

Title: From the Pasture to the Present: the History of Grass Introductions in Hawai‘i¹

Short title: The History of Grass Introductions in Hawai‘i

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Abstract

Before European contact, natural grasslands covered relatively little of Hawai‘i, with a grass flora composed of ~48 species including 40 endemics. Following the proliferation of cattle ranches after the Great *Mahele* (land division) in the 1840s, it was quickly realized that the native grasses were not suitable for high intensity grazing. This sparked the importation of “improved” pasture grasses and set the path toward the contemporary dominance of foreign grasses across Hawai‘i. The importation of foreign grasses for forage accelerated dramatically in the early 1900s with the establishment of the Hawai‘i Agriculture Experiment Station (HAES) on O‘ahu by the United States government. The HAES imported seed, trialed grasses in introduction gardens, and distributed seed to ranchers across the islands. I performed a systematic review of literature produced by the HAES and similar organizations, newspapers, herbarium specimens, and floristic treatments to compile a record for the timeline of grass introductions, provide detailed historical context surrounding the introduction of these grasses, and reassess the status of species of controversial nativity. In total, 577 grasses were introduced post-1778, 158 of which were likely accidental introductions whereas 419 were deliberately imported. There are 232 species of grasses naturalized in Hawai‘i, including 102 deliberately introduced and 130 likely accidental. Deliberate introductions comprise the majority of invasive species which invade natural areas, whereas most accidental introductions are weeds associated with human disturbances. While deliberate introductions largely plateaued after 1970, new accidental introductions and some deliberate introductions with long lag periods continue to naturalize, with 30 newly naturalized grass species recorded between 2000 and 2023.

Background

The grasses (Poaceae) have likely had the largest impact of all introduced plants on the ecology and landscape of the islands of Hawai‘i over the past 200 years. These modern landscape and ecological impacts have been relatively well documented (e.g. Hughes et al. 1991, D’Antonio and Vitousek 1992, D’Antonio et al. 2011). However, the timing and intent

(accidental vs deliberate) with which each grass species was transported to Hawai‘i has never been reviewed, nor has much of the historical context surrounding these introductions. The purpose of this work is to give a detailed history of grasses in Hawai‘i, starting before human arrival on the islands and then focusing on the history surrounding the introductions of grasses across the main islands of Hawai‘i (Hawai‘i to Ni‘ihau) from 1778 to the present day. To this end, a checklist of all grasses which have been introduced after 1778, along with the intent of introduction, naturalization status, and the first year found naturalized, is assembled. The historical context surrounding these introductions along with their modern impacts is also discussed and synthesized.

Taxonomic revision

This work began as I realized that the published information on species composition of the Hawaiian grass flora did not reflect the species I observed across the landscape. For example, *Urochloa glumaris* (Trin.) Veldkamp, a new state record, was widespread at the University of Hawai‘i Mānoa campus, but it had never been collected or identified. Furthermore, many specimens of grasses in the Bishop Museum Herbarium (BISH) that represented new records for Hawai‘i were filed as unidentified material at the genus or family level. Therefore, a critical revision of the non-native Hawaiian grass flora was undertaken.

The majority of the grass specimens at BISH were examined along with the entirety of the Haleakalā National Park (HALE), Hawai‘i Volcanoes National Park (HAVO), Rock Herbarium (HAW), and the National Tropical Botanical Garden (PTBG) herbaria. All photographed material at the US and NY herbaria was examined, and selected specimens were loaned and examined in further detail. The University of Hawai‘i Agronomy Herbarium, formerly the herbarium of the HAES, now incorporated into the BISH collection, was examined and annotated as part of this revision. Specimens were compared to various worldwide grass treatments and monographs to determine what name best applies to each species, with a focus on morphological identification. Genetic analysis was performed for certain species when morphology was equivocal (Faccenda et al. 2024a). New identification keys were also prepared for select genera. The results of this revision and the keys produced were published separately (Faccenda 2022, Faccenda 2023, Faccenda et al. 2024a,b, Faccenda in prep.).

Species are considered naturalized when it is clear a self-sustaining population exists. Historical collections were not considered naturalized if they were collected in the wild more than 60 years ago and if the area of the initial collection was resurveyed recently. Species not meeting the naturalization criteria, principally due to not being seen in the past 60 years, were considered questionably naturalized. While some of these questionably naturalized species are

surely extirpated, I expect further survey effort to find some still persisting. Even with these recent surveys, there simply has not been sufficient botanical study and collecting of grasses in Hawai‘i to determine with confidence whether most questionable naturalizations are actually extirpated.

Critical examination of specimens stored at BISH revealed 40 new species of grasses never before reported as naturalized in Hawai‘i. There were also 144 new island records found (species never reported on a certain island). Furthermore, 22 state-level corrections and 74 island-level corrections were found for species that were previously published erroneously or based on misidentified material. Forty-nine island records were changed to questionable naturalizations as they had no recent collections in the past 50 years.

As no focused effort had been made to collect grasses across the islands since E.Y. Hosaka ceased collecting in the 1950s, roadside grass surveys were conducted on Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Maui, and Hawai‘i with the goal of finding new state and island records. Surveys were conducted along public roads with stops every 1–5 miles for observation of roadside grass flora. Many grasses were collected for the first time during roadside grass surveys by the author, including 20 new state records, and 92 new island records. The surveys confirmed that 5 questionably naturalized species are fully naturalized. See Faccenda (2023) for more details about these surveys.

While many hundreds of hours were spent in the field surveying wild grasses and examining effectively all specimens of grasses held in Hawaiian and major mainland herbaria, the checklist of naturalized grasses reported here is still incomplete. The herbarium record is far from complete as evidenced by 20 new state records identified during the author’s fieldwork. It is certain that more undocumented, naturalized grasses exist across the landscape, especially on the private property of the many ranches. Future field work should focus especially on Hawai‘i Island, where surveys were less complete compared to the other islands.

In total, 232 species of grasses are naturalized among the main Hawaiian Islands. The number may be as high as 273 when questionably naturalized species are included. Including natives, 279 grass species grow wild in Hawai‘i and only 16% of these (48) are native. Grasses are the largest family of naturalized plants in Hawai‘i, making up 16% of the 1466 species naturalized in Hawai‘i (Imada 2019). On the island level, Maui has the most naturalized grass species at 148, with Hawai‘i Island closely following at 147 species. With a new checklist of grasses of Hawai‘i, their histories can now be examined.

Types of introductions

In the context of this study, introduction intent is defined as whether the plant was first introduced to Hawai‘i deliberately or accidentally. An accidental introduction is defined as the movement of a plant or its propagule to Hawai‘i when its movement was not intended by the party which transported it. Examples include but are not limited to seeds contained in hay, packing material, contaminated soil, contaminated seed, or live plants imported as weeds in pots (Table 1). The earliest introduction intent was recorded as the intent for each species. Species with multiple known introductions with different intents are noted in Appendix 1; in most cases, it was not clear which introduction(s) were successful at forming wild populations.

While the accidental vs deliberate dichotomy is simplistic, the lack of available records regarding grass importations do not allow for a more nuanced system to account for the quantity or quality of seed imported. Some deliberate introductions stem from a small packet of seed that rapidly and unintentionally naturalized, whereas for others, large quantities of seed were imported by multiple actors over many years and planted widely across the landscape. Notes are provided in Appendix 1 to provide extra detail regarding introduction intent when available.

Pathway is defined as the specific method or reason that a species was introduced. The Convention of Biological Diversity (CBD 2014, Harrower et al. 2018) introduced a standardized system of classifying human mediated introduction pathways that is commonly used in the literature (e.g Turbelin et al. 2022). However, in this study, these pathways could not be easily applied, and they were extensively modified to fit the unique historical factors involved in the introductions of grasses to Hawai‘i (Table 1).

Table 1. Introduction pathways used in this paper and their associated pathways *sensu* CBD (2014).

This study	This study’s definition	CBD pathway(s)
Deliberate introductions		
Ornamental	Imported for aesthetic purposes in gardens. Includes bamboos.	Botanical gardens / zoo / aquaria; Ornamental; Horticulture
Forage	Imported for use or trial as forage	Agriculture
Cereal	Imported for use as cereal	Agriculture

	grain (wheat, rye, sorghum, etc)	
Accidental introductions		
Seed contaminant	Contaminant of crop / horticultural seed	Seed contaminant
Hay	Seeds within hay bales	Contaminant of plants(?)
Live plants	Propagules / live plants imported in soil of live plants	Contaminant of plants
Ballast / contaminated soil	Solid ballast material used during the age of sail and then dumped, or soil / rock substrate imported deliberately	Other stowaway (CBD pathways not designed for historical pathways like solid ballast material); Transportation of habitat material
Packing material	Straw / other plant parts used as packing	Packing material
Vehicles	Propagules attached or contained within vehicles	Land vehicles; Airplane; Machinery and equipment
Internal / external attachment to livestock	Propagules attached to livestock	Contaminant of animals

Data sources

To determine which species of grasses have been introduced to Hawai‘i but did not naturalize, data were assembled from botanical literature, herbarium specimens, agricultural literature, English language newspapers, the HAES introduction notebook, and nursery catalogs. Species names, naturalization statuses, introduction intents, introduction mechanisms, and introduction dates were compiled from the checklists contained within the following sources: Reichardt (1877), Hillebrand (1888), Heller (1897), McClelland (1915), Hitchcock (1922), St. John and Hosaka (1932), Ripperton et al. (1933), Whitney et al. (1939), Ripperton and Hosaka

(1942), Degener (1946), Neal (1948), Hosaka and Thistle (1954), Rotar (1968), St. John (1973), Nagata (1985), O'Connor (1990), Staples and Herbst (2005), and Clayton and Snow (2010).

Digitized herbarium data were obtained from all herbaria listed above with the exception of HAW, which has not yet digitized its Poaceae collection. Data were also obtained from GBIF (GBIF.org 2023). Plants of the World Online (POWO 2023) was used as the authority to determine which names should be accepted and which should be synonymized. The digitized herbarium data were curated extensively to remove obviously misidentified specimens and erroneous database records, as well as duplicate specimens. Specimens were tagged as cultivated if the label indicated they were cultivated, part of a grass garden, or from the site of one of the Agriculture Experiment Stations such as Pensacola, Poamoho or Makawao. Many misidentified specimens were found in the data from the GBIF. If an image of the specimen was available, the name was corrected based on examination of the photo; otherwise, the record was excluded from analyses.

A corpus of agricultural literature was downloaded from <https://hathitrust.org> (Appendix 2) comprising literature produced by the HAES, Hawai'i Sugar Planters Association, and various agricultural periodicals published in Honolulu. These volumes were loaded into an Elastic Search database using the *elastic* package for R (Chamberlain 2021). Using this database I searched for each grass genus which was found during my review of floristic literature. Searches were also conducted for “new introduction”, “grass garden”, “new grass”, “introduced grass”, etc. Similar searches were completed using the Library of Congress's Chronicling America newspaper database (<https://chroniclingamerica.loc.gov/>). From each article, species names, introduction intent, date of introduction, and naturalization status were recorded. Species were only recorded as deliberate introduction when it was unambiguous that the plant was introduced deliberately. For example, species commonly found as pasture grasses in Hawai'i were not assumed to be deliberate unless a source was found specifically stating that it was imported.

A critical examination was given to references that report species which have no herbarium specimens supporting their occurrence in Hawai'i; through the examination of old determinations on herbarium material, some modern names which apply to these misapplied names were located. For example, the name *Apera interrupta* (L.) P.Beauv. was published by St. John (1973); a specimen identified by the author as *Pentapogon micranthus* (Cav.) P.M.Peterson, Romasch. & Soreng was found bearing an old annotation of *A. interrupta*, indicating that the name was based on a misapplication. The misapplied names encountered in historical literature are reported in Appendix 3.

Many first record dates were also found to have no reasonable reference to support them. For example, the introduction of Hitchcock (1922) states that fieldwork was completed in 1906,

but this was a typographic error, as Hitchcock actually visited Hawai‘i in 1916. Several authors (Whitney et al. 1939, Rotar 1968, St. John 1973) cited a 1906 introduction date for several grasses which were actually first found in Hawai‘i by Hitchcock in 1916. These 1906 dates and similar first record dates of dubious authenticity were excluded from the analysis (Appendix 4).

Determining introduction intent and dates of introductions

Determining the intent of deliberate introductions was straightforward, as many sources were explicit in stating that a species was deliberately imported. However, Rotar (1968) was an exception, as his checklist only states species names and dates of first occurrences. Several grasses that were reported by Rotar (1968) lacked herbarium specimens or were not mentioned by other sources. These grasses were likely introduced by the USDA soil conservation service, as that is the only source listed by Rotar that was not available to the author. When a species was listed in Rotar with a date preceding its appearance in the herbarium record, the year in Rotar was assumed to be the year of deliberate introduction.

All bamboos were recorded as deliberate introductions despite some species lacking explicit reports that they were introduced, as their biology and rare seed production makes an accidental introduction exceedingly unlikely. All species lacking evidence of deliberate introduction were recorded as putatively accidental introductions. However, some were also labeled as “unclear”, as they are well known forage species in other regions of the world. They were likely introduced to Hawai‘i as such, but no records of deliberate introduction could be located.

For grasses imported by the HAES, introduction dates were obtained from the HAES introduction notebook (HAES n.d.). However, not all sources were as straightforward; for some species, the introduction intent was clearly stated by a source, but no date was provided. In these cases, the publication date of the reference was recorded and a “less-than” sign was prefixed to the date to indicate the date is earlier than the date listed. For species that were found to be accidental, the date of introduction was recorded as the date of the first specimen or first literature reference with a less-than (<) sign.

Grasses through time

Prehistory - 1778

Before humans arrived on the islands of Hawai‘i, there were 48 species of grasses growing on the main islands, 40 of which are endemic. These grasses are hypothesized to have originated from 23 initial colonists according to Price and Wagner (2018) but the number is

corrected to 21 based on this research. Most grass colonizations are hypothesized to have arrived with the assistance of birds, either attached to feathers or adhered in mud to legs (Price and Wagner 2018).

Subfossil pollen evidence suggests that grasses were an important part of the vegetation of pre-contact Hawai‘i (e.g. Burney et al. 1995, Hotchkiss and Juvik 1999, Athens et al. 2009), but grass pollen is not identifiable to the genus level, limiting the ecological interpretation of these data. Based on modern observations, it is hypothesized that grasses would have primarily occurred in the understory of tree or shrub dominated landscapes, and grasslands would have been an uncommon to rare ecosystem in the lowlands (Heller 1897, Gagne and Cuddihy 1990, Athens et al. 1992). Any lowland grass dominated ecosystems would have been composed of *kāwelu* (*Eragrostis variabilis* (Gaudich.) Steud.) or *pili* (*Heteropogon contortus* (L.) P.Beauv. ex Roem. & Schult.) being the dominant grasses (Gagne and Cuddihy 1990, Cuddihy and Stone 1990).

The largest grass dominated areas in Hawai‘i likely occurred at Haleakalā or the Saddle Region of Hawai‘i island, where *Deschampsia nubigena* Hillebr., *Eragrostis atropioides* Hillebr., and *Panicum tenuifolium* Hook. & Arn. were dominant members of dry, relatively open plant communities (Gagne and Cuddihy 1990). Carbon isotopes and leaf wax evidence also shows that the lowland leeward areas on the Kohala region of Hawai‘i island and the ‘Ewa Plain on O‘ahu were dominated by C₄ (warm season grass) species, hypothesized to be *Eragrostis*, *Panicum*, and/or *Heteropogon* before human arrival (Chadwick et al. 2007, Uchikawa et al. 2010).

The paleoecology of grasses in Hawai‘i was not static. Grass distributions shifted their ranges based on global climate trends, as shown by the amount of grass pollen at a site fluctuating over multimillennial timescales (Burney et al. 1995). Additionally, during the Last Glacial Maximum, the climate of Hawai‘i was cooler and variably drier (Hotchkiss and Juvik 1999), leading to large increases in grass abundance. It is conceivable that at some points in the deeper past, grass dominated ecosystems may have been more common, especially during drier periods.

When humans first arrived on the islands of Hawai‘i, they brought with them many agricultural and cultural plants (canoe plants) to aid their survival on a new island. Among these were two grasses: *kō* (*Saccharum officinarum* L.) and ‘*ohe*’ (*Schizostachyum glaucifolium* (Rupr.) Munro). It is unclear if *pili* was also introduced as a canoe plant or if it is indigenous. However, it is generally regarded as an indigenous species (O’Connor 1990) due to its pantropical distribution and the ease with which its seeds attach to birds. It is also likely that *kukaepua‘a* (*Digitaria setigera* Roth) was accidentally introduced as a canoe plant by Polynesian voyagers or early Hawaiians (St. John 1978a).

After Polynesian settlement, pond pollen and leaf-wax evidence from lowland O‘ahu shows that grasses generally, and C₄ grasses specifically, expanded across the lowlands (Athens et al. 1992, Burney et al. 2001, Athens 2009, Uchikawa et al. 2010). These grasslands were likely dominated by *Panicum*, *Eragrostis*, and *Heteropogon contortus*. It is almost certain that this change was due to human and Polynesian rat (*Rattus exulans* (Peale, 1848)) disturbances in the lowland forests that led to declines in palms, trees, and shrubs, leaving an empty niche filled by these C₄ grasses rather than a natural change in climate during this period (Athens 2009, Uchikawa et al. 2010). The dominance of *pili* (*Heteropogon contortus*) also increased at this time, as Hawaiians promoted *pili* grasslands using fire in order to harvest the grass for thatching (Gagne and Cuddihy 1990, Cuddihy and Stone 1990).

Post-1778 (Ranching and Cattle)

Domestic ungulates were introduced to the islands immediately after European contact, including sheep and goats in 1778 by Cook and cattle by Vancouver in 1793 (Vancouver 1801, Fischer 2007). Vancouver pressured King Kamehameha to place a *kapu* (ban) on the slaughter of cattle, allowing them to reproduce in the wild (Fischer 2007). By 1810, cattle were present on most islands and more individuals had been introduced (Maly and Wilcox 2000, Barne 2013). By 1851, there were an estimated 20,000–40,000 cattle on the islands (Henke 1929, Schmitt 1977, Anon 1851b). Hawai‘i has no native ungulates, so the introduction of these mammals, especially cattle, had a dramatic impact on the landscape as well as the grass flora of the islands.

These cattle were largely in unmanaged herds that wandered across the islands and were hunted by *haole* (European) hunters and later *paniolo* (Hawaiian cowboys) around 1820 to 1850 (Henke 1929, Wellmon 1969). These wild cattle destroyed crops, wreaking havoc on human settlements (Wellmon 1969, Watson 2002). They also denuded grasslands to the extent that it made repairing *hale* (grass thatched buildings) difficult (Anon 1851a). In many areas, *pā pōhaku* (rock walls) were built to keep cattle away from settlements and agricultural areas, but these were not always effective (Watson 2002, Fischer 2007, Barne 2013).

By the 1830s, private ranches began to appear on the islands (Fischer 2007), and by 1851 they held 8,000 of the 20,000 cattle on Hawai‘i Island (Anon 1851b). The area of land used for cattle further increased following the Great *Māhele* (land division) in 1848, which allowed lands to be held by a single owner. This opened the door for large landholders to start ranches on their lands or on lands leased from the Hawaiian Kingdom (Barne 2013). Parker Ranch, the first permanent ranch with fenced pastures, was established in 1835 as wild cattle began to decline from hunting pressure (Henke 1929, Wellmon 1969). By the 1850s, the ranching industry in

Hawai‘i had shifted largely from hunting cattle owned by the King of Hawai‘i and high ranking kingdom officials to private ranches with more intensely managed herds (Henke 1929).

Up until approximately the 1880s, cattle were grazing principally on the native vegetation of the islands, with the exception of the introduced *mānienie* (*Cynodon dactylon* (L.) Pers.) which was of considerable abundance and grazing importance in the lowlands (Hillebrand 1888). The native species of Hawai‘i, however, were not adapted to heavy grazing, leading to the denudation of areas formerly dominated by native species vulnerable to grazing, the growth of less palatable species, and massive erosion issues (Anon 1846, Zschokke 1931, Hanson 1952, Cran and Dillingham 1992). Cattle also caused deforestation, as trampling and grazing were principally responsible for the loss of extensive forest in Waimea, Hawai‘i (Fischer 2007). The sandalwood trade, occurring between 1815–1826, also led to deforestation (St. John 1947) and a probable increase in grasses across the Hawaiian landscape, but it is unclear how significant this was compared to deforestation by cattle.

Between the 1880s and 1910s, individual ranch managers worked to import and spread foreign grasses across their paddocks with the goal of increasing grass cover and concomitantly, the number and quality of cattle they could raise (Anon 1889, Munro 1905:22). By 1904, multiple ranchers engaged in a concerted effort to introduce and trial so-called “improved forage grasses” (Munro 1905)— principally species that evolved under grazing pressure by ungulates. This effort focused on species which could grow in dry areas, and was undertaken in conjunction with the Hawai‘i Agricultural Experiment Station (Smith 1904). This focus on improvement such as “improved grasses” is a common theme associated with colonization where the land itself was modified to establish more efficient (profitable) agricultural systems, as opposed to modifying the agricultural system to suit the land. This reflects a broader pattern of imposing foreign agricultural and economic practices and priorities on indigenous lands (Fisher 2015).

Land area used as pasture generally increased during the 20th century, up to its approximate peak in around 1986, with 26% of the 4.1 million acres of Hawai‘i used for pasture (Hugh et al. 1986); most of these lands were planted with imported pasture grasses. Pastures are still a major land use across the islands, with 765,000 acres used for grazing in 2020. This amounts to 86% of the active agricultural land of the state or 18% of the total land area (Perroy and Collier 2020).

Hawai‘i Agriculture Experiment Station

In 1901, the Hawai‘i Agricultural Experiment Station (HAES) was established at Honolulu, O‘ahu by the United States federal government with the stated purpose “to conduct original researches and verify experiments” (HAES 1951:6), but were not permitted to do

research on sugarcane (Overfield 1986). The HAES aimed to improve and diversify agriculture in the territory by assisting smallholder farmers with agricultural issues using a scientific approach (Smith 1902). Research by the HAES included work on fertilizers, soils, new crops, forage grasses, pests and diseases, product distribution and packaging, and other topics relevant to agriculture.

Wang (2020) summarized the political motivation driving the creation of the HAES by government officials in Washington, DC as “[an] explicitly stated project of Americanization that sought to break Hawaiian dependence on sugar and plantation agriculture, expand small farming, and remake the islands’ racial order through white settlement from the mainland”. The work of the HAES did not break Hawai‘i’s dependence on plantation agriculture, and its ultimate impact on the demography of Hawai‘i is unclear. Nonetheless, the new plants and techniques HAES developed for the islands had a significant impact on agriculture.

The HAES proceeded to import many varieties of domesticated fruits and vegetables, cereals, forage legumes, and forage grasses to experimentally determine which grew well in Hawai‘i. The HAES kept an "introduction notebook" of all plants they imported, which lists species and variety identifications, dates, accession numbers from the plant senders, quantity of material received, plant origins, and occasional notes about the plantings. This notebook includes 6066 accessions of plants imported between 1906 to 1966 (HAES n.d).

Pasture grasses imported by the HAES were planted at several “grass gardens” across the islands— principally the Poamoho farm (Waialua, O‘ahu), Pensacola St. Station (Honolulu, O‘ahu), and Haleakalā substation (Makawao, Maui)— to test the plants across a wide climatic range and see which grew favorably (HAES 1939). At its peak, the Pensacola Station gardens trialed up to 135 species of grasses (HAES 1939). Those grasses which showed success in the trial gardens were distributed to ranches across the islands and planted widely. There was minimal effort made by the HAES to breed or hybridize forage grasses, meaning most grasses distributed by the HAES were usually wild type (Ripperton 1948), although there were efforts to trial multiple accessions of a species and release the ones most adapted to local conditions.

The HAES also worked to expand pasture lands across the islands. With the advent of mechanized clearing, bulldozers were used to clear higher elevation forest, making room for further “improved” pastures (HAES 1951, Greenwell 1959). The HAES was actively involved in research into clearing forests and brushlands and replacing them with improved pasture (e.g. Motooka et al. 1967).

In 1929, the HAES merged with the agriculture program at the University of Hawai‘i, located in Mānoa, and in 1978 the combined program was renamed the College of Tropical Agriculture and Human Resources (CTAHR; HAES 1951, Brennan and Hollyer 2008). After the

1970s, there has been relatively little experimentation by CTAHR with new imported pasture grasses, although some work has focused on improving existing pasture species, especially at the Mealani research station at Waimea, Hawai‘i.

Sugar cane

Discussion of the history of grass introductions in Hawai‘i would hardly be complete without mention of sugar cane due to the sugar plantation’s massive impact on the development, culture, and economy of islands. Its history will only be briefly summarized as it has been well-documented compared to all other grasses (e.g. Cushing 1985, Allan and Osgood 2015). Sugar plantations began their rise in the 1830s (Cushing 1985), initially using Hawaiian varieties of cane which originated from Polynesian introductions. In 1854, the first cuttings of foreign cane were imported for breeding material (Mangelsdorf 1950, Osgood and Wiemer 1992), and importation of new types of cane continued. By the 1900s, sugar cane plantations dominated the lowland landscape of Hawai‘i, eventually stabilizing at between 210–250 thousand acres of land used for sugar cultivation between 1910 and 1968 (HSPA 1969).

The Hawai‘i Sugar Planters’ Association (HSPA) was a non-profit formed and funded by the 25 plantations across the islands of Hawai‘i and tasked with the “maintenance, advancement and protection of the sugar industry in Hawai‘i” (HPSA 1969:18). One of the principal operations of the HSPA was an experiment station that worked on pests and diseases, had an active breeding program for development of new cultivars of cane, and introduced many new varieties of cane (Chang 1970). Several species of wild sugar cane relatives were imported for breeding purposes (Osgood and Wiemer 1992), but ultimately the sugar cane industry had a much smaller legacy on the Hawaiian grass flora as sugarcane tends not to persist long outside of cultivation. Furthermore, unlike many forage grasses, sugarcane is not grown from seeds, so it is unlikely that many weedy grass seeds were accidentally introduced in association with the sugarcane industry.

