GRASS IDENTIFICATION WORKSHOP

University of Arizona Herbarium
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What is a Grass?

Viridophytes (Green Plants) >> Embryophytes (Land Plants) >> Tracheophytes (Vascular Plants) >> Spermatophytes (Seed Plants) >> Angiosperms (Flowering Plants) >> Monocots (one embryonic seed leaf) >> order Poales (mostly sedges, rushes and grasses) >> family Poaceae (the grass family)

Grasses have jointed stems (culms) bearing leaves that alternate. At the distal end of the culm is an inflorescence. Many species also have shorter leaf bearing stems without inflorescences called tillers or innovations. The leaves alternate and attach to the culm on the opposite side from the one above and below. This alternating pattern is termed distichous. Leaves attach at culm nodes. Leaves have sheaths, blades and in most species ligules. Bracteate structures, called spikelets, in the inflorescence contain the flowers. Spikelets are unique to only the grass family. The flowers contain no recognizable perianth parts. The fruit is a caryopsis (grain). It is the product of one flower and contains one seed which is usually fused to the ovary wall (pericarp). Some authors disagree in calling all fruits of grass species caryopses but, whatever, the above fruit description is sufficient for our purposes. The anthers contain two locules (chambers) usually elongate each opening through longitudinal slits. Culm growth is only primary with no later secondary growth. Other closely related plant families may contain some of the same characteristics but not the entire suite.

Why Taxonomic Names?

Within the large family Poaceae are subfamilies which contain one or more tribes. There are approximately 12,000 species of grasses worldwide. Each one of those species fits within a genus having its unique characteristics which fits within a tribe etc. Species are recognized by taxonomic names also known as scientific names, taxons, Latin names or botanical names. Generally, common names are not used scientifically because they are random names for which there is no scientific meaning; nor are they within the common language used by botanists world wide. The taxonomic name consists of two words, the first being the genus (plural-genera) and the second being the species. There are hundreds of grass genera which are groups of closely related species. Genus names can stand alone because they do not duplicate, but species names cannot because they may duplicate among the various genera but not within a particular genus. Within a species there may be enough diversity to further divide it into subspecies (subsp.) or varieties (var.). There is little or no difference between subspecies and varieties. The name(s) of the person or persons who named the taxon (naming authority or authorities) follow after the species and subspecies/variety names. More information about the scientific naming of plants is found below in the Nomenclature section.

Taxonomic names can tell knowledgeable persons worldwide much about the plant in question. For example, if someone mentions Genus *Aristida* it brings to mind a group of grasses with a specific set of characteristics. **Note** that within this document genus, species and infraspecific names are always italicized. Classification has been largely morphology based but that is less so in modern times being largely DNA based. Information in the DNA provides a more accurate assessment of relationships in the tree of life than does just morphology. This has resulted in a number of taxonomic name changes; however in most cases morphologically similar species are also found to be genetically closely related. In the Some Arizona Grasses section below are

listed many synonyms (the old names) which occur in floras that were published prior to name changes.

Identification of Grass Species – Getting Started

There are two basic ways to identify the species of a specimen. One method is trial and error, such as looking at plant "mug shots" to make a selection. This often does not work too well. In this workshop we teach a science based approach.

In order to use a scientific approach one first must have some knowledge of the plant including its morphology plus the terminology associated with it. It is also necessary to know more about various grass parts such as texture and vestiture. With this knowledge one will be able to navigate through most dichotomous keys that are prepared to aid in species identification. We will study basic grass morphology, texture, surface texture and vestiture. This knowledge is vital to have for plant identification purposes.

To ease beginners into identifying some of our local grasses, I have provided a hybrid approach. It starts with a key to the various grass tribes found in Arizona. After determining the tribe (refer to the Arizona tribe key below) that best matches your specimen you can look through descriptions of a majority of the species/genera found locally in the Some Arizona Grasses section below where the featured genera/species are arranged by tribe. With this information you will likely be able to determine the genus or perhaps species, hopefully with just a 10x or more hand lens.

Grass Morphology

This section contains basic morphological information that one needs to understand in order to identify most grass species in Arizona and throughout the region. Discussed here will be all of the grass structures or components and how they fit together. The basic morphological plan stays fairly uniform for all grass species, but be prepared to find much variation within the individual parts that is unique to a given genus, species etc. In addition to morphology, texture, shape, size, vestiture (pubescence) and even color of various structures are usually quite species specific, so they have an important role in species identification. Texture vestiture etc. will be discussed in the next major section of this handout. In some species various structures may be greatly altered or never develop. It is important to note that any of the grass parts may play a role in identifying a species.

Prior to discussing the individual parts, an understanding of their relative location is important. First visualize the grass as a pump. Its roots gather water and nutrients from the soil and a vascular system "pumps" the water and nutrients to the far reaches of the plant. The terms proximal and distal refer to the position of one plant part in relation to another part along this "water route." Along the water route a distal plant part is farther from the roots than a proximal part. Other terms meaning the same as proximal include "below, lower, first or subtending". For distal one may see the term "above."

Bamboos are omitted because they have some unique characteristics for which a specialized language has been developed, nor are bamboos native to Arizona.

Roots
Grass roots do not develop from an embryonic tap root. The embryonic tap root soon becomes irrelevant leaving only fibrous roots to develop from the base of the stem (culm). Roots also may form from above ground culm nodes if they come in contact with the soil. Grass roots play a minor role in grass identification but indirectly provide some evidence in determination of grass life span (annual or perennial). See Collecting and Preservation Issues below for tips on how to determine whether annual or perennial.

Culm
This, the stem of grasses, contains three major features, the nodes, internodes and in most species a terminal inflorescence commonly called a seed head. Culm nodes are below the terminal inflorescences and are obvious bands where leaves, and in some species culm branches, spikelets (see below under Identifying the Parts), axillary inflorescences, roots, rhizomes or stolons may appear. Proximal culm nodes are usually quite closely spaced. Those above are more widely spaced. Culm branches bud from within the base of a leaf sheath and either exit the sheath at the top (intravaginal) or burst through the sheath (extravaginal). A leaf like structure with two major veins and smaller veins located in the axil between a culm and culm branch is called a prophyll. It plays no role in identification of most species.

Culms that do not terminate with an inflorescence are called innovations or tillers. Most authorities state that innovations are limited to perennial species. You might occasionally find some limited exceptions, but I believe that species generally come close to following the rule.

Some grasses reproduce vegetatively by rhizomes (underground stems) or stolons (above ground stems). These specialized stems begin at nodes on the parent plant. At nodes along these specialized stems new plants arise. Rhizomes which may be quite long and extensive may produce dense patches of culms (sod) such as seen in Bermuda grass lawns or more scattered single or perhaps small clumps of culms nearby. The spacing of individual plants is influenced by the spacing of nodes of the rhizomes and/or stolons and the density of rhizomes/stolons.

Those grasses that reproduce only by seed usually mature to be compact, dense clumps of culms usually somewhat isolated from other plants. They are said to be cespitose or caespitose and are commonly called bunch grasses. Culms of some species of warm wetter habitats creep across the soil surface.

Leaf
Grass leaves usually have three major parts. See plate I. Leaf formation starts at a culm node. Proximal is the sheath that envelops the culm. Sheaths are either open, closed or part closed below and open above. Open sheaths are similar to a sheet of paper rolled to form a tube. One edge overlaps the other. Closed sheaths have edges fused such as a metal or plastic pipe. Bending away from the distal end of the sheath is the blade. On the inside of the blade-sheath junction and forming a semicircle around the culm in most species is a small flap of membrane, a line of hairs or a combination with hairs atop a membrane called a ligule. Sheaths usually have a somewhat v-shaped opening at the top. Here, reaching out or around the top of the "vee" in the open space are in some species small often finger like projections, auricles, that may or may not clasp the culm.

The terms throat and collar refer to the area where the sheath and blade meet. The throat is the upper margin of the sheath in the area where the sheath opens to form the "vee." The collar refers to the exposed side away from the culm (abaxial side-see below) opposite to the side in

which a ligule would be located. In general the terms adaxial and abaxial refer to the relation of a plant part or plant part surface to an axis. Adaxial is the side or surface facing the axis and abaxial is the side or surface away from the axis. For example, the usual upper surface of a leaf blade (the ligule side) is adaxial while the underside is the abaxial side. In this case, the culm is understood to be the axis. The terms dorsal and ventral are sometimes used in place of the terms abaxial and adaxial respectively.

The uppermost leaf of a culm is called the flag leaf. It with other upper leaves may be shorter than the lower culm leaves. Often most of the leaves of a cespitose plant occur at the base; hence the name basal leaves. I have never figured out if they are attached to short innovations or are attached to culm nodes that are very closely spaced. Perhaps it is a little of both.

Leaf blades are often folded along the midvane (conduplicate) or longitudinally rolled upwards on the edges (involute). Blades are revolute when the edges are rolled downwards. Convolute leaves are completely rolled longitudinally with one edge overlapping the other. Most of our grasses have flat, involute or conduplicate blades. This does present some difficulties in trying to figure out how to measure width of the blades. More on this subject is discussed in the Measurements section. Blade length is measured from the sheath-blade junction to the tip of the leaf.

Most important words to remember—culm, sheath, ligule, blade, auricle, collar, abaxial/adaxial, proximal/distal

Inflorescence

This is the part of the culm which physically supports the sexual reproductive units (spikelets which contain the flowers) of grasses. Some newer references use the term synflorescence in place of the traditional term, inflorescence, that is used here. Plates I, II and III illustrate the three inflorescence types and features of each. Besides spikelets, grass inflorescences excluding bamboos can only have stems that support the spikelets. The stems may or may not rebranch; there are no leaves found in inflorescences.

The proximal portion of an inflorescence is the peduncle. It is a bare unbranched stem that supports the remainder of the inflorescence. The lower (proximal) end of the terminal inflorescence peduncle starts at the node to which the flag is attached. Its upper (distal) end is at the lowest node of the inflorescence. At this node will either be a spikelet or spikelets or a branch or branches. Distal to this node is the rachis that is the central stem of the inflorescence. Along the rachis at various points are nodes where spikelets or branches attach. Note that inflorescence nodes unlike culm nodes do not appear as distinct bands. Terminal inflorescences are most common but some species may have axillary inflorescences that attach at culm nodes below the flag leaf.

Often the lower portion of inflorescences do not emerge from the leaf sheath, so the sexual reproductive structures are never exposed; a condition more prevalent in some species than others Some pollination schemes and how the culms and inflorences grow will be mentioned later in this document.

Grass inflorescences (spikes, racemes or panicles) are determinate. This means that the most distal spikelets mature earlier than those lower. This is contrary to what you might have learned

about these inflorescence types. They are stated as being indeterminate for most or all other angiosperms.

There are many attributes about inflorescences in addition to the basic type that may be important in the identification of particular species. These might include the outline shape, whether or not branches are rebranched, size and number of branches and whether or not the branches might have spikelets on one side or not and the number of branches at one node. Good descriptions of the inflorescence should enable the reader to accurately visualize how it looks.

Most important words to remember—spike, panicle, raceme, rame, rachis, pedicel.

The three basic inflorescence types (spike, raceme and panicle) are as follows. The pattern of inflorescence branching defines the type.

Spike
This is the most simple inflorescence. The spikelets attach directly to the rachis (sessile), so the inflorescence consists only of spikelets and the rachis. There is no other branching

Raceme
The raceme is slightly more complex than a spike and is fairly uncommon. If all or some spikelets have pedicels attaching directly to the rachis without more complex branching the inflorescence is a raceme. The pedicel is a stem supporting a **single** spikelet. Some species of Tribe Triticeae have spikelets on very short pedicels. These inflorescences appear as spikes but technically they are racemes, but as a matter of convenience in some floras they are defined as spikes.

Panicle
Most complex is the panicle. If **any** branches of the rachis contain more than one spikelet the inflorescence is a panicle, the most common grass inflorescence. See plate II for some panicle branching patterns. Panicles have many different appearances depending upon the length of the branches, the density of the spikelets on the branch and whether the branches are appressed, ascending,widespreading or nodding. Branches may rebranch in some species. In some species the panicles may appear to be one sided and/or with branches with all the spikelets on one side (secund). *Bouteloua* species are good examples of secund branches and secund spikelets on the branches.

The panicle may have branches scattered all along an elongate rachis (raceme like or racemose branching), or in other species they may radiate from one location (verticillate, whorled, digitate). Sometimes most of the branches are verticillate but with one or two branches lower on the rachis (subdigitate); therefore the rachis is short or nonexistant.

At the base of panicle branches in some species are swellings called pulvini (singular pulvinus). The pulvini may play a role in increasing the angle between the rachis and the branch as might a wedge.

Most members of the "bristle clade" in family Paniceae have configurations said to be modifications of panicle branches. Locally, *Setaria* have one or more bristles subtending each spikelet. More modified are fascicles in *Cenchrus.* For example buffel and fountain grasses have a number of bristles that are united at the base to form a cupule called a fascicle in which

one or more spikelets are found. A more extreme example of a fascicle is found in *Cenchrus spinifex.* It will be mentioned in the Some Arizona Grasses section.

Floras describe panicles in various ways. Flora of North America (FNA) describes panicle branches in a manner that often uses the word "like." For example if branches appear to resemble the spike, the branches might be termed spike like or spikate. Other references might refer to this as "a panicle of spikes." This would be inappropriate in FNA because there can only be one inflorescence type. In this case it would be a panicle, not both a spike and a panicle. Another example in Hitchcock and Chase: "racemes racemose along the main axis." We know it must be a panicle because there are branches of the "axis" (rachis) that appear raceme like with more than one spikelet. In this situation FNA might now state this to be "a panicle with raceme like branches arranged along the main axis (rachis)."

Rame

Here I will follow the FNA treatment of the term rame which is applied specifically to the Andropogoneae tribe. FNA, vol. 25, has a thorough explanation of the Andropogoneae inflorescence. Though not specifically stated, the term rame is applied to disarticulating inflorescences meaning the stem itself disarticulates. Various species of the tribe may have common racemes, a single rame or panicles with branches that are rames. Plate III shows details of the Andropogon tribe inflorescences.

In paniculate inflorescences, rames branch from a rachis such as in locally common *Bothriochloa barbinodis;* therefore, the branches (rames) disarticulate but the rachis does not. *Trachypogon secundus,* a local grassland species, has an inflorescence of common racemes meaning that the axis of the raceme (the rachis) does not disarticulate; hence it is not a rame. *Heteropogon contortus*, common locally, has just one rame, which might also technically be called a raceme, but the term rame is more precise because the raceme disarticulates. A few Andropogoneae genera have common inflorescences without rames. Because the rame is morphologically similar to a raceme, some publications, especially older publications do not mention the term rame. Most likely they would refer to rames as "racemes." If it is part of a paniculate inflorescence perhaps it might be stated as "raceme branches of a panicle."

Curiously, similar situations of disarticulation occur in some species of other tribes eg *Hordeum murinum*, a locally common exotic annual, but their inflorescences are not termed rames.

In the FNA treatment the disarticulating stem of a rame is called the rame axis. To each rame segment (axis) are normally attached two spikelets, one sessile or near sessile and one distinctly pedicellate. The segments with attached spikelets are called spikelet units as illustrated in plate III. Note that some species have spikelet units with two pedicellate spikelets and one sessile spikelet. Within individual spikelet units depending upon the species the two or three spikelets may have differences in morphology and sex: (hetero meaning different or homo meaning similar —morphic) and (homo meaning similar or hetero meaning different–gamous). For example *Bothriochloa barbinodis* has spikelet units that are heterogamous and heteromorphic. The sessile spikelet is bisexual and larger than the pedicellate spikelet which is asexual (sterile). In this case the size difference means the spikelets are morphologically different.

