Purple Nutsedge (*Cyperus rotundus*)
Ecological Risk Screening Summary

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1 Native Range and Status in the United States

Native Range
Cyperus rotundus is reported as both native and introduced to the majority of the world based on various sources (ex. Lansdown et al. 2017; GISD 2018). This screening summary reports the contradictory information as accurately as possible.

From CABI (2018):

"*C. rotundus* is thought by some authorities to have originated in India but others believe that the origins are more widespread, including northern and eastern Australia (Parsons and Cuthbertson, 1992)."

"*C. rotundus* is thought to have originated in Southeastern Asia and from there it was spread to the rest of the world during the last 2000 years."

CABI (2018) lists *Cyperus rotundus* as native to Afghanistan, Bahrain, Bangladesh, Bhutan, China, Cook Islands, India (except Kashmir), Indonesia, Iran, Iraq, Israel, Japan, Kazakhstan, Korea, Kyrgyzstan, Lebanon, Malaysia, Nepal, Oman, Pakistan, Sri Lanka, Taiwan, Turkey, Turkmenistan, Uzbekistan, Aldabra, Algeria, Benin, Botswana, Burundi, Cape Verde, Central Africa Republic, Comoros, Congo Democratic Republic, Djibouti, Equatorial Guinea, Eritrea, Gambia, Guinea-Bissau, Libya, Malawi, Morocco, Réunion, Rodriguez Island, Rwanda, Saint Helena, Somalia, Togo, Cyprus, and Russian Federation.

CABI (2018) lists *Cyperus rotundus* as present but with no indication of native or introduced status in Jordan, Laos, Myanmar, Philippines, Saudi Arabia, Yemen, Angola, Burkina Faso, Cameroon, Chad, Congo, Cote d'Ivoire, Egypt, Ethiopia, Gabon, Ghana, Guinea, Kenya, Madagascar, Mali, Mauritania, Mauritius, Mozambique, Niger, Nigeria, Senegal, Seychelles, Sierra Leone, South Africa, Canary Islands, Sudan, Swaziland, Tanzania, Tunisia, Uganda, Zambia Zimbabwe, Bermuda, United States, Costa Rica, Cuba, Dominican Republic, Guatemala, Honduras, Jamaica, Nicaragua, Panama, Trinidad and Tobago, Argentina, Bolivia, Brazil, Chile, Colombia, Paraguay, Peru, Suriname, Uruguay, Venezuela, Albania, Bulgaria, France (including Corsica), Greece (including Crete), Italy (including Sardinia and Sicily), Portugal (including Azores and Madeira), Romania, Spain (including Balearic Islands), Switzerland, Yugoslavia, Australia, Fiji, New Zealand, Northern Mariana Islands, Papua New Guinea, Samoa, and Tonga.

From Lansdown et al. (2017):

"Native:
Afghanistan; Albania; Algeria; Angola; Argentina; Armenia; Australia (New South Wales, Northern Territory, Queensland, South Australia, Western Australia); Austria; Azerbaijan; Bahrain; Belize; Benin; Bolivia, Plurinational States of; Bosnia and Herzegovina; Botswana; Brazil; British Indian Ocean Territory (Chagos Archipelago); Bulgaria; Burkina Faso; Burundi; Cameroon; Cape Verde; Central African Republic; Chad; China (Anhui, Chongqing, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Hainan, Hebei, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Liaoning, Shaanxi, Shandong, Shanxi, Sichuan, Yunnan, Zhejiang); Christmas Island; Colombia; Comoros; Congo; Congo, The Democratic Republic of the; Costa Rica (Cocos I., Costa Rica (mainland)); Côte d'Ivoire; Croatia; Cyprus; Djibouti; Dominican Republic; Ecuador; Egypt (Egypt (African part), Sinai); El Salvador; Equatorial Guinea; Eritrea; Ethiopia; France (Corsica, France (mainland)); French Guiana; French Polynesia (Society Is. - Introduced, Tuamotu - Introduced); French Southern Territories (Mozambique Channel Is.); Gabon; Gambia; Georgia (Abkhaziya, Adzhariya, Gruziya); Ghana; Greece (Greece (mainland), Kriti); Guatemala; Guinea; Guyana; Honduras; India (Andaman Is., Andhra Pradesh, Arunachal Pradesh, Assam,

Bihar, Delhi, Goa, Gujarat, Himachal Pradesh, Jammu-Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh, West Bengal); Indonesia (Bali, Jawa, Kalimantan, Lesser Sunda Is., Maluku, Papua, Sulawesi, Sumatera); Iran, Islamic Republic of; Iraq; Italy (Italy (mainland), Sardegna, Sicilia); Japan (Ogasawara-shoto); Kazakhstan; Kenya; Korea, Democratic People's Republic of; Korea, Republic of; Kyrgyzstan; Lebanon; Lesotho; Libya; Macedonia, the former Yugoslav Republic of; Madagascar; Malawi; Malaysia (Peninsular Malaysia, Sabah); Mali; Malta; Marshall Islands; Mauritania; Mauritius (Mauritius (main island), Rodrigues); Mexico; Micronesia, Federated States of ; Morocco; Mozambique; Myanmar (Myanmar (mainland)); Namibia (Caprivi Strip, Namibia (main part)); Nepal; Nicaragua; Niger; Nigeria; Northern Mariana Islands; Oman; Pakistan; Palestinian Territory, Occupied; Panama; Paraguay; Peru; Philippines; Portugal (Azores, Madeira, Portugal (mainland), Selvagens); Puerto Rico (Puerto Rico (main island)); Qatar; Réunion; Romania; Rwanda; Saudi Arabia; Senegal; Serbia (Kosovo, Serbia); Seychelles (Aldabra, Seychelles (main island group)); Sierra Leone; Slovenia; Somalia; South Africa (Eastern Cape Province, Free State, Gauteng, KwaZulu-Natal, Limpopo Province, Mpumalanga, Northern Cape Province, North-West Province, Western Cape); South Sudan; Spain (Baleares, Canary Is., Spain (mainland)); Sri Lanka; Sudan; Suriname; Swaziland; Switzerland; Syrian Arab Republic; Taiwan, Province of China (Taiwan, Province of China (main island)); Tanzania, United Republic of; Thailand; Togo; Tunisia; Turkey (Turkey-in-Asia, Turkey-in-Europe); Turkmenistan; Uganda; United Arab Emirates; United States (Alaska, Arizona - Introduced, Arkansas, California - Introduced, Florida, Georgia, Hawaiian Is., Minnesota, Missouri, New Mexico, North Carolina, South Carolina, Tennessee, Texas, Virginia); United States Minor Outlying Islands (US Line Is. - Introduced, Wake Is.); Uzbekistan; Venezuela, Bolivarian Republic of; Viet Nam; Virgin Islands, British; Wallis and Futuna; Western Sahara; Yemen (North Yemen, Socotra, South Yemen); Zambia; Zimbabwe"

Status in the United States

From Bendixen and Nandihalli (1987):

"In the continental United States, purple nutsedge is found in the southeast from Texas to Virginia and in California [U.S. Department of Agriculture 1970]."

USDA, NRCS (2018) lists *Cyperus rotundus* as a noxious weed in Arkansas, a B list (noxious weeds) species in California, an "A" designated weed and quarantine species in Oregon, and a quarantine species in Washington.

GISD (2018) lists *Cyperus rotundus* as alien, established, and invasive in American Samoa (Swains, Ta'u, and Tutuila islands), Guam, Puerto Rico, Alabama, Arkansas, Hawai'i (Big Island, French Frigate Shoals, Kaua'i, Lana'i, Maui, Moloka'i, Nihau, and Oahu islands), California, Georgia, Johnston Island, Kure Atoll, Mississippi, North Carolina, Oregon, Tennessee, Texas, Washington, Midway Islands, U.S. Virgin Islands, and Wake Island.