The sugar industry in Hawai‘i is now defunct. Its collapse began in the 1980s, and the last mill closed in 2016. Some former sugar cane land is either still used for farming or has been converted into solar arrays or housing; however, much of this former cane land has been abandoned and natural regeneration has turned it into grassland or forest.

Introduction eras

The history of post-European grass introductions in Hawai‘i can largely be broken down into three periods: pre-HAES (1778–1900), HAES (1901–1978), and post-HAES (1979–present). In 1978, the HAES was integrated into the University of Hawai‘i at Manoa’s

agricultural college, later CTAHR, but interest in forage grasses introductions within the HAES stalled by 1966 (Figure 1c), making the end of the HAES era unclearly defined. These eras approximately correlate with the Hawaiian Kingdom, territorial, and statehood periods of Hawaiian history, but comparisons to broader Hawai‘i politics are beyond the scope of this work. The number of introductions tallied below exclude bamboos.

The pre-HAES period was characterized by a low rate of deliberate introductions at 0.2 per year, or 50 species total. The number of deliberate introductions was initially very low but began to accelerate in the 1870s (Figure 1c). Accidental introductions were relatively consistent over time at 0.2 per year and 23 species in total. There were also few herbarium specimens of introduced grasses made during this period, averaging 3 per year. However, this number underestimates the collecting effort as Hillebrand’s specimens were destroyed and thus cannot be tallied. The majority of native grasses were first collected and described during this period.

The HAES era was characterized by a much higher rate of deliberate introductions at 3.6 per year, or 277 species introduced total. Accidental introductions appeared at 1.1 per year. Focus by the HAES on importation of forage grasses was not consistent over time, as 1910–1920 and 1935–1940 accounted for most of the station’s grass introductions along with another brief resurgence of interest in tropical forages in 1964–1966. During the HAES period, the rate of grass herbarium specimens being made increased dramatically, to 109 per year (Figure 1a).

As the HAES began its decline into the present day, its rate of deliberate introductions decreased substantially, with only 13 species (0.3 per year) being introduced between 1979–2023. In contrast, the rate of accidental introductions (1.1 per year) hardly changed, and the rate of collection of herbarium specimens of grasses (133 per year) increased. The rate of collection of herbarium specimens of grasses did, however, begin to decline around 2005, but increased collecting effort between 2020–2024 during this project offset the decline (Figure 1a).

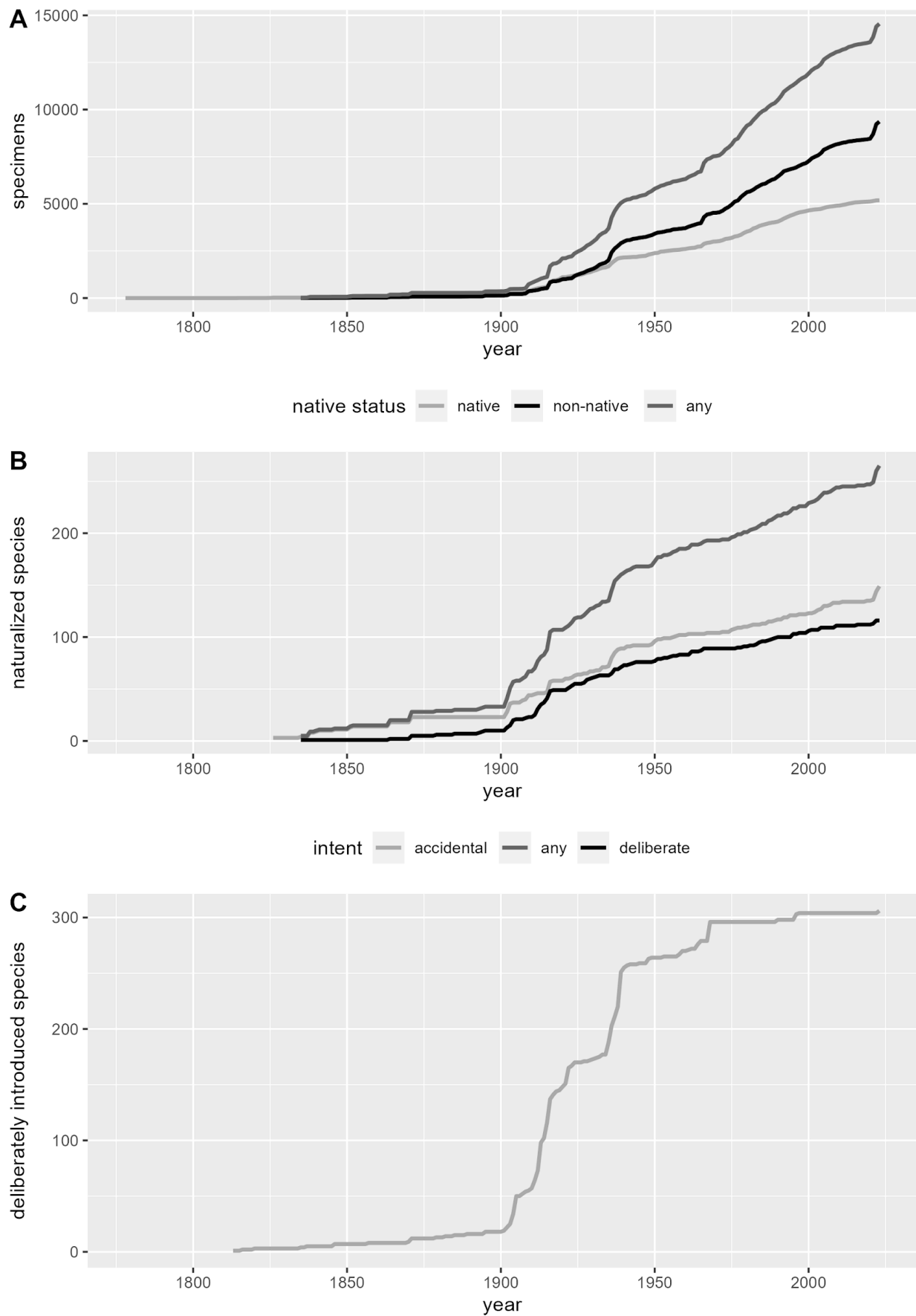


Figure 1. **A.** Number of herbarium specimens of grasses collected in Hawai'i over time by nativity status. This includes specimens of plants in cultivation. Duplicate collections from the

same collection event were removed. **B.** Number of naturalized grasses over time based on first recorded date of naturalization. **C.** Number of deliberately introduced forage grasses over time in Hawai‘i. This includes all species which have evidence of deliberate introduction, regardless of whether the plants naturalized or were only found in cultivation.

History of the study of grasses in Hawai‘i

The history of the study of grasses in Hawai‘i provides important context for understanding patterns of grass introductions as effectively all accidental arrivals were only discovered after wild populations were found by trained botanists. As botanical effort has varied dramatically throughout time, the lag period between arrival of a new weed and its first documentation has not been consistent.

Between 1778 and the 1850s, documented botanical exploration in Hawai‘i was conducted by botanists who visited only briefly during voyages, rarely staying longer than two weeks and making general collections. No collectors during this period had a special focus on grasses (Wagner et al. 1990). William Hillebrand was the first botanist to systematically collect grasses across the islands between 1851 and 1871 and was the first to publish a complete list of all grasses that occur in Hawai‘i (Hillebrand 1888). Unfortunately, there were many errors in Hillebrand’s grass checklist, and almost all of Hillebrand’s specimens were destroyed in the bombing of the Berlin herbarium during WWII (Hiepko 1987), making it unclear what species most of his misapplied names actually represent. Overlapping in time with Hillebrand was Horace Mann, Jr. and William Tufts Brigham who lived in Hawai‘i for several years and made many important collections of grasses in 1864 and 1865.

Beginning in 1899, the first herbarium specimens of grasses were made by local botanists, correlating with the founding of herbaria at the HAES, College of Hawai‘i, and the Bishop Museum at approximately that time. The Bishop Museum Herbarium was founded with the purchase of specimens from W.T. Brigham in 1894, but an active collecting program was not started until 1909 when Charles N. Forbes was hired as the museum’s first botanist. At the same time Joseph A. Rock also began work collecting plants for the Territorial Board of Forestry and Agriculture and also collected many grasses. No botanists affiliated with the College of Hawai‘i nor the Bishop Museum ever specialized in grasses, so many new naturalizations collected at this time were identified and published by later workers.

In 1916, the distinguished agrostologist Alfred S. Hitchcock (US National Herbarium, Smithsonian Institution) visited the islands for four months, collecting grasses on all islands except Ni‘ihau and Kaho‘olawe. He published a grass flora of Hawai‘i that was exceptionally complete for its time (Hitchcock 1922). This work was a major influence on future botanists in

Hawai‘i and formed the backbone of many subsequent grass floristic treatments. Hitchcock’s mission, besides basic scientific study, was also to find grasses to support livestock production on the islands (Anon 1916c).

The HAES established its own herbarium soon after its founding in 1901, but collecting effort was minimal for the first 30 years, with only 160 specimens being made during that period. Collecting effort increased dramatically between 1935–1945 when Edward Y. Hosaka and Leo D. Whitney collected over 500 specimens of naturalized grasses. After this burst of activity, collecting effort dwindled again with only 140 specimens being collected between 1946 and 1967 when the last specimen was deposited in the HAES herbarium. Despite the little collecting done in the early days of the HAES, much attention was given to the study of wild grasses. Two major grass works were completed during this period, documenting many new naturalizations and reporting species of grasses that were imported as forage grasses (McClelland 1915, Ripperton et al. 1933). Further work by Whitney et al. (1939) documented even more naturalized grasses.

The last major grass focused publication by the HAES was *The Grasses of Hawai‘i* by Rotar (1968), but this was of lower value compared to the prior works; it includes no identification keys to species level, and only presents one list of all grasses including species which are naturalized, cultivated, or have been trialed in experimental gardens with no indication of which category applied to each species. The appendix provides the earliest dates of occurrence in the published literature for 128 species of grasses. Of these, 99 share the same date with the HAES notebook (HAES n.d). Of the remaining 29 species, four more are supported by a cultivated herbarium specimen, 21 have no associated herbarium specimen, and four are supported by a naturalized specimen collected only after 1968.

Other prolific mid-century botanists including Harold St. John and Otto and Issa Degener did collect grasses, but were not particularly skilled in their identification. For example, Degener and Degener (1946) only treated a minority of the grasses naturalized at the time and published no new naturalizations, despite collecting several. In St. John’s (1973) seminal *List and summary of the flowering plants in the Hawaiian Islands*, the list of grasses is an almost verbatim copy of Rotar’s (1968) list with the grasses poorly annotated as to which are naturalized.

As part of the Manual of Flowering Plants of Hawai‘i project, O’Connor (1990) prepared the first new taxonomic treatment of the Hawaiian grass flora in 50 years. This treatment was quite acceptable in the taxonomy of the included species, but O’Connor failed to examine much of the undetermined material in the BISH herbarium, leading to many species which were both naturalized and collected at the time being excluded from the treatment. In 1996, world renowned agrostologist William D. Clayton visited the Bishop Museum herbarium and over

eight weeks examined the entirety of the Hawaiian grass collection and much of the Pacific collection as well (Herbst and Clayton 1998).

Subsequent work by Neil Snow found more new naturalizations in the Bishop Museum Collection (Snow 2008, Snow and Lau 2010, Snow and Davidse 2011) and concluded with the publication of the most modern grass treatment for Hawai‘i in *A Key to Pacific Grasses* (Clayton and Snow 2010). Unfortunately, neither W.D. Clayton nor N. Snow collected grasses on the islands. Between the 1990s and present day, grasses were continued to be collected by many local botanists including Tim Flynn, Derral Herbst, Bob Hobdy, Hank Oppenheimer, Forest and Kim Starr, Ken Wood, and assorted staff of the Army Natural Resources Program on O‘ahu in a largely opportunistic manner.

Species of controversial nativity

Several grasses have been claimed to be post-Cook introductions but are likely indigenous to the Hawaiian Islands or were introduced accidentally by the early Hawaiians. Many species of European accidental introduction are described as native by Hillebrand (1888), but no discussion is given to these species as subsequent authors have since corrected Hillebrand.

Kūkaepua‘a (Digitaria setigera)

Kūkaepua‘a is certainly not of European introduction as suggested by Hitchcock (1922). It was first recorded on the islands in 1779 (St. John 1978a). It is unlikely that this species is indigenous as it is not found in undisturbed native habitat and was considered a weed of disturbed areas, even by the pre-contact Hawaiians; its name translates to “pig feces”, describing its habit of growing around pig pens. *Digitaria setigera* is also found throughout the South Pacific and was likely accidentally carried by the Polynesians with the movement of soil during their oceanic voyages (Degener and Degener 1962, Nagata 1985, Wester 1992). *Kūkaepua‘a* has cultural significance and is considered a *kino lau* for *Kamapua‘a* (Degener and Degener 1962).

Pilipili‘ula (Chrysopogon aciculatus (Retz.) Trin.)

Some authors suggest that *pilipili‘ula* or *mānienie‘ula* was introduced post-1778, with the only evidence seemingly being its weedy habit (Hitchcock 1922, St. John 1973, Nagata 1985, Wester 1992). However, it is more likely that this grass is indigenous to Hawai‘i. It was first collected on O‘ahu in 1825 (St. John 1978b) and again in 1826 (Hooker and Arnott 1841). Such an early date suggests its nativity. G.C. Munro considered this grass native in 1903 (Munro 54 BISH), as did Whitney et al. (1939), two botanists who traveled across the islands and were the most knowledgeable of the grasses of Hawai‘i at that period. Furthermore, *pilipili‘ula* occurs

throughout the south Pacific (Gardner 2007, Gardner 2020, Lorence and Wagner 2019) and was recorded in Tahiti during Cook's first voyage (Gardner 2007), showing that this grass is of pre-European origin in Polynesia. Whistler (2022) considered this an accidental polynesian introduction to Sāmoa, and it is possible this was also the case in Hawai'i.

Mau'u laiki (Paspalum scrobiculatum L.)

The history of *mau'u laiki* in Hawai'i is the most unclear of all the potentially indigenous grasses. It was deemed a post-European introduction by several authors, largely on the basis of its weedy habit (Hitchcock 1915, Henke 1929, Wester 1992). However, *mau'u laiki* has also been considered indigenous or of Polynesian introduction (Degener and Whitney 1938, Whitney et al. 1939). For example, Whitney et al. (1939) describe it as abundant in native pastures on all islands. It was also used by the Hawaiians for thatching *hale* when the favored *pili* grass was not available (Hillebrand 1888). O'Connor (1990) treated this as a questionably indigenous species based on this conflicting evidence.

Mau'u laiki was first collected on O'ahu in 1851 (Remy 103 BISH), surprisingly late for a rather conspicuous lowland species. After this first collection, several other collections were made in the 1850s and 60s by others on O'ahu which may indicate that it expanded rapidly. A newspaper report by Rice (1915) also reports that *mau'u laiki* did not arrive in Līhu'e until at least 1865. Its weedy habit cannot be ignored, this grass is found almost entirely near trails and other disturbed areas but not in undisturbed native vegetation. McClellan (1915) states that *P. scrobiculatum* was gathered frequently for use as a packing material on Hawai'i, providing a feasible introduction pathway if it was similarly gathered in other regions.

The Hawaiian name *mau'u laiki* translates to "rice grass", a widely used English name for this species. The name *mau'u laiki* was used as early as 1895 (Judd 1895). This linguistic evidence also supports a post-European introduction of this grass given that *laiki* is a Hawaiianization of the English word "rice" (Andrews 1865). No other Hawaiian names for this grass are known, although it is possible they existed but were lost. *Mau'u laiki* is certainly of pre-European origin in Polynesia as it was found in 1773 during Cook's second voyage in Tonga (Fosberg et al. 2003) and French Polynesia (de Koning and Sosef 1985) and is considered indigenous in Sāmoa (Whistler 2022). This biogeographical evidence suggests that the species may be indigenous to Hawaii. However, based on the evidence available, it is most likely that this grass is a post-European introduction, but a pre-European introduction cannot be excluded.

Deliberate introductions

Cereal grasses

Cereal grasses were the first post-European deliberate grass introductions. The first two documented were both imported by Don Francisco de Paula Marín, with maize (*Zea mays* L.) introduced by 1813 (Gast 1973:209) and rice (*Oryza sativa* L.) introduced in 1816 (Nagata 1985). Wheat (*Triticum aestivum* L.) was likely introduced in the 1820s and established by 1840 (Wilkes 1845:268). An introduction date of 1792 for wheat also appears in some sources (e.g. Whitney et al. 1939, Rotar 1968, St. John 1973), but the absence of wheat in Vancouver's journal suggests that this is incorrect (Nagata 1985). The introduction date for oats (*Avena sativa* L.) is unclear but was before 1846, likely well before, given the utility of this plant (Anon 1846). Sorghum (*Sorghum bicolor* L. Moench subsp. *bicolor*) was introduced relatively late by Hillebrand in 1856 (Hillebrand 1857). In total, 15 species of cereal grasses were introduced to Hawai'i.

Ornamental grasses

In the context of this work, an ornamental is defined as a species grown principally for aesthetic use in gardens. Bamboos are also considered ornamental grasses in this work as they are largely cultivated as ornamentals in Hawai'i, although bamboos are certainly also cultivated for use as building material. Most turf grasses were not considered ornamental as most were imported for pasture use first and turf use secondarily. *Zoysia* species are the only exception to this rule and are considered an ornamental due to their low pasture value.

Many ornamental grasses have been imported to the Hawaiian Islands, but few references exist regarding cultivated grasses in Hawai'i and their importation. Much information about non-bamboo ornamental grasses came from herbarium specimens. A checklist of bamboos was compiled using the list of species in Bezona and Rauch (1997) along with both herbarium data and online catalogs of local bamboo nurseries including Hawai'i Tropical Plants Nursery in Kea'au Hawai'i; O'ahu Bamboo Nursery in Waialua, O'ahu; Quindembo Bamboo in Kapa'au, Hawai'i; and Whispering Winds Bamboo Nursery, in Kīpahulu Maui. Data were also included from an unpublished checklist of plants cultivated in botanical gardens (Imada et al. 1996). The Quindembo Nursery on Hawai'i island is notable as they were the first to import many species of bamboo now found in cultivation. This checklist of ornamentals was not extensively curated in the same way as the rest of the grass data, as only a minority of bamboo species listed in these catalogs have herbarium specimens, making curation impossible and misidentifications likely.

For most ornamental grasses, the date and context of their importation to Hawai‘i are unknown; as such, their introduction dates are likely earlier than reported in Appendix 1. Most of the first occurrences of ornamentals are from herbarium material or checklists made well after the species were imported. This is especially true of bamboos, as little information exists regarding their earliest dates of introduction. Many species of bamboos have an introduction year of 2022, the year when data was retrieved from nursery catalogs, as no earlier dates were found (Appendix 1). The list of ornamental grasses assembled here is certainly incomplete, as during the preparation of this manuscript *Muhlenbergia sericea* (Michx.) P.M.Peterson, previously not known to be cultivated in Hawai‘i, was observed on Maui (Danielle Frohlich pers. comm). New ornamental grasses such as this are surely being introduced, with mail-order seed being a major pathway.

In total, 118 ornamentals have been introduced to Hawai‘i. Bamboos dominate this list, at 91 species, however, only two bamboos have naturalized compared to 10 of the 26 non-bamboo ornamentals which have naturalized. Worldwide, introductions of ornamental plants currently pose one of the largest sources of invasive species (Beaury et al. 2021, Lehan et al. 2013). But this is not the case with grasses in Hawai‘i as ornamentals only make up only 5% of the naturalized grass flora, likely due to the low rate of bamboo naturalizations in Hawai‘i and relatively low interest in non-bamboo ornamental grasses among horticulturalists. This low rate is not unique, as most bamboo introductions globally tend not to become invasive (Canavan et al. 2017). However, it must be noted that bamboos flower infrequently, and this long generation time will increase the lag period before naturalization. Some introduced bamboos may be sleeper weeds (Groves 1999), and others may show signs of naturalization in the future if climate change is advantageous for them.

In Hawai‘i, five grasses introduced as ornamentals have become invasive including giant reed (*Arundo donax*), fountain grass (*Cenchrus setaceus* (Forssk.) Morrone), pampas grass (*Cortaderia selloana* (Schult. & Schult.f.) Asch. & Graebn.), *Cortaderia jubata* (Lemoine) Stapf, and black bamboo (*Phyllostachys nigra* (Lodd. ex Lindl.) Munro var. *henionis* (Mitford) Rendle) (Mike Ade pers. comm., Cordell and Sandquist 2008). While these weeds have generally had a lower environmental impact than pasture grasses, species such as fountain grass have formed pure monocultures and extensively modified habitats on Hawai‘i island. If it were not for active eradication campaigns by the Maui Invasive Species Committee and Big Island Invasive Species Committee, *Arundo donax* and *Cortaderia spp.* may have had similar effects.

Forage grasses

In total, 302 forage grasses were imported to Hawai‘i; the majority of these did not establish wild populations, as only 89 of these naturalized, and 18 are questionably naturalized. The first forage grass with evidence of deliberate introduction was mānieie (*Cynodon dactylon*) in about 1835 (see Histories of selected notable grasses). Between 1835 and the 1870s, there were evidently few forage grass introductions as there was no concept of “improved pasture” and little interest in new grass introductions among ranchers and agriculturalists. The second deliberate introduction was an unidentified grass described as having “rapid propagation and luxuriant growth” (Anon 1850). It is likely the grass did not establish, or was a repeat introduction of *Cynodon dactylon*, as no other reports mention it and no perennial forage grasses appeared in the herbarium record at the time or in the newspapers.

Beginning in the 1870s, individual ranch managers began to import forage grasses (Appendix 1). Many C₃ (cool season) European pasture grasses were imported as they were the only species available from American or European merchants. Due to their C₃ biology, these grasses could only grow above approximately 3000 feet leading to limited impacts of these species in the lowlands. The spread of these European grasses was dramatic toward the end of the century, especially at higher elevations. L.A. Thurston recounts the changes he saw over the just 10 years:

“On the western portion of Mauna Kea there is blue grass [*Poa pratensis* L.] and on the Hilo slopes other grasses [...] On the slopes of Haleakalā [...] a complete revolution has taken place [...] There is a very heavy growth of blue grass coming in [...] white clover and soft meadow grass [*Holcus lanatus* L.] are spreading [...] so that since my boyhood I have never seen such a growth of herbage on Haleakalā as now” (Judd 1904:28).

Cool season species imported during this period included creeping bent grass (*Agrostis stolonifera* L.), tall oat grass (*Arrhenatherum elatius* (L.) P.Beauv. ex J.Presl & C.Presl), rescue grass (*Bromus catharticus* Vahl), orchard grass / cocksfoot (*Dactylis glomerata* L.), tall fescue (*Lolium arundinaceum* (Schreb.) Darbysh.), Kentucky blue grass (*Poa pratensis*), and velvet grass (called mesquite at the time; *Holcus lanatus*). Some notable warm season forage grasses were also introduced by the ranchers between the 1870s and 1900 including Natal red top (*Melinis repens* (Willd.) Zizka), Johnson grass (*Sorghum halepense* (L.) Pers.), Sudan grass (*Sorghum bicolor* (L.) Moench subsp. × *drummondii* (Nees ex Steud.) de Wet ex Davidse), and Guinea grass (*Urochloa maxima*).

Between 1904 and 1906, in the first years of HAES, Jared Smith, the special agent in charge of the station, was already working to import improved forage grasses with the Hawai‘i Livestock Breeders Association (HLBA). In a meeting with the HLBA, Jared Smith stated:

“I think that the introduction of new forage plants, of new range plants, new grasses and clovers, is one of the very best lines of work to be undertaken [...] Take mānienie; it is best at certain seasons of the year. In summer time, especially in a dry summer, the feed which it affords is very poor. If you could get good grasses to grow with the mānienie—and I believe there are such—it would help out during dry seasons, or would give feed at a time when these two dominant pasture grasses [the other being Hilo grass] are not in their best condition, I believe that you could grow cattle cheaper, that you could raise better cattle” (Judd 1904:25).

Ten new grasses from the Southwestern United States were imported by J. Smith the following year and, of those grasses, only *Bothriochloa barbinodis* (Lag.) Herter persisted to the present.

Around 1910, the HAES took over importing and trailing new species of grasses. Few, if any, ranchers were importing grasses that had not already been trialed by the HAES in a grass garden. This ended the era from 1870 to that point where ranch managers were the dominant actor for forage grass importations, consolidating importation records to one agency which kept detailed notes of grass introductions. This consolidation of records helps give confidence that almost all deliberate introductions are correctly identified as such. In total, 1863 accessions representing 267 species were trialed by the HAES for forage purposes. Approximately 67 still persist today across the landscape.

The HAES grass introductions which seem to be most successful for forage purposes were kikuyu (*Cenchrus clandestinus* (Hochst. ex Chiov.) Morrone), pangola (*Digitaria eriantha* Steud), buffelgrass (*Cenchrus ciliaris* L.), Dallis grass (*Paspalum dilatatum* Poir.), and California grass (*Urochloa mutica* (Forssk.) T.Q.Nguyen) (Asem-Hiablíe et al. 2018). Numerous accessions of Guinea grass (*Urochloa maxima*) were also imported by the HAES, but they were not the first to bring the grass to Hawai‘i (see Histories of selected notable grasses). The HAES was also directly responsible for the first importation of many grasses that are now major environmental weeds in Hawai‘i, including narrow leaf carpet grass (*Axonopus fissifolius* (Raddi) Kuhl.), buffelgrass, kikuyu, sourgrass (*Digitaria insularis* (L.) Mez ex Ekman), *Digitaria scalarum* (Schweinf.) Chiov., molasses grass (*Melinis minutiflora* P.Beauv.), and California grass (HAES n.d.).

