The grass family (Poaceae or Gramineae) is the fourth largest flowering plant family in the world and contains about 11,000 species in 800 genera worldwide. Twenty-three genera contain 100 or more species or about half of all grass species, and almost half of the 800 genera are monotypic or diatypic, i.e., with only one or two species (Watson and Dallwitz 1992, 1999).

Over the last 150 years the grass flora of California has been the subject of considerable attention by botanists. Bolander (1866) prepared the first comprehensive list, recognizing 112 grasses from California, of which 31 were introductions. Thurber (1880) mentions 175 grasses in California, and Beetle (1947) enumerates 400 known species. It is interesting to note that Crampton (1974) recognized 478 grasses in California, and of these, 175 were introduced and 156 were reported as annuals (we report 152 annuals here).

We recognize 524 grass species in 144 genera; of these, 233 (44.5%) species in 65 genera are introduced (see Appendix 1), and the remaining 291 (55.5%) species in 79 genera are native. Thirty-seven species are endemic to California. One hundred fifty-two grasses in California are annual; of these 101 are introduced and 51 are native. Obviously the grass flora has been altered by humans, especially over the last 300 years since European settlement. The percentage of introduced grasses is perhaps higher in California than in any other state, simply because there are many different habitats (from 212 feet below sea level in Death Valley to 14,496 feet on top of Mount Whitney) available for colonization of weedy species. In addition, many annual species and genera of Mediterranean origins have found suitable habitats in California (see D’Antonio et al., Chapter 6).

To understand the important adaptations within the grasses, a firm grasp of the unique morphological features that define this family is needed. We start this chapter with an introduction to the morphology and ecology of grasses and then discuss the phylogeny (evolutionary relationships among organisms) of the major tribes of California grasses.

Morphology

The most important feature of grasses (Poaceae) is a one-seeded indehiscent fruit (seed coat is fused with the ovary wall), known as a caryopsis or grain (see Figure 2.1; Peterson 2003). The grain endosperm is rich in starch, although it can contain protein and significant quantities of lipids. The embryo is located on the basal portion of the caryopsis and contains high levels of protein, fats, and vitamins. The stems are referred to as culms, and the roots are fibrous and principally adventitious or arising from lower portions of the culms. Silica-bodies are a conspicuous component of the epidermis and are stored in silica short-cells. Many grasses have rhizomes (underground stems) or stolons (horizontal aboveground branches) that allow for vegetative reproduction in perennial grasses. Another important feature of grasses is intercalary meristems; these allow growth well below the apex, typically near the base of the plant. The leaves are parallel-veined and two-ranked with the basal portion forming cylindrical sheaths and the upper portion referred to as a blade. A ligule, located on the upper surface at the junction of the blade and sheath, commonly consists of a flap of tissue or hairs but can be lacking. The primary inflorescence is referred to as a spikelet with one to many two-ranked bracts inserted along the floral axis or rachilla. The lowest two bracts of each spikelet, inserted opposite each other, are called glumes, above which, along the rachilla, are borne pairs of bracts termed florets. Each floret consists of a lemma (lower bract) and palea (upper bract). Within each pair of lemma and palea the highly reduced flowers can be found. Each grass flower usually consists of two or three small scales at the base called lodicules, an ovary with a style and two plumose stigmas, and one to six
FIGURE 2.1. Diagnostic features of a grass (Festuca californica): caryopsis, culm, floret, flower, and spikelet. Illustrated by Alice R. Tangerini.

(but more commonly three) stamens with basifixed anthers that contain single-pored, wind-dispersed pollen grains. Lodicules function to open the florets during flowering and evidently represent reduced perianth (sepals and petals) segments. Since the morphological features are often cryptic, or occasionally lacking, identification to species is often very difficult and requires a trained specialist.

Ecology

Specializations for open habitats and grazing tolerance, highly reduced floral structure, and wind pollination in the grasses have enabled the family to be extremely successful at planetwide radiation and colonization. One notable feature of grasses and other monocots is intercalary meristems that allow individual culms to resprout once they have been removed. Grasses are well adapted to open, marginal, and frequently disturbed habitats and can be found on every continent, including Antarctica. Two major photosynthetic or carbon dioxide (CO₂) assimilation pathways can be found in the grasses: C₃-fixing CO₂ by ribulose 1,5-biphosphate (Calvin-Benson cycle, found in all vascular plants), and C₄-fixing of CO₂, in which the initial product of photosynthesis is not the C₃ unit 3-phosphoglycerate but a unit with four C atoms (oxaloacetate). This is produced when CO₂ is bound to phosphoenolpyruvate to form four-carbon molecules (oxaloacetate or malate) in the Hatch-Slack cycle. There are corresponding anatomical, physiological, phyto-geographical, and ecological differences between these two types. The C₃ grasses are well adapted to temperate climates with winter precipitation, whereas C₄ grasses are well suited to tropical environments with summer/fall precipitation. The evolution of C₄ photosynthesis has allowed grasses to outcompete other plants in warm, tropical and subtropical environments by limiting oxidation (photorespiration) of photosynthetic products (Ehleringer and Monson 1993). All of these features have led to the family's ability to occupy nearly one-quarter of the earth's land surface in various climatic environments as the dominant component of grasslands.
by annual species and xerophytic shrubs, and perennial

border dry out and become flammable (Axelrod 1985). Found these grasslands to be spatially diverse with many

Holstein Wester (1981) and (2001) have presented well-

mental at maintaining and further opening up grassland

herbivorous mammals (e.g., bison and antelope) are instru-

usually is a dry season in which grasses and adjacent forest

the number of genera within a tribe, and the numeral in parentheses () indicates the number of species in California.

A cladogram showing the relationships of the 17 tribes

represented in California is given in Figure 2.2. All grasses in

the BEP (Bambusoideae, Ehrhartoideae, and Pooideae) clade

(all descended from a single common ancestor) and the

Californian Danthonioideae are C3, whereas all grasses in

the Aristidoideae and Chloridoideae are C4. The Panicoideae

have C3, C4, and C3-C4 intermediates, although the major-

ity of the species in California are C4.

Historically, the grassland biome has been maintained by

a myriad of biotic, climatic, and edaphic effects. First, there

usually is a dry season in which grasses and adjacent forest

border dry out and become flammable (Axelrod 1985).

Repeated fires favor grasses over most tree and shrub species,

since they very easily resprout from the base. Second, large

herbivorous mammals (e.g., bison and antelope) are instru-

mental at maintaining and further opening up grassland

communities (Axelrod 1985). An often overlooked conse-

quence of grazing animals is their effect on soil compaction,

which again favors sod-forming grasses over trees and

shrubs.

The exact species composition of California's pre-

agricultural grasslands is not very well documented. Wester (1981) and Holstein (2001) have presented well-
documented accounts based on historical records and current ecological samples of relict vegetation in California. They

found these grasslands to be spatially diverse with many dif-

ferent species of the annual or perennial habit. In the

San Joaquin Valley, grasslands were apparently dominated

by annual species and xerophytic shrubs, and perennial

bunchgrasses were common only on well-watered flood-

plains (Wester 1981).