Spikelet

Spikelets house the flowers of grasses. Each flower is called a floret. Some genera or species always have one floret per spikelet and some species may always have two florets. In other

species the floret numbers may vary. Each floret contains usually two bracts which surround the sexual reproductive parts. Each spikelet also usually has two empty bracts that subtend all of the florets. The arrangement of subtending (lower) bracts and florets is usually distichous i.e. the bracts are not exactly opposite, but one is slightly below the other.

Bracts may have somewhat various shapes but most are somewhat cupped like a spoon. They partially protect the included parts. Below in the Identifying the Parts section are some drawings of various bract shapes.

The distichous arrangement is most easily seen in spikelets with multiple florets. In these, the florets alternate on opposite sides of the central stem with all being in the same plane as shown in the following drawings that illustrate compression. In some species the subtending bracts become somewhat rotated or fused so they are not always in the same plane as the florets, but the florets in these species tend to be distichous.

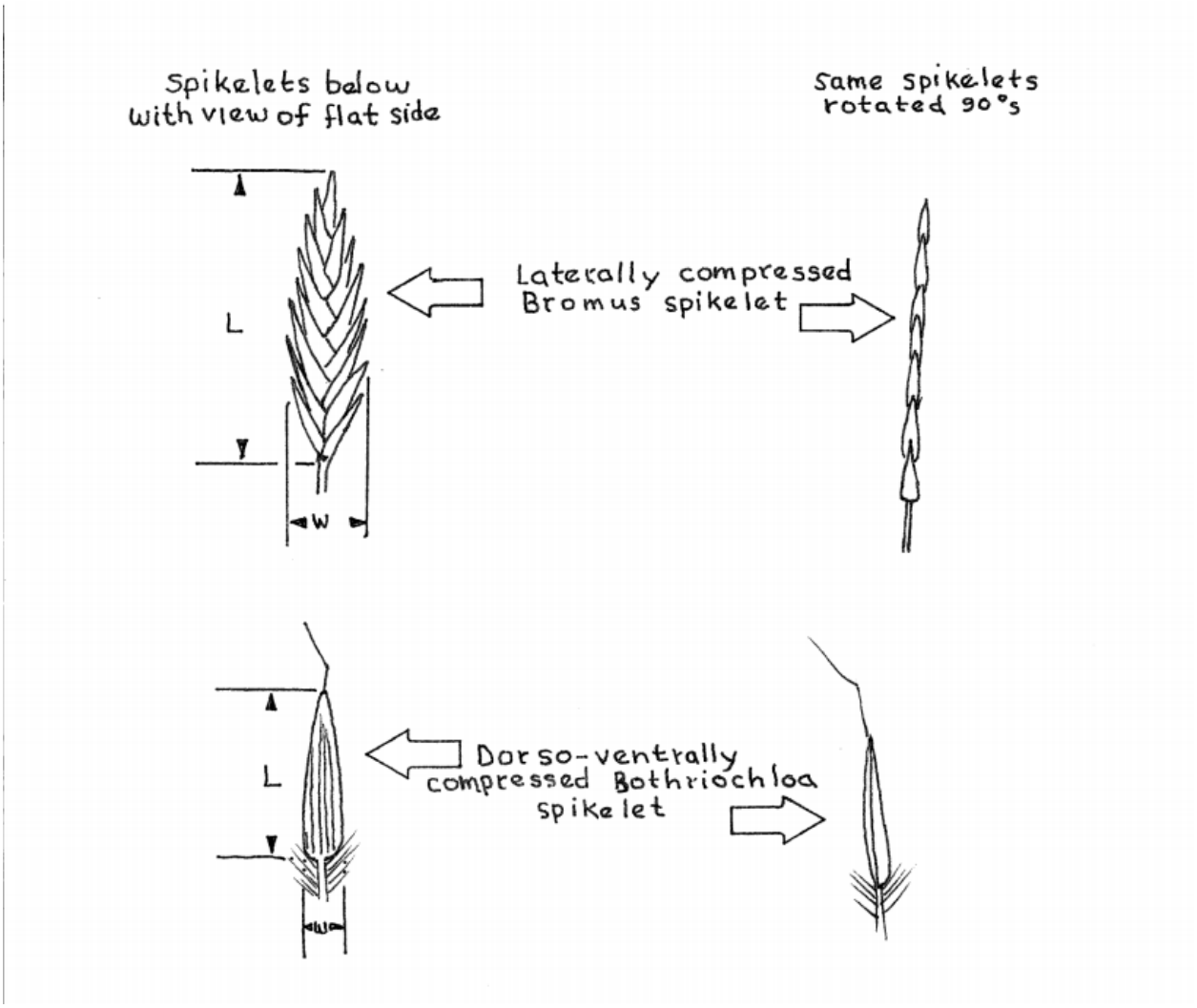
An understanding of spikelet compression is important. Below are drawings illustrating compression. There are two types: lateral and dorso-ventral also simply called dorsal compression. The shape of the bracts help determine the shape of the spikelet and whether or not it is compressed. If the spikelet is narrower in the lateral plane than the other plane (the dorso-ventral plane) it is laterally compressed. If we placed the laterally compressed spikelet on a flat surface the bracts would be lying on their edge. Conversely if a spikelet is dorso-ventrally compressed and placed on a flat surface the mid ribs of the bracts would be in contact with that surface. Spikelets without compression tend to be somewhat spherical, cigar shaped, or slightly lance shaped (lanceolate)

Multi flowered spikelets of most species in tribes other than Andropogoneae and Paniceae are laterally compressed and usually ovate or lanceolate in outline when lying on their side as illustrated. Think of the single flowered spikelet as just a multi flowered spikelet that has been reduced to one floret. Andropogoneae and Paniceae spikelets, always with two florets, vary from being somewhat dorso-ventrally compressed to somewhat spherical (globose) in cross section. Longitudinally these spikelets are often somewhat oblong to lanceolate or almost round in *Paspalum.* In cross section *Paspalum* species are mostly flat on one side and curved outwardly (convex) on the other.

Grass students should be knowledgeable about four different basic spikelet types: three with bilateral symmetry (distichous) and one in which some of the subtending bracts as mentioned above are in a somewhat different plane; hence they are asymmetrical. Bilateral symmetry is found in the spikelets of most species but there are enough differences to address the three configurations separately—1)--Andropogoneae Tribe, type 2)--Paniceae Tribe type and 3)--those of most other tribes.

Bilaterally asymmetrical spikelets, a variant of number three above, are found in some local genera. Good examples are found in *Hilaria* and in many species of the Triticeae Tribe. In *Hilaria* species three spikelets are closely adjacent at the same node and, although I have not seen this mentioned in the literature, the lower (subtending) bracts of each seem to be shared with the adjacent spikelets, fused and virtually inseparable. When the inflorescence breaks up the three spikelets all drop together in a group (fascicle) as do the fascicles of buffel and fountain grass. Within the Triticeae Tribe many of the species have asymmetrical aspects with the subtending bracts being rotated as mentioned above.

Spikelets are generally the most important parts of a grass necessary for identifying individual species. Stated another way 'it's almost all about spikelets, spikelets, spikelets or perhaps more exactly bracts, bracts, bracts!' Only those spikelets exposed to view in inflorescences will be examined in this workshop. In some species spikelets are hidden in leaf sheaths or even underground but more on that later.



L equals spikelet length and w represents spikelet width. Note that in the two spikelet types shown above width is measured in different planes. Length and width are the only spikelet measurements noted in species descriptions. More information on measurements is mentioned in the Measurements section below.

The Bromus spikelet is typical of multi flowered bilaterally symmetrical spikelets. Most tend to have a lanceolate to ovate shape when outlined as above left.

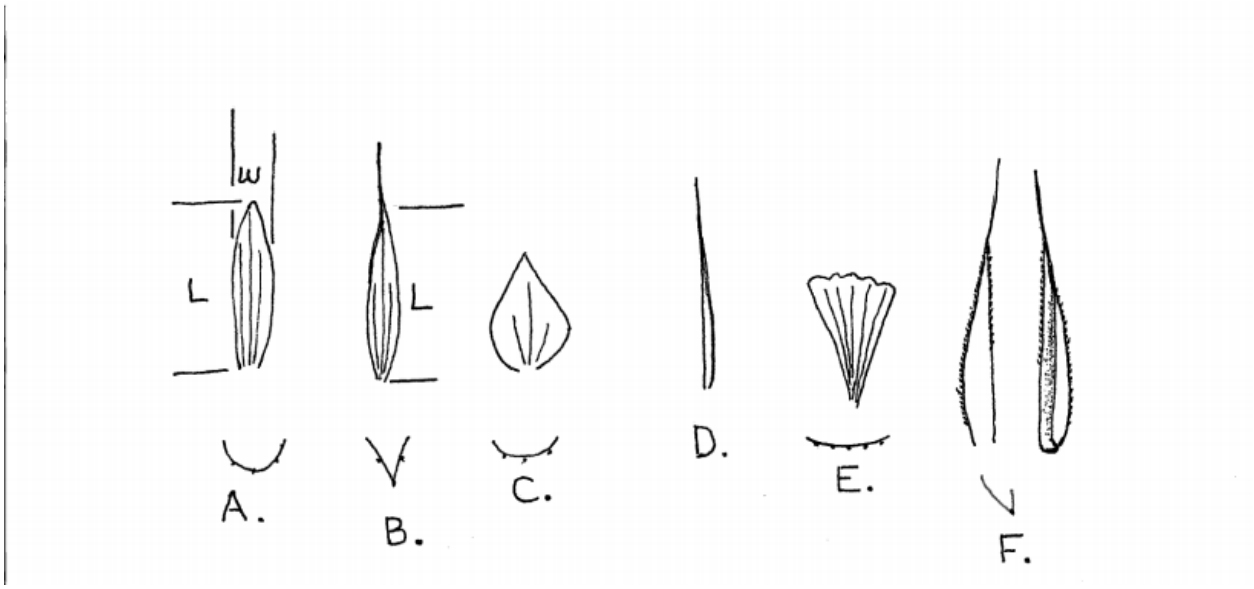
The Bothriochloa spikelet is also multiflowered and bilaterally symmetrical, but the individual florets are fully contained within the subtending but empty bracts.

Locating the spikelet
Remember that inflorescences only contain the bracteate structures (spikelets) and stems to which they are attached. That means there are no leaves or culm branches in an inflorescence. In most species finding the spikelets is easy because they are isolated at the ends of branches. For some species isolating the individual spikelets is more difficult because there may be little or no space between them.

In these more challenging species, it might be helpful to first locate an individual floret then work from that point down to the subtending bracts. An understanding of the information in the following section of this handout should be helpful when trying to identify those crowded spikelets.

Once the spikelet is isolated navigating it is both simple and complex. It is simple because the basic architecture is similar in spikelets of all species but complex due to the infinite variation of size, shape, venation, pubescence etc. found among different species. There is usually some variation between individual plants of the same species too. In most species the bracts tend to vary from linear, lanceolate to being wider than long.

Identifying the parts
As noted above, for the most part, the basic plan of the spikelet shows a bilateral symmetry. Plates II, IV, V and VI all illustrate the various spikelet parts. Keep in mind that the distances shown between bracts and reproductive parts in the exploded views in plate II are greatly exaggerated. Most spikelets have bracts with a midrib vein and other veins parallel to the midrib that start at or near where the bract attaches to the stem and converge near or at the tip of the bract somewhat like lines of longitude on a globe. Common mostly symmetrical bract shapes and one uncommon asymmetrical bract shape are all illustrated on the next page.



Dorsal view of some various outer bract shapes (typical palea shapes not shown) likely to be seen in Arizona grasses. The lower drawings illustrate cross sections. See Plate III for names of various shapes.

A. and B. Many species have this basic lanceolate to ovate shaped bracts. Note that width (w) is measured at the widest part without flattening the bract. Length usually does not include the awn as shown in B. unless otherwise stated or as in D. mentioned below. Cross sections may be either somewhat "vee" shaped or rounded or part rounded and part "vee" shaped. A sharply folded "vee" is known as a keel as shown in B. More information on measurements is mentioned in the Measurements section below.

C. Bract shape commonly seen in some Paniceae genera/species; width usually not important but the length often is important.

D. Subulate (awl shaped) bract commonly found in many species of the Triticeae Tribe; the awn is somewhat inseparable from the lower part of the bract. Width may or may not be important. If the length is stated the bract length probably most often includes the awn unless otherwise stated.

E. An uncommon flabellate (fan shaped) bract; a few local species of *Hilaria, Enneapogon, Cottea,* and *Pappophorum* all have somewhat flabellate bracts.

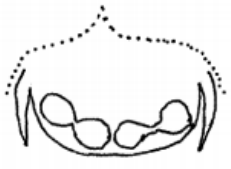
F. An example of an asymmetrical bract. This uncommon shape is found in *Secale cereale* (cultivated rye). Note that the midrib located at the fold is distinctly off center. With the tight angle and sharpness of the fold it is considered to be a keel.

The lower empty bracts, (glumes), usually form that somewhat spoon shaped or cupped hands like structure alluded to above. Because the structures are alternate as opposed to being opposite, one glume attaches slightly above the other. The first or lower glume is sometimes referred to as $g^{1.}$ and the other as $g^{2.}$ Those species with multi flowered spikelets have a stem that emerges from between the glumes called a rachilla to which the individual florets are attached.

Along the rachilla the florets alternate, the first (lower) flower on one side, the next above on the other side etc. (distichous). Often a floret terminates a rachilla, but in some species the rachilla may extend beyond the distal floret and just terminates or perhaps ends with a very incompletely developed sterile rudimentary spikelet (rudiment). Depending upon the tribe, genus and species the number of florets may vary from one to 10+. In most species with multi flowered spikelets, except those of the Andropogoneae and Paniceae tribes, the lower one or more florets tend to be the largest and bisexual. The upper are often smaller and sterile or perhaps unisexual.

The bracts of the individual flowers (lemma and palea) form a somewhat cuplike structure surrounding the male and/or female reproductive parts. The lemma and palea are considered part of the floret. In bilaterally symmetrical spikelets the first (lower) floret is always directly above $g^{1.}$ and the second floret is always above $g^{2..}$ Many species may have only one floret with all the bracts somewhat jammed together but still distinct. Plate VI illustrates this compactness in a two flowered Paniceae Tribe spikelet. When the fruits mature in spikelets with multiple florets they usually break apart (disarticulate) at various specific locations including below or above the glumes, at each floret or in some species one of the bracts may fall with the fruit but not the other. Each species has its own uniform disarticulation points. In some species the disarticulation point at the base of the lemma is hardened and often sharp pointed and termed a callus. In the Stipeae Tribe the callus area is often well defined and often of value in species determination.

Within each bisexual floret are one pistil (female) with two styles and usually three stamens (male) but some species may have two stamens. Although on separate axes, the lemma being attached to the rachilla which is the spikelet axis and the palea being attached to the floral axis, they often fall together when grass inflorescences break up or as is sometimes said "going to seed." The technicality of the lemma and palea being on separate axes is unimportant in species identification. I only mention it because I show that arrangement in the exploded drawings, want them to be accurate and want students to understand that arrangement. In most species the lemma partially clasps the palea both of which encircle the reproductive parts. Plate V (12 and 13) and the drawing below illustrate how the lemma usually partially encloses the palea. Paleas of most species are longitudinally two veined with the veins usually located along the edges of keels. Venation of lemmas is variable depending upon the species. Being the largest and most visible of the two floral bracts in most spikelet types, the lemma is usually the most important for species identification.