GISD (2018) lists *Cyperus rotundus* as alien, established, and invasiveness unknown in Northern Mariana Islands (Pagan, Rota, Saipan, and Tinian islands), and Palmyra Island.

From GISD (2018):

"Purple nutsedge and yellow nutsedge are the most troublesome weeds of vegetable crops in Alabama, Georgia, Mississippi, Tennessee, and Texas (Webster 2002, Webster and MacDonald 2001, in Webster 2005b)."

"Based solely on the lack of nutsedge control with methyl bromide alternatives, a critical-use exemption for methyl bromide was granted for several vegetable crops in Georgia beyond 2005 (A. S. Culpepper, personal communication, in Webster 2005b)."

"In North Carolina field crops, herbicides have influenced the current nutsedge population. […] Purple nutsedge is now the predominant *Cyperus* weed species due to use of herbicides that have activity on yellow nutsedge such as metolachlor and bentazon (Webster and Coble 1997b, in Warren & Coble 1999)."

"[…] Purple and yellow nutsedge infestations continue to increase in many Texas peanut fields due to the use of dinitroaniline herbicides, which control most grass and small-seeded broadleaf weeds but have no effect on either nutsedge species (Grichar et al. 1992, Grichar and Nester 1997, in Warren & Coble 1999)."

CABI (2018) lists *Cyperus rotundus* as present with no indication of native status in Alabama, Arizona, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, Virginia, and Puerto Rico.

CABI (2018) lists *Cyperus rotundus* as present and introduced in Delaware, District of Columbia, Kentucky, Maryland, Minnesota, Missouri, New Jersey, New York, Oklahoma, and Pennsylvania.

CABI (2018) lists *Cyperus rotundus* as present, introduced, and invasive in Hawaii, Oregon, U.S. Virgin Islands, American Samoa, Guam, U.S. Minor Outlying Islands, Vanuatu, Wake Island, and Wallis and Futuna Islands.

Means of Introductions in the United States

From CABI (2018):

"In the United States, it is considered that it was unintentionally introduced during the 1800s (USDA-NRCS 2014). Since the 1880s, this species appears in collections made on islands in the West Indies."

Remarks

Cyperus rotundus is reported as both native and introduced to the majority of the world based on various sources (ex. Lansdown et al. 2017; GISD 2018). This screening summary reports the contradictory information as accurately as possible.

From GISD (2018):

"The impact of climate change on invasive species is a fascinating aspect of invasion biology. Rogers and colleagues (2008) tested the effects of a rise in atmospheric CO2 on purple nutsedge in controlled studies. Purple nutsedge exposed to elevated CO2 had greater total dry weight, leaf area, root length and numbers of tubers and tended to increase allocation belowground, which led to greater root-to-shoot ratio (R:S). These findings suggest that purple nutsedge may be more invasive in a future high-CO2 world (Rogers et al. 2008), however, the experiment did not account for the competitive impact of other biota."

"The use of chickens and geese to control nutgrass *Cyperus rotundus* has also been promoted in Palau and the United States (PestNet 2009)."

From CABI (2018):

"The risk of introduction of *C. rotundus* is very high. This species is highly mobile and highly adaptable to different environments. It also benefits from human-related activities. Consequently it is considered one of the "world's worst weeds" with the potential to negatively impact agriculture and natural ecosystems by displacing native plants or by changing the availability of food or shelter for native animals. This rapidly growing plant can quickly form dense colonies due to its ability to produce an extensive system of rhizomes and tubers. Thus, its likelihood of invading new habitats remains high."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2018):

"Kingdom Plantae
Subkingdom Viridiplantae
Infrakingdom Streptophyta
Superdivision Embryophyta
Division Tracheophyta
Subdivision Spermatophytina
Class Magnoliopsida
Superorder Lilianae
Order Poales
Family Cyperaceae
Genus *Cyperus*
Species *Cyperus rotundus* L."

"Taxonomic Status:
Current Standing: accepted"

From CABI (2018):

"*Cyperus rotundus* is the universally accepted name. Several subspecies are described though they are rarely recognized in literature on the weed. Haines and Lye (1983) describe four subspecies from East Africa, *rotundus*, *merkeri*, *taylorii* and *tuberosus*, but this is not accepted by all authors. Hutchinson et al. (1972), for example, recognize *C. tuberosus* Rottb. as a species, not as a subspecies of *C. rotundus*. Variations in *C. rotundus* have led to descriptions of ecotypes, such as those from India based on glume colour (Ranade and Burns, 1925), morphotypes (Wills, 1998) and chemotypes, such as those from Japan and China based on sesquiterpenes in tubers (Komai and Ueki, 1981)."

Size, Weight, and Age Range

From GSID (2018):

"It usually attains a height of about 30 cm (Quayyum et al. 2000)."

From CABI (2018):

"Flowering stems are erect, up to 60 cm tall, […]"

Environment

From GISD (2018):

"Purple nutsedge grows well in almost every soil type, over a wide range of soil moisture, pH and elevation. […] grows best in moist fertile soils (Swarbrick 1997, in PIER 1999). In cool or waterlogged soils it grows slower, flowers little and produces fewer tubers (Holm et al. 1977, in PIER 1999). It is less tolerant of low temperatures and shaded areas than yellow nutsedge (Santos et al. 1997, in Rogers et al. 2008)."

"Travlos and colleagues (2009), however, claim that purple nutsedge is one of the most serious weed problems of the arid and semiarid environments. Moreover, *C. rotundus* is one of the most common weeds of the secondary succession occurring in abandoned and dry fields of arid environments (El-Sheikh 2005, in Travlos et al. 2009)."

From CABI (2018):

"*C. rotundus* […], growing in almost every soil type, altitude, humidity, soil moisture and pH, but not in soils with a high salt content (Holm et al., 1977). […] Generally, it does not tolerate shade."

Climate/Range

From Bendixen and Nandihalli (1987):

"Purple nutsedge is a problem throughout the thermal belt. It is a weed of importance in […] tropical and subtropical countries of the world (Table 2 [in source matieral])."

From GISD (2018):

"Purple nutsedge is relatively sensitive to cold and is restricted to latitudes where the average minimum air temperature for January is higher than -1°C (Bendixen & Nandihalli 1987).\n"

"Greece is among the countries with the highest percent winter survival of purple nutsedge (Wills, 1998, in Travlos et al. 2009) making it even more difficult to control."

From Lansdown et al. (2017):

"This species has an almost global distribution and is absent only from northern regions; […]"

Distribution Outside the United States

Cyperus rotundus is reported as both native and introduced to the majority of the world based on various sources (ex. Lansdown et al. 2017; GISD 2018). This screening summary reports the contradictory information as accurately as possible.

Native

See Section 1 – Native Range for information on the native range of *Cyperus rotundus*.

