The seed pods are small and contain blue colored seeds which are unusual in the Bahamas. The seeds germinate readily if they are scarified. This species has been found only on Abaco and South Andros in the Bahamas. It is also known from Cuba. The flowers are produced in the spring and fruits ripen in summer.

Tabebuia bahamensis (Bignoniaceae) is another attractive small tree from the Bahamas. There are many species of *Tabebuia* grown in Florida but this one is unusual in making a small slender tree with a sparse grayish foliage. The leaves generally have 3 to 5 leaflets. Flowers vary in color from white to pink. The seeds germinate readily but are only viable for a short time. Selected cultivars are easy to graft by the side veneer method. This species is very useful where small slender trees without heavy foliage are needed. It flowers and fruits throughout the year.

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THE AUSTRALIAN PINE OR BEEFWOOD (CASUARINA EQUISETIFOLIA L.), AN INVASIVE "WEED" TREE IN FLORIDA

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Abstract. **The Australian pine has become widely distributed in the tropics and subtropics. It was introduced into Barbados about 1870, into Hawaii before 1895; was naturalized in the West Indies and Florida before 1920. It is very fast-growing (5 to 10 ft—1.5 to 3 m per year), salt-tolerant and readily colonizes rocky coasts, dunes, sandbars, islets and islands, and invades moist sites far inland, forming dense stands largely devoid of wildlife. On sandy coasts it usurps the nesting ground of sea turtles. It has crowded out native vegetation over vast stretches of Florida. Attaining 85 to 115 ft (25 to 35 m) in height and being shallow-rooted, the trees are readily toppled by hurricanes. The wood cracks and splits when dried, is valued as fuel in parts of Africa and Asia; has no economic value in Florida. The pollen is plentifully airborne from December to April and has been definitely linked to respiratory complaints during these months. Some efforts are being made to eradicate the tree from environmentally critical areas and former landscape plantings are being removed from some highways. Giant specimens along city streets, which have greatly increased in height since South Florida's last hurricane in 1966, are a definite threat to adjacent dwellings.**

Casuarina trees have received little mention in the Proceedings of the Florida State Horticultural Society despite their predominance in the Florida landscape and impact on the environment. All are fairly stout-trunked, rough-barked, fast-growing trees with nearly erect or semi-spreading main branches, slim branchlets, and tufts of deciduous, jointed, grooved, green twigs resembling pine needles but separating easily at the nodes where the true leaves are seen as tiny, pointed teeth ringing the joint. Male flowers are borne in slender, cylindrical spikes at the twig tips; female in lateral heads on non-shedding branchlets, forming woody cones when ripe. In moist soils at certain sites in Australia and elsewhere, the roots of one-third or more of the trees of a given species (including those cited below) are well-nodulated by nitrogen-fixing bacteria (37).

Casuarina Species in Florida

Seven Australian and one East Indian species were introduced into the United States before 1924, beginning with seeds brought from France by the U. S. Department of Agriculture's Plant Explorer, Dr. Walter T. Swingle, in 1898. Some seeds were distributed under erroneous names (40, 41) and problems of misidentification still persist. It is important to distinguish the three common species in southern Florida:

C. equisetifolia L. (*C. litorea* L.); AUSTRALIAN PINE, WHISTLING PINE, BEEFWOOD, or HORSETAIL TREE; native to coastal Queensland and offshore islands, Malaysia, southern Asia and Oceania; reaches 100 to 150 ft. (30 to 45 m) in height, usually 60 to 80 ft (18 to 24 m) in Florida; is slender and open in aspect though the trunk may attain 3.3 ft (1 m) in diameter; has pale, slim, often drooping branchlets and drooping twigs 4 to 18 in (10 to 45 cm) long, 1/32 to nearly 1/16 in (0.79 to 1.5 mm) thick, deeply grooved; nodes 1/4 in (6.35 mm) apart; with 5 to 8 (usually 7) teeth at each node; monoecious, or sometimes dioecious; producing twice a year an abundance of spiny cones nearly 1/2 in (12.5 mm) wide, 3/8 to 3/4 in (1 to 2 cm) long, each containing about 12 rows of dehiscent achenes. The winged seeds are said to number 300,000 in one pound. The tree is non-suckering; highly salt-tolerant.

C. glauca Sieb. ex Spreng., the so-called "BRAZILIAN OAK" which would be better given its Australian name, SWAMP SHE-OAK, is native to northwestern Victoria, coastal New South Wales, western Australia and Queensland. It reaches 60 to 80 ft (18 to 24 m) in height, is a dense, spreading, opaque tree, branching close to the ground; with drooping twigs 8 to 12 in (20 to 30 cm) long, 3/64 to 4.5/64 in (1 to 1.5 mm) thick, moderately grooved; the nodes 5/16 to 3/8 in (8 to 10 mm) apart; with 9 to 16 (usually 10 to 15) teeth at each node. Cones are barrel-shaped, 1/2 to 3/4 in (1.25 to 2 cm) wide; but not produced in Florida (35), Puerto Rico (29) or Malaya (11). This species has been often planted as a roadside tree, windbreak, or hedge; it suckers aggressively from the wide-spreading roots, especially when pruned; prefers inland, swampy sites or dry land with subterranean freshwater, but will also thrive in brackish and salty coastal locations (20, 40). It has been long misidentified as the following species which is rarely if at all seen in Florida (3).