A typical palea shape found in many species shown in cross section. Dotted lines represent the lemma and how it often fits around the palea. Along the fold lines of the two outward pointing keels are the two veins common to paleas of nearly all species. In the pocket of the palea often are found some of the two chambered anthers. They often seem jammed in the pocket especially in paleas with deeper, narrower and perhaps even with incurving pocket sides. In those florets with developing fruits they will largely fill the space between the palea and the lemma. In some species the fruit may adhere to the palea.

Lodicules are tiny mostly ephemeral structures of the floret that swell during anthesis and may pry open the lemma and palea which exposes the reproductive parts to wind pollination. They are thought of as being vestigial corolla parts. They usually play a minor role in species identification and we will not deal with them.

Remember that in some species certain bracts may never form, most commonly the paleas or one or both glumes.

Perhaps it is helpful to think of spikelets as little spikes as the suffix -let would imply, eg. pig and piglet. Furthermore, similar to the rachis of the grass spike, the spikelet has its axis, the rachilla at least in multi flowered species. The florets are sessile to the rachilla similar to the spikelets being sessile to the spike rachis. The suffix -illa comes from Latin meaning similar but little.

Some modern references actually consider the spikelet as the inflorescence (primary inflorescence). The usual structure with an accumulation of spikelets that is usually referred to as the inflorescence is termed the synflorescence.

Here is an aid to remembering the location of the three types of bracts-**GULP;** proximal are the **G**lumes which are **U**nder (proximal) the **L**emma then the **P**alea.

The presence or absence of awns, bristle like structures, and their qualities may be important in species identification. Awns may be found on any of the three bracts, but most commonly on the lemmas. Most awns are terminal (they extend from the distal tip of the bract and may appear as an extension of the midvein. In some species lemma awns may attach from lower on the back of the lemma. In other species, spikelet bracts may have a mucro (mucronate). See illustration in plate III. Often hair like, the mucro may be seen as an abruptly protruding short vein extension. In some species, such as is many *Bromus,* the lemma awns originate between two terminal teeth or lobes (bifid or bilobed).

Most important words to remember – glume, lemma, palea, rachilla, floret and awn.

On the Floral Axis – Sexual Reproductive Parts

In perfect (bisexual) flowers the stamens arise from below the pistil. Most grasses have perfect flowers but some species may be dioecious and/or monoecious. Yes, specimens being monoecious or dioecious may be found within the same species. Stamens (anthers) may not be found long after anthesis, but sometimes they may remain trapped in place within the palea as illustrated above. Most anthers are oblong and all release their pollen through longitudinal slits. Stigmas are also usually ephemeral. Anthesis with fully exposed stamens, as shown in plate V 2., is fleeting lasting only a few days at most. Note the somewhat fuzzy stigmas. Fuzziness of the stigmas is typical of many grass species. They appear somewhat like pipe cleaners or bottle brushes.

The ovary (fruit) type is a caryopsis, a thin walled dry fruit with one ovule (seed). What are commonly thought of as seeds of the cereal grains such as wheat are actually fruits. Some grasses do have modified fruits variously termed berries, achenes or utricles but I think most agree that they are caryopses. Generally the seed and ovary are tightly bonded but in some species, including the local *Sporobolis* species, the bond may break when the fruit is moistened. This can separate the seed from the fruit. Occasionally the size, shape and surface texture of the

fruit may be important in species identification. Yearly production of mature fruits is variable perhaps due to weather conditions. In some years mature fruits are tough to find.

Cleistogamy/Chasmogamy
Cleistogamous spikelets contain florets where open pollination cannot occur, so they must be self pollinated. The spikelets are either occluded from the atmosphere or they are open to the atmosphere but the florets do not open. A fair number of Arizona grasses have cleistogamous spikelets. In *Enteropogon chlorideus,* an uncommon species here, the cleistogamous spikelets are buried underground. More common *Muhlenbergia microsperma* and *Enneapogon desvauxii* have spikelets buried deep with lower leaf sheaths. All of these species also have more normal terminal inflorescences that are open to the air. In *Sporobolus cryptandrus* only the distal portion of the inflorescence opens above the flag leaf sheath, so the lower occluded spikelets are cleistogamous.

It is reasonable to assume that those species that habitually produce partially occluded inflorescences would be capable of self pollination. Otherwise it would be a major waste of energy.

Chasmogamous spikelets open to the air with florets that open to allow open pollination.

There are a number of schemes to either prevent or promote self pollination. Grasses tend not to be 100% either, just a greater percentage of one or the other in any species.

It is good to understand the concept of cleistogamy and chasmogamy when trying to identify a few species including the local species mentioned above.

Major Spikelet Types
In order to avoid redundancy you are directed to my Arizona tribe key. Note the major differences in the lead 2 couplet. Species in the Paniceae and Andropogoneae tribes contain spikelets with basic differences from the other tribes which I will term the Cynodonteae spikelet types.

> **Paniceae Type** and **Andropogoneae Type –** Couplet 3 in the Arizona tribe key and content in the Some Arizona Grasses….. section below explain the differences. Note that the spikelet architecture and textures of the bracts of species in these two groups are quite different from those of most other grass species. Spikelets also are usually dorso-ventrally compressed or terete. Extreme modification is found in some Andropogoneae species with thickened inflorescence axes such as found in genera *Zea* (corn), *Tripsacum* and *Hackelochloa.*
>
> Plate II shows a somewhat typical Paniceae spikelet in this case, *Setaria.* Plate V (9-14) shows this same spikelet in latitudinal cross section and Plate VI shows it in longitudinal cross section. In some references the upper floret in Paniceae is called the fruit.
>
> **Cynodonteae Type** – I will use the term "Cynodonteae Type" just for convenience, because it is the largest tribe in Arizona. Most or all species in Arizona tribes excluding the Paniceae and Andropogoneae tribes possess this general type of spikelet. Species with both bilaterally symmetrical and asymetrical spikelets are included in this group. All of the spikelet bracts are of the same or nearly the same texture, though often the

palea is slightly more flimsy. Spikelet compression is usually lateral. Depending upon the tribe, genus and species the number of florets is highly variable.

How Grass Grows – Just Ask Poaceae

I asked Poaceae about how it grows and got some interesting sometimes quirky information:

I, Poaceae, really don't know anything other than how to reproduce and survive, so I turn to you humans to learn more about myself. Of course I don't have a language , so I use one of your languages. I speak to you for all of my members. I don't use your word species because that is too restrictive. You might wonder how I grow and why I have become so dominant across vast regions of our sphere, thrive in others or just survive in others. Whatever, it seems like I am always around any place where you humans live.

When I started out as one member, I suppose, I was just one of many plants trying to make a living. Then in the Cretaceous back perhaps 80 to 90 million revolutions of our sphere around our star the super landmasses were still around. I probably started out somewhere in that southern hemisphere perhaps in the Africa-South America landmass. That's where my closest relatives are found and on islands in the present day South Pacific Ocean. From the beginning or at some early time my brain (DNA) told me that I would be highly adaptable and gave me the tools to adapt to just about every condition found on the lands of this planet.

No wonder I have become dominant, because my members have been given such a wide array of reproductive systems and fruit dispersal techniques. If you look at my sex life you will see that I am quite promiscuous. In most members my DNA easily gets around on the wind. Some can also spread asexually by rhizomes, stolons or even by giving "live birth" to seedlings in some of my members. Some have cleistogamous spikelets that hide in various locations that are protected from grazing such as near the base of the culms, even underground. Many have cleistogamous spikelets within terminal inflorescences that are self pollinated. These spikelets may be exposed but just do not open for wind pollination or may never become exposed because they don't emerge from the flag leaf sheaths. Many have various polyploids which broaden the range of habitats suitable for them. Some produce large amounts of fruits. Some are with florets with special features that aid in wind dispersal and perhaps even help plant the seeds. All of these tools allow creation of many new DNA combinations; therefore natural selection has lots to work with. Perhaps more than in any other plant family it has created members that survive in the hottest, coldest, driest and wettest environments and dominate in many. I don't brag I just do what I do and am what I am. I am Poaceae.

All of this is important, but there are other reasons that may have helped me dominate. Let us look at you humans. You have a love/hate relationship with my members but you have certainly helped spread my members around the sphere. Long ago early in your history you found that I was a good source of food, so you cultivated us. Today, many of you would not exist without the food my members produce. You have transported them all over the world for food, animal food, erosion prevention, timber and for beauty. For you, especially Arizonans, you have found that some of these transports were mistakes, but you certainly found how good I am at colonization and domination. I have another tool that may also have helped me dominate, my life form.

You all know the basic look of my members, so let's look at how that life form grows from seed. As that embryo grows into my initial culm, it pushes up through the soil with many nodes lined up close together like railroad ties. The lower three or so stay very close together, lengthen very little and the leaves associated with each node stay short. Above these lower nodes, one by one, up the culm in succession the internodes lengthen following some growth of the associated leaf sheath. The sheaths, mostly overlapping the ones above during this elongation period, protect and give support to the growing culm which is very weak and fragile during its elongation period. You must know how tender these growing internodes are if you have ever pulled out a young grass culm to chew on. When the culm is still quite short the terminal inflorescence starts to form. This happens while the culm is still elongating, so its leaf sheaths are protecting both the growing culm and its developing inflorescence.

The terminal inflorescence stays within the flag leaf sheath while the spikelets develop. Upon emergence from the sheath the florets are nearing anthesis Some will open to shed pollen for wind dispersal, but remember some may never open. I assume some of these would be self pollinated (cleistogamous), but the only way to know is for you to look for mature caryopses. Remember also that in some of my members males are optional. They can produce mature caryopses without pollination; just another tool that may have helped me become dominant.

Some of my members have culms that freely branch in their upper nodes. The branches would grow and perhaps terminate in inflorescences as was just described for the initial culm. Fairly early in life new culms in both my annual and perennial members form from underground basal buds. In annuals these branches are all reproductive (produce inflorescences). In perennials they may be reproductive or just stay as non reproductive culms called tillers or innovations. Innovations usually stay shorter than the reproductive culms. The innovations may help my perennials survive harsh conditions through the seasons and years by providing more nutrients. Producing fruits take a lot of energy and nutrition.

My growing seasons are variable due to weather conditions. In cold climates my members have only one growing season. In more temperate climates my members growth may start and stop then start again when conditions of moisture, day length and temperature permit growth. Your D.R. Cable wrote "Growth and Development of Arizona Cottontop (Trichachne californica [Benth.] Chase)" in Botanical Gazette, 132 (2) 1971; University of Chicago. He gave a detailed description of how growth of this perennial Arizona native can in some years start in the fall, pause then start again after spring rainfall then pause then resume growth during and after summer rainfall.

You may wonder about annual vs perennial. I have questions about that too, but there are some things that I know. My annual members place all of their energy into reproduction. They usually produce multiple culms that are all reproductive. Some just seem to grow a few culms then immediately die, but others may keep producing culms as long as conditions allow. Early, these culms may look like innovations, but a careful look (remember "a careful look") inside the sheaths will reveal a developing inflorescence. I guess their brain just tells them when their time is up after that one season of growth. This happens to my annual members even when there is an unlimited growing season. Each member is programmed with its own life span.

Perennials, of course, want to as Spock would say "live long and prosper," but they have so many ways they can live long. Individuals of each member can make up its own mind on how

to cope with the vagaries of where it is growing. Some of these tools were pointed out by Mr. Cable. In colder climates it is simple. All culms and innovations die back in winter, but life still persists underground. From those live buds new culms arise in the following growing season. In milder climates, as mentioned above, there may be some dieback during seasons of hardship such as aridity but growth can continue when conditions moderate.

I do know that after my members terminal inflorescence matures there will not be another, but remember that if the culms don't die after fruiting they can branch in some of my members. These branches might be just an inflorescence or leafy branches with or without inflorescences. At some point individual culms just die, and individual plants just die, perhaps of old age, severe weather, over grazing or for any number of other reasons. Then we have another question of just how long my individual plants live. I suspect a long life for most of members individual plants would be 10-15 years. Then we have those that clone such as Bermuda grass. Individuals of the clone die regularly, but the clone lives on for how long?

You may wonder why my perennial members don't freeze to death in colder climates when all of their above ground parts die. I don't know either, because I have not located research by you humans that gives answers. I do suspect that snow cover may help insulate plants in some areas. I also suspect that my members vascular systems transport high amounts of sugar from photosynthesis to my parts that are below ground level that include those vital basal buds from which next years growth will start. Consider the buds "mouths to feed." This sugar "syrup" would serve as antifreeze for the buds. For this their innovations may be very helpful. Their leaves are sugar factories and they are not feeding a terminal inflorescence which is a major mouth to feed. Much of the sugar those leaves produce can go right to those basal buds and roots. With all that sugar (food) these guys are primed to take off when the next growing season begins. It is quite plausible that some of my perennial members also have other tools in play to protect them from death in extreme climate and weather conditions.

It would be easy to say that my members DNA is the key to my success. Yes, members of other groups of plants have many of the same tools as in my members DNA tool boxes, so why have we, my members, become so dominant? Perhaps most or all of our plant cousins just don't seem to be as efficient at what they do. There is probably no one thing that makes us dominant. It must be that combination of reproductive tools, fast growth, ease of making new members and our life form that make us dominant. I am also good at surviving extreme weather that may kill other plants. Usually it just slows me down. Perhaps now you will understand why I am so successful. I don't brag. I just do what I do and am what I am. I am Poaceae.

Sincerely Poaceae

Edited by M. Bauer and approved by Mary Barkworth, March 2024

Texture, Surface Texture, and Vestiture

These characteristics play an important role in the identification of most grasses. There are many terms used to describe them. Many of the terms will be mentioned here but will not be defined because they are found in the glossary. Those not in the glossary will be briefly defined.

Expect overlap between the terms; therefore for a particular species different floras may use slightly different terms because of this overlap. For example, chartaceous and membranaceous conditions are quite similar, so it is sometimes difficult to define a structure as being one or the other.

Texture is mostly used to describe the characteristics of bracts such as flexibility, hardness, brittleness, thickness and sometimes color with terms such as membranaceous, indurate, cartilaginous, chartaceous, hyaline, coriaceous and scarious.

The texture of surfaces is often important in species identification. The term glabrous depending upon the authority may mean just without hairs. Others use the term to mean without hairs and having a smooth surface. I believe most authors of floras use the term for both conditions. There are many terms used to describe conditions other than smooth. The most common surface textures other than glabrous that I have seen are papillose and transversely rugose. The latter term refers to striations that are perpendicular to the venation of the bracts somewhat similar to an old fashioned washboard. Some grasses have a waxy coating appearing as a translucent white film (glaucous) on the leaves and culms that may give the plant a somewhat bluish color. When rubbed off a slight change of color is noticed.

The terms scabrous or setaceous are used to define the saw like edges caused by tiny projections sometimes called prickles, setae (plural or seta for one prickle) or spicules. These are often noted along the edges of leaf blades and in rows along veins of leaves and bracts. Although not hair like, these projections are often stated to be short rigid hairs. The projections point one way like saw teeth, so when one runs the fingers along the structure into the teeth they can easily be felt. I believe most agree that if a surface is scabrous it is not glabrous.

Vestiture refers to the presence of hairs. Many species, perhaps most, have hairs somewhere, and they may be found on any surface. There are many terms to describe various hair types. Hairs may be long, short, firm or quite flexible, arise from papilleae, club shaped, gland tipped, fine tipped or appear chopped, glassy or not, straight or not, perpendicular to the surface or not and sparse or dense. It follows that there are terms to describe all these conditions. Some of the most common terms are pilose, strigose, villous, hirsute, sericeous (long, dense, silky mostly appressed hairs), hispid, lanose/lanate and velutinous (dense soft hairs feeling like velvet.