Phylogeny

Despite variation among grass species in inflorescence struc-
ture and vegetative morphology, the grass family was proba-

bly characterized as a distinct entity in most early cultures.

Three hundred years before the Christian era, Theophrastus,

a Greek scholar, recognized the grass family and began to
teach his students the concepts of plant morphology. The

first scientific subdivision of the family was made by Robert

Brown (1814), who recognized two different spikelet types

between subfamily Panoicoideae and Pooideae (Festucoideae).

Bentham (1881) recognized 13 tribes grouped in the two

major subfamilies. Hitchcock (1935) and Hitchcock and

Chase (1951), in their treatments of the grasses of the United

States, recognized 14 tribes in these two major subfamilies.

The two-subfamily classification was used by most agrostol-

ogists for almost 150 years until more modern syntheses were
developed.

With the infusion of molecular data our present concept

and classification of the grasses is changing at a rapid rate.

In California we currently recognize eight subfamilies:

Bambusoideae, Ehrhartoideae, Pooideae, Andropoideae,

Danthonioideae, Aristidoideae, Chloridoideae, and Pani-

coideae (GPWG 2001; Soreng and Davis 1998, 2005), and in these sub-

families we recognize 18 tribes and 44 subtribes (Table 1). A

cladogram (see Figure 2.2) of these 18 tribes summarizes

the most widely accepted concepts regarding the phyloge-

netic relationships among the tribes and subfamilies repre-

sented in California (GPWG 2001, Soreng and Davis 1998,

2000). The tree is rooted between the PACAD and BEP

clades. Three numerically small, tropical subfamilies of

grases, not represented in California, diverge below this

root point. In the PACAD clade, a clade containing Pani-

coideae (Andropogoneae, Thysanolaenaeae, and Paniceae)

and the Andinoideae (Andinoideae) is sister to a clade

containing the Chloridoideae (Cynodonteae, Eragrostideae,

and Zoysieae), Aristidoideae (Aristideae), and Dantho-

nioideae (Danthonieae). In the BEP clade the Pooideae

(Andropoideae, Bromieae, Meliceae, Poeae, Stipeae, and Triteae) is sister to a clade of the Ehrhartoideae (Ehrharteae

and Oryzeae) and the Bambusoideae (Bambuseae). The BEP

clade corresponds, in part, to the old term “festucoid”
grases used by historical agrostologists. The three most
diverse subfamilies in California are the Pooideae with 323

(61.6%) species in 73 genera, the Chloridoideae with 94

(17.9%) species in 30 genera, and the Paniocoideae with 80

(15.3%) species in 24 genera.

Panoicoideae

The Panoicoideae are the least diverse of the three major sub-
families represented by the California grasses, and there are

no endemic Panoicoideae within the state. This paucity of

FIGURE 2.2. A hypothetical phylogeny of the grass tribes represented

in California based on Soreng et al. 2005. The first numeral indicates

the number of genera within a tribe, and the numeral in parentheses

() indicates the number of species in California.
<table>
<thead>
<tr>
<th>Subfamily Bambusoideae</th>
<th>Subtribe Phalaridinae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tribe Bambuseae</td>
<td>Anthoxanthum, Phalaris</td>
</tr>
<tr>
<td>Subtribe Arundinariae</td>
<td></td>
</tr>
<tr>
<td>Pseudosasa</td>
<td></td>
</tr>
<tr>
<td>Subtribe Shibataenae</td>
<td></td>
</tr>
<tr>
<td>Phyllostachys</td>
<td>Briza</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subfamily Ehrhartoideae (synonym: Oryzoideae)</th>
<th>Subtribe Agrostidinae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tribe Ehrharteae</td>
<td>Agrostis, Ammophila,</td>
</tr>
<tr>
<td>Ehrharta</td>
<td>Bromidium, Calamagrostis,</td>
</tr>
<tr>
<td>Tribe Oryzeae</td>
<td>Podagrostis, Polypogon</td>
</tr>
<tr>
<td>Subtribe Oryzinace</td>
<td></td>
</tr>
<tr>
<td>Leersia, Oryza</td>
<td></td>
</tr>
<tr>
<td>Subtribe Zizaniinae</td>
<td></td>
</tr>
<tr>
<td>Zizania</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subfamily Pooideae</th>
<th>Subtribe Puccinellinae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tribe Stipeae</td>
<td>Puccinellia, Sclerochloa</td>
</tr>
<tr>
<td>Subtribe Stipinae</td>
<td></td>
</tr>
<tr>
<td>Achnatherum, Hesperostipa, Jarava, Nassella,</td>
<td></td>
</tr>
<tr>
<td>Piptatherum, Piptochaetum, Ptilagrostis, Stipa</td>
<td></td>
</tr>
<tr>
<td>Subtribe Ampelodesminae</td>
<td></td>
</tr>
<tr>
<td>Ampelodesmos</td>
<td></td>
</tr>
<tr>
<td>Tribe Meliceae</td>
<td></td>
</tr>
<tr>
<td>Glyceria, Melica, Pleuro bogus</td>
<td></td>
</tr>
<tr>
<td>Tribe Brachypodieae</td>
<td></td>
</tr>
<tr>
<td>Brachypodium</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supertribe Pooideae</th>
<th>Subtribe Scribnerinae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tribe Pooideae</td>
<td>Scribneria</td>
</tr>
<tr>
<td>Subtribe Torreyochloinae</td>
<td></td>
</tr>
<tr>
<td>Amphibromus, Torreyochloa</td>
<td></td>
</tr>
<tr>
<td>Subtribe Aveninae</td>
<td></td>
</tr>
<tr>
<td>Arrhenatherum, Avena, Cinna, Gaudinia,</td>
<td></td>
</tr>
<tr>
<td>Graphephorum, Koeleria, Lagurus, Rostraria,</td>
<td></td>
</tr>
<tr>
<td>Sphenopholis, Trisetum</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supertribe Triticoidae</th>
<th>Subtribe Loliinae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tribe Bromae</td>
<td>Festuca, Leucopoa, Lolium, Schenomus, Vulpia</td>
</tr>
<tr>
<td>Bromus</td>
<td></td>
</tr>
<tr>
<td>Tribe Triticae</td>
<td></td>
</tr>
<tr>
<td>Subtribe Hordeinae</td>
<td></td>
</tr>
<tr>
<td>Agropyron, Elymus, Hordeum, Leymus, Pascopyrum, Pseudoroegneria, Secale</td>
<td></td>
</tr>
<tr>
<td>Subtribe Triticinae</td>
<td></td>
</tr>
<tr>
<td>Aegilops, Taeniatherum, Thinopyrum, Triticum</td>
<td></td>
</tr>
</tbody>
</table>
## Table 2.1 (continued)
Classification of the Grasses Found in California