C. cristata Miq. (*C. lepidophloia* F. v. M.; *C. glauca* Benth., in part; NOT Sieb.), the BLACK SHE-OAK, is native to Victoria, New South Wales and South Australia. It reaches 45 to 70 ft (14 to 21 m) in height; has ascending branchlets bearing twigs 3/64 to 4.5/64 in (1 to 1.5 mm) thick, smooth or faintly grooved, the nodes 5/16 to 15/32 in (8 to 12 mm) apart; with 9 or 10 (rarely 11) teeth;

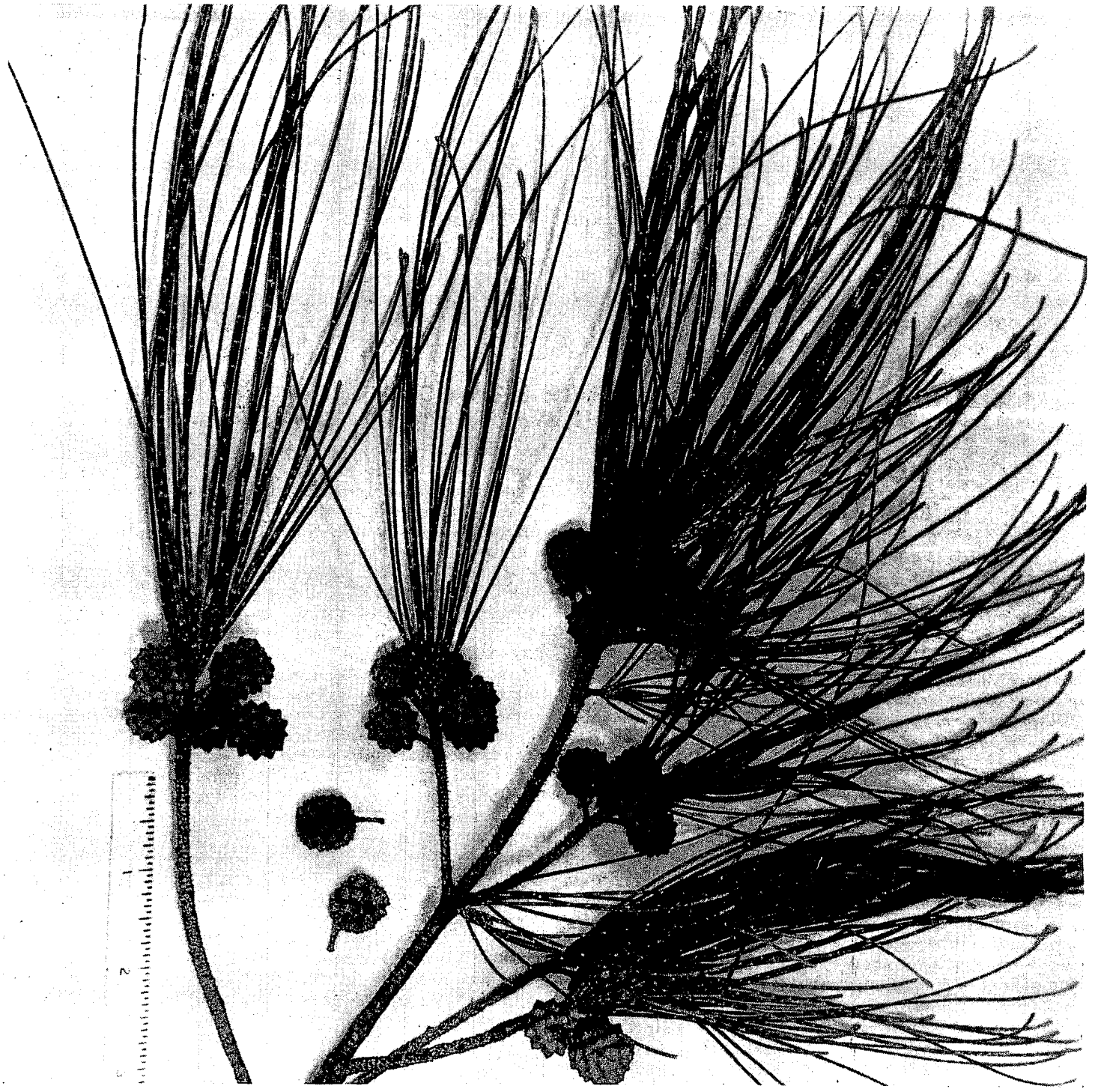

Fig. 1. The Australian pine produces spiny cones on non-shedding branchlets. Male flowers are borne in slender, cylindrical spikes at the tips of the jointed twigs. Photo by Julia Morton

dioecious; the cone nearly round or oblong, to 1 in (2.5 cm) wide and 1-1/4 in (3.2 cm) long, downy when young. The tree is not salt-tolerant; suckers freely; is easily killed by ring-barking which halts suckering (20).

C. cunninghamiana Miq., the RIVER SHE-OAK, native to New South Wales and Queensland, is a pyramidal tree 40 to 100 ft (12 to 30 m) tall, with drooping, wiry twigs 3 to 7 in (7.5 to 16.25 cm) long, 1/32 to 1/16 in (0.79 to 1.5 mm) thick; nodes 3/8 in (1 cm) apart and 6 to 9 (usually 8) teeth at each node. Usually dioecious; the male spikes have prominent whorls of bracts; cones are 1/4 to 1/2 in (6.35 to 12.5 mm) long, 1/4 to 3/8 in (6 to 10 mm) wide; the tree is non-suckering; not salt-tolerant; *cannot* withstand salt-spray; is the most cold-resistant of our three casuarinas; is often planted as a windbreak in central Florida, and in a few groves north of DeLand is interplanted among *Citrus* trees as cold protection despite the disadvantage of shading and competing with the adjacent fruit trees. It is sometimes used as a rootstock for *C. glauca* in southern Florida (47).