Legacy of forage grasses

The ecological legacy of the importation of forage grasses can hardly be understated; these grasses are dominant across the landscape, from managed pasture, to abandoned lands, to conservation land: 17–42% of the land of Hawai‘i is currently dominated by grasslands (Jacobi et al. 2017, Lucas 2017). Furthermore, approximately 50% of the land area of the Hawaiian

Islands was at one time converted to grass dominated landscapes (Gagne and Cuddihy 1990). These grasslands have replaced forest or shrublands, with the dry forest communities being among the most strongly affected (Litton et al. 2006, Medeiros et al. 2014). These foreign grasses have not been conclusively linked to any extinctions, but they are listed as threats to many endangered species through competition for resources and promotion of fire (Trauernicht et al. 2018, Rønsted et al. 2022).

Impacts of these grasses on native ecosystems include, but are not limited to, the fire-mediated transition from woodland to savannah (Smith and Tunison 1992, D’Antonio and Vitousek 1992); alterations to hydrology (Mueller-Dombois 1973); displacement of native species through burning (Hughes et al. 1991); modification of nitrogen cycling through burning (D’Antonio and Vitousek 1992); and direct competition with native plants (Soti and Thomas 2022).

Across the tropics, introduced forage grasses have had disastrous ecological consequences, perhaps because, as Overholt and Franck (2017:260) have noted: “The traits associated with value as forage in grasses are also traits that predispose the grasses to invasiveness”. These traits of value for forage grasses, as defined by HAES agronomists, include: herbivory resistance, wide environmental tolerance, drought tolerance, high fecundity, and competitive ability (Hosaka and Goodell 1954, Hosaka and Carlson 1957, Hosaka 1958, Cran and Dillingham 1992). These traits are all associated with invasive species (Daehler 2003, Catford et al. 2009), but are not uniformly present among all invasive species.

Among invasive tropical grasses, forage grasses of African origin are especially invasive compared to species from other regions (Visser et al. 2016, Overholt and Franck 2017). In Hawai‘i, the widespread African grasses include *Cenchrus ciliaris*, *Cenchrus clandestinus*, *Cenchrus setaceus*, *Hyparrhenia rufa* (Nees) Stapf, *Melinis minutiflora*, *Melinis repens*, *Urochloa mutica*, and *Urochloa maxima*. Hawai‘i is far from the only region impacted heavily by deliberately introduced African forage grasses, as impacts have been well-documented in Florida (Overholt and Franck 2017), Australia (Lonsdale 1994), and South America, where the spread of these grasses was termed the “Africanization of the grasslands” (Parsons 1972, Mack and Lonsdale 2001).

The introduction of pasture grasses, both in Hawai‘i and worldwide, was a colonial enterprise. Outside of Hawai‘i most major colonial powers including England, France, Spain, Portugal, and the Netherlands also operated systems to introduce new plants to their colonies (Mack and Lonsdale 2001). Most of the grasses imported by the HAES came from other colonial governments including the United States Department of Agriculture Bureau of Plant Industry

(see Williams 2005) or the Australian Commonwealth Plant Introduction Program, in addition to smaller territorial experiment stations across the tropics.

The introduction of these foreign grasses with the explicit goal of replacing native habitat with cattle pasture is one aspect of “ecological imperialism” (Crosby 2004, Mastnak et al. 2014). Ecological imperialism explains how the introduction of plants, animals, and disease worked directly to aid European settlers in furthering colonization, and often these introductions were agents of displacement of indigenous people (Fischer 2015). In Hawai‘i, foreign forage grasses allowed high density stocking of cattle on islands where this would have otherwise been a biological impossibility. This advanced colonial economic development on the islands and the dominance of cattle ranches, which have occupied up to 26% of Hawai‘i’s land (Hugh et al. 1986). These grasses were also highly utilized to feed the draft animals needed for sugar plantations before engines and mechanization.

Another dramatic legacy of escaped forage grasses in Hawai‘i is the fires fueled by them, which burn an average 8500 hectares every year (Trauernicht et al. 2015). Fires of this scale were unknown before the introduction of these grasses. These fires threaten not only human life, but watersheds, rare species, and reefs (due to increased erosion and sedimentation). The issue of grass-fueled fires came to a head in 2023, when the most deadly wildfire in Hawai‘i’s history burned the town of Lāhainā on Maui, fueled by buffelgrass (*Cenchrus ciliaris*) and Guinea grass (Romero and Kovaleski 2023). Conservationists and residents across Hawai‘i have long known the danger these grasses create for Hawai‘i, but these fires have brought the threats of invasive grasses to the forefront of public consciousness (Blair 2023).

Accidental introductions

The first accidentally introduced grass is unclear as three species, *Eleusine indica* (L.) Gaertn., *Oplismenus hirtellus* (L.) P.Beauv. subsp. *hirtellus*, *Stenotaphrum secundatum* (Walter) Kuntze, were recorded in 1826 by the Beechy Voyage. On the basis of their weedy ecology and general absence from native dominated habitat, these are considered non-native despite their early introduction date. It is possible that *Stenotaphrum* was deliberately introduced for cattle, but no historical evidence exists regarding this grass. In total, 158 grass species were likely introduced into Hawai‘i accidentally. Of these, 132 have produced wild populations which persist into the present and 26 are questionable naturalizations. Of course, the true number is necessarily higher than this, as most introductions are likely to fail to naturalize (Blackburn et al. 2011). For almost all of these putative accidental introductions, the pathway of introduction is unknown. However, the pathways of 21 species which were first introduced accidentally were

identified (Appendix 1), including hay (4), grasses used as packing material (1), contaminated seed (10), and the soil of live plants (6).

Contaminated seed

Most of our knowledge about arrivals of grasses as seed contaminants comes from the HAES, who imported large quantities of seed and whose workers made frequent herbarium specimens of species which volunteered among the planted seeds. From these HAES specimens we know that five species were first accidentally introduced via contaminated seed grown at the HAES experiment stations (*Aristida divaricata* Humb. & Bonpl. ex Willd., *Bromus japonicus* Houtt, *Chloris cucullata* Bisch., *Eleusine coracana* (L.) Gaertn, and *Paspalum paniculatum* L.). Many other notes and specimens also mention contaminant grasses growing from seed, but the majority of these were species which had already been deliberately introduced at that point.

Contaminated seed was also very likely the first introduction pathway for five further species. It was hypothesized as the pathway for *Glyceria notata* Chevall. (Hitchcock 1922). *Hackelochloa granularis* (L.) Kuntze first appeared in a recently seeded pasture and was likely a contaminant among the seed scattered there. Contaminated seed was almost certainly the pathway for *Lolium temulentum* L. and *Echinochloa oryzoides* (Ard.) Fritsch, which were frequent contaminants of wheat and rice historically (Barkworth et al 1993, Thomas et al 2011, Thomas et al 2016). Bird seed is also a pathway by which some species were likely introduced, such as *Setaria viridis* (L.) P.Beauv. (Oseland et al. 2020). Bird seed also appears to be the main source of the non-persistent *Sorghum bicolor* subsp. *bicolor* and *Phalaris canariensis* L. plants sometimes found in urban areas.

Across the mainland United States during the 1800s, crop seed imported from Europe was often adulterated with low value seed or weeds, and it is assumed that the same occurred in Hawai‘i. Even when not intentionally adulterated, contamination of crop and grass seeds with weeds was ubiquitous, especially pre-1900, and many other species were likely also introduced in contaminated seed (Mack and Erneberg 2002, Conn 2012).

Hay

Imported hay was reported as the introduction pathway for four species: *Hordeum murinum* L. subsp. *leporinum* (Link) Arcang., *Phalaris minor* Retz, *Schizachyrium microstachyum* (Desv.) Roseng., B.R.Arrill. & Izag., and *Setaria parviflora* (Poir.) Kerguélen (McClelland 1915, *O. Degener 35273 (BISH)*, O’Connor 1990). Although hay was cited as an introduction pathway for only four species, the true contribution of hay as a dispersal vector of species to Hawai‘i is likely underestimated. Vast quantities of hay were imported into Hawai‘i

between the late 1800s and early 1900s as the local production of hay was minimal, and fresh green forage was often not available. Hay was typically imported from California and was often wheat hay (Anon 1871, Anon 1885, Wilcox 1909).

The quantity of hay imported to Hawai‘i was substantial. For example, in 1917, 34 million pounds of hay were imported (Anon 1917). Of this, about 18 million pounds were imported for use by the United State Army (Anon 1916b). Many efforts were made to produce local hay with some success, (e.g. Anon 1916a, Rice 1917), but difficulties persisted (Britten 1959). Even into the 1970s, hay continued to be principally imported rather than produced locally (Nishimura 1975). Hay is well-documented to contain propagules of invasive plants (Conn et al. 2010) and, owing to the sheer quantities of hay imported, it is hypothesized that many, if not most, pre-1930 accidental introductions arrived into Hawai‘i with hay.

Other pathways

Importation with live plants was the cause of introduction for *Dinebra panicea* (Retz.) P.M.Peterson & N.Snow subsp. *brachiata* (Steud.) P.M.Peterson & N.Snow; *Eragrostis tenella* (L.) P.Beauv. ex Roem. & Schult.; *Setaria palmifolia* (J.Koenig) Stapf; *Sporobolus tenuissimus* (Mart. ex Schrank) Kuntze; and *Urochloa reptans* (L.) Stapf. (Appendix 1). Hillebrand (1888) also reports an accidental introduction of *Urochloa maxima* (Jacq.) R.D.Webster with live plants (but see Histories of selected notable grasses).

Contaminated soil and seeds adhered to vehicle undercarriages are also suspected to be a source of accidental introductions, although these pathways are difficult to determine (Conn et al. 2008). Ballast material is also a potential source of invasive grass propagules (Schmidt et al. 2023) and ballast was surely discarded on the islands during the sandalwood trade. Some species may have also been introduced lodged in the hair of imported livestock (Couvreux et al. 2004a,b, Chuong et al 2016). However, there is no evidence that any grasses were introduced through these pathways.

Impacts

As the ecological impact of most introduced grasses is undocumented (with the exception of a small number of well studied species), the following section draws heavily from the observations I have made across the islands while surveying grasses. The most ecologically damaging grasses that are considered accidentally introduced are *Andropogon bicornis* L., *Andropogon virginicus* L., *Microlaena stipoides* (Labill.) R.Br., *Paspalum conjugatum*, *Setaria palmifolia*, and *Schizachyrium microstachyum* (Faccenda pers. obs, Ainsworth and Kauffman 2010, D’Antonio et al. 2011, May 2014). While these grasses are widespread across the

landscape, most accidental introductions are confined to frequently disturbed habitats such as roadsides, farms, and yards. Only a minority tend to invade native dominated habitat. Although the Pareto principle simultaneously applies to the deliberately introduced grasses and the majority of deliberate species also have few impacts or are confined to disturbed habitats; the deliberately introduced species cover more land area and are associated with more significant ecological impacts on the islands than the accidentals.

Study of accidental introductions

This paper provides the first checklist of the putative accidentally introduced grasses in Hawai‘i, compiled with the aid of historical agricultural literature. Previous workers such as O’Connor (1990) did not report the introduction intent for most species. O’Connor noted 13 species as deliberately introduced and only one as accidentally introduced (O’Connor 1990). Of these 13 deliberate introductions, one was erroneous: no evidence was found during this work that *Phalaris minor* was deliberately introduced. Going further back, Whitney et al. (1939) or Ripperton et al. (1933) list many deliberate introductions, but did not explicitly state which species were likely accidentals.

In fact, few literature sources have identified accidental introductions. Of the 158 putative accidental introductions, only 21 are referred to in published references as accidental introductions. This may stem from a combination of factors, including disinterest, lack of historical knowledge about deliberate introductions, and lack of direct observations of the accidental introduction event. In almost all cases, authors (including myself) must treat accidental introductions as a diagnosis of exclusion, eliminating species with known economic uses or known importations.

However, 69 of the 158 species have combined biological/cultural evidence that they may have been accidental introductions, as they are weedy annuals or short lived perennials with little value for forage or any other economic activity. Many more are known weeds elsewhere and have a propensity for dispersing with human commerce. Of the remaining 64 perennial species, four were recorded as desirable forage species (*Dichanthium annulatum* (Forssk.) Stapf var. *annulatum*; *Paspalum jesuiticum* Parodi, *Paspalum maniocanum* Trin. var. *mandiocanum*, *Urochloa arrecta* (Hack. ex T.Durand & Schinz) Morrone & Zuloaga) and may have been deliberately imported, but there are no records of their introduction which could be located during this research. These species are labeled as having an “unclear” introduction intent as it is most likely they were deliberate on the basis of their value for forage, but lack any records of deliberate introduction.

Wester (1992) was the only previous study to identify the intent of introductions for naturalized grasses in Hawai‘i. Wester’s study included 123 grasses; excluding natives, duplicates, misidentifications, and species without introduction intents leaves 97 grasses that can be compared to this study. Of these, the introduction intents for 52 (53%) agree with this study. For the 45 which disagree, three were reported as accidental by Webster but were found to be deliberate in this study (*Calamagrostis arenaria* (L.) Roth, *Dactyloctenium aegyptium* (L.) Willd., and *Holcus lanatus*). The remainder were cited as deliberately introduced by Wester, but this study could find no evidence of deliberate importation despite the extensive accession logs of the HAES. Among these 42 species, this study also found earlier first introduction dates than those reported by Wester (1992) for 22 species. Almost all species whose introduction intents differ between this study and Wester (1992) are weedy annuals such as *Bromus rigidus* Roth, *Eragrostis pilosa* (L.) P.Beauv, *Panicum repens* L. etc. which are of little economic value and are well-known weeds in other regions. These 42 were considered deliberate introductions based on their labels as “cult” in St. John’s (1973) checklist (Lydon Wester pers. comm. 2024). Unfortunately, St. John’s (1973) checklist is poorly annotated in terms of cultivation status for grasses as I found no evidence these grasses were ever cultivated.

Studies similar to that of Wester (1992) which list introduction intents without evidence from historical literature are not uncommon. Similar work includes that of Baker (1989), Lazarides (2002), and Milton (2004). This work adds to a growing body of evidence, including Cook and Dias (2006) and Mack and Erneberg (2002), showing that hypothesized introduction intents by modern workers are often discordant from that of the period literature.

Histories of notable grasses

During the course of this research, the introduction histories of several grasses were found which were worthy of detailed discussion as they have not been repeated in modern references. These histories are detailed here.

Mānienie (*Cynodon dactylon*)

The first imported forage grass was the *mānienie*, now often called Bermuda grass, despite its origin in Africa, not Bermuda. Quickly after its introduction, *mānienie* spread rapidly across the lowlands of the islands and was regarded as the premiere forage grass in lowland areas until the importation of other tropical grasses in the early 1900s (Judd 1904:25). *Mānienie* was also important as it stabilized the soil disturbed by feral ungulates, especially cattle, and prevented erosion.

According to Hillebrand (1888) recounting a report by Dr. Gerrit P. Judd, *mānienie* first appeared on O‘ahu around 1835. Hillebrand’s report provides the only date for the introduction of this grass. It likely was deliberately introduced by Don Francisco de Paula Marín (Henke 1929:64). Arbolero (1873) credits Marín with the introduction of this grass, but also falsely credits him as introducing the *kiawe* (*Prosopis pallida* (Humb. & Bonpl. ex Willd.) Kunth). Anon (1916c) who also claims it was introduced by Marín goes further to say the name *mānienie* descends from the Hawaiianization of Marín as *Manini*. This etymology may be incorrect as the word *māniania* means “smooth” or “even” and could refer to the habit of this grass (Neal 1948, Andrews 1865). Nagata (1985) indicates that Marín observed *Cynodon dactylon* in 1835, but no mention of the grass could be found in his biography (Gast 1973).

Marín introduced hundreds of edible and otherwise useful plants to Hawai‘i (Nagata 1985, Gast 1973:19), and there is little reason to doubt these reports. Marín also raised and sold cattle and other livestock, giving him further motivation to import this grass (Gast 1973:18,37). If Marín did introduce *mānienie*, the 1835 date reported by Hillebrand is likely later than this species was introduced, as Marín died in 1837 and was most active agriculturally earlier in life.

Guinea grass (*Urochloa maxima*)

The first mention of Guinea grass (synonyms include *Megathyrsus maximus* (Jacq.) B.K.Simon & S.W.L.Jacobs and *Panicum maximum* Jacq.) was by Hillebrand (1888), who lists *Panicum maximum*, *Setaria palmifolia*, and *Urochloa reptans* under a heading stating “Besides them [the endemics] the following species, accidentally introduced with living plants from abroad, had become established in gardens before my departure and are likely to have escaped to open country by this time”. It is also conceivable that the plants found by Hillebrand were imported deliberately and he only noticed after it began to naturalize. Hillebrand departed the islands in 1871, meaning that if his report is correct, Guinea grass may have occurred on Hawai‘i in the late 1860s. It is worth noting that Hillebrand made several erroneous grass identifications: of the 47 non-endemic grasses reported by Hillebrand, 13 (or 28%) were erroneous identifications or misapplied names compared to modern usage. It is possible, too, that *Panicum maximum* was one of these names. Also, Hillebrand refers to Guinea grass as native to India, but this is incorrect and casts doubt upon Hillebrand’s knowledge of Guinea grass.

In the early 1880s, a series of notes were published in the Planters’ Monthly documenting the sugar planters’ attempts to import the grass. The first, by Judge McCully (1883:119) who introduced the grass by writing:

“Guinea Grass is said to have retrieved the Jamaica Sugar Plantations from ruin, by affording them abundant forage for their working animals. It is a vigorous grower and has

run over the whole island. Flint on Grasses, and von Mueller's Catalogue of Industrial plants, mention very many valuable forage plants suitable for inter-tropical regions. The introduction of even one congenial grass or clover, might prove of incalculable value to the kingdom.”

Following the publication of this note, efforts were made to obtain Guinea grass seed from the USDA but were initially unsuccessful (Bailey 1883). A successful introduction of Guinea grass by Judge McCully was made later in 1883, and was reportedly initially planted at a plantation in Ka‘ū, Hawai‘i (Koeling 1893). By 1901, Guinea grass was widely used and known among the stock industry, “cultivated by many dairymen with great success” (Stubbs 1901). Ranchers were also using Guinea grass, at that point considered a “fine grass for livestock” (Judd 1903), and a prize was offered for the best bundle of cut Guinea grass presented at Territorial Agricultural Fair in 1902 (Anon 1902). The first herbarium specimen made of Guinea grass (*H.E. Kelsey 2 BISH*) is from 1903.

These reports in the 1880s give little reason to doubt their accuracy given that Guinea grass was certainly established by 1903, and the name Guinea grass had been consistently applied between 1883 and 1903. In the author’s opinion, the newspaper articles cast doubt upon the Hillebrand report. These men, largely ranchers and sugar planters who were eagerly interested in new grasses to feed to their livestock, would almost certainly have noticed if Guinea grass was already present on the islands, as it is remarkable in both size and growth. If Hillebrand’s report was correct, Guinea grass would have been naturalized and spreading for a minimum of 15 years by 1883. It is also unlikely that an aggressive invasive species like Guinea grass would have died out shortly after Hillebrand’s observation of it.

Further introductions of Guinea grass continued well past these first introduction(s). Between 1911 and 1964, 192 accessions of Guinea grass were imported by the HAES for pasture purposes. The majority of these were imported in the early 1960s and included germplasm from across much of Southern Africa, presumably to find ecotypes which are most well adapted to the climate of Hawai‘i. Guinea grass also appeared in local seed catalogs (e.g. Anon 1948). Guinea grass has also continued to be imported into the 21st century by the Ko‘olau Seed Company in Kāne‘ohe (<https://koolauseed.com/products.html>). The diversity of germplasm imported by the HAES and seed companies may explain the variability in and ecotypic specialization of Guinea grass across the islands.

***Eragrostis leptostachya* (R.Br.) Steud.**

Eragrostis leptostachya was deliberately imported into Hawai‘i from Australia for trial as a forage grass between 1900–1915 (McClelland 1915). Approximately 20 years later, *E.*

leptophylla had become naturalized and was collected at Pu‘u Nānā on Moloka‘i (*Hosaka 1848 BISH*) and simultaneously on Kaua‘i (*Hosaka 1647 BISH*). The Pu‘u Nānā specimen was named *Eragrostis hosakai* by Degener (1940) and described as a Hawaiian endemic species. It was not until 47 years later that Lazarides (1997) realized that *E. hosakai* is a synonym of *E. leptostachya*. In defense of Degener, no specimens of *E. leptophylla* had been made from a cultivated context in Hawai‘i.

Hilo grass (*Paspalum conjugatum* P.J.Bergius)

The exact origin of Hilo grass has apparently been forgotten for over 100 years but was located during the present research. The following editor’s note was written by H.M. Whitney in response to an anonymous letter about plant dispersal:

“About the year 1837, Rev. Mr. Lyman, of Hilo, received a crate of crockery and other ware from Boston, by ship via Cape Horn, in the packing of which straw and grass were used. When the package was opened in Hilo, and the goods removed, the straw and hay were thrown out in the pasture field adjoining his dwelling. A few months later, a new variety of grass was noticed springing up, of a different color from the native grass. As the horses readily ate this new grass, and seemed to prefer it to the old, Mr. Lyman thought he had found a new variety which would be of value to the country. The grass spread very rapidly, and in a few years it had run out all the old grasses, and was found spreading along the road ways into other districts, till finally it covered the whole Island of Hawai‘i, and has spread from thence to each of the other islands of the group. This is the origin of what is known as Hilo grass” (Whitney 1887:90).

Hilo grass is native to the Americas, from the Southeastern United States through Central America and most of South America. If the details of the introduction are correct, then the crockery was either repacked along its journey or was originally packed somewhere south of Boston. Before 1837 it is likely that Hilo grass had not yet escaped its native range, making Hawai‘i its first naturalization. Hilo grass was a dominant grass in sunny, wet, lowland areas across the islands where it thrived in forests disturbed by cattle and formed a dense mat, retarding tree regeneration (Hall 1904, Hitchcock 1922). Hilo grass is generally no longer dominant in Hawai‘i, having largely been replaced with Guinea grass, with the exception of overgrazed pastures where it can still be found in great density.

Sourgrass (*Digitaria insularis*)

Sourgrass, so-called because it is poor-tasting and strongly avoided by ungulates, is notable as an unfortunate deliberate introduction. Degener and Degener (1960) wrote:

“Leo Whitney, who early collaborated in publishing on grasses for this Flora, related that a Puerto Rican, employed as laborer at one of our government experiment stations [HAES Pensacola St. Station], told his director that in his country grew a grass valuable for the making of straw hats. The laborer was instructed to write for seed which, on arrival, was planted for observation in Makiki Valley, Honolulu.”

This report is corroborated by McClellan (1915; cited as *Panicum lanatum* Rottb.) who also lists this species as deliberately introduced and not yet naturalized in 1915. Only a year later in 1916 the first wild plant was collected, and by 1924 it had spread to Kaua‘i. By the 1930s, sour grass and its wind dispersed seed spread to nearly all the other islands. Sourgrass is now a major weed in overgrazed pastures or areas infested by deer on all islands, all because of its apparent (but evidently unrealized) desirability in hats.

Geographical patterns

Geographic origin of naturalized species

The native range of each naturalized species was described using the biogeographical regions of Olson et al. (2001) and distribution information from Plants of the World Online (POWO 2023). As most grasses inhabit more than one biogeographical region, they were tallied in each region in which they occur. Broken down coarsely, most grasses (160 spp.) come from Afroeurasia+Oceania, 56 are from the Americas, and 12 species inhabit both regions. The Afrotropics had the largest number of deliberate introductions that naturalized; similarly the largest number of accidental introductions come from the Indo-Malay region (Figure 2).

Grasses which were introduced accidentally belonged to more biogeographical regions, compared to deliberately introduced species (1.92 and 1.50 respectively). Poisson regression was used to compare these, and the number of regions which accidentally introduced species naturally occupy is significantly higher than deliberately introduced species ($p = 0.01$; $df = 227$). This aligns with the data presented by Hayes and Barry (2008) which showed the range size positively correlates with establishment success of invasive species.

