AMARANTHUS SPECIES: A CURRENT AND EMERGING THREAT IN WYOMING

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Palmer amaranth is a new threat to agriculture that has recently arrived in Wyoming. Photo Credit: Shawn Askew

INTRODUCTION

The genus *Amaranthus* comprises more than 90 species worldwide, 38 of which are known to occur in North America (*1*, *2*). This group, often known simply as amaranths or "pigweeds," includes herbaceous species that are both native and non-native within the United States, with around a dozen considered to be serious agricultural weeds around the world (*1*). While *Amaranthus* species inhabit a wide range of habitats, including natural and human-disturbed areas, the weedy species of concern primarily impact cultivated lands. Weedy *Amaranthus* species have a long history of association with crop production and can cause significant damage, with many having evolved resistance to herbicides (*3*). However, not all *Amaranthus* species are weeds; some are cultivated for beneficial purposes, such as for their edible seeds or as leaf-vegetable crops or dyes, and many were historically significant food sources for Native American tribes (*4*).

Most species in the *Amaranthus* genus (and all of the weedy ones we discuss here) are summer annuals, meaning that they germinate in spring and set seed in late summer or fall. *Amaranthus* species exhibit a range of reproductive strategies that may influence their adaptability and competitiveness. Palmer amaranth (*A. palmeri*) and waterhemp (*A. tuberculatus*) are dioecious, meaning that male and female flowers exist on separate plants and pollination by another individual is required for seed production. Pollen is dispersed between plants by wind. Some researchers suggest that, since these dioecious species must mate with other plants, adaptive traits such as herbicide resistance spread rapidly throughout a population. In contrast, many other *Amaranthus* species, like redroot pigweed (*A. retroflexus*), are monoecious, with both male and female flowers on the same plant. This characteristic allows for self-pollination and results in lower genetic diversity.

CURRENT DISTRIBUTION

About half of *Amaranthus* species are native to North and Central America, but several of these species have become widespread globally, particularly in areas influenced by human cultivation and disturbance (*4*). Many species within this genus have adapted to thrive in agricultural settings, leading to their spread beyond their native ranges and becoming significant agronomic weeds. Palmer amaranth, a native to the southwestern United States, is a good example of this trend. It has undergone a major range expansion and can now be found outside of its native range in North America and around the world (*5*).

Wyoming currently hosts seven species within the *Amaranthus* genus, including both native and non-native species, with three recognized as major agricultural weeds (Table 1). Redroot pigweed, Palmer amaranth and waterhemp are considered the most concerning *Amaranthus* species in Wyoming, although surveys are underway to search for new species and to understand the prevalence of Powell amaranth (*A. powellii*) in local crop systems. Unlike redroot pigweed and Powell amaranth, which are native to Wyoming, Palmer amaranth and waterhemp are recent arrivals, first detected in the state in 2018 and 2025.

The ongoing spread of *Amaranthus* species is driven by their predisposition for disturbed environments and high seed production, highlighting the potential for further expansion wherever disturbed habitats occur—including in Wyoming. At least three other major weeds within the *Amaranthus* genus are present in Wyoming's neighboring states, including smooth pigweed (*A. hybridus*) and spiny pigweed (*A. spinosus*) but have yet to be reported within Wyoming's borders.

IMPACTS

Severe impacts of major weeds within the genus *Amaranthus* (e.g., Palmer amaranth, redroot pigweed) have been noted in a variety of crops worldwide. *Amaranthus* species have several traits in common that drive their negative impacts on agriculture, including rapid growth rates, high photosynthetic efficiency in dry environments, and prolific seed production, which allow them to outcompete crops and cause significant yield losses (*3, 7*). Their ability to develop resistance to multiple herbicide modes of action makes them some of the most challenging weeds to control and increases management costs (*7*). *Amaranthus* species also produce copious amounts of seeds and, as a result, can outnumber other species in the seedbank by a large margin (*8*). Additionally, the seeds are very small and may contaminate crops and other agricultural products, which can reduce their value (*9, 10*). Several *Amaranthus* species have been known to hybridize with other members of the genus, which allows them to rapidly spread traits that favor the plant's survival, like herbicide resistance (*11*).