Spontaneous hybrids have occurred between these species. There are stray reports of *C. glauca* with cones. Such trees are probably hybrids of *C. glauca* and *C. equisetifolia* or *C. cunninghamiana.*

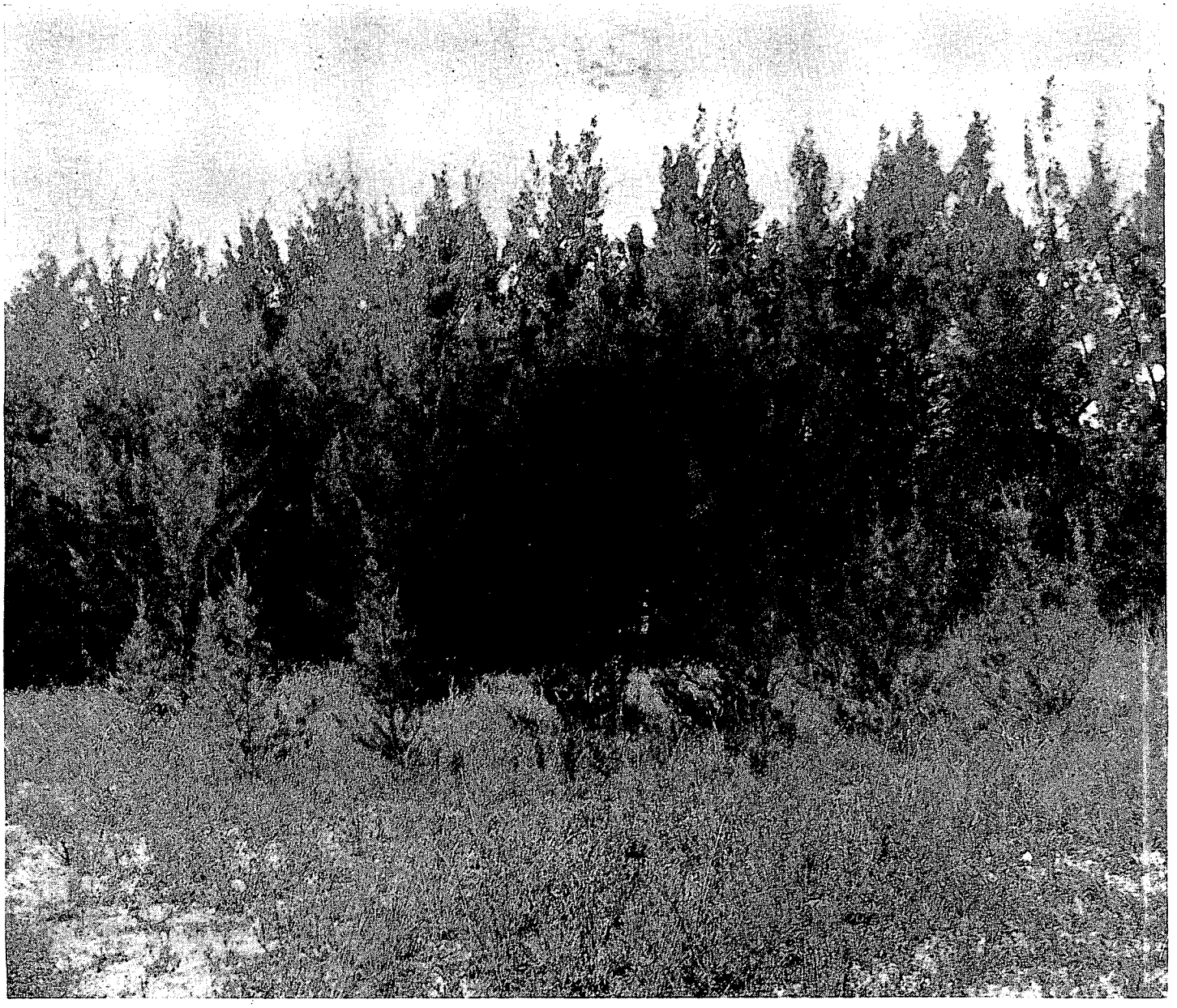

Fig. 2. The Australian pine has become naturalized in South Florida through self-seeding. It is quick to colonize any exposed coastal surface. Seedlings grow at the rate of 5 to 10 ft (1.5 to 3 m) a year. Photo by Julia Morton

Introduction and Cultivation of C. equisetifolia

The Australian pine was observed by botanists in Mexico prior to 1852; was introduced into Barbados about 1870 (26), into Hawaii before 1895 (17); was naturalized in the West Indies and Florida before 1920. The early introductions by the U. S. Department of Agriculture (SPI Nos. 9818, 19386, 29178, and 30380) were not the only means of giving this invader a foothold in Florida. Dr. John C. Gifford wrote: "There are many old casuarinas in South Florida. On the seashore of Biscayne Bay, not far from Homestead, there was a group of them called 'The Cedars'. For sailors these striking trees formed a landmark that was conspicuous for a long distance. They were the leftovers of an old nursery which had obtained the seed from Cuba" (27).[1]

Henry Pennock acquired seeds from California in 1908 (42). In 1921, J. B. Donnelly of Palm Beach reported that the Australian pine was commonly grown as a shade tree, windbreak and hedge along the Lower East Coast (19). That same year, the prominent nurseryman, Norman Reasoner, of Oneco, in a paper presented before the Florida State Horticultural Society, pleaded with gardeners to "give the Australian pine a rest," saying ". . . the good Lord never meant it for every use under the canopy, which is about what you seem to expect of it" (45). In 1924, Mrs. Marian McAdow of Punta Gorda reported: ". . . the Australian pine . . . [has] a somber funereal aspect that does not invite enthusiasm, but when grown along the line of a back fence they have a useful purpose in forming a quickly available background for the more ornamental trees . . ." (32). Along the sand dunes of the southeast coast, low, solid walls of Australian pines have been installed by some property owners as a bulwark against sand drift.

