Panicum repens

INTRODUCTORY

Photo by Forest & Kim Starr, Starr Environmental, Bugwood.org

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FEIS ABBREVIATION:
PANREP

NRCS PLANT CODE [102]:
PARE3

COMMON NAMES:
torpedograss
couch panicum

dog-tooth grass
torpedo grass

TAXONOMY:
The scientific name of torpedograss is *Panicum repens* L. (Poaceae) [2,24,40,43,58,87,104,112,114,115].

SYNONYMS:
None

LIFE FORM:
Graminoid

DISTRIBUTION AND OCCURRENCE

SPECIES: Panicum repens

- GENERAL DISTRIBUTION
- HABITAT TYPES AND PLANT COMMUNITIES

GENERAL DISTRIBUTION:
Torpedograss is native to both the Old and New Worlds [44], with reported sources of origin including southern Europe [105], the Mediterranean, the Arabian Peninsula, Israel [29], northern [29], tropical, and southern Africa [29,105], Argentina [29], and Australia [29,109].

Torpedograss was introduced to the Gulf Coast of the United States sometime prior to 1876, when it was first collected in Alabama [65]. It was introduced in seed for forage crops [65,69]. Seed may also have been transported via ballast from sailing vessels carrying lumber from the Mediterranean [109]. In the early 1900s the United States Department of Agriculture imported and distributed torpedograss seed to provide forage for cattle [69]. By 1950, it was planted in nearly every southern Florida county and in a few central and north-central counties [65]. It subsequently escaped cultivation [29].

As of this writing (2011), torpedograss occurs in tropical and subtropical regions throughout the world from latitude 35 °S to 43 °N [49]. In the United States, the distribution of torpedograss is limited to the southern Atlantic coast from North Carolina south and west to Texas, and isolated populations in California and Hawaii [58]. It also occurs in Mexico [11]. Plants Database provides a distributional map of torpedograss.

HABITAT TYPES AND PLANT COMMUNITIES:
Torpedograss occurs in both aquatic and terrestrial plant communities [44], including coastal sand, wetland, and forested plant communities.

Coastal sand plant communities: Torpedograss establishes in coastal sand plant communities around the Gulf of Mexico, including sand dunes [11,67,68,74,77,81], ridges [67], plains [11], and beaches [68]. Torpedograss occurred in coastal dune communities along the northern Gulf Coast including Texas, Mississippi, Louisiana and the west coast of Florida. Common associates included turtleweed (*Batis maritima*), saltgrass (*Distichlis spicata*), marsh fimbry (*Fimbristylis castanea*), largeleaf pennywort (*Hydrocotyle bonariensis*), and dwarf saltwort (*Salicornia bigelovii*) [77]. On a barrier island between the Mississippi Sound and the Gulf of Mexico, torpedograss occurred on sand dunes dominated by seaoats (*Uniola paniculata*), moist dunes with Le Conte's flatsedge (*Cyperus lecontei*) and largeleaf pennywort, and in a coastal sand frostweed-woody goldenrod (*Helianthemum arenicola-Chrysoma pauciflosculosa*) plant community [81]. On an island off the coast of Louisiana, torpedograss established on sandy, compacted turf with erect centella (*Centella erecta*) and starrush whitetop (*Rhynchospora colorata*) [10]. Herbarium records from Texas documented torpedograss occurring between a seawall and saltgrass flats [36]. In coastal areas of Mexico, torpedograss occurred on sand dunes and sandy plains with slender grama (*Bouteloua repens*), sideoats grama (*B. curtipendula*), Acapulco grass (*B. dimorpha*), bahiagrass (*Paspalum notatum*), hilograss (*P. conjugatum*), and mesosetum grasses (*Mesosetum* spp.) [11].

Wetlands and riparian areas: Torpedograss establishes in a variety of moist plant communities, including wetlands [13,17,18,30,35,36,76,80,84,113], wet prairies [24,33,34,61,73,113], and in or around water bodies [29,88,93,113].

Wetlands: In Gulf Coast freshwater marshes, torpedograss occurred with alligatorweed (*Alternanthera philoxeroides*), herb of grace (*Bacopa monnieri*), fragrant flatsedge (*Cyperus odoratus*), common water hyacinth (*Eichhornia crassipes*), spikerush (*Eleocharis* sp.), hydrocotyle (*Hydrocotyle* sp.), sprangletop (*Leptochloa* sp.), maidencane (*Panicum hemitomon*), common reed (*Phragmites australis*), bulltongue arrowhead (*Sagittaria lancifolia* ssp. *media*), saltmeadow cordgrass (*Spartina patens*), cattail (*Typha* sp.), hairypod cowpea (*Vigna repens*), and giant cutgrass (*Zizaniopsis miliacea*) [30]. On a barrier island in the Gulf Islands National Seashore, Florida, torpedograss occurred in freshwater marshes with southern umbrella-sedge (*Fuirena scirpoidea*) and broomsedge bluestem (*Andropogon virginicus*) [76]. In Florida, torpedograss dominated part of a 1-year-old wetland constructed for wastewater treatment but 2 years later had been replaced by pickerelweed (*Pontederia cordata*), bulltongue arrowhead, and Olney's threesquare bulrush [13]. In southwestern peninsular Florida, torpedograss was an occasional species in disturbed wet areas and seasonal ponds and sloughs occurring within dry prairies with saw-palmetto (*Serenoa repens*); in South Florida slash pine (*Pinus elliottii* var. *densa*) flatwoods; and in river-corridor hammocks with live oak (*Quercus virginiana*), laurel oak (*Q. laurifolia*), and cabbage palmetto (*Sabal palmetto*) [55].

On the Mississippi River delta, torpedograss occurred in coastal marsh plant communities containing mixtures of common reed [17,18,84], saltmeadow cordgrass [17], smooth cordgrass (*S. alterniflora*), cattails (*Typha* spp.), Olney's threesquare bulrush (*Schoenoplectus americanus*), and giant cutgrass [84]. In the same region, torpedograss occurred on mud flats with giant cutgrass, seacoast bulrush (*Bolboschoenus robustus*), smooth cordgrass, and narrow-leaved cattail (*Typha angustifolia*) [72]. In southeastern Louisiana, torpedograss occurred in thick-mat floating-marsh plant communities. Species composition varied, but tehse communities contained monocultures or mixtures of bulltongue arrowhead (*Sagittaria lancifolia*), cattails, Olney's threesquare bulrush, cordgrass (*Spartina* spp.), giant cutgrass, and common reed [80]. Herbarium records from Texas documented torpedograss occurring in a small freshwater marsh with spadeleaf (*Centella asiatica*), jointed flatsedge (*Cyperus articulatus*), tapertip flatsedge (*C. acuminatus*), velvet panicum (*Dichanthelium scoparium*), Virginia buttonweed (*Diodia virginiana*), and mountain spikerush (*Eleocharis montana*) [36].

Wet prairies: In southeastern Florida, torpedograss occurred in wet prairies characterized by St. Johnswort (*Hypericum* spp.), yelloweyed grass (*Xyris* spp.), spadeleaf, rush (*Juncus* spp.), panicgrass (*Panicum* spp.), and Tracy's beaksedge (*Rhynchospora tracyi*) [73]. Torpedograss occurred infrequently and at low cover in wet prairies in west-central Florida. Common species included dwarf crabgrass (*Digitaria serotina*), broadleaf carpetgrass (*Axonopus compressus*), knotgrass (*Paspalum distichum*), and pineland threeawn (*Aristida stricta*) [24]. In southwestern Louisiana, torpedograss occurred in plant communities of intermixed prairie and cheniere (ridges made of shell fragments and sand that rise above sea level in coastal marshes). Species commonly found in prairies included golden tickseed (*Coreopsis tinctoria*), rosy camphorweed (*Pluchea rosea*), blackeyed Susan (*Rudbeckia hirta* var.*pulcherrima*), marsh flatsedge (*Cyperus pseudovegetus*), keeled bulrush (*Isolepis koilolepis*), slickseed fuzzybean (*Strophostyles leiosperma*), tapertip rush (*Juncus acuminatus*), forked rush (*J. dichotomus*), gaping grass (*Panicum hians*), brownseed paspalum (*Paspalum plicatulum*), and prairie wedgescale (*Sphenopholis obtusata*). Common species on chenieres included live oak, sugarberry (*Celtis laevigata*), and Hercules' club (*Zanthoxylum clava-herculis*) [34]. Torpedograss occurred in smooth cordgrass prairies along the Mississippi River delta [33] and in Louisiana and Texas [33,61].

