

Hardy Fern Foundation NEWSLETTER

Editor Sue Olsen ■ VOLUME 7 NUMBER 2 ■ SPRING 1997



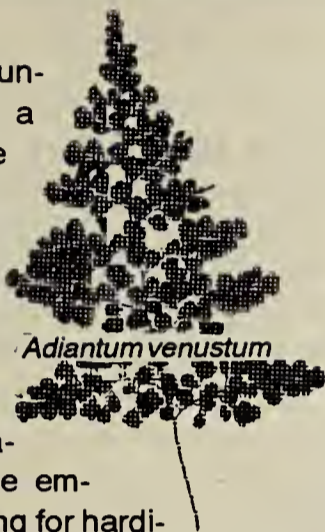
PRESIDENT'S MESSAGE

Sylvia Duryee

The Hardy Fern Foundation has come a long way in the nine years since Sue Olsen had a dream of growing all the species we could find. Here in the temperate climate of the Pacific Northwest the embryo idea of growing for hardiness began. In the beginning finding the spores of the known species was slow and I admit intriguing - you may remember that almost no seed exchanges included ferns. This has changed in these past years and the idea of testing for hardiness in other places developed. Today we have ten satellite gardens which do just that for us. Our mission at this time is to get the results out to you and the gardening world. Along this line I am pleased to announce that we have a new satellite garden in Texas, the Stephen F. Austin Arboretum in Nacogdoches which already has a fine fern garden under the direction of Roger Hughes.

All of you should consider visiting our satellite sites when you travel. As emissaries from our Foundation your comments are important - remember to send your thoughts back to our editor. Thanks!

Here in the Pacific Northwest we had another success at the Flower Show in February. The display was jointly presented with the Rhododendron Species Botanical Garden. Note that many questions were directed toward *Adiantum venustum*. We had a lovely display of this very hardy Himalayan fern. Unfortunately this creeping evergreen spe-



Adiantum venustum

cies is difficult to propagate from spore. Even with flooding the prothallia several times, success is very slow. (*I am happy to report that by exposing the spores to several hours of heat from an incandescent light as in a previous experiment with Arachniodes, I have a good crop of sporelings coming along. While this may not be particularly scientific, it has certainly increased production of heretofore impossible to propagate species.....Ed.*) So far the most success has been from dividing the growing tips from large stock plants. We usually have a few plants for our Fern Festival.

We hope to display even more species at the next Flower Show. This should be possible with increasing production in our hoop house at the Rhododendron Species Botanical Garden which is being managed by Michelle Bundy. She is growing species from spore, growing on young plants from other sources and taking care of our accession records. Also, she and Steve Hootman are responsible for fern sales at the Species Garden gift shop to profit both organizations. We are very happy to have her on our team!

The Bellevue Botanic Garden project is proceeding well and we expect to install many more ferns within the month. Wish them good growing.

We do have a Fern Festival coming in combination with our annual meeting June 6 and 7. See the schedule elsewhere in the newsletter. This year's lecture will feature "The Fantastic Ferns of New Zealand" with slides by Sue Olsen. Remember many New Zealand ferns grow well in our gardens and here is an opportunity to learn about more of them. We hope you all plan to join us.

Calendar

Hardy Fern Foundation and the Northwest Horticultural Society

FERN FESTIVAL

Friday June 6 and Saturday June 7
at the Center for Urban Horticulture,
3501 NE 41st St., Seattle, WA

June 6

Plant Sale 1:00- 4:00

HFF Annual Meeting 6:30

Lecture "Fantastic Ferns of New Zealand" by Sue Olsen 7:30

Plant sale continues

June 7

Plant sale 10:00 - 2:00

The sale will feature hardy and exotic ferns and companion plants including an extensive collection of hostas and other shade loving plants.

South Florida Fern Society 20th Anniversary Show and Sale

Fairchild Tropical Garden
10901 Old Cutler Rd., Miami, FL

June 14 and 15

More Inside:

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Hardiness Zone Information

By Tony Avent

Reprinted with permission from the catalog of Plant Delights Nursery

The revised hardiness zone map is based on average winter low temperatures. While the map is based on a tremendous amount of data, it isn't perfect. Cold temperatures are only one factor that affect plant hardiness.

Cold temperatures for one night are not the same as cold temperatures for a period of weeks, even though the same low temperature is reached in both cases. In many cases, a low temperature of zero degrees may cause cellular damage, that will start to heal if the temperature rises rapidly. If the temperatures remain low for several days, cell damage may continue, and result in the death of the plant.

In areas with lots of snow cover, plants may survive normally deadly winter temperatures, due to the insulating effect of the snow. Layers of ice, however, are different, as they tend to keep oxygen from reaching the soil and can result in the death of many normally hardy plants.

In areas with warm autumn nights, plants may die from not being acclimated to the cold weather, while plants in cooler zones that hardened off earlier might survive. Another overlooked, but very important factor is winter moisture. While many plants, especially southwest natives, can survive incredibly low temperatures, they cannot tolerate rain in the winter dormant season.

Another phenomenon, seen in England and in the cool areas of the west coast of the US is the difference in winter hardiness due to a lack of summer heat. In many plants, summer heat causes increased sugar production, which allows the plants to survive more stress in winter. In areas without summer heat, a particular plant may only be hardy to 20 degrees F, while in an area with hot summers, the same plant may easily be hardy to 0 degrees F.