<table>
<thead>
<tr>
<th>Subfamily Panicoideae</th>
<th>Subfamily Danthonioideae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tribe Thysanolaeneae</td>
<td>Tribe Danthoniaceae</td>
</tr>
<tr>
<td><em>Thysanolaena</em></td>
<td><em>Cortaderia, Danthonia, Karroochloa, Rytidosperma,</em></td>
</tr>
<tr>
<td>Tribe Paniceae</td>
<td><em>Schismus, Tribolium</em></td>
</tr>
<tr>
<td>Subtribe Cenchrinae</td>
<td></td>
</tr>
<tr>
<td><em>Cenchrus, Pennisetum</em></td>
<td></td>
</tr>
<tr>
<td>Subtribe Digitarinae</td>
<td></td>
</tr>
<tr>
<td><em>Digitaria</em></td>
<td></td>
</tr>
<tr>
<td>Subtribe Melinidiniae</td>
<td><em>Eriochloa, Melinis, Urochloa</em></td>
</tr>
<tr>
<td>Subtribe Setariinae</td>
<td><em>Setaria, Stenotaphrum</em></td>
</tr>
<tr>
<td>Subtribe Panicinae</td>
<td><em>Dichanthelium, Echinochloa, Panicum</em></td>
</tr>
<tr>
<td>Subtribe Paspalinae</td>
<td><em>Axonopus, Paspalum</em></td>
</tr>
<tr>
<td>Tribe Andropogoneae</td>
<td></td>
</tr>
<tr>
<td><em>Imperata, Miscanthus, Saccharum (Erianthus)</em></td>
<td><em>Hilaria (Pleuraphis)</em></td>
</tr>
<tr>
<td>Subtribe Sorghiniae</td>
<td><em>Distichlis, Monanthochloae</em></td>
</tr>
<tr>
<td><em>Bothriochloa, Sorghum</em></td>
<td><em>Lycurus, Muhlenbergia, Schedonnardus</em></td>
</tr>
<tr>
<td>Subtribe Andropogoninae</td>
<td><em>Dasyochloa, Eriochloa, Erioneuron, Munroa</em></td>
</tr>
<tr>
<td><em>Andropogon, Schlizachyrium</em></td>
<td><em>Neostaphia, Orcuttia, Tuctoria</em></td>
</tr>
<tr>
<td>Subtribe Anthistirinae</td>
<td></td>
</tr>
<tr>
<td><em>Heteropogon, Hyparrhenia, Themeda</em></td>
<td><em>Zea</em></td>
</tr>
<tr>
<td>Subtribe Tripsacinae</td>
<td></td>
</tr>
<tr>
<td><em>Zea</em></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subfamily Arundinoideae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tribe Arundinace</td>
</tr>
<tr>
<td><em>Arundo, Phragmites</em></td>
</tr>
<tr>
<td>Subfamily Aristidoideae</td>
</tr>
<tr>
<td>Tribe Aristideae</td>
</tr>
<tr>
<td><em>Aristida</em></td>
</tr>
</tbody>
</table>

**NOTE:** Based on Soreng et al. 2005. Native taxa are **bold**, introduced taxa are lightface type. All genera are *italicized*. A genus is considered native if it includes one or more native species (see Appendix 1 for clarification of native versus introduced species).
species diversity is likely a direct response to the climatic patterns of the past and present, because Panicoideae grasses are best suited to warm and humid environments of tropical and warm temperate zones. The spikelets in this subfamily usually have two glumes and two closely spaced florets; the lower floret is usually sterile, the upper floret without a rachilla extension.

**Paniceae**

The Paniceae in California contain 57 species in 13 genera and are the sister to the Andropogoneae (Figure 2.2). They are characterized by having two-flowered spikelets with membranous glumes, the lower floret stamine or reduced, membranous, and the upper floret perfect and firm. Even though *Panicum* (10 spp. in California) and *Paspalum* (4 spp. in California) are large genera in the eastern United States and especially in tropical America, they are very poorly represented in the western United States, where the climate is generally dryer, especially in the warmer months.

**Andropogoneae**

The Andropogoneae are characterized by having fragile racemes of paired spikelets, where there is a sessile and a pedicellate spikelet with differing sexuality. Commonly the pedicellate spikelets are stamine or reduced, and the sessile spikelets are usually perfect or pistillate. Within spikelets, typically the glumes are firm, and the two florets have membranous bracts. The Andropogoneae in California contains 23 species in 11 genera, most of which are uncommon in California grasslands.

**Pooideae**

There are a few morphological synapomorphies (diagnostic characteristics) delineating the Pooideae. In this subfamily trends include parallel-sided subsidiary cells, nonvascularized lodicules with a membranous margin, an epiblast with no scutellar cleft, and the absence of microhairs.

**Stipeae**

In California the earliest diverging lineage in the Pooideae clade (Figure 2.2) is the Stipeae. The Stipeae probably arose in Laurasia (37–24 mybp) since a few fossil reports, e.g., *Stipideum* and possibly *Piptochaetium*, are from the Oligocene in North America (Thomasson 1987). Therefore, ancestors of this tribe likely were able to colonize the North American and Eurasian continents before they separated. The Stipeae are characterized as having one-flowered spikelets without rachilla extensions and terete florets that are usually awned near or immediately below the apex and have a well developed, often sharply pointed callus. The Stipeae include three endemics centered in the western United States, where the climate is generally dryer, especially in the warmer months.

**Meliceae**

The next tribe to diverge from the main lineage in the Pooideae clade is Meliceae, also reported as having possible fossils in the Oligocene of North America (Thomasson 1987). The Meliceae have closed sheaths and lemmas that are five- to 13-nerved; short, bushy stigmas; and short, truncate, fleshy lodicules. *Melica torreyana* is an endemic from the southwestern region, the Sierra Nevada, and central western California. Three other varieties of *Melica* are also endemics: *Melica californica* var. *nevadensis* Boyle from northwestern and central western regions, Sierra Nevada foothills, western Transverse Ranges, and the Tehachapi Mountains; *M. geyeri* var. *aristulata* J.T. Howell from the San Francisco Bay Area; and *M. stricta* var. *albicans* Boyle from the western Transverse Ranges. The endemics *Pleumpogon californicus* and *P. hooverianus* occur in marshy areas from northwestern California, Cascade Range foothills, and north and central Sierra Nevada foothills; and from the southern North Coast and northern Central Coast regions, respectively.