The use of the terms pubescent/pubescence are often used as general terms for vestiture or more precisely for short soft hairs.

Asexual Reproduction

Vegetative reproduction and other types of asexual reproduction are not uncommon in some grass genera. In addition to new plants forming along nodes in rhizomes and stolons, grasses may develop new plants when lower culm nodes of the parent plant contact the soil and produce roots. Some species reproduce by developing tiny plantlets within the spikelet (vivipary) rather than caryopses. These plantlets then fall to the ground to take root. *Poa fendleriana* is dioecious but some populations without male plants produce viable fruits. This type of reproduction is called apomixis.

The Big Picture

Now that you should know a little about grass morphology, textures and vestiture the next step is to work towards identifying your species of interest. You should now understand that out of the thousands of possible combinations of traits available the mystery species has a specific combination unique only to that species.

Other than basic morphology etc. other issues to consider may be very important and are covered in the sections below. Be aware too that, unfortunately, there is often some subjectivity involved in identifying a species. What differentiates one species from a very similar one may be somewhat arbitrary and dependent upon the thoughts of the naming authority. That continuum between similar species may also be complicated by hybridization.

It might best be stated that some specimens may just be so "on the edge" of a species description that they are impossible to identify. That's just the nature of the beast along with the human element that just cannot encompass all specimens in a tidy little pigeon hole. Accept this but don't be discouraged, because those on the edge specimens are uncommon perhaps rare given that you have a good specimen.

In the section "Collecting and Preservation Issues" is a discussion of points to consider when collecting a specimen.

Measurements

Sometimes measurements found in botanical descriptions are vague about what is included in the measurement. For example, different regional floras often have widely varying ranges for culm length of a species. Some variation might be explained by environmental factors but the question of what is included persists. Does culm length include the terminal inflorescence or not? This is usually not indicated but after examination of numerous floras I believe most authors do include it. M. Barkworth, editor of the FNA grass volumes (personal communication) agrees. It is helpful that some contributors for the various genera found in the grass volumes of Flora of North America do make mention of how some measurements of various parts are made.

Other instances of uncertainty include width and/or length measurements of curved structures such as the lemmas, glumes and paleas of most grasses. Unless otherwise stated, I believe the measurement of a curved structure should be made in the natural condition rather than pressed (flattened). Width should be measured at the widest point.

Spikelet length normally does not include the awns; however in a few cases this is not always clear. For example, in genus *Eriochloa* stated spikelet length includes the awn as mentioned in Gould (see references section); and in Shreve and Wiggins (Vegetation and Flora of the Sonoran Desert, Stanford U. Press, 1964). Lengths given in FNA for *Eriochloa* species are similar but without explanation.

Leaf blade width is often problematic. Some blades are naturally longitudinally curled or curl upon drying while some fold along the midrib. There is no easy answer on how width is measured unless specified in the description or key. In dealing with curled blades, some authors

state that measurements are of the diameter. For folded (conduplicate) blades, some mention width is from the folded edge to the blade edge.

Unfortunately, unless stated there may be no way to resolve such questions about measurements, but there may be clues found among the various floras including drawings to scale etc. Perhaps there are other definitive characteristics that allow one to work around some measurement problems.

References for Identification of Local Species

The primary goal of this workshop is to expose participants to basic grass structure but also to provide some information about a number of local genera/species. Mentioned in the Some Arizona Grasses.....handout are some other simple tools that would be helpful. For those who may become more interested in serious identification work this herbarium is open to the public and provides assistance if requested. Also found at the herbarium are many references featuring not only local species but those found in many parts of the world. You are always welcome to bring in specimens and use the scopes and reference materials.

The best references that include all or many local species are as follows:

Grasses of the Southwestern United States; Gould, F.; University of Arizona Press, Tucson; 1973. Somewhat betraying its title this flora covers only Arizona. Since publication, more species have been found here and there have been a number of name changes but this is still a good handy reference.

Intermountain Flora, Vascular Plants of the Intermountain West, U.S.A. Vol. 6; Cronquist, A. et. al. New York Botanical Garden; 1977. Though not covering southern Arizona this volume has excellent illustrations and good keys and descriptions of many of the northern species that enter our area mostly at higher elevations in the sky islands..

Manual of Grasses for North America; Barkworth, M. et al editors; Intermountain Herbarium and Utah State University Press, Logan, Utah; 2007. This flora is essentially a condensed paperback version of Flora of North America volumes 24 and 25 with a few revisions. FNA keys, drawings and maps, all reduced in size, are used. Space was also saved by eliminating species descriptions and using abbreviations extensively in the keys and genus descriptions.

Floras of New Mexico by Kelly Allred are good and they cover most species in our area. Two editions are available. One without illustrations is more compact than the other.

Manual of the Grasses of the United States; Hitchcock, A.S.; second revised edition by Agnes Chase; U.S. Government Printing Office, Washington D.C.; 1950. This has been the long established standard for the United States until the publication of volumes 24 and 25 of Flora of North America. The publication may still be available reprinted in two volumes by Dover. Even with the many changes that have occurred since publication this reference still has value.

Flora of North America, volumes 24 (2007) and 25 (2003) covering North America north of Mexico; Barkworth, M. et al. editors; Oxford University Press, New York and London; These volumes are the "gold standard" of today. Published after year 2000, they generally have the most complete species descriptions, excellent illustrations, good range maps and generally good keys of all species. Taxonomic name changes in grass species have occurred since publishing and there are occasional errors but overall the volumes are the best available.

A 2019 article in a Smithsonian newsletter written by Robert Soreng of the Smithsonian reviews a number of grass identification field guides for primarily western states which are listed below.

Field Guide to Wisconsin Grasses; Judziewicz, E.J. et al; University of Wisconsin Press, Madison; 2014

Field Guide to Nevada Grasses; Perryman, B.L. and Q.D. Skinner; Indigenous Rangeland Management Press, Lander, WY; 2007

Field Guide to the Grasses of Oregon and Washington; Roche, C.T. et al; Oregon State University Press, Corvallis; 2019; a definitive work.

Grasses of Colorado; R.B. Shaw; University of Colorado, Boulder; 2008; a definitive work.

Guide to Texas Grasses; R.B. Shaw; Texas A & M University Press, College Station; 2012

A Field Guide to Wyoming Grasses; Q.D. Skinner; Education Resources Publishing, Cumming, Georgia; 2010

A Field Guide to Alaska Grasses; Q.D. Skinner et al; Education Resources Publishing, Cumming, Georgia; 2012; note that the Smithsonian report states that this guides is distributed by Alaska Dept. of Natural Resources, Palmer.

Field Guide to Grasses of California; J.P. Smith, Jr.; University of California Press, Oakland; 2014; not definitive. Some species are not included.

Anatomy

In this workshop we will not look at anatomical structures which can only be viewed from material mounted on glass slides prepared for higher power light transmitting microscopes, but some grass keys do mention the following anatomical structures, so they deserve brief mention here. The various references that are available should provide enough information for you to work around questions of anatomy.

Sclerenchyma patterns in leaf blades help identify many species of genus *Festuca.* Sclerenchyma cells are normally thick walled cells which run longitudinally in leaf blades to provide strengthening of the blades.

Kranz anatomy refers to a particular arrangement of cells surrounding veins in the leaf blades of carbon four (C^4) plants. C^4 refers to a type of photosynthesis process common in many plants subject to hot and drought conditions. More temperate climate grasses are generally C^3; therefore many of our Arizona grasses are C^4 with Kranz anatomy.

Working with Dichotomous Keys

This workshop will provide enough information so that you can use dichotomous keys found in the above publications for species identification. It is best to start with keys found in local floras, if available, in order to narrow the number of species you are dealing with.

When using the keys, one has to read the couplets very carefully. Ideally the keys are all objective but in many cases subjectivity is necessary leaving gray areas in which the user needs to try to interpret the author's thoughts. Of course, this raises the possibility (or probability?) of going astray. One can usually know when this happens because further leads or species descriptions just don't match the characteristics of the specimen. At this point it might be time to take a break and start over or go backwards through the key to a couplet where you believe you might have selected the wrong lead, then proceed in that other direction; still no satisfactory identification? Then it's time to try another key. Don't think that the newer floras are always the best references. Earlier botanists may have noted details that may have been "lost" over time.

The specimen being identified presents another variable. There is enough variability within a species that either lead in a key may not always quite match the specimen in hand. In this case, as mentioned earlier, one may need to follow both leads. The correct lead usually soon becomes obvious.

After a determination is made it is then time to go to a description of the plant and see if it fits the specimen in question. Keep in mind that you will rarely obtain a perfect fit. At times some measurements may be out of range or some characteristics may not quite fit the specimen. If in doubt, you can always compare your specimen with others at the herbarium. I have found that spikelet parts of numerous fairly local specimens often have measurements on the low end or slightly less than the ranges mentioned in various references.

One last caveat: "haste makes waste." Preformed ideas rather than careful observation are a good recipe for shoddy work. Read the keys and descriptions thoroughly and don't "see" what you want to see but **see what is there**!

Questions regarding anatomical features do appear in some of the FNA grass keys but the couplets also mention other characteristics allowing one to proceed without knowledge of the anatomy.

Recently a state agency sent some grass specimens to ARIZ for identification.They were passed on to me for identification. All I knew was that they were sent from Flagstaff. I had problems with one specimen, but finally figured out the species after hours of thought, keying and studying its characteristics. I'll relate how I solved the problem in hopes that it might be helpful in your endeavours.

It was a dirty specimen which I dislike, but that did offer some clues not present in a nice clean specimen. Mixed in were Ponderosa pine needles which indicated it came from the tall timber forest. It looked like a perennial with a few inflorescences of the previous year and lots of green innovations beneath, but on closer examination and carefully picking out the inflorescences I could see that they were on separate plants and later saw that all the innovations were individual seedlings indicating that it was annual. The inflorescences were just rachis and branches with no spikelet parts; not much help there. Finally, looking at the roots of the seedlings I saw that some were still attached to spikelets from which they germinated. Then I finally found one perhaps two above ground spikelets that were in poor shape. I still didn't even know the genus and was getting nowhere in FNA, so I decided to try Gould. The keys in Gould indicated it was *Bromus tectorum*, cheat grass. Finally, that seemed reasonable, so I checked the description in FNA and found a good match. Vein counts are often important in determining brome species. I had apparently miscounted the veins along with perhaps some other misstep which caused the problems. Being an old U.S. Forest Service retiree I should have recognized this common exotic pest of the west, but I hadn't been around much cheat for forty years.

Collecting and Preservation Issues

If you are absolutely certain of the species that you are looking at in the field you may or may not want to collect a specimen. For beginners, I recommend that in most cases you will want to collect a specimen to examine more carefully later.

Prior to collecting there may be some things to consider if you are not on your own private property. Anyone who plans to collect specimens must follow some ethical considerations:

1. Follow the regulations if collecting on public lands. Various land management agencies from city/county to federal probably all have regulations regarding removal of plants.
2. Respect private property.
3. Use discretion; for example there may be no regulation prohibiting collecting along a popular public trail, but it would be best not to start grubbing out grasses for collection along the trail in front of others even if special permission was granted.
4. Practice good land ethics. In Arizona there are some grass species of concern and perhaps needing special management due to their being uncommon or rare, so don't be a hog and grub out the only specimen of a plant you see in a particular area. If you believe it is important to identify the specimen off site, consider writing good field notes (see below) and perhaps removing only a small portion of the plant without harming the parent.

When collecting, always select average appearing specimens. If possible, I try to keep specimens hydrated and carefully handled until I get home. Then I wash the roots and remove foreign matter such as soil, stones or parts from other plants that may be mixed in with the specimens. Then I blot off excessive water with old towels or rags prior to pressing. After a couple of days or so in the press especially for more moist specimens it is desirable to move them to dry plant press sheets in order to keep them mold free. The damp sheets should be thoroughly dried before reusing.

Some information needs to be noted in the field. Without it identification of a species may be impossible or at least more difficult. Presence or absence of rhizomes or stolons must be noted

especially if they were not collected as part of the specimen. In some cases it is important to note how the culms grow such as caespitose, geniculate, prostrate etc. Perhaps even noting the character of inflorescence branches while the plants are still in the ground may be helpful. Plate II illustrates how some inflorescence branches might appear such as nodding, ascending etc.

A record of where a specimen was collected is very important. Many good floras mention or map the range of the species but also mention the general habitats in which they grow. This can aide in identifying the species.

Being able to compare a number of specimens in the field should make it fairly easy to correctly determine annual/perennial status. Otherwise it may be difficult. Live (green) annuals normally pull out of the ground quite easily. Perennials are generally well anchored and may only produce innovations in their first year. Annuals are often short (<0.5m), but a number of annuals reach 1-2 m. height, eg. corn. Often local annuals have small tight root crown areas compared to perennials which may have a fairly large base that expands over its life. Annuals may have a few dead leaves near the base but usually don't have a mass of older dead material at the base which is often gray colored. All or nearly all culms of annuals should bear inflorescences; therefore they should have very few or no innovations (tillers). Some species stated as annuals may not die after producing an inflorescence but may live long enough to produce a second, though perhaps diminished in size.

Some species have fragile ligules, auricles or leaf tips, so care must be taken to treat them gently. If you have species with complex inflorescences the branching patterns are sometimes useful in identification, so if you press the specimens it will be helpful to not press them into a tangled messy blob of tissues. The lesson, therefore, is to attempt to press complex specimens so that the patterns can best be later seen. This may be difficult, so it is often wise to collect one or two extra specimens or at least the more complex parts that can be later mutilated if necessary for examination. Leaving them unpressed may be helpful. Lightly pressed specimens should show less distortion of the spikelets than heavy.

You should now understand that a good specimen is not just the physical plant but also includes other supporting information mostly obtained in the field. For small grasses it is best to include the entire plant or at least a few culms including all parts from roots to inflorescence. Innovations should be included if present. For large species that cannot be collected in their entirety, the collected parts must be such that an identification could reasonably be made. This might mean including the inflorescence, portions of a culm complete with a node, or nodes, and complete leaves. A good specimen is one that can be identified to species by a person with basic knowledge of grass structure armed with pertinent reference materials.

For beginners some of the following information may not be applicable, but I provide it for those who wish to collect specimens for themselves, herbarium contributions, research or land management issues. A number of folks with little or no botanical background have become very interested in not only learning more about local plant species but in being important contributors to the U. of A. Herbarium (ARIZ). These volunteer contributions are becoming more valuable in aiding research especially in light of limited research budgets, changing environment conditions due to climate change and other increasing human impacts on the environment. Land managers need to know what is growing out there.

To be of value for a herbarium collection, in addition to knowing the genus and species plus the naming authority other information is necessary. It must include the date of collection, name(s) of collector(s), and location of the collection. The best location description would allow others to relocate the collection site. For research and management purposes, relocation of collection sites may be valuable. Relocation is usually difficult without GPS coordinates (latitude and longitude—WGS 84 or NAD 83 datums are probably best and most often seen with herbarium specimens). Without GPS, one should make an effort to describe the location as accurately as possible. Many herbarium specimens have insufficient location data. For example, descriptions such as "Madera Canyon" or "highway such and such east of Payson" are of limited or no value when trying to relocate a population.

Online Resources

The most complete reference is the online version of FNA. Search floranorthamerica.org. It may take some time to figure it out but it appears to have all of the keys and botanical descriptions found in the printed volumes. Some new information has been added for some genera and species.

Seinet has some interesting keys, species descriptions, location data and photographs of many plant species. Data found on the labels of herbarium specimens and sometimes photos of each specimen from many herbaria may be found in Seinet. Data from all specimens at ARIZ that are in the herbarium data base are loaded into Seinet.

