denuded in the mid-1800's to supply firewood to whaling ships, plantations, and island residents.

Native plants were undoubtedly affected by these practices. Also, sandalwood and tree fern harvesting occurred in many areas, changing forest composition and affecting native species (Cuddihy and Stone 1990).

Beginning with Captain James Cook in 1792, early European explorers introduced livestock, which became feral, increased in number and range, and caused significant changes to the natural environment of Hawaii. The 1848 provision for land sales to individuals allowed large-scale agricultural and ranching ventures to begin. So much land was cleared for these enterprises that climatic conditions began to change, and the amount and distribution of rainfall were altered (Wenkam 1969). Plantation owners supported reforestation programs that resulted in many alien trees being introduced in the hope that the watershed could be conserved. Beginning in the 1920's, water collection and diversion systems were constructed in upland areas to irrigate lowland fields, and this undoubtedly destroyed individuals and populations of native plants. The irrigation system also opened new routes for the invasion of alien plants and animals into native forests (Cuddihy and Stone 1990, Culliney 1988, Wagner *et al.* 1990, Wenkam 1969).

Past and present activities of introduced alien mammals are the primary factor in altering and degrading vegetation and habitats on Molokai. Feral ungulates trample and eat native vegetation and disturb and open areas. This causes erosion and allows the entry of alien plant species (Cuddihy and Stone 1990, Wagner et al. 1990). Only one of the species in this proposal, Schiedea sarmentosa, is directly threatened by habitat degradation resulting from introduced ungulates. However, goats, deer, and pigs are known to occur in areas adjacent to the other two proposed plants. Because they may invade the areas where these plants occur, ungulates pose a potential serious threat to Cyanea dunbarii and Lysimachia maxima.

The goat (*Capra hircus*), a species originally native to the Middle East and India, was successfully introduced to the Hawaiian Islands in 1792. Currently populations exist on Molokai and four other islands. On Molokai, feral goats degrade dry forests and are now invading the wetter regions along the northern coast of East Molokai (Stone 1985; J. Lau, pers. comm. 1990). Goats are managed in Hawaii as a game animal

and goat hunting is allowed year-round or during certain months, depending on the area (Hawaii Department of Land and Natural Resources (DLNR) n.d.-a, n.d.-b, n.d.-c, 1988). Goats browse on introduced grasses and native plants, especially in drier and more open ecosystems. Feral goats trample roots and seedlings, cause erosion, and promote the invasion of alien plants. They are able to forage in extremely rugged terrain and have a high reproductive capacity (Culliney 1988, Cuddihy and Stone 1990, Scott et al. 1986, Tomich 1986, van Riper and van Riper 1982). Although northeastern Molokai is considered one of the most remote and inaccessible places in the main Hawaiian islands, the vegetation there is predominantly exotic (Culliney 1988). The replacement of native vegetation is attributed to the large number of goats. Due to their agility, goats are able to reach vegetation not usually accessible to other animals (Culliney 1988). Goats are a threat to the larger population of Schiedea sarmentosa and a potential threat to the only known population of Lysimachia maxima, since they may invade the area where this taxon occurs (L. Mehrhoff, in litt. 1994; S. Perlman, pers. comm. 1994).

The pig is a species originally native to Europe, northern Africa, Asia Minor, and Asia. European pigs, introduced to Hawaii by Captain James Cook in 1778, became feral and invaded forested areas, especially wet and mesic forests and dry areas at high elevations. They are currently present on Molokai and four other islands, and inhabit rain forests and grasslands. Pig hunting is allowed on all islands either year-round or during certain months, depending on the area (DLNR n.d.-a, n.d.-b, n.d.-c, 1988). While rooting in the ground in search of the invertebrates and plant material they eat, feral pigs disturb and destroy vegetative cover, trample plants and seedlings, and threaten forest regeneration by damaging seeds and seedlings. They disturb soil and cause erosion, especially on slopes. Alien plant seeds are dispersed on their hooves and coats as well as through their feces (Cuddihy and Stone 1990, Scott et al. 1986, Stone 1985, Tomich 1986, Wagner *et al.* 1990). Feral pigs pose an immediate threat to Schiedea sarmentosa and a potential threat to Cyanea dunbarii and Lysimachia maxima. If not controlled, habitat degradation by pigs may become a significant problem to the only known populations of the latter two species (L. Mehrhoff, in litt. 1994; S. Perlman, pers. comm. 1994).

Of the ungulates that have become established on Molokai during the past 150 years, the axis deer has probably had the greatest impact on the native vegetation. Eight axis deer, introduced to Molokai in 1868, increased to thousands of animals by the 1960's (Culliney 1988, Graf and Nichols 1966, Tomich 1986). By the turn of the century, these deer had occupied much of the dry to mesic lowland areas and were also found in the wet forests of East Molokai, where herds so damaged the vegetation that professional hunters were hired to control their numbers (Culliney 1988, Graf and Nichols 1966, van Riper and van Riper 1982). The native vegetation has suffered irreparable damage from overgrazing by these animals. Deer degrade the habitat by trampling, consuming, and overgrazing vegetation, which removes ground cover, exposing the soil to erosional action (J. Lau, pers. comm. 1990). Alien plant species are then able to exploit the newly disturbed areas.

A large portion of the axis deer population on Molokai has been actively managed for recreational hunting by the Hawaii Division of Forestry and Wildlife since 1959. At present, five of the seven managed hunting areas on Molokai are within the Molokai Forest Reserve. Many areas lack maintained boundary fences that would prevent deer from entering more fragile habitats to the north (Cuddihy et al. 1982) and non-game areas to the east. Recently, axis deer have begun to enter the windward valleys and northern coastline of East Molokai where they were not previously observed (J. Lau, pers. comm. 1990). Axis deer have been observed in areas south of the only known population of Cyanea dunbarii, and pose a potential threat to this species (E. Misaki, pers. comm. 1991).

Although not a direct threat at present to the plant species in this proposed rule, cattle (Bos taurus) ranching on Molokai has played a significant role over most of the past 150 years by reducing areas of native vegetation to vast pastures of alien grasses (Cuddihy and Stone 1990, Pekelo 1973, Stone 1985). In 1960, approximately 61 percent of Molokai's land area was devoted to grazing, primarily the lower elevation dry to mesic forests, shrublands, and grasslands of west and central Molokai (Baker 1961). Cattle degraded the habitat by trampling and feeding on vegetation, eventually opening up the ground cover, exposing the soil, and increasing its vulnerability to erosion (Cuddihy and Stone 1990, Lindgren 1908, Pekelo 1973). Because of this alteration of vegetation, natural areas became limited to the upper