In 1940, Arthur Rhoads, Plant Pathologist, Cocoa Laboratory of Florida Agricultural Experiment Stations, wrote in the *Subtropical Gardening* magazine: "By reason

[1]Dr. Robert Knight has called my attention to the 1887-88 catalog of Royal Palm Nurseries offering 6 species of *Casuarina* including *C. equisetifolia* described as "the variety planted out in Key West and Cuba."

Fig. 3. Many Australian pines exhibit ugly bulges ranging up to 2 ft (60 cm) in width. The cause of these deformities is not known. Photo by Julia Morton

of its early introduction, *C. equisetifolia* is the most widely planted [*Casuarina*] species in Florida. It tolerates brackish soils and salt spray with no apparent injury and, as a result, is a favorite tree for planting in close proximity to the seacoast. This species is so tolerant of salt that it even may be found growing where the bases are completely inundated by salt water for considerable periods" (46).

Disadvantages

In some areas, obnoxious features of this tree were becoming apparent. The branches are easily broken by any strong wind. Trees precariously standing along canal banks are readily felled by gusts. Dead trees will often topple over for no apparent reason. The susceptibility of healthy trees to windstorms was dramatically demonstrated in the major hurricane of September 1945. Many, with broad, "pancake" root systems shallowly perched on the limestone of South Dade crashed to the ground. While the windbreaks of *C. glauca*, which Dr. Gifford had advocated around the fruit groves on the theory that the suckering habit would shunt winds up and over without harm (26), fell in rows on the fruit trees.

The roots are aggressive. Before 1952, the City of Hollywood adopted an ordinance prohibiting the planting of Australian pines because those that had been planted during

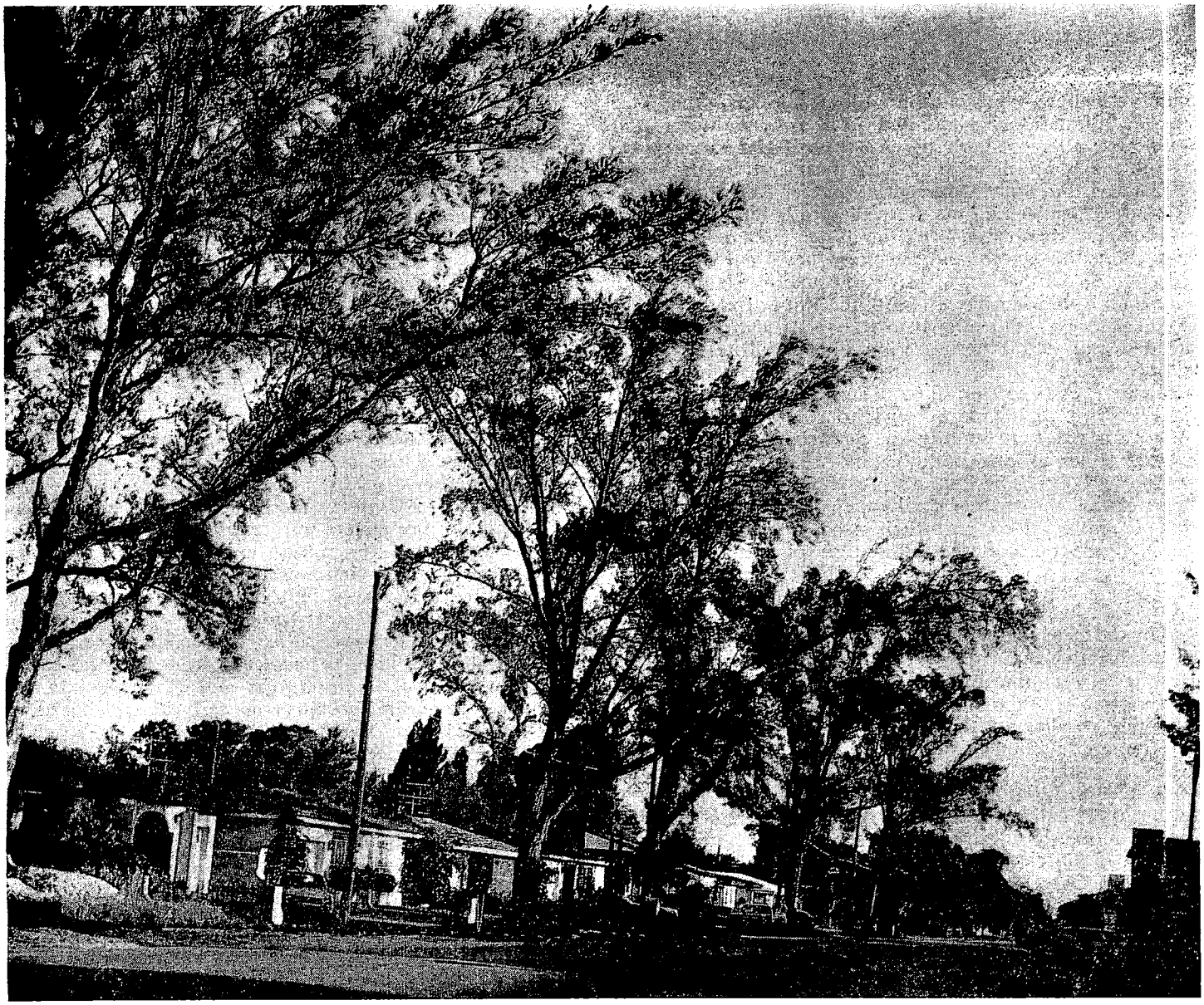

Fig. 4. Many Australian pines along roads and city streets have become too tall for safety. Those which now have newly-built dwellings at their feet should be removed without any objection, for they present a serious tornado and hurricane hazard.

