of Millspaugh, Bowman and Davis. In addition a great deal of incidental topographic and botanical information is contained in extensive studies of the Dry Tortugas sooty tern colonies, notably by Stevenson (1938), Sprunt (1948, 1950, 1962-63), Robertson (1964), and Dinsmore (1972). Robertson in particular makes a major attempt to collate all previous information, published and unpublished, on the topographic development and nomenclature of the keys, and his results have been used in the present paper.

Given this data base, it is not surprising that MacArthur and Wilson (1968), 51-55) used the Dry Tortugas as one of their two examples (the other being Kapingamarangi Atoll) of the relationship between floristic diversity and area on small islands. MacArthur and Wilson used plant diversity levels in 1904 and 1916 (the Lansing and Bowman surveys) to calculate extinction rates during this period, and related these to island areas derived from Bowman's surveys.

Plant collections were made by the present authors on the Dry Tortugas keys in 1962 and 1977, and the islands were mapped by pace-and-compass methods in 1977. Comparison of the 1977 maps with earlier maps shows beyond doubt that the maps published by Millspaugh are thoroughly unreliable, and indeed none of his maps possesses any scale at all. Even worse, the scales of maps published by Bowman in 1918 are variable and misleading: the scales of each of his maps are given only in captions, and it is clear that the printer has differentially reduced the figures without a corresponding correction in the cited scale. The island areas derived from Bowman's maps by MacArthur and Wilson are thus wrong. Davis's (1942) maps, in contrast, are meticulous, but unfortunately he maps only Bush, Garden, Loggerhead and Long Keys.

In view of this situation, and especially of the theoretical discussions already based on the Dry Tortugas data, this paper does two things. First, we present maps of the keys in 1977, compare them with previous maps, and attempt to provide reasonable estimates of size and area at the times of the successive surveys. In this section the earlier work of Robertson (1964) is of outstanding importance. Second, we list the plant collections made in 1962 and 1977 and collate the previous records given by Millspaugh, Bowman and Davis. This collation is based only on literature records; no herbarium material from the earlier surveys has been examined; nor have we seen any lists or collections from Tandy's surveys in 1931 and 1933. These data are then used to provide revised floristic lists for each island at the time of each survey. Finally, the usefulness of these revised data for the kind of analysis carried out by MacArthur and Wilson is discussed.

#### ENVIRONMENT

Rainfall recording at Key West began in 1832; the long term annual mean is 961 mm, with extremes of 1770 mm (1870) and 520 mm (1838). There is a dry season from December to April, with an average of less than 50 mm rainfall per month, a secondary rainfall peak of 105 mm in June, and the main wet season from August to October. September is the wettest month with 165 mm. Hurricanes are frequent between August and December and may bring heavy rainfall as well as high winds and seas; the highest individual monthly rainfall recorded is 533 mm in November 1954. Mean daily temperature ranges from 21.3°C in January to 29.1°C in August; cold spells of several days, with temperatures exceptionally approaching 0°C, may occur during 'northers'



in the dry season. Prevailing winds are easterly, and so are currents (Vaughan 1935), so that the fauna and flora of the Keys are probably mainly derived from the Florida Keys and mainland. The Dry Tortugas are almost tideless: range at springs (MHHW to MLLW) is only 0.2 m.

#### DESCRIPTIONS OF THE KEYS

##### Bird Key

Bird Key, the Booby Key of Gault (1790), was located 1.3 km southwest of Garden Key; it disappeared in 1935. Audubon (1835, 263-269) visited it (and called it Bird Key) in May 1832, when it was occupied by a party from Havana collecting tern and noddy eggs.

Robertson (1964) quotes a survey by Tatnall and Gednery in 1829 which gave an area of 4 acres 2 roods 20 poles, equal to 18,210 m<sup>2</sup>, and an estimate by Scott in 1890 of about 8 acres, or 32,400 m<sup>2</sup>. Millspaugh (1907) gave dimensions of 500 x 250 ft (= 153 x 76 m), derived from Lansing's map of 19 March 1904, and if this is used to scale the map the resulting area is 6,440 m<sup>2</sup>. Bowman's (1918) map, at its cited scale of 1:6340, yields an area of 47,695 m<sup>2</sup>; MacArthur and Wilson (1968) derive an area of 13,935 m<sup>2</sup> from Bowman's account; while correcting Bowman's scale to 1:2717 by reference to his text, where he gives dimensions of 500 x 300 ft (= 152 x 92 m), yields an area of 9,375 m<sup>2</sup>. Watson (1908), however, gave dimensions of 400 x 300 yds (= 366 x 274 m). Table 1 summarises dimension and area estimates for the island, and Figure 2 gives the maps by Lansing and Bowman at the same scale and orientation: it is clearly impossible to estimate the size of the island with any confidence from these conflicting data.

Wurde mann (1861) in 1857 described a scrub of *Suriana* 7-8 ft (2.1-2.4 m) high, with some *Opuntia*. Lansing found a 'dense growth of *Suriana maritima*', with a marginal zone of herbs and shrubs, especially on the eastern side (Millspaugh 1907, 233). Watson (1908, 192) also mentioned the *Suriana* cover, as well as *Opuntia*. Much of the *Suriana* was killed by a hurricane on 15-17 October 1910, after which Bowman (1918) described *Euphorbia mesembrianthemifolia* as dominant, with extensive *Portulaca* and *Opuntia*. The vegetation was stripped in another storm on 10-11 September 1919 (Robertson 1964, 8, 60-61), and the key itself was destroyed by a hurricane variously dated as 1933, 1935 and 1938. By 1934 it was no more than a sandbar. In January 1940 it was a sandbar 40 ft (12 m) long and 2 ft (0.6 m) high (Robertson 1964, 9); it was not seen in 1977.

Table 2 lists the plant species recorded by Lansing on 19 March 1904 and by Bowman in 1915-1916. The total flora of 15 species includes only one certain introduction, *Cocos nucifera*, which was probably planted between the two surveys. Bartsch (1919, 470) mentions "a few ornamental shrubs near the buildings", but there is no record of their identity.

Apart from the noddies and sooty terns, Robertson (1964, 25) records that pigs were taken to the island from Long Key in July 1865.

#### Bush Key (Plates 1-5)

Bush Key, immediately east of Garden Key, has had a varied topographic history. It does not appear at all in Gauld's (1790) survey of 1773-75, but according to Bartsch (1919) it was vegetated at the time of Audubon's visit in 1832. Robertson (1964) quotes the Tatnall and Gednery survey of 1829 as yielding an area of 5 acres 3 roods 22 poles, or 23,270 sq m. Robertson summarises the subsequent history as follows: a sizeable island by the 1850s; hurricane damage ca 1870; a sandbank in 1889; not mentioned as a separate island in 1890; used as a source for dredged sand for fill at Garden Key in 1901-5. The island was stated to be awash in Millspaugh's (1907) account of Lansing's 1904 survey.

Bowman (1918) prepared the first map in 1915-16 (Figure 3), in a composite map of Bush and Long Keys, said to be on a scale of 1:6340. Bush was given dimensions of 583 x 342 m, and was said to have shrubs on it 12 years old. However, Bartsch (1919, 469) said in 1917 that all vegetation had 'long since' been swept away, and that the island was 'barren'; it is, however, possible that he was really describing Long Key rather than Bush. It is clearly difficult to relate Bowman's map to the present topography of the key, or even to Davis's map of 1937-38; Davis (1942, 187) indeed states that Bowman's map is wrongly oriented by 90°, but even reorientation does not make identification easier.

Davis's map is the first reliable one, giving an area of 115,900 m<sup>2</sup>. Davis (1942, 188) shows three small ponds at the western end of the key, said to have resulted from dredging in 1905, to have been cut off from the sea since about 1919, and to have been infilled during the next decade as the eastern spit gradually extended towards Long Key. He noted (1940, 377) a 'young swamp of *Laguncularia*' around one of these ponds, together with recently established *Avicennia* and *Rhizophora*. Many *Rhizophora* seedlings also drifted ashore here during dispersal experiments in 1937-38 (Davis 1940, 373). In 1942 bombing practice led to a fire 'that burned all vegetation' (Robertson 1964, 35). In 1946 Sprunt (1948, 6) found a 'remarkable spread' of vegetation. There was an eastern pond with *Laguncularia*, *Rhizophora* and some *Suriana*, and a western pond with *Opuntia*, *Salicornia* and *Tournefortia* on its margins; *Salicornia* and *Tournefortia* covered large areas of the key.

In 1962 Fosberg found a dense thicket of *Laguncularia* with a few *Rhizophora* in the main depression; a second small pond covered with *Rhizophora* 4-5 m tall; and much of the island occupied by *Suriana* scrub 2 m tall and by *Opuntia*, with scattered *Sesuvium*, *Sporobolus* and *Uniola*. Areas at the western end used by the sooty terns were almost bare of vegetation. In 1977 the island was much narrower than in 1937. The location of *Conocarpus* and *Laguncularia* thicket indicates that the narrowing has been by erosion along both north and south shores. The

main change in the vegetation has been the development of *Avicennia* woodland within the eastern spit. Dinsmore (1972, 131-132) gives an accurate brief account of the vegetation.

Table 4 lists the plants recorded in 1915-16, 1937, 1962 and 1977. Of the total of 28 species, 25 are native, in spite of the very large number of introductions on the adjacent Garden Key. *Casuarina*, the only certain introduced species, was first recorded in 1977, and could have dispersed naturally from Garden Key.

#### East Key (Plates 5-8)

East Key was charted by Gault (1790) in 1773-75. Tatnall and Gednery in 1829 give an area of 12 acres or 48,600 m<sup>2</sup> (Robertson 1964). The key was said to be eroded during the nineteenth century, but Agassiz's (1888) chart shows the island as one of the largest in the group, with a length of about 500 m and a pronounced NW-SE orientation. Scott in 1890 gave an area of 18 acres or 72,800 m<sup>2</sup>. Lansing mapped it on 21 March 1904, when it was 'a mere sand bank about 280 x 50 feet in area' (Millspaugh 1907, 224-225). Using these dimensions to scale his map gives an area of 2170 m<sup>2</sup>; if, however, the measurements were really in yards rather than feet the area would be 6500 m<sup>2</sup>. Bowman's (1918) map at its stated scale of 1:6340 yields an area of 115,610 m<sup>2</sup>; MacArthur and Wilson (1968) estimate the area from Bowman's survey at 111,480 m<sup>2</sup>; but if Bowman's dimensions of 540 x 250 m are used to rescale the map to 1:5512 the area becomes 87,220 m<sup>2</sup>. Other estimates are given in Table 5. Unfortunately the island was not mapped by Davis. Its area in 1977 was 27,145 m<sup>2</sup>, and its orientation had altered to NE-SW. The sediments of the key have been studied by O'Neill (1976). The variation in size alone of the maps of the island shown in Figure 5 strongly suggests that gross errors have entered the earlier records.

Robertson (1964, 12) quotes Holder's (1892) observation in 1860 that the vegetation comprised 'a dense stand of bay cedar bushes [*Suriana*] and numerous mangroves'; records in 1875 mention it 'partly covered with a growth of cedar', in 1889 as having 'a few bushes on it', and in 1890 as 'covered in parts with stunted bushes'. According to Lansing in 1904 "the vegetation consists principally of *Cenchrus* and *Euphorbia* with a sprinkling of *Uniola* at the southern end; two isolated patches of *Sesuvium* near the centre of the islet; and a few other species scattered without definite association" (Millspaugh 1907, 225): Lansing records *Scaevola*, *Iva* and *Tournefortia*, but not *Suriana*. In 1915-16 Bowman (1918) found the key "almost entirely covered with vegetation", with "large well-grown bushes", but again he does not record *Suriana*. Bartsch (1919, 469) describes "a dense growth of Bermuda grass [meaning *Uniola*?] on the flattened, upper portion, with a scattered growth of *Scaevola* bushes and other plants". Davis (1942) mentions a thicket of *Suriana* on the highest ridge, together with *Ipomoea*, *Sesuvium* and *Cenchrus*. In 1946 Sprunt (1948, 17) found that "Sea-oats (*Uniola*) or sea-lavender (*Tournefortia*) and some bay cedar (*Suriana*) are the principal growths, and there is a

great deal of the goat's-foot vine (*Ipomoea pes-caprae*) running along the beach". Robertson (1964, 13) in about 1960 found "sizeable bushes of bay cedar [*Suriana*], sea lavender (*Tournefortia gnaphalodes*), and *Scaevola plumieri*". In 1977 the island was dominated by open *Uniola* grassland with *Scaevola*, *Suriana*, *Iva*, *Tournefortia* and herbs.

