Shieldcress

By James A. Young, Charlie D. Clements, and Daniel Harmon

It is easy to succumb to the crying wolf syndrome when dealing with exotic, invasive weeds of rangelands. There seems to be no end to new exotic invasive species. In the Intermountain Area of western North America, weeds such as Russian thistle, halogeton, and cheatgrass have become such ubiquitous species of rangelands and reflect such a significant degradation of environments, it is hard to exercise restraint when a new weed is suddenly the dominant of many thousands of acres of rangeland. However, driving across the desert basins of northern Nevada during the summers of 2005 and 2006, the mustard-family species, shieldcress (*Lepidium perfoliatum*), was the apparent dominant species of tens of thousands of acres. It has become impossible not to cry wolf. This urge became impossible to suppress after repeated inquiries of, "Why didn't the 'cheatgrass' burn in Buena Vista Valley (a dozen other desert basins) this year?" The "cheatgrass" did not burn because it was not cheatgrass that was present but shieldcress.

Shieldcress is not a recent introduction to intermountain ranges. The oldest specimen at the University of Nevada Herbarium was collected at Derby Dam on the Truckee River in 1909. Derby Dam is the diversion structure for the Newlands Reclamation Project, one of the first federal desert-irrigation projects in the West. Such projects became notorious for weed introductions because contractors used horses for much of the power required for the excavation of canals and ditches. The early literature on Russian thistle traced the spread of this weed from one western irrigation project to the next in hay and bedding transported with construction horses in railroad cars. Shieldcress is distributed over much of the United States but is most abundant west of the Rocky Mountains. In Nevada, shieldcress became a minor weed of crop land, vacant lots, and roadsides. On rangelands, it found a transitory home in the ecotone between salt desert and sagebrush vegetation. Because of the unique leaf morphology, shieldcress was perceived by most range managers as more of a botanical

Dominant desert basin species

Common name	Nomenclature
Annual wheatgrass	*Eremopyrum triticeum*
Big sagebrush	*Artemisia tridentata*
Blue mustard	*Chorispora tenella*
Bur buttercup	*Ranunculus testiculatus*
Cheatgrass	*Bromus tectorum*
Desert alyssum	*Alyssum desertorum*
Filaree	*Erodium cicutarium*
Halogeton	*Halogeton glomeratus*
Prickly lettuce	*Lactuca serriola*
Russian thistle	*Salsola tragus*
Sagebrush	*Artemisia*
Shieldcress	*Lepidium perfoliatum*

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oddity rather than an aggressive invasive species for much of the 20th century.

Botanical History and Ecology

Linnaeus published the scientific name of *Lepidium perfoliatum* in his original classification of plants in 1753. It is not considered native to western Europe, but apparently, it was an invasive weed by the time Linnaeus wrote the description. The species is native to southeastern Europe and central Asia. In the Russian plant community literature for central Asia, shieldcress is a component of a large variety of desert plant communities, including many with a saltcedar overstory. In its native habitat, shieldcress is not restricted to salt-affected soils but occurs as an occasional species in sagebrush and perennial grass communities.

Common Names

As with many species of weeds, there are several common names for *Lepidium perfoliatum.* The term *cress* is applied to many different species of mustard that have relatively pungent foliage similar to watercress, which is used as a green in salads. *Standard Plant Names* uses *pepperweed* instead of cress. Again, this is in reference to the pungent taste of the green fruits. There are 2 versions of the origin of the *shield* portion of the common name. There are 2 types of fruits in the mustard family. One is a long and thin capsule (silique), and the other is squat and shield shaped (silicle). *Shieldcress* may refer to the shield-shaped fruits on a plant with a pungent taste when green. The second version of the origin of the name is that the upper leaves on the flowering stalk can be interpreted as shield shaped. We will describe this feature in detail later. Among range technicians in the field, *Lepidium perfoliatum* is commonly used as a name because the perforated appearance of the cauline (flowering stalk) leaves is so obvious.

Figure 1. Flowering shieldcress plant with leaves that appear to be pierced by the flower stalk. This image was taken in a mixed stand with cheatgrass.