Table 1. Amaranthus species present in Wyoming or nearby

Common name	Scientific name	Presence in Wyoming	Potential Impact
Redroot pigweed	*Amaranthus retroflexus* L.	Native	A highly problematic weed in many cropping systems; well-known to producers in Wyoming and globally.
Palmer amaranth	*Amaranthus palmeri* S. Watson	First recorded in 2018	One of the most damaging crop weeds in the United States, with significant harm predicted for Wyoming.
Powell's amaranth	*Amaranthus powellii* S. Watson	Native	Significant yield loss reported worldwide for multiple crop systems, but underrecognized in Wyoming; possibly being misidentified as redroot pigweed.
Waterhemp	*Amaranthus tuberculatus* (Moq.) J.D. Sauer	First recorded in 2025	Notorious weed in the United States, especially of corn and soybean in the Midwest.
Smooth pigweed	*Amaranthus hybridus* L.	Not yet known to be present, but reported in CO, UT, ID, MT, SD, NE*	A highly problematic weed in many cropping systems in the U.S. and globally.
Spiny amaranth	*Amaranthus spinosus* L.	Not yet known to be present, but reported in SD and NE	A spiny weed well known for its negative impacts in rangelands and forage systems in the U.S.
Prostrate pigweed	*Amaranthus blitoides* S. Watson	First recorded in 1894	Although it can reduce yields in some crops, it typically causes less harm and is easier to manage than other *Amaranthus* weeds.
Tumble pigweed	*Amaranthus albus* L.	First recorded in 1894	Impacts are not reported in Wyoming, but it poses management challenges in certain crops elsewhere in the world.
Sandhills amaranth	*Amaranthus arenicola* I.M. Johnst.	Native	Can grow in places with disturbed ground, and may be emerging as a weed in some part of the United States.
California amaranth	*Amaranthus californicus* (Moq.) S. Watson	Native	Can grow in places with disturbed ground, but not known as a serious weed of agriculture in Wyoming or elsewhere.

*CO = Colorado, UT = Utah, ID = Idaho, MT = Montana, SD = South Dakota, NE = Nebraska

In addition to negative impacts on crops, these species also pose health risks, as their pollen is allergenic and is a common cause of hay fever (*12*). *Amaranthus* can be harmful to livestock as well, especially during drought because they can accumulate toxic levels of nitrates, which can be poisonous to animals like cattle (*13*). *Amaranthus* species can also provide alternate hosts for a variety of pests and pathogens, which can subsequently increase the harm inflicted by pests on co-occurring crop species (*10*, *14*). Some negative impacts have been reported to biodiversity in natural areas where these species have been transported outside of their native ranges, although studies outside of crop systems are lacking (*15*).

PALMER AMARANTH

Due to its recent arrival, Palmer amaranth populations are currently thought to be small in Wyoming. Nonetheless, this species is one of the most notorious species within the genus, as it is capable of significantly reducing crop yields when left unmanaged (*16*). This plant outcompetes many crops due to its rapid growth rate, with some reporting that it can grow 3 inches per day in ideal conditions (*17*). Studies comparing growth rates among *Amaranthus* species found that Palmer amaranth had the fastest growth rate (*16*). Management is difficult because Palmer amaranth emerges throughout the growing season, often escaping control measures. Palmer amaranth is currently the most problematic species in the genus with respect to herbicide resistance, as populations readily develop resistance when not managed appropriately (e.g., repeated use of a single herbicide or lack of diversity in management tactics; *7*). In the U.S., herbicide-resistant populations have been reported in several states, with resistance to eight different modes of action now documented. Several cases of plants with resistance to multiple modes of action simultaneously have also been reported (*19*).

WATERHEMP

Only a small population of waterhemp has been detected in Wyoming so far, first identified in the Bighorn Basin in 2025. Like Palmer amaranth, waterhemp is considered one of the most damaging weeds of row crops when left unmanaged. Yield losses of 30–60% have been reported in soybean and more than 70% in corn. Waterhemp shares several biological traits with Palmer amaranth that make management difficult, including a prolonged germination window that allows plants to emerge throughout the growing season; however, some studies indicate that waterhemp may begin emerging earlier than Palmer amaranth. Herbicide resistance is also a major concern, as many waterhemp populations have evolved resistance to multiple herbicide modes of action. Recent studies show that sugar beet is particularly vulnerable to waterhemp due to poor early-season competitiveness and limited effective herbicide options. Similarly, uncontrolled waterhemp in dry bean has majorly reduced yields in some production systems.