Table 6 shows the plants recorded from East Key by Lansing, Bowman, Davis and Stoddart. All ten species are native. *Suriana*, not recorded by Lansing and Bowman, was certainly present in the nineteenth century, and *Ipomoea pes-caprae*, also not recorded by them, may have simply been overlooked. The only mangrove records for East Key are the *Rhizophora* seedlings which drifted there in 1937 and 1938 during Davis's dispersal experiments (Davis 1940, 373).

### Garden Key

Garden Key, the Bush Key of Gault's (1790) survey of 1773-75, has been enormously altered by the construction of Fort Jefferson, said to be the largest brick construction in the western hemisphere, during 1846-1864. The original sand key, on which a lighthouse was built in 1825, was estimated at 7.5 acres (30,350 m<sup>2</sup>) by Tatnall and Gedney in 1829, and at 8.8 acres (35,610 m<sup>2</sup>) by Bache in 1845 (Robertson 1964). The total area of the Fort, including the moat, is 64,400 m<sup>2</sup>, and the area within the walls 34,000 m<sup>2</sup>. The Fort was abandoned in 1875; the island was used as a coaling station by the U.S. Navy in 1901-1905, when its area was increased and modified by dredging in the channel to the east and on the site of Bush Key; and it was again abandoned in 1910 and once more in 1925. It was declared a National Monument in 1935.

The island was mapped by Lansing on 22 March 1904 (Millspaugh 1907, 228-231), by Vaughan (1918), by Bowman (1918), and, in greatest detail, by Davis (1942). Fort Jefferson itself provides a common scale to all these maps. By calculation Lansing's map is at 1:3680; Bowman's is said to be at 1:6340 but is actually at 1:4900; and Davis's is at 1:4646. Comparison of the maps (Figure 7) shows that Bowman's is clearly inaccurate (e.g. in the relative location of the coaling sheds), and that as a result his map overestimates the total area of the island by about 50 per cent.

Millspaugh (1907, 228-231) and Bowman (1918, 125-128) map the vegetation outside the Fort and describe that inside; Davis (1942, 184-187) gives the most detailed account and distribution map. The island was not remapped in 1977. In addition to the main sources, Bartsch (1919, 469-470) gives a brief note on the vegetation. Table 8 lists over 100 species of plants recorded from Garden Key. Of these only 24 are native, and all of the native species were recorded by Millspaugh and by Bowman.

### Loggerhead Key (Plate 9)

Loggerhead or Turtle Key (of Gault 1790) is the westernmost of the group. A lighthouse 50 m high was built on it in 1856-1860. The island was the site of the Tortugas Laboratory for more than thirty years (only the foundations now remain); and it is permanently inhabited. Maps are available for 1904, 1915-16, 1937-38 and 1977 (Figure 8). These show variability in length, which is undoubtedly seasonal, and also a general decrease in width. Both types of change are traced by relict beachrock distributions. Loggerhead Key is the only island in the group to possess actively forming beachrock. This was noted by Agassiz (1888, 67), but characteristically misinterpreted as the equivalent of the last interglacial limestones of the Florida Keys. More recent studies of the Loggerhead Key beachrocks are those of Field (1919, 1920), Ginsburg (1953) and Multer (1971).

The vegetation has changed greatly over the last century. Initially, ca 1840, according to Bowman (1918, 120), the island was covered with 'a large stand of old white buttonwood trees, *Conocarpus erectus* L.' These were either cut down or burned by residents. By the time of Lansing's visit in 1904 the centre of the island was covered by a 2 m tall scrub of *Suriana*. Bowman (1918, 121) found *Suriana* dominant, supplemented by an *Opuntia* association. Bartsch (1919, 470) also briefly describes this vegetation. Today the island is dominated by a tall woodland of *Casuarina*, originally introduced by the director of the Tortugas Laboratory ca 1910. *Casuarina* seedlings were growing all over the island by the time of Davis's survey in 1937-38, though *Suriana* was still dominant. It is also interesting that many of the *Rhizophora* seedlings released up to 65 km east of the Dry Tortugas by Davis in 1937 and 1938 arrived on the east beach at Loggerhead Key (Davis 1940, 371-377).

Both Millspaugh (1904, 235) and Bowman (1918, 121) found the key remarkably free from common weeds. Table 10 lists plants recorded from the island. Of the total of 57 species, 19 are native. Fifteen of the 24 definitely introduced species were recorded before 1916.

### Long Key (Plate 10)

Long Key, the Rocky Key of Gault (1790), was first mapped by Bowman (1918, 129): it was described as awash and without vegetation by Lansing in 1904. The difficulties of interpreting Bowman's map (Figure 3) have already been discussed in the account of Bush Key. Bartsch (1919, 469) mentioned scattered *Scaevola* and grasses on the southern end of the island, which otherwise was a simple boulder ridge. Davis (1940, 381-382, plate 12; 1942, 189-190) was responsible for planting mangrove seedlings: a few in 1937, 4100 in 1938, 575 in 1940. 2500 were alive in February 1942. Additional seedlings also drifted ashore here during dispersal experiments (Davis 1940, 373). In 1940 also there were 25 *Avicennia* bushes, four of which were more than 60 cm tall. Other plants mentioned by Davis were the mangrove

associates *Batis*, *Salicornia* and *Sesuvium*. Since Davis's survey the key has reduced in area by about 80 per cent.

By 1962 Fosberg found a considerable low scrub of *Avicennia* and much *Salicornia* on the leeward side, with mats of *Sesuvium*, and small numbers of *Rhizophora* up to 1 m tall. In 1977 Stoddart found a woodland of *Rhizophora* and *Avicennia* 4.5 m tall on the west side of the beach ridge, with strand shrubs and herbs on the seaward side.

Table 12 documents the plant species recorded from Long Key. Fifteen of the 16 species recorded are native; *Casuarina* is the only introduced species, recorded as a seedling 50 cm tall.

#### Middle Key

Middle Key, the Bird Key of Gault (1790), is the smallest of the vegetated islands of the group. It lacked vegetation in 1875 (Robertson 1964). Agassiz's map (1888) shows it to be about 140 m long. In March 1904 Lansing found it awash, with no vegetation. Bowman (1918, 131) described it as an oval patch of sand 80 x 50 ft (24 x 15 m), with an area of 194 m<sup>2</sup>, with clumps of dead *Cakile*. Bowman's map, said to be at 1:6340, is actually at 1:520, and this yields an area of 370 m<sup>2</sup>. Davis (1942) described it as 75 ft (23 m) long in 1937, with *Cakile*, *Iva* and *Euphorbia*. In July 1938 it was intertidal, and in 1940 and 1942 non-existent. Fosberg in 1962 described it as a crescent-shaped sand bar with no vegetation, and it remained the same in 1977.

Table 13 lists the plant records from Middle Key: all three recorded species are native.

#### North Key

This was charted by Gault (1790) in 1773-75. It was a sandbar in 1860, and had disappeared by 1875 (Robertson 1964, 16). According to Bartsch (1919, 492-493) it may have been the island of a few acres in area named Booby Island by Audubon in 1832.

#### Northeast Key

This was charted as Sandy Key by Gault (1790) in 1773-75. In the 1850s it possessed a tern colony, but had disappeared by 1875 (Robertson 1964, 16). It was not seen in 1977.

#### Sand Key (Plate 11)

Lansing mapped Sand Key (or Hospital Key) (the Middle Key of Gault 1790) on 21 March 1904, when it was a small oval island (Figure 10) of only 80 x 50 ft (24 x 15 m), though possibly these measurements should be in yards (= 73 x 46 m): on Agassiz's (1888) chart the island is about 160 m long. Bowman (1918) described it as measuring 90 x 45 ft (27 x 14 m) and mapped it at a scale said to be 1:6340 but actually 1:460. The true area at both surveys, assuming the dimensions in feet

to be correct, was about 225 m<sup>2</sup> (Table 14). The flora was confined to few scattered herbaceous species; there were no plants on it at all at the time of Bartsch's (1919, 469) survey. In 1938 Davis gave dimensions of 110 x 70 ft (34 x 21 m) but did not map it. It had a sparse vegetation, but *Rhizophora* seedlings which drifted there in 1937-38 failed to become established (Davis 1940, 373). It was unvegetated in 1946 (Sprunt 1948). Fosberg noted 'a patch of bushes and a patch of grass' in 1962. Robertson (1964, 14) described it as "always a small, shifting sandbar with little vegetation ... no permanent plant cover has been established". In 1977 it was much larger than in the past, but again unvegetated (Figure 10).

A hospital was built on the key in the 1870s, and became derelict and ruined at an unknown date. Broken blocks of masonry were noted on the key by Bowman in 1938, Davis in 1938, and again in 1977. Davis also noted relict beachrock, which is extensive in shallow water south of the key.

Table 15 lists plants recorded from the key: all eight species are native.

#### Southwest Key

This was charted by Gault (1790) in 1773-75; it had disappeared by 1875 (Robertson 1964, 16).

### FLORA

The flora comprises 35 native or probably native species (including five species of sea-grasses and 4 species of mangroves); at least 73 introduced species; and 23 species of uncertain status; giving a total of 131 species. This compares with 25 species (20 native) at Alacran Reef, Gulf of Mexico; 16 species (15 native) at the Morant Cays, 11 species (6 native) at the Pedro Cays, and 63 species at Glover's Reef, all in the Caribbean Sea. It is striking that the smaller Dry Tortugas islands, other than Garden and Loggerhead Keys, are dominated by native species, and that a very small number of native species occur on most of the islands. These include *Cenchrus incertus*, *Uniola paniculata*, *Cyperus planifolius*, *Sesuvium portulacastrum*, *Cakile lanceolata*, *Suriana maritima*, *Euphorbia mesembrianthemifolia*, *Ipomoea pes-caprae*, *Tournefortia gnaphalodes*, *Scaevola plumieri* and *Iva imbricata*, all present on at least five islands. The other two-thirds of the native species are more patchily distributed (Table 16).

The native flora is characteristic of small Caribbean/West Indian coral islands, but with some distinctive additions and several omissions. The five native grasses include the tall and distinctive sea-oats *Uniola paniculata*. This species extends along the coast of Florida, round the Gulf of Mexico into Tabasco, through the Bahamas, and along the north coast of Cuba (Yates 1966), but it is otherwise absent from the Caribbean strand flora. The other grasses are

widespread strand species. The single sedge (*Cyperus planifolius*) is also a widespread reef-island species.

The shrubs are dominated by *Suriana maritima* (also extensive at Alacran); *Tournefortia gnaphalodes*, a widespread Caribbean beach shrub; *Scaevola plumieri*, common in the northeastern and eastern Caribbean; and *Iva imbricata*, a variable plant of the tropical and subtropical Atlantic coast of North America but not otherwise found on Caribbean coral islands. *Borrchia arborescens*, which extends through the Florida Keys to the Marquesas, and is also extensive in Cuba and the Bahamas, as well as further south (Semple 1978), is curiously absent from the Dry Tortugas.

The herbaceous flora includes common reef island species of *Portulaca*, *Sesuvium*, *Cakile*, *Euphorbia*, and the vines *Ipomoea macrantha*, *Ipomoea pes-caprae* and *Canavalia rosea*. *Cassytha filiformis* is notably absent. On some islands with suitable substrate conditions there is a mangrove community (*Conocarpus*, *Laguncularia*, *Rhizophora*, *Avicennia*) with associated *Batis maritima*, *Atriplex pentandra*, *Salicornia bigelovii*, *Alternanthera maritima* and *Philoxerus vermicularis*, but the mangroves are much less extensive than in the nearby Marquesas and may be a recent development (Bowman 1918, 115, describes mangroves as 'entirely lacking').

