

ELEMENT STEWARDSHIP ABSTRACT
for

Dioscorea bulbifera

Air potato

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SPECIES CODE

PMDIO01040

SCIENTIFIC NAME*Dioscorea bulbifera* L.**COMMON-NAMES**

air potato, bitter yam

DESCRIPTION & DIAGNOSTIC CHARACTERS

Monocotyledonous, dioecious, herbaceous, perennial vine; stems annual, twining counterclockwise, slightly angled to 15 m or more long, glabrous, arising from a small tuber 5-10(20) cm in diameter. Leaves simple, alternate, blades broadly ovate, cordate, cuspidate, 4-20 cm long and wide (or larger), prominently 7-11-nerved, glabrous, entire; petioles 6-16 cm long; bulbils (aerial tubers) usually in axils, generally subspherical, smooth-surfaced, from <1-10 cm in diameter. Inflorescences axillary, pendent; flowers small, fragrant, unisexual - male and female superficially alike; staminate flowers in slender, simple or fasciculate spikes or elongate panicles to 11 cm long, each flower subtended by 2 unequal ovate bracts, tepals 6, white, lanceolate, 2.5-3 mm long, stamens 6, ovary rudimentary; pistillate flowers in simple spikes to 23 cm long, these clustered 3-6 in fascicles, tepals 6, white (yellow with age), staminodes 6, stigmas irregularly 2-lobed. Fruit a loculicidal capsule, ca. 2-5 cm long, deeply 3-lobed; seeds 1-2 per cell, winged on basal side only, 15-18 mm long. (Martin 1974, Morton 1974, Long & Lakela 1976, Ward 1977, Correll & Correll 1982, and Wagner, Herbst & Somer 1990.)

Martin (1974) reported the bulbils of Asian varieties are usually spherical to ellipsoid, occasionally slightly flattened, their surface relatively smooth. Those of African varieties are sharply angled, often characterized by depressions of preformed buds.

Dioscorea bulbifera (Dioscoreaceae) is characterized by its aggressively high-climbing annual twining stems, large heart-shaped leaves with prominent veins, and potato-like aerial tubers in the leaf axils (Morton 1974, Long & Lakela 1976, Morton 1982.) An excellent line drawing is in Correll and Correll (1982) and a color photograph is in Bell and Taylor (1982).

D. bulbifera may be confused by *D. alata* in the field. Although the latter species has opposite leaves in contrast to the former's alternate leaves, *D. alata* often aborts one leaf and may appear to be alternate. The remaining leaf scar is evident and may be used to distinguish the species. Additionally, *D. alata* often has winged stems and the bulbils may have emergent "roots" (Gann-Matzen, pers. comm. 1992).

STEWARDSHIP SUMMARY

Dioscorea bulbifera is an aggressive exotic invader of native hammock vegetation over much of peninsular Florida. Any occurrence of *D. bulbifera* in uncultivated areas should be considered undesirable. High production of aerial tubers allows for rapid population growth. The plants grow rapidly in full sun where they can overgrow and kill native flora. Current practices of manual and herbicide control are very labor intensive and thus expensive. Research is needed on improving control methods of this pest species. In

addition, a public education program needs to be initiated to inform people that: 1. this "attractive ornamental" will easily spread out of control and 2. care needs to be taken in disposing of aerial and underground tubers to avoid the magnification of this problem.

IMPACTS (THREATS POSED BY THIS SPECIES)

GLOBAL RANGE

HABITAT

Dioscorea bulbifera has been widely distributed through human activities and has become naturalized in many tropical and sub-tropical regions of the world (Martin 1974). In 1905, the U.S. Bureau of Plant Industry sent samples of air potato to horticulturalist Henry Nehrling for experimental cultivation in Gotha, Florida (Nehrling 1944). [This is the earliest record of its introduction to the state that can be substantiated by this author]. The species may now be found from Key West (Doria Gordon, pers. comm. 1992) to at least as far north as Alachua County (Dan Ward, pers. comm. 1992). We have found no written reference of this species invading other states within the continental U.S. However, the species appears to be present in southern Illinois (Randall, pers. comm. 1992 as reported to him by Vicki Nuzzo).