In or around water bodies: In and around Lake Okeechobee in Florida, torpedograss established with Gulf Coast spikerush (*Eleocharis cellulosa*), American white waterlily (*Nymphaea odorata*) [93], and little sand cordgrass (*Spartina bakeri*) [29]. Herbarium records from Florida documented torpedograss occurring in and around a pond with

Spanish needles (*Bidens bipinnata*), shortleaf spikesedge (*Kyllinga brevifolia*), taperleaf water horehound (*Lycopus rubellus*), and baldcypress (*Taxodium distichum*) [113]. Torpedograss occurred in a disturbed shoreline plant community in southeastern Alabama. The shoreline plant community contained yellowfruit sedge (*Carex annectens*) and southern waxy sedge (*C. glaucescens*). Woody species included wax-myrtle (*Myrica cerifera*) and black tupelo (*Nyssa sylvatica*) [88].

Forested plant communities: Torpedograss establishes in some areas with a tree canopy. Herbarium records from Florida documented torpedograss occurring along a road in sand pine (*Pinus clausa*) scrub and in slightly disturbed areas in white sand scrub associated with coastal plain honeycombhead (*Balduina angustifolia*), blue maidencane (*Amphicarpum muhlenbergianum*), lopsided Indiangrass (*Sorghastrum secundum*), jeweled blue-eyed grass (*Sisyrinchium xerophyllum*); in oak (*Quercus*) woods, and in pinelands with cabbage palmetto, serenoa (*Serenoa*), and sweetgale (*Myrica*) [113]. At the Cumberland Island National Seashore off the coast of southern Georgia, torpedograss was restricted to open areas along roads bisecting maritime hammocks and pine (*Pinus*)-oak forests. Live oak dominated maritime hammocks, while loblolly pine (*Pinus taeda*), slash pine (*P. elliottii*), longleaf pine (*P. palustris*), and live oak occurred in pine-oak forest [116]. On a barrier island between the Mississippi Sound and the Gulf of Mexico, torpedograss occurred in open forests with slash pine, sand live oak (*Q. geminata*), and myrtle oak (*Q. myrtifolia*) [81]. Herbarium records from Texas documented torpedograss as common in a drainage ditch along the edge of a patch of forest dominated by sugarberry and nonnative Chinese tallow (*Triadica sebifera*)[36].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Panicum repens

- GENERAL BOTANICAL CHARACTERISTICS
- SEASONAL DEVELOPMENT
- REGENERATION PROCESSES
- SITE CHARACTERISTICS
- SUCCESSIONAL STATUS

GENERAL BOTANICAL CHARACTERISTICS:

- **Botanical description**
- **Raunkiaer life form**

Botanical description: This description covers characteristics that may be relevant to fire ecology and is not meant for identification. Keys for identification are available (e.g., [40,43,115]).

Torpedograss is a perennial grass growing up to 3 feet (1 m) tall from sturdy, widely creeping or floating rhizomes [65]. Culms are erect or leaning [65]. Leaf sheaths are hairy and leaf blades are stiff, linear, flat, or folded with an often waxy or whitish surface [69]. Inflorescences are loose, open, terminal panicles, 3 to 9 inches (7-22 cm) long, with erect or ascending branches. Spikelets are 2 to 3 mm long and about 1 mm wide [65]. Fruits are lanceolate, straw-colored caryopses [105]. Seeds are 2.2 to 3.1 mm long, white, and smooth [37].

Photo by John D. Byrd, Mississippi State University, Bugwood.org

Torpedograss has fibrous roots [37], though plants examined on a golf course in southern Florida had few roots [14].

Torpedograss has both long and short, knotty rhizomes [40]. Rhizomes have a rigid, sharp-pointed tip that gives the plant its name [65]. In wet fields in Sierra Leone, rhizomes formed a mat 6 inches (15 cm) thick [27]. A nonnative plant guide reports that rhizomes may reach lengths of >20 feet (6 m) [105]. Two literature reviews suggest that most torpedograss rhizomes are found within the top 24 inches (60 cm) of soil, but some may penetrate to 23 feet (7 m) [20,92]. On sand dunes and dry sand ridges in the Mississippi Sound, torpedograss rhizomes were found to a depth of 30 inches (80 cm) [67]. In field experiments in Japan most rhizome and roots were found in the top 12 inches (30 cm) of the soil, but some extended down to 17 inches (42 cm) [52].

Torpedograss populations form extensive colonies [40] and may form dense, floating mats where they establish in or adjacent to water [44]. Population expansion may be rapid; in the Lake Okeechobee region, torpedograss cover increased 21% in 5 years, from 220 acres (89 ha) in 1994 to 264 acres (107 ha) in 1999 [45].

Raunkiaer [86] life form:
Hemicryptophyte
Geophyte
Helophyte

SEASONAL DEVELOPMENT:
A nonnative plant guide suggests that torpedograss flowers nearly year round [65]. Flowering months range from May to November in Florida [25,43,113,114,115]. Herbarium records from Texas documented it flowering and fruiting in June, July, August, October, and December [36].

Torpedograss growth may be related to local hydroperiods. In Sierra Leone, torpedograss rhizomes were dormant while under seasonal floodwater from mid-June to early January. As floodwaters retreated, shoots grew to a height of 3 feet (1 m) in 3 months. Seeds were produced in June [27].

REGENERATION PROCESSES:

- **Vegetative regeneration**
- **Pollination and breeding system**
- **Seed production**
- **Seed dispersal**
- **Seed banking**
- **Germination**

- **Seedling establishment**
- **Plant growth**

Vegetative regeneration appears to be the primary means of torpedograss establishment and spread [1,37,49,69]. Seed production and viability appear to be limited [1,69].

Vegetative regeneration: Torpedograss is rhizomatous [14,20,27,40,43,65,105,112], and most reproduction is accomplished via vegetative spread from and fragmentation of rhizomes [49,65,105]. Rhizome sprouting is not limited to apical regions; it can also occur via axillary buds, which are produced along the entire length of the rhizome [82,106,109]. Torpedograss plants allocate much of their biomass to rhizomes [14,52,109]. On a golf course in southern Florida, rhizomes comprised 87% of total plant biomass [14]. Rhizomes are strong enough to penetrate wood and asphalt [44].

Photo by Karen Brown, University of Florida, Bugwood.org

Regenerative buds are not limited to rhizomes but can also form on tillers [20,40,52,89] and stem fragments. In greenhouse studies in Florida, 1-node stem sections cut from erect shoots and tillers were laid on top of potting soil. Roots appeared from nodes within 1 day of planting, with new shoots arising within 3 to 4 days of planting. After 4 weeks of growth, 79% of tiller segments and 93% of shoot segments had produced new vegetative growth [89].

Torpedograss rhizome fragments are capable of fast growth. In field experiments in Japan, 1-node rhizome fragments reached 76 inches (192 cm) in length 190 days after planting, with a growth rate as high as 0.5 inches (1.3 cm)/day. One rhizome produced 22,635 nodes in a year [52]. In growth trials in Florida, torpedograss rhizomes placed in flooded pots and fertilized at a rate of 40 g/330 cm^2 (17-6-10) increased their dry weight 728-fold over 16 weeks in the summer (0.9 g to 656 g) [96]. In greenhouse growth trials, new shoots of torpedograss emerged from 1-node rhizome fragments after 21 days. Rhizome production did not begin until after 4 weeks of growth, when plants produced 1 to 3 rhizomes. Tiller production from the primary culm began after 2 weeks of growth. After 16 weeks, approximately 5 "primary" tillers had developed from the primary culm, though numbers were higher at 8 weeks, followed by some tiller death. After 16 weeks of growth, plants averaged 3 to 4 "secondary" tillers arising from primary tillers. Tillers also developed from rhizomes after 4 weeks of growth and were more abundant than tillers arising from the primary culm; after 16 weeks of growth, rhizome tillers averaged approximately 22/plant [20].