Introduced

GISD (2018) lists *Cyperus rotundus* as alien, established, and invasive in Afghanistan, Zaire, Argentina, Australia (Lord Howe Island, New South Wales, Queensland), Brazil, Brunei, Cambodia, Chad, Chile, China, Christmas Island, Colombia, Cook Islands (Aitutaki, Atiu, Mangaia, Mauke, Mitiaro, and Rarotonga islands), Costa Rica, Cote d'Ivoire, Cuba, Ecuador (San Cristobal Island), Egypt, El Salvador, Ethiopia, former Yugoslavia, Fiji (Kandavu, Taveuni, Vanua Levu, and Viti Levu islands), France, French Polynesia (Fatu Hiva, Hiva Oa, Maupiti, Nuku Hiva, Raiatea, Raroia, Tahiti, Tahuata, Takapoto, Tupai, Ua Huka, and Ua Pou islands), Ghana, Greece, Guinea, Honduras, India, Borneo, Indonesia, Iran, Iraq, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Kiribati (Abemama and Tarawa atolls, Butaritari, Christmas, Fanning, Kanton, and Maiana islands), Lesser Antilles, Madagascar, Malaysia, Marshall Islands (Arno, Eniwetok, Jaluit, and Kwajalein islands and Majuro Atoll), Mauritius, Melanesia, Mexico, Micronesia (Kosrae), Morocco, Mozambique, Nauru, New Caledonia (Grand Terre, Isle of Pines, Lifou, New Caledonia, and Ouvea islands), New Guinea, New Zealand (including Kermadec and Raoul islands), Nigeria, Niue, Norfolk Island, Pakistan, Palau (Angaur, Babeldaob, Koror, Malakal, Ngercheu, Ngerekebesang, Palau, and Peleliu islands), Panama, Papua New Guinea, Paraguay, Peru, Philippines, Polynesia, Portugal, Russian Federation, Samoa (Savai'i and Upolu islands), Singapore, Solomon Islands, South Africa, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Taiwan, Tanzania, Thailand, Tokelau, Tonga (Tongatapu and Vava'u islands), Trinidad and Tobago, Tunisia, Turkey, Uganda, Venezuela, Vietnam, Wallis and Futuna (Wallis Island), Zambia, and Zimbabwe.

GISD (2018) lists *Cyperus rotundus* as alien, established, and invasiveness unknown or uncertain in Angola, Bangladesh, Bermuda, Bolivia, Diego Garcia (British Indian Ocean Territory), Cameroon, Cook Islands (Penryn Island), Dominican Republic, French Polynesia (Makatea and Moorea islands), Gabon, Guatemala, Bonin Islands (Japan), North Korea, South Korea, Lebanon, Maldives (Male Atoll), Mali, Marshall Islands (Likiep and Maloelap islands), Mauritiania, Micronesia (Pohnpei, Weno, and Yap islands), Nicaragua, Niger, Saint Helena, Senegal, Seychelles (Alphonse and Fregate islands), Tonga (Niuatoputapu and Eua islands), Uruguay, and Vanuatu.

From Lansdown et al. (2017):

"Introduced:
Cook Islands (Cook Is.); Fiji; New Zealand (Kermadec Is.); Norfolk Island; Saint Helena, Ascension and Tristan da Cunha (Ascension, Saint Helena (main island)); Tonga"

CABI (2018) lists *Cyperus rotundus* as present and invasive in Brunei Darussalam, Cambodia, Chagos Archipelago, Thailand, Vietnam, and Solomon Islands.

CABI (2018) lists *Cyperus rotundus* as present, introduced, and invasive in Christmas Island, Kashmir province (India), Singapore, Mexico, British Virgin Islands, Galapagos Islands, Cook Islands, French Polynesia, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, New Caledonia, Niue, Norfolk Island, and Palau.

CABI (2018) lists *Cyperus rotundus* as present and introduced in Maldives, Anguilla, Aruba, Bahamas, Barbados, Belize, Cayman Islands, Curaçao, Dominica, El Salvador, Guadeloupe, Haiti, Martinique, Netherlands Antilles, Saint Lucia, Ecuador, French Guiana, Guyana, Austria, Belgium, and Czech Republic.

Pagad et al. (2018) lists *Cyperus rotundus* as alien in Bonaire, Botswana, Brazil, Burundi, Cambodia, Cameroon, Chad, Chile, China, Colombia, Cook Islands, Costa Rica, Côte d'Ivoire, Cuba, Czech Republic, Dominican Republic, Ecuador, Egypt, El Salvador, Fiji, Gabon, Ghana, Guatemala, Guinea, Honduras, Iraq, Israel, Jamaica, Jordan, Kiribati, Lao People's Democratic Republic, Malaysia, Maldives, Mali, Marshall Islands, Mauritania, Mauritius, Mexico, Micronesia, Morocco, Mozambique, Myanmar, Nauru, Nicaragua, Niger, Nigeria, Niue, Palau, Panama, Papua New Guinea, Peru, Samoa, Senegal, Singapore, Solomon Islands, South Africa, Spain, Sri Lanka, Sudan, Suriname, Thailand, Tonga, Trinidad and Tobago, Tunisia, Tuvalu, Vanuatu, Venezuela, Viet Nam, Zambia, Zimbabwe, Ethiopia, Kenya, Uganda, United Republic of Tanzania, Afghanistan, Albania, Angola, Argentina, Aruba, Australia, Austria, Barbados, Belgium, Belize, Bermuda, Bhutan, and Bolivia.

Means of Introduction Outside the United States

From CABI (2018):

"*C. rotundus* is thought to have originated in Southeastern Asia and from there it was spread to the rest of the world during the last 2000 years. […] The most likely method of introduction of this species into new habitat could be related to human activities. Seeds, tubers, and rhizomes may have been introduced as a contaminant in soil, mud, agricultural machinery, fodder, pastures, and crop seeds (Holm et al. 1977)."

From GISD (2018):

"Tubers are also transported intentionally by food fadists and for animal feed such as chufa (Bendixen & Nandihalli 1987).Nutsedge tubers are known to develop in potato (*Solarum tuberosum*) tubers and other commercial root crops. Nutsedge thus is distributed with these foods and seed stocks. Nutsedge tubers also may contaminate peanut (*Arachis hypogaea*) during harvest and shipment. Tubers and seeds might contaminate commercial seeds and feeds and be distributed widely (Bendixen & Nandihalli 1987).Entire plants, including rhizomes and tubers, may have been used as shipping ballast then discarded after use (Bendixen & Nandihalli 1987)."

Short Description

From Swearingen and Bargeron (2016):

"The leaves are three-ranked, shiny, dark green, and corrugated in cross section. They are 0.24-0.39 in. (6-10 mm) wide and 3.9-13.8 in. (10-35 cm) long. The rachis, which grows through the center of the leaf bundle, is erect, simple, smooth, triangular in cross section, and 3.9-23.6 in. (10-60 cm) long."

"Near the ends are clusters of narrow spikelets, 0.3-1 in. (0.8-2.5 cm) long and 0.07 in. (2 mm) wide, 10- to 40-flowered, acute and compressed with a red, reddish-brown, or purplish-brown color."

"Fruits are 3 angled achene."

From GISD (2018):

"*Cyperus rotundus* (purple nutsedge) is a smooth, erect and perennial weed with an extensive subterranean tuber system (Hauser 1962, in Quayyum et al. 2000; Singh Pandey & Singh 2009). […] Purple nutsedge appears grass like, but its stems are triangular in cross-section. It has fibrous roots that branch prolifically, rhizomes, tubers, bulbs, and inflorescences that consist of irregular compound umbels. Its leaves are mostly basal and linear in shape with a prominent mid-rib (Ministry of Agriculture and Lands of British Columbia 2007, in Rogers et al. 2008)."

From CABI (2018):

"In the vegetative stage, *C. rotundus* resembles several other sedge weeds but it can be distinguished by its wiry rhizomes (usually three per basal bulb) linking a network of tubers. By contrast, *C. esculentus* has numerous soft stolons bearing terminal tubers and annual species of *Cyperus* have no tubers or rhizomes. The purplish-brown inflorescence distinguishes *C. rotundus* from *C. esculentus* with its yellow inflorescence."

Biology

From Swearingen and Bargeron (2016):

"*Cyperus rotundus* is a perennial which rarely reproduces by seed but extensively reproduces by rhizomes which initially are white and fleshy with scale leaves, later becoming ligneous or "wiry.""

