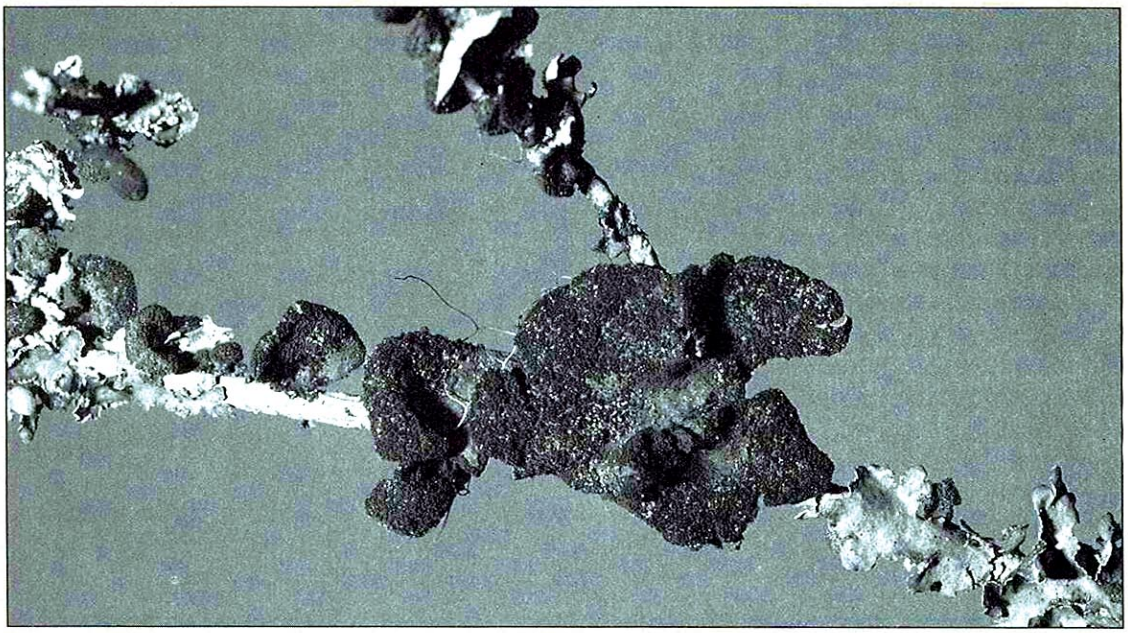
Living ANTIQUITIES



R.D. WILLIAMS

The tiny breathing pores on the surface of the peppered moon lichen (Sticta fuliginosa) *resemble craters.*

TINY LICHENS MAY HOLD THE KEY TO PROTECTING BC'S ANCIENT FORESTS

BY TREVOR GOWARD

CHAENOTHECA SUBROSCIDA IS A STUBBLE LICHEN. WORSE than that, it is a stubble lichen of lilliputian proportions: a brown, scraggly scrap of a thing about as inconspicuous as squirrel dung, and every bit as valued by humankind.

A more tenuous lease on existence would be difficult to imagine. For all economy, *Chaenotheca subroscida* asks only the trunks and branches of conifers. For neighbourhood, it requires only those ancient cedar-hemlock woodlands that, until lately, have been so much out of favour with those who manage British Columbia's forests.

Thus far I have told you nothing about *Chaenotheca subroscida* that could not be said of dozens of other lichen species. Not even the obligatory association with old-growth forests is out of the ordinary—for a lichen. Old-growth forests may not be particularly productive in terms of carbon fixation, but for lichens they are absolutely the last word in productivity.

The lowland old-growth forests of western North America are a thesaurus of superlatives. Home to some of the most majestic trees on the planet, they are living cathedrals of green-tinted light, filtered through ancient columns and arches of spruce, cedar, hemlock, and fir.

SINCE THE FIRST WORLD WAR, BC'S OLD-GROWTH forests have supported a multinational forest industry that claims, nowadays, 50 cents on every dollar earned in the province. Even if this figure is wildly exaggerated, it does point up the alarming rate at which old growth is being converted into chips and shakes and boards and pulp.

According to the 1991 federal "State of the Environment Report," approximately 250,000 hectares of forestlands are logged in British Columbia each year. In coastal areas, roughly

This dog lichen (Peltigera membranacea) *occurs in old-growth forests. It is one of approximately 30 species of pelt lichens in Canada—a group that is associated with many parasitic fungi that are specific to the genus. This association has led to suggestions that pelt lichens may be especially ancient, and could have evolved during the time of, or even prior to, dinosaurs.*

60 percent of the original old growth has been replaced by clearcuts or second-growth plantations. At current rates of cutting, most of the rest can be expected to disappear within the next few decades.

