

## *Cladonia firma*, Sponsorship for the CALS Conservation Committee

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### Executive Summary

*Cladonia firma* (Nyl.) Nyl. occurs at scattered locations in maritime habitats in Europe and is locally abundant. In North America it is known from only four populations in California on the southeast side of Morro Bay, in Los Osos and at Montana d'Oro State Park in San Luis Obispo County.

*Cladonia firma* occurs on soil and detritus on stabilized sand dunes in California, in pure stands or intermixed with other lichens and mosses forming biotic soil crusts, covering areas up to several meters. When dry the large primary squamules, which resemble leaves, become desiccated and curl-up, exposing the white undersides. From this fact is derived the vernacular "popcorn lichen." *C. firma* is easily visible to the naked eye and its squamules are the largest of any member of the genus *Cladonia* in California.

When *Cladonia firma* was first collected it was locally abundant in the Los Osos area, and was still reported as being locally abundant recently (Ahti and Hammer 2002), though neither author had personally visited the area in the last decade and a half. Unfortunately, since the discovery of the populations, housing developments have spread through the area severely reducing local habitats and extirpating populations. Existing populations are in decline and ultimately in danger of extirpation, especially from invasive veldt grass (*Ehrharta calycina* Sm.) (Knudsen and Lendemer 2006.)

In California, the Los Osos populations need to be protected through posting and possibly fencing of remaining habitat as well as acquisition of any significant populations on private property. On state park and BLM lands the populations need to be inventoried and

mapped and a management plan developed and implemented. It is proposed for listing on the California Natural Diversity Database's (CNDD) Special Vascular Plant, Bryophyte, and Lichen List with a Global Rank of G4-2 but a local rating of 1-1.

### TAXONOMY

**Accepted scientific name:** *Cladonia firma* (Nyl.)  
Nyl. Bot. Z., 1861: 352, 1861.

**Common name:** Popcorn lichen

**Type specimen and location:** PORTUGAL:  
Algarve, marim in glareosis maritimis, elevation about 5 m. C.N. Tavares: Lichenes Lusitaniae selecti exsiccati No. 39 (H! neotype)

**Basionym:** *Cladonia alcicornis* var. *firma* Nyl., Syn.  
Lich., 1: 191, 1858.

**Synonyms:** *Cladonia foliacea* var. *firma* (Nyl.)  
Vain.; *Cladonia nylanderii* Cout.

### DESCRIPTION

The thallus is squamulose and the squamules are persistent forming small clumps, 2-25 cm. in diameter, often sterile and without podetia when young. It is conspicuous when dry because the large squamules roll inward, are upright and densely packed together, exposing white or brown, esorediate undersides. The primary squamules are the largest in California, up to 25 mm. long and 10 mm. wide, deeply cleft and digitate with often secondary crenulation. They are up to 250  $\mu$ m thick. The crenulations of squamules elongate into digitate straps at the end of which squamules form. It is this process of elongation that gives the species its complex form. In undisturbed sites, *C. firma* forms contiguous populations. In mildly disturbed sites, *C.*

*firma* readily fragments, eventually forming new thalli that are tangled, attenuated structures of interconnected squamules, stalked pycnidia, and podetia with secondary squamules. This ability to regenerate, even if turned completely underside down, is well-adapted to the sandy maritime sites *C. firma* favors.

The thallus does not usually grow directly on the sand in the Los Osos and Montana de Oro populations, but actually favors openings in the maritime dune scrub or openings formed by the death of maritime chaparral where the sand is covered with a thick layer of detritus and there is abundant rabbit dung. It also grows on mosses. These sites are generally level or gently inclined.

The lower surfaces of the squamules are corticate with periclinal prosoplectenchyma and covered with a thick white fibrous coat of fine hyphae. In older squamules, this coat can blacken, probably due to interaction with soil or bacteria. Usually the fibrous coating eventually thins or disappears and the cortex turns dark brown. This can appear in fresh specimens to have a bluish tint to some people.

The upper surface of the squamules is a green to olive, sometimes becoming brown. It is glaucous because of a syncortex, an upper and uneven gelatinous coating up to 100  $\mu\text{m}$  thick, punctuated with pits and valleys where the gelatinous layer is often as thin as 5  $\mu\text{m}$ . This variation of thickness gives the surface a bumpy texture which is probably functional because water accumulates between the thick bumps in lower areas on the squamule surface and can easily be absorbed where the gelatinous layer is thin. The eucortex *in sensu* Knudsen is formed of mostly anticlinal prosoplectenchyma and is 30-50  $\mu\text{m}$  thick beneath the upper syncortex.

The podetia usually begin from the center of the primary squamules, arising to a height of up to 15 mm, sometimes branching, but narrow, usually 1 mm in diameter. Several podetia can arise from one squamule. The podetia surface is corticated and covered with bumps which are nascent squamules but can develop into new podetia. The podetium is cup-bearing, the cup usually abruptly flaring out as in *C. fimbriata*. The cups are usually shallow, 2-3 mm in diameter, and often one to three podetia arise from the center to form a second tier, resembling *C. cervicornis*. Sometimes secondary squamules develop around the rim of the cup.