REDROOT PIGWEED

Redroot pigweed is a widespread weed in Wyoming that can reach high abundances and impact field and row crops by reducing yields (*20*). Similar to other *Amaranthus* weeds, it is highly competitive due to its rapid growth and prolific seed production, capable of producing over 250,000 seeds per plant under favorable conditions (*21*). While often considered less impactful than Palmer amaranth in regions where the two species co-occur, redroot pigweed still poses a significant threat, with studies indicating yield losses in corn, soybeans, dry beans, and sugar beets, among others (*22*, *23*). Although not as notorious for herbicide resistance as Palmer amaranth, redroot pigweed has developed resistance to at least three herbicide modes of action, necessitating diverse management strategies (*19*). Effective control is further complicated by its resemblance to other pigweeds and its adaptability across various tillage systems (*18*).

POWELL AMARANTH

Though less studied, Powell amaranth is known to pose significant challenges due to its competitive nature, particularly in cool regions where it can outcompete crops (*10*, *24*). In comparison to other major *Amaranthus* weeds like Palmer amaranth and waterhemp, it is less renowned for evolving herbicide resistance, although resistance to two modes of action have been reported (*19*). While this species is well documented across the state by professional botanists in Wyoming, it lacks notoriety among producers—perhaps due to the difficulty in distinguishing *Amaranthus* species, as it closely resembles redroot pigweed. Nonetheless, potential negative impacts to Wyoming crops can be extrapolated from studies and reports nearby. In a controlled experiment in northern Colorado, for example, planting 24 Powell amaranth plants per row of sugar beet reduced yields by an average of 25% (*25*).

DOOR-KNOCKING AMARANTHS: SMOOTH & SPINY

At least two weedy *Amaranthus* species are present in the states surrounding Wyoming (see Table 1), including smooth amaranth (*A. hybridus*) and spiny amaranth (*A. spinosus*). Both are highly competitive agricultural weeds known for their ability to reduce crop or forage yields and complicate farming operations through prolific seed production, rapid growth, and propensity to evolve herbicide resistance (*19*). These species thrive in a variety of climates, including tropical, subtropical, and temperate regions, and generally experience warmer and sometimes wetter conditions than Wyoming's cooler and drier climate. However, the *Amaranthus* genus is notably adaptable, tolerating a wide range of soils, temperatures, and moisture levels, and can establish in diverse environments, including those modified by human activity. If these species were to arrive in Wyoming, their adaptability could allow them to establish and become significant pests, threatening the state's agricultural production and increasing management costs.

POTENTIAL DISPERSAL IN WYOMING

Amaranthus species have small, inconspicuous seeds that are typically 1–2 millimeters in length. They can easily adhere to equipment or act as a contaminant in transported grain. Special considerations should be given to potential vectors of seed dispersal.

- *Manure transport*. Manure is a significant pathway for the spread of major *Amaranthus* weeds, as they can pass undamaged through the digestive system of livestock. Studies have shown that a notable percentage of these seeds remain viable after digestion, with about 1/3 of amaranth seeds germinating after digestion (*26*). Therefore, awareness of manure sourcing is critical to minimizing the risk of dispersing these troublesome and potentially herbicide-resistant weeds (*27*)

- *Movement of agricultural equipment*. The seeds can easily attach to dirty equipment and be mistaken for dust. Extra care should be taken when cleaning equipment to avoid transportation.

- *Contaminated feed*. *Amaranthus* species may infest forage crops and possibly spread when contaminated forage is sold. One new population of Palmer amaranth in Wyoming is suspected to have originated from contaminated hay. Because of its small size, amaranth seed is difficult to remove from other seed-based feeds (*9*, *10*).

- *Restoration seed*. The use of contaminated seed mixes for restoration projects (like the USDA Farm Service Agency's Conservation Reserve Program) has been confirmed as a source of new amaranth introductions in other states (*28*).