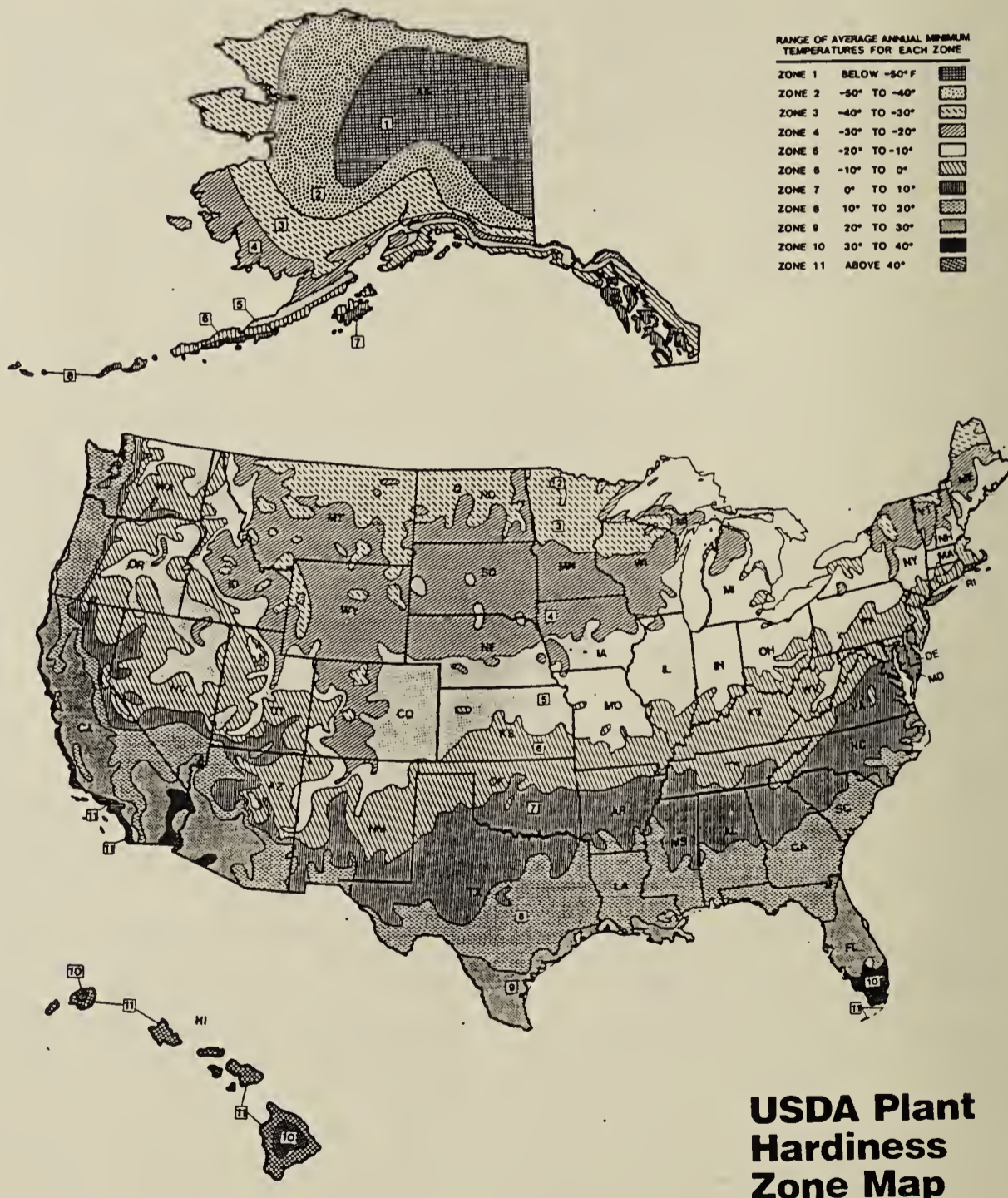
Also related to hardiness is the issue of fertilizers. Research has indicated that a fall application of a high potassium fertilizer (assuming the plants or soils are deficient) aids in winter survivability of many plants. Conversely, a fall application of nitrogen can make some plants continue to grow, causing them to be more susceptible to winter damage.

Our hardiness zone information (both cold and heat) is the result of trials by us and other keen plant collectors around the country. Our zone information relates only to the United States, and has no significant relation to foreign countries like California, which has its own zone map.

If no information exists, our computer randomly assigns numbers between 2

and 10 (we figure nothing worth having grows in zone 1). If you think our computer got a little carried away, please speak up. One of the draw backs to growing new and different plants is that there is no information on the plants or their hardiness. In some cases, we have been particularly conservative, possibly up to two zones too warm....if you are brave and like to try plants out of zone, we would love to hear your results...let us know if your results were achieved with or without snow cover.

If you enjoy growing plants in zones which are too cold, try to create microclimates. Microclimates are areas of your garden that are particularly protected, such as near a brick wall, near heat vents from the house, near a body of water, between two structures, in courtyards, or



other such areas. Good plant nuts can usually squeeze out an extra zone in either direction...that should build some egos!

As mentioned, the siting of marginal plants is critical. Marginal evergreens should be located on the north side of a structure or in some shade in the winter time. With the ground frozen, the evergreen foliage is desiccated since water given off to the sun and wind cannot be replenished. On deciduous marginals, a location in a sunny spot will allow the ground to warm, often making the difference in survivability.

Unmentioned, but not to be overlooked, are rodents that are active in the winter. Many reports of plants that didn't survive the winter temperatures, are actually plants that have become dinner to hungry rodents. Be particularly aware of voles, tiny rodents that tunnel around your plants (especially the expensive ones), and snack during the fall, winter and spring. A dead plant with a quarter sized tunnel nearby is a sure sign of voles. Check with your local extension service on eradication methods available in your area.

For further musings and just incidentally an outstanding selection of plants send Tony a box of chocolates or 10 stamps at Plant Delights Nursery, 9241 Sauls Road, Raleigh, NC 27603 and request a catalog. Ed.



Cultivation of Tree-Ferns in Cold Climates

Martin Rickard - Tenbury Wells, England

Tree-ferns are not reckoned to be very hardy, but quite a few can stand a few degrees of frost. I hope this is hardy enough to interest members of the HFF. I have been playing with these magnificent plants here in a cold part of the English West Midlands for some time and hopefully my experiences will be of interest.