Phytoneuron www.phytoneuron.net, is an online publisher. The late prominent local botanist and author, Richard Felger, has published a coauthored document *Ajo Peak to Tinajas Altas; A Flora of Southwestern Arizona Part 6. Poaceae-Grass Family,* 2014, on Phytoneuron. Other interesting publications might also be found on this website.

Phytokeys has many publications published by leading U.S. taxonomists including articles and monographs regarding the grass family and also other plant families

Nomenclature

Brief mention of taxonomic names was made in the "Why taxonomic names" section above. In many cases individual species may have had name changes as was explained in that section. The old names become synonyms of the new names. We need not state why because there are many possible reasons. Just know that synonyms appear in the literature and can cause much confusion. For example are *Sitanian hystrix* (Nutt.) J.D. Smith and *Elymus elymoides* (Raf.) Seezey the same plant? Yes, but if the synonyms are not listed in the publication you are using how do you know they are the same plant? You might go to another reference with a better list of synonyms or check web sites that list synonyms. We use the website Tropicos of the Missouri Botanical Garden extensively at ARIZ. If a species has synonyms you will likely find them in Tropicos. It also has a wealth of other nomenclature information for every species.

To access the lists just enter Tropicos in your web browser. Enter a taxonomic name. It will then show the naming authorities, when the name was published and the publication in which it was published. Click on synonyms for a list of them. If you click on accepted names you may be surprised. In the thousands of published floras throughout the world covering areas from the

size of, for example, a sky island mountain range to those that cover perhaps a continent, you may see many names for the same plant; however the accepted names listed in Tropicos are those accepted only by a few of the usually more prominent floras, data bases etc. More on accepted names later. In a perfect world all authorities would agree on one accepted taxonomic name, but for various reasons that does not always happen.

A little background is in order at this point. Though perhaps not necessary information for the beginner it is passed on to help explain the perplexities of nomenclature. Perhaps the best way to explain some of the basics is to start with a plant that seems different from other named populations. After studying the situation, a knowledgeable person or persons determine(s) it really is different from named species, subspecies, varieties etc and decides it should be named. In order to receive recognition as a legitimate name the protocol found in the International Code for Botanical Nomenclature must be followed. The authority or authorities will select a type specimen (type) that should be representative of the population and will publish details of this plant in a manner consistent with the code. If the rules in the code are followed this name is accepted. If you see the words “illegitimate” and “invalid” mentioned our naming authority or authorities did not follow the rules in the code.

An illegitimate name means that the naming authority(ies) did not follow the exacting protocols of the code. The same might be said about “invalid” but more specifically it means that the name was not validly published. Reasons are normally unspecified in Tropicos. Illegitimate and invalid names are shown because they may be found “hanging around” in old floras and old herbariuim specimens. It is important to be aware of them for the simple reason that they may affect today’s proper identification of a specimen. When different authorities publish names for the same plant, the name first published has priority assuming that the rules of the code were followed.

The type specimen is said to “fix” the application of the new name. The naming authority may use as a type specimen (type) a physical specimen or an illustration of the plant. This original type specimen is called the holotype. The code establishes other categories of type specimens that may augment the holotype or replace it should it be lost, destroyed or for various other reasons. These other types are designated only by publication and in most cases must be accepted by the original naming authority. Alternative types include lectotypes, isotypes, syntypes among others each having its own definition.

Besides synonyms you may encounter other 'nyms—basionyms, homonyms and autonyms. The basionym is the original name given by the naming authority(ies) to the group of plants represented by the type. Yes, some species etc. may have more than one basionym. This would seem impossible in a perfect world, but one reason may be that back in the 18th and 19th centuries communications were poor. The same species, variety etc. may have been validly published by naming authorities in widely separate locations each, of course, giving it a different name and each name becoming a basionym.

It is fairly common to see the word homonym in Tropicos. This is often but not always the same name or a very similar name given to two or more different species, obviously causing problems. I have seen some cases where the same authority named the same species twice but one name is a homonym. In these cases, perhaps the authority violated the rules in the code, but may have later validly republished the name to legitimize it. One homonym has to be either invalid or illegitimate.

One more 'nym and we are done with them-autonym. Autonyms are default names. If a **new** variety or subspecies of a species is named, it must be named other than the species name because the species name at this point also becomes the variety or subsp. name of the group of plants that are not included in the new variety or subspecies. *Aristida purpurea,* a common local species has many varieties. By default *Aristida purpurea* var. *purpurea* becomes the name of that group of plants represented by the type specimen of *Aristida purpurea* and which is not identified as being of one of the later named varieties. *Aristida purpurea* var. *purpurea* does not have to be validly published because it **is** the validly published *Aristida purpurea.*

Hopefully this will answer most of your questions about synonyms and give you an idea of the big picture regarding the naming of plants. Bear in mind though that it only scratches the surface of a very complex subject governed by pages and pages of protocol. Similar to the English Language, there are many rules but also many exceptions for certain situations.

Now, to choose an accepted name for a plant that you just collected realizing that there may be many depending upon the references you are using. At ARIZ our updating of names is a work in progress. For grass names we currently almost exclusively refer to three references: Flora of North America; the website Catalog of New World Grasses which is accessed as a project of Tropicos and for some primarily old world species the website Plants of the World. For our collection that includes numerous Latin American species, we usually use the name accepted in the Catalog. It is easy to use, is more up to date than the Flora of North America and includes the entire new world (FNA only covers North American species north of the U.S.-Mexico boundary). The Catalog is maintained by some of the leading agrostologists in the U.S. and Latin America. These references sometimes do not all agree upon accepted names, so a decision on which to use needs to be made. At ARIZ we usually go with what the latest research suggests.

Plants of the World is easy to use. It is based at Kew Gardens in England.

With the current very time consuming updating process underway for our grass collection there is some disarray; therefore we advise most users to seek the help of staff when trying to locate specimens. Don't let this discourage you from asking questions and using the collection. We believe that outreach is one of our most important jobs. Remember also that there may be a story behind those specimens you bring in that may teach us something too. I have been surprised by some of the specimens that folks have brought in.

Citations

Flora of North America was used throughout this document for small details about some genera and species. It was the sole source for information both for the plates and narrative concerning the unique inflorescences of tribe Andropogoneae.

The glossary was reproduced from the second edition of the Manual of Grasses of the United States. Both of these publications are more fully referenced above in the references section above.

The publication Grass Systematics and Evolution edited by Soderstrom et.al., Smithsonian Institution Press, Washington and London, undated, provided some clarification on certain morphological details; in particular is section 3 by H. Clifford, Spikelet and Floral Morphology; section 4 by T. Sendulsky et. al., Fruits, Embryos and Seedlings and section 5 by L. Clark et. al., Vegetative Morphology of Grasses: Shoots and Roots.

For plant identification terminology, An Illustrated Glossary by Harris and Harris, second edition, 2001; Spring Lake Publishing, Spring Lake, Utah, provided good information when drawing the various shapes illustrated in the plates.

The publication Grass Systematics, second edition by F.W. Gould and R.B. Shaw; Texas A & M University Press, College Station, Texas, is a good general reference about all aspects of grasses and provided clarifications regarding vivipary and vestiture. My copy is a second edition, 1983.

In the Ask Poaceae section my use of D.R. Cable's work on *Digitaria californica* was fully credited.

Some other citations throughout this document gave incomplete reference information. Complete information can be found in the References for Identification of Local Species section above.

Michael M. Bauer revised July 2024

ARIZONA TRIBES, FAMILY POACEAE

M. Bauer

The following key was developed for folks who wished to have a tribe key more easy to use for beginners than the key in Flora of North America. This key steers one to the appropriate sections in the "Some Southern Arizona Grasses" section that follows. Eliminated were tribes that include species that are not known to occur within Arizona. You may note that two tribes, Cynodonteae and Poeae, occur twice. These are very large tribes with species of widely varying characteristics that could not satisfactorily be located at only one location in the key. With the great number of similar characteristics shared among many tribes, it is important to read through the entire descriptions in the couplets before proceeding.

1. Very large, tall culms with large much branched plumose panicles; spikelets long pubescent; rhizomatous; grows in very wet areas.....……..Tribe **Arundineae**

1. Plants of various heights of various habitats; inflorescences of spikes, racemes or panicles; combination of characteristics not as above..... **2**.

2. Spikelets with 2 florets; glumes of different texture than at least one of the florets; spikelets usually dorsally compressed or terete..... **3.**

3. Spikelets usually somewhat obovoid (egg shaped) to nearly spherioidal (globose); spikelets may be subtended by bristles, in disarticulating groups (fascicles) subtended by bristles and/or indurate spines or without bristles or spines; glumes and lower lemma usually somewhat herbaceous; upper floret usually cartilaginous, shiny, rugose or dull (usually not green and mostly enclosed by the lower lemma and upper glume)….....Tribe **Paniceae**

3. Spikelets usually somewhat ovate in outline and paired-one mostly sessile, the other pedicellate; often on a disarticulating axis called a rame axis; in a few other species the spikelet pairs on conventional non disarticulating rachises; inflorescences in some with highly modified thickened axes into which usually the female spikelets may be partially embedded; the paired spikelets often different in size (heteromorphic) and different sexually (heterogamous); usually only one spikelet of the pair with awns; glumes somewhat indurate (chartaceous to cartilaginous glumes usually completely enclosing the small hyaline fragile florets which are difficult to dissect); in Arizona genus *Tripsacum* monoecious.....Tribe **Andropogoneae**

2. Spikelets with one to many florets usually with all bracts of the same texture; spikelets in most species laterally compressed to terete in some; reduced florets usually above the fertile..... **4.**

4. Florets usually greater than one..... **5.**

5. Sheaths usually partly open or mostly open; panicle branches often spike like..... **6.**

6. Sheaths usually open; inflorescences mostly panicles, some with racemes (Genus) *Microchloa* with spikes?); lemmas usually with 1-3 or 7-13 often conspicuous veins; hairs often seen in the blade-sheath junction area.....Tribe **Cynodonteae**

6. Combinations usually not as above..... **7.**

7. Sheaths open; paleas 3 veined; glumes no more than a ring or lobes.....Tribe **Oryzeae**

7. Paleas 2 veined..... **8.**

8. Inflorescences spikes or very spike like racemes; one or more spikelets per node; some with disarticulating rachises; spikelets usually long and narrow conjested, or not, on the rachises; glumes 1-5 veined, lanceolate often tapering into an awn; see also Genus *Lolium* in lead 10 below..... Tribe **Triticeae**

8. Inflorescences usually panicles, less often racemes [spikes in Genus *Lolium* (see couplet 10 below)]..... **9.**

9. Culm internodes solid, not hollow; most small to moderate sized plants with the exception of Genus *Cortaderia*, a large caespitose perennial with large plumose inflorescences; ligules of culm leaves of hairs or ciliate membranes, the cilia being longer than the membranous basal portion; glumes usually exceed the distal florets; lemmas with 3-11 usually somewhat obscure veins and often bilobed or bifid with a mucro or awn between the lobes; awns usually twisted and geniculate; rachilla usually extends beyond the distal floret.....Tribe **Danthonieae**

9. Culm internodes usually hollow..... **10.**

10. Lemmas awned or not; some with multiple short awns/mucros [Genus *Lolium* some with spikes, the edge of the spikelet laying against the rachis (radial)]; spikelets usually pedicellate; culms not branching above the base; lemmas usually with 1-7 (9) inconspicuous veins; no hairs at the blade sheath junction……..……..Tribe **Poeae**

10. Lemmas with multiple awns and/or teeth often giving the panicles a plumose appearance.....Tribe **Pappophoreae**

5. Sheaths closed for most or all of their length.....….**11**

11. Lemmas mostly awned, often with bifid or bilobed tips, the veins usually convergent distally; panicles, some congested but mostly open, often with nodding branches or spikelets; florets usually numerous; palea usually adnate to the caryopsis; ovaries

(prior to much development into a mature caryopsis) pubescent tipped. ….....Tribe **Bromeae**

11. Lemmas of our species mostly unawned with veins that are usually somewhat parallel and not converging; lemma apices entire or bilobed or bifid and usually non green, fragile (scarious). ….....Tribe **Meliaceae**

4. Spikelets nearly always with one floret and no infertile florets above or below..... **12.**

12. Sheaths usually partially closed; see lead 10 above.....Tribe **Poeae**

12. Sheaths usually entirely open..... **13.**

13. Usually awned, the point of awn attachment to the lemma usually quite distinct (stark); lemma usually inconspicuously veined, the edges often tightly surrounding or partly surrounding the palea; lemma often hairy and the distal end often having a chopped off appearance; awns from short to extremely long (>5 cm.), often twisted and plumose, especially the basal segment, and geniculate; calluses usually well developed, often short and strigose; glumes usually longer than the floret; spikelet (floret) usually laterally compressed to terete.....Tribe **Stipeae**

13. Characteristics usually not as above..... **14.**

14. Usually with an awn column that divides into 3 branches, the branches of varying lengths, often the central branch being the longest; lateral branches may be suppressed in two local species (*Aristida schiedeana* and *A. ternipes ternipes*) but often rudiments may be found; spikelets usually long and narrow with the glumes, lemma and palea tightly enclosing the long linear caryopses; glumes shorter or longer than the florets but not exceeding the awn column; palea may be adnate to the caryopsis; one genus-*Aristida*.....Tribe **Aristideae**

14. Characteristics usually not as above; see lead 6 above……..Tribe **Cynodonteae**

Key based mostly on tribal information contained in Flora of North America, volumes 24 and 25.

Some Arizona Grasses Arranged by Tribes

Michael M. Bauer

Some southern Arizona tribes, genera and species are shown below. Selected are more common taxa and/or those with unique easily seen features. Although "easily seen," grass parts are **tiny!** and a 10x or higher power (higher is better) hand lens is an important aid for field identification. Other tools that might be helpful for the beginner include a magnifying hood, forceps and a probe. In this document unless otherwise stated, floret texture, vestiture etc. usually refers to the lemma which is usually the most prominent and readily seen structure of the floret. Note that the tribe must be determined prior to genus and/or species identification.

Bromeae

Sheaths closed most of the length; disarticulation above the glumes; multiple florets usually in a fairly long more or less lanceolate spikelet; often a fairly open lax to nodding panicle; lemma usually bilobed to bifid and with a straight awn.

Bromus carinatus (mountain brome) and *B. arizonicus* (Arizona brome) species are fairly difficult to distinguish; mountain brome, annual to short term perennial, is found above the desert while Arizona brome, an annual, is found in the low to mid elevations; Arizona brome said to have the 2nd glume about equalling the lower lemma; mountain brome said to have a shorter 2nd glume; both have conspicuously keeled lemmas unlike many of the other bromes; both with awns usually greater than 3 mm. long; both with panicles various with few spikelets; see also *B. catharticus.*

Bromus catharticus naturalized annual or perennial, exotic of mostly mid elevations similar to the above species also with keeled lemmas; 9-13 lemma veins often forming ribs contrasts with 7-9 veins of *B. carinatus* and *arizonicus*; lemma also has a rather broad whitish hyaline edge that is often quite obvious; awns shorter than 3 mm. The three above bromes all have some pubescence somewhere on the lemma and/or the sheath areas, but a very similar brome, *B. polyanthus*, with keeled lemmas is entirely glabrous in these areas.

Bromus rubens (red brome) invasive exotic short to midsized annual of the low to mid elevations; may form dense patches; panicle usually of dense, reddish and awned spikelets on ascending to appressed short (to about 1 cm.) branches that may obscure the rachis.