Plant Morphology

The basal leaves or rosettes of shieldcress are composed of leaves that are deeply divided 2 to 3 times until they appear almost fern-like in appearance. This leaf form is so distinctive that shieldcress is one of the few mustards that you can identify to a species level as soon as the first true leaf emerges. Once the flowering stalk starts to elongate, the foliage changes dramatically. In a distance of 1 or 2 stem nodes, the finely divided leaves virtually disappear, and all that is left is a greatly expanded leaf petiole that forms a heart-shaped shield that the stems appear to perforate.

The flowers are the typical 4-petal arrangement of the mustard family and are pale yellow (occasionally almost white). The inflorescence is a branching panicle, but when the plants grow in dense stands in arid conditions, a single nearly vertical branch occurs with the fruiting bodies arranged on short pedicels in perfect order. If you stare at one of these stands with columns of "shields" for a couple minutes in the hot sun, you begin to wonder if the harvester ants have revolted, and the queen is marshaling her shield-bearing legions for attack. It is definitely time to get back in the truck, turn up the air conditioning, and have a cool drink.

Figure 2. Looking down on a mature stand of shieldcress in the salt desert. Each seedhead represents a single plant.

Shieldcress Seeds

Until shieldcress suddenly increased in distribution, density, and dominance, its main claim to fame were its unusual seeds. The seeds are about one-eighth of an inch long, flattened, and roughly ovoid in outline. This might seem small, but for a mustard seed it is huge. For mustard species with the long tapered fruiting body (silique), the seeds graduate in size as the fruit tapers and can become nearly microscopic. Most descriptions give the seed color for shieldcress as brownish-red. The surface appears smooth to the unaided eye, but has a minute texture. Rough-out red might be a good cowboy description of the seed color and texture. The big surprise occurs when you moisten the seeds.

A copious amount of a clear mucilage encompasses the seed. Many seeds (even some achenes and caryopses) belonging to a variety of plant families have mucilaginous seeds; shieldcress takes the abundance of mucilage to a higher level. If you let the mucilage dry and examine the seed coat under the microscope at moderate magnification, the surface is openly covered with fine white hairs that extend from individual cells of the seed coat.