There is no indubitably native tree species, though the status of *Cordia sebestena*, *Bursera simaruba*, *Coccoloba uvifera* and *Thespesia populnea* is open to question. All are common Caribbean coral island species.

#### VEGETATION

Both Bowman (1918, 115) and Davis (1942) have described vegetation units from the Dry Tortugas. Bowman distinguished a *Uniola* grass community (with *Cakile*, *Cenchrus*, *Sesuvium*, *Tournefortia*, *Ipomoea* and *Scaevola*); a *Suriana* scrub community (with *Canavalia*); an *Opuntia* community (with *Paspalum*, *Ipomoea macrantha*, *Ipomoea pes-caprae*, and *Melanthera aspera*); and a *Euphorbia* [*Chamaesyce*] community with *Iva imbricata* and *Cyperus planifolius*. Davis's categories were broader and described in terms of topographic units common to the Florida Keys as a whole. They included:

- (a) Strand-beach Associates (*Sesuvium*, *Cakile*, *Ipomoea*, *Sporobolus*, *Uniola*, *Euphorbia*, *Tournefortia*).
- (b) Strand-dune Associates (*Uniola*, *Euphorbia*, *Hymenocallis*, *Tournefortia*, *Suriana*).
- (c) Strand-scrub Associates (dominated by *Suriana*, with *Caesalpinia*, *Solanum* and *Opuntia*).

In addition he describes an *Opuntia* Associates, a *Euphorbia* [*Chamaesyce*] Associates, an *Agave* Associates, and a *Laguncularia* Associates. He comments on the absence of mangrove communities, except around the ponds on Bush Key.



These categories remain useful for describing vegetation units on the keys, but an additional unit of *Casuarina* woodland must be added for the tall woodland which has grown up on Loggerhead Key since 1940.

#### CONCLUSION

It will be apparent from this paper that the uncertainty over past estimates of dimension and area of the Dry Tortugas keys is too great for acceptable estimates to be derived from the surveys made in 1904 and 1915-16. This results from a combination of surveying error, printer's error, and natural change in the islands themselves. Only Davis's surveys in 1937-38 of Bush, Garden, Loggerhead and Long Keys meet required standards of reliability. Since there is also much evidence of considerable topographic changes in the islands themselves, it is not acceptable in analyses of area-diversity relationships to standardise island area on the basis of any one survey, however reliable it may be.

Second, we do not believe that the plant species records from the earlier surveys can be made to bear inferences of colonisation or extinction between the surveys, except for those islands such as Bird, Middle and Sand Keys which underwent catastrophic destruction during cyclones and were then recolonised. On the larger islands inadvertent non-recording is at least as plausible an explanation as colonisation or extinction. Indeed, apart from the cyclone-damaged islands, where floristic change resulted from massive substrate disturbance, we are impressed by the stability of the native floras over time. The fact that on all of the islands the total number of native species recorded has increased between 1904 and 1977 we interpret as simply the result of collecting intensity rather than any true increase in the number of native species present.

This is not to deny that processes of the kind envisaged by MacArthur and Wilson (1968) may operate on small reef islands, but rather to say that the data from the Dry Tortugas are not of sufficient quality to support their theoretical speculations. Furthermore, we feel it highly likely that more species remain to be recorded on the keys, and that such new records should not themselves be inferred to be new arrivals.

The data considered in this paper are summarised in tabular form in Table 17 (numbers of all species, of native species, of introduced species, and of species of uncertain status, recorded for each island at the time of each survey) and in Table 18 (the area, total number of species, and number of native species for each island at each survey). Table 19 revises MacArthur and Wilson's (1968) Table 5, which sets out data on presumed extinctions between 1904 and 1916. Finally, Figure 11 uses the 1977 island areas and the total recorded number of species for each island (other than Garden and Loggerhead Keys) to give a visual impression of the relationship between species number and island area both for the Dry Tortugas and for other Gulf of Mexico and Caribbean

groups of reef islands. In addition to a rather diffuse area control, Figure 11 also shows that wet islands close to continental areas (such as Glover's Reef) have higher species numbers than more remote and drier islands such as the Pedro and Morant Cays, with the Dry Tortugas in an intermediate position. These relationships have been analysed further by Stoddart and Fosberg (in press).

The problems examined here are not, of course, unique to the Dry Tortugas. It is worth recalling that Millspaugh (1899) was also responsible for a series of early maps and species records for the islands of Alacran Reef, Gulf of Mexico. These islands were remapped by Folk (1967) in 1960, and the flora restudied by Bonet and Rzedowski (1962) and Fosberg (1962) in 1961. Table 20 summarises the Alacran data from these surveys. Island areas derived from Folk's maps vary from 1.4 to 6 times the areas measured in 1899, the average increase being about four times; Folk (1967, 415, 343) used these apparent increases in a detailed commentary on stages of island evolution. Similarly Fosberg (1962, 4) commented on the 'profound changes' which had occurred since Millspaugh's visit. In view of the ambiguities demonstrated in the Dry Tortugas data, it would perhaps be wise to be sceptical of the Alacran - and indeed other early - records which purport to indicate massive changes over short periods of time.

The temptation to use such data in support of general theory is considerable, but we need to remember that such theory is no better than the data by which it is supported.

#### ACKNOWLEDGEMENTS

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## PLANTS RECORDED FROM THE DRY TORTUGAS KEYS

This list derives mainly from the published records of Millspaugh (1907), Bowman (1918) and Davis (1942), together with determinations by F.R. Fosberg of collections made by the authors in 1962 and 1977. Species marked N are judged to be native; those marked I to be introduced; and those marked ? are of uncertain status.

## PANDANACEAE

I *Pandanus tectorius* Park.

Garden Key: Fosberg sight record in 1962.

## ZOSTERACEAE

N *Halodule wrightii* Aschers. (sensu lato)

Garden Key: Fosberg 43018 (US).

Bird Key: W.R. Taylor, 7 June 1926 (MICH) (den Hartog 1970, as *H. beaudettei* (den Hartog) den Hartog).

Long Key: W.R. Taylor, 25 June 1926 (MICH) (den Hartog 1970, as *H. beaudettei* (den Hartog) den Hartog).

N *Syringodium filiforme* Kütz.

Garden Key: Fosberg 43013 (US).

Loggerhead Key: W.R. Taylor, 19 June 1926 (MICH) (den Hartog 1970).

## HYDROCHARITACEAE

N *Halophila decipiens* Ostenfeld

Dredged, 15 fathoms, H.H.M. Bowman, July 1915 (MICH);  
10 fathoms, Tandy 1111 (BM), Tandy 1254 (BM); 18-20 fathoms,  
Tandy 1570 (BM) (all citations from den Hartog 1970).

N *Halophila engelmanni* Aschers.

Dredged, 18-20 fathoms, Tandy 1569 (BM), Tandy 1599 (BM) (den Hartog 1970).

N *Thalassia testudinum* Banks ex König

Bird Key: Tandy 1068 (BM) (den Hartog 1970).

'Long Bush Key': Tandy 1264 (BM) (den Hartog 1970).

## GRAMINEAE

I *Brachiaria* sp.

Garden Key: Fosberg 43021 (US).

- ? *Cenchrus echinatus* L.  
 Garden Key: Millspaugh 1907; Davis 1942; Fosberg 43059 (US).  
 Loggerhead Key: Bowman 1918; Stoddart 8056 (US).
- ? *Cenchrus myosuroides* H.B.K.  
 Loggerhead Key: Fosberg 43041 (US).
- N *Cenchrus incertus* M.A. Curtis  
 Bird Key: Millspaugh 1907 (as *C. tribuloides*); Bowman 1918.  
 Bush Key: Bowman 1918.  
 East Key: Millspaugh 1907 (as *C. tribuloides*); Bowman 1918;  
 Davis 1942; Stoddart 8033 (US).  
 Garden Key: Millspaugh 1907 (as *C. tribuloides*); Fosberg 42983,  
42990, 43060 (US).  
 Loggerhead Key: Bowman 1918; Fosberg 43045 (US).
- I *Cynodon dactylon* (L.) Pers.  
 Garden Key: Bowman 1918 (as *Capriola dactylon*); Davis 1942;  
Fosberg 42996 (US).
- I *Digitaria horizontalis* Willd.  
 Garden Key: Fosberg 42981 (US).
- ? *Digitaria sanguinalis* (L.) Scop.  
 Garden Key: Millspaugh 1907 (as *Syntherisma fimbriatum*);  
 Bowman 1918 (as *Syntherisma marginatum*); Davis 1942;  
Fosberg 42985 (US).
- I *Eragrostis ciliaris* (L.) R.Br.  
 Garden Key: Fosberg 43017 (US).
- ? *Eragrostis prolifera* (Sw.) Steud.  
 Garden Key: Fosberg 43019 (US); Stoddart 8065 (US).  
 Loggerhead Key: Stoddart 8052 (US).
- I *Eragrostis tenella* (L.) Beauv. ex. R. & S.  
 Garden Key: Davis 1942.  
 Loggerhead Key: Fosberg 43032 (US).
- N *Eustachys petraea* (Sw.) Desv.  
 Bush Key: Davis 1942 (as *Chloris*).  
 Garden Key: Millspaugh 1907; Davis 1942 (as *Chloris*);  
Fosberg 43056 (US).  
 Loggerhead Key: Fosberg 43051 (US); Stoddart 8058 (US).
- I *Panicum maximum* Jacq.  
 Loggerhead Key: Fosberg 43047 (US).
- ? *Paspalum caespitosum* Fleugge  
 Garden Key: Bowman 1918; Davis 1942.  
 Loggerhead Key: Bowman 1918.

- N *Paspalum distichum* L.  
 Bird Key: Millspaugh 1907.  
 Garden Key: Millspaugh 1907.
- ? *Sporobolus domingensis* (Trin.) Kunth  
 Garden Key: Davis 1942.
- ? *Sporobolus purpurascens* (Sw.) Hamilt.  
 Garden Key: Millspaugh 1907.
- N *Sporobolus virginicus* (L.) Kunth  
 Bush Key: Davis 1942; Fosberg 43000 (US); Stoddart 8004 (US).  
 Garden Key: Bowman 1918; Davis 1942.  
 Loggerhead Key: Millspaugh 1907; Bowman 1918; Davis 1942;  
Fosberg 43029 (US).  
 Long Key: Stoddart 8029 (US).
- I *Stenotaphrum secundatum* (Walt.) O. Ktze.  
 Garden Key: Fosberg sight record in 1962.
- N *Uniola paniculata* L.  
 Bird Key: Millspaugh 1907; Bowman 1918.  
 Bush Key: Bowman 1918; Davis 1942; Fosberg sight record in  
 1962; Stoddart 8001 (US).  
 East Key: Millspaugh 1907; Bowman 1918; Stoddart 8031 (US).  
 Garden Key: Millspaugh 1907; Bowman 1918; Davis 1942.  
 Loggerhead Key: Millspaugh 1907; Bowman 1918; Davis 1942;  
Fosberg 43038 (US); Stoddart 8048 (US).  
 Sand Key: Millspaugh 1907; Davis 1942.

## CYPERACEAE

- N *Cyperus planifolius* L.C. Rich.  
 Bird Key: Millspaugh 1907 (as *C. brunneus*).  
 Bush Key: Fosberg 42999 (US); Stoddart 8018 (US).  
 Garden Key: Millspaugh 1907; Bowman 1918; Davis 1942 (as  
*C. brunneus*); Fosberg 42982, 43054, 43055 (US).  
 Loggerhead Key: Bowman 1918 (as *C. brunneus*); Fosberg 43033  
(US); Stoddart 8053 (US).  
 Long Key: Bowman 1918 (as *C. brunneus*).