The apothecia are brown and usually developed sessile or stalked on the rim of cups. The ascospores are hyaline, simple, and 14-17 x 2-4  $\mu\text{m}$ .



*Cladonia firma*, Knudsen 7261 (UCR). Characteristic look of large squamules when dry. Image © Janet Good 2007, printed with permission.



Podetia of *Cladonia firma*, usually one-tiered. Image © Janet Good 2007, printed with permission.

The pycnidia are brown, urn-shaped, sessile or stalked, arising on the edge of cups, on the sides of podetia, and from upper surface of primary squamules. The conidia are sickle-shaped, 5-7 x 1  $\mu\text{m}$ . Fine rhizohyphae, acting as anchors, can occur on the underside of thalli.

**Similar species and distinguishing characteristics:**

*Cladonia firma* can be easily determined by its primary and persistent squamules, the largest in California. The key in *Lichen Flora of the Greater Sonoran Area*, Vol. 2 (Ahti and Hammer 2002) works well for determining all *Cladonia* collected so far in San Luis Obispo County.

*Cladonia firma* (Nyl.) Nyl. belongs to the cervicornis group. All species of this group have tiered podetia. *Cladonia cervicornis* can easily distinguished from *C. firma* because the squamules of *C. firma* are distinctly larger and *C. firma* contains atranorin which *C. cervicornis* lacks.

There are atranorin-rich populations of an undescribed species in western North America, reported by Ahti and Hammer (1990). This species occurs in scattered populations from northern California to southern California, but has not been collected in San Luis Obispo County. It is easily distinguished from *C. firma* by its much smaller squamules and keys out as *C. cervicornis* in the key in *Lichen Flora of the Greater Sonoran Area*, Vol. 2 (Ahti and Hammer 2002)

**BIOLOGICAL CHARACTERISTICS**

**Growth form:** squamulose.

**Reproductive method:** spores or conidia or fragmentation.

**Dispersal agents:** wind, rain, and natural disturbance.

**Substrate and specificity:** on soil, detritus, moss on stabilized sand dunes.

**Habitat and specificity:** maritime habitat.

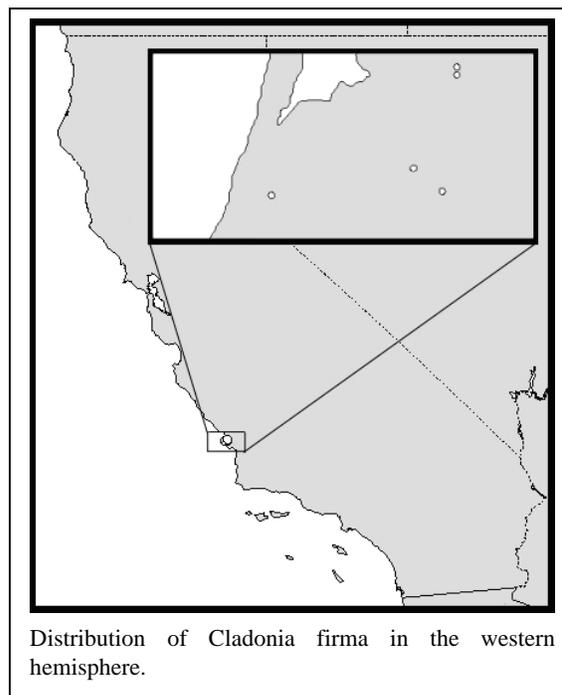
**Pollution sensitivity:** unknown.

**Ecological function:** soil stabilization, often forming biological crusts with other lichens and mosses.

**GEOGRAPHY**

**Global:** *Cladonia firma* is abundant locally in Spain and Portugal with populations scattered in sandy maritime habitats around the Mediterranean as well as on the Canary Islands and the Channel Islands of Great Britain (Knudsen and Lendemer 2006; Ahti and Hammer 2002.) In North America, *Cladonia firma* is restricted to Los Osos area in San Luis Obispo County.

**Local:** In recent surveys we have observed only two major populations of *C. firma*, one in Los Osos and one in Montana de Oro State Park. Both contain thousands of individuals. The main population occurs on land owned by BLM and California State Parks, called Powell 1 east of Bayshore Drive, in area pf 35°



19' N, 120° 49' W, elev. 33-50 m, and occurs also on the adjoining properties Powell 2 & 3. The second main population is on ridge of stabilized dune above the Sandpit parking lot in Montana d'Oro State Park, 35° 18' N 120° 52' W, elev. 58 m We observed only two smaller populations. One was on a vacant lot in Los Osos where it occurred on detritus under several decorticate and lichen-covered shrubs s/e corner of South Bay and Nipomo Street, 34° 18' N 120° 49' W, elevation 36 m. The other site is under BLM control, the Cordoniz property east of Bayview Heights & Calle Cordoniz , 35° 18' N 120° 49' W, elev. 78 m, which appears in decline due to disturbance and Veldt grass (Knudsen and Lendemer 2006). The sites are vouchered at the UCR Herbarium and can be accessed on the public database [http://sanders5.ucr.edu/lichensflat\\_index.php](http://sanders5.ucr.edu/lichensflat_index.php). [Coordinate precision reduced to protect precise locations.]