From GISD (2018):

"Tuber Sprouting (Stoller & Sweet 1987): In purple nutsedge, tuberization can begin within 17 days after shoot emergence (Hammerton 1974, in Stoller & Sweet 1987), but dormant tubers are not found until 6 to 8 weeks after sprouting (Hauser 1962, in Stoller & Sweet 1987); this is followed by chain formation 10 weeks after shoot emergence (Hauser 1962b, in Bangarwa et al. 2008). Tuberization in purple nutsedge may be a response to excess carbohydrate, regulated by growth substances, photoperiod and temperature (Garg Bendixen & Anderson 1967, Hammerton 1975, in Stoller & Sweet 1987). A single purple nutsedge tuber can produce 100 tubers when allowed to grow for 12 weeks (Rao 1968, in Bangarwa et al. 2008). A patch originating from a single tuber can expand up to 5.5 m2 and produce 750 shoots within 6 months (Webster 2005, in Bangarwa et al. 2008)."

"Tubers lie dormant in the soil until stimulated to sprout. When a tuber sprouts, one or more rhizomes elongate vertically from tuber buds. Roots radiate horizontally from the rhizome as it grows toward the soil surface. The rhizome tip at the soil surface is exposed to sunlight and diurnal temperature fluctuations which are the principal factors that stimulate the basal bulb to form on the rhizome under the soil surface (Stoller & Woolley 1983, in Stoller & Sweet 1987). These rhizome tips are strong and sharp and can penetrate hard substrates, so mulching is an ineffective control. The rhizome extends mostly by internode elongation until the basal bulb is initiated. Basal bulbs consist of a section of stem (rhizome) with compacted internodes containing meristems for roots, secondary rhizomes, leaves, and the flower stalk. Parent tubers remain attached to the plant throughout the season, and the plant may derive food from tubers in times of stress (Hammerton, 1974, Stoller, Nema & Bhan 1972, in Stoller & Sweet 1987).\n\n Vegetative Development: Several weeks after the primary shoot emerges, secondary rhizomes radiate horizontally from the basal bulb. In the early growth stages, the rhizome tips turn upward, differentiating into secondary basal bulbs similar to the primary basal bulb. Secondary bulbs produce shoots, rhizomes, and flower stalks as described for primary bulbs; and subsequent development of tertiary and higher order bulbs forms the complex system of subterranean, vegetative growth."

"Flowering: Flowering is erratic among yellow and purple nutsedge populations. Many populations of yellow and purple nutsedge do not flower after growth for a cropping season, but tubers always are produced when these weeds grow for that length of time."

“Seed Biology: Purple nutsedge is a perennial which rarely reproduces by seed (Thullen & Keeley 1979, in Wills 1987). Purple and yellow nutsedges have been documented to produce achenes (an achene is a small dry fruit with one seed) from aerial inflorescences; however, there are low rates of viability for purple nutsedge achenes (less than 5%), whereas yellow nutsedge achenes have 50 to 90% germination (Justice and Whitehead 1946, in Webster et al. 2008). Evidence is lacking that seeds play a significant role in propagation, especially in cultivated fields (Mulligan & Junkins 1976, Stoller 1981, in Stoller & Sweet 1987). Light does not stimulate germination of seedlings (Bell et al. 1962, in Stoller & Sweet 1987).”

“Tuber Biology: The aggressiveness of purple nutsedge is associated primarily with its asexual means of reproduction by underground tubers (Benedixen & Nandihalli 1987, Stoller & Sweet 1987, in Bangarwa et al. 2008). The tubers serve as perenniating organs by storing carbohydrates in a continuous reproductive cycle (Anderson 1999, Stoller & Weber 1975, in Bangarwa et al. 2008). Purple nutsedge produces a complex underground system of basal bulbs, rhizomes, and tubers (Stoller & Sweet 1987); rhizomes are initially white and fleshy with scale leaves, later becoming woody or wiry (Wills 1987); tubers are recognized as the primary dispersal unit for both species, so the literature abounds with reports on tuber biology (Stoller & Sweet 1987).”

“Tuber formation begins from 4 to 6 weeks after seedling emergence; many authors report that more than 95% of purple and yellow nutsedge tubers usually are formed in the upper 45 cm of and in most soils, more than 80% of tubers occur in the upper 15 cm (Stoller & Sweet 1987). When purple and yellow nutsedge are cultured in fields without interference from other plants, they produce an estimated 10 to 30 million tubers per ha in a season (Hauser 1962, Horowitz 1972, in Stoller & Sweet 1987). Both purple and yellow nutsedge tuber longevity is a function of tuber depth in the soil; tuber survival time increases as its depth in the soil increases (Stoller 1981, in Stoller & Sweet 1987). Yellow nutsedge tubers had a half-life of 4 and 6 months at 10 and 20 cm, respectively, in a non- crop environment in Illinois (Stoller & Wax 1973, in Stoller & Sweet 1987). Desiccation and temperature extremes can kill both yellow and purple nutsedge tubers (Stoller & Sweet 1987).”

From CABI (2018):

“Tuber dormancy is high on undisturbed sites and may last for at least 7 years (Parsons and Cuthbertson, 1992). [F]ragmentation of the rhizome/tuber network by cultivation breaks the dormancy imposed by a growing tuber on others in the same chain. Hence, cultivation stimulates the growth of *C. rotundus*. Large populations of shoots and tubers can develop from a single tuber; as many as 600 plants have been produced in a single year. Horowitz (1972) has reported that 2-3 million tubers per hectare per week can be produced during active growing periods, yielding 30-40 million tubers/ha. Forty tonnes of underground organs have been produced on 1 hectare in a year, giving *C. rotundus* a phenomenal capacity for vegetative reproduction. Most tubers are found in the upper 15 cm of soil but they can grow down to 30 cm or more in favourable conditions. Neeser et al. (1997) found that a tuber population has a half-life of 16 months and a predicted longevity (99% mortality) of 42 months.”

“*C. rotundus* has C4 metabolism which supposedly makes it increasingly competitive when temperatures and light intensity rise (Black et al., 1969). It has low tolerance of shade, a property that can be exploited in controlling this weed by crops with dense canopies (Rambakudzibga, 1999). Temperature has a marked effect on the germination of tubers. Sprouting has been reported at temperatures of 13-43°C but the range varies with biotype. Desiccation kills tubers but the duration and temperature of the drying period affects this process. The critical moisture level for tuber germination seems to be in the region of 11.5-15% (Jha and Sen, 1985)."

Human Uses

From GISD (2018):

"Several chemical compounds have been isolated from world's worst weed *Cyperus rotundus* (Jeong et al. 2000, Sonwa & Konig 2001) and some of these chemicals possess medicinal properties and are used in Latin America, China and elsewhere (Ellison & Barreto 2004; Singh et al. 1970, Gupta et al. 1971, Weenen et al. 1990, Hamada 1993, Thebtaranonth et al. 1995, Makino et al. 2003, in Sharma & Gupta 2007). For example, decoctions of the plant in Brazil are used for their anti-infective and anti-inflammatory properties (Cristina et al. 2005). Various preparations of *C. rotundus* have been used for centuries in perfumes, spices and traditional medicines in India, China, Arab and Africa (Sharma & Gupta 2007). *C. rotundus* is also an important ingredient of anti-aging Ayurvedic neutraceutical Chyavanprash [herbal supplement] (Sharma & Gupta 2007). Pigs eat its tubers; however it makes a poor fodder species; it is also reportedly used as a soil stabilizer (Ellison & Barreto 2004)."

From CABI (2018):

"Parsons and Cuthbertson (1992) claim that *C. rotundus* is an important medicine in India and China and note its use by pharmaceutical companies to produce diuretics, anthelminthics and treatments for coughs, bronchial asthma and fever. […]."