Photo by Julia Morton

the Depression and allowed to run wild had damaged sewers and water mains. The roots entered the joints and broke the pipes (53).

Development as a Weed

While the prolific suckering of *C. glauca* creates local jungles of that species, and its wide-spreading root system disrupts pavements and lawns, its inability to fruit in Florida fortunately restricts its activity as an exotic weed. *C. equisetifolia*, in contrast, has unlimited ability to extend itself in both coastal and inland areas of southern Florida, unless killed by disease, wind-damage, fire or cold.

Arthur Rhoads had warned that: "At several points along the coasts of Florida, both on natural land and that made by dredging, this species has become naturalized through self-seeding and is rapidly forming forests of considerable extent" (46).

Naturalists at the Everglades National Park were among the first to sound an alarm concerning the environmental impact of this tree on natural areas. Richard Klukas, Management Biologist, expressed grave concern in *The Anhinga*, a newsletter published by the Everglades Natural History Association, in April 1969: "At present, the Australian pine represents a serious threat to the ecology of certain areas of the Park and is considered a major problem species. Prior to Hurricane Donna [1960] it was found near a few abandoned homesites along the west coast of the Park and a few individuals were scattered through the glades and on the Florida Bay Keys. In the period since Donna this species has undergone a tremendous population explosion. It is now present in numbers up in the hundreds and thousands on several Florida Bay keys and beaches from Cape Sable to the Ten Thousand Islands. One can expect to find this scraggly Australian plant on any sandy area that is above the high-tide mark. In some areas such as Highland Beach it has completely displaced large areas of native vegetation. . . In the thickest portions of the stand it is common to find the forest floor covered with nothing but a barren carpet of dull brown needles. . . A single 4- or 5-year old tree is able to produce thousands of seeds that are borne by winds to new colonization sites. At one small

test site, less than 40 sq ft (12.19 sq m) in area, more than 300 newly sprouted seedlings were counted."

At Cape Florida State Park, at the southern tip of Key Biscayne, the Australian pine dominates hundreds of acres almost to the total exclusion of native vegetation. This massive infestation has resulted from row plantings that were made after the building of a seawall and the creation of this pumped-up land in 1948. At Bear Cut, on the north end of Key Biscayne, a towering stand of Australian pines is steadily encroaching on the ecologically-important mangrove forest that extends to the beach area of Crandon Park. Both this species and *C. glauca* have had a devastating effect on Sanibel and Captiva and smaller islands off the west coast of Florida. Yet, in 1976, the Punta Gorda nursery of the Florida State Department of Agriculture recommended and sold 400 Australian pine seedlings to a developer for planting as soil-binders on the sandbar called Morgan Beach, south of Marco Island, near Cape Romano.

The Australian pine is quick to colonize any exposed coastal surface. It is infesting the artificial berms along the cooling canals of Florida Power and Light's nuclear plant at Turkey Point. The trees are plentiful out on Mangrove Point east of the cooling-canal system, are competing with the mangroves there and their seeds, blown inland by storms, will continue the infestation of the canal area.

Rate of Growth

On the marl berms at Turkey Point, which constitute a "stress environment," the Australian pine volunteers grow at the rate of only 3 to 5 ft (0.91 to 1.5 m) a year but seed rapidly—in 1 to 2 years. In Pompano, under more favorable conditions, the trees attain a height of 15 ft (4.57 m) and a diameter of 2 to 4 in (5 to 10 cm) within 3 years. In another 3 to 4 years they may attain a height of 30 to 40 ft (9 to 12 m) and reach a diameter of 8 to 10 in (20 to 25 cm). The Plant Pathologist, Arthur Rhoads, wrote that in rich, moist soils, "trees of lead-pencil caliper may attain a height of 30 ft (9 m) within 3 years from time of planting" (46). Dr. Henry Nehrling reported that a seedling planted at Naples grew 10 ft (3 m) in less than a year, and that a windbreak planted around George Hendrie's garden grew 50 ft (15.24 m) high in 4 years (34). In Puerto Rico the tree reaches 140 ft (42.67 m) in 15-20 years after planting (31). Fastest growth is reported from Barbados where a height of 30 ft (7 m) is gained in 2 years (28). At the age of 50, vertical growth decreases but the trunk continues to thicken. On unfavorable sites in India, the trunks become hollow and misshapen and the trees die in about 25 years (2). But Corner says: "The age of the tree is not known but from our observations on old forest trees at Jason Bay [Malaya] we are confident that it can extend to several hundred years" (11).

Effect on Wildlife

By crowding out natural vegetation, the Australian pine eliminates the normal habitats and food sources of wildlife. Richard Klukas observed that the cotton rat, the marsh rabbit and the gopher turtle were unable to gain sustenance in the sterile situation created by a stand of Australian pines. More seriously, he realized that the trees usurp the nesting places of the loggerhead and green sea turtles and the American crocodile, the sandy beach areas above the high-tide line.

The tree has little to offer native songbirds but the exotic, naturalized red-whiskered bulbul from India uses the twigs for nest-building (10) and consumes the diaspid scale insects (Homoptera) and larvae of spittle insects (Cercopidae) commonly found on the twigs (9). Perhaps these insects are the attraction for the migrating gold finches which Dr. Robert Knight has seen visiting Australian pines. Insectivorous birds are said to be "remarkably scarce" in casuarina plantations in India (2).

Flocks of the exotic, naturalized canary-winged parakeet, *Brotogeris versicolurus*, spend much time in these trees feeding on the seeds (50) and also eating the twigs (7). The red-crowned parrot, *Amazona viridigenalis*, introduced and flying wild in large numbers, feasts on the seeds and lays its eggs in hollows in old trunks (39). In Malaya, it is said that the old trees afford favorite roosting places for a certain kind of hornbill (11). Degener says that the seeds attract doves and linnets in Hawaii (17).