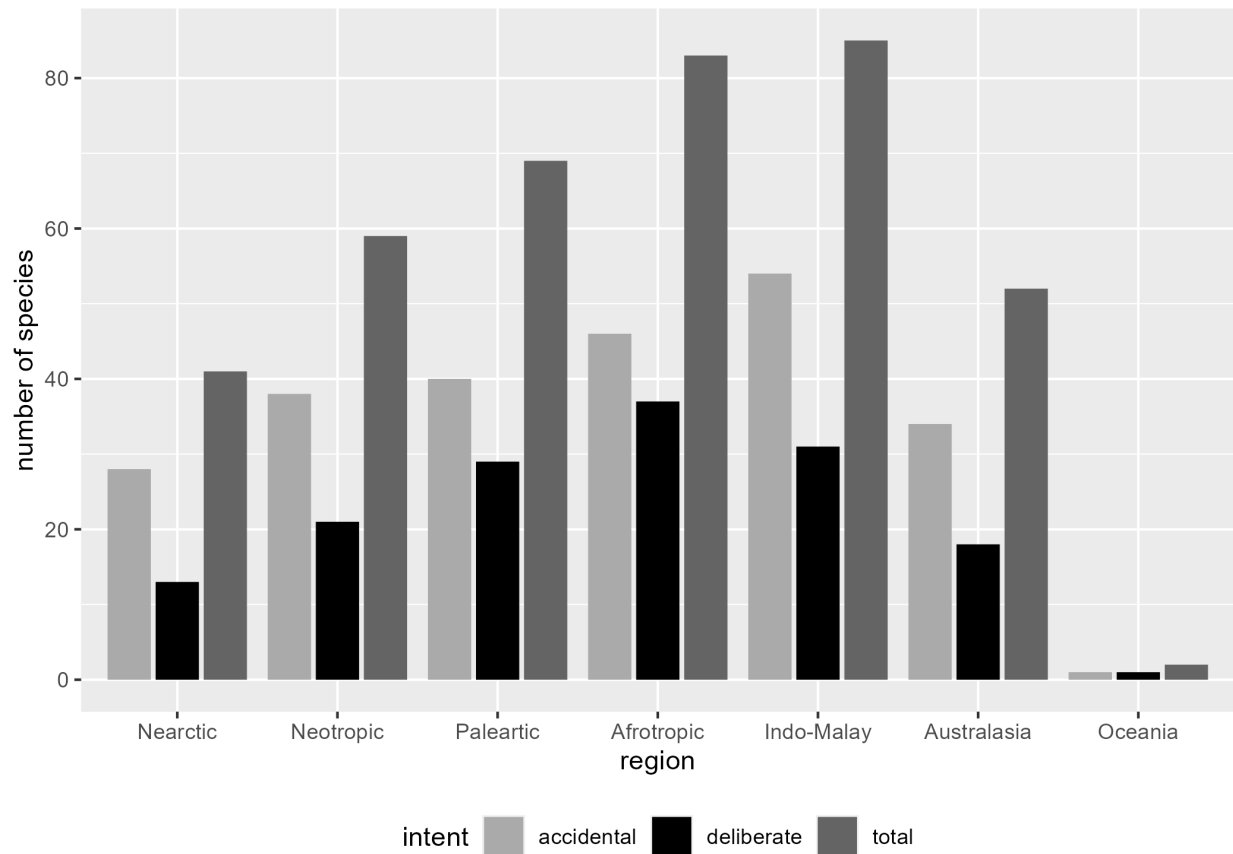


Figure 2. Geographic distribution of the native range of naturalized grasses in Hawai'i (excluding questionable naturalizations). As most species inhabit more than one biogeographic region, they were tallied in all regions as in almost all cases it is unknown which specific region the Hawaiian populations descend from. Thus, the values on the x axis do not sum to the total number of naturalized species.

It is noteworthy how few post-European grass introductions came from Oceania (Figure 2). This may be due to some of the weedier species having colonized before European contact (e.g. *Chrysopogon aciculatus*, *Digitaria setigera*, *Heteropogon contortus*), and the Oceanic flora generally lacking species adapted to grazing which would have been desirable imports for forage. It is also noteworthy how few species from the Nearctic (North America) which were deliberately imported have naturalized, the smallest number outside of Oceania. A large number of forage grasses from North America were imported and trialed by the HAES, and many are adapted to grazing, but few established, even at medium to high elevation sites where European temperate grasses flourish. It is unclear why this is the case.

Comparison with other regions

Historical reviews of tropical grass introductions are few in number worldwide, and the most analogous studies come from Australia. In Australia, 58% of 374 naturalized grasses were deliberately introduced (Cook and Dias 2006), higher than the 43% reported in this paper. Strictly among tropical grasses in Australia, 100 (64%) of 155 total naturalized species were imported for pasture purposes, and the remainder were imported as ornamentals (7), contaminant (14), crop (13), or unexplained (21) (van Klinken et al. 2015). Of the 188 tropical grass species naturalized in Hawai‘i, 88 (47%) were deliberately introduced. Why Hawai‘i would have a greater number of accidental introductions is not immediately clear, but the large amounts of hay imported into Hawai‘i may have been a factor as well as the geography of Hawai‘i as a center of trading in the Pacific.

In South Africa, approximately 58% of naturalized grasses were accidentally introduced (Milton 2004, interpreted from Table 1). Milton did not appear to conduct an in-depth analysis of historical grass importations as part of this work, however, so the numbers may exaggerate accidental introductions.

Approximately 579 species, representing 5% of the worldwide grass flora, were introduced to Hawai‘i since 1778. This was relatively minor compared to Australia, where the Commonwealth Plant Introduction Program imported 2250 grass species, or approximately 20% of all described grass species which are not native to Australia (Cook and Dias 2006). In Australia, almost all deliberate pasture grass introductions which naturalized proved to have weedy qualities; only four were listed as useful plants which lacked weedy qualities (Lonsdale 1994), but three of these were later reported by Low (1997) as weeds. This left only one legume out of hundreds of species which failed to become weedy. This is also true in Hawai‘i, as the majority of grasses which became established in pastures subsequently naturalized outside of their pastures.

Compared to temperate regions, the proportion of deliberate grass introductions in Hawai‘i is substantially lower. For example, among invasive grasses across the continental United States, 75% were deliberately introduced (Lehan et al 2013). Baker (1989) claims that the Californian introduced grass flora is almost entirely the product of accidental introductions, but this is likely biased as they did not review historical literature.

Of the 419 grasses which were deliberately imported, 102 (24%) have since naturalized, or 31% of non-bamboos. This rate is rather high when compared to 10% naturalization among 2250 grasses imported to Australia (Cook and Dias 2006). Comparing across regions is difficult, as much context is lost regarding climate matches and how widely plants were propagated across the landscape, important factors in determining naturalization success (Bartlett et al. 2023).

However, the naturalization rate in Hawai‘i is still rather high when compared to 8% of 2230 woody perennials in South Africa (Caley et al. 2008), 15% of 34,650 plants in Australia (Bartlett et al. 2023), or 27% of 648 ornamental outdoor plants in Quebec (Lovoie et al. 2016)

Weeds and biosecurity

The importance of biosecurity in Hawai‘i has long been recognized for preventing the introduction of unwanted plants. For example, Leckenby (1908) writes:

“These islands are nearly new; most of the living things were introduced without sufficient care and knowledge in selection. Witness the sadness of the presence of lantana [*Lantana camara* L.] and nut grass [*Cyperus rotundus* L.] and contrast with the benefit of algaroba [*Neltuma pallida* (Humb. & Bonpl. ex Willd.) C.E.Hughes & G.P.Lewis] and maniania [*Cynodon dactylon*] grass. The past should serve as a lesson for the future, and all introductions of animal and plant life should be under proper control until their importance could be ascertained. There are still some weeds, including the Russian thistle, that should be tabued, and a few bad insects that we have not got. The *Polygonum* family of plants should be introduced with great caution, while leguminous plants should be welcomed.”

While this is not the earliest call for enhanced biosecurity in Hawai‘i, it is one of the first to call for careful quarantine of each new imported species. Unfortunately, such a quarantine protocol was not required during the HAES era, and is still not required in the present.

Quarantine efforts for plants have focused almost entirely on pests and pathogens of economically important plants while little attention was given to plants themselves. This includes voluntary quarantine protocols on sugar cane implemented by the sugar plantations (Osgood and Wiemer 1992) and the current regulations for the state of Hawai‘i, which requires a permit and quarantine to import live grasses

(<https://hdoa.hawaii.gov/pi/pq/import-program/plant-guidelines/>). However, the importation of grass seed from the mainland United States is unrestricted to this day, with the exception of species declared as state and federal noxious weeds. These noxious weed lists prohibit importation of a limited number of grasses, so they must be updated in order to serve as a more effective tool for restricting importation of weeds (Lakoba et al. 2020).

The HAES did evidently attempt to prevent the establishment of some species which were immediately recognized as problematic. For example, *Bothriochloa ischaemum* (L.) Keng was imported in 1935 and subsequently killed in 1936 as “it appeared that these might become serious pests if allowed to become naturalized” (HAES 1936). However, this wisdom was

evidently forgotten as it was reimported again after only four years (HAES n.d., HAES acc. no. 3872). *Bothriochloa ischaemum* is now naturalized on O‘ahu and Moloka‘i (Faccenda 2022).

The HAES or other organizations imported various species of questionable value and weedy traits. Species such as sourgrass (*Digitaria insularis*), rat-tail (*Sporobolus indicus* (L.) R.Br.), *Diplachne fusca* (L.) P.Beauv. ex Roem. & Schult., African lovegrass (*Eragrostis curvula* (Schrad.) Nees), *Cenchrus setosus* Sw. (syn. *Pennisetum polystachion* auct. non), and *Ehrharta erecta* Lam. stand out as species imported by the HAES which are low-value forages and have now become environmental weeds across the islands. These introductions were anticipated by Degener and Degener (1960) who wrote:

“It is regrettable that such a troublesome introduction [*Digitaria insularis*], one of so many, does not deter some present government employees from continuously repeating like blunders by not only introducing exotic plants and animals of questionable value to our islands. They even introduce those that are notoriously harmful. They are opening a veritable Pandora’s box of foreign weeds, vermin and large herbivores at the taxpayers’ expense on our shores. Future generations of farmers, ranchers, garden lovers and tourists will curse this present giddy and wanton recklessness”

Indeed, these introductions are disparaged by hikers, gardeners, conservation workers, and farmers to this day.

Conclusion

For the first time, all grasses known to be imported to Hawai‘i were given an introduction intent of either accidental or deliberate based on historical literature. By the number of naturalized species, accidental introductions outnumber deliberate introductions, but despite their lower diversity, deliberately introduced grasses are much more dominant across the landscape. Four-hundred and twenty deliberate introductions of grasses were identified but only 25% naturalized. While the deliberate importation of new species of grasses peaked between 1900 and 1940 at 5.8 species per year, it largely plateaued after 1966. The introduction rate decreased and has largely stagnated after the 1960s, with only 10 new non-bamboo introductions occurring between 1998 and 2023. Accidental introductions continue to be introduced to Hawai‘i, and the rate of introductions has been relatively constant over the entire history of Hawai‘i; between 1900 to 2023, an average of one accidental arrival was documented per year, and this rate is equivalent to the rate during the past 25 years. Based on these trends, new accidental introductions are likely to continue to become invasive weeds, indicating that enhanced biosecurity is needed to protect both the ecosystems and economy of Hawai‘i.

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Appendices

Appendix 1. Introduction intent, introduction date, notes, naturalization status, and number of HAES accessions for all introduced in Hawai‘i. Note that many species labeled as cultivated were historically cultivated, but are now no longer present in Hawai‘i.

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
× <i>Phyllosasa tranquillans</i> (Koidz.) Demoly	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Agropyron cristatum</i> (L.) Gaertn.	intentional - forage	1922		HAES acc. no. 1625	cultivated	12
<i>Agropyron desertorum</i> (Fisch. ex Link) Schult.	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Agrostis canina</i> L.	accidental	<1912		ROCK, JFC 12738 (BISH)	questionable	
<i>Agrostis capillaris</i> L.	intentional - forage	<1904	"Cultivated grasses introduced by the old managers and now growing abundantly". Much earlier than 1904, probably 5-20 years prior	Brown (1906)	naturalized	8
<i>Agrostis exarata</i> Trin.	accidental	<1916		HITCHCOCK, AS 14245 (BISH)	questionable	
<i>Agrostis hyemalis</i> (Walter) Britton, Sterns & Poggenb.	accidental	<2005		CRAGO, LM 2005-241.5 (BISH)	naturalized	
<i>Agrostis mertensii</i> Trin.	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Agrostis scabra</i> Willd.	intentional - forage	<1915		McClelland (1915).	cultivated	
<i>Agrostis stolonifera</i> L.	intentional - forage	1905		Thielen (1905)	naturalized	5
<i>Aira caryophyllea</i> L.	accidental	<1916		HITCHCOCK, AS 14938 (US)	naturalized	
<i>Alloteropsis cimicina</i> (L.) Stapf	intentional - forage	1916		HAES acc. no. 1062	cultivated	4

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Alopecurus pratensis</i> L. subsp. <i>pratensis</i>	intentional - forage	1913		HAES acc. no. 853	naturalized	3
<i>Andropogon bicornis</i> L.	accidental	<1987	Earliest report by Rotar (1968) with a date of 1955. No context was provided regarding this date. It is likely erroneous as it was not collected until 1987 and it is hard to believe that such a large and distinctive grass could have been overlooked for 32 years. It is likely that this name derives from a misidentification of <i>Schizachyrium microstachyum</i> , as the name <i>A. bicornis</i> was historically misapplied (e.g. Hasselwood & Motter 1983). It seems unlikely that this was intentionally introduced like other species that first appear in Rotar as it is a very coarse forage.	FLYNN, TW 2679 (BISH)	naturalized	
<i>Andropogon gerardi</i> Vitman	intentional - forage	1916		HAES acc. no. 1055	cultivated	5
<i>Andropogon hallii</i> Hack.	intentional - forage	1940		HAES acc. no. 4054	cultivated	1
<i>Andropogon tenuispathus</i> (Nash) Nash	accidental	<2002		KAWELO, K s.n. (BISH)	naturalized	
<i>Andropogon virginicus</i> L. var. <i>virginicus</i>	accidental	<1924		LEE, HA 124 (MICH)	naturalized	
<i>Antheophora hermaphrodita</i> (L.) Kuntze	intentional - forage	1916		HAES acc. no. 1072	questionable	2
<i>Anthoxanthum nitens</i> (Weber) Y.Schouten & Veldkamp	intentional - ornamental	2007		STAPLES, GW 1267 (PTBG)	cultivated	
<i>Anthoxanthum odoratum</i> L.	accidental	<1907	Evidently an accidental introduction. Writers at the time did not speak positively of it when it appeared and no records of importation found. It was already naturalized before HAES imported it	MUNRO, GC s.n. (BISH)	naturalized	1
<i>Aristida adscensionis</i> L.	accidental	<1903		MUNRO, GC 128 (BISH)	naturalized	
<i>Aristida divaricata</i> Humb. & Bonpl. ex Willd.	accidental	1938	First found as a seed contaminant at the Poamoho grass garden	HOSAKA, EY 2418 (BISH)	questionable	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Arrhenatherum elatius</i> (L.) P.Beauv. ex J.Presl & C.Presl subsp. <i>elatius</i>	intentional - forage	<1904	"Cultivated grasses introduced by the old managers and now growing abundantly". Much earlier than 1904, probably 5-20 years prior	Brown (1906)	naturalized	4
<i>Arthraxon hispidus</i> (Thunb.) Makino	accidental	<1972		DEGENER 32781 (BISH)	questionable	
<i>Arundo donax</i> L.	intentional - ornamental	<1871	Ornamental; no reference for when this was imported, but it was cited by Hillebrand (1888)	Hillebrand (1888)	naturalized	
<i>Astrebla elymoides</i> F.Muell. ex F.M.Bailey	intentional - forage	1938		HAES acc. no. 3534	cultivated	3
<i>Astrebla lappacea</i> (Lindl.) Domin	intentional - forage	1905		Munro (1905)	cultivated	5
<i>Astrebla pectinata</i> (Lindl.) F.Muell. ex Benth.	intentional - forage	1904		HAES (1904)	cultivated	
<i>Austroderia richardii</i> (Endl.) N.P.Barker & H.P.Linder	intentional - ornamental	<1996		Imada et al. (1996)	cultivated	
<i>Avena barbata</i> Pott ex Link	accidental	<1916		HITCHCOCK, AS 13934 (US)	naturalized	
<i>Avena byzantina</i> K.Koch	intentional - cereal	1936		HAES acc. no. 3239	cultivated	2
<i>Avena fatua</i> L.	intentional - forage	<1904	Cited as "wild oat". "Cultivated grasses introduced by the old managers and now growing abundantly". Much earlier than 1904, probably 5-20 years prior	Brown (1906)	naturalized	
<i>Avena sativa</i> L.	intentional - cereal	<1846	Very likely earlier than 1846	Anon (1846)	naturalized	33
<i>Avenella flexuosa</i> (L.) Drejer	intentional - forage	1913		HAES acc. no. 838	cultivated	2
<i>Axonopus compressus</i> (Sw.) P.Beauv.	intentional - forage	1938		HOSAKA, EY 2498 (BISH)	naturalized	3
<i>Axonopus fissifolius</i> (Raddi) Kuhlm.	intentional - forage	1912		Whitney et al. (1939) [appendix]	naturalized	1
<i>Axonopus scoparius</i> (Flüggé) Kuhlm.	intentional - forage	1940		HAES acc. no. 4055	cultivated	1
<i>Bambusa balcooa</i> Roxb.	intentional - ornamental	<1992		HERBST, DR 9603 (BISH)	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
Bambusa bambos (L.) Voss	intentional - ornamental	<1949		LANDGRAF, MF 10A (MICH)	cultivated	
Bambusa beecheyana Munro	intentional - ornamental	<1928		CARTER, GR 1 (BISH)	cultivated	
Bambusa boniopsis McClure	intentional - ornamental	<2022		List of bamboo species in collection and available for sale from the Hawaii Tropical Plants Nursery in Kea'au Hawaii http://www.hawaiiantropicalplants.com/bamboo.html	cultivated	
Bambusa burmanica Gamble	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
Bambusa chungii McClure	intentional - ornamental	<2022		Whispering Winds bamboo nursery catalog. Based in Kipahulu Maui https://www.whisperingwindsbamboo.com/bamboo-varieties	cultivated	
Bambusa dissimulator McClure	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
Bambusa distegia (Keng & Keng f.) L.C.Chia & H.L.Fung	intentional - ornamental	<2022		List of bamboo species in collection and available for sale from the Hawaii Tropical Plants Nursery in Kea'au Hawaii http://www.hawaiiantropicalplants.com/bamboo.html	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
Bambusa glaucophylla Widjaja	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	
Bambusa heterostachya (Munro) Holtum	intentional - ornamental	<2022		O'ahu Bamboo Nursery catalog; Wailua, O'ahu; https://www.oahubamboo.com/shop	cultivated	
Bambusa lako Widjaja	intentional - ornamental	<2022		List of bamboo species in collection and available for sale from the Hawaii Tropical Plants Nursery in Kea'au Hawaii http://www.hawaiiantropicalplants.com/bamboo.html	cultivated	
Bambusa longispiculata Gamble	intentional - ornamental	<1951		LANDGRAF, MF 18 (BISH)	cultivated	
Bambusa malingensis McClure	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
Bambusa multiplex (Lour.) Raeusch. ex Schult.f.	intentional - ornamental	<1949		ST JOHN, H 23562 (BISH)	cultivated	
Bambusa oldhamii Munro	intentional - ornamental	<1951		LANDGRAF, MF 16 (BISH)	cultivated	
Bambusa oliveriana Gamble	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
Bambusa pachinensis Hayata	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
Bambusa polymorpha Munro	intentional - ornamental	<1943		MAGUIRE, T s.n. (BISH)	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Bambusa rigida</i> Keng & Keng f.	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	
<i>Bambusa spinosa</i> Roxb.	intentional - ornamental	<1948		Neal (1948)	cultivated	
<i>Bambusa textilis</i> McClure	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Bambusa tulda</i> Roxb.	intentional - ornamental	<1935		CAUM, EL 7 (US)	cultivated	
<i>Bambusa tuldoidea</i> Munro	intentional - ornamental	<1948		Neal (1948)	cultivated	
<i>Bambusa ventricosa</i> McClure	intentional - ornamental	<1951		LANDGRAF, MF 29 (BISH)	cultivated	
<i>Bambusa vulgaris</i> Schrad. ex J.C.Wendl.	intentional - ornamental	<1900	Potentially introduced in the mid 1800s. Hillebrand's treatment mentions this grass, but it seems to actually describe <i>Schizostachyum</i> .	Koebele (1901)	cultivated	
<i>Beckmannia eruciformis</i> (L.) Host	intentional - forage	1922		HAES acc. no. 1639	cultivated	1
<i>Bothriochloa barbinodis</i> (Lag.) Herter	intentional - forage	1905		Munro (1905)	naturalized	3
<i>Bothriochloa bladhii</i> (Retz.) S.T.Blake	accidental	1916	First observation of this grass was wild, it was later imported	HITCHCOCK, AS 15079 (BISH)	naturalized	1
<i>Bothriochloa insculpta</i> (Hochst. ex A.Rich.) A.Camus	intentional - forage	1941		HAES acc. no. 4067	cultivated	1
<i>Bothriochloa ischaemum</i> (L.) Keng	intentional - forage	1935		HAES acc. no. 3185	naturalized	2
<i>Bothriochloa laguroides</i> (DC.) Herter subsp. <i>laguroides</i>	intentional - forage	1905	Cited as <i>Andropogon saccharatus</i> , this name was misapplied at the time	HAES (1906)	questionable	6
<i>Bothriochloa macra</i> (Steud.) S.T.Blake	accidental	<1936		JUDD, AF s.n. (BISH)	naturalized	
<i>Bothriochloa pertusa</i> (L.) A.Camus	intentional - forage	1911		Anon (1911)	naturalized	2

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Bouteloua barbata</i> Lag.	intentional - forage	1935		Whitney et al. (1939) [appendix]	cultivated	4
<i>Bouteloua chondrosioides</i> (Kunth) Benth. ex S. Watson	intentional - forage	1937		HAES acc. no. 3483	cultivated	1
<i>Bouteloua curtipendula</i> (Michx.) Torr.	intentional - forage	1905		Munro (1905)	questionable	11
<i>Bouteloua dactyloides</i> (Nutt.) Columbus	intentional - forage	1905		Thielen (1905)	naturalized	10
<i>Bouteloua eriopoda</i> (Torr.) Torr.	intentional - forage	1935		Whitney et al. (1939) [appendix]	cultivated	4
<i>Bouteloua gracilis</i> (Kunth) Lag. ex Griffiths	intentional - forage	1905		Thielen (1905)	cultivated	9
<i>Bouteloua hirsuta</i> Lag.	intentional - forage	1905		Munro (1905)	cultivated	4
<i>Bouteloua parryi</i> (E.Fourn.) Griffiths	intentional - forage	1937		HAES acc. no. 3484	cultivated	1
<i>Bouteloua repens</i> (Kunth) Scribn. & Merr.	intentional - forage	1937		HAES acc. no. 3485	cultivated	1
<i>Brachypodium distachyon</i> (L.) P.Beauv.	intentional - forage	1936		HAES acc. no. 3346	cultivated	1
<i>Briza maxima</i> L.	accidental	<1917		LYON, HL s.n. (BISH)	naturalized	
<i>Briza minor</i> L.	accidental	<1838		WILKES EXPEDITION s.n. (US)	naturalized	
<i>Bromus arvensis</i> L.	intentional - forage	1941		HAES acc. no. 4102	cultivated	1
<i>Bromus carinatus</i> Hook. & Arn.	accidental	<1936	Collected in wild before later being imported by HAES	HOSAKA, EY 1562 (BISH)	naturalized	2
<i>Bromus catharticus</i> Vahl	accidental	<1871	Hillebrand stated that it appeared very recently and could not be considered naturalized at this time. It was likely an accidental at this time given it was found in a wheat field. It was later intentionally imported in the 1890s.	Hillebrand (1888)	naturalized	17
<i>Bromus commutatus</i> Schrad.	intentional - forage	1913		HAES acc. no. 832	cultivated	1