"It has been used by ancient people in Africa (i.e., Nile Valley), China, and eastern Mediterranean as food, perfume, and medicine for centuries. For example, this species first appeared in a Chinese medicine book around 500 AD (Negbi 1992)."

Diseases

From GSID (2018):

"Biocontrol:*Athesapeuta* [sic] *cyperi* Marshall (Coleoptera: Curculionidae) was released in 1981 as a biocontrol agent against C. rotundus and probably failed to establish (Fowler et al. 2000). Larvae feed internally and adults feed externally on foliage (Fowler et al. 2000)."

CABI (2018) lists *Ascochyta cypericola*, *Balansia cyperi*, *Belonolaimus longicaudatus*, *Cercospora caricis*, *Cintractia limitata*, *Cochliobolus tuberculatus*, *Dactylaria higginsii*, *Dousporium cyperi*, *Fusarium oxysporum*, *Phytophthpora cyperi*, *Puccinia canaliculata*, *Puccinia conclusa*, and *Puccinia philippinensis* as parasites and pathogens of *Cyperus rotundus*.

Poelen et al. (2014) lists *Acerophagus angelicus*, *Dipara* sp., *Trichogrammatoidea bactrae*, *Euderomphale hyaline*, *Apoleptomastix bicoloricornis*, *Trichogramma chilotraeae*, *Trichogrammatoidea nana*, *Trichogramma semifumatum*, *Trichogramma pretiosum*, *Trichogramma chilonis, Anagyrus californicus, Encarsia luteola,* and *Anisopteromalus calandrae* as parasites of *Cyperus rotundus*.

Threat to Humans

Many sources list *Cyperus rotundus* as a significant pest that reduces yield, sometimes significantly, in crops (Webster 2005; Sharma and Gupta 2007; CABI 2018; GISD 2018).

3 Impacts of Introductions

From Webster (2005):

"[…]; by 1939, uncontrolled purple nutsedge encroachment caused growers to abandon agricultural land (Godfrey 1939). Purple nutsedge and yellow nutsedge are the most troublesome weeds of vegetable crops in Georgia and many states in the southern United States (Webster 2002; Webster and MacDonald 2001)."

From GISD (2018):

"In Pakistan, purple nutsedge is one of the most common weeds found throughout the Indus valley during the summer season in major field crops such as cotton, sugarcane and maize (Iqbal Cheema & An 2008). Bryson et al. (2003, in Iqbal Cheema & An 2008) reported that purple nutsedge causes seed cotton yield reductions of 62–85%."

From CABI (2018):

"Holm et al. (1977) state that *C. rotundus* has been reported as a weed of 52 crops including vegetables and ornamentals. Some examples are cited in the list of hosts but, in reality, this weed can occur in virtually all crops grown within its range."

"In their survey of the world's weeds, Holm et al. (1977) deduced that *C. rotundus* was the worst, based on its occurrence in 52 crops in 92 countries and its capacity to cause substantial yield losses. In a later publication (Holm et al., 1979) it was listed as a 'serious' or 'principal' weed in no less than 70 countries, substantially more than any other species. Losses are caused largely as a result of competition for nutrients (for example, Rochecouste, 1956; Bhardwaj and Verma, 1968) and the competitive effects can, to some degree, be counteracted by adding extra fertilizer, especially nitrogen (Horowitz, 1973a, b). In other cases, however, additional nitrogen may exaggerate the losses, for example, in upland rice (Okafor and de Datta, 1976), radish (Santos et al., 1998) and pepper (Morales-Payan et al., 1998). It is presumed that in these cases the extra vigour of the weed in a relatively low growing crop causes competition for light. Competition for water can also be important, as shown in Phaseolus bean, when yields were reduced by 80% in a dry season but by only 50% in a wet season (William, 1973). Additionally there is evidence for an allelopathic effect that cannot be reversed even under optimal conditions of nutrient, light and moisture. In this respect, Horowitz (1973a, b) showed that *C. rotundus*, together with *Sorghum halepense* had more serious allelopathic effects than *Cynodon dactylon* on orange, cotton and mustard. Valliappan (1989) and Warner and Fox (1977) showed probable allelopathic effects on rice and banana respectively, while Meissner et al. (1979, 1982) demonstrated almost certain allelopathy against barley, cucumber, tomato and strawberry. Keeley (1987) provides a comprehensive review of the literature on these topics up to 1987.

The levels of loss caused by *C. rotundus* are not often satisfactorily separated from those caused by other weeds but by varying techniques, estimates have been obtained which occasionally show little or no loss, as in cassava, where populations up to 60 shoots/square m had no effect on root yields (Villamayor, 1983). Sierra and Mercado (1975) also showed no loss in transplanted tomato. More often very substantial losses have been recorded when the weed is allowed to compete for much or all of the growing season. Mangoesoekarjo (1977) compared a range of annual crops for their susceptibility to competition from *C. rotundus* and ranked them in the order upland rice (most susceptible), groundnut, maize and sorghum. In a similar study, Kondap et al. (1982) showed losses of 6% in maize, 12% in sorghum, 16% in cowpea, 22% in mung bean, 32% in groundnut and 58% in soyabean. Other studies emphasise the susceptibility of upland rice, losses recorded being 51% (de Datta, 1979), 41% (Okafor and de Datta, 1974) and over 40% (Sierra and Mercado, 1975). Particularly severe losses have also been recorded in squash, with over 90% yield reduction from a heavy population of nearly 900 shoots per square m (Ponchio et al., 1984) and in radish, with 100% yield loss from 125 shoots per square m at 100 kg N/ha or from only 75 per square m at 200 kg N/ha (Santos et al., 1998). In pepper, the loss was as high as 73% from 300 shoots per square m at 210 kg N/ha (Morales-Payan et al., 1998), though losses were much lower at lower densities of weed and at lower N levels (Morales-Payan et al., 1997). Other severe examples include 60% loss in onion (Tewari and Shukla, 1991). Cotton may be seriously affected (Sierra and Mercado, 1975). Cruz et al. (1969) recorded 30% loss in this crop and Saeed et al. (1977) a 14% yield loss from a population of about 600 shoots per square m. In the USA, Whitwell and Everest (1984) reviewed the results of a widespread survey in southern USA and concluded that *C. rotundus* was among the top 10 most troublesome weeds, infesting 460,000 ha of cotton across 15 states, but yield losses after normal weed control practices were probably modest. Losses in potato have been recorded as 25% (Tewari and Shukla, 1991), and in another study as only 3% (Tewari and Singh, 1991). In maize, results have likewise been varied with losses of only 14% (Tewari and Singh, 1991), while a study in Ghana showed that where *C. rotundus* was well controlled by prior glyphosate treatment, yields were almost doubled, corresponding to a 46% yield loss where it had not been controlled in spite of hand-weeding in the crop (Darkwa et al., 1999). In Brazil, studies in a range of irrigated vegetable crops showed losses from C. rotundus of 35% in cabbage, 39-50% in carrot, 41% in Phaseolus bean, 43% in cucumber, 62% in okra and 89% in garlic (William and Warren, 1975).

Perennial crops can also be seriously affected and in the study by Mangoesoekarjo (1977), cocoa was most susceptible followed by oil palm and rubber. Turner (1985) and Cerrizuela (1965) recorded 83% and 75% reductions in sugarcane yield respectively and Arevalo et al. (1974) also concluded that competition from *C. rotundus* for more than 30 days must be avoided if yields of sugarcane were not to be seriously affected. He recorded losses of approximately 15, 30 and 45% from infestations allowed to compete for 30, 45 and 90 days, respectively. Perez recorded 20% losses in pineapple (Perez, 1977). Nedunzhiyan (1995) notes that yields of taro can be 'drastically reduced' by *C. rotundus*. Holm et al. (1977) also refer to reductions in mulberry in Japan, citrus in Israel and coffee in Kenya.