The potential for torpedograss plants to reproduce vegetatively may be related to several factors, including soil depth, plant density, temperature, and moisture.

Results of greenhouse [53,92,107] and field [106] experiments show that torpedograss rhizome sprouting decreases as burial depth increases. In greenhouse experiments, the emergence of sprouts from 6-node-long torpedograss rhizomes after 30 days was significantly reduced at burial depths greater than 2 inches (4 cm) ($P<0.05$), with only 25% of rhizomes sprouting from depths of 6 inches (16 cm) [107]. In field experiments in Florida, sprout emergence was reduced by burying rhizomes at depths >3 inches (8 cm) [106]. After 1 year, 67% of 1-node rhizomes produced shoots when buried at 0.4 inches (1 cm) while no 1-node rhizomes produced shoots when buried at 8 inches (20 cm). No rhizomes with any number of nodes sprouted from burial depths >20 inches (50 cm). Shoots emerged more quickly from rhizomes buried at shallower depths; sprouts from rhizomes buried 2 inches (5 cm) emerged as early as 5 days after burial, while no sprouts from rhizomes buried 12 inches (30cm) emerged until 21 days after burial [53]. Some experiments show that rhizome size (length or number of nodes) increases the potential for rhizomes to sprout at greater depths [53,92].

Plant density may impact torpedograss tillering, but it may not influence allocation of resources to rhizomes. In greenhouse growth trials, tiller production and tiller dry weight were significantly lower at high (4 plants/pot) versus low (1 plant/pot) density, on both a per pot and per plant basis ($P<0.05$). Torpedograss plants at both densities allocated about one-fifth of their dry weights to rhizomes [21].

Torpedograss rhizome survival and sprouting are limited by extremes of temperature. See Climate for more information on this topic.

Torpedograss rhizomes can survive both extremely dry and extremely wet conditions. In greenhouse experiments, air-drying 6-node-long torpedograss rhizomes to 35% to 60% of initial fresh weight had no effect on subsequent growth [107]. In growth chamber experiments in Japan, air-drying rhizomes led to a reduction in bud sprouting but not to an increase in rhizome death [1].

Torpedograss is tolerant of flooding. In growth trials in Florida, all of the rhizomes ($n=64$; 3 to 4 buds) tested survived flooding for approximately 4 months [96]. Flooding may or may not induce rhizome dormancy. In Sierra Leone, torpedograss rhizomes were dormant while under seasonal floodwater from mid-June to early January. Shoots emerged after floodwaters retreated [27]. If rhizomes do sprout in water, their establishment may be limited. Field observations in Florida suggested that fragments of torpedograss did not readily establish in deep standing water. Once fragments became anchored along shorelines, they established quickly [89]. Experimental pond studies showed that stem and rhizome fragments remained buoyant through 10 weeks of observations. Shoot and root production began within 2 weeks. Both rhizomes and stem fragments produced stems averaging 5.5 inches (13.9 cm) in length by the 10th week of the study. Fragments were unlikely to establish without contact with sediment, however. Stem and root fragments produced roots when inundated at all water depths tested (up to 50 inches (125 cm)), but stem elongation above the water in the 1st 4 weeks of growth was more likely in shallow (<10 inches (25 cm)) than deep water. After 12 weeks, stem fragments planted in shallow water had new stems with an average height of 22 inches (55 cm) above the water line. Only fragments in shallow water initiated rhizome growth. The number and radial spread of rhizomes from the parent plant decreased significantly with water depth ($P<0.05$). The growth of 15-week-old plants originating from stem fragments declined as water depth increased [93].

Torpedograss sprouts after herbicide application [14,39,54,59,83,92], grazing [79], cutting, [19,39], plowing or disking [83,92], and burning [45,46,92,98]. Population spread may be accomplished either through the vegetative expansion of existing populations or via the transport of plant fragments along waterways [69], in fill dirt and hay, and attached to boat trailers and machinery [92].

Pollination and breeding system: No information is available on this topic.

Seed production: As of this writing (2011), limited information exists regarding seed production in torpedograss. Researchers from Japan described torpedograss as "incapable of fruiting" [52]. A nonnative plant guide reports that seed abundance is variable [65]. Torpedograss seeds have been found or studied in Spain [26], Mexico [71], Mississippi [107], Sierra Leone [27], and Florida (Smith 1995 personal communication cited in [96]). However, some sources report that seeds are largely unviable. Researchers reported that torpedograss does not bear fertile seeds in Taiwan [83].

Seed dispersal: As of this writing (2011), little information was available regarding dispersal of torpedograss seeds. Seeds of torpedograss were found in fecal pellets of wild spur-thighed tortoises (*Testudo graeca*) in Spain [26]. Seed viability was not tested.

Seed banking: As of this writing (2011), little information was available regarding seed banking by torpedograss. Researchers in Florida were unable to germinate torpedograss seed from the soil seed bank near Lake Okeechobee

[93].

Germination: The germination potential of torpedograss appears to be variable, with some studies reporting low or no seed viability, and others reporting high germination rates. One manager reports that no viable torpedograss seed was found in Florida (personal communication [6]). In another Florida study, Smith (1995 personal communication cited in [96]) found extremely low germination (1 out of 1,000) of torpedograss seeds. In a series of laboratory experiments testing the effects of light, temperature, scarification, and chemical stimulation on torpedograss germination, no fresh-collected seeds from Mississippi germinated [107]. In contrast, a weed identification guide suggests that torpedograss seeds germinate easily, though they require moisture [37].

In laboratory germination trials, torpedograss seeds collected from Veracruz, Mexico, had low germination rates when held at constant temperatures. Germination rates were higher when seeds were exposed to fluctuating temperatures. At both temperature regimes, fresh seeds had lower germination rates than those stored for 7 to 14 months.

Germination rates (%) of fresh and stored (7 to 14 months) torpedograss seeds held at constant or fluctuating temperatures [71].

	Constant temperature			Fluctuating temperature		
	15 °C	20 °C	35 °C	20-25 °C	20-32 °C	20-40 °C
Fresh seed	3	2	0	86	90	80
Stored seed	20	25	2	86	88	97

Germination rates were not affected by light regime, burial depth, or nitrate availability. Seeds were capable of germination under high-salinity conditions, including exposure to 100% sea water [71].

Seedling establishment: As of this writing (2011), little information was available regarding torpedograss seedling establishment. Establishment via seed has been reported secondhand from Portugal [59,109]. In Sierra Leone, there was no evidence of plants emerging from seed despite documented seed production [27].

Plant growth: Growth of established torpedograss plants may be influenced by light, nutrient availability, moisture, and temperature (See Climate for more information on this topic). In field experiments, 75% shading significantly reduced dry matter production, leaf area, and height of torpedograss ($P<0.05$) [109]. In greenhouse experiments, nitrogen fertilizer significantly increased torpedograss shoot length, shoot production, and aboveground biomass ($P<0.05$) [51]. A nonnative species guide for the world reports that plant morphology may vary with soil moisture; torpedograss growing in dry soils may be short and produce few flowers per panicle, while in moist soils it may grow tall and produce a many-flowered panicle [49].

SITE CHARACTERISTICS:

Torpedograss tolerates a range of site characteristics. It has documented preferences for a warm climate, sandy soils, and moist conditions [92], though it tolerates other site characteristics.

Site types: In North America, torpedograss occurs in both aquatic and terrestrial plant communities [44,69]. Floras and herbaria records document torpedograss on a variety of site types, including disturbed areas [38,43,104,113,114,115] like roadsides [36,43,104,113], along paths [113], in fields [113] or in agricultural areas [43]. Torpedograss establishes in coastal areas, including coastal swales [25,36,40,115], beaches [40], sand dunes, sand bars, seawalls, island shores [36], tide pools [113], and tidal flats [40,113]. It also occurs along inland waterways, including lakes [40,113,114,115], ponds [36,40,113], canals [40,43,113], ditches [36,40,43,104,113], and moist plant communities, including marshes [25,36,43,113,115], bogs [43], and wet prairies [43,113]. See Habitat Types and Plant Communities for detailed descriptions of plant communities where torpedograss occurs.