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Bromus diandrus</i> Roth	accidental	<1871		HILLEBRAND, WB 1842 (US)	naturalized	
<i>Bromus erectus</i> Huds.	intentional - forage	1913		HAES acc. no. 832	cultivated	3
<i>Bromus hordeaceus</i> L.	accidental	<1909		ROCK, JFC 5128 (BISH)	naturalized	
<i>Bromus inermis</i> Leyss.	intentional - forage	<1904	This was apparently naturalized in the early 1900s but appears to now be extinct." "Cultivated grasses introduced by the old managers and now growing abundantly." Much earlier than 1904, probably 5-20 years prior	Brown (1906)	cultivated	34
<i>Bromus japonicus</i> Houtt.	accidental	<1937	Likely imported with contaminated seed; appeared as volunteer in experimental grass plot	HOSAKA, EY s.n. (BISH)	questionable	
<i>Bromus madritensis</i> L.	accidental	<1903		MUNRO, GC 62 (BISH)	naturalized	
<i>Bromus marginatus</i> Nees ex Steud.	intentional - forage	1939		HAES acc. no. 3566	cultivated	2
<i>Bromus rubens</i> L.	accidental	<1921		ANON s.n. (US)	questionable	
<i>Bromus secalinus</i> L.	intentional - forage	1936		HOSAKA, EY 1447 (BISH)	questionable	
<i>Bromus sterilis</i> L.	accidental	<1921		ANON s.n. (US)	naturalized	
<i>Bromus tectorum</i> L.	accidental	<1933		FOSBERG, FR 9936 (BISH)	naturalized	
<i>Bromus vulgaris</i> (Hook.) Shear	intentional - forage	1922		HAES acc. no. 1615	cultivated	1
<i>Calamagrostis arenaria</i> (L.) Roth	intentional - forage	1895	Introduced by commissioner of agriculture Marram but evidently failed on the main islands	Anon (1895)	cultivated	1
<i>Calamagrostis canadensis</i> (Michx.) P.Beauv.	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Calamagrostis purpurea</i> (Trin.) Trin.	intentional - forage	<1915		McClelland (1915)	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
Capillipedium spicigerum S.T.Blake	accidental	<1951		SAHARA s.n. (US)	naturalized	
Catabrosa aquatica (L.) P.Beauv.	intentional - forage	1913		HAES acc. no. 862	cultivated	1
Cenchrus × cupreus (Thorpe) Govaerts	intentional - ornamental	<2000		BARANGAN, J s.n. (BISH)	cultivated	
Cenchrus × peregrinus Faccenda	autochthonous	1990	Formed spontaneously as a hybrid between C. clandestinus and C. setaceus	MATAYOSHI, N s.n. (BISH)	naturalized	
Cenchrus americanus (L.) Morrone	intentional - cereal	1910		HAES acc. no. 463	naturalized	25
Cenchrus americanus (L.) Morrone × C. purpureus (Schumach.) Morrone	intentional - forage	1954		HAES pers. comm.	cultivated	
Cenchrus ciliaris L.	intentional - forage	1916	First importation from USDA. No. 33611 in the USDA "Inventory of seeds and plants imported" periodical. It seems like this accession may not have grown as it was not mentioned in any HAES literature at the time. It was imported again in 1935 and its values were extolled. The 1916 introduction may have been planted at Parker Ranch or it may have been imported again after 1916 as a herbarium specimen dated 1932 came from an "old grass experimental plot"	HAES acc. no. 1045	naturalized	39
Cenchrus clandestinus (Hochst. ex Chiov.) Morrone	intentional - forage	1924	Widely distributed for forage use	Ripperton (1933)	naturalized	6
Cenchrus complanatus (Nees) Morrone	intentional - forage	1921		HAES acc. no. 1488	naturalized	1
Cenchrus echinatus L.	accidental	<1864		MANN, H 309,780 (BISH)	naturalized	
Cenchrus elegans (Hassk.) Veldkamp	intentional - ornamental	1914		HAES acc. no. 897	naturalized	2
Cenchrus flaccidus (Griseb.) Morrone	intentional - forage	1990		EVANS, M M-119 (BISH)	cultivated	
Cenchrus longisetus M.C.Johnst.	intentional - ornamental	1938		Whitney et al. (1939) [appendix]	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Cenchrus orientalis</i> (Rich.) Morrone	intentional - forage	1938		HAES acc. no. 3647	cultivated	1
<i>Cenchrus purpureus</i> (Schumach.) Morrone	intentional - forage	1912		Whitney et al. (1939) [appendix]	naturalized	11
<i>Cenchrus setaceus</i> (Forssk.) Morrone	intentional - ornamental	<1914	Under an eradication campaign until about the 1940s	LEE, HA 233 (BISH)	naturalized	
<i>Cenchrus setigerus</i> Vahl	intentional - forage	1905	1905 date from material cited as " <i>Cenchrus montanus</i> "	Thielen (1905)	naturalized	5
<i>Cenchrus setosus</i> Sw.	intentional - forage	1921		HAES acc. no. 1487	naturalized	1
<i>Cenchrus tribuloides</i> L.	accidental	<1992		PERLMAN, SP 12607 (PTBG)	naturalized	
<i>Chasmanthium latifolium</i> (Michx.) H.O.Yates	intentional - ornamental	2023	Based on iNaturalist observation in community garden https://www.inaturalist.org/observations/145876671	https://www.inaturalist.org/observations/145876671	cultivated	
<i>Chimonobambusa marmorea</i> (Mitford) Makino	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Chimonobambusa quadrangularis</i> (Franceschi) Makino	intentional - ornamental	<1996		Imada et al. (1996)	cultivated	
<i>Chloothamnus elatus</i> (Holtum) Widjaja	intentional - ornamental	<2022		Whispering Winds bamboo nursery catalog. Based in Kipahulu Maui https://www.whisperingwindsbamboo.com/bamboo-varieties	cultivated	
<i>Chloris</i> × <i>pseudosagrana</i> Faccenda	autochthonous	2023	Formed spontaneously as a hybrid between <i>C. barbata</i> and <i>C. divaricata</i>	FACCENDA, K 3002 (BISH)	naturalized	
<i>Chloris barbata</i> Sw.	accidental	<1902		ANON s.n. (BISH)	naturalized	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Chloris cucullata</i> Bisch.	accidental	<1942	Specimen is labeled "Volunteer in grass garden, Pensacola Hosaka s.n." This implies the date is between 1938-1942 as all other Hosaka specimens from Pensacola are dated in that range.	HOSAKA, EY s.n. (BISH)	cultivated	
<i>Chloris divaricata</i> R.Br.	accidental	<1924		MUNRO, GC s.n. (BISH)	naturalized	
<i>Chloris gayana</i> Kunth	intentional - forage	1904		McClelland (1915).	naturalized	19
<i>Chloris pycnothrix</i> Trin.	accidental	<2022		FACCENDA, K 2864 (BISH)	naturalized	
<i>Chloris radiata</i> (L.) Sw.	accidental	<1851		REMY, MJ 76 (BISH)	naturalized	
<i>Chloris truncata</i> R.Br.	accidental	<1904		SMITH, JG s.n. (BISH)	naturalized	
<i>Chloris virgata</i> Sw.	accidental	<1903		MUNRO, GC 127 (BISH)	naturalized	4
<i>Chrysopogon aucheri</i> (Boiss.) Stapf	intentional - forage	<1916		HITCHCOCK, AS 15001 (US)	cultivated	
<i>Chrysopogon fulvus</i> (Spreng.) Chiov.	intentional - forage	1913		HAES acc. no. 789	cultivated	3
<i>Chrysopogon zizanioides</i> (L.) Roberty	intentional - ornamental	<2005		OPPENHEIMER, H H100508 (BISH)	cultivated	
<i>Chusquea coronalis</i> Soderstr. & C.E.Calderón	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Chusquea culeou</i> É.Desv.	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Chusquea liebmannii</i> E.Fourn.	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Coix lacryma-jobi</i> L.	intentional - ornamental	<1895	First record was from the wild, but it is very likely that this was intentional given the cultural uses of this plant	Whitney et al. (1939) [appendix]	naturalized	7
<i>Cortaderia jubata</i> (Lemoine) Stapf	intentional - ornamental	<1987	Under eradication campaigns	Staples et al. (2005)	naturalized	
<i>Cortaderia selloana</i> (Schult. & Schult.f.) Asch. & Graebn.	intentional - ornamental	1922		University of Hawai'i n.d.	naturalized	1
<i>Cymbopogon citratus</i> (DC.) Stapf	intentional - oil/food	<1916		FORBES, CN 695.K (BISH)	cultivated	1
<i>Cymbopogon flexuosus</i> (Nees ex Steud.) Will. Watson	intentional - oil/food	2007		KANESHIGE, C s.n. (PTBG)	cultivated	
<i>Cymbopogon refractus</i> (R.Br.) A.Camus	accidental	<1929		SHIPMAN, HC s.n. (BISH)	naturalized	
<i>Cymbopogon schoenanthus</i> (L.) Spreng.	intentional - oil/food	<1948	Potentially erroneous identification. Only reference is Neal (1948). No specimens exist.	Neal (1948)	cultivated	
<i>Cynodon aethiopicus</i> Clayton & J.R.Harlan	intentional - forage	<1962	<i>Cynodon aethiopicus</i> was described in 1970 (Clayton & Harlan 1970) and thus could not have been reported as that name when it was introduced. No specimens of <i>Cynodon plectostachyus</i> have been seen from Hawaii, making it likely that material introduced under this name was <i>C. nlemfuensis</i> , <i>C. aethiopicus</i> , or a hybrid between these.	LYMAN, CL s.n. (BISH)	naturalized	
<i>Cynodon aethiopicus</i> Clayton & J.R.Harlan × <i>C. nlemuensis</i> Vanderyst	intentional - forage	<1984		HOBODY, RW 1964 (PTBG)	naturalized	
<i>Cynodon barberi</i> Rang. & Tadul.	intentional - forage	1937	No specimens made of cultivated <i>Cynodon</i> spp. Some of these names may be erroneous	HAES acc. no. 3493	cultivated	1
<i>Cynodon dactylon</i> (L.) Pers.	intentional - forage	1835	See text	Hillebrand (1888)	naturalized	17
<i>Cynodon magennisii</i> Hurcombe	intentional - forage	1961	No specimens made of cultivated <i>Cynodon</i> spp. Some of these names may be erroneous	HAES acc. no. 5555	cultivated	1
<i>Cynodon nlemfuensis</i> Vanderyst	intentional - forage	<1915	Apparently imported as "giant bermuda grass" as the scientific name was not published until 1922, after this was imported	Anon (1916a)	naturalized	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Cynodon plectostachyus</i> (K.Schum.) Pilg.	intentional - forage	1937	No specimens made of cultivated <i>Cynodon</i> spp. Some of these names may be erroneous	HAES acc. no. 3494	cultivated	2
<i>Cynodon radiatus</i> Roth	intentional - forage	1918	No specimens made of cultivated <i>Cynodon</i> spp. Some of these names may be erroneous	HAES acc. no. 1199	cultivated	1
<i>Cynodon transvaalensis</i> Burtt Davy	intentional - forage	1958	No specimens made of cultivated <i>Cynodon</i> spp. Some of these names may be erroneous	HAES acc. no. 5561	cultivated	1
<i>Cynosurus cristatus</i> L.	intentional - forage	1887	Seeds offered for sale in newspaper ad	Anon (1887)	cultivated	6
<i>Cyrtococcum patens</i> (L.) A.Camus	accidental	<2019		BEACHY, J USARMY509 (BISH)	naturalized	
<i>Dactylis glomerata</i> L.	intentional - forage	1884	Seeds offered for sale in newspaper ad	Herbert (1884)	naturalized	26
<i>Dactyloctenium aegyptium</i> (L.) Willd.	intentional - forage	<1908	McClelland lists it as intentionally introduced before 1915. But the speciem by HAPEMAN, H 5785 (MO) demonstrates it was introduced by at least 1908	McClelland, C. K. (1915).	naturalized	
<i>Dendrocalamus asper</i> (Schult. & Schult.f.) Backer	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Dendrocalamus brandisii</i> (Munro) Kurz	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Dendrocalamus giganteus</i> Munro	intentional - ornamental	1930		Judd (1930)	cultivated	
<i>Dendrocalamus latiflorus</i> Munro	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Dendrocalamus membranaceus</i> Munro	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Dendrocalamus minor</i> (McClure) L.C.Chia & H.L.Fung	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
Dendrocalamus peculiaris Hsueh & D.Z.Li	intentional - ornamental	<2022		List of bamboo species in collection and available for sale from the Hawaii Tropical Plants Nursery in Kea'au Hawaii http://www.hawaiiantropicalplants.com/bamboo.html	cultivated	
Dendrocalamus sikkimensis Gamble ex Oliv.	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	
Dendrocalamus strictus (Roxb.) Nees	intentional - ornamental	1921		Judd (1921)	cultivated	
Dendrocalamus tibeticus Hsueh f. & T.P.Yi	intentional - ornamental	<2022		List of bamboo species in collection and available for sale from the Hawaii Tropical Plants Nursery in Kea'au Hawaii http://www.hawaiiantropicalplants.com/bamboo.html	cultivated	
Dendrocalamus yunnanicus Hsueh & D.Z.Li	intentional - ornamental	<2022		List of bamboo species in collection and available for sale from the Hawaii Tropical Plants Nursery in Kea'au Hawaii http://www.hawaiiantropicalplants.com/bamboo.html	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Deschampsia cespitosa</i> (L.) P.Beauv. subsp. <i>beringensis</i> (Hultén) W.E.Lawr.	intentional - forage	1913	HAES imports without subspecific identification, subsp. assumed for those plants	HAES acc. no. 836	naturalized	1
<i>Deschampsia elongata</i> (Hook.) Munro	intentional - forage	1935		HAES acc. no. 3188	cultivated	1
<i>Dichanthelium acuminatum</i> (Sw.) Gould & C.A.Clark	accidental	<1951		HOSAKA, EY 3636 (BISH)	naturalized	
<i>Dichanthelium oligosanthes</i> (Schult.) Gould	intentional - forage	1939		HAES acc. no. 3697	cultivated	1
<i>Dichanthium annulatum</i> (Forssk.) Stapf var. <i>annulatum</i>	accidental	<1950	Also reported by Hillebrand (at the species level as <i>Andropogon annulatum</i> so unsure exactly which variety). But it seems unlikely that this wouldn't be seen for 100 years. Hillebrand was either mistaken or the population he observed died off.	HOSAKA, EY 3614 (BISH)	naturalized	
<i>Dichanthium annulatum</i> (Forssk.) Stapf var. <i>papillosum</i> (Hochst. ex A.Rich.) de Wet & Harlan	intentional - forage	1927		HAES acc. no. 2075	naturalized	
<i>Dichanthium aristatum</i> (Poir.) C.E.Hubb.	intentional - forage	1911	Grown from seed brought by G.P. Wilder from Jamaica, West Indies	Anon (1911)	naturalized	1
<i>Dichanthium caricosum</i> (L.) A.Camus	accidental	<2023		FACCENDA, K 3093 (BISH)	naturalized	
<i>Dichanthium sericeum</i> (R.Br.) A.Camus	intentional - forage	1912		HAES acc. no. 745	naturalized	1
<i>Dichanthium tenue</i> (R.Br.) A.Camus	accidental	<1936	First seen naturalized in 1936, was later seen in 1956 in a grass garden. It is assumed that the material in the grass garden was from the wild population but it's possible that this was also imported even after it had become naturalized	HOSAKA, EY 1467 (BISH)	naturalized	
<i>Digitaria abyssinica</i> (Hochst. ex A.Rich.) Stapf	accidental	<1979		HOBDY, RW 434 (BISH)	naturalized	
<i>Digitaria argyrograpta</i> (Nees) Stapf	intentional - forage	1965		HAES acc. no. 5910	cultivated	1
<i>Digitaria bicornis</i> (Lam.) Roem. & Schult.	accidental	<1968		Rotar (1968)	naturalized	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Digitaria brownii</i> (Roem. & Schult.) Hughes	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Digitaria californica</i> (Benth.) Henrard	intentional - forage	1939		HAES acc. no. 3699	cultivated	1
<i>Digitaria ciliaris</i> (Retz.) Koeler	accidental	<1864		MANN, H s.n. (US)	naturalized	
<i>Digitaria diagonalis</i> (Nees) Stapf	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Digitaria didactyla</i> Willd.	intentional - forage	1916		HAES acc. no. 1085	naturalized	4
<i>Digitaria divaricatissima</i> (R.Br.) Hughes	accidental	<1950		HOSAKA, EY 3611 (BISH)	naturalized	
<i>Digitaria diversinervis</i> (Nees) Stapf	intentional - forage	1964		HAES acc. no. 5690	cultivated	1
<i>Digitaria eriantha</i> Steud.	intentional - forage	1935		HAES acc. no. 2993	naturalized	104
<i>Digitaria eriostachya</i> Mez	intentional - forage	<1968	Mentioned by Rotar 1968 but no context is provided. It is assumed an intentional introduction as it has traits of a favorable forage grass, and few other accidental introductions have come from its region of South America.	Rotar (1968)	naturalized	
<i>Digitaria exilis</i> (Kippist) Stapf	intentional - forage	1923		HAES acc. no. 1706	cultivated	10
<i>Digitaria fuscescens</i> (J.Presl) Henrard	accidental	<1916		HITCHCOCK, AS 14186 (BISH)	naturalized	
<i>Digitaria glauca</i> A.Camus	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Digitaria henryi</i> Rendle	accidental	<1923		MUNRO, GC 516 (BISH)	naturalized	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Digitaria horizontalis</i> Willd.	intentional - forage	1916		HAES acc. no. 1048	naturalized	1
<i>Digitaria iburua</i> Stapf	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Digitaria insularis</i> (L.) Mez ex Ekman	intentional - forage	<1913		Degener & Degener (1960); McClelland (1915)	naturalized	
<i>Digitaria longiflora</i> (Retz.) Pers.	accidental	<2023		FACCENDA, K 3008 (BISH)	cultivated	
<i>Digitaria milanjiana</i> (Rendle) Stapf	intentional - forage	1935		HAES acc. no. 2995	cultivated	69
<i>Digitaria mollicoma</i> (Kunth) Henrard	accidental	<2022		FACCENDA, K 2591 (BISH)	naturalized	
<i>Digitaria monodactyla</i> (Nees) Stapf	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Digitaria natalensis</i> Stent	intentional - forage	1964		HAES acc. no. 5691	cultivated	7
<i>Digitaria nuda</i> Schumach.	accidental	<1931		HOSAKA, EY 480 (PTBG)	naturalized	
<i>Digitaria orbata</i> Hughes	accidental	<1990		HOBDY, RW 4043 (BISH)	naturalized	
<i>Digitaria phaeothrix</i> (Trin.) Parodi	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Digitaria radicata</i> (J.Presl) Miq.	accidental	<1909		ROCK, JFC 1297 (BISH)	naturalized	
<i>Digitaria scalarum</i> (Schweinf.) Chiov.	intentional - forage	1940		ANON s.n. (BISH)	naturalized	1
<i>Digitaria seriata</i> Stapf	intentional - forage	1965		HAES acc. no. 5952	cultivated	2

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Digitaria setigera</i> Roth	accidental	~1200	See text	see text	naturalized	
<i>Digitaria stricta</i> Roth var. <i>stricta</i>	accidental	<2003		KAWELO, K s.n. (BISH)	naturalized	
<i>Digitaria tricholaenoides</i> Stapf	intentional - forage	1964		HAES acc. no. 5697	cultivated	1
<i>Digitaria velutina</i> (Forssk.) P.Beauv.	accidental	<2022		FACCENDA, K 2798 (BISH)	naturalized	
<i>Digitaria violascens</i> Link	accidental	<1852		ANDERSSON, NJ s.n. (BISH)	naturalized	
<i>Dinebra panicea</i> (Retz.) P.M.Peterson & N.Snow subsp. <i>brachiata</i> (Steud.) P.M.Peterson & N.Snow	accidental	<2011	Likely introduced in contaminated soil of nursery stock	OISC OISC20110801 (BISH)	naturalized	
<i>Dinebra retroflexa</i> (Vahl) Panz. var. <i>retroflexa</i>	accidental	<2022		FACCENDA, K 2707 (BISH)	naturalized	
<i>Diplachne fusca</i> (L.) P.Beauv. ex Roem. & Schult. subsp. <i>uninervia</i> (J.Presl) P.M.Peterson & N.Snow	intentional - forage	1913		HAES acc. no. 794	naturalized	1
<i>Disakisperma dubium</i> (Kunth) P.M.Peterson & N.Snow	accidental	<1950		HOSAKA, EY s.n. (BISH)	naturalized	
<i>Distichlis spicata</i> (L.) Greene	accidental	<1977		WATANABE, T s.n. (BISH)	naturalized	
<i>Drepanostachyum khasianum</i> (Munro) Keng f.	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Echinochloa colonum</i> (L.) Link subsp. <i>colonum</i>	accidental	<1835		NUTTALL, T s.n. (BISH)	naturalized	
<i>Echinochloa colonum</i> (L.) Link subsp. <i>edulis</i> (Honda) Banfi & Galasso	intentional - cereal	<1915		McClelland (1915).	cultivated	1
<i>Echinochloa crus-galli</i> (L.) P.Beauv. subsp. <i>crus-galli</i>	accidental	<1846	Intentionally imported by HAES 90 years after first record of naturalization	ANON s.n. (BISH)	naturalized	1
<i>Echinochloa crus-galli</i> (L.) P.Beauv. subsp. <i>utilis</i> (Ohwi & Yabuno) T.Koyama	intentional - cereal	1915		HAES (1916)	questionable	
<i>Echinochloa haploclada</i> (Stapf) Stapf	accidental	<2023		FACCENDA, K 3092 (BISH)	naturalized	
<i>Echinochloa oryzoides</i> (Ard.) Fritsch	accidental	<1903	Very likely imported with contaminated rice seed	MUNRO, GC 92 (BISH)	questionable	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Echinochloa picta</i> (J.Koenig) P.W.Michael	accidental	<1927		HADDEN, FC 307 (BISH)	questionable	
<i>Echinochloa stagnina</i> (Retz.) P.Beauv.	intentional - forage	1920	Unclear if actually imported as this name was misapplied frequently during the period to related <i>Echinochloa</i> . No specimens exist	HAES acc. no. 1416	cultivated	2
<i>Ehrharta calycina</i> Sm.	intentional - forage	1932		HAES acc. no. 2644	naturalized	2
<i>Ehrharta erecta</i> Lam.	intentional - forage	1936		HAES acc. no. 3320	naturalized	1
<i>Eleusine coracana</i> (L.) Gaertn.	accidental	<1939	From contaminated seed, first appeared in experimental plot where it was not planted	LYMAN, RA s.n. (BISH)	cultivated	
<i>Eleusine indica</i> (L.) Gaertn.	accidental	<1826		Hooker & Arnott (1841)	naturalized	
<i>Elymus canadensis</i> L.	intentional - forage	1935		HAES acc. no. 3198	cultivated	1
<i>Elymus caninus</i> (L.) L.	intentional - forage	1911		HAES acc. no. 667	cultivated	5
<i>Elymus glaucus</i> Buckley	intentional - forage	1922		HAES acc. no. 1623	cultivated	3
<i>Elymus</i> L. × <i>Triticum</i> L.	intentional - forage	1939		HAES acc. no. 3951	cultivated	1
<i>Elymus lanceolatus</i> (Scribn. & J.G.Sm.) Gould	intentional - forage	1922		HAES acc. no. 1612	cultivated	2
<i>Elymus repens</i> (L.) Gould	intentional - forage	1939		HAES acc. no. 3588	naturalized	1
<i>Elymus smithii</i> (Rydb.) Gould	intentional - forage	1911		HAES acc. no. 662	cultivated	7
<i>Elymus violaceus</i> (Hornem.) J.Feilberg	intentional - forage	1913		HAES (1916)	cultivated	
<i>Elymus virginicus</i> L.	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Enneapogon cenchroides</i> (Licht.) C.E.Hubb.	accidental	<2023		FACCENDA, K 2983 (BISH)	naturalized	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
Enneapogon desvauxii P.Beauv.	accidental	<1937		HOSAKA, EY 1709 (BISH)	questionable	
Enteropogon macrostachyus (Hochst. ex A.Rich.) Munro ex Benth.	intentional - forage	1959		HAES acc. no. 4965	cultivated	1
Entolasia marginata (R.Br.) Hughes	intentional - forage	1949		HOSAKA, EY 3607 (BISH)	naturalized	
Eragrostis barrelieri Daveau	accidental	<2004		OPPENHEIMER, H H10404 (BISH)	naturalized	
Eragrostis brownii (Kunth) Nees	intentional - forage	<1915		McClelland (1915).	naturalized	
Eragrostis cilianensis (All.) Vignolo ex Janch.	accidental	<1864		MANN, H 71 (US)	naturalized	
Eragrostis ciliaris (L.) R.Br.	accidental	<1976		HERBST, DR 5865 (US)	naturalized	
Eragrostis curvula (Schrud.) Nees	intentional - forage	1916	First imported intentionally by HAES in 1916 but this introduction did not appear to establish. A later accidental introduction into an erosion experiment plot on Kaho'olawe was the first naturalization of this species.	HAES acc. no. 1061	naturalized	5
Eragrostis cylindriflora Hochst.	accidental	<1981		HOBDY, RW 976 (BISH)	naturalized	
Eragrostis dielsii Pilg.	accidental	<2008		DIBBEN-YOUNG, A s.n. (PTBG)	naturalized	
Eragrostis elongata (Willd.) J.Jacq.	accidental	<1949		HOSAKA, EY 3596 (US)	naturalized	
Eragrostis intermedia Hitchc.	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
Eragrostis lehmanniana Nees	intentional - forage	1935		Whitney et al. (1939) [appendix]	cultivated	6
Eragrostis leptostachya (R.Br.) Steud.	intentional - forage	<1915		McClelland (1915).	naturalized	
Eragrostis mexicana (Hornem.) Link	intentional - forage	1940		Rotar (1968)	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Eragrostis multicaulis</i> Steud.	accidental	<1943		FAGERLUND, GO 818 (BISH)	naturalized	
<i>Eragrostis parviflora</i> (R.Br.) Trin.	accidental	<1929		MUNRO, GC 466 (BISH)	questionable	
<i>Eragrostis pectinacea</i> (Michx.) Nees var. <i>pectinacea</i>	accidental	<1915		HITCHCOCK, AS 13843 (US)	naturalized	
<i>Eragrostis pilosa</i> (L.) P.Beauv. var. <i>pilosa</i>	accidental	<1937		HOSAKA, EY 1696 (BISH)	naturalized	
<i>Eragrostis plana</i> Nees	intentional - forage	1916		HAES acc. no. 1060	cultivated	1
<i>Eragrostis sessilispica</i> Buckley	intentional - forage	1938		LYMAN, RA s.n. (BISH)	cultivated	
<i>Eragrostis superba</i> Peyr.	intentional - forage	<1968	Mentioned by Rotar 1968 but no context is provided.	Rotar (1968)	naturalized	
<i>Eragrostis tef</i> (Zuccagni) Trotter	intentional - cereal	1913		HAES acc. no. 823	questionable	3
<i>Eragrostis tenella</i> (L.) P.Beauv. ex Roem. & Schult.	accidental	<1871	Accidentally imported with live plants from China (Hillebrand 1888)	Hillebrand (1888)	naturalized	
<i>Eragrostis tenuifolia</i> (A.Rich.) Hochst. ex Steud.	accidental	<1985		ANON NA (NY)	naturalized	
<i>Eragrostis trichodes</i> (Nutt.) Alph.Wood	intentional - forage	1938		ANON s.n. (BISH)	cultivated	1
<i>Eragrostis unioloides</i> (Retz.) Nees ex Steud.	accidental	<1958	Also reported by Hillebrand, but it seems unlikely that it would not be seen again until 1958, thus the Hillebrand record is treated as inaccurate	KAWASAKI, A s.n. (BISH)	naturalized	
<i>Eremochloa ophiuroides</i> (Munro) Hack.	intentional - forage	1920		HAES acc. no. 1407	naturalized	1
<i>Eriochloa acuminata</i> (J.Presl) Kunth var. <i>acuminata</i>	accidental	<2000		OPPENHEIMER, H H90002 (PTBG)	naturalized	
<i>Eriochloa procera</i> (Retz.) C.E.Hubb.	accidental	<1925		ANON s.n. (BISH)	naturalized	
<i>Eriochloa punctata</i> (L.) Ham.	intentional - forage	1916		HAES acc. no. 1058	naturalized	1

