Lobaria pulmonaria: One Lichen, Three Kingdoms!

Jim Cornish

Lobaria pulmonaria is a "flagship species" used by scientists to inform the public about lichens, their role in nature, and the potential impact of climate change on their future distribution and status. I first encountered this model species growing on a mature maple tree in a mixed forest in the Annapolis Valley of Nova Scotia two decades ago (Fig. 1). Conspicuous and well within reach, I was surprised it had not been picked by passers-by in the mistaken belief that lichens parasitize their hosts. Over the years, I have found two other *L. pulmonaria* thalli on trees near my Newfoundland and Labrador home. Unfortunately, both were sun-scorched (bleached) and died as the result of changes to their microenvironment after ski and walking trails were cut through their habitat.

I was reacquainted with *L. pulmonaria* in the fall of 2024 when images of the lichen started appearing in posts on my Facebook page as mushroom foragers ventured deep into what remains of our old-growth forests looking for chanterelles. Most posters correctly identified the well-known lichen but few realized it is a symbiosis of three microbial partners from three different kingdoms! This article covers the use of this lichen in traditional medicine, its unique biological features, ecological importance, distribution and preferred habitat, and how it could be impacted by climate change.

Figure 1. My first photo of *Lobaria pulmonaria*. In the middle of a very dry summer, it took a bottle of water to turn it green.

Ethnolichenology of Lobaria pulmonaria

The earliest recognizable drawing of *L. pulmonaria* appears in a 1650 illustrated botanical book by Flemish botanist Matthias de L'Obel (Fig. 2). Influenced by the Doctrine of Signatures (DOS), a belief that the Creator provided signs within plants to indicate their therapeutic uses, L'Obel gave the lichen the lengthy name *Muscus Pulmonarius sive Pulmonaria Officinarum*, as was often the case in naming plants in pre-Linnaean taxonomy. In L'Obel's nomenclature, "*pulmonaria*" recognizes the lichen's resemblance to lung tissue, while "*officinarum*" recognizes its use in treating bodily ailments. Although DOS is no longer in use, the doctrine's influence on nomenclature from Antiquity to the mid-1700s has left us with many interesting scientific and common names for plants and fungi believed to be therapeutic (Richardson, 1975).

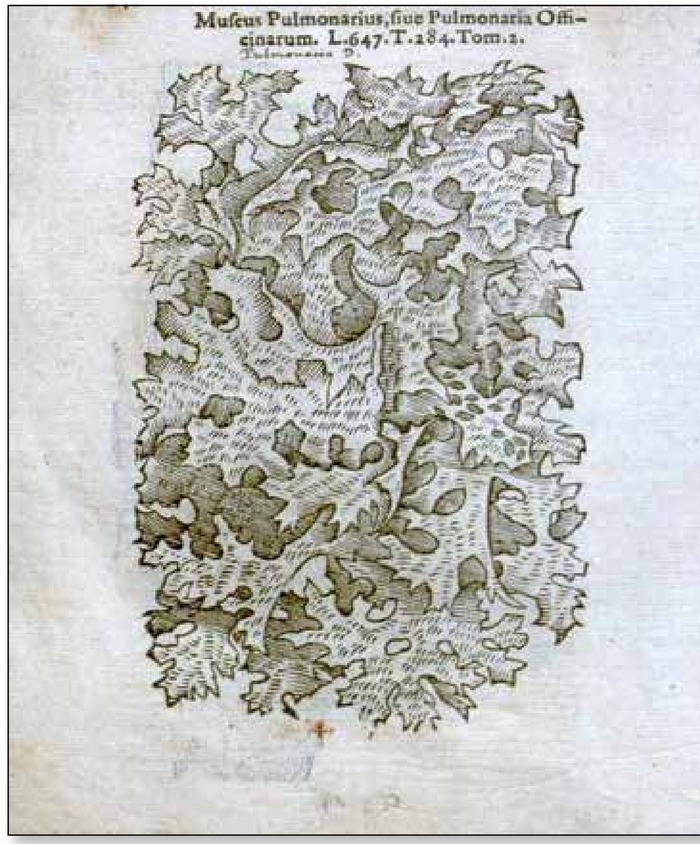

Figure 2. A 17th-century drawing of *Lobaria pulmonaria* by Flemish botanist Matthias de L'Obel. (Public domain.)