Bromus diandrus (*Bromus rigidus*) (ripgut brome) invasive exotic mostly midsized annual; panicle with ascending to spreading branches; spikelets outstanding for their size (lemmas >20mm) and long awns (30–60 mm.). This species is well named because its firm awns can damage the mouths of grazing animals. At this time it is not known to be common locally but is a problem in some parts of Arizona.

Bromus tectorum (cheat grass) an invasive old world exotic small to midsized annual of the higher elevations here; widespread over the western U.S.; leaves usually pubescent; inflorescence with a few mostly nodding branches each with only a few spikelets; lemmas

about 10-12 mm long with deeply notched (up to 3 mm) tip and awns 10-20 mm. This species may often have a reddish or purplish look and rather few culms.
The identification of some of the other Arizona brome species is problematical partly because various references are not in agreement regarding species geographic distributions and morphological characteristics.

Triticeae
Usually with auricles; usually spikes or spike like racemes with very short pedicels; often more than one spikelet at each inflorescence node; glumes often subulate or narrowly lanceolate tapering into an awn; lemmas usually tapering into an awn**.**

Hybridization is common within this tribe. Not only do many species within some genera hybridize but often species of different genera hybridize. Hybrids are best determined in the field where they are found growing near both parent, but have a "between" look with some characteristics of each parent. Most hybrids are sterile without developed caryopses and with anthers that are indehiscent (not opening).

Hordeum species (barley) glumes awn like; lemma with 5 veins usually awned; rachis usually disarticulates with the spikelets.

H. murinum common weedy annual in the Tucson area along local roadsides; 3 spikelets at each node and 1 floret per spikelet; awns usually ascending; see plate IV; compare with *Elymus elymoides.*

Elymus species (rye) perennial, some rhizomatous or stoloniferous; may have auricles; spikes with 1-3 spikelets per node; species often tough to identify; species id often includes length of inflorescence internodes, venation and texture of glumes, awn lengths, disarticulation points and orientation of awns (straight, or curved etc); species more of the riparian, woodland and grassland areas.

E. elymoides (squirrel tail) most common of the genus in Pima County; a bunchgrass without rhizomes or stolons; inflorescence similar to *H. murinum* but prior to disarticulation the awns at maturity flare outward similar to bristles of a bottle brush; common at mid elevations above the desert.

Poeae
Usually open sheaths; collars without hairs on the sides (see also Cynodonteae); usually panicles; spikelets laterally compressed; usually with multiple florets with asexual florets above the sexual. Many if the species in this tribe are more northern species of Eurasia and North America and either do not reach Arizona or are only found in northern Arizona.

Agrostis species mostly montane and/or riparian; inflorescence branches often in whorls; spikelets with one delicate usually hyaline floret; glumes as long or longer than the florets; lemmas awned or not; disarticulation above the glumes.

Polypogon species mostly riparian to aquatic; panicle branches ascending to appressed, dense; spikelet detail similar to genus *Agrostis* except disarticulation below the glumes.

P. monspeliensis (rabbitfoot grass) annual; panicle dense (obscuring the rachis), spike like oblong with yellow awns.

P. viridis perennial; disarticulates with a portion of the pedicel attached to the spikelet. This disarticulating upper portion of the pedicel is called a stipe.

Festuca species (fescues) mostly montane; perennial; most species narrow leaved, caespitose; panicles usually with few branches at the lower nodes; spikelet with numerous florets; disarticulation above the glumes; lower glume 1 (3) nerved; upper 3 (5) nerved; lemmas mostly rounded proximally with 5 (7) veins usually awned from at or near the acute tip.

Festuca arizonica lemma short awned; ovary (grain) apices "densely pubescent"--FNA <1/2 of sheath closed.

Festuca octoflora (*Vulpia octoflora*) small winter or early spring low to mid elevation annual; inflorescence with appressed spikelets or panicle branches; spikelets with numerous florets; lemmas short awned and notably scabrous or pubescent; this probably the most common local annual *Festuca.* The annual fescues have bounced back and forth between genera *Vulpia* and *Festuca.*

Lolium species (rye grass) non-natives probably not well established locally but might be seen in wetter areas and those under cultivation; inflorescence a spike with awned or unawned spikelets laterally flattened and positioned so the flat side is not tangent to the rachis but oriented radially to it; spikelets missing a lower glume; a few species that may be difficult to identify; see also *Schedonarus arundinaceus* below.

Schedonarus arundinaceus (*Festuca arundinacea, Lolium arundinaceum*) (tall fescue) is most likely to not be found in references under its latest name (*Lolium a.*); morphologically the inflorescences are more fescue like rather than what most references indicate for traditional genus *Lolium* having spikes; an introduced old world perennial caespitose species that would most likely be found here in more moist disturbed areas; can be fairly tall with broad leaves (4-12 mm) and auricles having a few cilia; inflorescences with ascending to appressed branches; spikelets fescue like; lemmas fairly short awned or unawned; although there are significant morphological differences among the species, genera *Festuca, Lolium* and *Schedonarus* are closely related.

Phalaris species (canary grasses) ours annuals of various habitats; panicle dense (obscuring the rachis), spike like; spikelets tightly compressed laterally with glumes keeled or winged; upper floret fertile usually shiny pubescent; lower florets sterile and reduced to needle like structures curling around the edge of the upper floret.

P. minor exotic annual; glumes winged in cross section and with one sterile floret; see plate V, 4-6.

P. caroliniana annual, probably exotic; winged or not with 2 sterile florets (one on each side of the fertile floret).

Avena species (oats) ours most likely to be *A. fatua,* an alien annual, often seen along local roadsides; panicles with branches usually nodding and with large, awned spikelets (to approx. 3 cm); glumes usually exceed the 2-3 florets; calluses long bearded; lemmas strigose with reddish hairs; long awns stout, geniculate and twisted arising from upper portion of the bifid lemmas.

Poa species (bluegrasses) here mostly montane species; prow shaped blade tips and grooves on both sides of the blade midrib (adaxial surface) are common features; spikelets usually notably laterally compressed and small; lemmas unawned, often keeled and with hyaline margins distally; calluses blunt and many species with tufts of tangled hairs in the callus area; 2-5+ florets common; paleas often hyaline or milky shaded with green veins.

P. bigelovii a small to moderate height native annual reaching the desert floor here; lowest 1/4-1/2 of sheath closed.

P. fendleriana (mutton grass) here a higher elevation native dioecious perennial; a widespread species exhibiting both sexual and asexual production which occurs in populations without male plants (apomixis); distal cauline leaves with sheath only or with very short blades; caespitose to somewhat rhizomatous; narrow panicle; calluses glabrous but lemmas glabrous to pubescent; compare with *Koeleria macrantha.* Sheaths open to closed in lower third.

P. pratensis (Kentucky bluegrass) a higher elevation perennial species here but extremely widespread over the northern hemisphere; in S. Arizona a rhizomatous species with wooly callus hairs is probably *P.* pratensis; lower 1/4-1/2 of sheath closed.

Koeleria macrantha (June grass) most publications still have this name but some include include it within *K. pyramidata*; looks similar to *Poa fendleriana* but flag leaf blades fully developed; leaf blade tips are boat prow shaped similar to those of *Poa* sp.; rachis and panicle branches puberulent compared to being glabrous or scabrous in *P. fendleriana*; here found at higher elevations; lemma often shiny and sometimes with a mucro; compare also *Sphenopholis obtusata.*

Sphenopholis obtusata (wedgegrass) also similar to *P fendleriana* and *K. macrantha;* it is also found at higher elevations; narrow panicle with ascending branches with closely spaced spikelets with 2-3 florets; the notable difference from the other species is that disarticulation is below the glumes and the lower glume is **much** narrower than the somewhat oblanceolate upper glume.

Cynodonteae

Flora of North America states: recognized by two or more of the following characteristics: 1-3 or 7-13 veined lemmas; laterally compressed spikelets; spike like inflorescence branches; long hairs in the collar area**;** locally our largest group of desert plants; probably evolved in areas of water stress in the tropics and subtropics; featured here are mostly genera common to the local low and mid elevations..

Eragrostis species (lovegrasses) plants caespitose; panicles with usually ascending to spreading branches; glabrous and unawned spikelets often with many imbricate florets; many species with dark lead colored spikelets prior to curing; glumes usually one veined and not

exceeding adjacent florets; palea on some species with a lateral wing below eg. *E. echinochloidea* and *E. superba;* many species with persistent paleas and deciduous lemmas; some species with non green glandular tissue or pits in various locations, such as on the leaves, pedicels or lemma midribs (look closely-they may be tiny). The caryopsis may be necessary for proper identification of the species. Caryopses may be readily teased out of mature spikelets. Some species have grooved caryopses, the groove appearing on the side opposite the usually dark embryo; native and many alien species, some quite invasive; local species often best determined with the aid of a dissecting scope; determining whether annual or perennial is best done in the field.

E. echinochloidea (tick grass) rapidly locally increasing exotic invasive medium sized perennial; culms often geniculate; small spikelets (usually <5 mm. long) mostly pendant and light colored; paleas with ear like wings; crateriform glands on the glumes may be difficult to see with a hand lens; see also *E. superba.*

E. superba (saw tooth lovegrass) medium sized invasive exotic perennial found at moderate elevations locally; the somewhat triangular shaped flat spikelets with individual florets appearing like saw teeth are quite distinct, hence the common name; the individual florets (lemmas) may show distinct green veins; like *E. echinochloidea,* the winged paleas may or may not be readily seen if they are hidden beneath the lemma edges.

E. barrelieri (Mediterranean lovegrass) here in the desert areas a rather short invasive exotic annual of the disturbed areas; although said to be annual it may produce small inflorescences a second time late in the year; spikelets usually narrow (linear) and 5-10 mm. long, often dark colored; caryopses not grooved; spots often of colored tissue found in random locations of the panicle branches and below the culm nodes are fairly definitive for this species here.

E. cilianensis (stink grass) medium height annual invasive exotic locally; inflorescence fairly compact with numerous spikelets; spikelets usually 5-12+ mm. long, ovate to lanceolate; spikelets may be dark colored; lemmas with green veins and crateriform glands on the midribs; caryopses not grooved; spots or bands of glandular tissue on the panicle branches and culms missing, unlike in *E. barrelieri.*

The above *Eragrostis* species are all fairly easily identified. Two native annual species more of the mid elevations may be hard to differentiate. Both species (*E. mexicana and pectinacea*) have fairly dark reddish brown opaque to slightly translucent caryopses. *E. mexicana* caryopses are striate and have a grooved side that should be easily seen with a hand lens. The groove may be pronounced or fairly shallow. *E. pectinacea* caryopses are not grooved but round edged and are smooth or faintly striate.

E. intermedia (plains lovegrass) widespread medium height native perennial of the grasslands; panicles widespreading, not dense; many of the pedicels longer than the spikelets which are somewhat lanceolate 3-6 or 7 mm; caryopses grooved.

E. curvula (weeping or Boer lovegrass) medium to tall invasive exotic perennial of low to probably mid elevations; panicles oblong somewhat narrow early, more open when mature; spikelets similar to *E. intermedia*; caryopses may or may not be grooved; long

(to 50+ cm.) narrow blades differentiate this species from other local *Eragrostis* species.

E. lehmanniana (Lehman lovegrass) an extremely invasive mid height perennial species of the mid elevation grasslands which is becoming more common locally at the lower elevations; culms often geniculate; panicles fairly compact and oblong; spikelets somewhat linear 5-12 mm. long; caryopses grooved or not; many of the pedicels are shorter than the spikelets.

Dasyochloa pulchella (*Erioneuron pulchellum*) (fluff grass) very low growing stoloniferous somewhat mat forming perennials; inflorescence somewhat hidden in fascicles and light colored with dense pubescence; folded leaves with prickly tips; common locally; see plate I.

Munroa squarrosa (false buffalo grass) very similar to fluff grass (above) but an annual of more northern Arizona and at higher elevations; low growing and stoloniferous also with inflorescences and leaves in fascicles; blades with white cartilaginous edges unlike fluff grass.

Leptochloa species (sprangletop) many species in this genus have been relocated taxonomically into new, or in some cases older generic names; panicle branches with spikelets on one side in 2 rows; often found in more moist areas; multiple mostly short awned or mucronate lemmas:

L. dubia (*Disakisperma dubia*) (green sprangletop) usually a fairly tall native perennial with a few digitate or subdigitate long panicle branches; unawned lemmas usually with an emarginate tip.

Diplachne and *Dinebra* species *Diplachne* in general have more florets (>4), relatively short glumes compared to the length of the spikelet and ligules that are acute to attenuate compared to those of *Dinebra* which are truncate to obtuse. Both may have short awns or mucros:

L panicea subsp. *brachiata* (*Dinebra panicea* subsp *brachiata*) (red sprangletop) weedy usually medium height annual with many shorter (usually <10 cm) racemosely arranged spreading panicle branches; sheaths sparsely to densely hairy with papillose based hairs; spikelets usually not exceeding 3 mm. with mostly <4 florets; generally the glumes are longer than the lower florets; lemmas <2 mm. long; caryopsis usually with a groove.

Dinebra viscida (*L. viscida*) medium height annual; few to many racemosely arranged branches; sheaths glabrous or with a few non papillose hairs and often with a sticky exudate; lemmas a little longer than in *panicea.*

Diplachne fusca (*L. fusca*) Medium to tall mostly annual exotic with racemose panicle branching similar to the above species; ligules tend to be decurrent; glumes usually short compared to the overall spikelet length; lemmas >2 mm. long. It may or may not have short awns. Subspecies *fascicularis* has inflorescences often included within the upper leaf sheath and whitish lemmas often with a dark spot at

the base. Subsp. *uninervia* usually with the entire inflorescence exerted and with green to lead colored lemmas without a spot at the base.

Enteropogon chlorideus (*Chloris chloridea* and latest *Tetrapogon chlorideus*) a somewhat tall native of low to mid elevations with a panicle that is similar to *Leptochloa dubia;* panicle with a few racemose branches; spikelets awned with two florets, the upper being small and sterile; uncommon and in the U.S. only known from Pima County and Texas; included here due to its unique underground cleistogamous spikelets which terminate rhizomes.

Sporobolus and *Muhlenbergia* species of these genera have some morphological similarities but differ in lemma venation and ligule type; both have quite small spikelets with single florets in a wide variety of panicle shapes; *Sporobolus* (dropseed or sacaton) species have one veined lemmas and ligules of hairs; glumes 0-1 veined; "muhly" species have 3 veined lemmas and membranous ligules or membranous ligules with a ciliate fringe; glumes usually one veined; *Muhlenbergia* is the largest genus in Arizona; only a few are mentioned below.

S. wrightii and airoides these large moisture loving caespitose native perennials are the famed sacaton of Arizona history; some suggest they are one species; *S. wrightii* normally has a long narrower inflorescence while the latter normally has an inflorescence about as long as wide.

M. microsperma short to moderate height much branched native annual of the low to mid elevations; culms often geniculate; panicle usually with ascending branches; spikelets often purplish and awned; often with cleistogamous spikelets forming a bulge within the lower leaf sheaths.

M. porteri (bush muhly) native perennial of the low to mid elevations locally; inflorescence similar to *M. microsperma* but the plant is much more bushy with tangled geniculate culms and larger (to almost 1 meter high); culms narrow but wiry; panicle open with relatively few spikelets which may blend with the foliage; no cleistogamous spikelets.

M. rigens (deer grass) a large perennial of the wetter areas of the mid elevations locally; panicle extremely narrow with appressed branches and long (up to about 0.5 meter); this native species is sold in the nursery trade and often seen locally in yards.

S. contractus (spike dropseed) somewhat similar to deer grass this medium to large widespread native perennial also has a very narrow spikelike dense panicle often partially enclosed within the upper leaf sheath; sheath apices with a conspicuous tuft of hairs.