Apart from direct effects on yield, Mangoesoekarjo (1977) notes how the rhizomes and tubers of *C. rotundus* can interfere with the harvest of groundnuts. Furthermore, Holm et al. (1977) quote estimates of the very substantial quantities of plant nutrients (and water) not only absorbed during the growing season, but locked away in the rhizome and tuber system for prolonged periods. In economic terms it can be conjectured that infestations of *C. rotundus* significantly raise the cost of manual weeding operations owing to the difficulty of removing the rhizomes and tubers, though quantification of these extra costs has not been seen."

From Sharma and Gupta (2007):

"[*Cyperus rotundus*] inhibited seed germination and seedling growth in wheat and tomato. Our results suggest that inhibitor of AChE in nutgrass possibly acts as agent of plant's war against (a) herbivore animals, and (b) other plants trying to grow in the same habitat."

4 Global Distribution

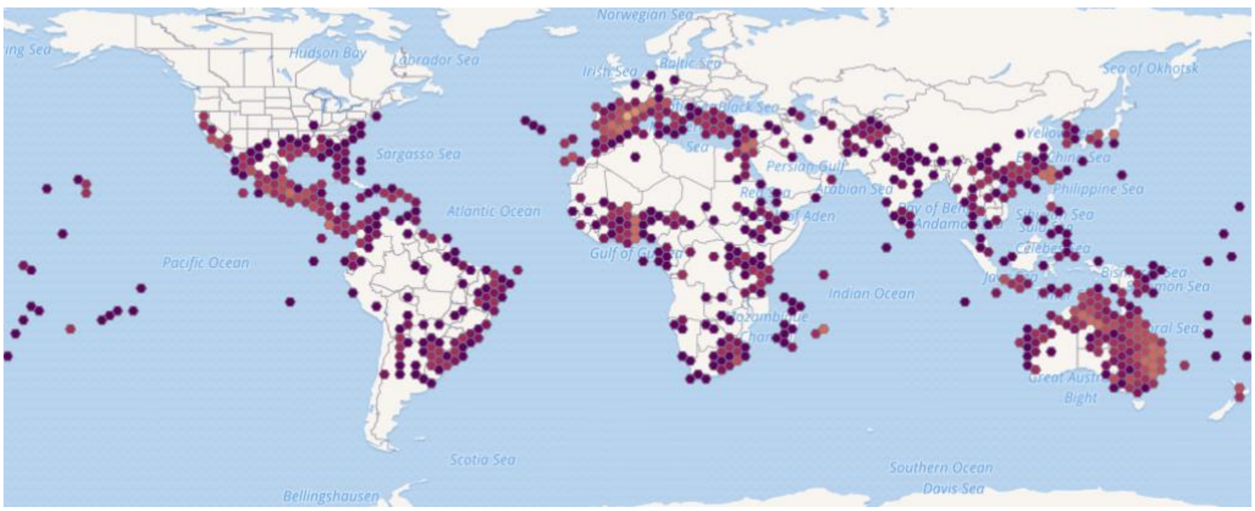

Figure 1. Known global distribution of *Cyperus rotundus*. Map from GBIF Secretariat (2018).

5 Distribution Within the United States

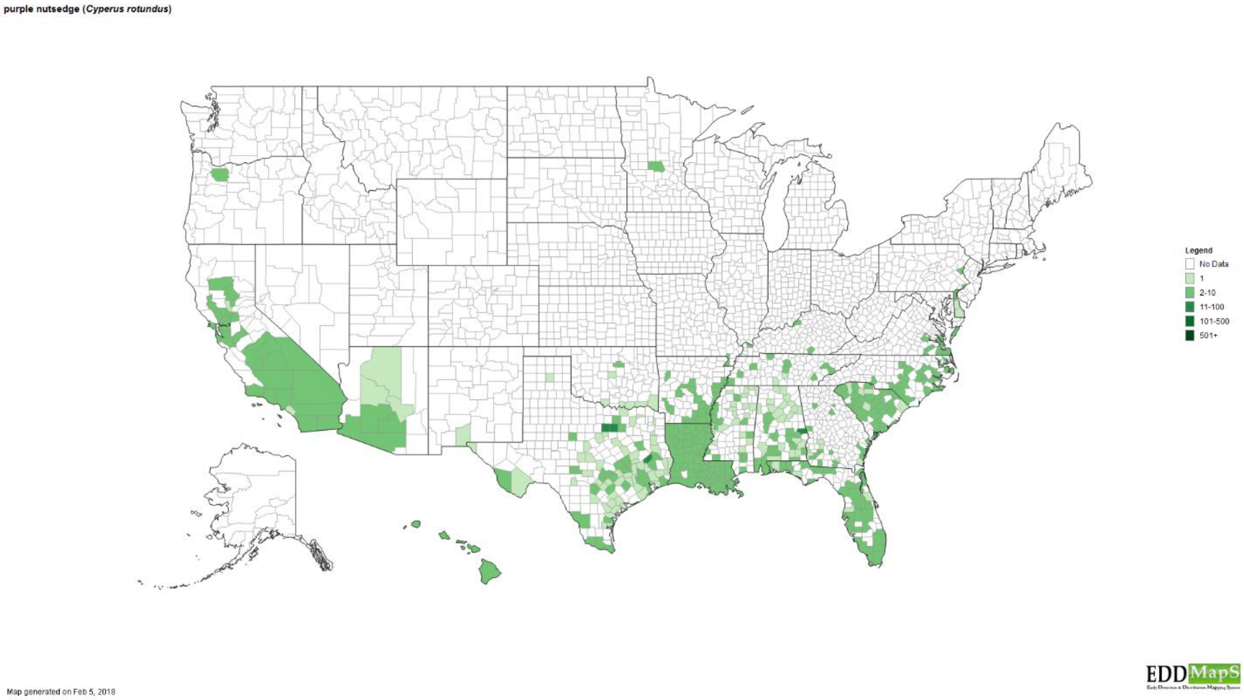

Figure 2. Known distribution of *Cyperus rotundus* by county in the United States. Map from EDDMapS (2018).

The location in Minnesota was not used as a source point for the climate match. The record indicates that the specimen is housed in a nearby herbarium (EDDMapS 2018) and while CABI (2018) does list *Cyperus rotundus* as introduced to Minnesota there is no indication that it is established at that location.

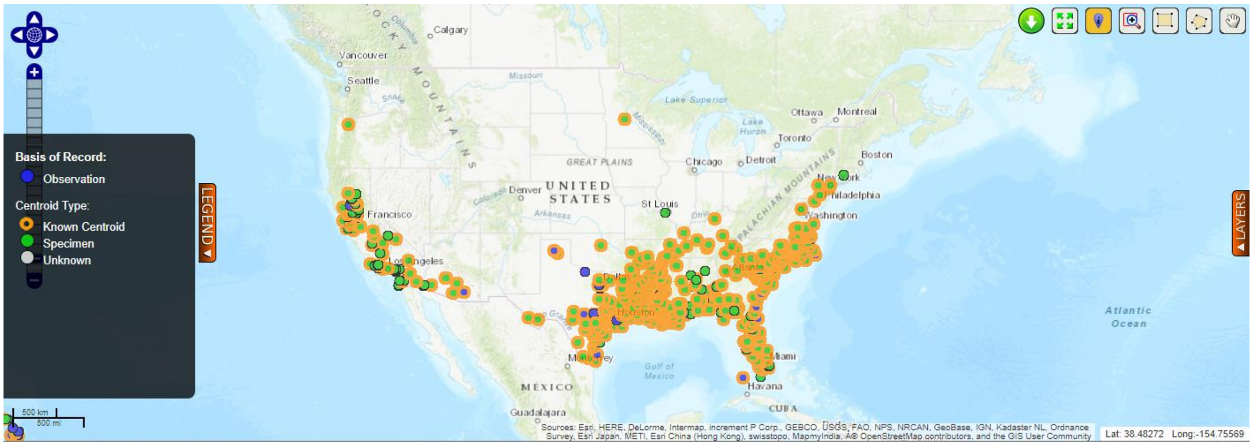

Figure 3. Known distribution of *Cyperus rotundus* in the contiguous United States. Map from BISON (2018).