L'Obel's nomenclature for *L. pulmonaria* shows a rudimentary use of family and genus as taxonomic groups, a system adopted and further developed by Swedish taxonomist Carolus Linnaeus (1707–1778). In 1753, Linnaeus renamed the lichen *Lichen pulmonarius* but it was subsequently moved to the genus *Lobaria* by Georg Franz Hoffmann in 1796, which explains why both taxonomists are credited as authors in the lichen's present official name, *Lobaria pulmonaria* (L.) Hoffm. (Petruzzello, 2025). In its modern taxonomy, *Lobaria* is Latin meaning "lobes" while *pulmonaria* means "like the lungs." Its DOS common name, tree lungwort, distinguishes it from the plant *Pulmonaria* *officinalis* (known as lungwort; wort meaning "plant"), whose petal patterning also resembles lung tissue and whose ethnobiology also includes treatment for lung ailments. Today, the most commonly used vernacular name for *L. pulmonaria* is lung lichen (McMullin, 2023).

Lobaria species were also widely used in the medical traditions of North America's Indigenous Peoples. Called "frog blankets" by the Gitkan and "tree blankets" and "cloud leaves" by the Haida Gwaii First Nations of British Columbia, *Lobaria* were used to treat skin diseases, coughs, sore throats, and digestive issues. Modern herbalists use the lichen to treat respiratory problems like hay fever, colds, flu, and other ailments such as intermittent fever, night sweats, and ulcers. In modern medicine, pharmacological companies are interested in the antimicrobial and antioxidant properties of their lichen substances (secondary metabolites) in developing new medications (Rogers, 2025).

Species Profile

The morphology of *L. pulmonaria* thalli is determined by the substrate, microclimate, and the lichen's age. Typically, the lichen appears as a mass of broad, showy, and partially overlapping lobes called ramets. Each lobe measures 0.5–3 inches in width and five inches or more in length. The lobes are typically branched, truncated at the tips, and loosely attached to the substrate (Fig. 3). When appearing en masse, the lichen can reach a foot or more in width and cascade down tree trunks or carpet moss-covered rock substrates (McMullin, 2023).

Figure 3. The wet green thallus of a maturing *Lobaria pulmonaria* showing long lobes and branching truncated tips typical of the species. Alan Pitman photo.

The upper cortex of the lichen is normally pale brown to olive-green and brittle when dry but turns bright green and rubbery when wet, a change that occurs in all foliose and fruticose lichens (Figs. 1 & 3). The absorbed water also causes the upper cortex to expand and become translucent, creating a translucent "window" that allows the green color of phototrophic algae located in a layer immediately below to shine through (Lücking and Spribille, 2014). The lower cortex of many foliose lichens differs from the upper cortical layer in both color and texture. In lung lichen, the lower cortex appears reticulated (net-like), a pattern formed by white, bald, convex sections of thallus that correspond to the depressions on the upper surface that are separated by lines of melanin-rich tomentose cortical hyphae (Fig. 4) (McMullin, 2023).

Figure 4. The lower cortex of *Lobaria pulmonaria* shows convex surfaces separated by lines of brownish melanin-rich hyphae. Lotus Johnson photo.

Unlike plants, lichens cannot regulate water, so hydration fluctuates as the availability of rain, fog, and humidity changes in the surrounding air. The shape and size of the *L. pulmonaria* thallus are believed to enhance its ability to retain water and hence prolong photosynthesis. As the air dries, the lichen dehydrates and shuts down all metabolic activity, including photosynthesis. While in this dormant state, lichens are vulnerable to light-induced stresses which explains why *L. pulmonaria* limits its habitats to damp and shady old-growth forests.

Lobaria pulmonaria is less desiccation tolerant than most other lichens and often shows visible signs of their response to dehydration. One reaction is the melanization of the outer cortex which tends to darken the lichen's coloration when dry (Fig. 5), something that is visible to the naked eye. This extra melanin helps the lichen to absorb DNA-damaging ultraviolet rays and dissipate this energy as heat. Another reaction to desiccation is inward curling lobe margins, a morphological adaptation that reduces the thalline surface area exposed to sunlight, hence shading other parts of the thallus for additional photoprotection (Fig. 5). Not visible is an increase in the production of secondary metabolites that aid in photoprotection and antioxidation (Grimm et al., 2021; Barták et al., 2006; Daminova et al., 2023).

Figure 5. A dry *Lobaria pulmonaria* thallus looks gray-green. Note the curled tips on some lobes. Pieter van Heerden photo.

