Australia/New Zealand Weed Risk Assessment adapted for United States (see Gordon and Gantz 2008)

Data used for analysis published in: Gordon, D.R., K.J. Tancig, D.A. Onderdonk and C.A. Gantz. In press. Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian weed risk assessment. Biomass and Bioenergy. doi:10.1016/j.biombioe.2010.08.029.

Saccharum arundinaceum -- United States test			
	Question	**Answer**	**Score**
1.01	Is the species highly domesticated?		
1.02	Has the species become naturalised where grown?		
1.03	Does the species have weedy races?	2	
2.01	Species suited to U.S. climates (USDA hardiness zones; 0-low, 1-intermediate, 2-high)	2	
2.02	Quality of climate match data (0-low; 1-intermediate; 2-high)	y	1
2.03	Broad climate suitability (environmental versatility)	y	1
2.04	Native or naturalized in regions with an average of 11-60 inches of annual precipitation	y	
2.05	Does the species have a history of repeated introductions outside its natural range?	n	-2
3.01	Naturalized beyond native range	n	0
3.02	Garden/amenity/disturbance weed	n	0
3.03	Weed of agriculture	n	0
3.04	Environmental weed	y	2
3.05	Congeneric weed	n	0
4.01	Produces spines, thorns or burrs		
4.02	Allelopathic	n	0
4.03	Parasitic	n	-1
4.04	Unpalatable to grazing animals	n	0
4.05	Toxic to animals	y	1
4.06	Host for recognised pests and pathogens	n	0
4.07	Causes allergies or is otherwise toxic to humans		

4.08	Creates a fire hazard in natural ecosystems	?	
4.09	Is a shade tolerant plant at some stage of its life cycle	y	1
4.10	Grows on one or more of the following soil types: alfisols, entisols, or mollisols	n	0
4.11	Climbing or smothering growth habit		
4.12	Forms dense thickets		
5.01	Aquatic	n	0
5.02	Grass	y	1
5.03	Nitrogen fixing woody plant	n	0
5.04	Geophyte		
6.01	Evidence of substantial reproductive failure in native habitat	n	0
6.02	Produces viable seed		
6.03	Hybridizes naturally	?	
6.04	Self-compatible or apomictic		
6.05	Requires specialist pollinators	n	0
6.06	Reproduction by vegetative fragmentation	y	1
6.07	Minimum generative time (years)		
7.01	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)		
7.02	Propagules dispersed intentionally by people	y	1
7.03	Propagules likely to disperse as a produce contaminant	n	-1
7.04	Propagules adapted to wind dispersal	n	-1
7.05	Propagules water dispersed	?	
7.06	Propagules bird dispersed		
7.07	Propagules dispersed by other animals (externally)	n	-1
7.08	Propagules dispersed by other animals (internally)		
8.01	Prolific seed production		
8.02	Evidence that a persistent propagule bank is formed (>1 yr)		
8.03	Well controlled by herbicides		

8.04	Tolerates, or benefits from, mutilation or cultivation	?	
8.05	Effective natural enemies present in U.S.		
Total Score			3

Outcome	Accept*

*Used secondary screen from: Daehler, C. C., J.L. Denslow, S. Ansari, and H. Kuo. 2004. A risk assessment system for screening out harmful invasive pest plants from Hawaii's and other Pacific islands. Conserv. Biol. 18: 360-368.

section	# questions answered	satisfy minimum?
A	11	Yes
B	8	Yes
C	10	Yes
total	29	Yes