Effect on Humans

Otto Degener, writing of this tree in Hawaii, said: "Like the eucalyptus, the casuarina can be a nuisance, killing most plants in the neighborhood and disfiguring the sickly lawns around it with its shed pine-needle-like branches and cone-fruiting heads. These last . . . make walking painful for tenderfoot bathers" (17).

Apart from this minor mechanical hazard to humans, there is a major problem of respiratory irritation. Casuarinas are wind-pollinated and release large quantities of pollen (25). No casuarina pollen was detected in the Miami atmosphere in a 1930 survey (36). But in 1940, when allergists saw patients with typical symptoms of hay fever and asthma from an unknown pollen found on exposed slides, they took steps to have the material identified and found it was pollen of *C. equisetifolia* and *C. glauca*. It was present in the air in February and early March, but more concentrated during the first 2 weeks of April, especially when there was a breeze from the southeast. The following year the pollen first appeared on slides on December 30 but was most common in April. Three patients who spent their winters in Miami Beach suffered only when casuarina pollen was present on the slides—January-April. A physician in Tampa definitely linked the asthma of one patient with the October-November blooming period of *C. cunninghamiana* (55). In 1947-49, University of Miami Biology professor Lillian Fly found casuarina pollen present in the Greater Miami atmosphere from December to March and throughout August and early September (22). In 1956, after a comparative study of 42 genera, she reported casuarina pollen to be a relatively frequent cause of adverse reactions among people with respiratory sensitivity (23). Captain Scott says the heavy fallout acutely affects resident personnel at Cape Florida, causing eye irritation, runny-nose and hoarseness or sore throat.

Economic Value

Early promoters of *Casuarina* species in Florida envisioned a great future for these trees as sources of hardwood and pulpwood and of tannin; (*C. equisetifolia* bark contains 6 to 18% catechol tannin); and they expected that the abundant root sprouts of *C. glauca* would be prized as forage for cattle (5, 38). The State Forest Service began in 1957 to establish a large nursery stock to meet the potential demand (49).

In 1924 one tanner in Miami was treating alligator hides with tannin from casuarina bark (40). The bark extract has also been employed to preserve and brown-tint fishing lines (17). It is true that cattle relish seedlings of *C. cunninghamiana* (1) and eat the sprouts of *C. glauca*, and I have been in ranches where horses have clean-grazed the young shoots. However, in Australia they are recognized as high in tannin, astringent and constipating and useful for hardship fare only (20). It is now known that

tannin interferes with the system's utilization of protein, results in weight deficits, is carcinogenic, and therefore far from desirable in the diet.

As for the russet-hued wood, it is hard, heavy and strong, with a fine texture and tightly interlocked grain, is used in Australia for tool handles, cabinetwork and furniture but is brittle, difficult to plane smooth and prone to crack and split (4, 20, 33).

Tests at the Tropical Forest Research Center in Puerto Rico, where extensive plantings had been made in the lower mountain regions, proved that seasoning of *C. equisetifolia* results in heavy and uneven shrinkage, severe cupping, surface checking, casehardening and other defects. The logs are very difficult to saw; the saws tend to heat, chatter and veer off course producing offsize timber with little market value (31). Puerto Ricans use the wood mainly for fenceposts and poles, rough barns and other structures (29). In India it is considered almost unworkable by carpenters and there as in Africa it is used for hardly more than beams and posts (12), fenders against wharves, pilings, oars, masts and mine props (16). Though reportedly durable in salt water (15, 54), it is very susceptible to drywood termites and not long-lasting in the ground, being satisfactory only if thoroughly treated with preservatives (31). Samoans have fashioned the wood into spears and war clubs (48).

The Department of Wood Science and Technology, School of Forestry, North Carolina State College, Raleigh, reported on the machining characteristics in 1962, after a study financed by the Florida Forest Foundation. The relative performance of casuarina wood was good as compared to the average hardwood. *C. glauca* rated close to dogwood, while *C. equisetifolia* rated lower (52).

The St. Joe Paper Company was induced to experiment with casuarina pulp and they exhibited samples of Kraft and bond paper at the Florida Industrial Exposition in Miami in 1948 (24). However, the paper potential of *C. equisetifolia* and *C. cunninghamiana* had already been evaluated by the USDA Forest Products Laboratory in Madison, Wisconsin, with the conclusion that these trees are short-fibered and their pulps were inferior to pulps of the same type from common pulpwood species and to that from sand pine, black gum, tupelo and stunted cypress. It was suggested that casuarina pulp could conceivably be mixed with stronger and more suitable fibers in some specialty product not then envisioned (14).

Currently, Philippine foresters are optimistic about planting *C. equisetifolia* on unutilized seashores and river deltas because a certain Asian country is interested in importing the wood at about $35 U.S. dollars per cubic meter for use in manufacturing rayon fabrics (18).

It is widely held that the best use of casuarina wood is for fuel. Some say it is hard to get the fire started, but the wood of *C. equisetifolia* will burn when green and the ashes retain heat for a long time (2). It has a calorific value of 4,950 cals., 8,910 b.t.u. and has been called the "best firewood in the world" (8). Outdoor chefs in Florida declare that this wood is excellent for barbecuing, imparting a fine flavor to the meat. India has extensive plantings of this tree as a source of fuel, especially for steam locomotives. It is harvested on a 7- to 35-year rotation, with a 7- to 15-year rotation most profitable, yielding 40 to 80 tons per acre (100 to 200 tons per ha) (2).