**Poeae**

The largest tribe, Poeae (184 spp.), includes *Poa* with 34 species. *Poa* has diversified throughout temperate, boreal, and arctic regions around the world and occurs on islands of similar habitats in the tropics (Gillespie and Soreng 2005). The Poeae clade, equivalent to supertribe Pooideae, is sandwiched between the ancestral Brachypodieae, with only five introduced species, and the sister supertribe Triticeae, which includes the Bromeae, with 32 species, and the Triticeae, with 45 species. In California, *Poa* exhibits both high species diversity (34 spp., of these, 28 are native) and a high degree of endemism, with eight species confined to the state (see Appendix 1). *Poa* is characterized as having rather small, multiflowered spikelets; lemmas that are keeled, unawned, usually five-nerved, commonly with weiblike hairs from the dorsal side of the callus, Caryopeses that are firm with lipid and a short hilum; lodicules that are broadly lanceolate, often with a lateral lobe; leaf sheaths closed above the base between 1/20 the entire length and the top; leaf blades that generally have two rows of bulliform cells; and no additional rows of bulliform cells; and blades commonly with naviculate (boat-shaped) apices (Soreng 1993; in press a, b). The Poeae endemics, *Poa kecki*, *P. stebbinsii*, and *Cinna bolanderi*, have originated on “islands” of arctic habitat in the high Sierra Nevada between 1,800 and 4,000 meters. *Poa atriceps* is known only from high-elevation meadows (1,500–2,000 meters) in the Peninsular Ranges and the San Bernardino Mountains. *Poa sierra* and *P. tenerina* (known only from serpentinite outcrops)
Dissanthelium indicates that species in this genus should be in the subtribe Poinae, which was previously named. Dissanthelium californicum and P. pringlei, P. douglasii, and P. kelloggii belong to three subgenera and four sections. Poa kelloggii belongs to the earliest-diverging lineage in the genus, Poa napensis and P. tenerima belong to subgenus Stenopoa section Secundae and are closely related to P. secunda, which is perhaps the most common native grass across California, occurring in a wide range of habitats from coast range low-elevation sites to high-elevation Sierra Nevada meadows and Great Basin grasslands. Poa keckii belongs to a complex of short-anthered species of the western cordillera of North America (Beringia), placed in subgenus Stenopoa section Abbreviatae. Poa atropurpurea, P. douglasii, and P. diaboli are members of the diclinous Poa subgenus Poa section Madropoa, which is centered in and mostly endemic to western North America. Several other species of Poa section Madropoa are nearly confined to California; P. piperi, P. pringlei, and P. rhizonata extend into SW Oregon on serpentine, volcanic, and peridotite substrates, respectively.

Other endemic species in the Poeae, subtribe Agrostidinae include Agrostis bladalei, A. hooveri, Calamagrostis aphidis, and C. foliosa, all from the North and South Coast Ranges, and Dissanthelium californicum (subtribe Poinae), which was previously thought to be extinct but was recently re-collected on Santa Catalina Island. Scribneria bolanderi, the sole species of subtribe Scriberliniae, is endemic to vernal pool habitats in the California Floristic Province, although it also reaches Oregon. The generic relationship between Agrostis and Calamagrostis is somewhat controversial since both are morphologically similar and have one-flowered spikelets. Species of Calamagrostis have rachilla extensions (usually hairy), a calyx with hairs, and membranous to chartaceous lemmas, whereas species of Agrostis do not have rachilla extensions, have a calyx that is usually glabrous, and have hyaline to membranous lemmas (Peterson and Saarela in press). Current research on Dissanthelium indicates that species in this genus should be subsumed within Poa (Gillespie and Soreng 2005; Refulio Rodriguez, personal communication). Puccinellia howellii (Puccinellioideae), another endemic, is known only from mineral springs in the YoUa BolUy Mountains and the Klamath Range.

Bromaceae

The Bromaceae are characterized as having closed sheaths, lemmas that are bifid or toothed with a subapical awn, hairy apically bilabiate appendages of the ovary, and simple starch grains. In California, Bromus (Bromaceae) consists of 32 species; of these, 17 are native. Bromus can be distinguished from other grasses by having connate leaf sheath margins, subapically inserted awns, hairy apical bilabiate appendages of the ovary, and simple starch grains (Wagnon 1952; Saarela and Peterson in press). This genus is widely distributed in temperate and mountainous regions of the Northern and Southern Hemispheres, and several species are important native forage grasses in California [B. ciliatus, B. richardsonii, B. saksdorfii] (Peterson et al. 2002). Endemics within California include Bromus grandis and B. hallii from the southern Sierra Nevada, Transverse and Peninsular ranges; and B. pseudolaevipes from the San Francisco Bay Area, Outer South Coast Ranges, South Coast, Channel Islands, Western Transverse Ranges, and the Peninsular Ranges (Saarela and Peterson in press). All three of these species were included in Wagnon's (1952) Pacific Slope Group of Bromus section Bromopsis, where he mentions that B. grandis and B. hallii perhaps share a common origin with B. occitanius. Bromus carinatus is a widespread native that occurs in many habitats mostly below 3500 meters.

The genus Bromus contains 15 introduced species; many of these are invasive in California grasslands. Bromus diandrus and B. hordeaceus are widespread and dominant or codominant throughout coastal and valley grasslands (see D’Antonio et al., Chapter 6). Bromus tectorum and B. madritensis subsp. rubens (L.) Husn. are more common in the California deserts. These four species of Bromus are listed by the California Invasive Plant Council (Cal-IPC at http://www.cal-ipc.org) as invasive pest plants of concern to wildland habitat.

Triticeae

The Triticeae (sister to the Bromaceae), or wheat grass tribe, in California includes 45 species in 10 genera. The tribe is characterized by having a true spike inflorescence where all the spikelets are sessile and aligned singly or in groups of two or three along the central rachis; corollaceous glumes and lemmas; ovaries with densely hairy spicules; and caryopses with simple starch grains and long hilums. The evolutionary history of this tribe is fairly well known since wheat (Triticum aestivum), barley ( Hordeum vulgare), and rye (Secale cereale) are members. The tribe is thought to have originated in Eurasia, possibly during the Miocene, and then radiated to the New World (Blattner 2006). Two species, Elymus californicus and Leymus pacificus, are endemic to coastal California. The former species is known from the North and Central Coast prairies, North Coast Ranges, and San Francisco Bay Area, and the latter is known from the North and Central Coast and the Channel Islands. Leymus condensatus is also a conspicuous associate (culms 1.5–3.5 meters tall) of the chaparral and coastal sage scrub in California and Baja California, Mexico, and L. triticeoides was perhaps historically dominant on heavier soils in valleys and hillslopes of Central California (Gould and Moran 1981; Holstein 2001).

Chloridoideae

The core species in this subfamily share two morphological synapomorphies. All exhibit “Kranz” or C₄ leaf anatomy (except Eragrostis walteri Pilg. from South Africa) and most...
have chloridoid bicellular microhairs (broad, short terminal cell the same thickness as the basal cell) present on leaf surfaces (Peterson et al. in press). Other character trends in the chloridoideae include a base chromosome number of \( x = 10 \) (a pleomorphism or ancestral characteristic), embryos with nonlinear hilums that are usually punctiform or small with elongate mesocotyl internodes, and two fleshy, vascularized, truncate lodicules (GPWG 2001; Soreng and Davis 1998).

However, most of these character trends are seen in sister subfamilies: Aristidoideae, Arundinoideae, Danthonioideae, and Panicoideae.

The Eragrostideae is considered the earliest diverging tribal lineage of the chloridoideae and is sister to a clade that contains the Zoysieae and the Cynodonteae (Figure 2.2). Character combinations in the Eragrostideae include spikelets with many florets, lemmas with 3 to 13 nerves, and many species adapted to xeric habitats. At this point we have no clear idea as to the relationships among the seven Cynodonteae subtribes (see Table 1). However, we do have good molecular support for maintaining the tribe Cynodonteae and morphological support for all of the seven subtribes (Peterson et al. in press). There are no definitive morphological characters that differentiate the Cynodonteae from the Eragrostideae and/or Zoysieae; the Cynodonteae essentially includes most of the variation present in the entire subfamily.