## PALMAE

- I *Cocos nucifera* L.  
 Bird Key: Bowman 1918.  
 Garden Key: Fosberg sight record in 1962; Stoddart sight  
 record in 1977.  
 Loggerhead Key: Bowman 1918; Davis 1942; Stoddart sight  
 record in 1977.
- I *Phoenix canariensis* Hort ex Chabaud.  
 Garden Key: Bowman 1918; Davis 1942.

I *Phoenix dactylifera* L.  
Garden Key: Bowman 1918; Davis 1942; Fosberg sight record  
in 1962.

I *Pritchardia* sp.  
Garden Key: Fosberg sight record in 1962.

I *Washingtonia filifera* (Lindl.) Wendl.  
Garden Key: Fosberg sight record in 1962.

#### COMMELINACEAE

I *Rhoeo spathacea* (Sw.) Stearn  
Garden Key: Fosberg sight record in 1962.

#### LILIACEAE

I *Agave decipiens* Baker  
Garden Key: Bowman 1918.

I *Agave americana* L.  
Garden Key: Davis 1942.  
Loggerhead Key: Davis 1942.

I *Agave rigida* Mill.  
Loggerhead Key: Bowman 1918.

I *Agave* sp.  
Loggerhead Key: Fosberg sight record in 1962; Stoddart sight  
record in 1977.

I *Aloe barbadensis* Mill.  
Garden Key: Fosberg sight record in 1962.  
Loggerhead Key: Bowman 1918; Davis 1942 (both as *Aloe*).

I *Asparagus sprengeri* Regel  
Loggerhead Key: Bowman 1918.  
Without locality: Davis 1942 Table 7.

? *Hymenocallis latifolia* (Mill.) Roem.  
Bird Key: Bowman 1918 (as *H. caymanensis* Herb.).  
Garden Key: Millspaugh 1907 (as *H. caribaea* (L.) Herb.);  
Bowman 1918 (as *H. caymanensis* Herb.); Davis 1942 (as  
*H. caymanensis* Herb.).  
Loggerhead Key: Millspaugh 1907 (as *H. caribaea* (L.) Herb.);  
Bowman 1918 (as *H. caymanensis* Herb.); Davis 1942 (as *H.*  
*caymanensis* Herb.); Fosberg 43050 (US); Stoddart sight  
record in 1977.

I *Hymenocallis littoralis* (Jacq.) Salisb.  
Garden Key: Fosberg sight record in 1962.

- I *Yucca aloifolia* L.  
 Loggerhead Key: Bowman 1918; Davis 1942.

## MUSACEAE

- I *Musa sapientum* L.  
 Garden Key: Fosberg sight record in 1962.

## CASUARINACEAE

- I *Casuarina equisetifolia* L.  
 Bush Key: Stoddart 8008 (US).  
 Garden Key: Davis 1942.  
 Loggerhead Key: Bowman 1918; Davis 1942; Stoddart 8050 (US).  
 Long Key: Fosberg 43005 (US).

## MORACEAE

- I *Ficus carica* L.  
 Without locality: Davis 1942 Table 7.

- I *Ficus hispida* L.f.  
 Loggerhead Key: Bowman 1918; Davis 1942.

- I *Ficus palmata* Forsk.?  
 Loggerhead Key: Fosberg 43048 (US).

## POLYGONACEAE

- ? *Coccoloba uvifera* L.  
 Garden Key: Bowman 1918; Davis 1942; Fosberg sight record in  
 1962; Stoddart 8062 (US).  
 Loggerhead Key: Bowman 1918; Stoddart 8041 (US).

## BATIDACEAE

- N *Batis maritima* L.  
 Bush Key: Stoddart sight record in 1977.  
 Long Key: Davis 1942.

## CHENOPODIACEAE

- N *Atriplex pentandra* (Jacq.) Standl.  
 Bush Key: Bowman 1918 (as *A. cristata*); Stoddart 8019 (US).  
 Garden Key: Millspaugh 1907; Bowman 1918 (both as  
*A. cristata*); Stoddart 8081? (US).  
 Long Key: Bowman 1918 (as *A. cristata*); Fosberg 43004 (US);  
Stoddart 8021 (US).  
 Without locality: Davis 1942 Table 7 (as *A. cristata*).
- N *Salicornia bigelovii* Torr.  
 Long Key: Davis 1942; Fosberg 43007 (US); Stoddart 8026 (US).

## AMARANTHACEAE

- N *Alternanthera maritima* J. St. Hil.  
 Bush Key: Bowman 1918; Davis 1942.  
 Garden Key: Bowman 1918.  
 Long Key: Bowman 1918.
- ? *Alternanthera philoxeroides* (Mart.) Griseb.  
 Bush Key: Stoddart 8009 (US).
- I *Amaranthus viridis* L.  
 Garden Key: Millspaugh 1907.
- I *Amaranthus* sp.  
 Without locality: Davis 1942 Table 7.
- N? *Philoxerus vermicularis* (L.) Beauv.  
 Bush Key: Fosberg 42975 (US).  
 Garden Key: Millspaugh 1907 (as *Lithophila vermicularis*).  
 Without locality: Davis 1942 Table 7 (as *Lithophila*  
*vermicularis*).

## NYCTAGINACEAE

- ? *Boerhavia coccinea* Mill.  
 Garden Key: Millspaugh 1907; Bowman 1918; Davis 1942  
 (all as *B. viscosa*); Fosberg 43061 (US).  
 Loggerhead Key: Bowman 1918; Davis 1942 (both as *B. viscosa*);  
Stoddart 8055? (US); Fosberg 43035 (US).  
 Without locality: Davis 1942 Table 7.
- I *Bougainvillea glabra* Choisy  
 Garden Key: Fosberg sight record in 1962.



## PORTULACACEAE

N *Portulaca oleracea* L.

- Bird Key: Millspaugh 1907; Bowman 1918.  
 Garden Key: Millspaugh 1907; Bowman 1918; Fosberg 43008, 43009 (US); Stoddart 8073 (US).  
 Loggerhead Key: Millspaugh 1907; Bowman 1918; Davis 1942.

## AIZOACEAE

N *Sesuvium portulacastrum* (L.) L.

- Bird Key: Millspaugh 1907; Bowman 1918.  
 Bush Key: Bowman 1918; Davis 1942; Fosberg sight record in 1962; Stoddart 8011 (US).  
 East Key: Millspaugh 1907; Bowman 1918; Davis 1942; Stoddart 8032 (US).  
 Garden Key: Millspaugh 1907; Bowman 1918; Davis 1942.  
 Loggerhead Key: Millspaugh 1907; Bowman 1918; Davis 1942; Fosberg sight record in 1962.  
 Long Key: Bowman 1918; Davis 1942; Fosberg sight record in 1962; Stoddart 8029 (US).  
 Sand Key: Millspaugh 1907.

## PAPAVERACEAE

I *Argemone mexicana* f. *leiocarpa* (Greene) G.B. Ownbey

- Garden Key: Millspaugh 1907 (as *Argemone leiocarpa*).

N *Cakile lanceolata* (Willd.) O.E. Schulz

- Bird Key: Millspaugh 1907 (as *C. fusiformis*); Bowman 1918.  
 Bush Key: Bowman 1918; Stoddart 8002 (US).  
 East Key: Millspaugh 1907 (as *C. fusiformis*); Bowman 1918; Stoddart 8035 (US).  
 Garden Key: Millspaugh 1907 (as *C. fusiformis*); Bowman 1918; Stoddart 8080 (US).  
 Loggerhead Key: Millspaugh 1907 (as *C. fusiformis*); Bowman 1918.  
 Middle Key: Bowman 1918; Davis 1942.  
 Sand Key: Bowman 1918.

## CRUCIFERAE

I *Lepidium virginicum* L.

- Garden Key: Bowman 1918; Fosberg 43025 (US).

## LEGUMINOSAE

I *Abrus precatorius* L.

- Garden Key: Fosberg sight record in 1962.

- ? *Caesalpinia bonduc* (L.) Roxb.  
 Garden Key: Bowman 1918 (as *Guilandina crista*).  
 Loggerhead Key: Millspaugh 1907 (as *Caesalpinia crista*);  
Stoddart 8059 (US).
- I *Caesalpinia pulcherrima* (L.) Sw.  
 Garden Key: Fosberg sight record in 1962.
- I? *Caesalpinia* sp.  
 Loggerhead Key: Fosberg 43042 (US).
- I *Cajanus cajan* (L.) Millsp.  
 Garden Key: Bowman 1918 (as *Cajanus cajan*).  
 Without locality: Davis 1942 Table 7.
- N *Canavalia rosea* (Sw.) DC.  
 Garden Key: Millspaugh 1907 (as *C. obtusifolia*); Bowman 1918;  
 Davis 1942 (both as *C. lineata*); Fosberg 43057 (US);  
Stoddart 8063 (US).  
 Loggerhead Key: Millspaugh 1907 (as *C. obtusifolia*); Bowman  
 1918; Davis 1942 (both as *C. lineata*); Fosberg sight  
 record in 1942.
- I *Ceratonia siliqua* L.  
 Garden Key: Fosberg 43064 (US, POM).
- I *Crotalaria pallida* Ait.  
 Garden Key: Stoddart 8078 (US).
- I *Delonix regia* (Boij.) Raf.  
 Garden Key: Fosberg sight record in 1962; Stoddart 8070 (US).
- ? *Desmanthus depressus* H. & B.  
 Garden Key: Fosberg 43011 (US).
- I *Desmodium incanum* (Gmel.) Schinz  
 Garden Key: Fosberg 43067 (US).
- I *Rhynchosia minimum* (L.) DC.  
 Without locality: Davis 1942 Table 7 (as *Dolicholus minimum*).
- I *Rhynchosia parviflorus* DC.  
 Garden Key: Bowman 1918 (as *Dolicholus parviflorus*).
- I *Sesbania* sp.  
 Garden Key: Millspaugh 1907 (as *S. sericea*); Bowman 1918 (as  
*Glottidium vesarium*); Davis 1942 (as *S. macrocarpa*).
- I *Tamarindus indica* L.  
 Garden Key: Bowman 1918; Davis 1942; Fosberg sight record in  
 1962.

## ZYGOPHYLLACEAE

- ? *Tribulus cistoides* L.  
 Loggerhead Key: Millspaugh 1907.

## RUTACEAE

- I *Citrus aurantiifolius* (Christm.) Swingle  
 Garden Key: Fosberg sight record in 1962.

## SURIANACEAE

- N *Suriana maritima* L.  
 Bird Key: Millspaugh 1907; Bowman 1918.  
 Bush Key: Bowman 1918; Davis 1942; Fosberg sight record in  
 1962; Stoddart 8020 (US).  
 East Key: Davis 1942; Stoddart 8037 (US).  
 Garden Key: Millspaugh 1907; Bowman 1918; Davis 1942;  
Stoddart 8071 (US).  
 Loggerhead Key: Millspaugh 1907; Bowman 1918; Davis 1942;  
Stoddart 8051 (US).  
 Long Key: Bowman 1918; Fosberg 43006 (US); Stoddart 8023  
 (US).

## BURSERACEAE

- ? *Bursera simaruba* (L.) Sarg.  
 Garden Key: Bowman 1918; Davis 1942 (both as *Elaphrium*  
*simaruba*); Fosberg sight record in 1962.  
 Loggerhead Key: Fosberg 43027 (US).

## EUPHORBIACEAE

- I *Breynia disticha* (J.R. & G. Forst.)  
 Garden Key: Fosberg sight record in 1962.
- I *Codiaeum variegatum* (L.) Blume  
 Garden Key: Fosberg sight record in 1962.
- ? *Euphorbia adenoptera* Bert.  
 Garden Key: Millspaugh 1907.
- ? *Euphorbia blodgettii* Engelm. ex Hitchc.  
 Garden Key: Fosberg 42980, 42995 (US).
- I *Euphorbia glomerifera* (Millsp.) Wheeler  
 Garden Key: Bowman 1918 (as *Chamaesyce hypericifolia*);  
Fosberg 42994 (US), 43062 (US, POM).