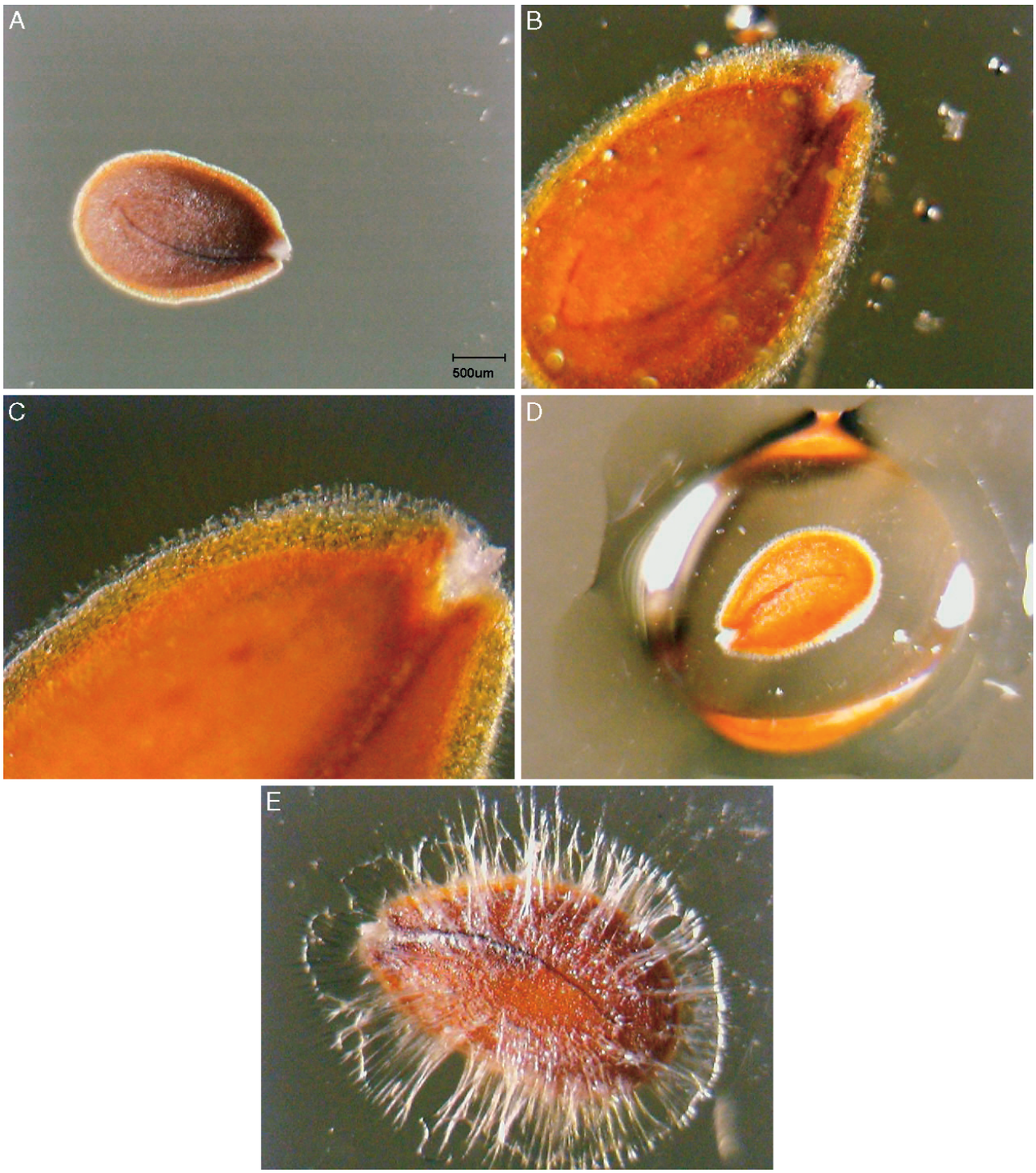

Figure 3. One of the most interesting aspects of the ecology of shieldcress is the copious amount of mucilage that forms on the seed coats when moistened. **A,** Shieldcress dry seed. **B,** Shieldcress seed 2 minutes after moistened with water. **C,** Shieldcress seed 30 minutes after moistening. **D,** Shieldcress seed in envelope of mucilage. **E,** Shieldcress seed allowed to dry after mucilage formed. Mucilage forms from individual cells on the surface of the seed coat.

There has been a lot of argument among seed physiologist over the years on the function of seed mucilage. We showed many years ago that the presence of mucilage on seeds of shieldcress allows them to germinate on the surface of a water-supplying substrate with the seed exposed to a very dry atmosphere. It has been suggested that the mucilage both aids in hydraulic conductivity of moisture from the substrate to the seed and prevents the loss of moisture to the atmosphere. For moisture relations during germination, mucilage seems to be a great adaptation for shieldcress seeds in a desert environment. Could it be applied to seeds of desirable forage and browse species for artificial seeding on depleted rangelands? All that is required to make this a viable alternative is to explain how shieldcress avoids desiccation when the mucilage forms. The seed mucilage will form at extremely negative osmotic potentials, levels that would rapidly desiccate or even kill an unprotected seed. Shieldcress not only imbibes moisture through the mucilage but also extends an embryonic root (radicle), complete with fragile root hairs, through the mucilage to the seedbed. Attempts to apply mucilage artificially to seeds has hampered or eliminated germination.

Shieldcress Ecology on Desert Rangelands

In most floras, shieldcress is listed as an annual or biennial. In Nevada, it is a facultative winter annual with germination in the late fall or very early spring. It does not commonly survive the dry summers as a rosette and flower the next year as a biennial. Unless you are consciously looking for the small rosettes of finely divided leaves they are very easily overlooked. In the Great Basin, the only exotic, invasive annual to flower before shieldcress is bur buttercup. Shieldcress is the first exotic mustard species to flower and produce seeds before cheatgrass. Blue mustard and desert alyssum are exotic mustard family species that also mature before cheatgrass, but after shieldcress. During the 1930s, R. L. Piemeisel formulated what has become known as the Piemeisel Rule for life histories of exotic annual species. The species that matures first, wins, in terms of survival and dominance. In Piemeisel's day the suite of exotic species consisted of Russian thistle, tumble mustard, and cheatgrass. Life among the exotic annuals has become a lot more complicated with the repeated introduction of new annual species. As previously mentioned, bur buttercup is the first exotic annual to mature on Great Basin rangelands, but it is such an extremely ephemeral species it may not "compete" with cheatgrass for the same resources (moisture and nitrogen).