Reproduction

The upper cortex of *L. pulmonaria* has ridges where the thallus thickens and hollows where the thallus thins, giving the lichen surface its characteristic lung tissue appearance. The ridges and lobe margins on older thalli frequently rupture to form raised circular gaps called soralia (Fig. 6). These gaps release packets of fungus-covered algae called soredia, which can be dispersed by the wind or animals brushing against the thallus. The area around the soralia may also feature finger-like outgrowths called isidia. They contain hyphae and algae bound by a cortex—a lichen in waiting. If both types of vegetative propagules find suitable environments, they can form new lichens (McMullin, 2023; Purvis, 2000).

Figure 6. The rough-looking ridges and lobe margin of *Lobaria pulmonaria* show soralia, openings through which the vegetative reproductive structure soredia can escape. Lotus Johnson photo.

Figure 7. Although not that common, in a large population, the upper cortex of a *Lobaria pulmonaria* thallus can be spotted with red disc-shaped apothecia, the sexual reproductive structures of most lichens. Joan Disley photo.

Although vegetative reproduction is predominant in most lichens, the ascomycete *Lobaria pulmonaria* can reproduce sexually via ascospores produced in disc to cup-like structures called apothecia. Typically, red and 0.1 inch in diameter, apothecia appear in late spring and discharge their spores throughout the year (Fig. 7). Since apothecia occur on less than 25% of thalli present in a population (Denison, 2003), they are less likely to be seen, if at all. Unlike isidia and soredia, which may contain all three partners, spores must find and lichenize compatible partners to synthesize a new thallus (Ravera et al., 2023).

One Lichen, Three Kingdoms

Figure 8. A young *Lobaria pulmonaria* with its characteristic lung tissue pattern but lacking vegetative reproductive structures such as soredia and isidia. Javier Vecino photo.

Lichens are microbiomes traditionally described as dual organisms, a symbiosis primarily between a fungus and an alga as first noted by German botanist Anton de Bary and hypothesized by Swiss microscopist Simon Schwendener in the 1860s. A distinguishing characteristic of *L. pulmonaria* is its tripartite or three-way symbiosis. The primary partners in this microbiome include the fungus *L. pulmonaria* (the mycobiont) which forms the bulk of the thallus, the photosynthetic alga *Symbiochloris reticulata* (the photobiont) which forms a continuous layer beneath the upper cortex and photosynthesizes sugar alcohols, and a species of *Nostoc* cyanobacteria (the cyanobiont) that amass in 0.02–0.05-inch diameter gall-like structures called cephalodia and fix nitrogen from the air (Grimm et al., 2021). Typically inconspicuous, cephalodia are scattered throughout the thallus interior next to the lower cortex. This symbiosis places *L. pulmonaria* in a group called cyanolichens, including bipartite species (one fungus and one cyanobacterium) and tripartite species (one fungus, one alga, and one cyanobacterium). Cyanolichens account for about 10% of all lichens (Grimm et al., 2021; Daminova et al., 2022).

Other microbes like bacteria and viruses have been found in the lichen microbiome but how they contribute to the lung lichen's symbiosis is not completely understood. Additional mysterious partners are lichenicolous fungi—obligate microfungi that live conspicuously or inconspicuously on and with the lichen thallus. Lichenologists have identified about two thousand lichenicolous fungi, some of which are host-specific. They are either mutualistic, commensal, or parasitic and may be involved in recycling, reorganizing, or reshaping lichen thalli. They may also affect the production of secondary metabolites, which in turn may affect the lichen's fitness and ability to defend itself against biotic and abiotic stressors (Grimm et al., 2021; De Carolis et al., 2023).

The upper and lower cortices and internal hyphal cells of *L. pulmonaria* can be colonized by a biofilm of heterotrophic bacteria that are known to participate in carbohydrate metabolism and nutrient uptake, amino acid synthesis, stress tolerance mechanisms, and defensive activities against pathogens. They may even be involved in the decay of the lichen after death (Grube et al., 2015; Chavarria-Pizarro et al., 2022; Grimm et al., 2021).