S. cryptandrus (sand dropseed) a widespread native perennial with a fairly large and mostly widespreading panicle that is usually partially enclosed within the upper leaf sheath; prominent white tufts of hairs are found at the sheath apex.

M. straminea (screwleaf muhly) moderate to large sized perennial of the mid to higher elevations; flattened and coiled lower leaf sheaths (similar to wood shavings) should be

easy to find underneath the younger foliage; lemmas with 12–27 mm. long delicate awns; upper glume 3 veined, the veins sometimes extending into mucros; upper glume equal to or exceeding the floret.

M. montana (mountain muhly) quite similar to *M. straminea* but the 3 veined upper glume is shorter than the floret and the leaf sheaths, though flattening do not coil as frequently.

M. emersleyi (Bullgrass) large perennial found in the grasslands and higher elevations; sheaths of lower leaves compressed and keeled; ligule 10-25 mm long; panicle large to 30-40 mm sometimes purplish with many ascending branches which are naked basally; spikelets with glumes that equal or exceed the florets; lemmas pubescent, awned or not

M. longligula large perennial similar to *emersleyi* in location, size and form but with sheaths of lower leaves round, not keeled; ligules long but unlike the former are brown and firm basally; glabrous lemmas which may be very short awned or not.

Some small fragile annual species of *Muhlenbergia* including *M. sinuosa, minutissima, texana, fragilis* and *ramulosa* are found in the grasslands and higher elevations. They may blend in with other vegetation and be difficult to see. The first three have glumes with hairs; the latter two have glabrous glumes.

M. arizonica (Arizona muhly) and *M. torreyi* (ring muhly) both species are somewhat decumbent small to medium size and with short (<7 cm) leaf blades; Arizona muhly distinguished by its thickened white leaf edges and midvein; both with fairly large widespreading panicles.

Bouteloua species (gramma grasses) annual and perennial natives with two types of distinctive inflorescences; common to both are spikelets with 1-3 florets, the lower one being bisexual and usually short awned while the upper may be male or rudimentary with long awns; spikelets are fairly tightly spaced in two rows along one side of a panicle branch; one inflorescence type has relatively short disarticulating branches with few spikelets while the other type has longer non disarticulating branches with many pectinate and tightly spaced spikelets; in both inflorescence types the branches normally align to one side of the rachis (secund).

B. aristidoides (six weeks gramma) a small annual which may form dense patches here in the desert; with very short scabrous and sharp pointed disarticulating panicle branches, the patches it may be irritating to walk through when the branches penetrate one's socks.

B. curtipendula (side oats gramma) a moderate height usually caespitose perennial with a large number of disarticulating panicle branches; see also *B. repens.*

B. repens (slender gramma) another common moderate height local perennial species with disarticulating panicle branches; distinguished from *B. curtipendula* by having much fewer panicle branches (4-12).

B. barbata (also six weeks gramma) common small local annual with 4-9 pectinate non disarticulating inflorescence branches; var. *rothrockii* is a short term mid-sized caespitose perennial with fairly erect straight culms more common at the mid elevations; usually with 4 or more panicle branches.

B. gracilis (blue gramma) a moderate height perennial widespread species of North American grasslands with usually about 3 non disarticulating pectinate inflorescence branches; spikelets mostly glabrous; commonly with short rhizomes allowing the plant to expand in size often into a ring after the older interior culms die.

B. hirsuta (hairy gramma) locally a moderate height perennial of the lower to mid elevations with non-disarticulating pectinate panicle branches; distinct from *B. gracilis* and *B. barbata rothrockii* because of its papillose hairy spikelets and obvious naked extension of each panicle branch axis beyond the distal spikelets.

Lycurus species (wolf's tail) two very closely related native mid sized perennial species now included in genus *Muhlenbergia;* most common at slightly higher elevations; both with narrow spikelike panicles; both species with mostly 2 unequal awns on lower glumes and one awned upper glumes; leaf tip and ligule characteristics of our two species are fragile and best examined prior to drying and pressing.

L. setosus (*Muhlenbergia alopecuroides*) has fragile hair like tips on blades of upper leaves and long acute to acuminate membranous ligules.

L. phleoides (*Muhlenbergia phleoides*) without the hair like leaf tips and shorter [1.5-3 (4) mm.] membranous ligule with evident triangular lobes.

Hilaria species ours perennial natives of the desert and higher elevations; rhizomatous or stoloniferous so may form patches; inflorescences spikelike with groups of 3 spikelets tightly held together along the rachis in disarticulating groups called fascicles.

H. belangeri (curly mesquite) a short low to mid elevation stoloniferous perennial;

H. mutica (tobosagrass) probably the most common of three larger *Hilaria* sp.in S. Arizona; identification of species difficult in these three species; *H. mutica* a mid-size rhizomatous perennial with wiry culms which may form thickets; glumes tend to be fabellate only in *H. mutica*; very gray coloration of plants contrast with other local grasses..

Tridens muticus (*Tridentopsis mutica*) (slim tridens) locally a common medium height perennial of the desert scrub; panicle narrow but spikelets not severely congested; spikelets often purplish with 5+ florets; glumes and lemmas somewhat thin-hyaline; lemmas with prominent hairs on the veins; hairs of the midrib occur on the lower half; lemma often notch tipped; palea with marginal hairs.

The following five species all have largely digitate panicles with spike like branches:

Chloris virgata (feather fingergrass) locally weedy medium height annual of the lower to moderate elevations; may or may not be native; often found in disturbed areas; panicles

digitate with usually numerous <10 cm. long spikate branches; spikelets closely spaced in 2 rows; spikelet with one fertile floret and usually just one sterile floret above; lower lemma awned and showing obvious long hairs distally.

Cynodon dactylon (Bermuda grass) a mid to low elevation exotic weed; locally of concern as a serious invader in seasonally wet areas including roadsides where road surface runoff concentrates; being stoloniferous and/or rhizomatous, it is capable of forming a dense ground cover; usually <6 spikate panicle branches which are triangular in cross section; spikelets tightly spaced in two rows; spikelets usually with one floret; see plate I.

Eleusine indica (goose grass) exotic caespitose annuals of moderate height; sometimes 1 or 2 panicle branches seen below the digitate branches; panicle branches fairly flat and ending with a spikelet; spikelets with 5-7 florets; occasionally seen around Tucson.

Dactyloctenium aegyptium (crow foot grass) small to moderate height exotic annual that may be increasing around Tucson; panicle branches 2 to about 6 cm. long with the branches projecting beyond the distal spikelets; spikelets with a few florets; see also *D. radulans.*

Dactyloctenium radulans similar to *D. aegyptium* but with very short panicle branches (to about 1.5 cm.) in which "most spikelets touching those of an adjacent branch"--Flora of North America; few or no spikelets touch in *D. aegyptium.*

Danthonieae

Rachilla extends beyond the last floret although I do not see this in *Schismus barbatus* (below) which I have examined; lemma apices bilobed to bifid; lemma often with a mucro or awn (awn usually geniculate) emerging between the lobes; lemma of fertile florets with 3-11 inconspicuous veins and pubescent**;** only one genus of local importance.

Schismus species two very similar species, S. *barbatus and arabicus,* of late winter to early spring; ephemeral exotic generally small annuals of low to mid elevations; locally the plants are characteristically vee shaped with a large number of culms radiating from a small basal area; inflorescences usually <6 cm. long with ascending panicle branches; spikelets with about 5-6 florets with glumes exceeding at least some of the lower florets; lemmas glabrous or pubescent with bifid tips and often mucronate.

Aristideae

Native species with one floret per spikelet; spikelets usually long and narrow. A lemma awn usually has 3 digitate branches, the lateral branches sometimes greatly reduced or absent. The lemma often tapers into a beak also called an awn column. The awn branches usually branch at sharp angles from the beak or top of the lemma. If thought of as being similar to spokes of a wheel the awns mostly cover an arc of less that 180 degrees. This tribe contains 3 genera; *Aristida,* the only genus in Arizona is found worldwide in usually dry tropical and subtropical habitats; a number of mostly perennial species are found throughout Arizona often on harsh sites.

A. purpurea (purple three awn) a widespread medium height perennial native with many varieties which are often hard to differentiate; fine examples of some varieties are seen along local roads where it thrives on runoff from the roads; very striking with their reddish purple inflorescences that glisten in the sun light prior to curing. Varieties are based mostly upon

how the inflorescences branch, glume lengths, awn length and beak details. *A. purpurea* is a perennial with lateral awns well developed though often somewhat shorter than the central awn; junction of the lemma and awn cloumn is not distinct. One just tapers into the other. All or some of the panicle branches appressed at their base; lower branches may or may not be appressed depending upon the variety; awn length may vary between 8mm and 10 cm or longer depending upon the variety; blades usually involute. *A. arizonica* is somewhat similar to some vars. of *purpurea.* It has a very narrow inflorescence with appressed branches, a distinctly twisted awn column and flat blades which tend to coil. Older publications may show many species that are now considered to be varieties of *Aristida purpurea. Aristida. longiseta, glauca, fendleriana, wrightii* and *parishii* are all now varieties of *A. purpurea; A. glauca is* now *A. pur.* var. *nealleyi.*

A. adscensionis very similar to *A. purpurea* but it is a smaller annual; only other major difference between the two species is that the central awn of this species is winged, the wings being about as wide as the central axis; the translucent wings may be best seen while holding it against a bright sky and observing with a hand lens.

A. ternipes (spidergrass) this species is common locally in the low to mid elevations; depending upon the variety this medium to large perennial may or may not have the 3 awns found in most *Aristida* sp*;* var. *gentilis* (*A. hamulosa*) has 3 awns while var. *ternipes* has a long central awn with normally suppressed lateral awns; looking closely one can sometimes find the short rudiments of the lateral awns; the inflorscence of *A. ternipes* has wide spreading branches which are naked on the proximal portions and with few spikelets.

Paniceae

Spikelet with two florets, the lower reduced, sterile or male depending upon the species and the upper usually bisexual (I have seen on a very few occasions three florets. In one, I remember that almost adjacent to the normal upper floret was another fully developed second floret similar to the normal upper floret); lower glume may be missing but present in most genera; if present, usually shorter than the spikelet; lower lemma and upper glume usually similar and membranous with chlorophyll; upper floret (lemma and palea) "indurate, coriaceous, or cartilaginous..." -- Flora of North America...often glabrous, dull or shiny or rugose and not green; usually the florets are appressed to outwardly appear as one; most genera of the "bristle clade" have individual spikelets or groups of spikelets subtended by one to numerous bristles or spines; "bristle clade" genera normally having bristles subtending individual spikelets include genus *Setaria;* those with groups of spikelets termed fascicles subtended by bristles or spines include genus *Pennisetum (Cenchrus)*; see plates II and V, 9-14 for details of a somewhat typical Paniceae spikelet. Plate VI shows the relationship of the various bracts of a *Setaria* spikelet in longitudinal cross section.

Setaria species (the bristlegrasses) most with one bristle under each spikelet; spikelets clustered on short branches of spikelike panicles; spikelets tend to be somewhat globose, so the inflorescence appears as beads along the rachis with protruding bristles; common locally are the medium to large height perennials, *S. leucopila and macrostachya*; both are similar and occur locally from low to mid elevations; smaller annual species are also found locally and may be difficult to identify; most common annual is probably *S. grisebachii.* Another annual bristlegrass that may be seen locally is *S pumila.* It is easily identified by having numerous bristles below each spikelet that may be reddish or yellowish.

S. leucopila fairly common locally; blades usually <5 mm. wide; spikelets usually somewhat elliptical; lower palea usually much smaller than the upper palea.

S. macrostachya blades often >5 mm. wide; spikelets more often subglobose; lower palea nearly the same length as the upper palea.

Cenchrus species (now including genus *Pennisetum*) spikelike panicles with short branches of fascicles containing one or more spikelets surrounded by subtending ranks of bristles and/or spines; unlike most Paniceae species, the lemma and palea of upper florets tend to be fairly similar in texture to the glumes and lower lemma; indurate spines of some form burs; the fascicles including the bristles/spines disarticulate intact; for non bur type fascicles see plate V, 7. The bristles and spines are modified or in the case of the spines highly modified panicle branches.

Traditionally genus *Cenchrus* has been applied to the bur producing species and genus *Pennisetum* applied to species with bristles.

C. spinifex (*C. incertus* and *pauciflorus*) (common sandbur) medium height annual locally on more moist sites; most common of the bur forming species; easily determined by the pain one will feel if grabbing a bur with its indurate spines; spines wide based, somewhat triangular in shape, are very randomly placed and protrude at various angles from an indurate cup surrounding a few spikelets; beneath the spines may be a few bristles.

C. echinatus (southern sandbur) locally less common annual than *C. spinifex*; most spines somewhat more orderly ascending from the cup than in *C. spinifex*; a number of bristles beneath the cup.

C. ciliaris (*P. ciliare*) (buffelgrass) this low to lower mid elevation invasive exotic caespitose perennial may reach maturity at any size between 10-100 cm+ height; branching culms with fairly short blades give the larger plants a weedy look; fascicles with many bristles in two ranks plus one longer primary bristle; inner bristles ciliate as is the primary bristle; panicle 2-20 cm long and green, brownish to purple; fascicles with more than one spikelet and including the bristle length up to approx 1 cm.

C. setaceus (*P. setaceum*) (fountain grass) another large caespitose invasive exotic perennial with long arching leaf blades and long (to approximately 30 cm) narrow spike like inflorescences that are plumose; low to mid elevations; fascicles usually with more than one spikelet; inner bristles plumose 20 or more mm. long; panicles silvery often somewhat pink or purplish; unfortunately often cultivated as an ornamental.

C. advena (*P. advena*) (purple fountain grass) a very large caespitose exotic ornamental seen and sold locally; its very large size and often burgandy foliage differentiate it from similar *P. setaceum*; not supposed to set viable fruits but.....…?

C. longisetus (*P. villosum*) a rhizomatous invasive exotic seen around Bisbee; fascicles very plumose; spikelets longer (about 1 cm.) than in fountain and buffel grasses.

Melinis repens (*Rhynchelytrum repens*) (natal grass) invasive caespitose medium sized annual to short lived perennial of low to mid elevations; inflorescence with spreading to

ascending panicle branches notably shiny pink-silvery colored due to the many long glassy hairs of the spikelets; spikelets greatly laterally compressed so that the outer bracts appear to be folded.

Urochloa species small to medium height annual caespitose natives of the low to mid elevations; panicle branches usually few and somewhat spike like; two local closely related species with rugose upper florets and usually some cross venation evident in the upper glumes.

> *U. arizonica* (*Brachiaria arizonica*) (Arizona signal grass) cross venation confined to the upper half of the glume; spikelets hairy; panicle branches hairy with papillose based hairs; upper glumes may be pubescent.
>
> *U. fusca* (*Brachiaria fasciculata*) (brown top signal grass) probably less common than *U. arizonica;* panicles mostly scabrous, somewhat hairy but with few or no papillose based hairs; upper glumes glabrous with cross venation, if evident, throughout; spikelets may be somewhat yellow to somewhat rusty colored.

Digitaria species inflorescences various from simple branched/rebranched panicles to subdigitate or digitate panicles with spikelike branches; lower glumes may be missing, tiny or to no more than approx ¼ the length of the spikelet; in local species the upper floret is unique due to the thin hyaline margins of the lemma.