Among minor uses of the Australian pine are the employment of the cones in decorative novelties, the utilization of the wood ash in making soap (43), the extraction of red or dark-blue dye from the bark, and the administration of the astringent bark decoction as a remedy for diarrhea and dysentery and as a lotion in beri-beri (2) and a gargle to relieve sore throat (43). It is taken very strong as an emmenagogue (44). Powdered bark is applied on skin eruptions (10). A decoction of the twigs is taken to relieve colic (3). The twigs are bound on (8), or a paste of the seeds is plastered on, the forehead and temples to allay headache (2). The twigs are acid and are chewed to relieve thirst. Potable water may be drained from the branches or roots in emergency (13). Japanese in Hawaii miniaturize the tree as a substitute for pine in their bonsai gardens (17).

Natural Enemies

Dr. Henry Nehrling made large-scale plantings of *E. equisetifolia* in Orange County about 1909 and "all of them succumbed to even a slight freeze" (3). Hundreds of mature specimens along the Courtney Campbell Causeway between Clearwater and Tampa and along the Gandy Causeway between St. Petersburg and Tampa were killed when the temperature fell below 20°F (–6.6 C) the night of December 12, 1962, and remained below freezing for two days (51). Prior to this unusual onslaught from the west there was a solid green stand of Australian pines bordering the beaches from Fort DeSoto in Tampa Bay to Dunedin. Ronnie Reed, a Tampa resident, says that thousands (about 95%) were killed, creating an enormous disposal problem. Many stood dead for years; some fell over. Here and there are individual survivors and a scattered growth of seedlings.

Another plantation hazard is fire, to which these thin-barked trees are particularly sensitive. And there has been a high rate of mortality from mushroom root rot caused by the fungus *Clitocybe tabescens* (Scop.) Bres., primarily on high sandy soils previously populated by oaks; considerably less on low hammock soils, drainage districts and beach fills. All three species are affected (46). This disease acts swiftly and is killing some Australian pines at Long Key State Park.

In India, the root fungus, *Trichosporium visiculosum* is a serious problem encouraged by excessive watering and crowding (2). The hyphae of a seed-borne symbiotic fungus, *Phomopsis casuarinae* F. Tassi, are found in all parts of the tree in India and Australia (6).

Many Australian pines were killed by a die-back disease in the Guánica area of Puerto Rico in 1940, and stem canker and die-back were affecting trees on the Dorado Beach Hotel golf courses in 1971. Investigators attributed these syndromes to the fungus *Diplodia natalensis* (syn. *Botryodiplodia theobromae*) (30). A similar problem attacked Australian pines at the U. S. Naval Base in Key West around 1965.

Twig girdlers have done much damage to young trees in Florida by cutting off the new shoots and branch tips in the fall, and this often results in misshapen trees (46). In Puerto Rico the tree has not run wild to any extent because ants devour the seeds (29). When seeds are sown in India, they are pretreated or watered after planting with a dilute copper sulphate solution or a decoction of *Derris elliptica* root, or wood ash is spread on the beds, to prevent ants from carrying the seeds away. Nursery seedlings in India are attacked by crickets (principally *Brachytrupes achatinus*), a bark-eating caterpillar (*Arbela tetraonis*), a longicorn (*Coelosterna scabrata*), and the grubs of the rhinoceros beetle (*Oryctes rhinoceros*) (2).

Many Australian pines in southern Florida exhibit ugly bulges—ranging up to 2 ft (60 cm) in width—on the trunk and exposed roots close to the base. The cause of these deformities is not known. They are mainly observed on roadsides.

Eradication Efforts

Felling large trees and treating the stumps to prevent resprouting is the simplest and most effective method of removal of Australian pines but can rarely be done without arousing resistance on the part of those who do not understand or appreciate the necessity for doing this in the interest of public safety and welfare. The Florida Department of Transportation has met with unreasonable opposition in its program to remove 1,750 hazardous Australian pines (some dead or dying) along State Road 84. There are many more along roads and city streets that have become far too tall for safety and which should be removed without any objection, especially those which now have newly-built dwellings at their feet where there was only unoccupied land. A dense stand of these trees leaning over a stretch of narrow Palm Drive, the only road from U. S. Highway #1 at Florida City to Florida Power & Light's plant at Turkey Point will most likely block that route if a hurricane occurs.

According to Richard Bailey, Metro-Dade Urban Forester, the Florida Keys Marine Institute successfully employed Young Adults Conservation Corps members to apply Ammate on Australian pines with 2- to 3-in (5 to 7.5 cm) stems along the highway from Big Pine Key southward on the Lower Keys to prevent obstruction of the escape route in case of a major storm.

In 1975, the Florida Department of Natural Resources approved the removal of Australian pines from all six South Florida state parks. Despite some misguided public protests (21), those which had been planted in 1965 at John Pennekamp State Park on Key Largo were cut down in 1975.

At Cape Florida State Park, Captain Don Scott, Superintendent, has a mandate to rid the Park of Australian pines on a gradual scale, with concurrent encouragement of native trees, shrubs and herbaceous species. In exposed areas, especially along the beach, a site is chosen where a seagrape, buttonwood or other native plant is under pressure from Australian pines, and the design is to remove the exotics from the area within 75 ft (23 m) of the native. A cut is made in the Australian pine trunk and 2,4-D is inserted. The tree will die in 6 to 8 months and then it can be felled without an outcry. The native species respond vigorously to the absence of competition.

In less-traveled areas, controlled burns are clearly the most practical means of eliminating Australian pines wholesale. In February 1980 they burned 9 acres, using a drip-torch and backfire pot containing gasoline and Diesel fuel. In the first attempt the "needles" [twigs] on the floor were too damp and there was no blazing fire. The "needles" smouldered for a week, but 90% of the trees died and there was little resprouting. Better results were obtained in a second area near the marina. Most of the trees with trunks up to 5 to 8 in (12.5 to 20 cm) thick, or even thicker, were thoroughly killed.

