THE BIOLOGY AND ECOLOGY OF BROOMS AND GORSE

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Brooms and gorse can form dense impenetrable brush fields that choke out nearly all other vegetation and prevent access to forests, recreational areas, and hiking trails. They can colonize nitrogen poor, seasonally dry, frequently soil-disturbed areas such as grasslands, sand dunes, gravel bars, river beds, fence rows, roadsides, overgrazed pastures, logged areas, and burned-over lands (26, 46). They represent a significant threat to native wildlands and forest regeneration efforts.

Taxonomy

The weedy brooms in California are represented by four species belonging to the genera *Cytisus*, *Genista*, and *Spartium*. Gorse (*Ulex europaea*) can occupy a similar habitat but is morphologically quite distinct from the broom species. All these species, however, are members of the Fabaceae (legume family). These five weedy brush species can be separated by stem, foliage, flower, and fruit characteristics (see table below). Portuguese broom (*Cytisus striatus*) is often misidentified as Scotch broom (*Cytisus scoparius*). Although it is locally abundant in the San Francisco Bay area and Southern California, it is not as widely distributed or as common as Scotch broom. Little is known of the biology and ecology of Portuguese broom, but it is thought to behave similar to Scotch broom. French broom (*Genista monspessulana*) is probably the most widespread and damaging of the broom species. In earlier taxonomic treatments, it was known as *Cytisus monspessulanus* (37), but more recent treatments have re-classified it in the genus *Genista* (21).

Morphological characteristics distinguishing weedy brooms and gorse.

Species	Stem	Foliage	Flowers	Fruit
Scotch broom (*Cytisus scoparius*)	5-angled, glabrous	lflts 1-3, sparse, deciduous	1-2 per cluster	hairy on margins only
Portuguese broom (*Cytisus striatus*)	8-10-angled, glabrous	lflts 1-3, sparse, deciduous	1-2 per cluster	appressed hairs all over
French broom (*Genista monspessulana*)	ridged, silky hairy	lflts 3, more abundant, evergreen	4-10 per cluster	hairy all over
Spanish broom (*Spartium junceum*)	round, glabrous	very sparse to lacking	several per cluster	glabrous
Gorse (*Ulex europaea*)	thorny, hairy	lflts 1, stiff or spiny, evergreen	1-2 per cluster	hairy all over

Introduction and Spread

Spanish broom (*Spartium junceum*) is native to the Mediterranean region and the Canary Islands. It was first introduced as a nursery plant in San Francisco in 1858 (29). In the 1930s, Spanish broom was planted along Southern California highways as an ornamental shrub (20). It has since become naturalized primarily along roadsides and in waste places in coastal counties, but can also be found in the Sacramento Valley and into the eastern foothills, primarily El Dorado County (33). It is not as widespread a problem as the other broom species and gorse, and has not significantly invaded native ecosystems.

Gorse is native to central and western Europe, where it is often cultivated as a hedgerow (41). It has been a major weed problem in Australia and New Zealand for over 150 years (35). It was first introduced into the United States from Ireland to Oregon some time before 1894 (22). Soon after its introduction, it was planted as an ornamental in Marin and Mendocino counties of California. Today, gorse is found in every coastal county in Northern California, but infestations are largest in Mendocino County (21). The California Department of Food and Agriculture (CDFA) lists gorse as a List B noxious weed.

French broom is native to the Mediterranean region, the Azores, and the Canary Islands (37). It was sold in California nurseries as early as 1871 (30) and escaped cultivation in central California by the 1940s (1). French broom is a major weed problem in California non-crop areas, and is found primarily along the coastal, but can occur as far east as the western foothills of the Sierra Nevada mountains (30). It has been rated a List C noxious weed by CDFA.

Scotch broom is native to central and southern Europe and the British Isles. In North America, it was first introduced into the east coast and Eastern Canada before 1850 (36). It was transported to California as an ornamental in the 1850's, and by the early 1900's was widely planted as a soil-binding roadside shrub (14, 23). It was recognized as a weedy problem by the 1930's (33) and today infests over a half million acres in the state (5). Two major areas of infestation include the coastal ranges from Monterey to Sonoma County, and in the Sierra Nevada foothills from Calaveras to Sierra County. Like French broom, Scotch broom is a CDFA List C noxious weed and a major weed problem in Australia and New Zealand.

Biology

Dormancy and Germination

Brooms and gorse have hard, water-impermeable seed coats that delay germination for months or years and enable seeds to survive in the environment for 25 to 80 years (5, 27, 34, 48). Although some seed will germinate soon after dispersal (20), the majority require mechanical scarification before germination can occur (9).

Scarified seeds can germinate throughout the year under suitable conditions. Typically, germination occurs after the first rains of fall through the last rainfall of late spring (5). Light does not appear to be necessary for germination, but few seeds germinate in the shade of established plants (24). Germination rates are highest at soil depth from 0-4 cm. Seedlings do not emerge when buried 10 cm or deeper (5). Seeds of Scotch broom germinate between 4-33°C, with maximum germination at 18-22°C (5). Similar temperature responses were reported for gorse (25). Short exposures to temperatures above 100°C are lethal to gorse seeds, whereas temperatures above 150°C destroyed the viability of broom seed (5). Thus, a hot prescribed burn

in areas infested with these shrubs could greatly decrease the seedbank at the soil surface. However, prescribed burns may stimulate germination of seeds deeper in the soil profile, where soil temperatures would not reach the lethal level (27, 34). Changes in soil temperature could also play a key role in the flush of new germinating seeds when established plants are removed (25). Increased solar radiation could heat the soil and stimulate seed germination.