The evolutionary history of the chloridoideae as a whole is even more obscure. Thomasson et al. (1986) identification of Kranz anatomy in a fossil from a Miocene Ogallala formation in Kansas is the first definitive record. Since more than half of the genera within the Chloridoideae reside in Africa and all larger tribes and subtribes, excluding Muhlenbergiinae, have centers of diversity in Africa, Hartley and Slater (1960) concluded that the subfamily probably originated on the African continent (perhaps during the Oligocene) and spread from that region to other parts of the world.

The evolutionary history of the chloridoideae as a whole is even more obscure. Thomasson et al. (1986) identification of Kranz anatomy in a fossil from a Miocene Ogallala formation in Kansas is the first definitive record. Since more than half of the genera within the Chloridoideae reside in Africa and all larger tribes and subtribes, excluding Muhlenbergiinae, have centers of diversity in Africa, Hartley and Slater (1960) concluded that the subfamily probably originated on the African continent (perhaps during the Oligocene) and spread from that region to other parts of the world.

Cynodonteae

The Boutelouinae, Hilarinae, Muhlenbergiinae, and Orcuttinae are clearly North American subtribes, but how their ancestor(s) arrived there is obscure. These subtribes probably ultimately descended from a Laurasian ancestor, given the distribution of Muhlenbergia, i.e., predominantly from the southwestern United States and northern Mexico, and also with six species in China (Peterson 2000; Peterson and Ortiz-Diaz 1998; Peterson et al. in press; Wu and Peterson 2006). Since the Chloridoideae are most species-rich in South America, it seems likely that they originated in that continent and spread northward, although we have no genetic evidence for this. It is very difficult to determine any directional signal from the Monanthochloinae and Munroinae, although these two subtribes are slightly more species-rich in South America, suggesting a southern derivation. The Eragrostideae and Zoysieae are more likely west Gondwanaland groups, although the exact timing and routes of migration to both North America and South America are unknown.

The Muhlenbergiinae are characterized by having spikelets perfect, staminate, or sterile; occasionally with cleistogenes in the leaf sheaths; inflorescence paniculate of spicate main branches or a single raceme; spikelet-bearing axis disarticulating (falling entire) or persistent; spikelets solitary, rarely paired or in triplets, occasionally secund; glumes awned or unawed; lemmas three-nerved, awned or unawed; and a base chromosome number of \( x = 8-10 \) (Peterson 2000). The largest genus, Muhlenbergia, has 18 species in California with a single introduced species (Muhlenbergia schreberi). Two species, M. californica and M. jonesii, are endemic to California, the former occurring in the South Coast and Transverse Ranges and the latter known only from the northern Sierra Nevada and the Klamath and High Cascade ranges (Peterson 1993, in press).

Seven species (Neostapfia colisa, Orcuttia inaequalis, O. pilosa, O. tenuis, O. viscidula, Tictoria greenei, and T. mucronata) of the eight species in the Orcuttinae are endemic to California. Unlike most Chloridoideae, which are adapted to summer rains, these annual species are well adapted to winter rains and summer drought. They occur in the western part of the state in vernal pools, an endangered habitat. This subtribe is a unique lineage in the Cynodonteae and is exclusively restricted to the California biome [Orcuttia californica and Tictoria fragilis (Swallen) J. Reeder extend into Baja California, Mexico].

Introductions

There are 43 introduced grass species currently included in the Cal-IPC Invasive Plant Inventory (Cal-IPC), and 28 species in 20 genera do not share any native congeners (species belonging to the same genus). Two of these genera, Brachypodium with five species and Ehrharta with three species, represent introduced tribes, the Brachypodieae and Ehrharteae.

Strauss et al. (2006) compared three groups: introduced species that are harmful to California ecosystem, native species, and introduced species that cause relatively little harm to California ecosystems. They demonstrated that the harmful introduced species are more distant phylogenetically from the native species than the benign introduced species are. This is an interesting conclusion, since it implies that Darwin’s naturalization hypothesis and the “the escape from natural enemies” hypothesis are valid; species that are more distantly related to the native community are more likely to become noxious invasive weeds (Strauss et al. 2006).

The following grasses are currently on the alert category (species that appear to be expanding their range or species showing signs of being invasive in some areas) published by the Cal-IPC: Brachypodium sylvaticum, Ehrharta longiseta, Spartina alterniflora, S. argillica, S. densiflora, and Stipa capensis. Aegilops triuncialis, Ammophila arenaria, Arundo donax, Ehrharta calycina, and Taeniatherum caput-medusae are reported on the
Cal-IPC list as having a high rating (species that have severe ecological impacts, have moderate to high rates of dispersal, and are widely distributed).

**Evolution toward Specialization**

We can see several overarching patterns in the distribution of native and endemic species. There were repeated specializations to narrowly distributed habitats or restricted edaphic or climate settings: (1) isolated wetlands, including (a) vernal pools, mostly of the Central Valley and adjacent foothills, (Puccinellia simplex, *Pluchea lemmisonii*, *Pleuropano californicus*, *Puccinellia simplex* [now introduced in Utah]), (b) saline springs (*Puccinellia bowellii* and the rare *P. parishii*, which is sporadic across the southwestern states) and mineralized soils around springs (*Poa napensis*), (c) freshwater wetlands and moist mountain meadows (*Pleuropano hoovenianus*, *Poa atropurpurea*, *P. stebbinsii*, *Ptilagrostis kingii*); (2) sand dunes (*Agrostis blasdallii*, *Calamagrostis bolanderi*, *Leymus pacificus*, *Poa douglasii*, *Swallenia alexandrae*); (3) ultra-mafic substrates (*Calamagrostis ophitidis*, *Poa piped*, *P. rhizomata*, *P. tenerrima*) and isolated shales (*P. keckii*, *P. pringlei*); (4) alpine and isolated shales (*P. diaboli*); (5) the California Floristic Province (*Phalaris californica*, *P. lemmonii*).

We can see several overarching patterns in the distribution of native and endemic species. There were repeated specializations to narrowly distributed habitats or restricted edaphic or climate settings: (1) isolated wetlands, including (a) vernal pools, mostly of the Central Valley and adjacent foothills, (Puccinellia simplex, *Pluchea lemmisonii*, *Pleuropano californicus*, *Puccinellia simplex* [now introduced in Utah]), (b) saline springs (*Puccinellia bowellii* and the rare *P. parishii*, which is sporadic across the southwestern states) and mineralized soils around springs (*Poa napensis*), (c) freshwater wetlands and moist mountain meadows (*Pleuropano hoovenianus*, *Poa atropurpurea*, *P. stebbinsii*, *Ptilagrostis kingii*); (2) sand dunes (*Agrostis blasdallii*, *Calamagrostis bolanderi*, *Leymus pacificus*, *Poa douglasii*, *Swallenia alexandrae*); (3) ultra-mafic substrates (*Calamagrostis ophitidis*, *Poa piped*, *P. rhizomata*, *P. tenerrima*) and isolated shales (*P. keckii*, *P. pringlei*); (4) alpine and isolated shales (*P. diaboli*); (5) the California Floristic Province (*Phalaris californica*, *P. lemmonii*).