- ? *Euphorbia heterophylla* L.  
*Poinsettia pinetorum* Small  
*Euphorbia havanensis* Willd.  
 Bush Key: Stoddart 8005 (US).  
 Garden Key: Millspaugh 1907 (as *E. havanensis*); Davis 1942  
 (as *Poinsettia cyathophora*); Fosberg 42989 (US);  
Stoddart 8075 (US).  
 Loggerhead Key: Bowman 1918 (as *Poinsettia pinetorum*); Davis  
 1942 (as *Poinsettia cyathophora*); Fosberg 43046 (US);  
Stoddart 8054 (US).  
 Some of these seem intermediate between this species and  
*Euphorbia cyathophora* Murr.
- I *Euphorbia hirta* L.  
 Garden Key: Fosberg 43015 (US).  
 Loggerhead Key: Fosberg 43031 (US).
- N *Euphorbia mesembrianthemifolia* Jacq.  
*Chamaesyca buxifolia* in Bowman 1918.  
*Euphorbia buxifolia* in Millspaugh 1907, Davis 1942.  
 Bird Key: Millspaugh 1907; Bowman 1918.  
 Bush Key: Bowman 1918; Davis 1942; Fosberg 42976 (US);  
Stoddart 8012 (US).  
 East Key: Millspaugh 1907; Bowman 1918; Stoddart 8034 (US).  
 Garden Key: Millspaugh 1907; Bowman 1918; Davis 1942.  
 Loggerhead Key: Millspaugh 1907; Bowman 1918; Davis 1942;  
 Fosberg sight record in 1962; Stoddart 8045 (US).  
 Long Key: Bowman 1918; Fosberg sight record in 1962;  
Stoddart 8022 (US).  
 Middle Key: Davis 1942.  
 Sand Key: Millspaugh 1907; Davis 1942.
- I *Euphorbia prostrata* Ait.  
 Garden Key: Fosberg 42991 (US).  
 Loggerhead Key: Fosberg 43030 (US).
- I *Pedilanthus tithymaloides* (L.) Poit.  
 Garden Key: Fosberg sight record in 1962.  
 Loggerhead Key: Bowman 1918.  
 Without locality: Davis 1942 Table 7 (as *Tithymalus smallii*  
 (Millsp.) Small).
- I *Phyllanthus amarus* Schum. & Thonn.  
 Garden Key: Fosberg 43014 (US).
- I *Ricinus communis* L.  
 Garden Key: Bowman 1918.

## MALVACEAE

- I *Hibiscus rosa-sinensis* L.  
 Garden Key: Fosberg sight record in 1962.  
 Loggerhead Key: Bowman 1918.
- I *Malvaviscus arborea* Cav.  
 Garden Key: Fosberg sight record in 1962.
- I *Sida acuta* Burm. f.  
 Garden Key: Millspaugh 1907; Bowman 1918 (both as *Sida carpinifolia*); Fosberg 43016 (US).
- I *Sida procumbens* Sw.  
 Garden Key: Millspaugh 1907 (as *Sida diffusa*); Bowman 1918; Fosberg 43012 (US).
- I *Thespesia populnea* (L.) Solander ex Correa  
 Garden Key: Bowman 1918; Davis 1942; Fosberg sight record in 1962; Stoddart 8068 (US).  
 Loggerhead Key: Bowman 1918; Davis 1942; Stoddart 8042 (US).

## STERCULIACEAE

- I *Waltheria indica* L.  
 Garden Key: Fosberg 43068 (US).

## CARICACEAE

- I *Carica papaya* L.  
 Loggerhead Key: Millspaugh 1907 (as *Papaya*); Bowman 1918.

## CACTACEAE

- N *Opuntia dillenii* (Ker.) Haw.  
 Bird Key: Millspaugh 1907; Bowman 1918.  
 Bush Key: Davis 1942; Fosberg sight record in 1962;  
 Stoddart sight record in 1977.  
 Garden Key: Millspaugh 1907; Bowman 1918; Davis 1942.  
 Loggerhead Key: Millspaugh 1907; Bowman 1918; Davis 1942;  
 Stoddart sight record in 1977.

## LYTHRACEAE

- I *Lawsonia inermis* L.  
 Garden Key: Fosberg 43065 (US).

## COMBRETACEAE

- N *Conocarpus erectus* L.  
 Bush Key: Davis 1940, 1942; Fosberg sight record in 1962;  
Stoddart 8015 (US).  
 Garden Key: Bowman 1918; Davis 1942; Fosberg 42992, 42993  
 (US); Stoddart 8066, 8067 (US).
- N *Laguncularia racemosa* (L.) Gaertn. f.  
 Bush Key: Davis 1940, 1942 (as *Laguncularia*); Fosberg sight  
 record in 1962; Stoddart 8007, 8016 (US).  
 Long Key: Fosberg 43001 (US).
- I *Terminalia catappa* L.  
 Garden Key: Bowman 1918 (as *Terminalia*); Fosberg sight record  
 in 1962.

## MYRTACEAE

- I *Psidium guajava* L.  
 Garden Key: Bowman 1918; Davis 1942; Fosberg 43069 (US).

## RHIZOPHORACEAE

- N *Rhizophora mangle* L.  
 Bush Key: Bowman 1918; Davis 1940, 1942; Fosberg 42977 (US);  
Stoddart 8014 (US).  
 East Key: Davis 1940 (drift seedlings).  
 Garden Key: Bowman 1918; Davis 1940 (drift seedlings).  
 Loggerhead Key: Davis 1940 (drift seedlings).  
 Long Key: Bowman 1918; Davis 1940, 1942; Fosberg 43002 (US);  
Stoddart 8027 (US).  
 Sand Key: Davis 1940 (drift seedlings).

## ARALIACEAE

- I *Polyscias guilfoylei* (Cogn. & March.) Bailey  
 Garden Key: Fosberg sight record in 1962.

## GENTIANACEAE

- ? *Eustoma exaltatum* (L.) G. Don  
 Garden Key: Fosberg 42979 (US).

## APOCYNACEAE

- I *Catharanthus roseus* (L.) G. Don  
 Garden Key: Fosberg sight record in 1962.  
 Loggerhead Key: Bowman 1918 (as *Vinca roseus*); Fosberg  
 sight record in 1962.

- I *Nerium oleander* L.  
 Garden Key: Bowman 1918; Davis 1942 (both as *Oleander*);  
 Fosberg sight record in 1962.  
 Loggerhead Key: Bowman 1918.

- I *Ochrosia elliptica* Labill.  
 Garden Key: Stoddart 8064 (US, POM).

- I *Thevetia peruviana* (Pers.) Schum.  
 Loggerhead Key: Bowman 1918 (as *Cerbera thevetia*).

## ASCLEPIADACEAE

- I *Cryptostegia grandiflora* R. Br.  
 Garden Key: Fosberg sight record in 1962.

## CONVOLVULACEAE

- N *Ipomoea macrantha* R. & S.  
 Bush Key: Stoddart 8017 (US).  
 Garden Key: Bowman 1918 (as *Calonyction tuba*);  
Stoddart 8079 (US).  
 Loggerhead Key: Millspaugh 1907 (as *Calonyction album*);  
 Bowman 1918; Davis 1942 (both as *Calonyction tuba*);  
 Fosberg 43052 (US).  
 Long Key: Stoddart 8025 (US).

- N *Ipomoea pes-caprae* (L.) R. Br. subsp. *brasiliensis* (L.) v. Ooststr.  
 Bush Key: Bowman 1918; Davis 1942.  
 East Key: Davis 1942; Stoddart 8038 (US).  
 Garden Key: Millspaugh 1907; Bowman 1918; Davis 1942;  
Stoddart 8074 (US).  
 Loggerhead Key: Millspaugh 1907; Bowman 1918; Davis 1942;  
 Fosberg 43044 (US); Stoddart 8043 (US).  
 Long Key: Fosberg 43003 (US).  
 Sand Key: Millspaugh 1907.

## BORAGINACEAE

- I *Cordia sebestena* L.  
 Garden Key: Bowman 1918; Fosberg sight record in 1962;  
Stoddart 8069 (US).  
 Loggerhead Key: Millspaugh 1907; Bowman 1918 (as *Sebesten*  
*sebestina*); Fosberg sight record in 1962; Stoddart 8044  
 (US).

- N *Heliotropium curassavicum* L.  
 Garden Key: Millspaugh 1907; Fosberg 43066 (US).  
 Without locality: Davis 1942 Table 7.

- I *Heliotropium angiospermum* Murray  
 Garden Key: Fosberg 43024 (US).

- N *Tournefortia gnaphalodes* (L.) Kunth  
 Bird Key: Millspaugh 1907; Bowman 1918.  
 Bush Key: Bowman 1918; Davis 1942; Stoddart 8003 (US).  
 East Key: Millspaugh 1907; Bowman 1918; Stoddart 8040 (US).  
 Garden Key: Millspaugh 1907; Bowman 1918; Stoddart 8066 (US).  
 Loggerhead Key: Millspaugh 1907; Bowman 1918; Davis 1942;  
Fosberg 43043 (US); Stoddart 8049 (US).  
 Long Key: Bowman 1918; Stoddart 8024 (US).  
 Sand Key: Davis 1942.

## VERBENACEAE

- N *Avicennia germinans* (L.) L.  
 Bush Key: Davis 1940; Fosberg 42998 (US); Stoddart 8013 (US).  
 Garden Key: Bowman 1918 (as *A. nitida*); Davis 1940, 1942;  
Fosberg 43058 (US).  
 Long Key: Davis 1942 (as *A. nitida*); Fosberg sight record in  
 1962; Stoddart 8030 (US).
- ? *Lippia nodiflora* (L.) Michx.  
 Garden Key: Bowman 1918 (as *Phyla nodiflora*); Fosberg 43010,  
43020 (US).  
 Without locality: Davis 1942 Table 7.
- I *Stachytarpheta jamaicensis* (L.) Vahl  
 Garden Key: Millspaugh 1907; Bowman 1918; Davis 1942 (all as  
*Valerianoides jamaicense*); Fosberg 42997 (US);  
Stoddart 8077 (US).  
 Loggerhead Key: Stoddart 8046 (US).

## LABIATAE

- ? *Salvia serotina* L.  
 Loggerhead Key: Millspaugh 1907; Bowman 1918; Fosberg 43026  
 (US).  
 Without locality: Davis 1942 Table 7.

## SOLANACEAE

- N? *Solanum bahamense* L.  
 Bush Key: Fosberg 42974 (US).  
 Loggerhead Key: Fosberg 43034 (US).

## SCROPHULARIACEAE

- ? *Capraria biflora* L.  
 Garden Key: Millspaugh 1907 (as *C. saxifragifolia*);  
Fosberg 43023 (US).  
 Loggerhead Key: Millspaugh 1907; Bowman 1918; Fosberg 43028  
 (US).  
 Without locality: Davis 1942 Table 7.



## GOODENIACEAE

N *Scaevola plumieri* (L.) Vahl

Bird Key: Millspaugh 1907; Bowman 1918.

Bush Key: Bowman 1918; Fosberg 42978 (US); Stoddart 8006 (US).

East Key: Millspaugh 1907; Bowman 1918; Stoddart 8039 (US).

Garden Key: Bowman 1918; Stoddart 8072 (US).

Loggerhead Key: Millspaugh 1907; Bowman 1918; Fosberg 43053 (US); Stoddart 8047 (US).

Sand Key: Bowman 1918.

## COMPOSITAE

? *Ambrosia hispida* Pursh

Loggerhead Key: Fosberg 43039 (US).

I *Bidens alba* (L.) DC.

Garden Key: Millspaugh 1907; Bowman 1918 (both as *B. leucantha*); Fosberg 42987 (US).

Loggerhead Key: Davis 1942 (as *B. leucantha*); Stoddart 8060 (US).

I *Conyza canadensis* (L.) Cronquist

Garden Key: Bowman 1918; Davis 1942 (both as *Leptilon canadense*); Fosberg 42984 (US).

Loggerhead Key: Fosberg sight record in 1962.

I *Gaillardia pulchella* Foug.?

Garden Key: Fosberg 43022 (US).

N *Iva imbricata* Walt.

Bird Key: Bowman 1918.