Habitat

Lobaria pulmonaria prefers bark and moss-covered substrates in old-growth forests where shade and microclimates of cool, damp, and clear air provide optimal conditions for growth. While coniferous forests provide stable conditions year-round, deciduous forests create challenges for the light-sensitive lung lichen, forcing it to acclimatize to fluctuations in light intensity caused by the seasonal changes in the openness of the forest canopy. The lichen adapts by allocating resources from photosynthesis (during spring, summer, and fall) to photoprotection against increased insolation in winter. If the lichen can adapt to changing environmental conditions and its habitat remains undisturbed, *L. pulmonaria* can grow about half an inch per year and live for about two hundred years (Ravera et al., 2023). This makes it one of the fastest-growing and longest-living lichens of the foliose form (McMullin and Anderson, 2014; MacKenzie et al., 2001; Schofield et al., 2003).

Figure 9. The preferred habitat of *Lobaria pulmonaria* is an old-growth forest with large mature trees, a shaded understory, and cool damp pollution-free air. The images show two masses of ramets, the smaller top one being younger than the larger bottom one. The image also shows that *Hypogymnia* lichens also prefer this ecological niche. Pieter van Heerden photo.

Distribution and Status

Lobaria pulmonaria has a worldwide distribution but is confined to boreal, temperate, and montane forests in the Northern Hemisphere, and some tropical forests in Africa and South America in the Southern Hemisphere. Its occurrence elsewhere in the world is less well-known (Ravera et al., 2023).

Collectively, lichens are described as "extremophiles" because they can survive in harsh environments anywhere from pole to pole and sea level to well above the tree line. Yet, for many species even slight but sustained environmental changes in air quality, temperature, and humidity can cause them to disappear. In the case of *L. pulmonaria*, deforestation, acid rain, and poor air quality threaten the lichen's status locally and in large swaths of its traditional range. This is especially true in parts of Europe where the lichen is considered critically endangered and locally extinct (Gaio-Oliveira et al., 2004).

Lobaria pulmonaria is the most common *Lobaria* species in North America. While stable on the continent, regional differences exist in its status. In Saskatchewan and the Yukon of Canada, the lichen is deemed "critically imperiled," and at an extremely elevated risk of extinction or collapse due to a very restricted range. In Alberta, it is described as vulnerable. In the rest of Canada, it is considered secure. Its status throughout Appalachia is unknown, but it is presumed extirpated in Ohio and Iowa, and imperiled in Kentucky (NatureServe, 2025). There is hope that former ranges can be reestablished. In parts of the world, lung lichen has been translocated into areas where it had once been extirpated (Ravera et al., 2023). A recent study of lung lichen based on samples taken from my province of Newfoundland and Labrador and other parts of eastern and western Canada discovered that their populations formed distinct gene pools, differences that led the authors to suggest that the status of *L. pulmonaria* on both sides of the continent should be considered separately (Allen et al., 2021).

Ecology

Like other fungi, lichens are susceptible to predation. To protect themselves, juvenile *L. pulmonaria* store specific unpalatable secondary metabolites in their thalli. If partially consumed, the open wounds are usually enclosed by a secondary cortex, indicating that, like other lichens, lung lichen can repair itself. Herbivory is not entirely negative, however. Studies have demonstrated that new lichens have been resynthesized from fragments that have passed through the guts of snails (Ravera et al., 2023).

Cyanolichens, such as lungwort, play a crucial role in water and nutrient cycling within forest ecosystems. Their capacity to fix atmospheric nitrogen is particularly important in nutrient-poor forests, where nitrogen leached from a thallus by rainwater or fog can seep into the soil, becoming accessible to plants and fungi that cannot fix their own nitrogen. This nitrogen cycling continues when the cyanolichens die, litter the ground, and eventually decay (Grimm et al., 2021).

Large animals like deer and moose, and small creatures like microscopic insects use lung lichen for food. Smaller animals use it for nesting material.

Lobaria pulmonaria is one of the most researched species of all lichens. As a model species, it is used to study lichen biology, symbiosis, carbon pooling, and nutrient cycling. Since it thrives in environments with ecological continuity, the lichen is a dependable biomonitor and bioindicator of environmental health and species biodiversity and a bellwether species for indicating anthropogenic influences such as habitat fragmentation, deforestation, afforestation, and climate change (Ravera et al., 2023).

Figure 10. *Lobaria pulmonaria* shares its substrate with another cyanolichen, a *Peltigera* species. Richard Droker photo.

Climate Change

Although the use of lichens as indicators of environmental quality dates back to the mid-nineteenth century, investigating the impact of climate change on lichens is an emerging field of scientific research. Since lichens cannot separate themselves from temperature and water availability of the surrounding air, they are likely vulnerable to the higher temperatures and dryness characteristic of climate change.