**Appendix 1: A List of the Grass Species Known to Occur in California**

Intraspecific categories are not included. **Bolded** names are native, and those marked with an asterisk (*) are endemic. All other species are introduced and naturalized. This list was prepared using the *Catalogue of New World Grasses* (Soreng et al. 2005), *PLANTS* (USDA, NRCS 2006), and the Grass Manual on the Web (Barkworth et al. 2006). Also consulted but not completely followed were The Grasses of California (Smith 2006), *A Synthesis of the North American Flora* (Kartesz and Meacham 2006), and the Jepson Online Interchange for California floristics (JOI 2006). We have not done an extensive evaluation for all possible introductions, since these are continually being added as reports are published.

**Achnatherum altum** (Swallen) Hoge & Barkworth

**Achnatherum aridum** (M.E. Jones) Barkworth

**Achnatherum coronatum** (Thurb.) Barkworth

**Achnatherum diegoense** (Swallen) Barkworth

**Achnatherum hymenoides** (Roem. & Schult.) Barkworth

**Achnatherum latiglume** (Swallen) Barkworth

**Achnatherum lemmonii** (Vasey) Barkworth

**Achnatherum lettermanii** (Vasey) Barkworth

**Achnatherum nelsonii** ( Scribn.) Barkworth

**Achnatherum nevadense** (B.L. Johnson) Barkworth

**Achnatherum occidentale** (Thurb. ex S. Watson) Barkworth

**Achnatherum parisiis** (Vasey) Barkworth

**Achnatherum pinetorum** (M.E. Jones) Barkworth

**Achnatherum stillmanii** (Bol.) Barkworth

**Achnatherum thurberianum** (Piper) Barkworth

**Achnatherum webberi** (Thurb.) Barkworth

**Achillea aculeata** Host

**Aegilops cylindrica** Roth

**Aegilops geniculata** Roth

**Aegilops tauschi** Coss.

**Aegilops triuncialis** L.

**Agropyron cristatum** (L.) Gaertn.

**Agropyron desertorum** (Fisch. ex Link) Schult.

**Agropyron fragile** (Roth) P. Candargy

**Agrostis blasdalei** Hitchc.

**Agrostis capillicris** L.

**Agrostis densiflora** Vasey

**Agrostis eliottiana** Schult.

**Agrostis exarata** Trin.

**Agrostis gigantea** Roth

**Agrostis hallii** Vasey

**Agrostis hendersonii** Hitchc.

**Agrostis hooveri** Swallen

**Agrostis idahoensis** Nash

**Agrostis microphylla** Steud.

**Agrostis oreognocen** Vasey

**Agrostis palens** Trin.

**Agrostis scabra** Willd.

**Agrostis stolonifera** L.

**Agrostis variabilis** Rydb.

**Aira caryophylllea** L.

**Aira elegantissima** Schur

**Aira praecox** L.

**Alopecurus aequalis** Sobol.

**Alopecurus carolinianus** Walter

**Alopecurus geniculatus** L.

**Alopecurus myosuroides** Huds.

**Alopecurus pratensis** L.

**Alopecurus saccatus** Vasey

**Ammophila arenaria** (L.) Link

**Ammophila brevifilulata** Fernald

**Amphelodesmos macrantha** (Poir.) T. Durand & Schinz

**Amphiobromus neesii** Steud.

**Andropogon glomeratus** (Walter) Britton, Sterns & Poggenb.

**Andropogon virginicus** L.

**Anthoxanthum aristatum** Boiss.
Anthoxanthum nitens (Weber) Y. Schouten & Veldkamp
Anthoxanthum occidentale (Buckley) Veldkamp
Anthoxanthum odoratum L.
Apera interrupta (L.) P. Beauv.
Apera spica-venti (L.) P. Beauv.
Aristida adscensionis L.
Aristida californica Thurb.
Aristida dichotoma Humb. & Bonpl. ex Willd.
Aristida divaricata Michx.
Aristida oligantha Michx.
Aristida purpurea Nutt.
Aristida schiedeana Trin. & Rupr.
Aristida temipes Cav.
Arrhenatherum elatius (L.) P. Beauv. ex J. Presl & C. Presl
Arundo donax L.
Avena barbata Pott ex Link
Avena fatua L.
Avena occidentalis Durieu
Avena sativa L.
Avena sterilis L.
Avena strigosa Schreb.
Axonopus fissifolius (Raddi) Kuhlm.
Beckmannia syzigachne (Steud.) Fernald
Blepharidachne kiiigli (S. Watson) Hack.
Bothriochloa harphida (Lag.) Herter
Bothriochloa ischaemum (L.) Keng
Bothriochloa laguroides (DC.) Herter
Bouteloua aristoides (Kunth) Griseb.
Bouteloua barbata Lagen.
Bouteloua curtipendula (Michx.) Torr.
Bouteloua eriopoda (Torr.) Torr.
Bouteloua gracilis (Kunth) Lag. ex Griffiths
Bouteloua trifida Thurb.
Brachypodium distachyon (L.) P. Beauv.
Brachypodium phaeoicoides (L.) P. Beauv. ex Roem. & Schult.
Brachypodium pinnatum (L.) P. Beauv.
Brachypodium rupestre (Host) Roem. & Schult.
Brachypodium sylvaticum (Huds.) P. Beauv.
Briza maxima L.
Briza media L.
Briza minor L.
Bromidium tandilense (Kuntze) Rúgolo
Bromus arizonicus (Shear) Stebbins
Bromus berteroanus Colla
Bromus brigidiiformis Fisch. & C.A. Mey.
Bromus carinatus Hook. & Arn.
Bromus catharticus Vahl
Bromus cedimillus Steud.
Bromus ciliatus L.
Bromus communis L. Schrad.
Bromus diandrus Roth
*Bromus grandis (Shear) Hitchc.
*Bromus hallii (Hitchc.) Saarela & P.M. Peterson
Bromus hondeaceus L.
Bromus inermis Leyss.
Bromus japonicus Thunb.
Bromus laceres Shear
Bromus madritensis L.
Bromus marginatus Nees ex Steud.
Bromus maritimus (Piper) Hitchc.
Bromus occidentalis Vasey
Bromus panniculatus Scribn. ex Shear
Bromus porteri (J.M. Coult.) Nash
*Bromus pseudolaceres Wagnon
Bromus racemosus L.
Bromus richardsii Link
Bromus socalicus L.
Bromus stichensis Trin.
Bromus sterilis L.
Bromus suksdorfii Vasey
Bromus tectorum L.
Bromus vulgaris (Hook.) Shear
Calamagrostis bolanderi Thurb.
Calamagrostis breweri Thurb.
Calamagrostis canadensis (Michx.) P. Beauv.
*Calamagrostis foliosa Kearney
Calamagrostis koelerioides Vasey
Calamagrostis nitida Thurb.
*Calamagrostis ophitidis (J.T. Howell) Nygren
Calamagrostis purpurascens R. Br.
Calamagrostis rubescens Buckley
Calamagrostis stricta (Timm) Koeler
Catanopsum rigidum (L.) Dony
Cenchrus ciliaris L.
Cenchrus echinatus L.