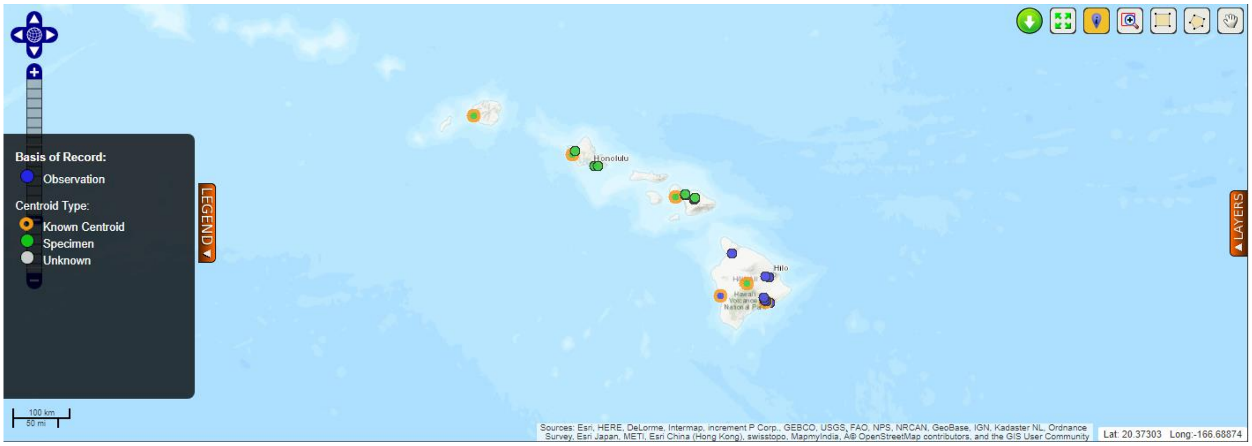

Figure 4. Known distribution of *Cyperus rotundus* in Hawaii. Map from BISON (2018).

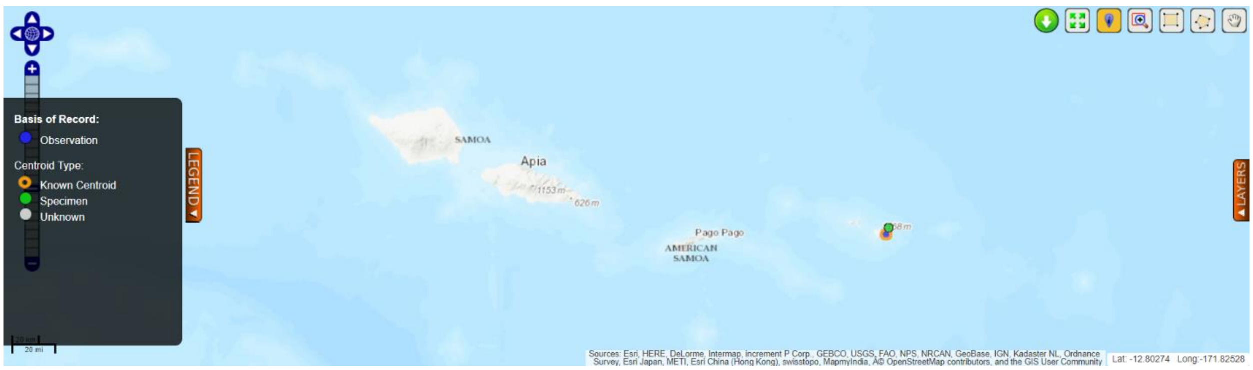

Figure 5. Known distribution of *Cyperus rotundus* in American Samoa. Map from BISON (2018)

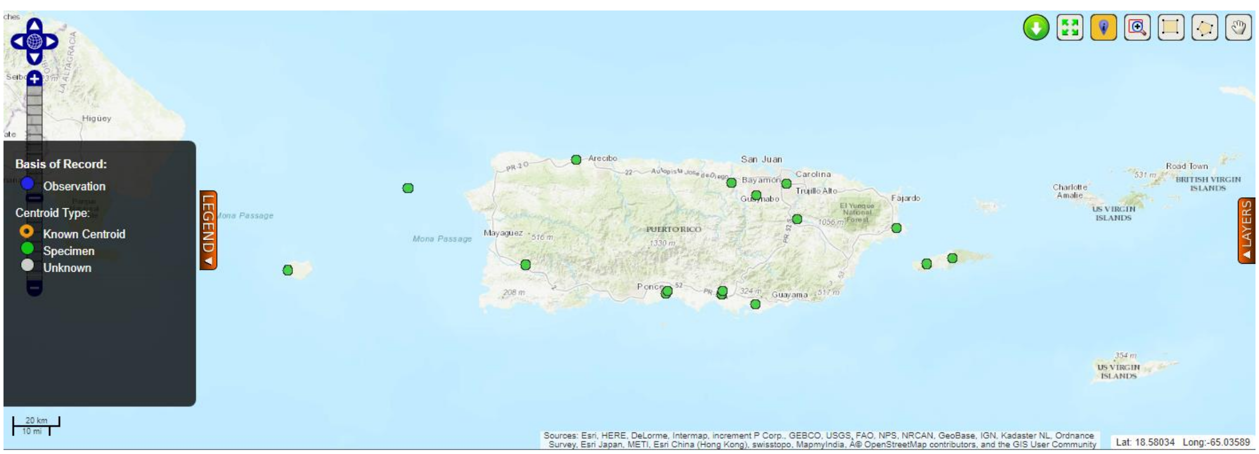

Figure 6. Known distribution of *Cyperus rotundus* in Puerto Rico and the U.S. Virgin Islands. Map from BISON (2018).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Cyperus rotundus* was high for much of the country. The very northern most coast of New England, and small areas of the upper Midwest, Great Plains, and Pacific Coast had a moderate climate match. The upper Midwest near the Canadian border and pockets along the Pacific Coasts of Oregon and Washington had low climate matches. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous United States was 0.780, high. All states in the contiguous United States had individually high climate scores except for Minnesota and North Dakota which had low climate scores.