In the early 80s I acquired my first plant of *Dicksonia antarctica*, I put straw over it in the autumn and never saw it again! In the mid 80s I was given a second plant, it had no trunk but fronds were about 1 yard long. For winter I lifted the fronds vertically and packed straw bales around the outside of the whole plant. I covered the lot with a glass sheet. That winter we dropped to 15°C and my little dicksonia did not mind at all. Encouraged by this first winter's success I acquired another plant of *D. antarctica* this time with a 3 foot trunk. This I planted next to the smaller specimen and protected it with polystyrene trays tied around the trunk with straw rammed down inside the polystyrene, the crown was covered with straw which was in turn covered with a polystyrene plate. This was then surrounded by a wall of straw bales around both plants. The top of the shelter was uncovered except in frosty weather when a sheet of polythene was pulled over the entire structure. In very cold weather this was supplemented by a sheet of space blanket. Both plants survived the next winter which was average with a minimum of -10°C.

Again encouraged by this success I experimented with other species in similar shelters:

- a) *Dicksonia fibrosa* a great success, from no trunk it grew to about 1 foot tall in 5 or 6 years.
- b) *Cyathea cooperi* survived 4 winters but did not flourish, perhaps it was too dry. The plant is now a fine specimen kept in a cold greenhouse.
- c) *Cibotium menziesii* like *Cyathea cooperi* this survived but did not flourish, probably for the same reasons.
- d) *Lophosoria quadripinnata* (from Mexico) as *C. cooperi*.
- e) *Marattia sp.* survived one winter, died during second. It must have survived temperatures around -5°C at least, temperatures outside the shelter were about -10°C.
- f) *Cyathea princeps* died after seemingly thriving for two winters and three summers. Perhaps it became too dry.
- g) *Cyathea australis* died during second winter, again, too dry?
- h) *Cyathea spp.* from Mexico as very young plants. Various unnamed species dwindled over two or three years. Larger plants may have fared better.
- i) *Dicksonia lanata* Tried twice, twice died first winter. I do not know why!

I recently moved, hence the transfer of some plants to a cold greenhouse. My *D. antarctica* plants have been replanted outside and I now have two techniques under test. 'Belt and braces' as described above although I no longer cover with a sheet in frosty weather. The second system is the same except the surrounding straw bales are not used. Both systems have worked well now for years. The leaves are always lost but the plant regrows.

Local to me, nursery stock of *D. antarctica* was left completely unprotected all winter except for a handful of leaf litter pushed into each crown. All plants with trunks 2 feet or more tall survived. This was an average winter for us with the minimum -10°C, but the cold weather at times went on for weeks with daily maxima often only -5°C. I had a similar experience in my unheated shed last winter when I lost a lot of plants with 6 inch trunks, these included *D. antarctica*, *D. fibrosa* and *D. squarrosa*, larger plants with trunks 2 feet or more tall were again fine, although I lost a newly imported 6 foot *D. fibrosa*. I think newly imported material needs special protection for the first winter until its roots are properly established.

So despite the failure quite a few successes. I know it is cheating to provide shelter but it is well worth it if like me you love tree-ferns. What experiences do HFF members have in this area?

Off to an Early Start - What Triggers the Germination of Fern Spores?

V. Raghavan - The Ohio State University

In the life cycle of ferns, a single-celled spore born out of a reduction division of the spore mother cell or sporocyte marks the beginning of the gametophytic phase. The gametophyte prepares for sexual recombination by the formation of sex organs and gametes. Fertilization, which is constrained by the requirement for free water, heralds the beginning of the sporophytic phase. It is the sporophytic fern plant that adorns the humble apartment flower pot as well as the well-manicured garden. Although the spore is the first cell of the gametophytic generation, development of the gametophyte itself begins with the germination of the spore. From the time the spore is set free in the atmosphere, it remains essentially a dormant cell. Compared to spores which germinate readily if placed in an environment that offers ample moisture, light, oxygen and a favorable temperature, dormant spores fail to germinate even when these conditions are supplied. Their germination can be provoked by a single essential factor. This characteristic is not only crucial to the survival of spores but also confers a boon to researchers who can study the factors that control their germination. The information obtained in this way using single-celled systems enable biologists to understand the mechanism of germination of multicellular seeds. In the short run, the knowledge makes it possible for the home gardener to try his or her hand at the game of inducing germination of the cloud of spores released by the fern and observe the complete life cycle in one's backyard.

Light Triggers Germination

What do seeds of higher plants and fern spores have in common? Both are dormant systems which can be awakened by the same triggers. Like seeds, light is one signal known to awaken dormant fern spores and cause them to germi-

nate. About 30 years ago, John H. Miller working at Syracuse University made a survey of the literature and found that out of about 80 species tested, spores of only seven species germinate in complete darkness. Erwin Bünning and Hans Mohr at the University of Tübingen in Germany had already studied in 1955 the light requirements for germination of spores of the male fern (*Dryopteris filix-mas*). The surprising conclusion that followed from this work about the light requirement is that germination of well-watered spores of very many ferns is promoted by red light in the range of 620 to 700 nm. The results were only marginally interesting by themselves, but what truly captivated the researchers was that red-light induced spores are inhibited from germinating if they are later exposed to far-red light (the wavelength between red and infra-red light, covering approximately the range of 700 to 800nm). It was also found that if far-red exposed spores are further irradiated with red light, the spores behave as if they have never seen any far-red light at all and germinate. The system is so precise because it responds maximally only to these two wavelengths of light; this was exactly what was observed with regard to the germination of seeds as lettuce (scientifically known as fruits called achenes). Traditionally, effects of light on a biological system are interpreted against a backdrop of a broad conjecture about the nature of the pigment. But in the early 1950's when the first results on lettuce seed germination appeared there was no pigment that fitted the strikingly characteristic red/far-red photoreversibility reaction. This photoreversibility was the touchstone that led to eventual isolation of the pigment, phytochrome, that controls germination of lettuce seeds and fern spores. As so often happens in science, investigators were studying the pigment that controls the flowering of photoperiodically sensitive plants - a seemingly unrelated problem at that time - when they stumbled into the first clues that a host of photomorphogenetic reactions in plants including flowering, seed and spore germination and expansion of leaves of dark-grown seedling is controlled by the same pigment.