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
Eriocoma hymenoides (Roem. & Schult.) Rydb.	intentional - forage	1936		HAES acc. no. 3264	cultivated	3
Eustachys distichophylla (Lag.) Nees	intentional - forage	1939		HAES acc. no. 3584	cultivated	1
Fargesia dracocephala T.P.Yi	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
Fargesia spathacea Franch.	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
Festuca bromoides L.	accidental	<1902	First appeared in the wild. HAES acc received as seed of this which was mislabeled as Danthonia pilosa	SMITH, JG s.n. (BISH)	naturalized	1
Festuca filiformis Pourr.	intentional - forage	1913		HAES acc. no. 837	cultivated	3
Festuca glauca Vill.	intentional - forage	2004		FLYNN, TW s.n. (PTBG)	cultivated	
Festuca idahoensis Elmer	intentional - forage	1939		HAES acc. no. 3542	cultivated	1
Festuca myuros L.	accidental	<1871		HILLEBRAND, WB s.n. (US)	naturalized	
Festuca octoflora Walter	intentional - forage	1940		MURPHY, FT s.n. (BISH)	cultivated	
Festuca ovina L.	intentional - forage	1911		HAES acc. no. 611	cultivated	6
Festuca rubra L.	intentional - forage	1912		HAES acc. no. 712	naturalized	12
Festuca viridula Vasey	intentional - forage	<1915		McClelland (1915).	cultivated	
Garnotia stricta Brongn. var. acutigluma (Steud.) Veldkamp	accidental	<1838		WILKES EXPEDITION s.n. (US)	naturalized	
Gastridium phleoides (Nees & Meyen) C.E.Hubb.	accidental	<1902		SMITH, JG s.n. (BISH)	naturalized	
Gigantochloa albociliata (Munro) Kurz	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
Gigantochloa apus (Schult.f.) Kurz ex Munro	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
Gigantochloa atrovioacea Widjaja	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
Gigantochloa atter (Hassk.) Kurz ex Munro	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	
Gigantochloa hasskarliana (Kurz) Backer	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	
Gigantochloa luteostriata Widjaja	intentional - ornamental	<2022		List of bamboo species in collection and available for sale from the Hawaii Tropical Plants Nursery in Kea'au Hawaii http://www.hawaiiantropicalplants.com/bamboo.html	cultivated	
Gigantochloa robusta Kurz	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	
Gigantochloa verticillata (Willd.) Munro	intentional - ornamental	<2022		List of bamboo species in collection and available for sale from the Hawaii Tropical Plants Nursery in Kea'au	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
				Hawaii http://www.hawaiiantropicalplants.com/bamboo.html		
Gigantochloa wrayi Gamble	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	
Glyceria grandis S.Watson	intentional - forage	1922		HAES acc. no. 1624	cultivated	1
Glyceria maxima (Hartm.) Holmb.	intentional - forage	<1915		McClelland (1915).	cultivated	
Glyceria notata Chevall.	accidental	<1916	Probably introduced with grass seed ; other European meadow grasses are nearby. (Hitchcock 1922)	HITCHCOCK, AS 14996 (BISH)	naturalized	
Guadua angustifolia Kunth	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
Hackelochloa granularis (L.) Kuntze	accidental	<1941	One specimen from "planted pasture", likely seed contaminant	HEYSELDEN, WH s.n. (BISH)	questionable	
Hemarthria altissima (Poir.) Stapf & C.E.Hubb.	intentional - forage	1964		HAES acc. no. 5699	naturalized	4
Hesperostipa comata (Trin. & Rupr.) Barkworth	intentional - forage	1922		HAES acc. no. 1629	cultivated	1
Hilaria belangeri (Steud.) Nash	intentional - forage	1939		HAES acc. no. 3593	cultivated	1
Hilaria cenchroides Kunth	intentional - forage	<1915		McClelland (1915).	cultivated	
Hilaria jamesii (Torr.) Benth.	intentional - forage	1939		HAES acc. no. 3594	cultivated	1
Hilaria mutica (Buckley) Benth.	intentional - forage	1907		Brown (1907)	cultivated	1

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
Himalayacalamus hookerianus (Munro) Stapleton	intentional - ornamental	<2022		List of bamboo species in collection and available for sale from the Hawaii Tropical Plants Nursery in Kea'au Hawaii http://www.hawaiiantropicalplants.com/bamboo.html	cultivated	
Holcus lanatus L.	intentional - forage	<1885		Munro (1905)	naturalized	4
Hopia obtusa (Kunth) Zuloaga & Morrone	intentional - forage	1936		HAES acc. no. 3213	cultivated	1
Hordeum bulbosum L.	intentional - forage	1935		Whitney et al. (1939) [appendix]	cultivated	1
Hordeum depressum (Scribn. & J.G.Sm.) Rydb.	accidental	<1936		HOSAKA, EY 1623 (BISH)	questionable	
Hordeum murinum L. subsp. leporinum (Link) Arcang.	accidental	<1903	Known on the Parker ranch as California grass, because it was introduced in California hay (McClelland 1915)	MUNRO, GC 61 (BISH)	naturalized	
Hordeum vulgare L. subsp. vulgare	intentional - cereal	1908		HAES acc. no. 397	naturalized	80
Hyparrhenia dregeana (Nees) Stapf ex Stent	accidental	<1975		HERBST, DR 5289 (BISH)	naturalized	
Hyparrhenia hirta (L.) Stapf	intentional - forage	1939	Date of 1916 listed by Rotar (1968) but this is likely erroneous	LYMAN, RA 3187 (BISH)	naturalized	
Hyparrhenia rufa (Nees) Stapf var. rufa	intentional - forage	1916		HAES acc. no. 1070	naturalized	3
Imperata cylindrica (L.) Raeusch.	intentional - forage	<1968	Naturalization status when reported by Rotar unclear, assuming he was referring to the cultivated "japanese bloodgrass". But I have found no records going back before 2000.	Rotar (1968)	eradicated	
Indocalamus tessellatus (Munro) Keng f.	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
Isachne myosotis Nees	intentional - forage	<1871	Mentioned in Hillebrand (1888) as "spreading from gardens" and "a handsome creeping lawn grass". Hillebrand does not state whether this grass was an intentional or accidental introduction. Given that this grass has not naturalized anywhere outside of its native range, it is assumed that this was an intentional introduction which did not persist. It is also possible that it was a misidentification.	Hillebrand (1888)	cultivated	
Ischaemum aristatum L.	accidental	<1994		WELTON, P 1855-002 (BISH)	naturalized	
Ischaemum ciliare Retz.	accidental	<1941		HOSAKA, EY 2596 (BISH)	naturalized	1
Ischaemum polystachyum J.Presl	intentional - forage	1955		Rotar (1968)	naturalized	1
Ixophorus unisetus (J.Presl) Schltldl.	intentional - forage	1921		HAES acc. no. 1486	questionable	1
Janochloa antidotale (Retz.) Zuloaga & Delfini	intentional - forage	1916		HAES acc. no. 1063	naturalized	5
Jarava plumosa (Spreng.) S.W.L.Jacobs & J.Everett	intentional - forage	1936		HAES acc. no. 3340	cultivated	1
Koeleria macrantha (Ledeb.) Schult.	accidental	<1909		ROCK, JFC 3257 (BISH)	naturalized	
Lamarckia aurea (L.) Moench	accidental	<1937		HOSAKA, EY 1831 (BISH)	questionable	
Leptochloa virgata (L.) P.Beauv.	intentional - forage	1911	HAES accession from Von. Tempsky in Makawao who imported it	MUNRO, GC 1725.O (BISH)	questionable	1
Leymus condensatus (J.Presl) Á.Löve	intentional - forage	1912		HAES acc. no. 686	cultivated	3
Leymus triticoides (Buckley) Pilg.	accidental	<1936		HOSAKA, EY 1605 (PTBG)	questionable	
Lolium arundinaceum (Schreb.) Darbysh.	intentional - forage	1887	Seeds offered for sale in newspaper ad	Anon (1887)	naturalized	18
Lolium multiflorum Lam.	intentional - forage	1884	Seeds offered for sale in newspaper ad	Herbert (1884)	naturalized	13

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Lolium perenne</i> L.	intentional - forage	1884	Seeds offered for sale in newspaper ad	Herbert (1884)	naturalized	41
<i>Lolium pratense</i> (Huds.) Darbysh.	intentional - forage	1905		Thielen (1905)	cultivated	1
<i>Lolium rigidum</i> Gaudin	intentional - forage	1936		HAES acc. no. 3333	cultivated	1
<i>Lolium subulatum</i> Vis.	intentional - forage	1931		HAES acc. no. 2525	cultivated	4
<i>Lolium temulentum</i> L.	accidental	<1841	Almost certainly imported with contaminated wheat seed	ANON s.n. (US)	naturalized	
<i>Macrochloa tenacissima</i> (L.) Kunth	intentional - forage	1908		Hosmer (1909)	cultivated	
<i>Melica californica</i> Scribn.	intentional - forage	1936		HAES acc. no. 3345	cultivated	1
<i>Melinis minutiflora</i> P.Beauv.	intentional - forage	1913		HAES acc. no. 744	naturalized	17
<i>Melinis nerviglumis</i> (Franch.) Zizka	intentional - ornamental	<2011		Snow & Davidse (2011)	questionable	
<i>Melinis repens</i> (Willd.) Zizka	intentional - forage	1894	It originated from a two penny packet” of seed purchased by W. Herbert Purvis of Kukuihaele, Hawaii, during the latter part of the Nineteenth Century." Degener (1938)	Ripperton (1933)	naturalized	3
<i>Melinis scabrida</i> (K.Schum.) Hack.	accidental	<2005		WELTON, P (HALE)	naturalized	
<i>Melocanna baccifera</i> (Roxb.) Kurz	intentional - ornamental	<1951		LANDGRAF, MF 13 (BISH)	cultivated	
<i>Microlaena stipoides</i> (Labill.) R.Br.	accidental	<1902	Naturalized date likely much earlier than this (Whitney et al. 1937). HAES accession received long after this was naturalized	SMITH, JG s.n. (BISH)	naturalized	2
<i>Miscanthus floridulus</i> (Labill.) Warb. ex K.Schum. & Lauterb.	intentional - ornamental	<1995	Almost certainly intentional given that this is an ornamental species, but no records have been recorded of it in captivity in Hawaii	FUNK, EJ s.n. (BISH)	naturalized	
<i>Miscanthus fuscus</i> (Roxb.) Benth.	intentional - ornamental	1948	Only mentioned by St. John (1973). Potentially erroneous identification of another cultivated <i>Miscanthus</i>	St. John (1973)	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
Miscanthus sinensis Andersson	intentional - ornamental	<1931		CAUM, EL s.n. (BISH)	cultivated	
Moorochloa eruciformis (Sm.) Veldkamp	accidental	<2023		FACCENDA, K 3080 (BISH)	naturalized	
Muhlenbergia mexicana (L.) Trin.	accidental	<1933		ST JOHN, H s.n. (BISH)	questionable	
Muhlenbergia microsperma (DC.) Kunth	accidental	<1907		ANON s.n. (BISH)	naturalized	
Muhlenbergia paniculata (Nutt.) P.M.Peterson	intentional - forage	1916		HAES acc. no. 1064	cultivated	1
Muhlenbergia phleoides (Kunth) P.M.Peterson	intentional - forage	1939		HAES acc. no. 3620	cultivated	1
Muhlenbergia porteri Scribn.	intentional - forage	1905		Munro (1905)	cultivated	2
Muhlenbergia racemosa (Michx.) Britton, Sterns & Poggenb.	intentional - forage	1922		HAES acc. no. 1618	cultivated	1
Muhlenbergia repens (J.Presl) Hitchc.	intentional - forage	1939		HAES acc. no. 3692	cultivated	1
Muhlenbergia sericea (Michx.) P.M. Peterson	intentional - ornamental	<2023		Daniella Frohlich pers. comm. https://www.inaturalist.org/observations/187203230	cultivated	
Narenga porphyrocoma (Hance) Bor	intentional - ornamental	1930		Rotar (1968)	cultivated	
Nassella cernua (Stebbins & Love) Barkworth	accidental	<1957		CHRIST, JH s.n. (BISH)	naturalized	
Nassella leucotricha (Trin. & Rupr.) R.W.Pohl	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
Nassella tenuissima (Trin.) Barkworth	intentional - ornamental	<2009		OED 2009032403 (BISH)	cultivated	
Nassella viridula (Trin.) Barkworth	intentional - forage	1922		HAES acc. no. 1619	cultivated	2

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Oloptum miliaceum</i> (L.) Röser & Hamasha	intentional - forage	1918		HAES acc. no. 1277	naturalized	4
<i>Oplismenus burmanni</i> (Retz.) P.Beauv.	accidental	<1916		FORBES, CN 495.K (BISH)	questionable	
<i>Oplismenus compositus</i> (L.) P.Beauv.	accidental	<1902		PAHU s.n. (BISH)	naturalized	
<i>Oplismenus hirtellus</i> (L.) P.Beauv. subsp. <i>hirtellus</i>	accidental	<1826	First introduction was the wild type plants, variegated plants were later intentionally introduced	Hooker & Arnott (1841)	naturalized	
<i>Oryza sativa</i> L.	intentional - cereal	1816	First introduction by Don Francisco de Paula Marin	Nagata (1985)	questionable	10
<i>Otatea acuminata</i> (Munro) C.E.Calderón ex Soderstr.	intentional - ornamental	<1995		FLYNN, TW 5820 (PTBG)	cultivated	
<i>Otatea glauca</i> L.G.Clark & G.Cortés	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	
<i>Oxytenanthera abyssinica</i> (A.Rich.) Munro	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	
<i>Panicum capillare</i> L.	intentional - forage	1922	Reported in 1826 in Bot. Beechey's Voyage, but this likely referred to a native <i>Panicum</i>	HAES acc. no. 1635	questionable	1
<i>Panicum coloratum</i> L.	intentional - forage	1938		HAES acc. no. 3780	naturalized	2
<i>Panicum decompositum</i> R.Br.	intentional - forage	<1930	Date approximately between 1915-1930 as this was when Munro collected. Specimens were undated.	MUNRO, GC 504 (BISH)	cultivated	
<i>Panicum dichotomiflorum</i> Michx.	intentional - forage	1939		O'Connor (1990)	naturalized	1
<i>Panicum miliaceum</i> L.	intentional - cereal	1913		HAES acc. no. 822	questionable	12

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Panicum pygmaeum</i> (R.Br.) E.J.Thomps.	accidental	<1989		PRATT, LW 2282 (HAVO)	naturalized	
<i>Panicum repens</i> L.	accidental	<1916		HITCHCOCK, AS 14145 (IAN)	naturalized	
<i>Panicum schinzii</i> Hack.	intentional - forage	1917		HAES acc. no. 1099	cultivated	1
<i>Panicum virgatum</i> L.	intentional - forage	1935		HAES acc. no. 3199	cultivated	6
<i>Pappophorum bicolor</i> E.Fourn.	accidental	<2008		HOBODY, RW 4300 (BISH)	naturalized	
<i>Paspalum alnum</i> Chase	intentional - forage	1939		HAES acc. no. 3992	cultivated	1
<i>Paspalum arundinaceum</i> Poir.	accidental	<2005		OPPENHEIMER, H H100509 (BISH)	naturalized	
<i>Paspalum atratum</i> Swallen	intentional - forage	1996		Glen Fukumoto The forages website https://www.ctahr.hawaii.edu/forages/grasses.html	cultivated	
<i>Paspalum bertonii</i> Hack.	intentional - forage	1916		HAES acc. no. 1049	cultivated	1
<i>Paspalum conjugatum</i> P.J.Bergius	accidental	1837	See text	Whitney (1887)	naturalized	
<i>Paspalum denticulatum</i> Trin.	intentional - forage	1939		HAES acc. no. 3696	cultivated	1
<i>Paspalum dilatatum</i> Poir.	intentional - forage	1903		Brown (1907)	naturalized	7
<i>Paspalum distichum</i> L.	accidental	1916	Later introduced deliberately	Wester (1992)	naturalized	1
<i>Paspalum fimbriatum</i> Kunth	accidental	<1916		HITCHCOCK, AS 13672 (US)	naturalized	
<i>Paspalum floridanum</i> Michx.	intentional - forage	1912		HAES (1913)	cultivated	1
<i>Paspalum hartwegianum</i> E.Fourn.	intentional - forage	1939		HAES acc. no. 3694	cultivated	1

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Paspalum humboldtianum</i> Flügge	accidental	<1953		HOSAKA, EY s.n. (BISH)	questionable	
<i>Paspalum jesuiticum</i> Parodi	unclear	<2003	Likely intentional, but no sources mention this grass. It is a highly regarded pasture grass in its native range, and there are few other accidental introductions from its native range	BIO, KF 03-2015 (BISH)	naturalized	
<i>Paspalum langei</i> (E.Fourn.) Nash	accidental	<2022		FACCENDA, K 2861 (BISH)	naturalized	
<i>Paspalum macrophyllum</i> Kunth	accidental	<1994		IMADA, CT 94-9 (BISH)	naturalized	
<i>Paspalum malacophyllum</i> Trin.	intentional - forage	1939		HAES acc. no. 3540	naturalized	2
<i>Paspalum mandiocanum</i> Trin. var. <i>mandiocanum</i>	unclear	<1987	Imported to other tropical areas as a forage grass and it seems likely that it would have been imported here too. But there is no evidence I have found that it was imported here in Hawaii.	HOBODY, RW 2913 (BISH)	naturalized	
<i>Paspalum minus</i> E.Fourn.	accidental	<2022		FACCENDA, K 2579 (BISH)	naturalized	
<i>Paspalum notatum</i> Flügge	intentional - forage	1913		HAES acc. no. 792	naturalized	12
<i>Paspalum paniculatum</i> L.	accidental	<1939	First record from "grass garden" seemingly as a volunteer. It was not identified to species level, further suggesting that it was not planted. J.C. Ripperton collected almost entirely wild plants giving further evidence that this was a volunteer. <i>P. paniculatum</i> was collected one year later where it was explicitly a volunteer in grass garden at Pensacola. No record of intentional importation.	RIPPERTON, JC s.n. (BISH)	naturalized	
<i>Paspalum pilosum</i> Lam.	accidental	<2007	Collected from trail which was hydroseeded to reduce erosion. It is unclear if this was seeded intentionally or was a contaminant	OPPENHEIMER, H H110708 (BISH)	naturalized	
<i>Paspalum plicatulum</i> Michx.	intentional - forage	1935		HAES acc. no. 3189	naturalized	1
<i>Paspalum racemosum</i> Lam.	intentional - forage	1913		HAES acc. no. 791	cultivated	1

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Paspalum setaceum</i> Michx.	intentional - forage	1939		HAES acc. no. 3598	cultivated	1
<i>Paspalum tenellum</i> Willd.	intentional - forage	<1915		McClelland (1915).	cultivated	
<i>Paspalum urvillei</i> Steud.	intentional - forage	1907		Brown (1907)	naturalized	4
<i>Paspalum vaginatum</i> Sw.	accidental	<1936		FOSBERG, FR 13182 (BISH)	naturalized	
<i>Paspalum virgatum</i> L.	accidental	<2003		KAWELO, K s.n. (BISH)	naturalized	
<i>Pentapogon crinitus</i> (L.f.) P.M.Peterson, Romasch. & Soreng	accidental	<1982		HOBODY, RW 1419 (BISH)	naturalized	
<i>Pentapogon micranthus</i> (Cav.) P.M.Peterson, Romasch. & Soreng	accidental	<1938		HOSAKA, EY 1947 (BISH)	naturalized	
<i>Phalaris aquatica</i> L.	intentional - forage	1914		HAES acc. no. 869	naturalized	14
<i>Phalaris arundinacea</i> L.	intentional - ornamental	1922		HAES acc. no. 1630	cultivated	3
<i>Phalaris californica</i> Hook. & Arn.	intentional - forage	1939		HAES acc. no. 3698	cultivated	1
<i>Phalaris canariensis</i> L.	intentional - forage	1933		EWART III, GR 331 (BISH)	questionable	
<i>Phalaris caroliniana</i> Walter	intentional - forage	1940		MURPHY, FT s.n. (BISH)	cultivated	
<i>Phalaris coerulescens</i> Desf.	intentional - forage	1912		HAES acc. no. 805	cultivated	1
<i>Phalaris minor</i> Retz.	accidental	<1903		MUNRO, GC 126 (BISH)	naturalized	
<i>Phalaris paradoxa</i> L.	accidental	<1903		COUTER, FE s.n. (BISH)	questionable	
<i>Phleum pratense</i> L.	intentional - forage	1846	First intentionally imported European forage	Anon (1846)	naturalized	5
<i>Phleum subulatum</i> (Savi) Asch. & Graebn.	intentional - forage	1913		HAES acc. no. 858	cultivated	1

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	accidental	<1956	Only known from naturalized collections on Oahu, but this a rather charismatic cane like species and may have been intentionally imported	PEARSALL, GA s.n. (BISH)	questionable	
<i>Phyllostachys aurea</i> (André) Rivière & C.Rivière	intentional - ornamental	<1935		CAUM, EL 25 (US)	naturalized	
<i>Phyllostachys dulcis</i> McClure	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Phyllostachys edulis</i> (Carrière) J.Houz.	intentional - ornamental	<1973		St. John (1973)	cultivated	
<i>Phyllostachys nidularia</i> Munro	intentional - ornamental	<1958		ROCK, JFC s.n. (BISH)	cultivated	
<i>Phyllostachys nigra</i> (Lodd. ex Lindl.) Munro	intentional - ornamental	<1935		CAUM, EL 15 (US)	naturalized	
<i>Phyllostachys nuda</i> McClure	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Phyllostachys reticulata</i> (Rupr.) K.Koch	intentional - ornamental	<1921		HITCHCOCK, AS 19700 (US)	cultivated	
<i>Phyllostachys vivax</i> McClure	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Piptatherum coerulescens</i> (Desf.) P.Beauv.	intentional - forage	1939		HAES acc. no. 3627	cultivated	1
<i>Pleioblastus argenteostriatus</i> (Regel) Nakai	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Pleioblastus distichus</i> (Mitford) Nakai	intentional - ornamental	1948		Neal (1948)	cultivated	
<i>Pleioblastus gramineus</i> (Bean) Nakai	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Pleioblastus variegatus</i> (J.Dix) Makino	intentional - ornamental	<1996		Imada et al. (1996)	cultivated	
<i>Pleioblastus viridistriatus</i> (Regel) Makino	intentional - ornamental	<1973		St. John (1973)	cultivated	
<i>Poa annua</i> L.	accidental	<1838		WILKES EXPEDITION s.n. (US)	naturalized	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Poa arachnifera</i> Torr.	intentional - forage	1912		HAES acc. no. 804	cultivated	2
<i>Poa bulbosa</i> L.	intentional - forage	1937		HAES acc. no. 3502	cultivated	1
<i>Poa compressa</i> L.	intentional - forage	1913		HAES acc. no. 841	questionable	1
<i>Poa flabellata</i> (Lam.) Raspail	intentional - forage	1916		Rotar (1968)	cultivated	1
<i>Poa nemoralis</i> L.	intentional - forage	1913		HAES acc. no. 859	cultivated	1
<i>Poa nervosa</i> (Hook.) Vasey	intentional - forage	1935		HAES acc. no. 3190	cultivated	1
<i>Poa pratensis</i> L.	intentional - forage	1879		McClelland (1915).	naturalized	15
<i>Poa secunda</i> J.Presl	intentional - forage	1922	Specimen with blank label and "College of Hawaii Herbarium" header indicating it is pre 1922. It is assumed this collection is of a cultivated plant.	ANON s.n. (BISH)	cultivated	1
<i>Poa trivialis</i> L.	intentional - forage	1913		HAES acc. no. 857	cultivated	3
<i>Polypogon fugax</i> Nees ex Steud.	accidental	<1838		WILKES EXPEDITION s.n. (US)	naturalized	
<i>Polypogon monspeliensis</i> (L.) Desf.	accidental	<1909		FAURIE, A 1310 (US)	naturalized	
<i>Polypogon viridis</i> (Gouan) Breistr.	accidental	<1864		MANN, H 273 (BISH)	naturalized	
<i>Polytoca macrophylla</i> Benth.	intentional - forage	<1929		CAUM, EL s.n. (BISH)	cultivated	1
<i>Polytrias indica</i> (Houtt.) Veldkamp	intentional - forage	1916		HAES acc. no. 1084	cultivated	3
<i>Pseudoroegneria spicata</i> (Pursh) Á.Löve	intentional - forage	1911		Whitney et al. (1939) [appendix]	cultivated	4
<i>Pseudosasa amabilis</i> (McClure) Keng f.	intentional - ornamental	<2022		<u>Lydgate Farms Bamboo inventory</u>	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
				https://lydgatefarm.com/our-story/		
<i>Pseudosasa japonica</i> (Siebold & Zucc. ex Steud.) Makino ex Nakai	intentional - ornamental	<1935		CAUM, EL 28 (US)	cultivated	
<i>Puccinellia distans</i> (Jacq.) Parl.	intentional - forage	1940		ANON s.n. (BISH)	cultivated	
<i>Raddia brasiliensis</i> Bertol.	intentional - ornamental	<1996		Imada et al. (1996)	cultivated	
<i>Rugolosa pilosa</i> (Sw.) Zuloaga	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Rytidosperma biannulare</i> (Zotov) Connor & Edgar	intentional - forage	1913		HAES acc. no. 851	naturalized	7
<i>Rytidosperma penicillatum</i> (Labill.) Connor & Edgar	intentional - forage	1903		Whitney et al. (1939) [appendix]	naturalized	4
<i>Saccharum edule</i> Hassk.	intentional - oil/food	<1996		Imada et al. (1996)	cultivated	
<i>Saccharum officinarum</i> L.	intentional - oil/food	~1200	Canoe plant; early polynesian introduction	see text	cultivated	23
<i>Saccharum robustum</i> E.W.Brandes & Jeswiet ex Grassl	intentional - oil/food	1929		Rotar (1968)	cultivated	
<i>Saccharum sinense</i> Roxb.	intentional - oil/food	1905		Rotar (1968)	naturalized	3
<i>Saccharum spontaneum</i> L.	intentional - oil/food	1918	Introduction date may have been earlier by the Hawaii Sugar Planters Association for breeding studies, but their literature was not reviewed extensively	HAES acc. no. 1204	naturalized	1
<i>Sacciolepis indica</i> (L.) Chase	accidental	<1908		LYON, HL s.n. (BISH)	naturalized	
<i>Sarga intrans</i> (F.Muell. ex Benth.) Spangler	intentional - forage	1949		HOSAKA, EY 3608 (BISH)	cultivated	1
<i>Sasa palmata</i> (Burb.) E.G.Camus	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
Schizachyrium microstachyum (Desv.) Roseng., B.R.Arrill. & Izag.	accidental	<1961	According to O. Degener 35273 (BISH), it was apparently imported to the islands with hay for mule feed after WWII.	FOSBERG, FR 42065 (BISH)	naturalized	
Schizachyrium sanguineum (Retz.) Alston	accidental	<1987		NAGATA, KM 3743 (BISH)	naturalized	
Schizachyrium scoparium (Michx.) Nash	intentional - forage	1922		HAES acc. no. 1626	cultivated	2
Schizostachyum brachycladum (Kurz ex Munro) Kurz	intentional - ornamental	<2022		O'ahu Bamboo Nursery catalog; Wailua, O'ahu; https://www.oahu.bamboo.com/show	cultivated	
Schizostachyum dumetorum (Hance ex Walp.) Munro	intentional - ornamental	<1935		CAUM, EL 23 (US)	cultivated	
Schizostachyum glaucifolium (Rupr.) Munro	intentional - ornamental	~1200	Canoe plant; early polynesian introduction	see text	cultivated	
Schizostachyum jaculans Holttum	intentional - ornamental	<2022		List of bamboo species in collection and available for sale from the Hawaii Tropical Plants Nursery in Kea'au Hawaii http://www.hawaiiantropicalplants.com/bamboo.html	cultivated	
Schizostachyum pergracile (Munro) R.B.Majumdar	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	
Secale cereale L.	intentional - cereal	1906		Whitney et al. (1939) [appendix]	cultivated	12
Sehima nervosa (Rottler) Stapf	intentional - forage	1936		HAES acc. no. 3322	cultivated	2