PLANT IDENTIFICATION

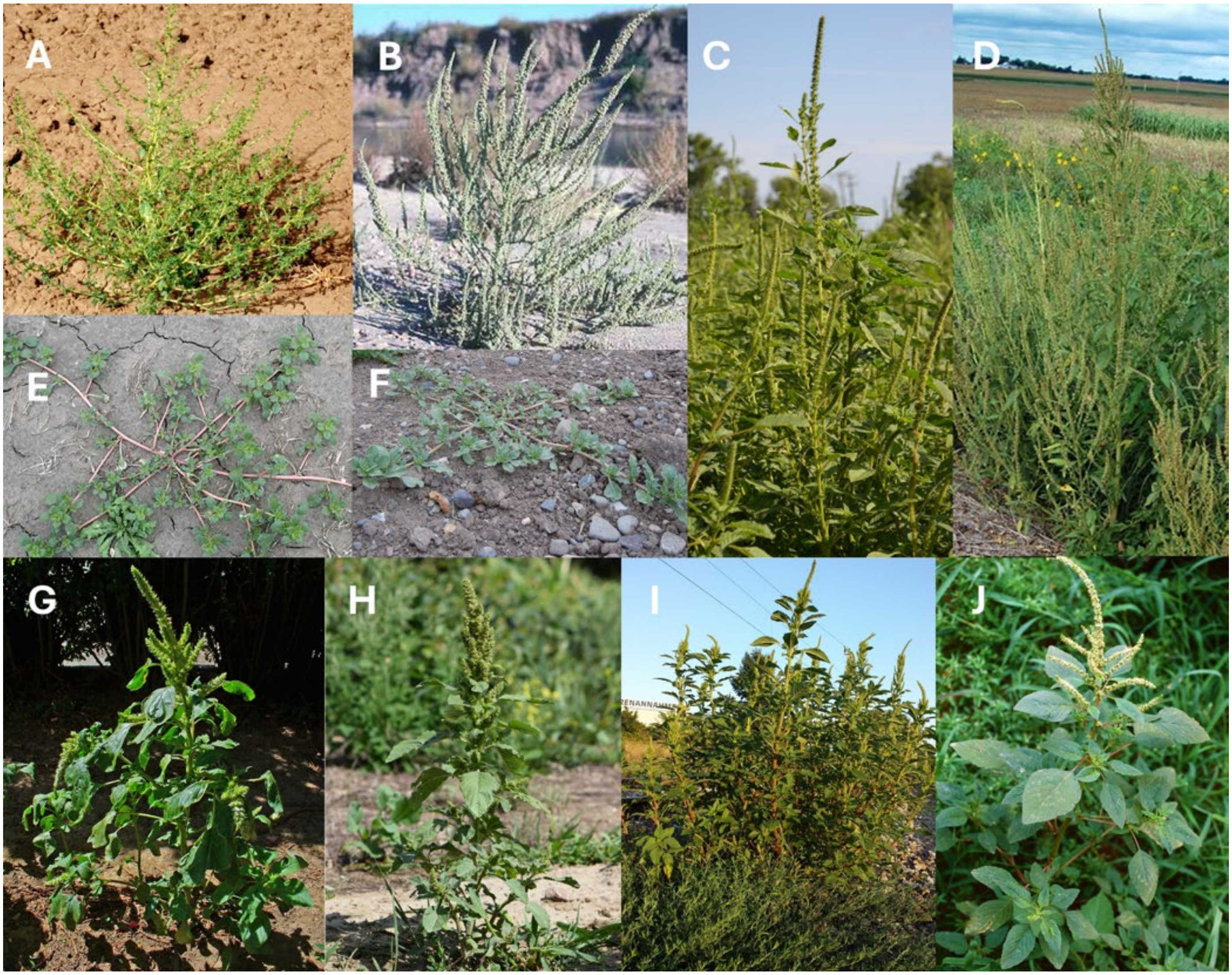
Pigweed identification can be very difficult because many species look similar during both the vegetative and reproductive stage and are highly variable. Plant height, as well as the size and shape of the leaf blades, is especially variable and may be only marginally helpful for identification. Identification can be further complicated as some *Amaranthus* species may hybridize. We have summarized some of the key features of the stems, leaves, and flowering stalks among species in Table 2 below, but acknowledge that inspection of the flowers and other small parts under a microscope may be necessary to make a definitive identification. New techniques to identify some of the weedy amaranths using DNA are also available. We recommend readers explore other identification resources and reach out for expert help (e.g., local extension office). An excellent pictorial guide to the common weedy *Amaranthus* species has been produced by Horak and colleagues (*29*) and is available at https://bit.ly/k-state-pigweed-id. An identification aid by Coles, Brock, and Kniss to help identify Palmer amaranth from lookalikes in Wyoming is available at https://bit.ly/palmer-wy.

CONTROL

Control tactics vary among species and their status here in Wyoming (Table 1). Detecting new arrivals like Palmer amaranth and preventing their establishment and spread is the most effective control method. Because of this, proper identification of the prevailing *Amaranthus* species in the field will enhance development of effective control tactics.