Climate: Torpedograss is limited to tropical and subtropical climates [40]. Its sensitivity to prolonged cold temperature limits the spread of torpedograss into upper latitudes or altitudes [7].

In the United States, torpedograss establishes in subtropical climates such as those found in Florida [55,78], Georgia [116], and Louisiana [34,80]. In west-central peninsular Florida, mean daily maximum temperature ranged from 70.5 °F (21.4 °C) in January to 90.3 °F (32.4 °C) in August. The mean daily minimum temperature ranged from 50.4 °F (10.2 °C) in January to 74.5 °F (23.6 °C) in August [78]. Areas where torpedograss establishes generally have high annual precipitation.

Average annual precipitation of sites with torpedograss within its North American distribution	
Location	Precipitation (mm)
Florida	1,219 [78]; 1,270-1,400 [56], 1,451 [55]
Georgia	1,295 [116]
Louisiana	1,431 [34]; 1,600 [80]
Mississippi Sound	1,549 [67]

Torpedograss may be killed by cold temperatures although it may withstand short exposure to cold. Apical 6-node-long rhizome fragments of torpedograss died following 24-hour exposure to 23.9 °F (-4.5 °C) but survived exposure to 39.2 °F (4 °C) [108]. Planted torpedograss rhizomes survived 2 winters in Auburn, Alabama, where air temperatures were as low as 23 °F (-5 °C) one year and 7 °F (-14 °C) the other. The soil froze to a depth of 1 to 2 inches (2-4 cm) in the colder year [109].

Torpedograss growth generally improves as temperatures increase. In incubator experiments, buds on torpedograss rhizomes did not sprout at temperatures <40 °F (5 °C). Sprouting increased from 50% to 96% when temperature increased from 50 °F (10 °C) to 68 °F (20 °C), and was consistently high (92-96%) at temperatures of 68 °F to 95 °F (20-35 °C) [50]. In greenhouse experiments, torpedograss dry weight, leaf area, and height significantly increased as temperature increased, with greater growth at day/night temperature regimes of 86/77 °F (30/25 °C) than at 81/72 °F (27/22 °C) or 75/64 °F (24/18 °C) ($P<0.05$) [108]. In greenhouse experiments, shoot elongation and shoot growth increased as temperature increased [50].

Torpedograss is sensitive to extremely high temperatures. In growth chamber experiments, most potted rhizomes immersed in heated water for 1 hour at temperatures of 120 °F (50 °C) and 130 °F (55 °C) survived, but all rhizomes immersed in heated water for 1 hour at temperatures >140 °F (60 °C) died [109]. In incubator experiments, buds on torpedograss rhizomes did not sprout at temperatures >113 °F (45 °C) [50].

Soils: Managers from Florida report that torpedograss grows in many soil types, from sandy, well-drained soils to heavy, waterlogged soils. They suggest that it grows best in soils that are poorly drained and have some degree of water-logging [7]. A nonnative plant guide suggests that it is found most frequently in sandy soils along seacoasts or in poorly drained, heavy soils [49].

Herbarium records and studies document torpedograss occurring in sandy soils in Florida [14,25,55,113] and Texas [36]. Herbarium records from Texas documented torpedograss establishment in sand, silt, loam, and clay [36]. Experimental pond studies in Florida showed that sediment type (muck versus sand) did not significantly affect the ability of torpedograss stem and rhizome fragments to initiate root production and did not affect biomass production [93].

Torpedograss prefers wet areas [37,92] and established on poorly drained soils in both Florida [25,55,78] and Texas [36]. It frequently establishes in areas experiencing seasonal or prolonged flooding (See Successional Status for more information on this topic). Torpedograss may also establish in dry areas [44,74]; large rhizomes allow plants to withstand drought [7,49,105].

It is not clear if torpedograss is limited by soil pH. In greenhouse experiments, torpedograss plants showed no differences in dry matter production, plant height, or leaf area when grown in soils of pH 4.7 vs. pH 6.7 [107]. Torpedograss occurred in a coastal marsh near New Orleans, Louisiana, where pH ranged from 5.5 to 8 [17] and on a golf course in southern Florida where pH ranged from 6.6 to 7.7 [14]. It established on "acid" marine deposits in west-central Florida [24].

Torpedograss is salt tolerant [105], though saline conditions may limit growth. It occurred in a coastal marsh near New Orleans, Louisiana where water salinity averaged 1.73 ±1.22 parts per thousand [17]. In marshes on the Mississippi River delta, torpedograss cover was reduced both 2 weeks and 1 year after an August hurricane exposed the area to high winds, tidal surges, and increased salinity [18]. In Asia, watering torpedograss weekly with salty water did not affect normal growth [82].

Elevation: In North America, torpedograss generally occurs in coastal or lowland areas close to sea level. However, it may occur at higher elevations in mountainous tropical areas in other parts of its range [49,92,104].

Elevation of sites with torpedograss	
Location	Elevation (feet)
Florida	20 [78]; 66-105 [24]; 76,85 [113]
Georgia	0-50 [116]
Hawaii	100- 3,600 [104]
Louisiana	sea level [34,80]
Texas	3-25 [36]
Sri Lanka	3,280-6,560 [21]

SUCCESSIONAL STATUS:

Torpedograss often establishes in disturbed areas [38,43,104,113,114,115] or early-successional plant communities [28,68], but it is not limited to these areas. At the Archbold Biological Station, Florida, torpedograss established primarily along fire lanes, in disturbed areas, and along ditches, but it also established in undisturbed hydric and mesic native plant communities, including wet prairies and seasonal ponds, especially where such plant communities were bordered by firelanes [56]. Torpedograss was frequent on new beaches at the Gulf Islands National Seashore, Florida [68]. In coastal areas of South Carolina, torpedograss established in newly-created sand dune restoration areas [28].

An invasive plant guide suggests that torpedograss grows best in open sunny areas but can withstand partial shade [49]. It is commonly documented in open areas (e.g., [14,36,73,113]) and many plant communities lacking a tree canopy, though it has also been documented in some forested areas (see Habitat Types and Plant Communities). In field experiments in Alabama, 75% shading significantly reduced dry matter production, leaf area, and height of torpedograss ($P<0.05$) [109]. In greenhouse experiments, increasing photoperiod increased shoot dry weight [92].

Torpedograss is generally tolerant of flooding. A nonnative species guide suggests that torpedograss does not tolerate permanently flooded conditions but can withstand occasional flooding [49]. Several sources document it occurring in standing water [29,36,45,93,113]. In the Lake Okeechobee region, torpedograss established on sites that were inundated for extended periods and tolerated prolonged exposure to relatively deep flooding; the population expanded in areas where the flooding depth was <3.3 feet (1.0 m) for 48 months and >3.3 feet (1.0 m) for 10 months [45]. Along the shores of Lake Okeechobee, torpedograss grew in water up to 23.0 inches (58.4 cm) deep during high water times in January, when torpedograss stems extended only 2.5 inches (6.4 cm) above the water's surface [29].

Torpedograss can reproduce under flooded conditions, but deep water may inhibit rhizome spread and plant growth. In growth trials in Florida, torpedograss rhizomes with 3 to 4 buds grew and produced flowers after 16 weeks of flooded conditions [96]. Experimental pond studies showed that stem and rhizome fragments remained buoyant through 10 weeks of observations and produced roots when inundated up to depths of 50 inches (125 cm). Only those fragments in water <10 inches (25 cm deep) initiated the production of rhizomes, however. The radial spread of the rhizomes from the parent plant decreased significantly with water depth, as did the number of rhizomes produced ($P<0.05$). The growth of 15-week-old plants originating from stem fragments was limited as water depth increased [93].