In peninsular Florida, air potato is an aggressive weedy invader in many different mesic habitats including thickets, disturbed areas, fence rows (Bell & Taylor 1982) and hardwood hammocks (Wunderlin 1982). Martin (1974) pointed out that an accumulation of leaves on the ground may be necessary to protect sprouting aerial tubers from desiccation. In South Florida, the species is almost always found in tropical hammocks, and invades habitats ranging from xeric uplands to deep solution holes. It is rarely found along disturbed edges of pinelands. Air potato is not salt tolerant and thus is not invasive in marine areas (Rob Line, pers. comm. 1992). Air potato is particularly abundant in Dade County where it is growing in almost every county park with hammock vegetation (Carol Lippincott, pers. comm. 1992). (Some records may confuse presence of *D. bulbifera* with that of *D. alata*. In Central and North Florida, *D. bulbifera* is most common in mesic hammocks and urban lots (Gordon, pers. comm. 1992) and alluvial flood plain forests (Francis E. Putz, pers. comm. 1992). Air potato growth appears most vigorous on hammock edges or where canopy gaps occur (Gordon, pers. comm. 1992, Lippincott, pers. comm. 1992).

BIOLOGY-ECOLOGY

The yam group (*Dioscorea* spp.) is one of the most important root or tuber crops grown in tropical areas (Martin 1974). *Dioscorea bulbifera* is one of the most common and widespread food yams and can be found in every hot humid tropical region of the world. Although not one of the best quality yams, some varieties of *D. bulbifera* produce large numbers of edible aerial tubers over long periods of time. The species is believed to be native to both Asia and Africa. The varieties from these 2 regions are quite distinct (see differences in bulbil morphology, discussed above). *D. bulbifera* is not native to the Western Hemisphere but it is so widespread that it is noted in most floras of tropical Central and South America. Wild forms, usually bitter and often poisonous, are the most common while the more desirable cultivars do not survive in the wild for long periods (Martin 1974).

U.S. Government chemists who received tubers back from Nehrling found them worthless for their intended use - medicinal research. Nehrling (1944) wrote: "It grew like a weed and there were thousands of air

potatoes along the stems. If not gathered, they all sprouted and soon formed impenetrable masses. With the exception of the kudzu vine, I have never seen a more aggressive and dangerous weed in Florida." Despite his terrible review of *D. bulbifera*, this species has long been recommended for ornamental planting.

Hume (1929) stated its "leaves are very attractive and form a dense shade. It is valuable for covering tree trunks and for screening purposes." Dickey (1968), in IFAS Bulletin 172B, wrote that *Dioscorea* "yams, although not recommended for permanent plantings, are very satisfactory for use as quick temporary vines."

Unfortunately, he did not tell how to insure their temporary status. The IFAS Circular 860, *Vines for Florida* (Black 1990), included air potato with the warning "should be planted in confined area as apt to spread rapidly." Conversely, *D. bulbifera* has been listed as an invasive pest species by many authors (Long & Lakela 1976, Morton 1976 & 1982, Bell 1982). It was listed among the top 15 invasive species on the Exotic Pest Plant Council's "1991 List of Florida's Most Invasive Species".

Almost all of the people contacted for this ESA had never seen *D. bulbifera* flower or fruit in Florida (Brinkley, Gann-Matzen, Gordon, Line, Lippencott, Maguire, pers. comm. 1992). Long and Lakela (1976) and Bell & Taylor (1982) also stated that flowers are not produced in our area. Putz (pers. comm. 1992) has observed flowering air potato in Alachua Co. The author located three flowering specimens at the University of Florida Herbarium (FLAS): Dade County (10/03/72), Lake County (09/23/68) and Marion County (10/02/40). George N. Avery, who made the Dade County collection, noted on the specimen label that the fragrant flowers were 3-5 m above the ground. Martin (1974) confirmed that the species is dioecious and observed that its flowers are small and often inconspicuous.

Dioscorea bulbifera insures its propagation by vegetative means, producing an abundance of bulbils (aerial tubers) in the leaf axils. Bulbils tend to form once stem growth is well under way and act as the main storage organ. These bulbils have the appearance and morphology of condensed stems. It has been noted that mature bulbils float in water suggesting that they may be dispersed by flood waters (Coursey 1967). Even small bulbils (1 cm diameter) can sprout and grow into new vines (Line, pers. comm. 1992).

Coursey (1967) described the life of a typical *Dioscorea* plant as an annually repeated cycle of growth and dormancy. During the active phase, the majority of the plant consists of above ground stems and leaves; the dormant phase has the subterranean tuber only. Growth of the stems at the beginning of the active phase can be very rapid, up to 15 cm/day (Coursey 1967). In relatively frost-free Dade County, die-back of the stems and leaves usually occurs in October and growth resumes in March (Brinkley, pers. comm. 1992, Line, pers. comm. 1992), but can be variable into July (Gann-Matzen, pers. comm. 1992).