Not surprisingly, these forests have become the focus of some of the most acrimonious environmental battles ever waged in North America. Every year the register of skirmishes won or lost grows longer as the names of BC's old-growth forests—South Moresby, Carmanah, Clayoquot Sound, the Walbran, the Kitlope, the Cariboo Mountains—are transmogrified into practically the only war cries uttered on Canadian soil since Confederation.

In an effort to end the fighting, the government of British Columbia recently announced a comprehensive land use strategy that defines, among other things, the amount of land needed to "complete" BC's parks system. According to the plan, protected areas will be expanded from 6 percent of the province's land base in 1992 to 12 percent by the year 2000.

With the stopwatch now ticking, and with the future of hundreds of protected area proposals hanging in the balance, loggers, miners, ranchers, fishermen, resort operators, environmentalists, and three million-odd other British Columbians are scrambling to argue and substantiate approximately three million different points of view.

This is where the lichens come in. Although the inconspicuous organisms have played at most a minor role in the debate over land use in British Columbia until now, they have much to tell us about the forests we wish to protect. Old growth-dependent lichens are, in a sense, the minute hand on the clock of environmental continuity.

Putting aside their doleful lack of feathers and lamentable want of big soft eyes, they are eminently suitable companions for the spotted owl and the marbled murrelet as rallying points for environmental reform.

STEPHEN SHARNOFF

In Canada, **Pseudocyphellaria anthraspis** *(dimpled specklebelly, below) is restricted to coastal old-growth ecosystems. Found only in western North America, this lichen is easily recognizable because of its pitted surface and reddish fruiting bodies (apothecia).*

In this country, **Pseudocyphellaria rainierensis** *(old growth specklebelly, above) has been reported in only six localized pockets in BC. Because this species reproduces through fragmentation of the thallus (body), it has a poor ability to disperse. Restricted to the province's old-growth and antique forests, it is suseptible to eradication through habitat destruction.*

GRADE SCHOOL SCIENCE INSTRUCTS that lichens are a symbiotic relationship between a fungus and an alga. True though this may be, it is by no means the whole story. To say that a lichen is a symbiotic relationship between a fungus and an alga is a bit like saying a vegetarian is a symbiotic relationship between a

MARK HORSON

Old-growth dependency among lichens is a relative thing. **Cladina stellaris***—the most old-growth dependent of the reindeer lichens—first appears when the northern boreal forests it inhabits are at least 50 years old. While it is the last member of its family to set up housekeeping there, like all reindeer lichen it is an important food source for caribou.*

ADRIAN DORST

human being and tofu. Perhaps a more helpful way of putting the case is that lichens are fungi that have taken up agriculture.

Fungi, like animals (but unlike most plants), are unable to manufacture their own carbohydrates; to survive, they must extract sugars from other organisms. In the case of most fungi, the things fed upon—live trees, dead fish, decaying leaves, readers of *Nature Canada*, and so on—are much larger than the fungi themselves. Lichen fungi, by contrast, get their sugar fix from green algal cells much smaller than they. The cells are so minute that the lichen fungi actually cultivate them internally, between and among their fungal threads.

The lichen symbiosis, or intimate exchange of advantages between fungus and alga, permits it to function as if it was a single organism. Yet a lichen is really a community of organisms that, in some species, may involve three different cohabitants—a fungus, an alga, and a nitrogen-fixing cyanobacterium.

Whereas fungi usually live hidden away inside the things they feed on, lichen fungi, in most cases, live exposed to the open air. Organized like living fungal greenhouses, they satisfy their energy requirements and complete their life cycle on a stringent economy of air, water, sunlight, and dust.

WHILE MONEY IS SAID NOT TO GROW ON TREES, MANY lichens grow nowhere else. For them, trees are not simply convenient perches on which to build a nest or keep out of the rain, they are *alpha* and *omega.* In British Columbia, as in other parts of Canada, many lichens (known as epiphytes) depend for their entire existence on trees.