Data collected 2008

Question number	Reference	Source data
1.01		Cultivated, but no evidence of selection for reduced weediness.
1.02		
1.03		
2.01	1. PERAL NAPPFAST Global Plant Hardiness (http://www.nappfast.org/Plant_hardiness/NAPPFAST%20Global%20zones/10-year%20climate/PLANT_HARDINESS_10YR%20lgnd.tif). 2. USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network- (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?32602 Accessed June 2, 2008. 3. Xu, Liyu. Vetiver Research and Development: A Decade Experience from China. China Vetiver Network, Nanjing, China. 4. *Saccharum arundinaceum* in Flora of China @ efloras.org. URL:	1. Global plant hardiness zones (4?-)5-13. 2. "Distributional range: Native: Asia-Temperate: China [s.]; Eastern Asia: Japan, Ryukyu Islands [Okinawa], Taiwan; Asia-Tropical: Indian Subcontinent: Bangladesh, India, Sri Lanka; Indo-China: Indochina, Myanmar, Thailand; Malesia: Malaysia, Philippines." 3. "It was recorded that the grass grew well after a severe winter with -15.9°C in winter of 1991 and early 1992 while the trunks and branches of orange trees were completely damaged and local cold tolerant grass Erianthus arundinaceus was also injured to some degree." 4. "S Anhui, Fujian, Gansu, Guangdong, Guangxi, Guizhu, Hainan, Hebei, Henan,Hubei, Jiangxi, Shaanxi, Sichuan, Taiwan, Xizang,

	http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200026230. Accessed July 15, 2008. 5. Gramineae in Flora of Taiwan. URL: http://www.efloras.org/florataxon.aspx?flora_id=1050&taxon_id=242320834. Accessed June 6, 2008. 6. Royal Gardens Kew: GrassBase- *Saccharum arundinaceum* Description. URL: http://www.kew.org/data/grasses-db/www/imp09033.htm. Accessed July 15, 2008.	Yunnan, Zhejiang [Bhutan, India, Indonesia, Laos, Malaysia, Myanmar, Sri Lanka, Thailand, Vietnam]." 5. "Malaysia, the Ryukyus and southern China. Taiwan, a tall reed along rivers."; "Distributed in Malaysia, the Ryukyus and South China." 6. "Distribution: Asia-temperate: China and eastern Asia. Asia-tropical: India, Indo-China, Malesia, and north Indian Ocean."
2.02		
2.03	1. Köppen-Geiger climate map (http://www.hydrol-earth-syst-sci.net/11/1633/2007/hess-11-1633-2007.pdf). 2. USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network- (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?32602 Accessed June 2, 2008. 3. *Saccharum arundinaceum* in Flora of China @ efloras.org. URL: http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200026230. Accessed July 15, 2008. 4. Gramineae in Flora of Taiwan. URL: http://www.efloras.org/florataxon.aspx?flora_id=1050&taxon_id=242320834. Accessed June 6, 2008. 5. Royal Gardens Kew: GrassBase- *Saccharum arundinaceum* Description. URL: http://www.kew.org/data/grasses-db/www/imp09033.htm. Accessed July 15, 2008.	1. Most like three climatic groups and possibly even four. 2. "Distributional range: Native: Asia-Temperate: China; Eastern Asia: Japan, Ryukyu Islands, Taiwan; Asia-Tropical: Indian Subcontinent: Bangladesh, India, Sri Lanka; Indo-China: Indochina, Myanmar, Thailand; Malesia: Malaysia, Philippines." 3. "S Anhui, Fujian, Gansu, Guangdong, Guangxi, Guizhu, Hainan, Hebei, Henan,Hubei, Jiangxi, Shaanxi, Sichuan, Taiwan, Xizang, Yunnan, Zhejiang [Bhutan, India, Indonesia, Laos, Malaysia, Myanmar, Sri Lanka, Thailand, Vietnam]." 4. "Malaysia, the Ryukyus and southern China. Taiwan, a tall reed along rivers."; "Distributed in Malaysia, the Ryukyus and South China." 5. "Distribution: Asia-temperate: China and eastern Asia. Asia-tropical: India, Indo-China, Malesia, and north Indian Ocean."
2.04	1. Climate Source (http://www.climatesource.com/cn/fact_sheets/chinappt_xl.jpg). 2. MSN Encarta (http://encarta.msn.com/encyclopedia_761566679_4/Japan.html). 3. Climate Source (http://www.climatesource.com/tw/fact_sheets/taippt_xl.jpg). 4. Atlapedia Online (http://www.atlapedia.com/online/countries/banglad.htm). 5. Microsoft Encarta World Precipitation and Average Rainfall	1. China (including all of the provinces of south China): For Xizang Province, the average annual precipitation is 2 inches/year -- greater than 196.9 inches/year; For Sichuan Province, the average annual precipitation is 19.7 in/yr -- 78.7 in/yr; For Yunnan Province, the average annual precipitation is 23.6 in/yr -- 196.9 in/yr; For Guangxi Province, the average annual precipitation is 31.5 in/yr -- 196.9 in/yr; For