The photoreversible property of phytochrome was attributed to its existence in two forms: a red-absorbing form (Pr) and a far-red-absorbing form (Pfr). The function of the pigment in fern spore germination is accomplished when red light converts the inactive Pr phytochrome into the active Pfr form.

The results with spores of the male fern were later confirmed in several follow-up studies, most importantly using spores of *Pteris vittata*, *Asplenium nidus* (bird's nest fern), *Cheilanthes farinosa*, *Ceratopteris thalictroides* and *Onoclea sensibilis* (sensitive fern), among others. To attack the deeper problem of how a red light stimulus is coupled to the germination of spores, Randy Wayne and Peter K. Hepler of the University of Massachusetts at Amherst capitalized on the phytochrome control of germination of spores of the sensitive fern. Aware of the propensity of calcium to function as a second messenger in animal systems, these investigators hoped that they could couple phytochrome-mediated photochemical reactions in the spore to changes in this ubiquitous metallic ion. The procedures employed worked beautifully. When calcium from outside the spores was eliminated by percolating them with a chemical that binds calcium (ethylene glycol-bis(β -aminoethylether)-N,N,N',N'-tetraacetic acid), it was found that their subsequent germination in red light is secured only in a calcium-rich medium. Moreover, the presence of calcium antagonists such as lanthanum and cobalt salts in the medium inhibits germination, whereas raising the internal calcium level in the spores by bathing them in the calcium ionophore A23187 potentiates germination even without red light. If increased calcium in the cell was promoting germination of spores in red light, then it should be possible to demonstrate increase in the calcium content of spores following exposure to a saturating dose of red light. That being the case, a sophisticated technique called atomic-absorption spectroscopy was used to show that exposure of spores to red light was followed by an increase in internal calcium; likewise far-red light decreased internal calcium. It has become evident

from these results that small molecules, including ions may have a regulatory function in germination, perhaps as a link in the signal transduction chain following photoreaction.

Gibberellic Acid Triggers Germination

Another substance that can trigger germination of lettuce seeds and spores of certain ferns is the plant hormone, gibberellic acid. Stimulation of dark-germination of spores of *Anemia phyllitidis* by this hormone reported in 1962 by Helmut Schraudolf, now at the University of Ulm in Germany was the first clear case of a specific chemical circumvention of light requirement in fern spore germination. This observation has been widely confirmed and extended by other investigators, but there is general agreement that the hormone is not a universal trigger for fern spore germination, as light is. Gibberellic acid induces high percentages of germination of spores of only a few additional species of *Anemia* and of the Japanese climbing fern (*Lygodium japonicum*). Spores of other ferns germinate sparsely or not at all in the presence of gibberellic acid in the medium. Given that the hormone can mimic the action of red light, it was of interest to know whether photoinduced germination of spores is modulated by the production of gibberellic acid. This issue is still unsettled; it might be that there is a common chemical substance that tantalizingly controls both red light-induced and gibberellic acid-induced germination of fern spores.

Beyond Light and Hormone

These experiments testify to the keen ability of dormant fern spores to recognize signals such as light and hormone and then germinate. Stimulated by these passwords, the spore channels its resources to a rapid burst of metabolic activity including synthesis of enzymes, digestion of storage reserves and the outgrowth of the rhizoid as the first visible sign of germination. Considerable experimental evidence now greatly strengthens the conclusion that the first proteins of germination are synthesized using

stored messenger RNA as templates. Because of the single-celled nature of spores, the biochemical and molecular changes that take place prior to the appearance of the rhizoid hold profound interest to explore many questions about spore germination and even the larger question of how germination processes unfold in the more complex seeds. Discoveries about the genes that are selectively activated during germination will position us to identify the first proteins of germination. Clearly our understanding of the factors that control germination of fern spores and their mode of action has advanced dramatically in the last few years. Yet, fern spores have lost their glamour at granting agencies as promising systems for investigations, since new ideas about phytochrome and the mechanism of its action during germination and potomorphogenesis have come from seeds and seedling of economically important plants. That is the frustrating part of working with germination of fern spores.

References

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V Raghavan is a Professor of plant biology at Ohio State University, where he has been a member of the faculty since 1970. Born in India, he studied botany at Madras University for a B. Sc. Degree (awarded in 1950) and at Benares Hindu University for an M Sc. Degree (awarded in 1952). He obtained a PhD in biology from Princeton University in 1961. Following two years of postdoctoral research at Harvard University he taught for seven years at the University of Malaya, Kuala Lumpur. Besides fern spores and gametophytes, his other principal areas of interest are plant tissue culture and embryogenesis.