Flooding may have facilitated the establishment of torpedograss in at least one instance. In southeastern peninsular Florida, historical flooding regimes were restored to wetland areas. Torpedograss was not present prior to restoration treatments, but was detected after flooding. In one area, "stoloniferous growth on the water surface" led to an increase in frequency from 0% to 86% in 9 years. Its establishment was limited in areas where maidencane was already established [32].

Some types of disturbance may limit torpedograss. In marshes on the Mississippi River delta, an August hurricane exposed the area to high winds, tidal surges, and increased salinity. Torpedograss cover was reduced from 6.3% 1 year before the hurricane to 2.4% 2 weeks after the hurricane and 0.5% 1 year after the hurricane [18].

It is not clear whether torpedograss would influence the successional trajectories of native plant communities where it establishes. In areas where it displaces native vegetation and/or establishes in patterns that differ from those of native plant communities, it is possible that torpedograss could alter successional trajectories. This topic had not been addressed in the literature as of this writing (2011).

FIRE EFFECTS AND MANAGEMENT

SPECIES: Panicum repens

- FIRE EFFECTS
- FUELS AND FIRE REGIMES
- FIRE MANAGEMENT CONSIDERATIONS

FIRE EFFECTS:

- **Immediate fire effect on plant**
- **Postfire regeneration strategy**
- **Fire adaptations and plant response to fire**

Immediate fire effect on plant: Managers report that torpedograss is often top-killed by fire, but belowground rhizomes usually survive ([7], personal communication [6]). Rhizome mortality may occur when heat from fire penetrates deep into the soil, soil conditions are unusually dry [7], or soils are shallow [98]. As of this writing (2011), it is not known whether torpedograss seeds survive fire.

Lake Okeechobee wildfire.
Photo by Chuck Hanlon, South Florida Water Management District

Postfire regeneration strategy [95]:

Surface rhizome and/or a chamaephytic root crown in organic soil or on soil surface
Rhizomatous herb, rhizome in soil
Geophyte, growing points deep in soil

Fire adaptations and plant response to fire:

- Fire adaptations
- Plant response to fire

Fire adaptations: Torpedograss exhibits some characteristics that enable it to survive fire. It is rhizomatous (see Vegetative regeneration), and managers report that rhizomes below the soil surface generally survive fire ([7], personal communication [6]). Torpedograss also often establishes in moist to wet areas where rhizomes are generally protected from fire damage, though aerial portions may burn [7]. Torpedograss has been observed sprouting following fire [45,46,92,98] (see Plant response to fire, below), herbicide application [14,39,54,59,83,92], grazing [79], cutting, [19,39], and plowing or disking [83,92]. However, rhizomes show some sensitivity to heat, so high-severity fire may kill rhizomes [7]. Growth chamber experiments showed that rhizomes died after 1 hour of immersion in heated water (>140 °F (60 °C)) [109].

As of this writing (2011), the limited available information suggests that torpedograss is not particularly adapted to establishing in burned areas via dispersed seeds or from the soil seed bank (see Seed production, Seed banking, and Germination).

Plant response to fire: The available information suggests that torpedograss biomass is reduced following fire but plants often survive and sprout quickly. Mortality may occur in areas where local conditions (e.g., moisture, soil depth) expose rhizomes to heat. Postfire recovery is likely, though recovery may be limited in areas that experience flooding or are treated with herbicides.

Several sources report torpedograss surviving and sprouting soon after fire in Florida. One manager in Florida observed that torpedograss exhibits faster postfire recovery than native plants, allowing it to dominate burned areas at the expense of native vegetation (personal communication [6]). Managers report that in areas around Lake Okeechobee where water depth was approximately 2 to 3 inches (5-8 cm), torpedograss recovered "rapidly and vigorously" following initial biomass reduction after fire, with new growth sprouting from previously dormant buds [7]. After a May prescribed fire near East Lake Tohopekaliga, Florida, torpedograss sprouted "immediately" in areas that were burned or burned and disked. Rhizome biomass was reduced by 66% in burned areas and 93% in burned and disked areas 100 days after treatment but recovered to approximately 20% of pretreatment levels after 250 days in both treatments [92]. Two studies provide information on aboveground growth after wildfire in the Lake Okeechobee region. One month after an August wildfire, the average torpedograss height in burned areas was 4 to 8 inches (10-20 cm) compared to ≥30 inches (70 cm) in unburned areas [45]. Six weeks after top-kill from a February wildfire, torpedograss height averaged 8 inches (20 cm) [46].

In Florida, managers observed torpedograss mortality in areas exposed to unusual drought conditions, where water levels receded 2 to 3 feet (0.6-0.9 m) below the surface of the ground. Fire consumed both aboveground vegetation and the upper, dry, compacted peat layers to a depth of 3 to 4 inches (8-10 cm). Torpedograss mortality was also observed following a prescribed fire in 1990 and a wildfire in 1997; in both years, water levels were below the ground's surface [7]. However, dry conditions do not always result in torpedograss mortality. In 2007, torpedograss populations in marshes around Lake Okeechobee survived repeated fires during a record low-water period (personal communication [6]).

Flooding after fire may also lead to torpedograss mortality. One manager from Florida reported that he expected torpedograss populations to respond well and potentially expand following fire, depending on postfire water levels; he observed torpedograss mortality and a subsequent population decline in an area that experienced flooding for months following fire (personal communication [6]). In the Florida Everglades, torpedograss cover was significantly lower 1 year after a mixed-severity prescribed fire in areas flooded after treatment ($P<0.001$) [98]. See Fire Management

Considerations for more information on this study.

Herbicide treatment following fire may reduce torpedograss populations. See Fire Management Considerations for more information.

Long-term impacts of fire on torpedograss have not been reported as of this writing (2011).

FUELS AND FIRE REGIMES:

- **Fuels**
- **Fire regimes**

Fuels: The limited information available (2011) suggests that torpedograss populations develop heavy fuel loads that may alter fire characteristics.

In Florida, torpedograss grows in dense stands and may comprise 80% of the biomass of an area where it establishes (personal communication [6]). Along the shores of Lake Kariba, Zimbabwe, the average standing crop biomass of torpedograss was 7,620 ± 21.8 kg/ha with an average moisture content of 72.91% ± 0.24 (sampled February to May) [16]. Dead leaves and culms of torpedograss accumulate in areas without grazing [79].

One manager from Florida believes that populations of torpedograss accumulate much more fuel than the native plant communities that it replaces, particularly in sawgrass (*Cladium jamaicense*) and spikerush prairies and American white waterlily sloughs. The increased biomass may lead to "hotter" fires resulting in higher mortality of native species, particularly sawgrass (personal communication [6]).

Fire regimes: It is not clear what fire regime torpedograss is best adapted to. Observations from Florida suggest that fire severity may impact torpedograss survival, with high-severity fires potentially killing torpedograss rhizomes [7]. Repeated fires have resulted in torpedograss mortality in some situations, but torpedograss has survived repeated fires under other conditions (see Plant response to fire). Alteration of local fuel characteristics following torpedograss invasion may change fire regimes.

In North America, torpedograss invasion is limited to relatively few plant communities, many of which lack fire regime information. See the Fire Regime Table for available information on fire regimes of vegetation communities in which torpedograss may occur.

FIRE MANAGEMENT CONSIDERATIONS:
Potential for postfire establishment and pread: Available information suggests that torpedograss populations likely survive fire and could potentially spread from existing populations into burned areas. There is little information available to suggest that torpedograss would establish from seed on burned areas in North America (see Fire adaptations and Plant response to fire).