	(http://uk.encarta.msn.com/encnet/RefPages/RefMedia.aspx?refid=461530746&artrefid=761554737&pn=3&sec=-1). 6. Atlapedia Online (http://www.atlapedia.com/online/countries/srilanka.htm). 7. Atlapedia Online (http://www.atlapedia.com/online/countries/myanmar.htm). 8. Atlapedia Online (http://www.atlapedia.com/online/countries/thailand.htm). 9. Atlapedia Online (http://www.atlapedia.com/online/countries/malaysia.htm). 10. Microsoft Encarta World Precipitation and Average Rainfall (http://uk.encarta.msn.com/encnet/RefPages/RefMedia.aspx?refid=461530746&artrefid=761554737&pn=3&sec=-1).	Guizhou Province, the average annual precipitation is 31.5 in/yr -- 66.9 in/yr; For Hainan Province, the average annual precipitation is 39.4-196.9 inches/year; For Guangdong Province, the average annual precipitation is 55.1 in/yr -- 196.9 in/yr. 2. For Japan: average annual precipitation in Kagoshima [south] is 2,240 mm (88 in). 3. Range for Taiwan is < 1000 mm (39.4 inches) to > 7000 mm (275.6 inches), so try to pinpoint a region of Taiwan. 4. For Bangladesh: the average annual precipitation varies between 1,270 mm and 1,520 mm (50 to 60 inches) depending on the region. 5. For India: average annual precipitation for the entire country ranges from less than 10 to greater than 80 inches, however most of the country falls into the 20-60 inch range. 6. For Sri Lanka: average annual precipitation varies between 1,270 mm and 1,900 mm (50 and 75 inches) on the southeast plains to between 2,540 mm and 5,080 mm (100 and 200 inches) on the southwest plains. 7. For Myanmar: the coastal and high mountain precipitation varies between 2,500 to 5,000 mm (98 to 196 inches) annually with the interior receiving 1,000 mm (39 inches) or less. 8. For Thailand: average annual precipitation varies from 1,020 mm (40 inches) to 2,030 mm (80 inches) depending on the region. 9. For Malaysia: average annual precipitation for West Malaysia is 2,540 mm (100 inches) and for East Malaysia it is 4,420 mm (150 inches). 10. For the Philippines, average annual precipitation is over 80 inches/year.
2.05	1. Darke, R (1999) The Color Encyclopedia of Ornamental Grasses: Sedges, Rushes, Restios, Cat-tails, and Selected Bamboos. Timber Press, Portland, OR. 2. Plant Delights Nursery, Inc. (http://www.plantdelights.com/Catalog/Current/page70.html).	1. beginning to be used ornamentally 2. for sale in online catalog of Plant Delights Nusery
3.01		No evidence
3.02		No evidence