Bush Key: Bowman 1918.

East Key: Millspaugh 1907; Bowman 1918; Stoddart 8036 (US).

Garden Key: Millspaugh 1907; Bowman 1918; Davis 1942.

Loggerhead Key: Millspaugh 1907; Fosberg 43040 (US); Stoddart 8052 (US).

Middle Key: Davis 1942.

Sand Key: Millspaugh 1907; Bowman 1918.

N *Melanthera aspera* var. *glabriuscula* (O. Ktze.) Parks.

Bush Key: Stoddart 8010 (US).

Garden Key: Millspaugh 1907 (as *M. nivea*); Bowman 1918; Davis 1942 (both as *M. brevifolia*); Fosberg 42986 (US); Stoddart 8076 (US).

Loggerhead Key: Millspaugh 1907 (as *M. nivea*); Bowman 1918 (as *M. brevifolia*); Fosberg sight record in 1962; Stoddart 8061 (US).

I *Sonchus oleraceus* L.

Garden Key: Millspaugh 1907; Bowman 1918; Fosberg 42988 (US).

Without locality: Davis 1942 Table 7.

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Table 1. Dimensions and area of Bird Key

<u>Source</u>	<u>Original estimate</u>	<u>Metric equivalent</u>
DIMENSIONS		
Millspaugh 1907, 233	500 x 250 ft	153 x 76 m
Watson 1908, 191	400 x 300 yds	366 x 274 m
Bowman 1918	500 x 300 ft	152 x 92 m
AREA		
Tatnall and Gednery 1829	4 ac 2 roods 20 poles	18,210 m <sup>2</sup>
Scott 1904, 278	ca 8 ac	ca 32,400 m <sup>2</sup>
Millspaugh 1907	from map	6,440 m <sup>2</sup>
Watson and Lashley 1915, 35	ca 6,000 sq yds	ca 5,017 m <sup>2</sup>
Lashley 1915, 61	less than 5 ac	less than 20,200 m <sup>2</sup>
Pearson in 1915	8 ac	32,400 m <sup>2</sup>
Ashe and Lowe in 1918	ca 6 ac	ca 24,300 m <sup>2</sup>
England 1928, 14	less than 5 ac	less than 20,200 m <sup>2</sup>
Bowman 1918	from map at given scale	47,695 m <sup>2</sup>
	from map by MacArthur and Wilson 1968	13,935 m <sup>2</sup>
	from map, corrected scale	9,375 m <sup>2</sup>

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Source: records in Robertson (1964) and papers cited

Table 2. Plants recorded from Bird Key

	<u>Status</u>	<u>1904</u>	<u>1915</u>
<i>Cenchrus incertus</i>	N	x	x
<i>Paspalum distichum</i>	N	x	-
<i>Uniola paniculata</i>	N	x	x
<i>Cyperus planifolius</i>	N	x	-
<i>Cocos nucifera</i>	I	-	x
<i>Hymenocallis latifolia</i>	?	-	x
<i>Portulaca oleracea</i>	N	x	x
<i>Sesuvium portulacastrum</i>	N	x	x
<i>Cakile lanceolata</i>	N	x	x
<i>Suriana maritima</i>	N	x	x
<i>Euphorbia mesembrianthemifolia</i>	N	x	x
<i>Opuntia dillenii</i>	N	x	x
<i>Tournefortia gnaphalodes</i>	N	x	x
<i>Scaevola plumieri</i>	N	x	x
<i>Iva imbricata</i>	N	-	x
<hr/>			
	<u>Total</u>	<u>1904</u>	<u>1915</u>
Number of species	15	12	13
Native species	13	12	11
Introduced species	1	0	1
Uncertain status	1	0	1
<hr/>			

N: native

I: introduced

?: uncertain status

Table 3. Dimensions and area of Bush Key

<u>Source</u>	<u>Original estimate</u>	<u>Metric equivalent</u>
DIMENSIONS		
Bowman 1918	from map	583 x 342 m
Davis 1942	from map	976 x 333 m
Stoddart in 1977	from map	880 x 207 m
AREA		
Tatnall and Gednery 1829	5 ac 3 roods 22 poles	23,270 m <sup>2</sup>
Davis 1942	19 ac	115,900 m <sup>2</sup>
Sprunt 1948	110,000 sq yds	91,960 m <sup>2</sup>
Robertson 1964, 12	20 ac	80,900 m <sup>2</sup>
Stoddart in 1977	from map	81,330 m <sup>2</sup>

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Source: records in Robertson (1964) and papers cited



Table 4. Plants recorded from Bush Key

	<u>Status</u>	<u>1915</u>	<u>1937</u>	<u>1962</u>	<u>1977</u>
<i>Cenchrus incertus</i>	N	x	-	-	-
<i>Eustachys petraea</i>	N	-	x	-	-
<i>Sporobolus virginicus</i>	N	-	x	x	x
<i>Uniola paniculata</i>	N	x	x	x	x
<i>Cyperus planifolius</i>	N	-	-	x	x
<i>Casuarina equisetifolia</i>	I	-	-	-	x
<i>Batis maritima</i>	N	-	-	-	x
<i>Atriplex pentendra</i>	N	x	-	-	x
<i>Alternanthera maritima</i>	N	x	x	-	-
<i>Alternanthera philoxeroides</i>	?	-	-	-	x
<i>Philoxerus vermicularis</i>	N?	-	-	x	-
<i>Sesuvium portulacastrum</i>	N	x	x	x	x
<i>Cakile lanceolata</i>	N	x	-	-	x
<i>Suriana maritima</i>	N	x	x	x	x
<i>Euphorbia heterophylla</i>	?	-	-	-	x
<i>Euphorbia mesembrianthemifolia</i>	N	x	x	x	x
<i>Opuntia dillenii</i>	N	-	x	x	x
<i>Conocarpus erectus</i>	N	-	x	x	x
<i>Laguncularia racemosa</i>	N	-	x	x	x
<i>Rhizophora mangle</i>	N	x	x	x	x
<i>Ipomoea macrantha</i>	N	-	-	-	x
<i>Ipomoea pes-caprae</i>	N	x	x	-	-
<i>Tournefortia gnaphalodes</i>	N	x	x	-	x
<i>Avicennia germinans</i>	N	-	-	x	x
<i>Solanum bahamense</i>	N?	-	-	x	-
<i>Scaevola plumieri</i>	N	x	-	x	x
<i>Iva imbricata</i>	N	x	-	-	-
<i>Melanthera aspera</i>	N	-	-	-	x

	<u>Total</u>	<u>1915</u>	<u>1937</u>	<u>1962</u>	<u>1977</u>
Number of species	28	13	13	14	21
Native species	25	13	13	14	18
Introduced species	1	0	0	0	1
Uncertain status	2	0	0	0	2

N: Native

I: introduced

?: uncertain status

Table 5. Dimensions and area of East Key

<u>Source</u>	<u>Original estimate</u>	<u>Metric equivalent</u>
DIMENSIONS		
Agassiz 1888	from chart	500 m long
Millspaugh 1907	280 x 50 ft	85 x 15 m
Bowman 1918	1/3 mile long, 1/6 mile broad	ca 540 x 250m
Davis 1942	1200 x 600 ft	366 x 188 m
Stoddart in 1977	from map	345 x 103 m
AREA		
Tatnall and Gednery 1829	12 ac	48,600 m <sup>2</sup>
Scott 1904 (in 1890)	18 ac	72,800 m <sup>2</sup>
Millspaugh 1907	from map (dimensions in ft)	2,170 m <sup>2</sup>
	from map (dimensions in yds)	6,500 m <sup>2</sup>
Bowman 1918	from map at given scale	115,610 m <sup>2</sup>
	from map estimated by MacArthur and Wilson 1968	111,480 m <sup>2</sup>
	from map, corrected scale	87,220 m <sup>2</sup>
Sprunt 1948	85,000 sq yds	71,070 m <sup>2</sup>
Stoddart in 1977	from map	27,145 m <sup>2</sup>

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Source: records in Robertson (1964) and papers cited

Table 6. Plants recorded from East Key

	<u>Status</u>	<u>1904</u>	<u>1915</u>	<u>1937</u>	<u>1977</u>
<i>Cenchrus incertus</i>	N	x	x	x	x
<i>Uniola paniculata</i>	N	x	x	-	x
<i>Sesuvium portulacastrum</i>	N	x	x	x	x
<i>Cakile lanceolata</i>	N	x	x	-	x
<i>Suriana maritima</i>	N	-	-	x	x
<i>Euphorbia mesembrianthemifolia</i>	N	x	x	-	x
<i>Ipomoea pes-caprae</i>	N	-	-	x	x
<i>Tournefortia gnaphalodes</i>	N	x	x	-	x
<i>Scaevola plumieri</i>	N	x	x	-	x
<i>Iva imbricata</i>	N	x	x	-	x
<hr/>					
	<u>Total</u>	<u>1904</u>	<u>1915</u>	<u>1937</u>	<u>1977</u>
Number of species	10	8	8	4	10
Native species	10	8	8	4	10
Introduced species	0	0	0	0	0
Uncertain status	0	0	0	0	0

N: native

I: introduced

?: uncertain status

This tables does not include the strand records of *Rhizophora mangle* resulting from Davis's (1940) drift experiments in 1937 and 1938.

Table 7. Dimensions and area of Garden Kay

<u>Source</u>	<u>Original estimate</u>	<u>Metric equivalent</u>
DIMENSIONS		
Millspaugh 1907	from map	515 x 310 m
Vaughan 1918	from map	541 x 319 m
Bowman 1918	from map	720 x 360 m
Davis 1942	from map	590 x 320 m
AREA		
Tatnall and Gednery 1829	7.5 ac	30,350 m <sup>2</sup>
Bache in 1845	8.8 ac	35,610 m <sup>2</sup>
Millspaugh 1907	from map	92,880 m <sup>2</sup>
Vaughan 1918	from map	*96,550 m <sup>2</sup>
Bowman 1918	from map	150,540 m <sup>2</sup>
Davis 1942	from map	112,420 m <sup>2</sup>

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Source: records in Robertson (1964) and papers cited

\*with the separate sandbar to the northwest the area is 101,200 m<sup>2</sup>

Table 8. Plants recorded from Garden Kay

	<u>Status</u>	<u>1904</u>	<u>1915</u>	<u>1937</u>	<u>1962</u>	<u>1977</u>
<i>Pandanus tectorius</i>	I	-	-	-	x	-
<i>Brachiaria</i> sp.	I	-	-	-	x	-
<i>Cenchrus echinatus</i>	?	x	-	x	x	-
<i>Cenchrus incertus</i>	N	x	-	-	x	-
<i>Cynodon dactylon</i>	I	-	x	x	x	-
<i>Digitaria horizontalis</i>	I	-	-	-	x	-
<i>Digitaria sanguinalis</i>	?	x	x	x	x	-
<i>Eragrostis ciliaris</i>	I	-	-	-	x	-
<i>Eragrostis prolifera</i>	?	-	-	-	x	x
<i>Eragrostis tenella</i>	I	-	-	x	-	-
<i>Eustachys petraea</i>	N	x	-	x	x	-
<i>Paspalum caespitosum</i>	?	-	x	x	-	-
<i>Paspalum distichum</i>	N	x	-	-	-	-
<i>Sporobolus domingensis</i>	?	-	-	x	-	-
<i>Sporobolus purpurascens</i>	?	x	-	-	-	-
<i>Sporobolus virginicus</i>	N	-	x	x	-	-
<i>Stenotaphrum secundatum</i>	I	-	-	-	x	-
<i>Uniola paniculata</i>	N	x	x	x	-	-
<i>Cyperus planifolius</i>	N	x	x	x	x	-
<i>Cocos nucifera</i>	I	-	-	-	x	x
<i>Phoenix canariensis</i>	I	-	x	x	-	-
<i>Phoenix dactylifera</i>	I	-	x	x	x	-
<i>Pritchardia</i> sp.	I	-	-	-	x	-
<i>Washingtonia filifera</i>	I	-	-	-	x	-
<i>Rhoeo spathacea</i>	I	-	-	-	x	-
<i>Agave decipiens</i>	I	-	x	-	-	-
<i>Agave americana</i>	I	-	-	x	-	-
<i>Aloe barbadensis</i>	I	-	-	-	x	-
<i>Hymenocallis latifolia</i>	?	x	x	x	-	-
<i>Hymenocallis littoralis</i>	I	-	-	-	x	-
<i>Musa sapientum</i>	I	-	-	-	x	-
<i>Casuarina equisetifolia</i>	I	-	-	x	-	-
<i>Coccoloba uvifera</i>	?	-	x	x	x	x
<i>Atriplex pentandra</i>	N	x	x	-	-	x
<i>Alternanthera maritima</i>	N	-	x	-	-	-
<i>Amaranthus viridis</i>	I	x	-	-	-	-
<i>Philoxerus vermicularis</i>	N?	x	-	-	-	-
<i>Boerhavia coccinea</i>	?	x	x	x	x	-
<i>Bougainvillea glabra</i>	I	-	-	-	x	-
<i>Portulaca oleracea</i>	N	x	x	-	x	x

Table 8 cont.