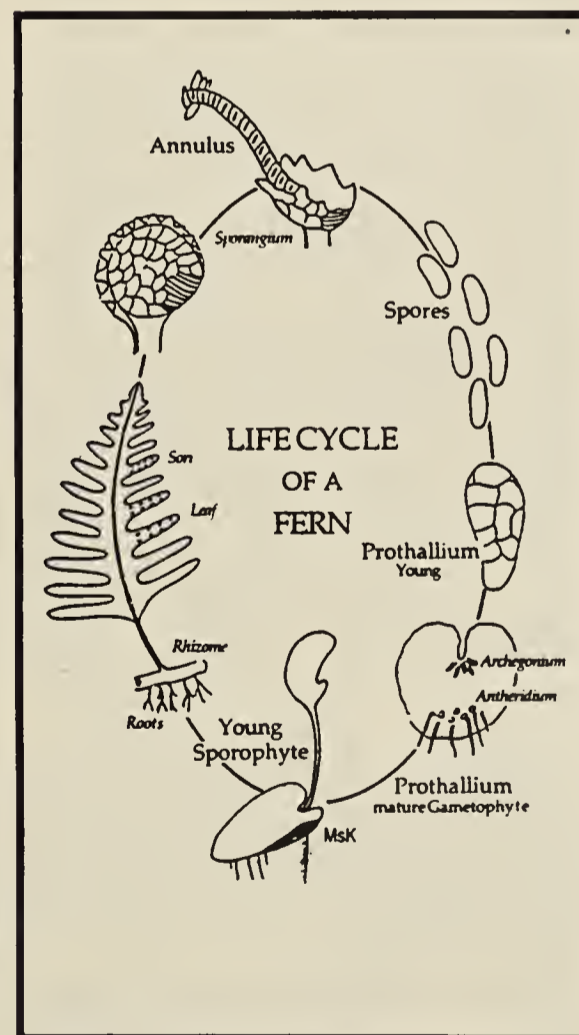
The Hardy Fern Foundation
NEWSLETTER

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Articles, photos, fern and gardening questions, letters to the editor, and other contributions are welcomed!

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Phyllitis scolopendrium

Hart's-Tongue Fern

James R. Horrocks

The old generic name for the Hart's-tongue fern was *Scolopendrium*, which was derived from the name of a centipede, *Scolopendra*, because of the fancied resemblance of the sori to the many legs of the centipede. These ferns are still referred to affectionately as "Scollies". The name *Scolopendrium* is now the species epithet. The name *Phyllitis*, from the Greek, "Phyllon", a leaf, is for the most part recognized as the generic name but some botanists unite the five similar species of *Phyllitis* under *Asplenium* since the two genera frequently hybridize in Europe. However, the double sori and the general shape of the fronds is quite distinct from North American *Aspleniums*, so, *Phyllitis* seems appropriate to distinguish the two genera.

The Hart's-Tongue fern, with its tongue-shaped fronds, is readily recognizable from other ferns and is not likely to be confused. There are essentially two major varieties of this species, virtually indistinguishable from each other. Var. *Americana* is the American Hart's-Tongue which is quite difficult to cultivate and has been considered as far back as the late nineteenth century to be one of the rarest of American ferns, mostly due to over-collecting. Var. *Scolopendrium*, the European Hart's-Tongue, is much more vigorous and responds rather well to cultivation if certain conditions are met. It is common in England as well as in parts of Europe. The European variant has also given rise to literally hundreds of varieties or forms. The fronds can be crested, crisped, undulate, dissected and even viviparous (plant bearing) Many are quite peculiar. Reginald Kaye writes: "Nature has excelled herself with the Hartstongue in composing so many variations upon a very simple theme." Even fronds of the type are variable enough that to wander through woodland colonies would scarcely reveal a single frond that would be a true textbook example.

The Hart's Tongue fern is generally a small to medium-sized plant inhabiting

woodlands and hedgebanks in limestone formations. It is also epipetric, that is, growing on rocks in damp areas. The rare American variant is limited to a few stations in New Brunswick, Ontario, New York, Michigan, Tennessee, and more recently, northern Alabama.

Description: The rhizome is short, upright and ascending, more or less branching and somewhat hidden by the nearly vertical stalks of the fronds. The stipe is variable in length, from a quarter to half the length of the frond. The blade can be up to three feet long in extreme cases of the European variant, but mostly, it is anywhere from 4 inches to about 20 inches in length, and 1 to 3 inches wide. The bright green fronds are subauriculate at the base and acute at the apex. They are typically strap-like and linear-lanceolate in outline. The margins may be slightly wavy, occasionally more so, but, rarely serrated. The apex may be digitate or crested. The midrib is rather stout and covered with soft white hairs when young, the hairs turning light brown to reddish in time. The sori are numerous, closely set in pairs on adjacent veins, facing each other, and when mature tend to run together. They are arranged in a herring-bone fashion, or, if you will, like the legs of a centipede, on the underside of the fertile fronds. The elongated indusium covering each sorus is rather silvery when young but disappearing as the spores mature.

Culture: All specimens in cultivation are of the European variety. The Hart's-

Tongue does best in a rather gritty soil in shade. The soil should be rich in humus but kept on the alkaline side by using ground oyster shells or small pieces of limestone. It is quite at home in a limestone rock garden but care should be taken not to overwater as it is

susceptible to root-rot. Good drainage is very important. Slugs and snails can be a problem so proper prevention should be observed. Hart's-Tongue can be propagated by inserting pieces of the stipe base into a propagating mixture. This is often preferred since spore culture may not always come true. Hart's-Tongue can be quite temperamental. In my own garden, I had a clump of eight or more crowns that thrived for several years, producing fronds up to 18 inches long. Strangely, in the spring of 1996, only a few fronds appeared from about 3 crowns. The fronds were only 8 to 10 inches long. I am still at a loss as to why. But I am optimistic. This spring my "Scolly" is still alive, by "golly".

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Phyllitis scolopendrium. Photo by Kim N. Durrant, Salt Lake City, Utah.

"Southern Alpines '96" And Beyond - Part II

Joan Elger Gottlieb



Mt. Cook and Mt. Ohau

The conference ended on January 10 and the next morning 38 of us left on a chartered bus for an eleven-day post-conference tour of the South Island - emphasis: alpine flora (what else?) It began inauspiciously with a stop at the ski area on **Mt. Dobson** (a front range basin between Fairlie and Tekapo, 85 miles southwest of Christchurch.) From the highest carpark in New Zealand (5530') we set stoic eyes on a cold, constant rain and heavy cloud cover that never lifted in almost three hours. Despite the miserable visibility it was easy to spot the fanatics. They donned waterproof pants and parkas and were out on the scree in search of their favorite "scab" plants, "cushions" and other ground hugging alpines above the hodge-podge of

shacks that passed for shelter.