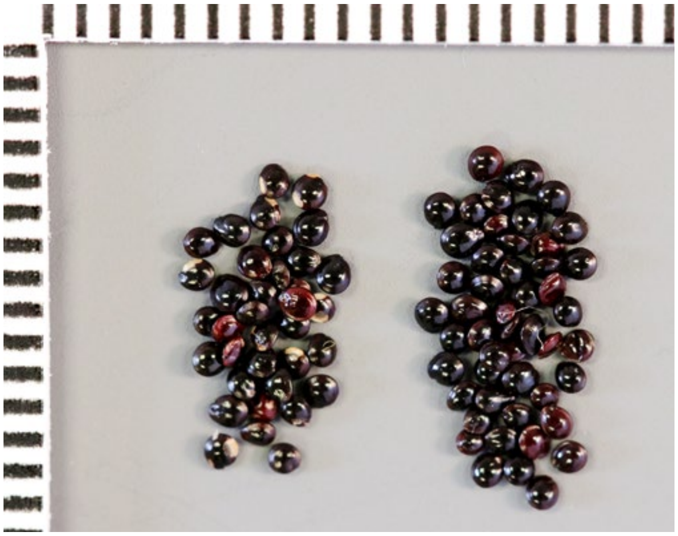
Given the propensity of *Amaranthus* species (especially Palmer amaranth and waterhemp) to develop herbicide resistance, herbicide selection needs to be considered carefully. Following the commercialization of genetically engineered crops, many farmers abandoned pre-emergence soil-applied herbicides because post-emergence herbicides like glyphosate were highly effective (*7*). Overreliance on a single herbicide has led to increased selection pressure and the rapid evolution of resistance (*7*, *27*). Weed management programs based mainly on post-emergence herbicides with little or no use of soil-applied residual herbicides have limited usefulness against populations that are already resistant to post-emergence herbicides. Thus, the use of multiple herbicide modes of action, including the combined use of soil-applied pre-emergence and post-emergence herbicides, are recommended to increase the probability that *Amaranthus* weeds are killed, even if they have already evolved resistance to one mode of action.

Given the ability of some *Amaranthus* species to quickly evolve herbicide resistance, relying solely on chemical strategies, even with diverse herbicide modes of action, is unlikely to provide sustainable long-term control (*30*). Integrated weed management strategies that combine chemical controls with non-chemical approaches, such as crop rotations, cover crops, and mechanical control methods, are essential to reduce selection pressure and manage herbicide-resistant populations effectively. Cultural practices that lead to optimal plant spacing and crop canopy development must be implemented to enhance crop competition (*30*). Cultivation after post-emergence herbicide application, whenever possible, can also help eliminate surviving plants and reduce the risk of developing an herbicide-resistant population in a field. The current trend toward reduced tillage or no-till systems favors establishment of small-seeded weeds like the *Amaranthus* species. This is because these systems tend to leave weed seeds near the soil surface, which is optimal for *Amaranthus* germination and emergence (*31*).



Many of the amaranths in our region are difficult to tell apart, even for expert botanists. Identification via DNA sequencing has been developed for some species. (A) tumble pigweed, (B) sandhill amaranth, (C) Palmer amaranth, (D) waterhemp, (E) prostrate pigweed, (F) California amaranth, (G) smooth pigweed, (H) redroot pigweed, (I) Powell's amaranth, (J) spiny amaranth.

Photo credit: John M. Randall (A), Donald Pratt (B), United Soybean Board (C), Katy Chayka (D), Peter Dziuk (E), Matt Lavin (F), H. Zell (G), Krzysztof Ziarnek (H), Stefan Lefnaer (I), John D. Byrd (J)."



Both Palmer amaranth (left) and redroot pigweed (right) are incredibly small seeded. 1-mm scale interval. Photo Credit: Andrew Kniss

All Amaranthus seedlings are small due to the small seed size with long, narrow cotyledons (first pair of leaves retained during germination). Credit: Shawn Askew

Palmer amaranth leaf arrangement is “poinsettia-like” to optimally expose leaves to sunlight. Credit: Shawn Askew

The inflorescence of Palmer amaranth, whether male or female, is very long.

Palmer amaranth (two right) petioles are as long or longer than the leaf length. Redroot pigweed (left) petioles are shorter than its leaves.

Redroot pigweed (left) has much more compressed flowers than Palmer amaranth (right). Credit: Shawn Askew

Table 2. Stem, leaf, and flowering stalk traits among *Amaranthus* species within or near Wyoming (1).