	<u>Status</u>	<u>1904</u>	<u>1915</u>	<u>1937</u>	<u>1962</u>	<u>1977</u>
<i>Sesuvium portulacastrum</i>	N	x	x	x	-	-
<i>Argemone mexicana</i>	I	x	-	-	-	-
<i>Cakile lanceolata</i>	N	x	x	-	-	x
<i>Lepidium virginicum</i>	I	-	x	-	x	-
<i>Abrus precatorius</i>	I	-	-	-	x	-
<i>Caesalpinia bonduc</i>	?	-	x	-	-	-
<i>Caesalpinia pulcherrima</i>	I	-	-	-	x	-
<i>Cajanus cajan</i>	I	-	x	-	-	-
<i>Canavalia rosea</i>	N	x	x	x	x	x
<i>Ceratonia siliqua</i>	I	-	-	-	x	-
<i>Crotalaria pallida</i>	I	-	-	-	-	x
<i>Delonix regia</i>	I	-	-	-	x	x
<i>Desmanthus depressus</i>	?	-	-	-	x	-
<i>Desmodium incanum</i>	I	-	-	-	x	-
<i>Rhynchosia parviflorus</i>	I	-	x	-	-	-
<i>Sesbania sp.</i>	I	x	x	x	-	-
<i>Tamarindus indica</i>	I	-	x	x	x	-
<i>Citrus aurantiifolius</i>	I	-	-	-	x	-
<i>Suriana maritima</i>	N	x	x	x	-	x
<i>Bursera simaruba</i>	?	-	x	x	x	-
<i>Breynia disticha</i>	I	-	-	-	x	-
<i>Codiaeum variegatum</i>	I	-	-	-	x	-
<i>Euphorbia adenoptera</i>	?	x	-	-	-	-
<i>Euphorbia blodgettii</i>	?	-	-	-	x	-
<i>Euphorbia glomerifera</i>	I	-	x	-	x	-
<i>Euphorbia heterophylla</i>	?	x	-	x	x	x
<i>Euphorbia hirta</i>	I	-	-	-	x	-
<i>Euphorbia mesembrianthemifolia</i>	N	x	x	x	-	-
<i>Euphorbia prostrata</i>	I	-	-	-	x	-
<i>Pedilanthus tithymaloides</i>	I	-	-	-	x	-
<i>Phyllanthus amarus</i>	I	-	-	-	x	-
<i>Ricinus communis</i>	I	-	x	-	-	-
<i>Hibiscus rosa-sinensis</i>	I	-	-	-	x	-
<i>Malvaviscus arborea</i>	I	-	-	-	x	-
<i>Sida acuta</i>	I	x	x	-	x	-
<i>Sida procumbens</i>	I	x	x	-	x	-
<i>Thespesia populnea</i>	I	-	x	x	x	x
<i>Waltheria indica</i>	I	-	-	-	x	-
<i>Opuntia dillenii</i>	N	x	x	x	-	-
<i>Lawsonia inermis</i>	I	-	-	-	x	-

Table 8 cont.

	<u>Status</u>	<u>1904</u>	<u>1915</u>	<u>1937</u>	<u>1962</u>	<u>1977</u>
<i>Conocarpus erectus</i>	N	-	x	x	x	x
<i>Terminalia catappa</i>	I	-	x	-	x	-
<i>Psidium guajava</i>	I	-	x	x	x	-
<i>Rhizophora mangle</i>	N	-	x	-	-	-
<i>Polyscias guilfoylei</i>	I	-	-	-	x	-
<i>Eustoma exaltatum</i>	I	-	-	-	x	-
<i>Catharanthus roseus</i>	I	-	-	-	x	-
<i>Nerium oleander</i>	I	-	x	x	x	-
<i>Ochrosia elliptica</i>	I	-	-	-	-	x
<i>Cryptostegia grandiflora</i>	I	-	-	-	x	-
<i>Ipomoea macrantha</i>	N	-	x	-	-	x
<i>Ipomoea pes-caprae</i>	N	x	x	x	-	x
<i>Cordia sebestena</i>	I	-	x	-	x	x
<i>Heliotropium curassavicum</i>	N	x	-	-	x	-
<i>Heliotropium angiosperumum</i>	I	-	-	-	x	-
<i>Tournefortia gnaphalodes</i>	N	x	x	-	-	x
<i>Avicennia germinans</i>	N	-	x	x	x	-
<i>Lippia nodiflora</i>	?	-	x	-	x	-
<i>Stachytarpheta jamaicensis</i>	I	x	x	x	x	x
<i>Capraria biflora</i>	?	x	-	-	x	-
<i>Scaevola plumieri</i>	N	-	x	-	-	x
<i>Bidens alba</i>	I	x	x	-	x	-
<i>Conyza canadensis</i>	I	-	x	x	x	-
<i>Gaillardia pulchella</i>	I	-	-	-	x	-
<i>Iva imbricata</i>	N	x	x	x	-	-
<i>Melanthera nivea</i>	N	x	x	x	x	x
<i>Sonchus oleraceus</i>	I	x	x	-	x	-
<hr/>						
	<u>Total</u>	<u>1904</u>	<u>1915</u>	<u>1937</u>	<u>1962</u>	<u>1977</u>
Number of species	107	35	51	36	71	21
Native species	26	19	21	14	9	11
Introduced species	64	8	22	13	51	7
Uncertain status	17	8	8	9	11	3
<hr/>						
N: native	I: introduced	?: uncertain status				

Table 9. Dimensions and area of Loggerhead Key

<u>Source</u>	<u>Original estimate</u>	<u>Metric equivalent</u>
DIMENSIONS		
Agassiz 1888	from chart	1140 x 190 m
Millspaugh 1907	3/4 x 1/8 mile	1210 x 200 m
Bowman 1918	from map	1635 x 353 m
Davis 1942	4500 x 600 ft	1380 x 208 m
Stoddart in 1977	from map	1280 x 243 m
AREA		
Tatnall and Gednery 1829	ca 30 ac	121,400 m <sup>2</sup>
Millspaugh 1907	from map	242,300 m <sup>2</sup>
Bowman 1918	from map at given scale	473,840 m <sup>2</sup>
	from map estimated by MacArthur and Wilson 1968	195,090 m <sup>2</sup>
	from map, corrected scale	278,665 m <sup>2</sup>
Davis 1942	from map	209,920 m <sup>2</sup>
Robertson 1964, 14	ca 30 ac	ca 121,400 m <sup>2</sup>
Stoddart in 1977	from map	227,700 m <sup>2</sup>

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Source: records in Robertson (1964) and papers cited



Table 10. Plants recorded from Loggerhead Key

	Status	1904	1915	1937	1962	1977
<i>Cenchrus echinatus</i>	?	-	x	-	-	x
<i>Cenchrus myosuroides</i>	?	-	-	-	x	-
<i>Cenchrus incertus</i>	N	-	x	-	x	-
<i>Eragrostis prolifera</i>	?	-	-	-	-	x
<i>Eragrostis tenella</i>	I	-	-	-	x	-
<i>Eustachys petraea</i>	N	-	-	-	x	x
<i>Panicum maximum</i>	I	-	-	-	x	-
<i>Paspalum caespitosum</i>	?	-	x	-	-	-
<i>Sporobolus virginicus</i>	N	x	x	x	x	-
<i>Uniola paniculata</i>	N	x	x	x	x	x
<i>Cyperus planifolius</i>	N	-	x	-	x	x
<i>Cocos nucifera</i>	I	-	x	x	-	x
<i>Agave americana</i>	I	-	-	x	-	-
<i>Agave rigida</i>	I	-	x	-	-	-
<i>Aloe barbadensis</i>	I	-	x	x	-	-
<i>Asparagus sprengeri</i>	I	-	x	-	-	-
<i>Hymenocallis latifolia</i>	?	x	x	x	x	x
<i>Yucca aloifolia</i>	I	-	x	x	-	-
<i>Casuarina equisetifolia</i>	I	-	x	x	-	x
<i>Ficus hispida</i>	I	-	x	x	-	-
<i>Ficus palmata</i>	I	-	-	-	x	-
<i>Coccoloba uvifera</i>	?	-	x	-	-	x
<i>Boerhavia coccinea</i>	?	-	x	x	x	x
<i>Portulaca oleracea</i>	N	x	x	x	-	-
<i>Sesuvium portulacastrum</i>	N	x	x	x	x	-
<i>Cakile lanceolata</i>	N	x	x	-	-	-
<i>Caesalpinia bonduc</i>	?	x	-	-	x	x
<i>Canavalia rosea</i>	N	x	x	x	x	-
<i>Tribulus cistoides</i>	?	x	-	-	-	-
<i>Suriana maritima</i>	N	x	x	x	-	x
<i>Bursera simaruba</i>	?	-	-	-	x	-
<i>Euphorbia heterophylla</i>	?	-	x	x	x	x
<i>Euphorbia hirta</i>	I	-	-	-	x	-
<i>Euphorbia mesembrianthemifolia</i>	N	x	x	x	x	x
<i>Euphorbia prostrata</i>	I	-	-	-	x	-
<i>Pedilanthus tithymaloides</i>	I	-	x	-	-	-

Table 10 cont.

	<u>Status</u>	<u>1904</u>	<u>1915</u>	<u>1937</u>	<u>1962</u>	<u>1977</u>
<i>Hibiscus rosa-sinensis</i>	I	-	x	-	-	-
<i>Thespesia populnea</i>	I	-	x	x	-	x
<i>Carica papaya</i>	I	x	x	-	-	-
<i>Opuntia dillenii</i>	N	x	x	x	-	x
<i>Catharanthus roseus</i>	I	-	x	-	x	-
<i>Nerium oleander</i>	I	-	x	-	-	-
<i>Thevetia peruviana</i>	I	-	x	-	-	-
<i>Ipomoea macrantha</i>	N	x	x	x	x	-
<i>Ipomoea pes-caprae</i>	N	x	x	x	x	x
<i>Cordia sebestena</i>	I	x	x	-	x	x
<i>Tournefortia gnaphalodes</i>	N	x	x	x	x	x
<i>Stachytarpheta jamaicensis</i>	I	-	-	-	-	x
<i>Salvia serotina</i>	?	x	x	-	x	-
<i>Solanum bahamense</i>	N?	-	-	-	x	-
<i>Capraria biflora</i>	?	x	x	-	x	-
<i>Scaevola plumieri</i>	N	x	x	-	x	x
<i>Ambrosia hispida</i>	?	-	-	-	x	-
<i>Bidens alba</i>	I	-	-	x	-	x
<i>Conyza canadensis</i>	I	-	-	-	x	-
<i>Iva imbricata</i>	N	x	-	-	x	x
<i>Melanthera aspera</i>	N	x	x	-	x	x

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	<u>Total</u>	<u>1904</u>	<u>1915</u>	<u>1937</u>	<u>1962</u>	<u>1977</u>
Number of species	57	22	39	22	32	24
Native species	19	15	16	11	15	11
Introduced species	24	2	15	8	8	6
Uncertain status	14	5	8	3	9	7

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N: native

I: introduced

?: uncertain status

This table does not include the strand records of *Rhizophora mangle* resulting from Davis's (1940) drift experiments in 1937 and 1938.