That night the warm, dry Tekapo Alpine Inn felt like a luxury resort. Its location on **Lake Tekapo** was both picturesque and interesting. The eight-mile long Waitaki system of dams and canals was built in this area to supply 35% of New Zealand's hydro-power. The great river systems of the South Island generate so much electricity this way that the excess is sent by cable under the Cook Strait to supply the North Island which has 70% of the country's 3.5 million people. The enormity of all these power projects was a dominant visual experience during our travels (as was geothermal power when we traveled through the North Island) and our affable, native bus driver delighted in rattling off the productivity statistics of power plants and sheep paddocks alike. The Tekapo area thus has a lot of heavily disturbed land on which European lupine, Scotch broom, viper's bugloss and foxglove bloom and spread with abandon. The mouse-eared hawkweed (*Hieracium pilosella*) forms suffo-

cating mats over countless acres, making them unusable. Pretty to the eye of the casual tourist, these introduced species choke out native plants, obliterate bird nesting habitat and are called "noxious weeds" by environmentally sensitive New Zealanders. The original seeds of these unwelcome exotics were contaminants in batches of European grass imported for sheep grazing.

The weather was still marginal the next morning (Jan. 12) when we pushed west again to **Mt. Cook National Park**. This is the home of New Zealand's highest peak (Mt. Cook at 12,275'), nineteen other peaks over 10,000' and incredible glaciers (Huddleston, Tasman, Hooker, Mueller *et al.*) Helicopter lifts onto these rivers of ice and small plane flyovers were available options and some members of the group elected to participate. The opalescent blue color of the glaciers here is due to light scattering from dissolved oxygen in the ice. Permanent snow starts at 5,880' here, which is unusually low. In this World Heritage National Park the relatively easy Governors Bush Track and the trail to Kea Point offered good glimpses of mixed temperate rain forest and the Hooker Valley respectively. Some "calving" of the Hooker glacier was observed from the latter as was the ubiquitous Mt. Parrot. And, in the magnificent beech (*Nothofagus menziesii*) - podocarp (*Podocarpus hallii*) forest along the Bush Track there were several different *Blechnum* species (including *B. fluviatile*), as well as *Grammitis billardieri*, *Asplenium flaccidum*, *Hymenophyllum* spp. and *Lycopodium scariosum*. But the most memorable pteridophyte here was *Lycopodium varium*, the only epiphytic clubmoss in New Zealand. It forms massive clumps on old tree trunks and has long, pendulous, primitive strobili. Interestingly, it also has a terrestrial form which we saw making smaller, upright-growing, curly-tipped colonies on mossy forest ledges.

The cool, moist temperate forests of southern New Zealand are Gondwana remnants - leftovers from the late Permian-early Triassic eras (200-250 million years ago) when the continental masses were merged in a huge super-continent. After drifting apart, each land area developed along its own evolutionary path and in New Zealand you can still see rem-

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nants of earth's oldest land flora, deliciously rich in ferns.

Glaciers form here (and elsewhere) because less snow melts each year relative to the amount that falls. Alpine zones (ca 3,000' expanses between treeline and permanent snow) are found at varying elevations around the globe and are not so much related to elevation as they are to warmth and duration of the growing season. In North America timberline is typically at about 11,500'; South America has the highest timberline at 15,400'; in New Zealand it can occur as low as 3,000' because of locally severe conditions. In addition, New Zealand's present mountains resulted from uplifts which occurred only five to six million years ago, and, are notably young in the geological sense.

We left Mt. Cook N.P. reluctantly, wanting to return to explore its amazing scenic, geologic and botanic treasures at greater leisure and in clearer weather. From here our now familiar bus and group headed south, along the western shore of Lake Pukaki toward the town of Twizel where there is a recovery program for the endangered Black Stilt, a red-legged shore bird. Our final destination for the day - the Lake Ohau Lodge. Accommodations there were spartan, but home-cooked meals were delicious. New Zealand visitors beware - desserts are abundant, rich (whipped cream *über alles*) and irresistible after long days on road and trail. "Hokey-pokey" ice cream, a New Zealand specialty flavor loaded with toffee pieces, adds to the calorie problem at bus pit stops as do the soft, peppermint "Mintees" candies distributed on the bus - SIGH!

Our third day, Jan. 13, was spent botanizing above the **Ohau ski field** (6,400') to which we ascended in a 30+ year old mini-bus owned by the lodge. We had to hike up the last mile of the narrow, zig-zag gravel road when the vehicle developed a vapor lock, but it did finally get to the ski shelter to take us back at the end of the day. Along the road golden spikes of Maori onion (*Bulbinella angustifolia*) were abundant and in the high alpine zone above the ski area (near the permanent snow) we had some close encounters with magnificent masses of "vegetable sheep" (*Raoulia eximia*.) From afar, the woolly, gray, compressed shoots of these tap-rooted mat shrubs look like

sheep grazing among rocks. Up close, their fuzzy, round, boulder-hugging branchlets bear tiny, composite flowers, typically missing showy bracts and, therefore, insignificant in appearance. There are 21 species of *Raoulia* plus hybrids in New Zealand, making it the largest endemic genus. A remarkable 75% of New Zealand's 2,400 native species are endemics (found nowhere else) and about 500 of them occur in the mountainous regions.

There were several new species of *Hebe* at this site as well as a dozen different *Celmisia* (including a hybrid.) Mats of *Celmisia sessiliflora* with its delicate, daisy-like flowers virtually enthroned on silvery, lance-leaved foliage were particularly notable. Among the ferns here were clumps of *Polystichum cystostegia*, creeping colonies of *Hypolepis millefolium*, nook-hiding plants of *Cystopteris tasmanica* and the ever-present *Lycopodium fastigiatum*. In keeping with the alpinists circumscribed focus, the "complete" plant lists we were given for each site did not usually list any ferns. The Ohau list was exceptional; it had two of the four. A notable feature of the alpine angiosperms in New Zealand was the monotony of flower color, white, yellow and pale lavender being the only ones encountered. There was a lot of discussion about this and the explanation seemed to relate to the narrow color perception of the early pollinators available here (mostly insects) in the high country. The Andes, Rockies and other high mountains around the globe have a more colorful flora and a wider selection of pollinators, although all alpine zones worldwide have about the same total number of plant species, +/-200, interesting factoids!