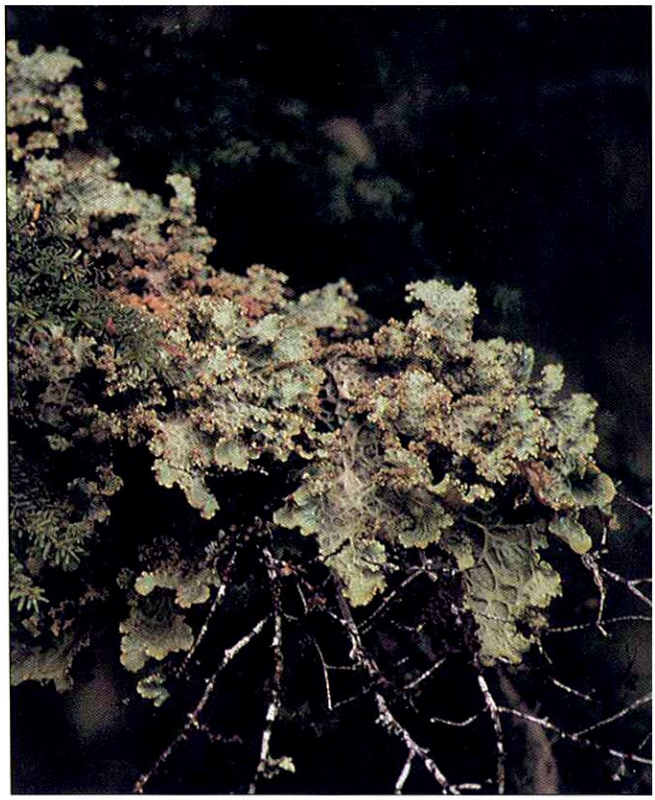
Epiphytic lichens, including *Chaenotheca subroscida,* do not feed on the trees they colonize, nor are they usually in the least injurious to them. To an epiphytic lichen, a tree is simply an address: a place to hang out without having to compete for

space with more aggressive members of the local flora.

While some lichens are important nutrient recyclers, others supply nesting material for birds and flying squirrels, and still others provide carbohydrates for hungry ungulates, including mountain caribou. A majority of epiphytic lichens, however, appear merely to fill the empty spaces in forest places. They are, so to speak, a form of biological chinking.

British Columbia is home to probably 1600 different species of lichens. No one has atempted to estimate how many of these are restricted specifically to trees, but an educated guess might put the figure at close to 300. In prime lichen habitat—say a well-ventilated forest in a region neither parched nor sodden—a hanging garden of 30, 40, or even 50 kinds of lichens may colonize a single tree, weighing in at up to three metric tonnes to the hectare.

Epiphytic lichens usually do not colonize all parts of their host tree equally. Some species thrive at the base, where conditions are moist; others occur only on bark permanently sheltered from rain. Some are found exclusively among the lower limbs, while others favour the crown. Everything depends on the availability of the particular set of microclimatic conditions for which the lichen has evolved.



STEPHEN SHARNOFF

The lettuce lung lichen (*Lobaria oregana, above*) depends on old-growth forests for survival. However, it has been found in younger forests on the Queen Charlotte Islands, where extremely humid conditions exist Old-growth forests (below) create microclimatic conditions that have no close counterpart in other ecosystems.

RALPH CURRIE

LIKE A MARRIAGE, A LICHEN IS NOTHING WITHOUT the working co-operation of its partners. Add too much or too little humidity, or shade, or heat, and the partnership dissolves. Unlike a marriage, however, failure invariably results in death. As a result, most lichens are particular about where they grow.

In general, one of the fundamental requirements of many lichen partnerships is that the lichen be wetted and dried at more or less frequent intervals. No conclusive explanation for this has yet been offered, but one promising guess has been advanced by Canadian ecophysiologist Kenneth Kershaw, formerly of McMaster University.

He theorizes that the lichen partners require different levels of thallus hydration for optimum functioning. The fungus, it would appear, performs best under moist conditions, whereas the alga is most productive under somewhat drier conditions. A periodic seesawing of thallus moisture appears to satisfy the needs of both partners.

Just how frequently the see must saw depends on the species involved, but it's safe to say that very few lichens tolerate continuous high humidity. This, together with competition for space from epiphytic mosses, doubtless accounts for the relative paucity of lichens in the wettest west coast rainforests.

EPIPHYTIC LICHENS ARE DISTINCTIVE IN MORE WAYS THAN habitat. Compared with soil-dwelling, rock-dwelling, duff-dwelling, and log-dwelling lichens, they are much more likely to have relatively small global ranges. Several species present in the forests of British Columbia are actually endemic to the Pacific Northwest of North America, occurring nowhere else on earth. Though endemics are by no means uncommon in other groups of plants and animals, they are much less common in lichens, especially at northern latitudes. More than two-thirds of lichens occurring in BC, for example, occur also in appropriate habitats across the northern half of the northern hemisphere.