Shieldcress overlaps with the spring growth stages of cheatgrass to a much greater extent than bur buttercup. As the supply of soil moisture is exhausted in the spring, shieldcress completes its life cycle before cheatgrass. This competitive advantage may be enhanced in salt-desert situations, where shieldcress is tolerant of markedly salt-affected soils, and cheatgrass is intolerant.

In 2005, when we first observed the huge expansion of shieldcress in both extent and dominance, it was interesting but could be accommodated in the normal variation in expression of annuals that reflects year-to-year differences in the amount and periodicity of precipitation. The previous years (2003 and 2004) were not particularly good years for cheatgrass growth, and we assumed that cheatgrass would rebound to dominance in the margins of salt deserts where the shieldcress' near-monospecific abundance was so pronounced. In the big sagebrush zone, 2005 was an excellent year for cheatgrass growth and seed production. Our prediction did not prove valid. In 2006, the dominance of shieldcress was greater.

Figure 4. Near-complete shieldcress dominance in the pluvial lake plain in Dixie Valley, Nevada. Clan Alpine Mountains are on the left and the Stillwater Mountains are on the right. The basin is about 48 miles wide, and the shieldcress community is continuous for 60 miles. The original plant community was Bailey's greasewood and saltgrass. Virtually the only herbaceous species besides shieldcress is annual wheatgrass.

Why the Increased Spread and Dominance of Shieldcress?

There are 3 readily apparent possibilities for the spread and dominance of shieldcress: 1) shieldcress has changed through hybridization and natural selection for new genotypes; 2) the environment of the Great Basin rangelands is changing, either through rangeland-management changes or through climatic changes on a variety of timescales; or 3) all of the above.

The species compositional structure of annual communities influences the total environmental consequences of the community, such as fire frequency, soil properties, and nutrient cycling. Cheatgrass communities are often referred to as having monospecific composition. Even though such communities sit atop a successional pyramid, they usually contain such species as burr buttercup, filaree, and prickly lettuce. It is the total of all the component species that wring the last drop of environmental potential, closing the site to recruitment of seedlings from perennials. For much of the 20th century, a few shieldcress plants could often be found in cheatgrass communities, especially on the margins of salt deserts. The current expansive areas of shieldcress

appear to be monocultures, but if you look closely, most contain annual wheatgrass plants. This is a relatively new combination, which may be synergistic in competitiveness.

Consequences of Shieldcress Spread and Dominance

Forage quantity and quality was most likely changed over tens of thousands of acres. Because it matures before cheatgrass, shieldcress dominance shortens the green-feed period. Russian thistle, and to some extent mustard species, extend the green-feed period and, therefore, digestible protein after cheatgrass maturity in years when cheatgrass is not completely dominant. We do not, however, see any expression of tumble mustard or Russian thistle in the dense shieldcress stands. The relative cattle preference for shieldcress vs cheatgrass is purely observational at this time, but the cows do not seem to be rushing to consume shieldcress, especially when it is mature.

Regarding the chance of ignition and the rate of fire spread, shieldcress communities are markedly different from cheatgrass. The exact wildfire characteristics of shieldcress communities must be developed by wildfire-suppression specialists. After decades of increasing wildfire hazards because of the spread of cheatgrass, is the dominance of shieldcress in specific areas going to reduce such fires? Shieldcress herbage will burn, but it burns with different timing, different chance of ignition, and different fuel characteristics compared with cheatgrass. On the down side, shieldcress may provide a continuity of fuel so that wildfires move more easily into black greasewood communities.

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