**POPULATION TRENDS**

Because of the division of populations through urban development of the area, *Cladonia firma* populations have been reduced and isolated through habitat reduction. Hiking, domestic animals, horseback riding, invasive grass, and off-road vehicles have further reduced populations through disturbance of sensitive stabilized Baywood fine sand

(Knudsen and Lendemer 2006). The extant populations need to be inventoried and surveyed and any remaining populations discovered.

#### THREATS

**History:** *Cladonia firma* was initially locally abundant when first collected in late eighties (Knudsen and Lendemer 2006). The major reduction in the population came with the development of the Baywood/Los Osos area. Uncontrolled land use and domestic animals, especially dogs and horses, as well as invasive grasses have further disturbed, reduced, or extirpated populations.

#### PROTECTION

Land management should be coordinated across the State Park, Bureau of Land Management, and private land holdings. For secure conservation of this and other species in the Los Osos/Baywood area dune systems, lands with appropriate habitat should be acquired and consolidated by a single management entity, perhaps expanding the state park system, or forming an Area of Critical Environmental Concern under the BLM. Continued and aggressive programs to reduce Veldt grass (*Ehrharta calycina* Sm.) are necessary to protect *C. firma* and sensitive vascular plants in stabilized dune habitat.

Large populations need special protection from local land use for recreation as was already done at the Elfin Forest site with fencing and elevated walkways and classified as preserves.

#### CONSERVATION STATUS SUMMARY

*Cladonia firma* in the Los Osos/Baywood is in long-term decline. It will eventually be extirpated from North America through habitat degradation.

*Cladonia firma* is well-adapted to moderate natural disturbance through seasonal flooding and non-domestic animal land use (Knudsen and Lendemer 2006). At this time, the populations overall appear to not have reached a level that they could not adequately sustain itself with monitoring and management. Though this conclusion needs to be verified through inventory and mapping. Protection of the remaining populations is possible and the long-term decline to extirpation can be halted through management.

#### SPECIFIC CONSERVATION RECOMMENDATIONS

**Recommended Global Rarity Rank:** G4

Although, the number of populations is unknown, the species is known to occur sporadically

over a large geographic area in and around the Mediterranean and the Channel Islands.

**Recommended Global Threat Rank:** 2

Although the exact threat is unknown, human population and tourism pressures in the core of the species range (the Mediterranean and Channel Islands) have likely reduced the number of populations and will probably continue to do so in the future.

**Recommended Local Rarity Rank:** S1

Only a small number of populations that were once contiguous are known to exist in North America and remaining appropriate, but un-colonized habitat is limited.

**Recommended Local Threat Rank:** 1

The populations have been reduced and fragmented by development. Although much of the remaining populations exist on public land, these populations remain vulnerable to fragmentation and extirpation by recreational use of the land including hiking, dog walking, and horseback riding. Veldt grass (*Ehrharta calycina* Sm.) is a serious threat to stabilized dune habitat and native species of non-vasculars like *C. firma* and vascular plants.

**Recommended List:** 2

The species is undoubtedly rare in California. If the species is subsequently reported to be rare throughout its range in and around the Mediterranean Sea, then it may be moved to list 1B.

#### RELEVANT EXPERTS AND KNOWLEDGABLE LOCAL BOTANISTS.

Lisa Andreano  
Environmental Scientist  
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**STAKEHOLDERS FOR NOTIFICATION OF COMMENT  
PERIOD**

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CDFG: Attention Deb Hillard  
Morro Bay Field Office  
PO Box 1079  
Morro Bay, Ca 93442

Los Osos Community Service District  
2122 9<sup>th</sup> St  
Los Osos, Ca 93402

SLO County, Natural Resources  
1050 Monterey St  
San Luis Obispo, Ca. 93408

USFWS, Ventura Field Office  
Attention Steve Henry  
2493 Portola Rd. Suite B  
Ventura, Ca. 93003

BLM  
Attention Mr. Larson  
Bakersfield Field Office  
3801 Pegasus Dr  
Bakersfield, Ca 93308

Calif. Native Plant Society (CNPS)  
Linda Chipping  
San Luis Obispo Chapter (no address listed)

Morro Estuary Greenbelt Alliance (MEGA)  
PO Box 6801  
Los Osos, Ca 93412

Small Area Wilderness Preserve (SWAP)  
PO Box 6442  
Los Osos, Ca 93412

**LITERATURE CITED**

- Ahti, T., Hammer, S. 2002. *Cladonia In:* Nash, TH, III, Ryan, BD, Gries, C, Bungartz, F. (eds.): Lichen Flora of the Greater Sonoran Desert Region. I. Lichens Unlimited, Arizona State University, Tempe, Arizona, pp. 131-158.
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- Knudsen, K., Lendemer, J.C. 2006. *Cladonia firma* in San Luis Obispo County, California. *Bulletin of the California Lichen Society* 13(2): 29-34.

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