Preventing postfire establishment and spread: Preventing invasive plants from establishing in weed-free burned areas is the most effective and least costly management method. This may be accomplished through early detection and eradication, careful monitoring and follow-up, and limiting dispersal of invasive plant propagules into burned areas. General recommendations for preventing postfire establishment and spread of invasive plants include:

- Incorporate cost of weed prevention and management into fire rehabilitation plans
- Acquire restoration funding
- Include weed prevention education in fire training
- Minimize soil disturbance and vegetation removal during fire suppression and rehabilitation activities
- Minimize the use of retardants that may alter soil nutrient availability, such as those containing nitrogen and phosphorus
- Avoid areas dominated by high priority invasive plants when locating firelines, monitoring camps, staging areas, and helibases

- Clean equipment and vehicles prior to entering burned areas
- Regulate or prevent human and livestock entry into burned areas until desirable site vegetation has recovered sufficiently to resist invasion by undesirable vegetation
- Monitor burned areas and areas of significant disturbance or traffic from management activity
- Detect weeds early and eradicate before vegetative spread and/or seed dispersal
- Eradicate small patches and contain or control large infestations within or adjacent to the burned area
- Reestablish vegetation on bare ground as soon as possible
- Avoid use of fertilizers in postfire rehabilitation and restoration
- Use only certified weed-free seed mixes when revegetation is necessary

For more detailed information on these topics, see the following publications: [3,8,41,101].

Use of prescribed fire as a control agent: While managers suggest that fire alone is not conducive to torpedograss control ([7], personal communication [6]), prescribed fire has been successfully used to increase the effectiveness of herbicide treatments ([45,46], personal communications [6,94]). Managers report that torpedograss plants regenerating after fire are often more susceptible to herbicides than unburned plants. Increased susceptibility may result both from better herbicide contact, as new growth is more exposed after burning has consumed mature torpedograss thatch, and from greater herbicide penetration through the immature cuticle of young shoots [7]. The results of 2 studies suggest that reestablishement of native vegetation is possible after a reduction in torpedograss cover due to fire and herbicide treatments [46,98].

The following text details the results of 4 studies integrating prescribed fire and herbicide application.

Study 1 [98]: In the Florida Everglades, areas treated with prescribed fire, herbicides, and combinations of these treatments exhibited significant declines in torpedograss cover for at least 1 year after treatment. Herbicide-only and herbicide-fire treatments reduced torpedograss cover more than fire-only treatments. Preferred vegetation established in areas with herbicide-only or herbicide-fire treatments. Flooding after treatment may have contributed to treatment success.

Treatments were applied to constructed stormwater treatment areas where dense torpedograss cover was limiting the establishment of preferred submerged aquatic vegetation. Prior to treatment, torpedograss made up the bulk of overall plant cover throughout the study area. The treatments included: 1) prescribed fire followed by imazapyr application; 2) prescribed fire followed by imazapyr and glyphosate application; 3) imazapyr and glyphosate application followed by prescribed fire; 4) prescribed fire only; 5) imazapyr and glyphosate only; and 6) untreated control. Treatment plots were 7 acres (3 ha) in size and treatments were replicated 2 to 5 times. The untreated control was not replicated. Pretreatment vegetation was sampled between December 2003 and February 2004. Treatments were applied in April and May 2004. Posttreatment vegetation was sampled approximately 5 months (September-October 2004) and 11 months (March-April 2005) after treatment. Reported fire information was limited; "burn coverage" varied from 5% to 55% in areas burned in April and 35% to 99% in areas burned in May. The study area was dry during pretreatment data collection and while treatments were applied. It was temporarily flooded prior to treatment in January and February 2004 and continuously flooded after 13 June 2004 following treatments. Mean water depth during posttreatment data collection was 26 inches (65 cm).

Torpedograss cover declined significantly following treatments (P<0.001). Herbicide-only and herbicide-fire treatments reduced torpedograss cover more than fire-only treatment.

Approximate torpedograss cover before and after control treatments in the Florida Everglades. Torpedograss cover data approximated from text and bar graph [98].

Treatment (Month/year)	Torpedograss cover (%)		
	Pretreatment	~ 5 months after treatment (9,10/2004)	~ 11 months after treatment (3,4/2005)
Fire (4/2004), imazapyr (5/2004)	48	<1	<1

Fire (4/2004), imazapyr and glyphosate (5/2004)	44	<1	<1
Imazapyr and glyphosate (4,5/2004), Fire (5/2004)	57	<1	<1
Fire (5/2004)	52	10	12
Imazapyr and glyphosate (5/2004)	30	<1	<1
Control	39	25	44

Burning before or after herbicide application did not seem to improve the efficacy of herbicide treatments. However, the author suggested that fire could still be a useful management tool, particularly in shallow muck soils. Flooding did not impact plant cover (demonstrated by control plots). After treatments and reduction of torpedograss cover to <1%, preferred submerged aquatic vegetation colonized treated areas. In untreated control areas and areas burned but not treated with herbicides, preferred submerged aquatic vegetation did not establish [98].

Study 2 [46]: In the Lake Okeechobee region burning prior to herbicide treatment resulted in better torpedograss control than burning after herbicide treatment. Results after 2 years of monitoring suggested that only high herbicide concentrations controlled torpedograss. Native plant species increased in treated areas.

In February 1997, a wildfire burned approximately 6,000 acres (2,500 ha) of the littoral zone north of Indian Prairie Canal near Lake Okeechobee. Prior to the fire, the area was covered with a dense monoculture of torpedograss that averaged 3 feet (1 m) in height. About 6 weeks after the fire (April 1997), torpedograss had regrown to an average height of 8 inches (20 cm) in the burned area. At this time, burned plots were treated with 4 different concentrations of imazapyr. Unburned control plots were also treated with the same imazapyr concentrations. Approximately 3 weeks after herbicide treatments, a wildfire burned the control plots. Thus the study, while originally designed to compare effectiveness of herbicide treatment after fire, ultimately compared effectiveness of postfire herbicide treatment with prefire herbicide treatment. Additional herbicides treatments were not made after the second fire. Treatment efficacy was visually evaluated as percent control of torpedograss. Control ratings were based on the estimated amount of dead plant material observed above and below the water line and on the amount of regrowth that followed each treatment.

Plots that burned prior to herbicide treatments had consistently less torpedograss than those burned after herbicide treatments at all imazapyr concentrations. By 118 weeks after treatment, torpedograss was considered controlled only in those plots burned before herbicide treatment and treated with the 2 highest concentrations of imazapyr [46].

Percent control of torpedograss following herbicide treatments of areas burned by wildfire 6 weeks prior to treatment or 3 weeks after the treatment [46].

Treatment	Imazapyr concentration (kg acid equivalent/ha)	Percent control (%)					
		Weeks after April herbicide treatment					
		12	26	42	59	68	118
Burned 6 weeks prior to herbicide treatment	0.28	70	80	65	10	0	0
	0.56	95	95	75	20	10	0
	0.84	90	95	70	80	90	90
	1.12	90	95	85	90	95	90
Burned 3 weeks after herbicide treatment	0.28	30	5	0	0	0	0
	0.56	50	15	0	0	0	0
	0.84	25	15	0	0	0	0
	1.12	70	30	20	0	0	0

Torpedograss stem counts were conducted, but due to logistical constraints, stem counts were only done in areas burned prior to herbicide treatment, not those burned after herbicide treatments. There were large reductions in stem density in the burned plots that were subsequently treated with the 2 highest rates of imazapyr.

Approximate average torpedograss stem density (stems/m²) in areas burned by wildfire (February 1997) before and after treatment with varied concentrations of imazapyr (April 1997) near Lake Okeechobee, Florida [46]		
Imazapyr concentration (kg ae/ha)	Stem density prior to herbicide treatment	Stem density 68 weeks after herbicide treatment
0.28	250	225
0.56	260	250
0.84	240	0
1.12	360	2

In areas where high concentrations of herbicides were applied, native plant species (e.g., bulltongue arrowhead and pickerelweed), became the dominant vegetation in less than 1 year [46].

Study 3 [45]: Managers in the Lake Okeechobee region integrated fire and herbicide treatments in attempts to control torpedograss at the landscape level. In August 2000, nearly 5,000 acres (2,000 ha) of marsh vegetation were ignited using a drip torch suspended from a helicopter. Imazapyr was applied in September 2000 to burned and unburned sites. At the time of herbicide treatments, average torpedograss height was 4 to 8 inches (10-20 cm) in the burned area and commonly >30 inches (70 cm) in the unburned area. Aerial color infrared imagery was used to measure torpedograss cover on the landscape before and after treatments. Eight months after herbicide treatments, torpedograss control was 95% and 60% in 2 burned plots and 40% in an unburned plot, suggesting that fire increased the efficacy of herbicide treatments, at least in the short term. The authors suggested that regional differences (e.g., soil moisture) may have impacted results, but noted that treatments tended to be most effective in areas burned prior to herbicide treatment. They suggested that fire reduced torpedograss biomass, increasing the exposure of sediment and newly emerged vegetation to herbicides. The authors mentioned several other treatments combining fire and herbicides, all of which seemed to control torpedograss at a rate greater than its rate of spread in the area [45].