Cenchrus incertus M.A. Curtis
Cenchrus longispinus (Hack.) Fernald
Chloris gayana Kunth
Chloris truncata R. Br.
Chloris verticillata Nutt.
Chloris virgata Sw.
*Cinna bolanderi Scribn.
Cinna latifolia (Trevir. ex Go(2ppp.) Griseb.
Cortaderia jubata (Lemoine) Stapf
Cortaderia selloana (Schult. & Schult. f.) Asch. & Graebn.
Crypsis alopecuroides (Piller & Mitterp.) Schrad.
Crypsis schoenoides (L.) Lam.
Crypsis vaginiflora (Forssk.) Opiz
Cytandia memphitica (Spreng.) K. Richt.
Cynodon dactylon (L.) Pers.
Cynodon plectostachyus (K. Schum.) Pilg.
Cynodon transvaalensis Burtt Davy
Cynosurus cristatus L.
Cynosurus echinatus L.
Dactylis glomerata L.
Dactyloctenium aegyptium (L.) Willd.
Danthonia californica Bol.
Danthonia decumbens (L.) DC.
Danthonia intermedia Vasey
Danthonia unispicata (Thurb) Munro ex Macoun
Dasyochloa pulchella (Kunth) Willd. ex Rydb.
Deschampsia cespitosa (L.) P. Beauv.
Deschampsia danthonioides (Trin.) Munro
Deschampsia elongata (Hook.) Munro
 Dichanthelium acuminatum (Sw.) Gould & C.A. Clark
Dichanthelium oligosanthes (Schult.) Gould
Digitaria bicornis
Digitaria ciliaris (Retz.) Koeler
Digitaria eriantha Steud.
Digitaria ischaemum (Schreb.) Schreb. ex Muhl.
Digitaria sanguinalis (L.) Scop.
*Dissanthelium californicum* (Nutt.) Benth.
Distichlis spicata (Greene
Echinochloa colonia (L.) Link
Echinochloa crus-galli (L.) P. Beauv.
Echinochloa crus-pavonis (Kunth) Schult.
Echinochloa muricata (P. Beauv.) Fernald
Echinochloa ozymoides (Arn.) Fritsch
Echinochloa phyllogon (Stapf) Stapf ex Kossenko
Ehrharta calycina Sm.
Ehrharta erecta Lam.
Ehrharta longiflora Sm.
Eleusine indica (L.) Gaertn.
Eleusine tristachya (Lam.) Lam.
Elymus arizonicus (Scribn. & J.G. Sm.) Gould
*Elymus californicus* (Boel. ex Thurb.) Gould
Elymus canadensis L.
Elymus eymoides (Raf.) Swezey
Elymus glaucus Buckley
Elymus lanceolatus (Scribn. & J.G. Sm.) Gould
Elymus multisetus (J.G. Sm.) Burtt Davy
Elymus repens (L.) Gould
Elymus scribneri (Vasey) M.E. Jones
Elymus sierrae Gould
*Elymus stebbinsii* Gould
Elymus trachycaulus (Link) Gould ex Shinners
Enneapogon desvauxii P. Beauv.
Eragrostis barekleri Daveau
Eragrostis cilianensis (All.) Vignolo ex Janch.
Eragrostis curvula (Schrad.) Nees
Eragrostis hypnoides (Lam.) Britton, Sterns & Poggeb.
Eragrostis lehmanniana Nees
Eragrostis lutescens
Eragrostis mexicana (Hornem.) Link
Eragrostis minor Host
Eragrostis pectinacea (Michx.) Nees
Eragrostis pilosa (L.) P. Beauv.
Eragrostis superba Peyr.
Eriochloa acuminata (J. Presl) Kunth
Eriochloa aristata Vasey
Eriochloa contracta Hitchc.
Eriochloa fatens (Hochst. & Steud.) Clayton
Eriochloa villosa (Thunb.) Kunth
Eriochloa pilosum (Buckley) Nash
Leersia oryzoides (L.) Sw.
Leptochloa dubia (Kunth) Nees
Leptochloa fusca (L.) Kunth
Leptochloa panicua (Retz.) Ohwi
Leptochloa viscosa (Scribn.) Beal
Leucopoa kingii (S. Watson) W.A. Weber
Levynus cinereus (Scribn. & Merr.) A. Love
Levynus condensatus (J. Presl) A. Love
Levynus mollis (Trin.) Pilg.
*Levynus pacificus (Gould) D.R. Dewey
Levynus salittus (M.E. Jones) A. Love
Levynus triticoides (Buckley) Pilg.
Loliuni multiflorum Lam.
Loliuni perenne L.
Loliuni rigidum Gaudin
Loliuni temulentum L.
Lycurus setosus (Nutt.) C. Reeder
Megathyrsus maxima (Jacq.) B.K. Simon & S.W.L. Jacobs
*Mélica aristata Thurb. ex Bol.
*Mélica bulbosa Geyer ex Porter & Coult.
*Mélica californica Scribn.
*Mélica frutescens Scribn.
*Mélica fusax Bol.
*Mélica geyeri Munro
*Mélica harfordii Bol.
*Mélica imperfecta Trin.
*Mélica spectabilis Scribn.
*Mélica stricta Bol.
*Mélica subalata (Griseb.) Scribn.
*Melinis repens (Willd.) Zizka
Miscanthus sinensis Andersson
Munroa squarrosa (Nutt.) Torr.
*Nassella cernua (Steubins & Love) Barkworth
*Nassella lepida (Hitchc.) Barkworth
*Nassella manicata (E. Desv.) Barkworth
*Nassella pulchra (Hitchc.) Barkworth
*Nassella tenuissima (Trin.) Barkworth
*Nassella viridula (Trin.) Barkworth
*Neostephia colusana (Burtt Davy) Burtt Davy
Orcuttia californica Vasey
*Orcuttia inaequalis Hoover
*Orcuttia piolosa Hoover
*Orcuttia tenuis Hitchc.
*Orcuttia viscosa (Hooven) Reeder
Oryza rufipogon Griff.
Oryza sativa L.
Panicum alatum Zuloaga & Morrone
Panicum capillare L.
Panicum dichotomiflorum Michx.
Panicum hirsutum Chase
Panicum hirticaule J. Presl
Panicum milaceum L.
Panicum repens L.
Panicum rigidulum Bosc ex Nees
Panicum urvillei Kunth
Paraphons incurva (L.) C.E. Hubb.
Paraphons striosa (Dumort.) C.E. Hubb.
Pascopyrum smithii (Rydb.) Barkworth & D.R. Dewey
Paspalum dilatatum Poir.
Paspalum distichum L.
Paspalum notatum Flüggé
Paspalum urvillei Steud.
Penisetum clandestinum Hochst. ex Chiov.
Penisetum glaucum (L.) R. Br.
Penisetum latifolium Spreng.
Penisetum macrourum Trin.
Penisetum nervosum (Nees) Trin.
Penisetum purpureum Schumach.
Penisetum setaceum (Forssk.) Chiov.
Penisetum villosum R. Br. ex Fresen.
Phalaris angustifolia Nees ex Trin.
Phalaris aquatica L.
Phalaris arundinacea L.
Phalaris brachystachys Link
Phalaris californica Hook. & Arn.
Phalaris canariensis L.
Phalaris caroliniana Walter
Phalaris coerulescens Desf.
Phalaris lemmonii Vasey
Phalaris minor Retz.
Phalaris paradoxa L.
Phleum alpinum L.
Phleum pratense L.
Phragmites australis (Cav.) Steud.
Phyllostachys bambusoides Siebold & Zucc.
Phyllostachys nigra (Lodd. ex Lindl.) Munro
Piptatherum exiguum (Thurb.) Dorn
Piptatherum microstachyum (Trin. & Rupt.) Barkworth
Piptatherum milaceum (L.) Coss.
Piptochaelium setosum (Trin.) Arechav.
Piptochaetium stipoides (Trin. & Rupt.) Hack. ex Arechav.