Back at the ski shelter we were rewarded with sweeping views of **Lake Ohau** and the front range mountains; the morning cloud cover had lifted for a brilliant afternoon in the sun. And a nature scavenger hunt after dinner that evening turned up a very interesting, miniature mistletoe, *Korthalsella salicornioides*, growing near the lake on matagouri shrubs (*Discaria toumatou* - New Zealand's only native thorny shrub - a bizarre-looking, viciously-armed member of the Rhamnaceae, also called "Wild-Irishman" by the locals.)

Cromwell and Bendigo Gold

On Jan. 14 we pushed farther south, meandering through the **Lindis Pass** in the front range, a beautiful, breeze-tossed tussockland reserve, dominated by *Agrostis capillaris* amid limestone outcrops. Our destination - the historic Bendigo gold mining area in the arid hills near **Cromwell** in Central Otago Province. In 1862 alluvial gold was discovered here at the junction of the Clutha and Kawarau Rivers and the area quickly grew into a chaotic mining center. Dredging quickly replaced panning and reached a peak in 1902, gradually declining, but experiencing renewed flurries of activity when gold prices rose. After the depression of the 1930's most of the gold miners turned to small farming and Cromwell is now the "Fruit Bowl" of the south, producing the delicious apricots, peaches and cherries we sampled with relish.

The hot, dusty trail up into the **Bendigo Station** and its 19th Century mining settlements (now abandoned and part of a reserve) led past remnants of a pine tree farm, large mullock's (mounds of mine tailings) and several mine shafts, including a massive one 582' deep, dug with an "electro-dynamic exploding apparatus" (explosives set off with a battery-operated detonator.) There were outstanding views of the Clutha River valley, encounters with dry-country Marino sheep raised only for wool, and open, desert-like expanses dotted with blue-green and gray-green "scabweeds" (*Raoulia* spp.) and two xerophytic ferns - *Cheilanthes humilis*, nestled in the shaded bases of open-area rocks and the delicate, tip-rooting *Asplenium flabellifolium*, hanging from grooves in boulders and trees in the shady wooded area.

From Cromwell the bus followed the north bank of the powerful Clutha River where the controversial and expensive 400 megawatt Clyde Dam and power plant (largest concrete structure in New Zealand) was completed in 1993 on the earthquake fault that runs through New Zealand's center. Because of the geologic sensitivity of the area, the dam had to have a flexible rubber bed and came in three times over budget (sounds familiar!) Lake Dunstan, formed by the dam, is still filling and has become a trout fishing mecca. It was a long day and we were happy to crash at the Centennial Inn

Motor Court in **Alexandra**, the town with the eleven-meter diameter electric clock built near the top of the town hill in 1968.

The Old Man and The Remarkables

The best of the tour was yet to come, starting the next morning (Jan. 15) with an adventuresome four-wheel drive safari into the **Old Man Range**, just 6 miles south of Alexandra. The day was well-paced by John Douglas and the drivers of Safari Mountain Excursions, including morning and afternoon "teas" and excellent handouts on the natural history, flora and fauna at each stop. The Old Man is one of several uplifted ranges in Central Otago Province. Its crest is a rather flat plateau studded with huge, erosion-resistant schist rocks ("tors.") The largest of these landforms is an 87' high obelisk called Old Man Rock which gives the range its name and its highest point - 5,575'. From here, on a clear day, there are panoramic views of the Southern Alps, including Mt. Cook to the north and the Remarkable Mountains to the west. The expansive, open conditions produce severe weather, with only 73 frost-free days per average year. The whole scene resembles a vast moor of grassy hummocks interspersed with open rock and cushion-plant fields. Nineteenth century livestock grazing, burning and the introduction of the rabbit for sport hunting and meat laid bare enormous tracts of the range. Much of the original, fragile, fescue-tussock grassland is now covered with native scabweeds (*Raoulia* spp.) and introduced thyme (*Thymus vulgaris*), stonecrop (*Sedum acre*), sheep sorrel (*Rumex acetosella*), hawkweeds (*Hieracium* spp.), California poppy (*Eschscholzia californica*) and many other exotics, colorful and showy, but disastrous competitors for the native flora.

There were stops at **Mitchells Cottage** - the unusually sturdy, stone home of a gold mining family at the turn of the century and at an alpine wetland - home to several rare plants, including *Geum pusillum* and *Parahebe trifida*. Trail bikes have contributed to the damage seen here and tourists, botanists *et al.* add to the problem. Amazingly, the plants were healthy and bright green. At **Campbells Basin**, an old glacial cirque, we saw impressive specimens of the giant spaniard, *Aciphylla scott-thomsonii*

(Umbelliferae,) which has separate staminate and pistillate plants, some of the latter displaying spring flower stalks which had gone to seed. *Aciphylla* is another distinctively New Zealand genus with 38 of its 40 species confined to the country. It is aptly named, for the spear-pointed leaves formed in tight masses can pierce human flesh at the most casual contact.

The best botanical treats awaited us in the mid-altitude snow-tussock zone where *Ophioglossum coriaceum* was found in a moist area among short turf grasses and in the alpine herb-fields where *Gentiana amabilis* was opening cream-colored blooms. The rare, alpine fern, *Grammitis poeppigiana* formed a nice mat in a rock indentation. Its minute fronds were only 3/8" long with a few round sori near the tips. *Ranunculus pachyrrhizus* formed striking clumps of bright yellow at the edge of a melting snow field. It seemed that virtually every New Zealand peak had its own species of buttercup (and other alpines,) in keeping with the long evolutionary isolation of these mountain "islands." Cave wetas (large, wingless grasshoppers) were glimpsed under rocks where they scavenged rotting vegetation. These Gondwana relics are being decimated by introduced omnivores like the opossum. More common under rocks were native roaches, well-adapted survivors everywhere. South Island Pied Oystercatchers nest in the cushion fields on the Old Man and several birds were sighted. All in all, it was an exciting and insightful, albeit bumpy journey into one of New Zealand's most unusual areas and an opportunity to share its secrets and study the problems that have beset the country from past mistakes. Thanks were deservedly given to our expert guides and drivers for it is very easy to lose one's sense of place and direction in the labyrinth of rutted tracks traversing the Old Man.