> *D. californica* (cottontop) fairly common local native extending up to mid elevations; medium sized caespitose perennial; branching culms notable; panicles with ascending branches (5-15 cm. long) are usually easily spotted during the summer due to the dense long white pubescence of the upper glumes and edges of the lower lemmas; no awns (*Bothriochloa barbinodis* looks similar but it has awns).
>
> *D. insularis* similar to *D. californica* but spikelet hair color renders the inflorescence a gold to light brown color; upper floret is dark brown; uncommon in SE Arizona.
>
> *D. sanguinalis* and *ciliaris* (crabgrasses) two very similar species with mostly spreading subdigitate to digitate branches; may occasionally be seen here but the two species are difficult to differentiate.

Eriochloa species (cup grasses) annual natives of moderate size of low to mid elevations locally; narrow inflorescence a panicle with racemosely arranged rather short spikelike ascending to appressed branches; the lower glume and the glabrous callus are modified to form (in ours) a doughnut shaped ring around the base of the spikelet.

> *E. acuminata* spikelet normally somewhat acute but with a short awn; spikelet length not including the awn usually 5 mm. or less; most common locally.
>
> *E. aristata* spikelet long tapering (aristate) into a short awn; spikelet length not including the awn >5 mm.
>
> *E. lemmonii* similar to *E. acuminata* but with easy to feel velvet like pubescence on the adaxial blade surfaces.

Echinochloa species (barnyard grasses) fairly narrow racemosely branched panicle with spikelike branches; spikelets tightly spaced on the branches; our most common species (below) have no ligule; in its place is an area of non-green coloration; the inflorescences are usually covered with stiff papillose hairs; low to moderate elevations; probably seen mostly on disturbed sites.

E. colona annual exotic; branches short (usually < 4 cm.) and never rebranched; unawned; upper floret has a somewhat herbaceous tip that withers as the fruit matures.

E. crus-galli annual exotic; longer branched than *E. colona*; branches may rebranch but the secondary branches are very short; look closely for rebranching on the side of the stem not obscured by spikelets; some or all of the spikelets with awns of varying length to about 5 cm.; upper florets also with a withering tip.

Dichanthelium species an interesting genus similar to and formerly included in genus *Panicum* but with unique growth habits; ours are two small to moderate sized species of the mid elevations; perennials with a basal rosette of leaves in the winter; spring brings typical culm growth with terminal, mostly exserted, panicles but in summer-fall the culms branch; these branches are short, leafy and bear small terminal panicles partly included within the leaf sheaths; ours native species.

D. oligosanthes ours with spikelets about 3 mm. long; upper glumes often with a prominent colored spot at the base.

D. acuminatum spikelets up to 2 mm. long without a colored area at the base of the upper glume.

Paspalum species inflorescence usually with one to a few either digitate, subdigitate or racemosely arranged spike like flattened branches; spikelets dorsally compressed with the lower lemma side being fairly flattened the other side convex (spikelet plano-convex); lower glumes absent or found only on some spikelets and may be extremely short.

P. distichum (knotgrass) moderate sized perennial native mostly of wet areas; some may have rhizomes; spikelets mostly solitary (sometimes paired) in two rows, one on each side of the branch midvein; usually two panicle branches; upper glumes 3-veined, short pubescent on the back; lower glume absent or tiny; spikelets 2.4 – 3.2 mm long.

P. dilatatum (dallisgrass) mid-size to large exotic perennial of mostly wet areas; panicles of usually 3–5 flattened spikelike branches racemosely arranged; spikelets usually 3–4 mm long; upper glumes and lower lemmas pubescent on the margins, 5–7 veined; short rhizomes form a knotty base.

P setaceum (sand paspalum) medium to large size perennial may be short rhizomatous forming a knotty base; said to prefer sandy not necessarily wet soils; spikelets about 2 mm long mostly paired along mostly 2–3 racemosely arranged panicle branches; lower glume absent; ours var. *stramineum* without an evident lower lemma midvein.

Panicum species by default if a local grass with the Paniceae spikelet is not one of the aforementioned genera it is probably a *Panicum* species.

P. hirticaule (witchgrass) an annual usually of moderate to large size mostly found in the wetter areas locally and to mid elevations; inflorescence from fairly small to large and often rebranched; branches usually naked along to lower half; herbage from glabrous to usually papillose pubescent; sheath said to be ciliate on one margin; spikelets with prominent veins, glabrous often rust colored with tips somewhat abruptly acuminate; lower glumes ½ to ¾ spikelet length; lower florets sterile.

P. hallii (Hall's witchgrass) moderate sized perennial of low to mid elevations with often crowded basal leaves; leaves tend to coil like wood shavings; leaf margins cartilaginous; plant somewhat glaucous; lower florets sterile.

P. obtusum (now *Hopia obtusa*) (vine mesquite) somewhat uncommon medium to large perennial of more moist habitats; low to fairly high elevations; inflorescences with a few spikelike branches; spikelets somewhat ellipsoid; stoloniferous and/or rhizomatous; lower florets staminate.

P. bulbosum (now *Zuloagaea bulbosa*) (bulb panicgrass) fairly large perennial of higher elevations; usually with a corm like root crown area; lower florets sterile or staminate; lower paleas may exceed lower lemma.

P. capillare (witchgrass) annual of disturbed soils, wet areas; plant mostly papillose hispid; outstanding feature of the species is the large open much branched inflorescence that is about half the size of the entire plant; inflorescence may break off when mature to become a tumbleweed; glabrous spikelets not dense, generally about 2.5 mm long; lower glume generally about ½ the spikelet length.

P. antidotale (blue panicgrass) a large almost bamboo like species with thick scaly rhizomes has been found along the Santa Cruz River; lower florets staminate.

Andropogoneae

Most with rames; some with simple racemes that do not disarticulate; spikelets with large glumes entirely enclosing the florets; most species with sessile-pedicellate spikelet pairs or sometimes triplets; in the rame each disarticulated segment usually includes one spikelet pair or triplet with a section of the rame axis; see plate III for various rame arrangements; spikelets with two florets, the lower often reduced; both with hyaline lemmas and paleas; upper floret often awned; after the foliage dries during fall/winter months many species have a somewhat rusty red pigmentation in contrast to the straw color of most species; some members of this tribe have extremely modified inflorescences as in the case of corn with its thickened cobs and two species briefly mentioned below-*Tripsacum lanceolatum* & *Hackelochloa granularis.*

Bothriochloa species (blue stems) this genus differs from other Andropogoneae species by having pedicels and rame axes with a hyaline longitudinal central groove so they appear somewhat barbell shaped in cross section; the hyaline portion appears translucent when held up to the light.

B. barbinodis (beard grass) quite common locally and to mid elevations; perennial, medium to large height; in summer the plumose silvery inflorescences each with many ascending rames usually about 10 cm. long are quite visible along roads; dense long hairs on the rame axes and pedicels; has long geniculate twisted dark awns contrary to somewhat similar appearing *Digitaria californica* without awns; see plate III.

Other native species, some of which are somewhat difficult to differentiate are more common in other parts of southern Arizona; one exotic increasingly seen locally is *B. ischaemum* usually with only a few subdigitate < 10 cm. long reddish pubescent rames; see also similar appearing *Dicanthium annulatum* (below) which does not have the hyaline grooves in the pedicels and rame segments..

The following two genera (*Heteropogon* and *Trachypogon*) might be confused; they almost always have single rames or racemes and look quite similar:

Heteropogon species terminal rames; distal pedicellate spikelets are sterile or male and without an awn; sessile spikelet perfect and with an awn; the proximal spikelet units are homogamous, either staminate or sterile and neither spikelet is awned.

H. contortus (tanglehead) common local to mid elevation medium to large perennial; long (5-9 cm.) dark awns which are pubescent below become entangled; culms near the soil level are quite flattened and somewhat lens shaped in cross section.

H. melanocarpus large uncommon annual species; may be found around Sabino Canyon; glumes of the pedicellate spikelet have a longitudinal row of pits.

Trachypogon secundus (*T. plumosus*) (crinkle awn) similar to *Heteropogon* species but has non disarticulating racemes; also different in that the long entangling lighter colored awns are on the longer and perfect pedicellate spikelet; the subsessile spikelet is sterile or male; large perennial of the mid elevations.

Schizachyrium species (blue stem) three species in Arizona that may be difficult to differentiate; single fragile appearing rames with shorter non tangled or twisted awns than the above two genera; culms often branching, each with a single terminal rame; sessile spikelets bisexual and awned; the pedicellate spikelets sterile or male and either unawned or with awns shorter than in the sessile spikelet; species of the mid elevations; usually caespitose.

Dichanthium annulatum an exotic stoloniferous perennial that may be naturalizing in our area; looks similar to *Bothriochloa ischaemum* but without the hyaline grooves in the rame segments and pedicels; less than 10 subdigitate rames that are naked (without spikelets) at their bases.

Sorghum species two very large species of exotics; these old world plants have been associated with humans for thousands of years, so many, many cultivars exist probably genetically entwined; therefore, it may be difficult to identify the species in this continuum of cultivars; the best clue may be whether or not the specimens in hand are rhizomatous or not.

S. halapense (Johnson grass) an invasive perennial rhizomatous weed of the more seasonally wet areas locally with large spreading terminal inflorescences of racemosely

branched and rebranched rames; sessile spikelets bisexual, either awned or not; pedicellate spikelets sterile or male and unawned; glumes indurate, pubescent and shiny; under certain conditions this plant can be poisonous to livestock.

S. bicolor (sorghum) mostly a yard or crop plant; annual, or perenial in warm winters; culms resemble corn; terminal inflorescences usually more compact than in *S. halapense* and with hairy spikelets; sessile spikelets bisexual and unawned; pedicellate spikelets sterile or male; not rhizomatous.

Tripsacum lanceolatum (Mexican gama grass) a tall rhizomatous native perennial mostly found near wet areas of Cochise and Santa Cruz Counties; this strange species has a two part rame; the paired male spikelets share the rame axis with the extremely indurate female spikelets beneath that are stacked one upon another with no evidence of sessile pedicellate pairing; female spikelets are embedded in the thickened axis; the male portion of the inflorescence is more typical of most Andropogoneae species having paired sessile and pedicellate spikelets.

Hackelochloa granularis (pitscale grass) another strange member of this tribe; an exotic annual of waste areas, roadsides etc. of extreme SE Arizona; rames terminal and axillary on a thickened axis; the small sessile spikelet partially embedded; spikelets look like tiny hand grenades; male pedicellate spikelets with more normal appearing glumes lie atop the sessile spikelets; the pedicel is hidden.

Pappophoreae
A small tribe with multiawned florets (lemmas).

Cottea pappophoroides mid-sized perennial of low to mid elevations with ascending panicle branches; lemmas long pubescent basally and with a mix of short awns and teeth with short awns.

Pappophorum vaginatum (pappus grass) medium to fairly large perennial of lower elevations with long very narrow spikelike panicles; lemmas with numerous awns which are not plumose; awns about 2x the lemma body length and which tend to bend outward as the fruits mature; lower glumes with one vein.

Enneapogon species (also pappus grass) two local species with 9 plumose awns on each lemma; awns 2x or more the length of the lemma body; lower glumes with 5-7 veins.

E. cenchroides medium to tall (usually > 0.5 meter) invasive exotic annual of low to mid elevations; panicles usually longer than 10 cm. and fairly narrow with appressed to ascending branches; culms usually about 2 mm. in diameter.

E. desvauxii medium sized native perennial (usually <0.5 meter) of the low to mid elevations; panicles usually < 10 cm. long somewhat spike like; cleistogamous spikelets are often found at or very near the base of the plant.

Stipeae
Most caespitose perennials including the species listed below; sheaths open; terminal panicles; spikelets with one floret and no prolonged rachilla; spikelets usually fusiform (cigar or spindle

shaped) with awned lemmas that are often densely hairy which tightly wrap around the floret; distal end of lemma often with a chopped off appearance (crown) and often flared at the tip; awns twisted and once or twice geniculate, sometimes plumose below; ours mostly of the sky islands. A number of taxonomic name changes have been made since most species were within *Stipa.* Since FNA was published that included many changes more gross changes have been made. A key has been developed based on these changes in the following publication that is available through the website PhytoKeys: A key to the North American genera of Stipeae (Poaceae, Pooideae) with descriptions and taxonomic names for species of Eriocoma, Neotrinia, Oloptum, and five new genera: *Barkworthia, xEriosella, Pseudoeriocoma, Ptilagrostiella,* and *Thorneochloa;* P.M. Peterson, K Romaschenko, R. Soreng and J. Valdes Reyna; PhytoKeys 126: 89-125 (2019). The genera and species below are based upon the FNA treatment

Jarava speciosa (*Stipa speciosa*) (desert needlegrass) medium height species of low to mid elevations; sheaths of basal leaves reddish brown, persistant; lower blades particularly with dense throat hairs and densely hairy ligules; blades usually rolled (involute) to about 1 mm. diameter; glumes longer than the florets; calluses long, sharp pointed; floret (lemma) densely hairy; awns >35 mm., once geniculate, the lower portion twisted with long (4-8 mm.) plumose hairs; upper portion glabrous to scabrous.

Hesperostipa neomexicana (*Stipa neomexicana*) (New Mexico needlegrass) ligules of lower leaves not densely hairy; glumes longer than the florets; florets evenly short pubescent with a long sharp pointed callus (4–5 mm long) and distally a ciliate crown; awns extremely long (>12 cm.) and twice geniculate sometimes weakly so; awns completely pubescent but with shorter hairs on the lower twisted segments.

Achnatherum species a few species in southern Arizona but most difficult to determine; the genus is also difficult to easily define; glumes longer than the floret; floret usually terete, fusiform and not compressed; lemma margins usually not or barely overlapping and uniformly hairy mostly with hairs of equal length or distal hairs slightly longer.

A. eminens (*Stipa eminens*) (southwestern needlegrass) a low to mid elevation moderate to large caespitose native; upper ligule to 4.5 mm long; florets 4–7.5 mm long; lemmas evenly hairy with 35–70 mm twice geniculate awns; panicle flexuous “relatively few flowered” (Gould) with lower branches 5-8 cm long ascending to divergent; early the lower portions of the panicle may be enclosed.

A. hymenoides (*Oryzopsis hymenoides*) (Indian ricegrass) a native mid elevation caespitose moderately sized species; the paired pedicels and widely divergent panicle branches and rebranches form zigzag patterns which are quite evident; florets obovoid 3–4.5 mm long uniformly hairy; awns to 6 mm, deciduous.

Piptochaetium species ligules decurrent (edges of the ligule extending downward forming the edges of the leaf sheaths); ours with calluses blunt to acute but not with extremely sharp points; florets hairy; lemmas indurate, the lemma edges fitting into a groove in the palea which may be most easily seen in cross section (slice with a sharp instrument); see plate V, 8 for schematic cross section; the palea is longer than the lemma and may be seen as a short projection above the distal rim (crown) of the lemma; awns twice geniculate, though sometimes not prominently so; twisted below usually scabrous.

P. pringlei (Pringle needlegrass) glumes and florets > 6 mm. long; florets brown, hairy, smooth shiny or perhaps tuberculate; awns scabrous usually 20-35 mm. long; (see also *P. fimbriatum.*

P. fimbriatum (pinon ricegrass) glumes and florets <6mm. long; florets brown, hairy, shiny smooth; awns 10-20 mm. long, scabrous; dense basal leaves said mostly tightly involute and spreading to drooping contrasting with more flat ascending leaves of *P. pringlei.*

Piptatherum micranthum (*Oryzopsis micrantha*) a caespitose mid-sized perennial of moderate to higher elevations; panicles with widely spaced lower nodes and few branches divergent at maturity having a few spikelets; glumes equal to or exceeding the florets; florets 1.5–2.5 mm long dorsally compressed; lemmas usually glabrous shiny with nearly straight 4–8 mm awns that are early deciduous; calluses very short (0.1–0.2 mm).

References for Some Arizona Grasses

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