Species	Stems	Leaves	Flowering Stalk
Tumble pigweed (***Amaranthus albus***)	Hairless or has sticky hairs. Usually grows upright and is very branched and bushy, with large plants forming tumbleweeds. Grows 4 inches to 3.5 feet tall.	Leaf stalk half as long as the blade (longer in leaves closer to the base). Blades are mostly small (0.25 × 0.25–0.5 inches), egg-shaped to narrowly spoon-shaped, but larger at the base. The tip is blunt with a small point at the end.	Roundish flower clusters are found at leaf bases and are green, whitish-green, or yellowish. Male and female flowers on same plant.
Sandhill amaranth (***Amaranthus arenicola***)	Hairless or nearly so. Grows upright from 1.5 to 5 (occasionally 6.5) feet tall.	Leaf stalk is shorter than or, rarely, about equal to the leaf blade. Blades are 0.5–3 × 0.25–1 inches, narrowly egg-shaped to lance-shaped, and thin and soft. Tips are pointed to blunt, with a small point at the end.	The flowers are in long, narrow clusters that are mostly in upright at the end of the stem. Rarely, there are also clusters at leaf bases near the lower part of the plant. Separate male and female plants.
Prostrate pigweed (***Amaranthus blitoides***)	Hairless. Grows flat on the ground or somewhat upwards at an angle. It is very branched and usually ranges from 8–24 inches tall.	Leaf stalk is about half as long as the leaf blade. The leaf blade is egg-shaped to spoon-shaped, usually 0.5–0.75 × 0.25–0.5 inches. Tips are blunt, rounded, often with a small point at the end.	Roundish flower clusters are found at the leaf bases and are green. Male and female flowers on same plant.
California amaranth (***Amaranthus californicus***)	Hairless. Lies flat on the ground and is often whitish or tinged with red. It is very branched from the base, grows 0.3–1.5 feet tall, and is rather fleshy.	Leaf stalk is less than half the length of the blade. Blades are small, 0.25–0.75 (occasionally 1.25) × 0.25–0.5 (occasionally 0.75) inches, pale green with prominent veins and variable in shape. Tip often has a prominent small point.	Roundish flower clusters are found at the base of leaves from the bottom to the top of the plant. Male and female flowers on same plant.
Smooth pigweed (***Amaranthus hybridus***)	Mostly hairless, but the stem and branches farthest from the base can be slightly hairy when young. Grows upright and is green or sometimes reddish-purple. Can be branched or unbranched and grows 1–6.5 (occasionally 8) feet tall.	Leaf stalk is half as long or equal to the blade. The blade is egg-shaped, diamond-shaped, or lance-shaped and usually 1.5–6 × 0.75–2.5 inches. The tip is pointed to blunt, with a small point.	Flower clusters are in long, narrow clusters found at the end of the stem and at leaf bases. They are upright or bent backward, and are usually green but may have a silvery or reddish-purple tint. Leaves are absent toward the tip, where the flower cluster at the end of the stem often droops slightly with many shorter branches at the base. Male and female flowers on same plant.

Table 2 (*continued*). Stem, leaf, and flowering stalk traits among *Amaranthus* species within or near Wyoming (1).