Table 11. Dimensions and area of Long Key

<u>Source</u>	<u>Original estimate</u>	<u>Metric equivalent</u>
DIMENSIONS		
Davis 1942	from map	512 x 178 m
Stoddart in 1977	from map	224 x 73 m
AREA		
Davis 1942	from map	47,300 m <sup>2</sup>
Stoddart in 1977	from map	8,120 m <sup>2</sup>

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Source: papers cited

Table 12. Plants recorded from Long Key

	<u>Status</u>	<u>1915</u>	<u>1937</u>	<u>1962</u>	<u>1977</u>
<i>Sporobolus virginicus</i>	N	-	-	-	x
<i>Cyperus planifolius</i>	N	x	-	-	-
<i>Casuarina equisetifolia</i>	I	-	-	x	-
<i>Batis maritima</i>	N	-	x	-	-
<i>Atriplex pentandra</i>	N	x	-	x	x
<i>Salicornia bigelovii</i>	N	-	x	x	x
<i>Alternanthera maritima</i>	N	x	-	-	-
<i>Sesuvium portulacastrum</i>	N	x	x	x	x
<i>Suriana maritima</i>	N	x	-	x	x
<i>Euphorbia mesembrianthemifolia</i>	N	x	-	x	x
<i>Laguncularia racemosa</i>	N	-	-	x	-
<i>Rhizophora mangle</i>	N	x	x	x	x
<i>Ipomoea macrantha</i>	N	-	-	-	x
<i>Ipomoea pes-caprae</i>	N	-	-	x	-
<i>Tournefortia gnaphalodes</i>	N	x	-	-	x
<i>Avicennia germinans</i>	N	-	x	x	x
<hr/>					
	<u>Total</u>	<u>1915</u>	<u>1937</u>	<u>1962</u>	<u>1977</u>
Number of species	16	8	5	10	10
Native species	15	8	5	9	10
Introduced species	1	0	0	1	0
Uncertain status	0	0	0	0	0

N: native

I: introduced

?: uncertain status

Table 13. Plants recorded from Middle Key

	<u>Status</u>	<u>1915</u>	<u>1937</u>
<i>Cakile lanceolata</i>	N	x	x
<i>Euphorbia mesembrianthemifolia</i>	N	-	x
<i>Iva imbricata</i>	N	-	x

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	<u>Total</u>	<u>1915</u>	<u>1937</u>
Number of species	3	1	3
Native species	3	1	3
Introduced species	0	0	0
Uncertain status	0	0	0

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N: native

I: introduced

?: uncertain status

Table 14. Dimensions and area of Sand Key

<u>Source</u>	<u>Original estimate</u>	<u>Metric equivalent</u>
DIMENSIONS		
Agassiz 1888	from chart	160 m long
Millspaugh 1907	80 x 50 ft	24 x 15 m
Bowman 1918	from chart	27 x 14 m
Davis 1942	110 x 70 ft	34 x 21 m
Stoddart in 1977	from map	113 x 42 m
AREA		
Millspaugh 1907	from map	228 m <sup>2</sup>
Bowman 1918	from map at given scale	41,733 m <sup>2</sup>
	from map estimated by MacArthur and Wilson 1968	3,344 m <sup>2</sup>
	from map, corrected scale	222 m <sup>2</sup>
Stoddart in 1977	from map	3,512 m <sup>2</sup>

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Source: papers cited

Table 15. Plants recorded from Sand Key

	<u>Status</u>	<u>1904</u>	<u>1915</u>	<u>1937</u>
<i>Uniola paniculata</i>	N	x	-	x
<i>Sesuvium portulacastrum</i>	N	x	-	-
<i>Cakile lanceolata</i>	N	-	x	-
<i>Euphorbia mesembrianthemifolia</i>	N	x	-	x
<i>Ipomoea pes-caprae</i>	N	x	-	-
<i>Tournefortia gnaphalodes</i>	N	-	-	x
<i>Scaevola plumieri</i>	N	-	x	-
<i>Iva imbricata</i>	N	x	x	-

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	<u>Total</u>	<u>1904</u>	<u>1915</u>	<u>1937</u>
Number of species	8	5	3	3
Native species	8	5	3	3
Introduced species	0	0	0	0
Uncertain status	0	0	0	0

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N: native

I: introduced

?: uncertain status

This tables does not include the strand records of *Rhizophora mangle* resulting from Davis's (1940) drift experiments in 1937 and 1938.

Table 16. Distribution of native plants (excluding sea-grasses) on Dry Tortugas keys

	Bird	Bush	East	Garden	Loggerhead	Long	Middle	Sand
<i>Cenchrus incertus</i>	x	x	x	x	x	-	-	-
<i>Eustachys petraea</i>	-	x	-	x	x	-	-	-
<i>Paspalum distichum</i>	x	-	-	x	-	-	-	-
<i>Sporobolus virginicus</i>	-	x	-	x	x	x	-	-
<i>Uniola paniculata</i>	x	x	x	x	x	-	-	x
<i>Cyperus planifolius</i>	x	x	-	x	x	x	-	-
<i>Batis maritima</i>	-	x	-	-	-	x	-	-
<i>Atriplex pentandra</i>	-	x	-	x	-	x	-	-
<i>Salicornia bigelovii</i>	-	-	-	-	-	x	-	-
<i>Alternanthera maritima</i>	-	x	-	x	-	x	-	-
<i>Philoxerus</i>	-	x	-	x	-	-	-	-
<i>vermicularis</i>								
<i>Portulaca oleracea</i>	x	-	-	x	x	-	-	-
<i>Sesuvium</i>	x	x	x	x	x	x	-	x
<i>portulacastrum</i>								
<i>Cakile lanceolata</i>	x	x	x	x	x	-	x	x
<i>Canavalia rosea</i>	-	-	-	x	x	-	-	-
<i>Suriana maritima</i>	x	x	x	x	x	x	-	-
<i>Euphorbia</i>	x	x	x	x	x	x	x	x
<i>mesembrianthemifolia</i>								
<i>Opuntia dillenii</i>	x	x	-	x	x	-	-	-
<i>Conocarpus erectus</i>	-	x	-	x	-	-	-	-
<i>Laguncularia racemosa</i>	-	x	-	-	-	x	-	-
<i>Rhizophora mangle</i>	-	x	-	x	-	x	-	-
<i>Ipomoea macrantha</i>	-	x	-	x	x	x	-	-
<i>Ipomoea pes-caprae</i>	-	x	x	x	x	x	-	x
<i>Heliotropium</i>	-	-	-	x	-	-	-	-
<i>curassavicum</i>								
<i>Tournefortia</i>	x	x	x	x	x	x	-	x
<i>gnaphalodes</i>								
<i>Avicennia germinans</i>	-	x	-	x	-	x	-	-
<i>Solanum behamense</i>	-	x	-	-	x	-	-	-
<i>Scaevola plumieri</i>	x	x	x	x	x	-	-	x
<i>Iva imbricata</i>	x	x	x	x	x	-	x	x
<i>Melanthera aspera</i>	-	x	-	x	x	-	-	-



Table 17. Numbers of species in different categories recorded from the Dry Tortugas keys

	<u>1904</u>	<u>1915</u>	<u>1937</u>	<u>1962</u>	<u>1977</u>	<u>Total</u>
TOTAL NUMBER OF SPECIES						
Bird	12	13	-	-	-	15
Bush	1	13	13	14	21	28
East	8	8	4	0	10	10
Garden	35	51	36	71	21	107
Loggerhead	22	38	22	32	24	56
Long	-	8	5	10	10	16
Middle	-	1	3	-	-	3
Sand	5	3	3	-	-	8
NUMBER OF NATIVE SPECIES						
Bird	12	11	-	-	-	13
Bush	1	13	13	14	18	25
East	8	8	4	0	10	10
Garden	19	21	14	9	11	26
Loggerhead	15	16	11	15	11	19
Long	-	8	5	9	10	15
Middle	-	1	3	-	-	3
Sand	5	3	3	-	-	8
NUMBER OF INTRODUCED SPECIES						
Bird	0	1	-	-	-	1
Bush	0	0	0	0	1	1
East	0	0	0	0	0	0
Garden	8	22	13	51	7	64
Loggerhead	2	14	8	8	6	23
Long	-	0	0	1	0	1
Middle	-	0	0	-	-	0
Sand	0	0	0	-	-	0
NUMBER OF SPECIES OF UNCERTAIN STATUS						
Bird	0	1	-	-	-	1
Bush	0	0	0	0	2	2
East	0	0	0	0	0	0
Garden	8	8	9	11	3	17
Loggerhead	5	8	3	9	7	14
Long	-	0	0	0	0	0
Middle	-	0	0	-	-	0
Sand	0	0	0	-	-	0

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Table 18. Summary of area and plant species numbers for Dry Tortugas keys

		<u>1904</u>	<u>1915</u>	<u>1937</u>	<u>1977</u>	<u>Total</u>
Bird	Area sq m	6,440	9,375	-	-	
	Total no. species	12	13	-	-	15
	No. native species	12	11	-	-	13
Bush	Area sq m	-	-	115,900	81,330	
	Total no. species	13	13	14	21	28
	No. native species	13	13	14	18	25
East	Area sq m	6,500*	87,220*	-	27,145	
	Total no. species	8	8	4	10	10
	No. native species	8	8	4	10	10
Garden	Area sq m	92,880	150,540*	112,420	-	
	Total no. species	35	51	36	21	107
	No. native species	19	21	14	11	26
Loggerhead	Area sq m	242,300	278,700*	209,900	227,700	
	Total no. species	22	39	22	24	57
	No. native species	15	16	11	11	19
Long	Area sq m	-	-	47,300	8,120	
	Total no. species	0	8	5	10	16
	No. native species	0	8	5	10	15
Middle	Area sq m	0	194	-	0	
	Total no. species	0	1	3	0	3
	No. native species	0	1	3	0	3
Sand	Area sq m	228*	222*	-	3,512	
	Total no. species	5	3	3	0	8
	No. native species	5	3	3	0	8

\*area considered unreliable

Table 19. 'Extinction' of plant species on Dry Torugas keys, 1904-1916

This table is a revision of Table 5 in MacArthur and Wilson (1968), p. 52; their original figures are given in brackets.

	Total number of species in 1904	Number of species present in 1904 but absent in 1916	Estimated per cent of all species extinct during 1904-1916	Number of local species in 1904	Number of local species present in 1904 but absent in 1916	Estimated per cent of local species extinct during 1904-1916
Bird	12 (12)	2 (1)	17 (8)	12 (6)	2 (1)	17 (17)
East	8 (8)	0 (0)	0 (0)	8 (3)	0 (0)	0 (0)
Garden	35 (35)	12 (6)	34 (17)	19 (24)	5 (6)	26 (25)
Loggerhead	22 (21)	3 (1)	14 (5)	15 (12)	1 (1)	7 (8)
Middle	0 (1)	0 (1)	- (100)	-	-	-
Sand	5 (5)	4 (5)	80 (100)	5 (-)	4 (-)	80 (-)

Table 20. Species-area data for Alacran Reef

	Area in 1899 based on maps in Millspaugh (1916), ha	Area in 1960 calculated by Folk (1967), ha	Ratio of 1960:1899 areas	Number of species in 1899, from Millspaugh (1916)	Number of species ca 1960, from Bonet and Rzedowski (1962)	Number of species in 1960, from Fosberg (1962)*	Total number of species recorded
Perez	5.37	19.83	3.69	17	17	16	24
Desertora	2.04	12.55	6.15	5	7	13	14
Pajaros	1.55	4.45	2.87	10	12	11	14
Chica	0.95	1.29	1.36	6	7	7	9
West Desterrada	-	6.67	-	-	-	7	7
East Desterrada	-	7.69	-	-	-	5	5
Desaparecida	-	0.4	-	-	-	0	0

\*excluding cultivated pot-plants