Hortus Third (1976) describes the subterranean tubers of *D. bulbifera* as small or not present. Martin (1974) reported that these tubers vary from none to very large depending on the variety. He added the Asian races produce spherical or ellipsoidal tubers, whereas those of African races are much more branched and irregular. In Florida, these tubers are usually less than 10 cm in diameter but can be up to 20 cm in sandy soil (Gann-Matzen, pers. comm. 1992, Line, pers. comm. 1992). The author (pers. obs. 1992) unearthed a tuber in Alachua County measuring 25 cm in diameter and weighing about 5 kg.

In Florida, bulbils begin to form in June or July and may begin to drop to the ground by late August (Gann-Matzen, pers. comm. 1992). They usually are from 1-5 cm in diameter but can grow up to 10 cm or more and are usually nearly round in outline (Ward 1977, Gann-Matzen, pers. comm. 1992). These tubers can

last a year or more on the ground or on old vines before sprouting, and can produce stems without soil contact (Brinkley, Gann-Matzen, Line pers. comms. 1992). There seems to be little or no predation on these tubers (Brinkley, pers. comm. 1992, Putz, pers. comm. 1992).

Air potato may have some impact on surrounding vegetation when it is growing in shaded areas (Gann-Matzen, pers. comm. 1992), but has greater impact when the foliage reaches direct sunlight (e.g. where a tree falls down to cause a light gap in the canopy). In these situations, its rapid growth and dense foliage can smother tree seedlings and other undergrowth near the ground (Line, pers. comm. 1992). Vines reaching the canopy can completely cover the trees present (Brinkley, pers. comm. 1992; Morton 1974).

RECOVERY POTENTIAL

MONITORING REQUIREMENTS

Dioscorea is rapidly invading new areas, especially in Dade County, Florida (Line, pers. comm. 1992). Its spread should be closely monitored. Natural areas close to known infestations should be checked frequently (semi-annually or quarterly) as the vines are easier to eliminate when detected early. The northern limit of the species requires careful monitoring so that we can determine and quantify the potential rate of range expansion.

MONITORING PROCEDURES

Ground surveys for new populations in managed areas should be conducted at least annually in the summer. Monitoring can be of numbers of climbing stems on trees, number of rooted stems in plots, or cover

MONITORING PROGRAMS

A cooperative project between Dade County Parks (Rob Line), Dade Co. DERM (Joe Maguire), Ecohorizons, Inc. (George Gann-Matzen) and The Nature Conservancy (Doria Gordon) has established monitoring in conjunction with a control experiment (described below) in two Dade Co. parks. The monitoring involved examines density of rooted stems and cover in 0-1 m, 1-3 m, and >3 m height categories.

The Nature Conservancy is also monitoring vertical vine numbers on trees at the Janet Butterfield Brooks Preserve, in Brooksville (Hernando Co.). In that site, suppression of other climbing species like *Paederia foetida* resulted in apparently higher numbers of bulbil production in the released air potato. Air potato stems appear to be readily killed by fire, although resprouting from the tuber is rapid. Mortality of bulbils on the ground is dependent on local fire intensity and bulbil size.

RESEARCH NEEDS

Research into biological control of *D. bulbifera* needs to be initiated as none is currently being done. However, such research should be approached cautiously because of closely related Florida natives (*D. floridana*; and 5 taxa within the genus listed by Radford et al. (1968) for the southeastern US) and agricultural species in Florida. Factors affecting the susceptibility of *Dioscorea* to herbicides need study: when is the best time to apply, at what stage of plant growth and at what frequency and concentration to obtain optimum results. Research into physical cutting and controlled burning techniques needs to be continued (see below). The frequency of flowering and possible fruiting also needs examination to see if

sexual reproduction is occurring in Florida. The presence of other naturalized *Dioscorea* spp. in Florida should be investigated. Gann-Matzen (pers. comm. 1992; confirmed by Line, pers. comm. 1992) reported *D. alata* is probably more common than currently realized. Presence of this species has been confirmed in Barnacle State Historic Site and Ross Hammock.

MANAGEMENT RESEARCH PROGRAMS

Initial research of control by prescribed burning is being conducted in Brooksville by The Nature Conservancy (Doria Gordon and George Gann-Matzen, pers. comm. 1992; see above).