Species	Stems	Leaves	Flowering Stalk
Palmer amaranth (***Amaranthus palmeri***)	Hairless or nearly so. Grows upright and is usually branched. It is typically 1.5–5 feet tall, but sometimes up to 10 feet. The branches near the base often grow upwards at an angle.	Leaf stalk is usually longer than the blade. Blades are variable, but are often 0.5–2.75 × 0.5–1.5 inches, spoon- or diamond-shaped, and sometimes lance-shaped toward the top. The tip is somewhat blunt to pointed, usually with a small point at the end.	The flowers are in long, narrow clusters at the end of the stem, usually drooping when mature, sometimes with a few clusters at the leaf bases. Separate male and female plants.
Powell's amaranth (***Amaranthus powellii***)	Usually moderately hairy, at least toward the flower clusters. It becomes more hairless at maturity. Grows stiffly upright from 1–5 (occasionally 6.5) feet tall and may or may not be branched. Green or sometimes reddish-purple.	The leaf stalk is mostly equal to or longer than the leaf blade. The leaf blade is 1.5–3 × 0.75–1.25 inches (occasionally larger) and diamond- or egg-shaped to broadly lance-shaped. The tip is wedge-shaped to blunt or indistinctly notched, with a small point.	The flowers are in long, narrow clusters, mostly at the end of the stem, usually with clusters at the leaf axils toward the top. They are upright and rigid, green to silvery-green, occasionally tinged red. Male and female flowers on same plant.
Redroot pigweed (***Amaranthus retroflexus***)	Densely to moderately hairy, especially furthest from the base. It is 0.75–5 (occasionally up to 6.5) feet tall and often reddish near the bvase. It can be branched or unbranched.	The leaf stalk is half the length or equal to the leaf blade. The leaf blade is 0.75–6 × 0.5–2.75 inches, egg-shaped to diamond-egg-shaped. The tip is pointed, blunt, or slightly notched, with a small point at the end.	Flower clusters are in elongate clusters, usually short and thick, found at the end of the stem and at leaf bases. They are upright or bent backward at the tip and green or silvery-green, often with a reddish or yellowish tint. They are branched and without leaves, at least toward the tip. Male and female flowers on same plant.
Spiny amaranth (***Amaranthus spinosus***)	Hairless or sparsely hairy in the upper, younger parts of the stems. It is 1–3.25 (occasionally up to 6.5) feet tall, grows upright, and is usually very branched and bushy. Each joint has a pair of spines up to 0.75 inch long.	The leaf stalk is about equal to or longer than the leaf blade, which is 1.25–4 × 0.75–2.5 inches, occasionally up to 6 inches long, and diamond-egg-shaped to lance-shaped. The tip is pointed or somewhat blunt to indistinctly notched, with a very small point.	Long narrow clusters of male flowers at the end of the stem and clusters of mostly female flowers at leaf bases. They are upright or have tips that are bent backward or drooping, usually green to silvery-green. Male and female flowers on same plant.
Waterhemp (***Amaranthus tuberculatus***)	Hairless. Grows upright, is usually branched, and is 1.75–6.5 (occasionally up to 10) feet tall.	The leaf stalk is a quarter to half the length of the leaf blade. The leaf blade is egg-shaped, or egg-shaped to narrowly lance-shaped toward the tip. It is 0.5–6 × 0.2–1.2 inches. The base is wedge-shaped. The edges are smooth and flat. The tip is blunt or rounded to pointed.	The flowers are in long, narrow (sometimes branched) clusters at the end of the stem. Occasionally there are interrupted, bead-like, rounded flower clusters that are far apart. Separate male and female plants.

REFERENCES

1. S. L. Mosyakin, K. R. Robertson, *Amaranthus* in Flora of North America. http://www.efloras.org. Volume 4, 410 (2004).
2. POWO, Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew, *Plants of the World Online* (2019). http://www.plantsoftheworldonline.org.
3. L. E. Steckel, The Dioecious Amaranthus spp.: Here to Stay. *Weed Technology* 21, 567–570 (2007).
4. K. E. Waselkov, A. S. Boleda, K. M. Olsen, A Phylogeny of the Genus *Amaranthus* (Amaranthaceae) Based on Several Low-Copy Nuclear Loci and Chloroplast Regions. *Systematic Botany* 43, 439–458 (2018).
5. M. C. Oliveira, A. J. Jhala, M. L. Bernards, C. A. Proctor, S. Stepanovic, R. Werle, Palmer Amaranth (*Amaranthus palmeri*) Adaptation to US Midwest Agroecosystems. *Frontiers in Agronomy* 4 (2022).
6. B. E. Nelson, B. S. Legler, *Checklist of the Wyoming Flora* (Rocky Mountain Herbarium, University of Wyoming, Laramie, WY., 2024; https://www.rockymountainherbarium.org/index.php/research/checklists).
7. G. B. P. Braz, H. K. Takano, Chemical control of multiple herbicide-resistant *Amaranthus*: A review. *Advances in Weed Science* 40, e020220062 (2022).
8. D. C. Brainard, R. R. Bellinder, Assessing variability in fecundity of *Amaranthus powellii* using a simulation model. *Weed Research* 44, 203–217 (2004).
9. E. Oseland, M. Bish, C. Spinka, K. Bradley, Examination of commercially available bird feed for weed seed contaminants. *Invasive Plant Science and Management* 13, 14–22 (2020).
10. S. E. Weaver, E. L. McWilliams, The Biology Of Canadian Weeds.: 44. *Amaranthus retroflexus* L., *A. powellii* S. Wats. and *A. hybridus* L. *Can. J. Plant Sci.* 60, 1215–1234 (1980).
11. T. A. Gaines, S. M. Ward, B. Bukun, C. Preston, J. E. Leach, P. Westra, Interspecific hybridization transfers a previously unknown glyphosate resistance mechanism in *Amaranthus* species. *Evol Appl* 5, 29–38 (2012).
12. M. Villalba, R. Barderas Manchado, S. Mas, S. Colás, E. Batanero Cremades, R. Rodríguez García, Amaranthaceae Pollens: Review of an Emerging Allergy in the Mediterranean Area. (2014).
13. R. H. Poppenga, B. Puschner, Drought-Related Poisoning and Nutritional Risks to Cattle. *California Animal Health and Food Safety Laboratory System: Davis, CA, USA* (2014).
14. M. Costea and FJ Tardif, The biology of Canadian weeds. 126. *Amaranthus albus* L., *A. blitoides S*. Watson and *A. blitum* L. *Canadian Journal of Plant Science* 83, 1039–1066 (2003).
15. D. Iamonico, *Amaranthus tuberculatus* (rough-fruited water-hemp). *CABI Compendium* CABI Compendium, 112200 (2015).
16. S. M. Ward, T. M. Webster, L. E. Steckel, Palmer Amaranth (*Amaranthus palmeri*): A Review. *Weed Technology* 27, 12–27 (2013).
17. T. R. Legleiter, B. Johnson, *Palmer Amaranth Biology, Identification, and Management* (Purdue Extension West Lafayette, IN, 2013).
18. E. Yu, S. Blair, M. Hardel, M. Chandler, D. Thiede, A. Cortilet, J. Gunsolus, R. Becker, Timeline of *Palmer amaranth* (*Amaranthus palmeri*) invasion and eradication in Minnesota. *Weed Technology* 35, 802–810 (2021).
19. I. Heap, The international survey of herbicide resistant weeds. *http://www.weedscience.org* (2025).
20. X. Ma, H. Wu, W. Jiang, Y. Ma, Y. Ma, Interference between Redroot Pigweed (*Amaranthus retroflexus* L.) and Cotton (*Gossypium hirsutum* L.): Growth Analysis. *PLOS ONE* 10, e0130475 (2015).