Why is this?

There are several possible explanations, long distance dispersal among them. Another hypothesis has it that many, if not most, lichens evolved to their present form in the far geologic past—in some cases prior to the break-up, roughly 200

million years ago, of the supercontinent Pangaea.

If this is true, then many lichen species in existence today would have been in attendance as a majority of the dinosaurs came and went. These early evolvers have presumably had plenty of time to disperse across the globe. By contrast, many of the tree-dwelling lichens of the Pacific Northwest appear to have evolved rather recently.

ANOTHER DISTINCTIVE FEATURE OF EPIPHYTIC LICHENS IS that a disproportionate number of them are (or are soon likely to become) rather rare. In Sweden, for example, roughly 60 to 70 percent of rare lichens are said to occur exclusively in forested habitats. Though comparable figures have yet to be computed for British Columbia, there is no reason to suppose that similar ratios won't hold here as well.

The most obvious explanation for this high incidence of rarity is that many epiphytic lichens are uncommonly slow at getting established. Some species, in fact, do not seem to occur at all in forests younger than about a century or two. Presumably they are unable to withstand rapidly changing environmental conditions of the kind associated with young, upshooting trees.

Imagine yourself as a young, upstart lichen thallus clinging tentatively to a young, upstart conifer branch in a young, upstart forest plantation of pine or fir or spruce. The fact that you have germinated at all attests to the existence, here and now, of just the right mix of sunlight, wind, moisture, and humidity. Conditions a little lower in the canopy are probably too humid for you. Conditions a little higher in the tree tops are patently too parched. Here, however, on the branch you happen to be growing on, the world is your cloister.

Twelve months later, all that has changed. The treetops now loom a metre taller than before, and the forest canopy has enlarged to engulf your homestead branch in dense, continuous shade. Where once was dappled sunlight and a light breeze occasionally blowing, now there is only unremitting dampness.

Only the most ecologically enterprising of lichens find comfortable foothold in such a shifting, kaleidoscopic cosmos. It is perhaps not surprising that such lichens also tend to be the most abundant, the most widespread, and therefore the most secure, of their kind.

After about 100 to 150 years, however, the forest (if it is a Canadian forest) is likely to take a turn for the senescent. Because of decelerated growth rates, it is now a much more stable place for epiphytes than it used to be. And as a result of a much more open canopy (an artifact of windthrow), the sun penetrates a little deeper into the trees, and the wind blows a little more freely over them.

Such a forest, having attained these and other earmarks of old growth, has lately become a farrago of lichen-friendly nooks and crannies—many of which occur in no other ecosystem. At last there is habitat even for the most particular of lichens.

Consider, for example, the lettuce lung (*Lobaria oregana*). According to William Denison, of Corvallis, Oregon, this species—a lime-coloured leafy thing bordered in Elisabethan frills—can tolerate a wide range of temperatures while dry, but sickens and dies, when wet, at temperatures above about 15°C.

Fortunately, the old-growth forests in which it grows are excellent climatic buffers. Their canopies are said to absorb as much as 20 milimetres of rain before the lettuce lung is roused, through wetness, to physiological activity. By then, however, evaporation from the needles holds canopy temperatures within manageable limits. Is it any wonder that this species enters a regenerating forest later rather than sooner?

In an old-growth forest, there is suitable habitat for even the most finicky of lichens

AS A RULE, LICHEN COLONIZATION IN A MATURING FOREST occurs in two pulses. The first consists of various species of widespread distribution, and is essentially complete by the time the forest has reached the century mark. The second, more diffuse pulse doesn't really begin to register until 50 to 100 years later. It is comprised of species living at or near the ecological limits of their range; many will remain rare even once they do become established.

These phenomena are by no means peculiar to the conifer forests of western North America. Similar patterns have already been amply documented in Britain by lichenologist Francis Rose.

In the mid-'70s, Rose conducted inventories of the lichens of 102 oak and beech woodlands in different parts of the British Isles. When later he compared his species lists against existing land use records, he found a definite positive correlation between lichen diversity and forest age. This led him to conclude that some lichens may be regarded as "historical indicators of lack of environmental change, within certain critical limits, over long periods of time."

British forests undisturbed for many hundreds of years

typically support between 120 and 150 lichen species per square kilometre. The richest forest for lichens by far is the New Forest which, ironically, is anything but new, having apparently escaped the woodcutter's axe since at least the Middle Ages. It was found to contain an astonishing 259 species of lichens. By contrast, British woodlands dating from less than 200 years ago tend to support fewer than 50 lichen species per square kilometre.