Using *L. pulmonaria* as a model species, lichenologists have discovered that lichen responses to climate change are habitat, species and growth stage dependent. This creates many variables which makes the effort to identify universal, or at least shared responses, across multiple taxa very difficult (Bogale et al., 2024). Researchers have tackled this problem by adopting inclusive approaches, again using *L. pulmonaria* as a model species. One such approach, called "lichen ecophysiology," focuses on the role of specific lichen traits, whole-thallus physiology, and ecological interactions to determine the impacts of climate change (Stanton et al., 2022).

Researchers are also interested in lichen plasticity—the ability of some species to switch algal partners or recruit microbes from their surroundings (Bogale et al., 2024). This flexibility may help them adapt to climate-induced changes that affect growth, health, and longevity.

Some of this work has been conducted in computer simulations, model niches, and climate-controlled structures. Much remains to be to be learned.

Some climate change impacts on macrolichens are becoming apparent. Because their tree hosts are shifting to higher latitudes and elevations, epiphytic lichens are likely to migrate too. But studies also show the microlichen distribution can constrict in some cases and expand in others. Studies on differing thallus sizes linked to age in *L. pulmonaria* show that juvenile thalli and adult thalli have different ecological requirements that are affected by changing climate, which in some areas is compounded by the damaging effects of habitat loss and air pollution (Nuzzo et al., 2022).

One concern that scientists have is related to attitudes towards lichens. As Zonca (2022) pointed out, when it comes to the impact of climate change on lichens, will anyone notice, and will anyone care?

Conclusions

Lichens are always seen but often overlooked (Zonca, 2022). This paradox of "familiarity and invisibility" noted by Zonca might be partly attributed to how we view life—dividing organisms into "higher" and "lower" forms—and from our tendency to value most those species with obvious economic importance. We often relegate lichens to the back pages of science textbooks and write little about them in natural history books and magazines, FUNGI excluded. But lichens **are** worthy of our attention. As Lücking and Spribille (2024) and Zonca (2022) all point out, lichens are examples of the complexity of life in some of its simplest forms. According to these researchers, lichens also relay social and political messages. Their symbiosis, life via cooperation rather than "might is always right," is a lesson for us all.

Acknowledgments

Special thanks to the following photographers who freely shared their images.

Pieter van Heerden, Canada, https://www.flickr.com/photos/vanheerdenpieter/albums/72157625274096576/

Lotus Johnson, Canada, https://www.flickr.com/photos/ngawangchodron/albums/72157661116949054/

Joan Disley, Britain, https://www.flickr.com/photos/joans_stuff/albums/72157717129640503/

Richard Droker, USA, https://www.flickr.com/photos/wanderflechten/albums/

Javier Vecino, Spain, https://www.flickr.com/photos/jvecino/albums/

References Cited

Allen, J.L., R.T. McMullin, Y.F. Wiersma, et al. 2021. Population genetics and biogeography of the lungwort lichen in North America support distinct eastern and western gene pools. *American Journal of Botany* 108(12): 2416–2424; doi: 10.1002/ajb2.1774.

Barták, M., K.A. Solhaug, H. Vráblíková, et al. 2006. Curling during desiccation protects the foliose lichen *Lobaria pulmonaria* against photoinhibition. *Oecologia* 149(4): 553–560; doi: 10.1007/s00442-006-0476-2.

Bogale, A., M. Braun, J. Bernhardt, et al. 2020. The microbiome of the lichen *Lobaria pulmonaria* varies according to climate on a subcontinental scale. *Environmental Microbiology Reports* 16(3): e13289; https://doi.org/10.1111/1758-2229.13289.

Chavarria-Pizarro, T., P. Resl, T. Kuhl-Nagel, et al. 2022. Antibiotic-induced treatments reveal stress-responsive gene expression in the endangered lichen *Lobaria pulmonaria. Journal of Fungi* 8(6): 625; doi: 10.3390/jof8060625.

Daminova, A.G., A.E. Rassabina, V.R. Khabibrakhmanova, et al. 2023. Topography of UV-melanized thalli of *Lobaria pulmonaria* (L.) Hoffm. *Plants* 12(14):2627; doi: 10.3390/plants12142627.