21. N. Singh, D. Rubione, D. Sarangi, Redroot and Smooth Pigweed. Getting Rid Of Weeds Through Integrated Weed Management. *GROW Info Sheet,* www.growiwm.org (2023).

22. S. Z. Knezevic, S. F. Weise, C. J. Swanton, Interference of Redroot Pigweed (*Amaranthus retroflexus*) in Corn (*Zea mays*). *Weed Science* 42, 568–573 (1994).

23. C. N. Bensch, M. J. Horak, D. Peterson, Interference of redroot pigweed (*Amaranthus retroflexus*), Palmer amaranth (*A. palmeri*), and common waterhemp (*A. rudis*) in soybean. *Weed Science* 51, 37–43 (2003).

24. S. E. Weaver, Differential growth and competitive ability of *Amaranthus retroflexus*, *A. powellii* and *A. hybridus*. *Can. J. Plant Sci.* 64, 715–724 (1984).

25. E. E. Schweizer, T. C. Lauridson, Powell Amaranth (*Amaranthus powellii*) Interference in Sugarbeet (*Beta vulgaris*). *Weed Science* 33, 518–520 (1985).

26. R. E. Blackshaw, L. M. Rode, Effect of Ensiling and Rumen Digestion by Cattle on Weed Seed Viability. *Weed Science* 39, 104–108 (1991).

27. J. K. Norsworthy, S. M. Ward, D. R. Shaw, R. S. Llewellyn, R. L. Nichols, T. M. Webster, K. W. Bradley, G. Frisvold, S. B. Powles, N. R. Burgos, W. W. Witt, M. Barrett, Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations. *Weed Science* 60, 31–62 (2012).

28. S. Follak, G. Brundu, D. Chapman, J. Ferrell, G. Fried, H. Bob, U. Starfinger, C. Picard, R. Tanner, *Pest Risk Analysis for Amaranthus tuberculatus* (2020).

29. M. J. Horak, D. E. Peterson, D. J. Chessman, L. M. Wax, EC94-138 Pigweed Identification: A Pictorial Guide to the Common Pigweeds of the Great Plains. *University of Nebraska-Lincoln Extension: Historical Materials* (1994).

30. P. J. Tranel, Herbicide resistance in *Amaranthus tuberculatus*. *Pest Management Science* 77, 43–54 (2021).

31. R. Assad, Z. A. Reshi, S. Jan, I. Rashid, Biology of Amaranths. *Bot. Rev.* 83, 382–436 (2017).

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