Growth

Broom plants grow rapidly in the first 4-5 years, but growth slows considerably thereafter (44, 45). Growth appears to be more vigorous in introduced habitats that lack native invertebrate predators (32). Individual broom and gorse plants typically live from 10 to 20 years (42, 44) and rarely survive longer than 30 years (10).

Brooms and gorse are relatively intolerant to heavy shade. Under low light conditions plants produce sparse foliage and few flowers. Although survival is greatest in high light areas, these species do not tolerate extreme high or low temperature conditions, nor can they grow at high elevation (48). Seedlings are sensitive to frost (46), but mature plants can tolerate fairly severe frosts, although they prefer habitats sheltered from cold winds. Brooms and gorse can tolerate some level of drought stress, but cannot survive in extremely arid regions in the southwestern United States (46). Gorse is more sensitive to drought stress than brooms.

All the invasive broom species and gorse have photosynthetic stem tissue (38). The leaves of Spanish, Scotch, and Portuguese broom are deciduous early in the season. These species rely heavily on stem photosynthesis during the hot summer months (6, 38). The leaves of gorse function primarily as defense spines. This characteristics makes them well adapted to the open high sunlight environments. However, drought stress severely inhibits photosynthesis of gorse and brooms (38).

Like many other members of the Fabaceae, invasive brooms and gorse have nitrogen-fixing bacteria located in nodules on their roots (48). This characteristic has allowed them to become established in low nitrogen soils.

The ratio of woody to green material increases as broom and gorse plants age. Dense infestations produce significant dry matter which can create a serious fire hazard. This is particularly true for gorse and French broom (2, 39).

Reproduction

Brooms and gorse can reproduce by seeds and stump sprouting (36). Vegetative regeneration occurs quickly following disturbance by fire, grazing, or other mechanism means (47). The primary means of reproduction is by seed.

Seed production

Flowers of these invasive shrubs are large, yellow and attractive. They are primarily pollinated by bumble and honey bees. Only a small proportion of flowers develop into fruit (<50%) with between 5-9 seeds per pod (42, 45). Unripe seeds and pods are largely free from predation (42). Outcross-pollinated flowers produce about four times as many flowers as self-pollinated flowers (40). Seed production is variable from year to year. Years of heavy pod production are generally followed by years of lighter pod production. Seed production can vary among species and locations. The number of pods and seeds produced in a drought year is about ten times less than in a normal year (7). Under optimum growing conditions, Scotch broom plants

have been estimated to produce 13 million seeds over the lifespan of the shrub (46). Others estimate that Scotch broom thickets can produce 4,000 to 20,000 seeds/m^2 (19, 42, 49).

Seed dispersal

Scotch broom contains a structure called an eliaosome on the seeds that attracts ants. After the seeds are dispersed from the pods, ants gather them, carried them back to their nest, and eat the eliaosome (4, 5). This does not kill the seed, and Scotch broom plants often are found in high density around ant nests (4). Gorse seed are also collected by ants (10). Birds and animals can also play a part in broom and gorse seed dispersal (33), although seed predation by birds and other animals is considered negligible (42).

Broom seeds have hard seed coats which can survive long distance transport in rivers and streams (42, 46). In the Sierran foothills, Scotch broom has spread rapidly by movement of the seed in water sources. Short distance transport of broom and gorse seeds is similar to that of many other legume species and involves the explosive action of the mature dried pods (30, 34). This mechanism can only disperse seeds within 2 m of the parent plant (35).

Human activity can also account for long distance transport of broom and gorse seed. Seeds can be moved along roads where they are distributed by roof gutters or mud on external surfaces of passing vehicles. Seeds can also be transported on shoes of hikers (42). Construction crews can disperse seeds long distances when seeds contaminate gravel being transported from river bottoms.

Ecology

Brooms and gorse stands can become established after soil disturbance in both their native range in Europe or in introduced areas, such as New Zealand, Australia, and the United States (4). Broom species grow best in seasonally dry, sandy, nitrogen poor soils in full sunlight (26, 46). However, they will survive under a wide range of soil conditions, including acid soils at pH values as low as 4.5 (15, 31), nitrogen and phosphorus deficient soils (46), serpentine soils (11), soils high in boron (43), and, though rarely, on highly calcareous soils (10). In New Zealand, gorse readily invades low fertility pastures where the organic content of the soil is less than 4% (28). Gorse requires greater soil moisture than do most species of broom (12) and thrives where the water table is very high (8).

In low light or shaded areas, broom plants tend to form a single upright shoot (46). The brooms do not typically do well in forested areas but rapidly invade recently logged, cleared or burned sites (33, 46). Gorse, however, survives better on shady slopes than in high sunlight areas (3).

In older dense broom infestations, the lower vegetation dies and subsequently blocks light penetration to the soil surface. This can suppress the germination and growth of herbaceous plants and tree seedlings (42). The competitive ability of brooms and gorse is also linked to their ability to tie up nitrogen by accumulating it in the dried litter (18). The rate of litter accumulation under gorse is higher than most warm temperate species and is near those recorded in tropical rainforests (13). This litter can also acidify and lower the cation exchange capacity of moderately fertile soils (16, 17, 27), and prevent the establishment of competing species.

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