3.03	Holm, L, et al. (1979) A Geographical Atlas of World Weeds. John Wiley and Sons, New York.	*S. arundinaceum* is Present as a weed in India and Vietnam. [Not enough evidence to be considered a weed of agriculture].
3.04		No evidence
3.05	Holm, L, et al. (1979) A Geographical Atlas of World Weeds. John Wiley and Sons, New York.	*S. spontaneum* is a Serious weed in Indonesia, India, and Thailand, and a Principal weed in the Philippines and Puerto Rico. *S. benghalense* is a Principal weed in Bangladesh.
4.01		No description of these traits.
4.02		
4.03		No description of parasitism.
4.04	*Saccharum arundinaceum* in Flora of China @ efloras.org. URL: http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200026230. Accessed July 15, 2008.	"This species is used for forage in China."
4.05	*Saccharum arundinaceum* in Flora of China @ efloras.org. URL: http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200026230. Accessed July 15, 2008.	"This species is used for forage in China." [And no other evidence of toxicity].
4.06	1. Harlapur, SI et al (2007) Saccharum arundinaceaum – a new report of alternative host of turcicum leaf blight of maize. Karnataka Journal of Agricultural Sciences 20: 867-868. 2. Piperidis, G, et al. (2000) Molecular contribution to selection of intergeneric hybrids between sugarcane and the wild species *Erianthus arundinaceus*. Genome. 43: 1033-1037.	1. *S. arundinaceum* was found to be an alternative host of turcicum leaf blight in India. BUT 2. "disease resistance including root rot caused by *Pachymetra chaunorhiza* Croft and Dick."
4.07		No evidence
4.08		
4.09	Darke, R (1999) The Color Encyclopedia of Ornamental Grasses: Sedges, Rushes, Restios, Cat-tails, and Selected Bamboos. Timber Press, Portland, OR.	"Best in full sun."
4.10	1. USDA, National Resources Conservation Services (NRCS), Soil Survey Division,	1. China (these are very approximate estimates): Xizang (S): rocky land with a very

	World Soil Resources (http://soils.usda.gov/use/worldsoils/mapindex/order.html). 2. *Saccharum arundinaceum* in Flora of China @ efloras.org. URL: http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200026230. Accessed July 15, 2008.	small amount of aridisols scattered throughout and a very small amount of gelisols and histisols; Sichuan: entisols, inceptisols, ultisols, rocky land; Yunnan: entisols, inceptisols, ultisols; Guangxi: mostly ultisols with some entisols and a small amount of inceptisols; Guizhou: mostly ultisols with some entisols and a small amount of inceptisols; Hainan: mostly ultisols with some alfisols and small amounts of entisols and inceptisols; Guangdong: mostly ultisols with some entisols and inceptisols and a small amount of alfisols; Japan: Okinawa: entirely ultisols; Taiwan: entisols, inceptisols, and ultisols with a small amount of alfisols (and also a very small amount of rocky land); Bangladesh: mostly ultisols with a small amount of entisols and inceptisols; India: mostly alfisols, inceptisols, and ultisols with some aridisols and entisols and a small amount of mollisols (and also a small amount of shifting sands); Sri Lanka: mostly alfisols with some ultisols and small amounts of inceptisols and entisols (and also a small amount of oxisols); Myanmar (Burma): mostly ultisols with some inceptisols and alfisols and a small amount of entisols (and also a small amount of either aridisols or shifting sands—it is difficult to tell from the map); Thailand: mostly ultisols with some entisols and small amounts of alfisols and inceptisols (and also a very small amount of oxisols); Malaysia: almost entirely ultisols, with very small amounts of alfisols, entisols and inceptisols (and also very small amounts of histisols and oxisols); Philippines: almost entirely ultisols, with small amounts of alfisols, entisols, and inceptisols (and also a small amount of andisols). 2. "Often on sandy soils."
4.11	1. *Gramineae* in Flora of Taiwan. URL: http://www.efloras.org/florataxon.aspx?flora_id=1050&taxon_id=242320834. Accessed June 6, 2008. 2. *Saccharum arundinaceum* in Flora of China @ efloras.org. URL: http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200026230. Accessed July 15, 2008. 3. Royal Gardens Kew:	1. "Tall reed; culm solid, up to 1 cm across, more than 2 m tall."; "Perennials; culms tufted, solid". 2. "Perennial, forming large clumps. Culms robust, (0.7-)1-6 m tall, 1-2 cm in diam., glabrous." 3. "Habit: Perennial; caespitose. Culms erect; robust; 200-400 cm long; 20 mm diam."