Daminova, A.G., A.M. Rogov, A.E. Rassabina, et al. 2022 Effect of melanization on thallus microstructure in the lichen *Lobaria pulmonaria. Journal of Fungi* 8(8): 791; doi: 10.3390/jof8080791.

De Carolis, R., L. Muggia, and G. Bacaro. 2023. Lichen and lichenicolous fungal communities tested as suitable systems for the application of cross-taxon analysis. *Diversity* 15(2): 285; doi: 10.3390/d15020285.

Denison, W.C. 2003. Apothecia and ascospores of *Lobaria oregana* and *Lobaria pulmonaria* investigated. *Mycologia* 95(3): 513–518; doi: 10.1080/15572536.2004.11833097.

Gaio-Oliveira, G., L. Dahlman, C. Máguas, et al. 2004. Growth in relation to microclimatic conditions and physiological characteristics of four *Lobaria pulmonaria* populations in two contrasting habitats. *Ecography* 27: 13–28; https://doi.org/10.1111/j.0906-7590.2004.03577.

Grimm, M., M. Grube, U. Schiefelbein, et al. 2021. The lichens' microbiota, still a mystery? *Frontiers in Microbiology* 12: 623839; doi: https://doi.org/10.3389/fmicb.2021.623839.

Grube, M., T. Cernava, J. Soh, et al. 2015. Exploring functional contexts of symbiotic sustain within lichen-associated bacteria by comparative omics. *ISME Journal* 9(2): 412–424; doi: 10.1038/ismej.2014.138.

Lücking, R., and T. Spribille. 2014. *The Lives of Lichens*. Princeton, New Jersey: Princeton University Press.

MacKenzie, T.D.B., T.M. MacDonald, L.A. Dubois, et al. 2001. Seasonal changes in temperature and light drive acclimation of photosynthetic physiology and macromolecular content in *Lobaria pulmonaria*. *Planta* 214(1): 57–66; doi: 10.1007/s004250100580.

McMullin, T., and F. Anderson. 2014. *Common Lichens of Northeastern North America*. New York: New York Botanical Garden.

McMullin, T. 2023. *Lichens, the Macrolichens of Ontario and the Great Lakes Region of the United States*. Firefly Books Ltd, Buffalo, N.Y.

NatureServe. 2025. NatureServe Explorer. https://explorer natureserve.org/.

Nuzzo, L., G. Canali, P. Giordani, et al. 2022. Life-stage dependent response of the epiphytic lichen *Lobaria pulmonaria* to climate. *Frontiers in Forest and Global Change* 5:903607; doi: 10.3389/ffgc.2022.903607.

Petruzzello, M. 2025. Matthias de L'Obel Flemish-born physician and botanist. *Britannica* Retrieved March 1, 2026. (https://www.britannica.com/biography/Matthias-de-LObel).

Purvis, W. 2000. *Lichens*. London: Natural History Museum.

Ravera, S., R. Benesperi, E. Bianchi, et al. 2023. *Lobaria pulmonaria* (L.) Hoffm.: the multifaceted suitability of the lung lichen to monitor forest ecosystems. *Forests* 14(10): 2113; https://doi.org/10.3390/f14102113.

Richardson, D. 1975. *The Vanishing Lichens, Their History Biology and Importance*. Vancouver: Douglas David & Charles Limited.

Rogers, R. 2025. *Medicinal Lichens: Indigenous Wisdom and Modern Pharmacology*. Rochester: Healing Heart Press.

Schneider, T., E. Schmid, J.V. De Castro, et al. 2011. Structure and function of the symbiosis partners of the lung lichen (*Lobaria pulmonaria* L. Hoffm.) analyzed by metaproteomics. *Proteomics* 11: 2752–2756; doi: 10.1002/pmic.201000679.

Schofield, S.C., D.A. Campbell, C. Funk, et al. 2003. Changes in macromolecular allocation in nondividing algal symbionts allow for photosynthetic acclimation in the lichen *Lobaria pulmonaria*. *New Phytologist* 159(3): 709–718; doi: 10.1046/j.1469-8137.2003.00857.

Stanton, D., A. Ormond, N. Koch, et al. 2022. Lichen ecophysiology in a changing climate. *American Journal of Botany* 110: e16131; https://bsapubs.onlinelibrary.wiley.com/doi/full/10.1002/ajb2.16131.

Zonca, V. 2022. *Lichens: Toward a Minimal Resistance*. Translated by J. Gladding. Polity Press, Cambridge, UK.