These researchers have also started an experiment in Dade County to study the effectiveness of repeated stem clipping and Round-Up herbicide applications to control *D. bulbifera*. Three sets of paired (treatment and control) 36 x 36 m blocks in areas invaded by air potato were established in two locations at the Charles Deering Estate and at one location at Kendall Indian Hammocks Park, Dade Co. Within each block, 20 randomly distributed 1 m² plots were located, and density and cover data taken for native and non-native species in each plot.

In June, 1992, all non-native species present in the treatment blocks were removed by clipping, hand-pulling, and herbicide application. No herbicide was applied in 9 m² areas encompassing each 1m² plot (20/block). Within half of these plots in each treatment block, all stems of air potato were pulled to uproot or break monthly starting in June. Within the remaining plots, stems were treated with Round-Up monthly following the initial pulling treatment.

Hurricane Andrew broke most trees and created similarly high light conditions across all six blocks in late August, 1992. As a result, only two of the planned six months of treatments were completed. Re-monitoring of the plots in May, 1993 will occur as planned.

An additional research project is underway to examine the potential for air potato to invade wetlands. Kathy Burks (pers. comm. 1993) was informed of the species invading a cypress dome and decided to examine the viability of air potato under wet conditions. She has established a factorial experiment using three bulbil sizes and three moisture regimes (always in wet soil, always in well drained soil, flooded and then drained soil) outside, to examine size specific response to water level. Stem length and other growth variables will be measured.

MANAGEMENT REQUIREMENTS

Air potato requires active management to prevent its spread and the resulting suppression of natural communities. It is difficult to eradicate because of its underground tuber and its abundant crops of bulbils (aerial tubers) (Morton 1982). The spread of invasive exotic vegetation can be significantly reduced by public education (Langeland 1990). This is especially true with *Dioscorea bulbifera* as humans are its main vector. People should be made aware of its potential to grow rapidly out of control and warned not to move tubers to areas where the resulting vines will become a nuisance. Manual removal of tubers can be an effective control measure but is very labor intensive.

BIOLOGICAL CONTROL:

There are no approved biological control agents for *Dioscorea bulbifera* in the U.S.

BURNING:

Controlled burns may be useful in certain situations to kill stem growth and bulbils on the ground. Gordon and Gann-Matzen (pers. comm. 1992) have done some preliminary work with this technique of physical control at Brooksville (see above).

CUTTING AND CHEMICAL:

Some control of vine stems can be obtained by physically cutting or spraying with Round-Up herbicide. Clipping back of stems should be done before new bulbils develop in late spring (about June) to weaken the underground tuber (Gann-Matzen, Line, pers. comms. 1992). This helps to contain the vines on the ground where they can be more easily sprayed with herbicide (Gann-Matzen, pers. comm. 1992). Round-Up herbicide can be used as a foliar spray and will kill above ground growth but the subterranean tuber will frequently resprout (Brinkley, Maguire, pers. comms. 1992). Care must be used as Round-Up is not a selective herbicide and may damage other desirable vegetation. A marker dye is very useful in the spray mixture to insure proper coverage (Brinkley, pers. comm. 1992). (Dyes and herbicide solvents may be toxic and should be used with care.)

MANUAL AND MECHANICAL CONTROL:

Subterranean tubers can be dug up but this is very time consuming (Gann-Matzen, pers. comm. 1992). Bulbils can be removed by manually picking or raking them up from under the vines in winter (Brinkley, pers. comm. 1992). In Dade County, bulbils are easiest to find in February before they are covered by live oak leaf fall (generally in March) (Line, pers. comm. 1992). Bulbils are readily evident following fire (Gordon, pers. comm. 1992). Care must be taken to avoid spreading the species when tubers are disposed of (e.g., if they are dumped on trash piles or left for composting (Line, pers. comm. 1992).

Mechanical removal by heavy machinery is of very limited value because the vines frequently grow between and over desirable native vegetation. Additionally, this activity causes extensive soil disturbance and results in sites more advantageous for colonization by non-native species.

MANAGEMENT PROGRAMS:

Active management programs have been started in Dade County. Laura Brinkley at Enchanted Forest Park (North Miami Parks Department) has supervised an air potato eradication program there for almost one year. Other key contacts are Rob Line at Dade County Parks Department and Joe Maguire at DERM. Doug DeVries (pers. comm. 1992) at Everglades National Park stated a control program was begun at Paradise Key in April of 1992.

Doria Gordon and George Gann-Matzen have initiated management programs at the Janet Butterfield Brooks Preserve (Brooksville), and the Deering Estate and Kendall Indian Hammock in Dade Co. (see above).

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**THIS EDITION UPDATED:
5 June 1993**

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