*Pleurogonon californicus* (Nees) Benth. ex Vasey

*Pleurogonon hooverianus* (L.D. Benson) J.T. Howell

Pleurogonon refractus (A. Gray) Benth.

Poa abbreviata R. Br.

*Poa atropurpurea* Scribn.

Poa bigelovii Vasey & Scribn.

Poa bolanderi Vasey

Poa bulbosa L.

Poa compressa L.

Poa confinis Vasey

Poa cusickii Vasey

*Poa diabolii* Soreng & D.J. Keil

Poa douglasii Nees

Poa fendleriana (Steud.) Vasey

Poa glauca (Steud.) Vasey

Poa hochstetteri Vasey & Scribn.

Poa infirma L.

*Poa keckii* Soreng

*Poa kelloggi* Vasey

Poa leptocotona Kunth

Poa macrana Vasey

*Poa napensis* Beetle

Poa nemoralis L.

Poa pahelii L.

Poa piperi Hitchc.

Poa pratensis L.

Poa pringlei Scribn.

Poa rhizomata Hitchc.

Poa secunda J. Presl

*Poa sierrae* J.T. Howell

*Poa stebbinsii* Soreng

*Poa tenerina* Scribn.

Poa trivialis L.

Poa unilateralis Scribn. ex Vasey

Poa wheeleri Vasey

Podagrostis humilis (Vasey) Björkman

Podagrostis thurberiana (Hitchc.) Hultén

Polypogon australis Brongn.

Polypogon elongatus Kunth

Polypogon imberbis (Phil.) Jhow

Polypogon interruptus Kunth

Polypogon maritimus Willd.

Polypogon monspeliensis (L.) Desf.

Polypogon viridis (Gouan) Breistr.

Pseudoroegneria spicata (Pursh) Á. Löve

Pseudosasa japonica (Siebold & Zucc. ex Steud.) Makino ex Nakai

*Ptilagrostis kingii* (Bol.) Barkworth

Puccinellia distans (Jacq.) Parl.

*Puccinellia howellii* J.J. Davis

Puccinellia lemmonii (Vasey) Scribn.

Puccinellia maritima (Huds.) Parl.

Puccinellia nutkaensis (J. Presl) Fernald & Weath.

Puccinellia nuttalliana (Schult.) Hitchc.

Puccinellia parishii Hitchc.

Puccinellia pumila (Vasey) Hitchc.

Puccinellia simplex Scribn.

Rostraria cristata (L.) Tzvelev

Rytiposperma biamnuare (Zotov) Connor & Edgar

Rytiposperma caespitosum (Gaudich.) Connor & Edgar

Rytiposperma penicillatum (Labill.) Connor & Edgar

Rytiposperma racemosum (R. Br.) Connor & Edgar

Rytiposperma richardsonii (Cashmore) Connor & Edgar

Saccharum ravennae (L.) L.

Schedonardus paniculatus (Nutt.) Branner & Coville

Schedonorus arundinaceus (Schreb.) Dumort.

Schedonorus pratensis (Huds.) P. Beauv.

Schismus arabicus Nees

Schismus barbatus (L.) Thell.

Schizachyrium cirratum (Hack.) Wooton & Standl.

Schizachyrium scoparium (Michx.) Nash

Sclerochloa dura (L.) P. Beauv.

Scleropogon brevifolius Phil.

Scribaniera bolanderi (Thurb.) Hack.

Scole cereale L.

Setaria faberi R.A.W. Herrm.

Setaria italica (L.) P. Beauv.

Setaria parviflora (Poir.) Kerguélen

Setaria pumila (Poir.) Roem. & Schult.

Setaria sphaecalata

Setaria verticillata (L.) P. Beauv.

Setaria viridis (L.) P. Beauv.

Sorghum bicolor (L.) Moench

Sorghum halepense (L.) Pers.

Spartina alterniflora Loisel.

Spartina anglica C.E. Hubb.

Spartina densiflora Brongn.

Spartina foliosa Trin.

Spartina gracilis Trin.

Spartina patens (Aiton) Muhl.

Sphenopholis obtusata (Michx.) Scribn.

Sporobolus airoides (Torr.) Torr.

Sporobolus contractus Hitchc.

Sporobolus creber De Nardi

Sporobolus cryptandrus (Torr.) A. Gray

Sporobolus flexuosus (Thurb. ex Vasey) Rydb.

Sporobolus indicus (L.) R. Br.

Sporobolus vaginiflorus (Torr. ex A. Gray) Alph. Wood

Sporobolus wrightii Munro ex Scribn.

Stenotaphrum secundatum (Walter) Kuntze

Stipa capensis Thunb.

*Swallenia alexandrae* (Swallen) Soderstr. & H.F. Decker

Taeniatherum caput-medusae (L.) Nevski

Themeda quadrivalvis (L.) Kuntze

Thinopyrum intermedium (Host) Barkworth & D.R. Dewey

Thinopyrum junceum (L.) Á. Löve

Thinopyrum ponticum (Podp.) Barkworth & D.R. Dewey

Thinopyrum pycnanthum (Godr.) Barkworth

Thysanolaena latifolia (Roxb. ex Hornem.) Honda
Torreyochloa erecta (Hitchc.) G.L. Church
Torreyochloa pallida (Torr.) G.L. Church
Tribolium obliterum (Hemsl.) Renvoize
Tridens flavus (L.) Hitchc.
Tridens muticus (Torr.) Nash
Trisetum cernuum Trin.
Trisetum flavescens (L.) P. Beauv.
Trisetum spicatum (L.) K. Richt.
Triticum aestivum L.
*Tuctoria greenei* (Vasey) Reeder
*Tuctoria mucronata* (Crampton) Reeder

Urochloa arizonica (Scribn. & Merr.) Morrone & Zuloaga
Urochloa texana (Buckley) R.D. Webster
Vahlodea atropurpurea (Wahlenb.) Fr. ex Hartm.
Ventenata dubia (Leers) Coss.
Vulpia bromoides (L.) Gray
Vulpia microstachys (Nutt.) Munro
Vulpia myuros (L.) C.C. Gmel.
Vulpia octoflora (Walter) Rydb.
Zea mays L.
Zizania palustris L.
Zoysia japonica Steud.