Study 4 [92]: One study in Florida examined the combination of fire, mechanical treatments, and herbicide application to control torpedograss. While control was generally high 1 year after integrated treatments, the results suggested that burning, mowing, and disking did not enhance the effectiveness of herbicide in torpedograss control, and the author suggested that these techniques would not result in long-term suppression of torpedograss.

Integrated treatments were applied to control a torpedograss monoculture established in the littoral zone of East Lake Tohopekaliga, Florida. Lake levels were drawn down in 1990 and 1991 to facilitate treatments. In May 1990, a 57-acre (23-ha) field of torpedograss was burned. Though fire information was not reported, the fire did consume all torpedograss foliage and thatch. After the fire, 50% of the area was disked to a depth of 8 inches (20 cm). Glyphosate was applied at several concentrations 3 times: in early July, late July, and August 1990. In 1991, 2 acres (1 ha) of the previously burned-disked area were mowed and disked to a depth of 8 inches (20 cm). Other areas were mowed without disking. Glyphosate was applied at several concentrations in early July. Burned areas without herbicide application were maintained in both years in areas with all mechanical treatments.

Torpedograss shoot biomass was entirely consumed by the fire, though sprouting occurred "immediately" in areas that were burned or burned and disked. Shoot biomass recovered to approximately 20% of its pretreatment biomass 750 days after treatment. Rhizome biomass was reduced by 66% in burned areas and 93% in burned and disked areas 100 days after treatment. Rhizome biomass recovered to approximately 20% of its pretreatment biomass after 250 days and then remained constant through 750 days in burned areas with different mechanical treatments.

Herbicide application in addition to fire and mechanical treatments did not result in increased torpedograss control. Visual observations confirmed that all rates of glyphosate application, regardless of other treatment, provided 100% control of torpedograss shoots 2 months after herbicide application. One year after treatment, however, all rates of glyphosate application provided approximately the same amount of control of torpedograss shoots (>78%), with the exception of the lowest concentration of glyphosate in areas that were not disked (55%). Rhizome response was generally less than shoot response for all glyphosate rates in both combinations of mechanical treatment.

Effects of glyphosate application, burning, mowing, and disking on torpedograss in Florida [92].

Glyphosate rate (kg/ha) (July-August 1991)	Percent inhibition*			
	Burned & disked (May 1990); Mowed & disked (1991)		Burned (May 1990); Mowed (1991)	
	Shoot	Rhizome	Shoot	Rhizome
0.57	89	31	55	56
1.12	78	66	88	74
2.24	79	55	94	71
4.48	82	66	92	68

*Percent inhibition is based on the difference between torpedograss shoot and rhizome biomass in control and treated plots 1 year after treatment.

Though some control was achieved, the author suggested that these treatments alone would not control torpedograss in long term.

MANAGEMENT CONSIDERATIONS

SPECIES: Panicum repens

- FEDERAL LEGAL STATUS
- OTHER STATUS
- IMPORTANCE TO WILDLIFE AND LIVESTOCK
- OTHER USES
- IMPACTS AND CONTROL

FEDERAL LEGAL STATUS:
None

OTHER STATUS:
Information on state-level noxious weed status of plants in the United States is available at Plants Database.

IMPORTANCE TO WILDLIFE AND LIVESTOCK:
Torpedograss has been widely planted as forage for livestock and may have some nutritional value to wildlife.

Palatability and nutritional value: Torpedograss has been planted throughout the world as forage for domestic livestock [2,44,65,69,79]. A nonnative species guide reports that, though used for pasturage, torpedograss has relatively low nutritional value, protein content, and palatability compared to other grasses. Its advantage as a forage grass is that it is relatively palatable when young and can withstand heavy grazing and trampling [49]. It can be fed to cattle either green or as hay [31]. However, torpedograss was reported as poisonous to horses in Florida [92,109].

Torpedograss may have some value as food for wildlife. Populations of torpedograss near Lake Okeechobee supported a diverse arthropod and nematode fauna, and plants were not limited by invertebrate herbivory or damage [29]. In feeding trials in Florida, it was consumed by the nonnative channeled apple snail (*Pomacea insularum*) [4,5]. On the Mississippi River delta, both above- and belowground vegetation of torpedograss was eaten by snow geese and brants in the fall [72]. It was eaten by redbread tilapia (*Tilapia rendalli*) in Lake Kariba in Zimbabwe [16]. Seeds of torpedograss were found in fecal pellets of wild spur-thighed tortoises in Spain [26].

Cover value: No information is available on this topic.

OTHER USES:
Torpedograss may be used as a soil binder [31,44] or for erosion control [50,105]. It has been evaluated for use in improving water quality; in laboratory experiments, torpedograss was credited with adjusting pH and reducing toxic chemicals and dissolved minerals in water supplies [111]. In Taiwan, torpedograss was evaluated for use as a substrate for oyster mushroom (*Pleurotus citrinopileatus*) cultivation [66]. In Indonesia, torpedograss rhizomes are used to treat abnormal menstruation [31].

IMPACTS AND CONTROL:

Impacts: Torpedograss invasion is problematic in agricultural systems, including tea, sugarcane, coconut, cacao, cotton, rubber, plantations, rice, and citrus plantations [92]. It is also problematic in pastures and along canal banks and roadsides [109]. Torpedograss invasion in and around water bodies may interfere with flood control, navigation, recreation, and irrigation [29].

In the United States, the impacts of torpedograss invasion have been most documented in Florida. An invasive plant management guide for Florida reports that torpedograss was established in > 70% of Florida's public waters by 1992 [69]. As of 2002, torpedograss had displaced more than 16,000 acres (6,500 ha) of the 100,000 acres (40,000 ha) of native plant communities in Lake Okeechobee's marsh [7]. In the late 1990s, torpedograss management in flood control systems cost approximately $2 million a year [65].

Photo by Ann Murray, University of Florida, Bugwood.org

Invasive plant management guides suggest that invasive torpedograss populations displace native vegetation [69,105]. Over a 5-year period in the Lake Okeechobee region, 20 acres (8 ha) of spikerush and open water were replaced by torpedograss. Torpedograss cover increased by 32%, from 62 acres (25 ha) in 1994 to 82 acres (33 ha) in 1999 [45]. In the Florida Everglades, herbicide and prescribed fire treatments were applied to constructed stormwater treatment areas where dense torpedograss cover was limiting the establishment of preferred submerged aquatic vegetation [98]. In coastal areas of South Carolina, torpedograss established in sand dune restoration areas and was expected to replace the desired planted species [28].

Torpedograss may affect ecosystem processes in water channels by stabilizing lake and stream edges [42]. In the Everglades drainage basin, persistent high cover of nonnative macrophytes, including torpedograss, resulted in a high accumulation of organic materials that depressed dissolved oxygen concentrations. In Lake Istokpoga, Florida, hypoxic conditions occurred in areas densely vegetated by torpedograss and other nonnative macrophytes [12]. Areas with dense stands of torpedograss are considered poor habitat for fish because high stem densities inhibit fish movement, and dissolved oxygen concentrations are too low [46].

< p>**Control:** Torpedograss is difficult to control. Plants possess numerous dormant buds associated with extensive rhizomes [64] and can sprout from deep in the soil [109]. Plants allocate a high proportion of resources to belowground biomass [96]. Plants sprout following rhizome fragmentation [109] or destruction of aboveground vegetation [39]. Several years of treatment may be needed to control torpedograss [64].