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Semiarundinaria fastuosa</i> (Lat.-Marl. ex Mitford) Makino	intentional - ornamental	<1996		Imada et al. (1996)	cultivated	
<i>Setaria adhaerens</i> (Forssk.) Chiov.	accidental	<1871		Hillebrand (1888)	naturalized	
<i>Setaria flavida</i> (Retz.) Veldkamp	accidental	<1937		HOSAKA, EY 1858 (BISH)	naturalized	
<i>Setaria italica</i> (L.) P.Beauv.	intentional - cereal	1904		Clark (1904)	naturalized	6
<i>Setaria jubiflora</i> (Trin.) R.D.Webster	intentional - forage	1939		HAES acc. no. 3596	cultivated	2
<i>Setaria longiseta</i> P.Beauv.	intentional - forage	1959		HAES acc. no. 4966	cultivated	1
<i>Setaria palmifolia</i> (J.Koenig) Stapf	unclear	<1871	Hillebrand states "the following species, accidentally introduced with living plants from abroad, had become established in gardens before my departure, and are likely to have escaped to the open country by this time." It is also possible that this was instead introduced as an ornamental or food plant, as such a mechanism would also lead to its establishment in gardens.	Hillebrand (1888)	naturalized	
<i>Setaria parviflora</i> (Poir.) Kerguelen	accidental	<1851	The seed was introduced in hay from California (McClelland 1915); Later imported intentionally by HAES. Subject to various eradication campaigns by ranchers.	REMY, MJ 106 (BISH)	naturalized	1
<i>Setaria sphacelata</i> (Schumach.) Stapf & C.E.Hubb. ex Moss	intentional - forage	1959		HAES acc. no. 4962	naturalized	42
<i>Setaria viridis</i> (L.) P. Beauv.	accidental	2023	Likely a birdseed contaminant	Faccenda (2023)	questionable	
<i>Shibataea kumasasa</i> (Zoll. ex Steud.) Makino	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Sinobambusa henryi</i> (McClure) C.D.Chu & C.S.Chao	intentional - ornamental	<1935		CAUM, EL 1 (US)	cultivated	
<i>Sinobambusa tootsik</i> (Makino) Makino ex Nakai	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
<i>Sorghastrum nutans</i> (L.) Nash	intentional - forage	1939		HAES acc. no. 3599	cultivated	1

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Sorghum alnum</i> Parodi	intentional - forage	1953		HAES acc. no. 4758	cultivated	2
<i>Sorghum bicolor</i> (L.) Moench subsp. <i>bicolor</i>	intentional - cereal	1857	First recorded importation is by W. Hillebrand	Hillebrand (1857)	questionable	187
<i>Sorghum bicolor</i> (L.) Moench subsp. <i>drummondii</i> (Nees ex Steud.) de Wet ex Davidse	intentional - forage	1895	Cited as Sunter Forage. Other sources link this to the scientific name	Anon (1885)	naturalized	20
<i>Sorghum bicolor</i> (L.) Moench subsp. <i>verticilliflorum</i> (Steud.) de Wet ex Wiersema & J.Dahlb.	intentional - forage	1948		HAES acc. no. 4270	cultivated	5
<i>Sorghum halepense</i> (L.) Pers.	intentional - forage	<1882	Possibly earlier, this is the date of publication. The introduction date is not stated.	McCully (1883)	naturalized	4
<i>Sorghum laxiflorum</i> F.M.Bailey	intentional - forage	1948		HAES acc. no. 4271	cultivated	1
<i>Sorghum virgatum</i> (Hack.) Stapf	intentional - forage	1913		HAES acc. no. 742	cultivated	1
<i>Sphenopholis obtusata</i> (Michx.) Scribn.	accidental	<1933		CAUM, EL s.n. (BISH)	questionable	
<i>Sporobolus africanus</i> (Poir.) Robyns & Tournay	accidental	<1903		COUTER, FE s.n. (BISH)	naturalized	
<i>Sporobolus airoides</i> (Torr.) Torr.	intentional - forage	1936		HAES acc. no. 3215	cultivated	2
<i>Sporobolus coromandelianus</i> (Retz.) Kunth	accidental	<2022		FACCENDA, K 2735 (BISH)	naturalized	
<i>Sporobolus cryptandrus</i> (Torr.) A.Gray	intentional - forage	1905		Munro (1905)	cultivated	
<i>Sporobolus diandrus</i> (Retz.) P.Beauv.	accidental	<1911		FORBES, CN 1715.O (BISH)	naturalized	
<i>Sporobolus domingensis</i> (Trin.) Kunth	accidental	<1992		FUNK, EJ s.n. (BISH)	naturalized	
<i>Sporobolus elongatus</i> R.Br.	intentional - forage	1905	Cited as "rat's tail or new zealand timothy" by Von Tempsky. McClelland (1915) later confirms that this is <i>S. elongatus</i>	Thielen (1905)	naturalized	
<i>Sporobolus fertilis</i> (Steud.) Clayton	accidental	<1936		HOSAKA, EY 1623 (BISH)	naturalized	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Sporobolus fimbriatus</i> (Nees ex Trin.) Nees	intentional - forage	1939		HAES acc. no. 3631	cultivated	1
<i>Sporobolus flexuosus</i> (Vasey) Rydb.	intentional - forage	1936		HAES acc. no. 3216	cultivated	1
<i>Sporobolus indicus</i> (L.) R.Br.	intentional - forage	1912	First introduction as live plants from Louisiana. Second introduction as seed contaminant in <i>Brachiaria</i> seeds	HAES acc. no. 709	naturalized	3
<i>Sporobolus pyramidatus</i> (Lam.) Hitchc.	accidental	<1967		HERBST, DR 486 (BISH)	naturalized	
<i>Sporobolus tenuissimus</i> (Mart. ex Schrank) Kuntze	accidental	<2022	Likely introduced in contaminated soil of nursery stock	FACCENDA, K 2516 (BISH)	naturalized	
<i>Sporobolus townsendii</i> (H.Groves & J.Groves) P.M.Peterson & Saarela	intentional - forage	1933		HAES acc. no. 2703	cultivated	1
<i>Sporobolus wrightii</i> Scribn.	intentional - forage	1905		Munro (1905)	cultivated	1
<i>Stapfochloa berroi</i> (Arechav.) P.M.Peterson	intentional - forage	1936		HAES acc. no. 3206	cultivated	2
<i>Stapfochloa ciliata</i> (Sw.) P.M.Peterson	intentional - forage	<1915		McClelland (1915).	cultivated	
<i>Stapfochloa elata</i> (Desv.) P.M.Peterson	intentional - forage	1914		HAES acc. no. 892	cultivated	2
<i>Stenotaphrum secundatum</i> (Walter) Kuntze	accidental	<1826		Hooker & Arnott (1841)	naturalized	3
<i>Themeda arguens</i> (L.) Hack.	intentional - forage	1938		HAES acc. no. 3650	cultivated	1
<i>Themeda quadrivalvis</i> (L.) Kuntze	intentional - forage	1939		HAES acc. no. 3953	questionable	1
<i>Themeda triandra</i> Forssk.	intentional - forage	1936		Whitney et al. (1939) [appendix]	cultivated	1
<i>Themeda villosa</i> (Poir.) A.Camus	intentional - forage	1924		O'Connor (1990)	naturalized	3
<i>Thinopyrum elongatum</i> (Host) D.R.Dewey	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
Thinopyrum intermedium (Host) Barkworth & D.R.Dewey	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
Thyrsostachys siamensis Gamble	intentional - ornamental	<1997		Bezona & Rauch (1997)	cultivated	
Thysanolaena latifolia (Roxb. ex Hornem.) Honda	intentional - ornamental	1916		University of Hawai'i n.d.	naturalized	
Tongpeia fungosa (T.P.Yi) Stapleton	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	
Trachypogon spicatus (L.f.) Kuntze	intentional - forage	1948		HAES acc. no. 4272	cultivated	1
Tragus berteronianus Schult.	accidental	<1935		Whitney et al. (1939) [appendix]	naturalized	
Trichoneura elegans Swallen	intentional - forage	1939		HAES acc. no. 3600	cultivated	1
Tridens flavus (L.) Hitchc.	accidental	1938	First appeared as grass introduction garden from contaminated seed. Intentionally imported one year later	ANON s.n. (BISH)	cultivated	1
Tripidium arundinaceum (Retz.) Welker, Voronts. & E.A.Kellogg	intentional - ornamental	1937		MANGELSDORF, AJ s.n. (BISH)	cultivated	
Tripidium bengalense (Retz.) H.Scholz	intentional - ornamental	1920		Rotar (1968)	cultivated	
Tripidium ravennae (L.) H.Scholz	intentional - ornamental	1939		HAES acc. no. 3954	cultivated	1
Tripsacum dactyloides (L.) L.	intentional - forage	1939		HAES acc. no. 4015	cultivated	2
Tripsacum laxum Nash	intentional - forage	1919		HAES acc. no. 1325	cultivated	3

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Triraphis mollis</i> R.Br.	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Trisetum flavescens</i> (L.) P.Beauv. subsp. <i>flavescens</i>	intentional - forage	1913		HAES acc. no. 835	questionable	1
<i>Triticum aestivum</i> L. subsp. <i>aestivum</i>	intentional - cereal	<1820	First introduction unclear as first report was by Wilkes after it had already been planted	Wilkes (1845)	questionable	20
<i>Triticum aestivum</i> L. subsp. <i>spelta</i> (L.) Thell.	intentional - cereal	1910		HAES acc. no. 407	cultivated	1
<i>Urochloa arrecta</i> (Hack.) Morrone & Zuloaga	unclear	<2022	Only known from one naturalized collection, but this is a highly regarded tropical forage and it seems likely it was imported	FACCENDA, K 2777 (BISH)	naturalized	
<i>Urochloa brizantha</i> (A.Rich.) R.D.Webster	intentional - forage	1938		HAES acc. no. 3766	naturalized	8
<i>Urochloa brizantha</i> (A.Rich.) R.D.Webster × <i>U. eminii</i> (Mez) Davidse	intentional - forage	<2010		USDA plant materials center molokai pers. comm	cultivated	
<i>Urochloa ciliatissima</i> (Buckley) R.D.Webster	intentional - forage	1938		HAES acc. no. 3767	cultivated	1
<i>Urochloa dictyoneura</i> (Fig. & De Not.) Veldkamp	intentional - forage	1935		HAES acc. no. 2996	cultivated	2
<i>Urochloa distachyos</i> (L.) T.Q.Nguyen	accidental	<1938	First found growing wild in pasture. Later introduced again intentionally.	HOSAKA, EY 2341 (BISH)	naturalized	
<i>Urochloa eminii</i> (Mez) Davidse	intentional - forage	1965		HAES acc. no. 5974	naturalized	4
<i>Urochloa fusca</i> (Sw.) B.F.Hansen & Wunderlin	intentional - forage	1939		LYMAN, RA s.n. (BISH)	cultivated	
<i>Urochloa glumaris</i> (Trin.) Veldkamp	accidental	<2021		FACCENDA, K 1763 (BISH)	naturalized	
<i>Urochloa lachnantha</i> (Hochst.) A.M.Torres & C.M.Morton	intentional - forage	1905		Thielen (1905)	cultivated	
<i>Urochloa maxima</i> (Jacq.) R.D.Webster	intentional - forage	<1871	See text for extensive discussion, it may have appeared accidentally before the first known importation.	Hillebrand (1888)	naturalized	186

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Urochloa mollis</i> (Sw.) Morrone & Zuloaga	accidental	<1997		STAPLES, GW 1153 (BISH)	questionable	
<i>Urochloa mutica</i> (Forssk.) T.Q.Nguyen	intentional - forage	1901	Cited as <i>Panicum</i> grass, a name used by many period sources for this species	Anon (1901)	naturalized	1
<i>Urochloa oligotricha</i> (Fig. & De Not.) Henrard	intentional - forage	<1968	Only mentioned in Rotar (1968) with no date or context provided. Assumed an intentional introduction that did not succeed given it has no herbarium specimens.	Rotar (1968)	cultivated	
<i>Urochloa panicoides</i> P.Beauv.	intentional - forage	1945		HAES acc. no. 4147	cultivated	1
<i>Urochloa plantaginea</i> (Link) R.D.Webster	intentional - forage	1916		HAES acc. no. 1050	naturalized	2
<i>Urochloa polystachya</i> (Kunth) Mabb.	intentional - forage	1916		HAES acc. no. 1057	cultivated	4
<i>Urochloa ramosa</i> (L.) T.Q.Nguyen	accidental	<2023		FACCENDA, K 2988 (BISH)	naturalized	
<i>Urochloa reptans</i> (L.) Stapf	accidental	<1871	Hillebrand reports that it was introduced with living plants from abroad	Hillebrand (1888)	naturalized	
<i>Urochloa texana</i> (Buckley) R.D.Webster	intentional - forage	<1915		McClelland (1915).	cultivated	2
<i>Urochloa trichopus</i> (Hochst.) Stapf	intentional - forage	1942		Rotar (1968)	cultivated	1
<i>Walwhalleya proluta</i> (F.Muell.) Wills & J.J.Bruhl	intentional - forage	1936		HAES acc. no. 3335	cultivated	1
<i>Yushania boliana</i> Demoly	intentional - ornamental	<2022		Quindembo Bamboo nursery catalog, Hawaii island https://bamboonursery.com/	cultivated	
<i>Zea diploperennis</i> Ittis, Doebley & R.Guzmán	intentional - forage	1984		SOHMER, SH s.n. (BISH)	cultivated	
<i>Zea luxurians</i> (Durieu & Asch.) R.M.Bird	intentional - forage	1916		HITCHCOCK, AS 14889 (US)	cultivated	
<i>Zea mays</i> L.	intentional - cereal	1813	First introduction by Don Francisco de Paula Marin	Gast (1973):209	cultivated	145

Species	Intent	Date of introduction	Notes	Citation for intent	Naturalization status	#HAES accessions
<i>Zea mexicana</i> (Schrud.) Kuntze	intentional - forage	1909		HAES acc. no. 317	cultivated	3
<i>Zea perennis</i> (Hitchc.) Reeves & Mangelsd.	intentional - forage	1940		HAES acc. no. 4029	cultivated	2
<i>Zizania latifolia</i> (Griseb.) Hance ex F.Muell.	intentional - cereal	<1930	Likely introduced as a food crop (O'Connor 1990)	ST JOHN, H 10520 (BISH)	naturalized	
<i>Zoysia japonica</i> Steud.	intentional - ornamental	1958		HAES acc. no. 5562	cultivated	1
<i>Zoysia matrella</i> (L.) Merr.	intentional - ornamental	1916		HAES acc. no. 1046	naturalized	7
<i>Zoysia matrella</i> (L.) Merr. × <i>Z. pacifica</i> (Goudsw.) M.Hotta & Kuroki	intentional - ornamental	1997		Glen Fukumoto & Milton Yamasaki Turf grass garden at Melani Research Station (word doc file) retrieved from https://www.ctahr.hawaii.edu/forages/turf_grasses.html	cultivated	
<i>Zoysia pacifica</i> (Goudsw.) M.Hotta & Kuroki	intentional - ornamental	<1929		CAUM, EL s.n. (BISH)	naturalized	
<i>Zuloagaea bulbosa</i> (Kunth) Bess	intentional - forage	1905		HAES (1906)	cultivated	

Appendix 2. Agricultural literature which was searched for mention of introduced grasses.

Title	Volumes searched
Sugar literature	
Bulletin of the experiment station of the Hawaiian Sugar Planters' association, Division of agriculture and chemistry. Honolulu	1–55
Bulletin of the experiment station of the Hawaiian Sugar Planters' association, Division of pathology and physiology Bulletin. Honolulu	1–12
Bulletin of the experiment station of the Hawaiian Sugar Planters' association, Botanical Series. Honolulu	Bulletin 3
Planter's monthly, Planters' labor and Supply Co, Honolulu	1–20
The Hawaiian planter's record, Experiment Station of the Hawaiian Sugar Planters's Association, Honolulu	1–5,7–8,13,17–26
Proceedings of the annual meetings of the Hawaiian sugar planters' association, Honolulu	31–46
Report of the experiment station committee of the Hawaiian sugar planters' association, Honolulu	1903–1918; 1922–1926
HAES	
Press bulletin. Hawai'i sugar planters' Association, Honolulu	1–54
Technical Progress Reports. Hawai'i Agricultural Experiment Station, University of Hawaii	142–169
Research Reports. Hawai'i Agricultural Experiment Station, University of Hawaii	170–242
Bulletin. Hawai'i Agricultural Experiment Station, Honolulu	1–133,135–160,170–198,
Annual report. Hawai'i Agricultural Experiment Station, Honolulu	1–62, 70–72, 76–79
Extension circular. Hawai'i Agricultural Experiment Station, Honolulu	1–129, 186–441
Extension bulletin. University of Hawaii, Honolulu	1–50, 52–63
Other	
Hawai'i farm science. Agricultural Experiment Station, College of Agriculture, University of Hawaii.	1–22
The Hawaiian forester and agriculturist. Hawaiian Gazette Co, Honolulu	2–30
Agricultural studies. University of Hawaii	1–7,12

Appendix 3. Names of grasses which have been reported as occurring in Hawai'i erroneously. Most of these are misapplied names in the local flora, but some descend from material which was labeled incorrectly as occurring in Hawaii. Names which have been misapplied by only one source have not been included unless they are from either Hillebrand (1888) or Hitchcock (1922).

<i>Misapplied name</i>	<i>Accepted name</i>	<i>Misapplied by</i>	<i>notes</i>
<i>Andropogon annulatum</i>	?	Hillebrand (1888)	Neither McClellan (1915), Hitchcock (1922), nor Ripperton et al. (1933) mention this name despite conducting more thorough surveys of the Hawaiian grass flora than Hillebrand.. It was not collected until it was imported by the HAES. There is no evidence it occurred in the 1800s and it is unclear what Hillebrand was referring to.
<i>Andropogon glomeratus</i>	<i>Schizachyrium microstachyum</i>	1960-2010, many authors	Herbarium specimens. Note that usage of <i>Andropogon glomeratus</i> after the year 2010 referred to <i>Andropogon glomeratus</i> var. <i>pumillus</i> , a distinct species now recognized as <i>Andropogon tenuispathus</i> .
<i>Andropogon nodosus</i>	<i>Dichanthium aristatum</i>	1910-1950, many authors	Herbarium specimens.
<i>Apera interrupta</i>	<i>Dichelachne micrantha</i>	1968-1973, Rotar (1968), St. John (1973)	Herbarium specimen
<i>Arundinella agrostoides</i>	-	Hillebrand (1888)	Specimen referenced was not collected in Hawaii
<i>Bambusa vulgaris</i>	<i>Schizostachyum glaucifolium</i>	Hillebrand (1888)	Hillebrand evidently misunderstood this as he refers to it as 'ohe, and says it grows along streams and at the base of palis, the exact habitat of <i>Schizostachyum</i> . <i>Bambusa vulgaris</i> was introduced shortly after Hillebrands time.
<i>Andropogon saccharoides</i>	<i>Bothriochloa laguroides</i>	1900-1940, many authors	Herbarium specimens.
<i>Bromus tectorum</i>	<i>Bromus diandrus</i>	1880-1992, Hillebrand and those who cite him	Hillebrand (1888) was the first to use this name, but one of his surviving specimens (Hillebrand 1842 US) is <i>Bromus diandrus</i> , a species which has contemporary collections. True <i>Bromus tectorum</i> was not observed in Hawaii until 1933. Any source which includes a date of 1888 with <i>Bromus tectorum</i> can be assumed to be misapplied <i>B. diandrus</i> .
<i>Cenchrus biflorus</i>	<i>Cenchrus setigerus</i>	1910-1950, many authors associated with HAES	Herbarium specimens
<i>Cenchrus caliculatus</i>	<i>Cenchrus agrimonoides</i>	1820-1880, several authors	Herbarium specimens
<i>Danthonia pilosa</i>	<i>Rytidosperma penicillatum</i>	1910-2000, many authors	Herbarium specimens
<i>Digitaria adscendens</i>	<i>Digitaria henryi</i>	1930-1970, many authors	Herbarium specimens
<i>Digitaria chinensis</i>	<i>Digitaria violescens</i>	Hitchcock (1922)	Herbarium specimens

Misapplied name	Accepted name	Misapplied by	notes
<i>Digitaria debilis</i>	<i>Digitaria ciliaris</i>	1920-1970, many authors	Herbarium specimens
<i>Digitaria longiflora</i>	<i>Digitaria violescens</i>	1920-1980, several authors notably Hitchcock (1922)	Herbarium specimens. This species was found naturalized in 2023.
<i>Digitaria sanguinalis</i>	<i>Digitaria ciliaris</i>	1860-1950, many authors	Herbarium specimens, see O'Connor (1990)
<i>Digitar abyssinica</i>	<i>Digitaria scalarum</i>	1990-2020	All specimens have been reidentified, however true <i>D. abyssinica</i> does occur in Hawaii, see Faccenda 2023a
<i>Echinochloa crus-pavonis</i>	<i>Echinochloa crus-galli</i>	1920-2020	Herbarium specimens, see Faccenda 2023b
<i>Echinochloa walteri</i>	<i>Echinochloa crus-galli</i>	1922-1990	Herbarium specimens
<i>Eragrostis falcata</i>	<i>Eragrostis paupera</i>	1880-1930, many authors	Herbarium specimens, see O'Connor (1990)
<i>Eragrostis mexicana</i>	<i>Eragrostis mauiensis</i>	Hillebrand (1888)	Herbarium specimens, see O'Connor (1990). Note that true <i>E. mexicana</i> was imported in 1940
<i>Eragrostis poaeoides</i>	<i>Eragrostis cilianensis</i>	Hillebrand (1888)	Description matches <i>E. cilianensis</i> , this species had also been vouchered during Hillebrands time but is not reported, making it very likely that this is a misidentification of <i>E. cilianensis</i>
<i>Eragrostis unioloidea</i>	<i>Eragrostis sp.?</i>	Hillebrand (1888)	Likely an erroneous identification, potentially an extreme form of <i>Eragrostis cilianensis</i> . <i>Eragrostis unioloidea</i> was found naturalized in Hawaii in 1958 and it is not considered plausible that this rather showy grass was overlooked for 80 years.
<i>Festuca drymeja</i>	<i>Festua hawaiiensis</i>	Hillebrand (1888)	Herbarium specimens, see O'Connor (1990)
<i>Gastridium ventricosum</i>	<i>Gastridium pheloides</i>	1900-2020, many authors	All specimens have been reidentified, see Faccenda 2023a
<i>Panicum filiforme</i>	<i>Digitaria violescens</i>	Hillebrand (1888)	Herbarium specimens
<i>Paspalum longifolium</i>	<i>Paspalum spp.</i>	2000-2020, several authors	Two separate species were independently identified as <i>P. longifolium</i> . See Faccenda (2022) for discussion
<i>Paspalum virgatum</i>	<i>paspalum urvillei</i>	1900-1980, many authors	"the name <i>P. virgatum</i> for <i>P. urvillei</i> has recently found its way into Hawaiian agricultural literature ." Chase (1929). Note that true <i>P. virgatum</i> was found naturalized in 2008.
<i>Pennisetum asperifolium</i>	<i>Pennisetum setaceum</i>	1930-1940, many authors	Herbarium specimens, see O'Connor (1990)
<i>Phragmites karka</i>	<i>Phragmites australis</i>	1950-2010, many authors	Herbarium specimens, see Herbst & Clayton (1998)
<i>Polypogon littoralis</i>	<i>Polypogon fugax</i>	1888-1970, many authors	Herbarium specimens
<i>Polypogon lutosus</i>	<i>Polypogon fugax</i>	1920-1950, many authors	Herbarium specimens
<i>Rytidosperma semiannularis</i>	<i>Rytidosperma biannulare</i>	1900-2010, many authors	Herbarium specimens

<i>Misapplied name</i>	<i>Accepted name</i>	Misapplied by	notes
<i>Schizachyrium condensatum</i>	<i>Schizachyrium microstachyum</i>	1990-2020, many authors	All specimens have been reidentified, see Faccenda (2023a)
<i>Setaria verticillata</i>	<i>Setaria adhaernes</i>	1890-2020, many authors	All specimens have been reidentified, see Faccenda (2023a)
<i>Spodiopogon aureus</i>	?	Hillebrand (1888)	Specimens were likely mislabeled and not from Hawaii.
<i>Sporobolus elongatus</i>	<i>Sporobolus africanus</i>	Hitchcock (1922)	specimens were <i>S. africanus</i> . <i>Sporobolus elongatus</i> did occur at this time, but was not actually collected by Hitchcock
<i>Sporobolus piliferus</i>	<i>Sporobolus pyramidatus</i>	1990-2022, many authors	All herbarium specimens have been reidentified, see Faccenda (2022)
<i>Themeda gigantea</i>	<i>Themeda villosa</i>	1920-1980, many authors	Herbarium specimens, see O'Connor (1990)
<i>Thuarea involuta</i>	-	Specimens by J. N. Anderson (1852)	These specimens were likely mislabeled were from the Society islands (O'Connor 1990)
<i>Cymbopogon nardus</i>	<i>Cymbopogon citratus</i>	1930-2010, many authors	No specimen exist of <i>C. nardus</i> from Hawaii, this name appears to have come from a misidentified specimen which has propagated through the literature. It may still exist in Hawaii, but have seen no evidence
<i>Echinochloa stagnina</i>	<i>Echinochloa oryzoides</i>	1910-2000, many authors	Herbarium specimens
<i>Panicum spectabile</i>	<i>Sorghum halepense</i>	1880-1920, many authors	see: McCully (1883)

Appendix 4. Literature references excluded from this analysis for dubious dates or dubious identifications. Many references were excluded because they referenced misapplied names described in Appendix 2 and are not repeated in this appendix. The accepted name is the modern name for the species, and the verbatim name is the name referenced by the publication.