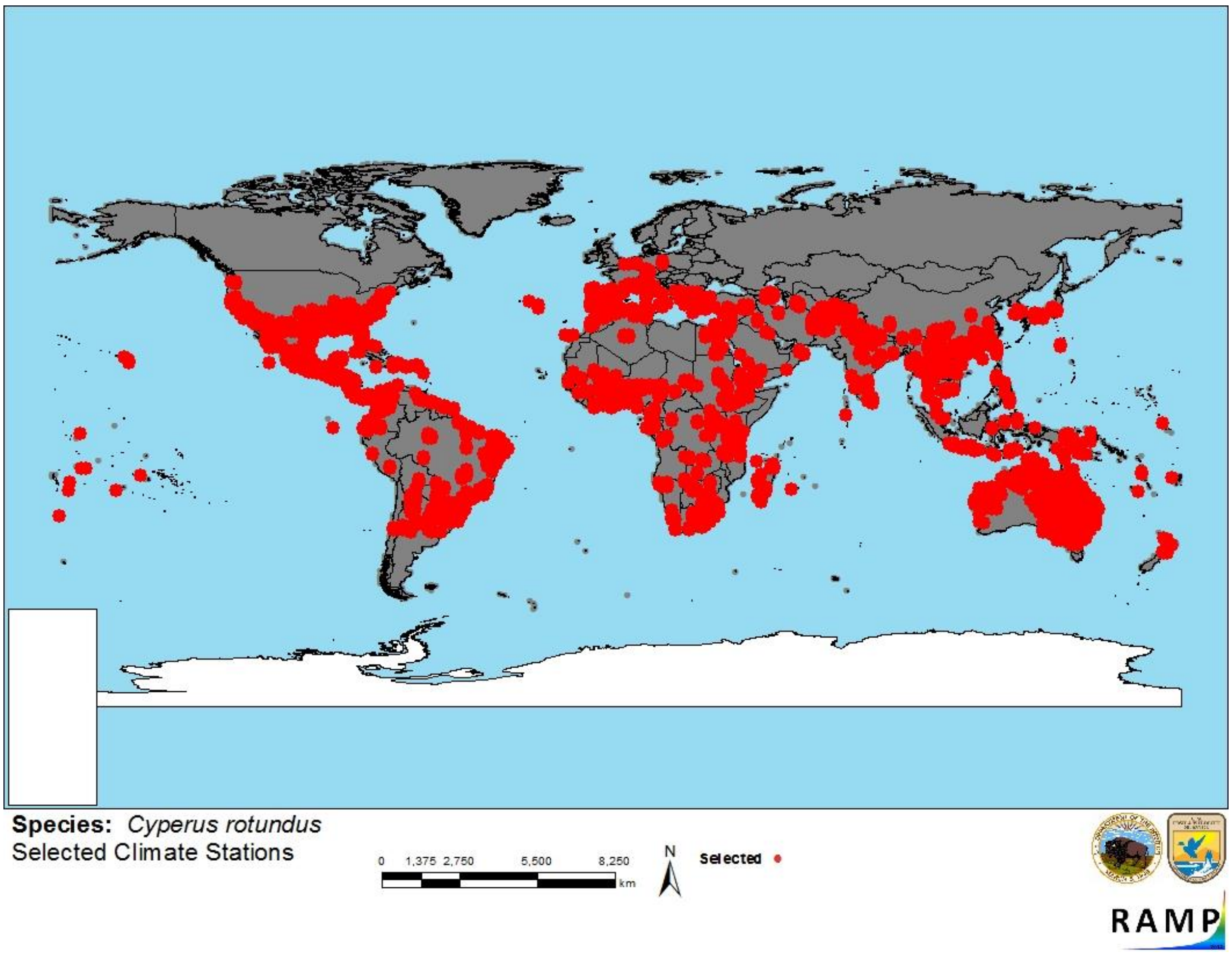

Figure 7. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Cyperus rotundus* climate matching. Source locations from BISON (2018), CABI (2018), EDDMapS (2018), and GBIF Secretariat (2018).

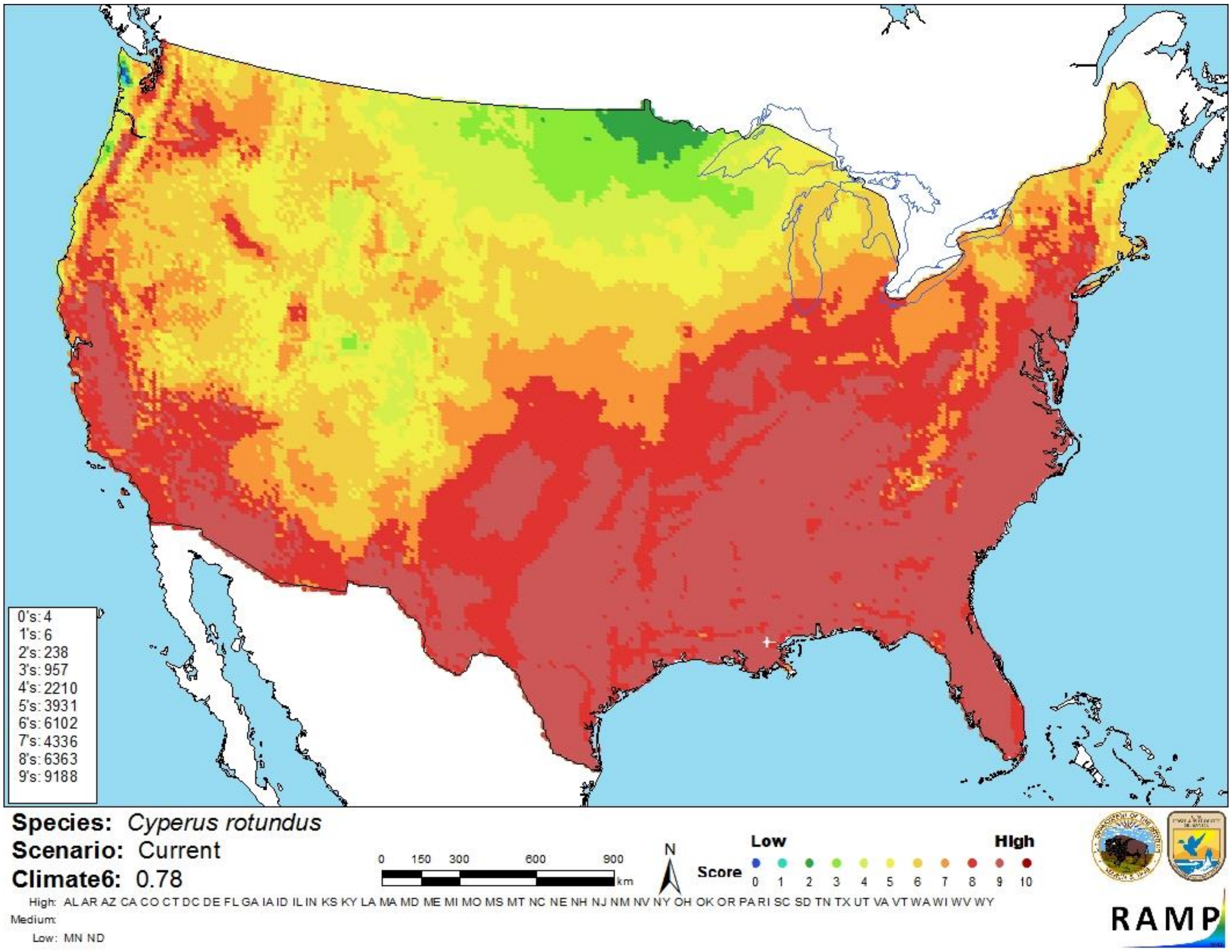

Figure 8. Map of RAMP (Sanders et al. 2014) climate matches for *Cyperus rotundus* in the contiguous United States based on source locations reported by BISON (2018), CABI (2018), EDDMapS (2018), and GBIF Secretariat (2018). 0 = Lowest match, 10 = Highest match. Counts of climate match scores are tabulated on the left.

The High, Medium, and Low Climate match Categories are based on the following table:

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

The certainty of assessment for *Cyperus rotundus* is high. Information on the biology, distribution, invasion history, and impacts of this species is extensive, including substantial peer-reviewed literature. There is ample information available to describe the risks posed by this species.

8 Risk Assessment

Summary of Risk to the Contiguous United States

The history of invasiveness for *Cyperus rotundus* is high. Peer reviewed literature is available discussing the impacts of *C. rotundus* invasions. This species is a significant problem for agricultural efforts in many countries. *C. rotundus* has been spread by humans for medicinal properties for centuries. This species has been repeatedly listed as one of the world's worst weeds and is controlled in some states. The climate match is high. Most of the contiguous United States has a climate that could support the establishment of this species. The certainty of assessment is high. The overall risk assessment category is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks/Important additional information** No additional information.
- **Overall Risk Assessment Category: High**

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