An example of the sensitivity of Australian pine to fire is the total kill of a tree 2 ft (60 cm) in diameter caused by a camper's dumping his hot charcoal around the base. There was no flash fire but the charcoal smouldered for about 5 or 6 hours. The dead tree was felled; the stump is still there and there is no regrowth. (A word of caution: fire should not be employed where the soil is burnable peat.)

It is significant that after the Hurricane David bypass in 1979, there was less sand erosion observed in areas of native plant regeneration than in areas dominated by Australian pine. In fact, the Australian pine does not prevent beach erosion. Corner describes the *C. equisetifolia* forests fringing the coasts of Malaya and says: "If the coast is now abraded many casuarinas may fall into the sea and they may all disappear. Such a strip of trees fronting the shore is to be seen on most parts of the East Coast of Malaya, perhaps a few saplings before them where the beach is locally extending and again with old trees fallen over where there is abrasion" (11).

Biscayne National Monument includes 25 keys, some not yet invaded but others with varying populations of Australian pines. All those that were on Sands Key and Adams Key have been eliminated by cutting and stump-treating with herbicide to prevent regrowth. Systematic removal will continue.

Robert F. Doren, Botanist, has supplied the following statement in regard to eradication efforts in the Everglades National Park: "*Casuarina* within the Park, except in the southeast corner, are in a monitoring phase. We have been successful in reducing populations in all areas to an annually manageable level. Each district monitors previously invaded sites, eliminating individual trees as they are found. The southeast corner has been placed in limbo for the time being. The vast numbers of *Casuarina* in this area, and accompanying access difficulties, have placed the costs of such a control program in the southeast corner out of our reach."

In discussions with Wallace Abel, Land Utilization Department of Florida Power & Light, Turkey Point, and S. L. Day, FPL Site Superintendent, Indiantown, I have learned that FPL has tested various vehicles (helicopter, airboat and truck) and various herbicides at Turkey Point in their struggle to get vegetation on the berms down to 3 ft (1 m) to prevent obstruction of airflow needed to cool the water. Solid stands of Australian pine that screen the water cause "wind shadows"—areas of calm water with no ripple. Wind is essential. If wind velocity doubles, the cooling effect is quadrupled.

In late 1979, 300 acres received combined 2,4-D and Dicamba via helicopter with 80-90% kill of trees under 15 ft (4.5 m); 20% kill of trees over that size. There was minor mangrove mortality and 30 to 40% damage to herbaceous plants.

At present FPL favors a new herbicide, GARLON 3A, which Dow Chemical has been developing for 5 years. It degrades rapidly in soil with an average half-life of 46 days depending on soil and climatic conditions. Photo-decomposition half-life in water is 10 hours. It has been tested for 2 years at Turkey Point; is a selective herbicide; kills Australian pines to 15 ft (4.5 m) in height; beyond that size mortality drops off. This chemical is applied by an E3 Bell helicopter equipped with 2 tanks—one filled with GARLON 3A and the other with IVOD (100% d-limonene and emulsifier) which is now preferred to Diesel. It forms a large droplet less apt to drift, and it rapidly degrades. The two materials are mixed in flight by two pumps and the product is dispersed through perforations in a microfoil boom attached to the aircraft, and application can be made in a narrow, straight line. The mixture burns red mangrove leaves but doesn't kill the tips, so new foliage comes out. Buttonwood is killed completely but is considered expendable because it grows too large too quickly on the berms—20 ft (6 m) wide in 3 years—and cuts off far too much air.

Some of the Australian pines put out a brief burst of false new growth ("whiskers") which soon falls off. FPL has encouraged and planted the soil-retaining seashore saltgrass (*Distichlis spicata* Greene) on the berms. In sprayed areas there is much regeneration of this grass, sawgrass and bushy beardgrass (*Andropogon glomeratus*), *Pluchea, Acrostichum,* bracken, black and red mangrove as well as buttonwood.

Outside the canal system (which covers 6,800 acres—

2,750 ha), FPL owns another 5,206 acres (2,103 ha) where they are pursuing a program of selective control. Australian pines and Brazilian pepper trees with single stems 2 in (5 cm) or more in diameter are treated individually with either 2,4-D Amine, undiluted, or TORDON 101R via Hypo-hatchet; or undiluted HYVAR X-L or VELPAR L via Spot-gun. These latter 2 chemicals are slow-acting soil sterilants. The emulsion (colloidal suspension) is applied to the basal stem; it dries and then rain carries it down in a narrow column into the soil around the roots and kills the plant. If it were sprayed on the ground it would spread out. HYVAR X-L has a 9-month breakdown period; VELPAR-L, 3 to 6 months. As an alternative, VELPAR GRID BALLS can be put at the base of a tree—2 balls per in (2.5 cm) of trunk diameter—and are activated by rain.

For trees under 6-8 ft (1.8-1.4 m) in height, on windless days, FPL uses a pressure-can sprayer and 5-gal (18.95 liter) backpack sprayer to apply 2,4-D Amine plus SA-77 and BANVEL plus SA-77. SA-77 is a non-herbicidal, biodegradable orange peel extract which takes the place of 1/4 to 1/3 of the amount of 2,4-D which would be normally used.

Conclusion

These and other programs for reduction of Australian pine populations are highly encouraging. But we need much wider recognition of the environmentally-detrimental impact of this tree, a great deal of public education, and unremitting efforts to erase this exotic "weed" tree and restore our native vegetation, to the benefit of our coastline, wildlife, human health and public safety.

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