In all cases where invasive species are targeted for control, no matter what method is employed, the potential for other invasive species to fill their void must be considered [9]. Control of biotic invasions is most effective when it employs a long-term, ecosystem-wide strategy rather than a tactical approach focused on battling individual invaders [70].

Prevention: An invasive plant management guide from Florida suggests that maintaining healthy ecosystems with good species diversity and limiting the presence of open and disturbed areas may help to deter establishment of nonnative species like torpedograss. Population spread may also be limited by preventing the fragmentation and spread of torpedograss rhizomes, controlling established populations near waterways [69], not accepting contaminated materials such as fill dirt and hay, and cleaning vegetation off of boat trailers and machinery [92].

It is commonly argued that the most cost-efficient and effective method of managing invasive species is to prevent their establishment and spread by maintaining "healthy" natural communities [70,91] (e.g., avoid road building in wildlands [100]) and by monitoring several times each year [57]. Managing to maintain the integrity of the native plant community and mitigate the factors enhancing ecosystem invasibility is likely to be more effective than managing solely to control the invader [48].

Weed prevention and control can be incorporated into many types of management plans, including those for logging and site preparation, grazing allotments, recreation management, research projects, road building and maintenance, and fire management [101]. See the Guide to noxious weed prevention practices [101] for specific guidelines in preventing the spread of weed seeds and propagules under different management conditions.

Fire: For information on the use of prescribed fire to control this species, see Fire Management Considerations.

Cultural control: The presence of other vegetation may limit the establishment or spread of torpedograss. In a wetland in southeastern peninsular Florida, torpedograss establishment and spread was limited or nonexistent in areas where maidencane, a native species, was already established [32].

Physical or mechanical control: An invasive plant management guide from Florida suggests that mechanical methods are only moderately effective for torpedograss control [69]. Mechanical control methods often produce numerous rhizome fragments capable of producing aerial shoots even if buried relatively deeply in the soil [107,109].

Tillage has the potential to fragment rhizomes and stimulate sprouting [65,69]. In field experiments, torpedograss sprouted following tilling, with most sprouts emerging 50 to 90 days after tilling. Because associated greenhouse experiments found that rhizomes with fewer nodes were less likely to sprout and that sprouting decreased with depth of burial, the authors suggested that fragmenting rhizomes by cross-plowing and deeply burying rhizomes by plowing below 12 inches (30 cm) might reduce sprouting after treatment [53]. In sugarcane fields in Taiwan, hand-hoeing torpedograss depleted rhizome reserves, but had to be repeated 6 times to achieve control [83]. An invasive plant management guide suggests that continuous tillage could provide control but is impractical in natural areas [69].

Digging may be an effective means of controlling small patches of torpedograss, but it is difficult to remove all rhizomes [105]. Digging is often unsuccessful because it is time consuming, expensive, and may result in the scattering of rhizome fragments [20].

Mowing is only marginally effective [69]. In Taiwan, repeated mowing through a growing season limited the development of new rhizomes, but did not ultimately prevent regeneration [82]. Torpedograss withstands grazing and trampling [49,79].

The results of experimental pond studies in Florida suggested that flooding or maintaining deep water could limit torpedograss establishment and growth. However, the authors caution that frequent flooding could negatively impact other wetland plants in Florida plant communities [93].

Biological control: As of this writing (2011), no biological agent has been identified to control torpedograss. Laboratory experiments suggest that fungal pathogens may be useful in controlling torpedograss [90]. In Florida, populations of torpedograss supported a diverse arthropod and nematode fauna, but the plant was not limited by invertebrate herbivory or damage [29]. In feeding trials in Florida, the nonnative channeled apple snail fed heavily on torpedograss but also consumed native species, suggesting that it would not be an appropriate biocontrol for torpedograss or other species nonnative to Florida [5].

Biological control of invasive species has a long history that indicates many factors must be considered before using biological controls. Refer to these sources: [103,110] and the Weed control methods handbook [99] for background information and important considerations for developing and implementing biological control programs.

Chemical control: Herbicide application is the most widely-used method for controlling torpedograss, though plants may sprout from rhizomes [14,19,39,54,59,83,89] or tillering may increase [19] following treatment. Repeated applications may be needed to achieve control [14,19,54,69], but may not always work [83,89]. In greenhouse growth trials, the level of torpedograss control by herbicides varied by strength of application, length of exposure, and number of treatments [19]. Greenhouse studies suggested that young torpedograss plants or plants in the reproductive stage may be most susceptible to herbicides [92]. Integration with other methods may increase the effectiveness of herbicide treatments (See Use of prescribed fire as a control agent).

In Florida, the use of herbicides to control torpedograss is complicated by concerns about impacts on nontarget vegetation and the use of herbicides in aquatic systems [45,69]. Chemical control may also be expensive, [59], labor intensive, and impractical on a large scale [39].

Herbicides are effective in gaining initial control of a new invasion or a severe infestation, but they are rarely a complete or long-term solution to weed management [15]. See the Weed control methods handbook [99] for considerations on the use of herbicides in natural areas and detailed information on specific chemicals. See the following references for specific recommendations on chemical control of torpedograss: [14,19,39,46,54,59,60,64,69,82,83,89,92].

Integrated management: See Use of prescribed fire as a control agent for information on integrating fire, mechanical, and chemical methods for controlling torpedograss.

APPENDIX: FIRE REGIME TABLE

SPECIES: Panicum repens

The following table provides fire regime information that may be relevant to torpedograss habitats based on information in available literature (2011). Follow the links in the table to documents that provide more detailed information on these fire regimes.

Fire regime information on vegetation communities in which torpedograss may occur. This information is taken from the LANDFIRE Rapid Assessment Vegetation Models [63], which were developed by local experts using available literature, local data, and/or expert opinion. This table summarizes fire regime characteristics for each plant community listed. The PDF file linked from each plant community name describes the model and synthesizes the knowledge available on vegetation composition, structure, and dynamics in that community. Cells are blank where information is not available in the Rapid Assessment Vegetation Model.

South-central US | Southeast

South-central US

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
South-central US Forested					
Southern floodplain	Replacement	42%	140		
	Surface or low	58%	100		

Southeast

- Southeast Grassland
- Southeast Woodland
- Southeast Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Southeast Grassland					
Everglades sawgrass	Replacement	96%	3	2	15
	Surface or low	4%	70		
Floodplain marsh	Replacement	100%	4	3	30

Everglades (marl prairie)	Replacement	45%	16	10	20
	Mixed	55%	13	10	
Palmetto prairie	Replacement	87%	2	1	4
	Mixed	4%	40		
	Surface or low	9%	20		
Pondcypress savanna	Replacement	17%	120		
	Mixed	27%	75		
	Surface or low	57%	35		
Southern tidal brackish to freshwater marsh	Replacement	100%	5		
Gulf Coast wet pine savanna	Replacement	2%	165	10	500
	Mixed	1%	500		
	Surface or low	98%	3	1	10
Southeast Woodland					
South Florida slash pine flatwoods	Replacement	6%	50	50	90
	Surface or low	94%	3	1	6
Atlantic wet pine savanna	Replacement	4%	100		
	Mixed	2%	175		
	Surface or low	94%	4		
Southeast Forested					
Sand pine scrub	Replacement	90%	45	10	100
	Mixed	10%	400	60	
	Replacement	18%	40		500

Maritime forest	Mixed	2%	310	100	500
	Surface or low	80%	9	3	50
Mesic-dry flatwoods	Replacement	3%	65	5	150
	Surface or low	97%	2	1	8
South Florida coastal prairie-mangrove swamp	Replacement	76%	25		
	Mixed	24%	80		
Southern floodplain	Replacement	7%	900		
	Surface or low	93%	63		

*Fire Severities—
Replacement: Any fire that causes greater than 75% top removal of a vegetation-fuel type, resulting in general replacement of existing vegetation; may or may not cause a lethal effect on the plants.
Mixed: Any fire burning more than 5% of an area that does not qualify as a replacement, surface, or low-severity fire; includes mosaic and other fires that are intermediate in effects.
Surface or low: Any fire that causes less than 25% upper layer replacement and/or removal in a vegetation-fuel class but burns 5% or more of the area [47,62].

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