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
?	<i>Andropogon annulatus</i>	before 1871	Not mentioned by Hitchcock or McClelland and no specimens were made until 1920 when it was intentionally introduced. It is unlikely that these botanists would have overlooked this species. However, it is unclear what name should be associated with this record.	Hillbrand (1888)
?	<i>Echinochloa polystachya</i>	1916	All <i>Echinochloa</i> references from 1916 (principally Hitchcock) do not mention this species, likely an issue with confused synonymy.	St. John (1973)
<i>Agrostis exarata</i>	<i>Agrostis microphylla</i> [misapplied <i>A. exarata</i>]	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Agrostis exarata</i>	<i>Agrostis microphylla</i> [misapplied <i>A. exarata</i>]	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	St. John (1973)
<i>Agrostis exarata</i>	<i>Agrostis exarata</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Aira caryophyllea</i>	<i>Aira caryophyllea</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Aira caryophyllea</i>	<i>Aira caryophyllea</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	St. John (1973)
<i>Aira caryophyllea</i>	<i>Aira caryophyllea</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Aira elegans</i>	<i>Aira elegans</i>	1944	No other sources report this from Hawai'i. It is likely based on misidentified material given that St. John was not particularly skilled in grass identification	St. John (1973)

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
<i>Andropogon bicornis</i>	<i>Andropogon bicornis</i>	1955	No context was provided regarding this date. It is likely erroneous as it was not collected until 1987 and it is hard to believe that such a large and distinctive grass could have been overlooked for 32 years. It is likely that this name derives from a misidentification of <i>Schizachyrium microstachyum</i> , as the name <i>A. bicornis</i> was historically misapplied (e.g. Hasselwood & Motter 1983).	Rotar (1968)
<i>Andropogon bicornis</i>	<i>Andropogon bicornis</i>	1955	citing Rotar (1968)	St. John (1973)
<i>Anthoxanthum odoratum</i>	<i>Anthoxanthum odoratum</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Anthoxanthum odoratum</i>	<i>Anthoxanthum odoratum</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Anthoxanthum odoratum</i>	<i>Anthoxanthum odoratum</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Arrhenatherum elatius</i>	<i>Arrhenatherum elatius</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Arrhenatherum elatius</i>	<i>Arrhenatherum elatius</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Arrhenatherum elatius</i>	<i>Arrhenatherum elatius</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Avena barbata</i>	<i>Avena barbata</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Avena barbata</i>	<i>Avena barbata</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Avena barbata</i>	<i>Avena barbata</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Avena byzantina</i>	<i>Avena byzantina</i>	1935	Erroneous date, first HAES accession 1936	Rotar (1968)
<i>Avena byzantina</i>	<i>Avena byzantina</i>	1935	citing Rotar (1968)	St. John (1973)
<i>Avena fatua</i>	<i>Avena fatua</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Avena fatua</i>	<i>Avena fatua</i>	1906	citing Rotar (1968)	St. John (1973)

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
<i>Avena fatua</i>	<i>Avena fatua</i>	1888	Species not listed in Hillebrand, despite the 1871 date necessarily referencing Hillebrand's Flora.	Wester (1992)
<i>Avena fatua</i>	<i>Avena fatua</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Bambusa vulgaris</i>	<i>Bambusa vulgaris</i>	perhaps before 1800	No evidence to support this date	Neal (1948)
<i>Bothriochloa bladhii</i>	<i>Bothriochloa intermedia</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Bothriochloa bladhii</i>	<i>Andropogon intermedius</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Bothriochloa insculpta</i>	<i>Bothriochloa insculpta</i>	1940	First HAES accession from 1941	Rotar (1968)
<i>Bothriochloa insculpta</i>	<i>Andropogon insculptus</i>	1940	citing Rotar (1968)	St. John (1973)
<i>Bothriochloa ischaemum</i>	<i>Andropogon ischaemum</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Bothriochloa macra</i>	<i>Bothriochloa ambigua</i>		No herbarium material or literature reference for this date	Hosaka & Thistle (1954)
<i>Bouteloua curtipendula</i>	<i>Bouteloua curtipendula</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Bouteloua curtipendula</i>	<i>Bouteloua curtipendula</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Bouteloua curtipendula</i>	<i>Bouteloua curtipendula</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Bromus hordeaceus</i>	<i>Bromus molliformis</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Bromus hordeaceus</i>	<i>Bromus mollis</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Bromus hordeaceus</i>	<i>Bromus racemosus</i> [misapplied <i>B. hordeaceus</i>]	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Bromus hordeaceus</i>	<i>Bromus molliformis</i>	1906	citing Rotar (1968)	St. John (1973)

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
<i>Bromus hordeaceus</i>	<i>Bromus mollis</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Bromus hordeaceus</i>	<i>Bromus racemosus</i> [misapplied <i>B. hordeaceus</i>]	1906	citing Rotar (1968)	St. John (1973)
<i>Bromus hordeaceus</i>	<i>Bromus molliformis</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Bromus hordeaceus</i>	<i>Bromus mollis</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Bromus hordeaceus</i>	<i>Bromus racemosus</i> [misapplied <i>B. hordeaceus</i>]	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Bromus madritensis</i>	<i>Bromus rubens</i> [misidentified <i>B. madritensis</i>]	1903	Misidentified, all herbarium material from this era initially identified as <i>B. rubens</i> has been later redetermined to <i>B. madritensis</i>	Whitney et al. 1939
<i>Bromus rubens</i>	<i>Bromus rubens</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Bromus rubens</i>	<i>Bromus rubens</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Bromus rubens</i>	<i>Bromus rubens</i>	1920	Date erroneous; references states date of first specimen but no specimen found with this date	Wester (1992)
<i>Bromus rubens</i>	<i>Bromus rubens</i>	1920	Date erroneous; references states date of first specimen but no specimen found with this date	Whitney et al. (1939) [appendix]
<i>Bromus sterilis</i>	<i>Bromus sterilis</i>	1920	citing Whitney et al. (1939) [appendix]	Rotar (1968)
<i>Bromus sterilis</i>	<i>Bromus sterilis</i>	1920	citing Rotar (1968)	St. John (1973)
<i>Bromus sterilis</i>	<i>Bromus sterilis</i>	1920	Date erroneous; references states date of first specimen but no specimen found with this date	Whitney et al. (1939) [appendix]
<i>Cenchrus elegans</i>	<i>Pennisetum macrostachyum</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Cenchrus elegans</i>	<i>Pennisetum macrostachyum</i>	1906	citing Rotar (1968)	St. John (1973)

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
<i>Cenchrus elegans</i>	<i>Pennisetum macrostachyum</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Chloris gayana</i>	<i>Chloris gayana</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Chloris gayana</i>	<i>Chloris gayana</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Chloris gayana</i>	<i>Chloris gayana</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Cymbopogon citratus</i>	<i>Cymbopogon citratus</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Cymbopogon citratus</i>	<i>Cymbopogon citratus</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Cymbopogon citratus</i>	<i>Cymbopogon citratus</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Cynodon dactylon</i>	<i>Cynodon dactylon</i>	1828	Citing Hillebrand for this date, but incorrectly as Hillebrand says 1835.	Staples et al. (2005)
<i>Dactylis glomerata</i>	<i>Dactylis glomerata</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Dactylis glomerata</i>	<i>Dactylis glomerata</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Dactylis glomerata</i>	<i>Dactylis glomerata</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Dactyloctenium aegyptium</i>	<i>Dactyloctenium aegyptiacum</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Dactyloctenium aegyptium</i>	<i>Dactyloctenium aegyptiacum</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Dactyloctenium aegyptium</i>	<i>Dactyloctenium aegyptium</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Digitaria filiformis</i>	<i>Digitaria filiformis</i>	1936	citing Rotar (1968)	St. John (1973)
<i>Digitaria fuscescens</i>	<i>Digitaria pseudo-ischaemum</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
<i>Digitaria insularis</i>	<i>Trichachne insularis</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Digitaria insularis</i>	<i>Trichachne insularis</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Digitaria insularis</i>	<i>Trichachne insularis</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Digitaria ischaemum</i>	<i>Digitaria ischaemum</i>		Misidentified herbarium material	Rotar (1968)
<i>Digitaria ischaemum</i>	<i>Digitaria ischaemum</i>		citing Rotar (1968)	St. John (1973)
<i>Digitaria sp.</i>	<i>Paspalum sanguinale</i>	1911	Impossible to know what precisely this name referred to as this time as there were many varieties of <i>P. sanguinale</i> which are currently recognized as distinct species.	HAES n.d. [HAES acc. no. 646]
<i>Digitaria virescens</i>	<i>Digitaria fuscescens</i> [misapplied <i>D. virescens</i>]	1852	Misidentified <i>D. virescens</i> . <i>Digitaria virescens</i> first appeared in Hawaii in 1852.	Wester (1992)
<i>Digitaria setigera</i>	<i>Digitaria ciliaris</i> [misapplied <i>D. setigera</i>]	1826	Misidentified <i>Digitaria setigera</i>	Hooker & Arnott (1841)
<i>Echinochloa stagnina</i>	<i>Echinochloa stagnina</i>	1828	Ambiguous misapplied name, herbarium specimens labeled with this name at this period were later identified as several species of <i>Echinochloa</i> .	Degener (1946)
<i>Elymus violaceus</i>	<i>Agropyron trachycaulum</i>	1911	Misidentified; likely refers to <i>Agropyron pauciflorum</i> imported that year	Rotar (1968)
<i>Elymus violaceus</i>	<i>Agropyron trachycaulum</i>	1911	Misidentified; likely refers to <i>Agropyron pauciflorum</i> imported that year	St. John (1973)
<i>Enneapogon desvauxii</i>	<i>Enneapogon brachystachyus</i>	1936	Date erroneous; first specimen from 1937	Rotar (1968)
<i>Enneapogon desvauxii</i>	<i>Enneapogon brachystachyus</i>	1936	Date erroneous; first specimen from 1937	St. John (1973)
<i>Enneapogon desvauxii</i>	<i>Pappophorum brachystachyum</i>	1936	Date erroneous; first specimen from 1937	Whitney et al. (1939) [appendix]

Accepted name	Verabitim literature name	Introduction date	Why erroneous	Source
<i>Eragrostis brownii</i>	<i>Eragrostis brownei</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Eragrostis brownii</i>	<i>Eragrostis brownei</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Eragrostis brownii</i>	<i>Eragrostis brownei</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Eragrostis minor</i>	<i>Eragrostis poaeoides</i>		Likely misidentified <i>E. cilianensis</i> , no herbarium specimens exist of <i>E. minor</i> exist from Hawai'i	Rotar (1968)
<i>Eragrostis minor</i>	<i>Eragrostis poaeoides</i>		citing Rotar (1968)	St. John (1973)
<i>Eragrostis pectinacea</i> var. <i>pectinacea</i>	<i>Eragrostis pectinacea</i>	1914	Specimen froms early 1900s were misidentified	O'Connor (1990)
<i>Eragrostis pectinacea</i> var. <i>pectinacea</i>	<i>Eragrostis pectinacea</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Eragrostis pectinacea</i> var. <i>pectinacea</i>	<i>Eragrostis pectinacea</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Eragrostis pectinacea</i> var. <i>pectinacea</i>	<i>Eragrostis pectinacea</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Eragrostis pilosa</i> var. <i>pilosa</i>	<i>Eragrostis pilosa</i>	1911	Specimen froms early 1900s were misidentified	O'Connor (1990)
<i>Eragrostis pilosa</i> var. <i>pilosa</i>	<i>Eragrostis pilosa</i>	1913	Specimen froms early 1900s were misidentified	Rotar (1968)
<i>Eragrostis pilosa</i> var. <i>pilosa</i>	<i>Eragrostis pilosa</i>	1913	citing Rotar (1968)	St. John (1973)
<i>Eragrostis pilosa</i> var. <i>pilosa</i>	<i>Eragrostis pilosa</i>	1913	Specimen froms early 1900s were misidentified	Wester (1992)
<i>Eragrostis tef</i>	<i>Eragrostis tef</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Eragrostis tef</i>	<i>Eragrostis tef</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Eragrostis tef</i>	<i>Eragrostis abyssinica</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
<i>Eulalia aurea</i>	<i>Eulalia fulva</i>		No specimens exist, St. John included many names from misidentified herbarium material in his checklist	St. John (1973)
<i>Festuca bromoides</i>	<i>Vulpia bromoides</i>	1901	No specimens from this date	Wester (1992)
<i>Festuca idahoensis</i>	<i>Festuca idahoensis</i>	1938	HAES records indicate it was introduced in 1939	Rotar (1968)
<i>Festuca idahoensis</i>	<i>Festuca idahoensis</i>	1938	citing Rotar (1968)	St. John (1973)
<i>Festuca kashmiriana</i>	<i>Festuca kashmiriana</i>		St. John lists <i>F. durisulca</i> as the synonym of this, which is a synonym of <i>F. rubra</i> . A grass from the kashmir region seems unlikely. It is assumed that St. John used the same synonym reference as Rotar.	Rotar (1968)
<i>Festuca kashmiriana</i>	<i>Festuca kashmiriana</i>		citing Rotar (1968)	St. John (1973)
<i>Festuca octoflora</i>	<i>Vulpia octoflora</i>	1936	Likely referred to <i>F. dertenensis</i> imported that year	Rotar (1968)
<i>Festuca octoflora</i>	<i>Festuca octoflora</i>	1936	citing Rotar (1968)	St. John (1973)
<i>Festuca ovina</i>	<i>Festuca ovina</i>	1910	HAES records indicate it was introduced in 1911	Rotar (1968)
<i>Festuca ovina</i>	<i>Festuca ovina</i>	1910	citing Rotar (1968)	St. John (1973)
<i>Glyceria notata</i>	<i>Glyceria fluitans</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Glyceria notata</i>	<i>Glyceria fluitans</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Glyceria notata</i>	<i>Glyceria fluitans</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Hordeum bulbosum</i>	<i>Hordeum nodosum</i>	1835	No evidence found for this early date	Rotar (1968)
<i>Hordeum bulbosum</i>	<i>Hordeum nodosum</i>	1835	citing Rotar (1968)	St. John (1973)
<i>Hordeum marinum</i>	<i>Hordeum hystrix</i>		No specimens exist, St. John included many names from misidentified herbarium material in his checklist	St. John (1973)

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
<i>Hordeum vulgare</i> subsp. <i>vulgare</i>	<i>Hordeum vulgare</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Hordeum vulgare</i> subsp. <i>vulgare</i>	<i>Hordeum vulgare</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Hordeum vulgare</i> subsp. <i>vulgare</i>	<i>Hordeum vulgare</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Hyparrhenia hirta</i>	<i>Hyparrhenia hirta</i>	1916	No evidence found for this early date	Rotar (1968)
<i>Hyparrhenia hirta</i>	<i>Hyparrhenia hirta</i>	1916	citing Rotar (1968)	St. John (1973)
<i>Leptochloa virgata</i>	<i>Leptochloa virgata</i>	1906	HAES records indicate it was introduced in 1912	Rotar (1968)
<i>Leptochloa virgata</i>	<i>Leptochloa virgata</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Leptochloa virgata</i>	<i>Leptochloa virgata</i>	1906	HAES records indicate it was introduced in 1912	Whitney et al. (1939) [appendix]
<i>Lolium multiflorum</i>	<i>Lolium multiflorum</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Lolium multiflorum</i>	<i>Lolium multiflorum</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Lolium multiflorum</i>	<i>Lolium multiflorum</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Melinis repens</i>	<i>Tricholaena repens</i>	1890	Likely rounded true introduction date of 1893	Neal (1948)
<i>Muhlenbergia repens</i>	<i>Muhlenbergia repens</i>	1937	HAES records indicate this was imported in 1939	Rotar (1968)
<i>Muhlenbergia repens</i>	<i>Muhlenbergia repens</i>	1937	citing Rotar (1968)	St. John (1973)
<i>Oplismenus hirtellus</i> subsp. <i>hirtellus</i>	<i>Oplismenus hirtellus</i>	1819	No evidence for this date, first recorded in 1826	O'Connor (1990)
<i>Panicum capillare</i>	<i>Panicum capillare</i>	1826	Likely referred to a native species, specimen unable to be located	Hooker & Arnott (1841)
<i>Panicum repens</i>	<i>Panicum repens</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
<i>Panicum repens</i>	<i>Panicum repens</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Panicum repens</i>	<i>Panicum repens</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Panicum schinzii</i>	<i>Panicum laevifolium</i>	1916	HAES introduction notebook lists introduction date as 1917	Rotar (1968)
<i>Panicum schinzii</i>	<i>Panicum laevifolium</i>	1916	citing Rotar (1968)	St. John (1973)
<i>Paspalum dilatatum</i>	<i>Paspalum dilatatum</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Paspalum dilatatum</i>	<i>Paspalum dilatatum</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Paspalum dilatatum</i>	<i>Paspalum dilatatum</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Paspalum distichum</i>	<i>Paspalum distichum</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Paspalum distichum</i>	<i>Paspalum distichum</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Paspalum distichum</i>	<i>Paspalum distichum</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Paspalum fimbriatum</i>	<i>Paspalum fimbriatum</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Paspalum fimbriatum</i>	<i>Paspalum fimbriatum</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Paspalum fimbriatum</i>	<i>Paspalum fimbriatum</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Paspalum urvillei</i>	<i>Paspalum urvillei</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Paspalum urvillei</i>	<i>Paspalum urvillei</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Paspalum urvillei</i>	<i>Paspalum urvillei</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Phalaris brachystachys</i>	<i>Phalaris brachystachys</i>		No specimens exist, St. John includes a brief note saying that specimens previously identified as <i>Phalaris canariensis</i> actually	St. John (1973)

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
			refer to <i>P. brachystachys</i> . However, St. John was incorrect in this conclusion.	
<i>Phalaris caroliniana</i>	<i>Phalaris caroliniana</i>	1939	HAES introduction notebook lists introduction date as 1917	Rotar (1968)
<i>Phalaris caroliniana</i>	<i>Phalaris caroliniana</i>	1939	citing Rotar (1968)	St. John (1973)
<i>Phleum subulatum</i>	<i>Phleum subulatum</i>	1906	No specimens exist, St. John included many names from misidentified herbarium material in his checklist	St. John (1973)
<i>Poa compressa</i>	<i>Poa compressa</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Poa compressa</i>	<i>Poa compressa</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Poa compressa</i>	<i>Poa compressa</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Poa pratensis</i>	<i>Poa pratensis</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Poa pratensis</i>	<i>Poa pratensis</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Poa pratensis</i>	<i>Poa pratensis</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Polypogon fugax</i>	<i>Agrostis semiverticillata</i>	1853-1871; 1864-1865	Misidentification, likely referred to <i>Polypogon littoralis</i> referenced by Hillebrand which is now known to represent <i>P. fugax</i> .	O'Connor (1990)
<i>Polypogon monspeliensis</i>	<i>Polypogon monspeliensis</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Degener (1946)
<i>Polypogon monspeliensis</i>	<i>Polypogon monspeliensis</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Polypogon monspeliensis</i>	<i>Polypogon monspeliensis</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Polypogon monspeliensis</i>	<i>Polypogon monspeliensis</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
<i>Sacciolepis indica</i>	<i>Sacciolepis indica</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Sacciolepis indica</i>	<i>Sacciolepis indica</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Sacciolepis indica</i>	<i>Sacciolepis contracta</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Sacciolepis striata</i>	<i>Sacciolepis striata</i>		No specimens exist, St. John included many names from misidentified herbarium material in his checklist	St. John (1973)
<i>Schizachyrium microstachyum</i>	<i>Schizachyrium condensatum</i>	1932	Erroneous date, seeming is referencing an <i>Andropogon virginicus</i> specimen	O'Connor (1990)
<i>Setaria barbata</i>	<i>Chaetochloa barbata</i>		Erroneous, no Hitchcock specimens of this exist from Hawai'i and the specimen cited is not even a grass.	Hitchcock (1922)
<i>Setaria barbata</i>	<i>Setaria barbata</i>		Citing Hitchcock	Rotar (1968)
<i>Setaria barbata</i>	<i>Setaria barbata</i>		Citing Hitchcock (1915)	St. John (1973)
<i>Setaria sphacelata</i>	<i>Setaria sphacelata</i>	1958	HAES introduction notebook lists introduction date as 1959	Rotar (1968)
<i>Setaria sphacelata</i>	<i>Setaria sphacelata</i>	1958	HAES introduction notebook lists introduction date as 1959	St. John (1973)
<i>Sporobolus diandrus</i>	<i>Sporobolus diander</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Sporobolus diandrus</i>	<i>Sporobolus diander</i>	1906	citing Rotar (1968)	St. John (1973)
<i>Sporobolus diandrus</i>	<i>Sporobolus diander</i>	1906	Citing a typographical error in Hitchcock (1922) that states fieldwork occurred in 1906, it actually occurred in 1916.	Whitney et al. (1939) [appendix]
<i>Sporobolus x townsendii</i>	<i>Spartina townsendii</i>	1932	HAES introduction notebook lists 1933 as introduction date	Rotar (1968)
<i>Sporobolus x townsendii</i>	<i>Spartina townsendii</i>	1932	HAES introduction notebook lists 1933 as introduction date	St. John (1973)
<i>Stenotaphrum secundatum</i>	<i>Stenotaphrum secundatum</i>	1816	Likely a typographical error as the first specimen is from 1826. This error descends from Whitney et al. (1939).	Degener (1946)

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
<i>Stenotaphrum secundatum</i>	<i>Stenotaphrum secundatum</i>	1816	Like a typographical error as the first specimen is from 1826. This error descends from Whitney et al. (1939).	Rotar (1968)
<i>Stenotaphrum secundatum</i>	<i>Stenotaphrum secundatum</i> var. <i>secundatum</i>	1816	Like a typographical error as the first specimen is from 1826. This error descends from Whitney et al. (1939).	St. John (1973)
<i>Stenotaphrum secundatum</i>	<i>Stenotaphrum secundatum</i>	1816	Like a typographical error as the first specimen is from 1826. This error descends from Whitney et al. (1939).	Whitney et al. (1939) [appendix]
<i>Triticum aestivum</i> subsp. <i>aestivum</i>	<i>Triticum aestivum</i>	1791	No evidence to support this date from Nagata (1985)	Degener (1946)
<i>Triticum aestivum</i> subsp. <i>aestivum</i>	<i>Triticum aestivum</i>	1792	No evidence to support this date from Nagata (1985)	Rotar (1968)
<i>Triticum aestivum</i> subsp. <i>aestivum</i>	<i>Triticum aestivum</i>	1792	No evidence to support this date from Nagata (1985)	St. John (1973)
<i>Triticum aestivum</i> subsp. <i>aestivum</i>	<i>Triticum aestivum</i>	1792	No evidence to support this date from Nagata (1985)	Whitney et al. (1939) [appendix]
<i>Urochloa maxima</i>	<i>Panicum maximum</i>	< 1871	See Histories of selected notable grasses	Hillbrand (1888)
<i>Urochloa maxima</i>	<i>Panicum maximum</i>	1870	See Histories of selected notable grasses	Whitney et al. (1939) [body text]
<i>Zea mays</i>	<i>Zea mays</i>	1792	No evidence to support this date from Nagata (1985)	Rotar (1968)
<i>Zea mays</i>	<i>Zea mays</i>	1792	No evidence to support this date from Nagata (1985)	Whitney et al. (1939) [appendix]
<i>Zoysia pacifica</i>	<i>Zoysia tenuifolia</i>	1906	Citing Whitney et al. (1939)	Rotar (1968)
<i>Zoysia pacifica</i>	<i>Zoysia tenuifolia</i>	1906	No evidence of introduction at this date, first HAES accession in 1916, this may have been a typographical error.	St. John (1973)

Accepted name	Verbatim literature name	Introduction date	Why erroneous	Source
<i>Zoysia pacifica</i>	<i>Zoysia tenuifolia</i>	1906	No evidence of introduction at this date, first HAES accession in 1916, this may have been a typographical error.	Whitney et al. (1939) [appendix]