	GrassBase- *Saccharum arundinaceum* Description. URL: http://www.kew.org/data/grasses-db/www/imp09033.htm. Accessed July 15, 2008.	
4.12		
5.01		Terrestrial
5.02	USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network- (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?32602 Accessed June 2, 2008.	"Family: *Poaceae*".
5.03	USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network- (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?32602 Accessed June 2, 2008.	"Family: *Poaceae*".
5.04		
6.01		No evidence
6.02		
6.03	Piperidis, G, et al. (2000) Molecular contribution to selection of intergeneric hybrids between sugarcane and the wild species *Erianthus arundinaceus*. Genome. 43: 1033-1037.	"Of 96 crosses made involving female *Saccharum officinarum* or sugarcane cultivars (*Saccharum* spp.) and male *E. arundinaceus*, 26 were fertile producing 1328 seedlings. 37 genuine hybrids were unequivocally identified but only 19 have survived. Genuine hybrids were produced from only three crosses, all involving *S. officinarum* as the female parent...The major limitation in the introgression of *E. arundinaceus* resides now in the apparent sterility of the hybrids." "Indeed, in only a few cases has conclusive evidence of true intergeneric hybrids been documented, and to our knowledge non of the hybrids have produced progeny." "Ninety-six intergeneric crosses between *Saccharum* and *E. arundinaceus* were made during the 1994-1998 crossing periods...and 54 involved pure

		S. officinarum." [These hybrids were not produced in the wild].
6.04		
6.05		This is a grass, so pollen is most likely wind dispersed.
6.06	Wagner, Herbst, and Sohmer (1999) Manual of the flowering plants of Hawai'i. University of Hawai'i Press/Bishop Museum Press, Honolulu.	rhizomatous [genus *Saccharum*]
6.07		
7.01		
7.02	1. Darke, R (1999) The Color Encyclopedia of Ornamental Grasses: Sedges, Rushes, Restios, Cat-tails, and Selected Bamboos. Timber Press, Portland, OR. 2. Plant Delights Nursery, Inc. (http://www.plantdelights.com/Catalog/Current/page70.html).	1. beginning to be used ornamentally 2. for sale in online catalog of Plant Delights Nusery
7.03		No evidence
7.04	*Gramineae* in Flora of Taiwan. URL: http://www.efloras.org/florataxon.aspx?flora_id=1050&taxon_id=242320834. Accessed June 6, 2008.	"Caryopsis oblong or linear-oblong, with a convex back and flat ventral side"; "Caryopsis about 2 mm long, cylindrical". [no evidence of adaptations to wind dispersal].
7.05	Gramineae in Flora of Taiwan. URL: http://www.efloras.org/florataxon.aspx?flora_id=1050&taxon_id=242320834. Accessed June 6, 2008.	"A tall reed growing along rivers."
7.06		
7.07	*Gramineae* in Flora of Taiwan. URL: http://www.efloras.org/florataxon.aspx?flora_id=1050&taxon_id=242320834. Accessed June 6, 2008.	"Caryopsis oblong or linear-oblong, with a convex back and flat ventral side"; "Caryopsis about 2 mm long, cylindrical" [no evidence of adaptations to external dispersal].
7.08		
8.01		
8.02		
8.03		
8.04	Mislevy, P, et al. (1997) Harvest management effects on quantity and quality of *Erianthus* plant morphological components. Biomass and Bioenergy 13 (1/2): 51-58.	"Harvesting *Erianthus* at a height of 1.2 m produced lowest yields for each year and a 4- y average yield of 5.2 Mg/ha. There was a 100% yield reduction and 100% stand loss, because plants died after the second ratoon year."; "Most tall grass species,

		including...*Erianthus*, will not tolerate continuous harvesting at an immature (1.2 m) stage. Plants will survive this type of intense harvest regime for one or two ratoon crops, producing significantly lower DB yields followed by death."
8.05		