Using these observations as a base, Rose constructed a Revised Index of Ecological Continuity (RIEC) designed to measure the extent of ecological continuity in a given woodland. The equation is a simple one: RIEC = n/20 x 100. Here "n" is the number of old-growth indicator lichens present at the site being examined. (This number is drawn from a list of 30 widespread epiphytes—and occasionally also ground-dwelling lichens—that seem to be restricted to ancient woodlands.)

Having constructed this scale, Rose used it to grade various British woodlands according to increasing or decreasing levels of past disturbance. For example, if n = 20, then RIEC is 100, whereas if n = 2, then RIEC is only 10. He found that a RIEC value of less than 50 "suggests either a much modified or else a secondary woodland."

At least two possible explanations can be offered to account for the greater diversity of epiphytic lichens in older old-growth forests. The first is that environmental conditions may have been more favourable to lichen colonization in the past than they are at present. According to this view (the "relict hypothesis"), some epiphytic lichens may be ecological leftovers: able to persist where already established, but currently incapable of dispersing to younger forest types nearby.

Here it is suggestive that climatic conditions from about 1350 to 1870 A.D., that is, during the Little Ice Age, were cooler, and therefore probably more humid, than they are today. The dispersal and establishment of some old-growth epiphytes might well have been favoured under such conditions.

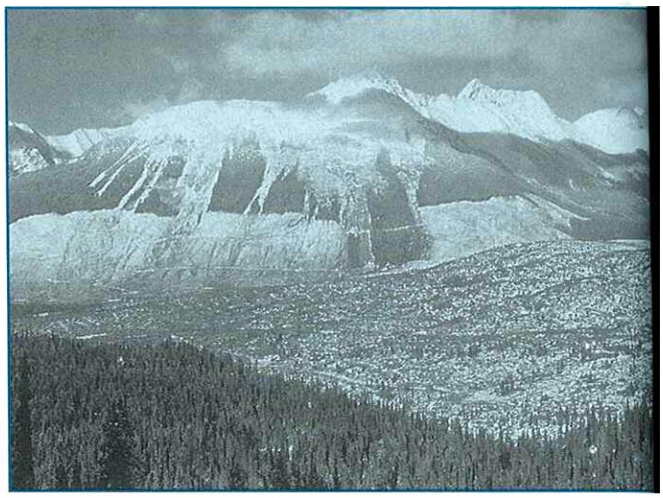
The second explanation is that older old-growth forests have simply been available for colonization over a longer period than younger ones. According to this view (the "petri dish hypothesis"), lichen colonization may be thought of as a series of random hit-and-miss inoculations by lichen propagules. In general, the rarer the species, the less likely that successful inoculation will occur (either because of propagule scarcity, or poor germinating abilities, or both), and the more likely that colonization will require the passage of many decades, perhaps even centuries.

In the British Isles, as in British Columbia, a 150-year-old forest will not acquire its full complement of epiphytic lichens for at least a century or two. That fact obliges us to think again about what we mean when we speak of "old growth."

Should an old-growth woodland 1000 years old be lumped, for the purposes of conservation, with one that is one-fifth that age? Both forests may appear identical to the untrained eye. But they clearly are not identical—whether as living archives of British Columbia's past, or as repositories of biological tradition.

"Antique forests," as I define them, are simply the oldest of the old: forests that have been around long enough to accumulate, among other things, a rich assemblage of old-growth epiphytes. Such forests seem invariably to be more than 300 to 350 years old, and may, in many cases, have been in existence much longer than the most ancient trees within them. This last point is important. A 150-year-old tree in a 500-year-old forest may well support more old-growth indicators than a 250-year-old tree in a forest dating from a fire of equivalent vintage.

ROSE'S WORK WITH THE ANTIQUE FORESTS OF BRITAIN raises the question whether a modified RIEC might be used to evaluate environmental continuity in the forests of British Columbia. Though no attempt has yet been made to adapt the RIEC to western North America, Steven Selva, of the University of Maine, has gotten good results with it in conifer forests in Maine and northern New Brunswick.



DOUG RADIES

In BC's Caribou Mountains, the thin strips of trees left behind after clearcut logging won't be enough to sustain old-growth dependent lichens like **Nephroma occultum.**

For each major forest type he examined, Selva constructed a separate RIEC index. With the aid of these, he was able to demonstrate strong positive correlations between RIEC values and forest age. He was also able to confirm the old-growth status of seven of the nine forests that had previously been designated as old growth in Maine.

Selva's work points up the possibility of simplifying the RIEC for use with a single family of lichens, the Caliciales. As a group, the Caliciales, or stubble lichens, including *Chaenotheca subroscida*, are remarkably faithful colonists of old-growth forests. The fact that antique forests tend to support many more of them than younger old-growth forests suggests these

lichens may be useful in helping to distinguish BC's antique forests from the rest.

IF OLD-GROWTH FORESTS ARE SCARCE AND BECOMING scarcer over much of British Columbia, antique forests are even more so. Except along the outer coast, where wildfires seldom burn, they have probably always been of limited occurrence here. At lower elevations, and prior to the days of Smokey the Bear, the only localities not routinely burned by fire were the valley bottoms. Not surprisingly, it is here that a majority of the province's most valuable antique forests are to be found.

Valley bottoms, however, are also attractive places for logging operations of the cost effective kind. It should come as no surprise, therefore, that antique forests tended to be among

R. D. WILLIAMS

The closest relatives of **Nephroma occultum**, *the cryptic paw lichen, live on the southern tip of South America. This lichen, thought to have been introduced to this continent by migrating birds, resides exclusively in valley bottoms of old-growth and antique forests on the west coast*

the first to disappear with the advent of logging. In the lower Fraser Valley and on eastern Vancouver Island, for example, many such forests had already been cut over by the early years of this century. Many of the rest are disappearing even as you read these words.

Until recently, the forest industry has tacitly and sometimes openly asked British Columbians to support the wholesale liquidation of old forests over large portions of the province. During the 1980s, the BC Ministry of Forests actually subsidized the practice of slashing and burning the province's original forests, and replanting them to more "productive" plantation forests. What went up in smoke during those years was not only some of western North America's most venerable trees, but also some of its most enduring biological traditions.

The question of how to maintain biodiversity and forest health in the face of continued cutting has provoked considerable debate. The majority response to date, as mentioned earlier, has involved an attempt to set aside representative old growth, and other forest lands, as parks, ecological reserves, and wilderness areas.

While this practice will doubtless slow the rate of decline among epiphytic lichens, it does not address the related issue of lichen diversity in those parts of the province that are not protected. Scientists argue that the existence of scattered islands of protected old growth and antique forests in a province-wide "ocean" of plantation forests cannot be adequate to ensure that British Columbia retains its full complement of old growth-dependent species into the long term.

ANOTHER APPROACH TO THE PROBLEM—ONE NOW supported by an increasing number of British Columbians—urges a complete revamping of current forestry practices. Several changes in harvesting techniques have been suggested in recent years, but certainly the most significant from the perspective of old growth-dependent lichens is the proposal to extend harvest rotations over much longer periods than the current 80- to 100-year intervals. The adoption, for example, of a 300-year rotation would go a long way towards maintaining lichen diversity in British Columbia's forests.

Not even this, however, would necessarily ensure the long-term maintenance of all epiphytic lichens. That objective will be realized only when antique forests are both protected and permitted to develop from currently existing old-growth forests on as many sites as possible.

It is probably safe to say that, all things being equal, old growth-dependent birds and mammals are well served by the preservation of younger old-growth forest types, e.g., 120-200 years in age. The same, however, cannot be said of old growth-dependent lichens. As a group, and in most parts of the province, they are well represented only in antique forests.

We are now on the cusp of decision. Any conservation strategy that fails to distinguish between differing degrees of age in old-growth forests is certain to result in the extirpation of at least some old growth-dependent organisms.

WHEN WE CLEARCUT AN ANTIQUE FOREST, WE DO MORE than liquidate a stand of old trees. We also destroy forest continuity. Though the individual trees may well be past their physiological prime, they are not beyond their ecological usefulness. As creators and maintainers of microhabitats that exist in no other ecosystem on earth, they are irreplaceable.

From the perspective of the organisms that depend upon these microhabitats, antique forests are the *sine qua non* of existence. Perhaps it is this, after all, that a certain scraggly lichen, as inconspicuous as squirrel dung, and every bit as valued, has been trying to tell us all along.

Trevor Goward, who lives in BC's Clearwater Valley, gives two-day, introductory courses in lichenology each September. He is also first author of a newly published volume on lichens entitled The Lichens of British Columbia: Illustrated Keys, Part 1, Foliose and Squamulose Species.