Jan. 16 was a travel day from Alexandra to Queenstown. There was a brief stop to gape at the bungee jumpers dangling from the A.J. Hackett Bridge over the Kawarau River - the place where this "sport" originated. Then we headed through the **Remarkables** - high bluffs of hard, schist rock forming a long spine of the front range. These uplifted mountains have been shaped by glaciers and

are home to several large ski fields. Alpinists go where ski roads take them, so the one to **Mt. Rasburston** was our botanizing place en route. The area is a typical *roche moutonee*, a gentle, round knob of bedrock sculpted by ice, perfect for a ski slope. A relatively steep trail above the ski lift led through fellfields and rock bluffs where many of the tussock-scrub and alpine plants we had seen elsewhere were flourishing. Then, suddenly, the scene opened onto Lake Alta, one of those exquisite high country glacial cirques hidden from view until you turn a crucial corner. One end of the lake was bordered by an interesting "solifluxion" field - a geomorphologic term for rock that has been moved by freeze-thaw cycles. It was the perfect place for lunch, which we enjoyed in the company of a colorful "man-of-the-mountain" botanist and a young N.Z. Department of Conservation naturalist who was educated at the University of Michigan before marrying a "kiwi." It is, indeed, a small world.

Notable plants around the lake included cushion-growing *Coprosma* shrubs (Rubiaceae,) literally blanketed with orange berries and white-flowered *Chionohebe densiflora*. There were rosette clusters of the rare, endemic and very locally distributed *Hectorella caespitosa* (Hectorellaceae,) with canary-yellow flowers following tight spirals of tiny leaves, the whole resembling Lilliputian "hens and chicks." On the way back we took note of another spaniard, *Aciphylla aurea* growing among the tussock grasses along with the now familiar *Lycopodium fastigiatum*, *Blechnum penna-marina* and *Polystichum vestitum*. The winding road down from the ski area was, itself, remarkable, with wide-canvas views of the valley formed by the Kawarau and Shotover Rivers and the S-shaped Lake Wakatipu with the city of Queenstown nestled in its curves - a perfect scene for a grand, impressionist painting.

Queenstown is small - only 9,000 residents, but, as a prime shopping area for local and imported goods, it is very prosperous with zero unemployment and the most expensive real estate in New Zealand. We enjoyed a late afternoon

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lake walk at the periphery of the Botanical Gardens and left the shopping to the "tourists." There was a Kiwi and Birdlife Park below the Skyline Gondola in town, both interesting attractions if we had had more time - a constant frustration.

Fiordland's Milford "Sound" and Gertrude Valley

Tours wait for no one and the next day, Jan. 17, we left Queenstown and headed south, then east to the town of Te Anau on a many-fingered lake of the same name. **Lake Te Anau**, largest on the South Island, forms the eastern boundary of New Zealand's wildest natural reserve - **Fiordland National Park** which extends all the way to the Tasman Sea. Limestone, glow-worm caves are located near Te Anau (New Zealand glow worms are the bioluminescent larvae of a gnat, *Arachnocampa luminosa*) but the most accessible attraction here is a wild bird reserve at the Burwood Bush Centre. Among many beautifully plumed, native birds displayed here is the rare takahe (*Porphyrio mantelli*). Thought extinct, a small colony of the birds was discovered in Fiordland's Murchison Mts. in 1948. With strong red deer control in place, 200 of these red-beaked, flightless, gallinule birds are now living in their native, high-altitude grasslands, where they pull up shoots and feed on their succulent bases. With respectful awe, we watched that remarkable feeding activity in the takahe's large, grassy pen. It is also worth noting that bracken fern, *Pteridium esculentum*, grows in exquisite, cinnamon-croziered abundance along the deep blue lakeshore at Te Anau.

The most scenic and dizzying drive of the trip awaited us the next morning, Jan. 18, as we headed north along the lake to the mountains of the main divide, through an engineering marvel known simply as the Homer Tunnel into the Milford Fiord area. We had to be at the tunnel by 5:00 PM to make our 7:00 PM overnight boat trip into Milford "Sound," so the bus trip was tightly timed. Only brief stops were allowed, first at **Klosk Creek** - a tantalizing, primeval forest reserve of red and silver beech, where the rainfall is the highest in the world (over 395"/year.) This wetland area was bursting with epiphytic *Grammitis*, *Hymenophyllum*, *Asplenium* and more, with too little time to enjoy it all. A "gentlemen's agreement" alternates

bus traffic direction through the narrow tunnel every half hour and navigating its long, dark, rough-hewn rock interior was an adventure not recommended to the claustrophobic.

Emerging from the tunnel into the untrammelled wilderness of Fiordland N.P. we had our best encounter with the pristine glory of New Zealand before the arrival of humans. A short hike in the **Chasm Tree Fern Forest** put us into a mature stand of *Dicksonia squarrosa* and *Cyathea medullaris* with epiphytes galore and an incredible variety of mosses resembling filmy ferns to a confusing extent. A nice fern find here was the endemic, osmundaceous "heruheru," *Leptopteris hymenophylloides*, its large, tissue-thin, tripinnate fronds bearing scattered sporangia (no sori,) giving new meaning to "feathery." In this forest it was not difficult to imagine a time (less than two thousand years ago) of giant moas, kiwis and other ratite birds, of no mammals (other than bats,) of archaic tuatara lizards and skinks (but no snakes) and of unspoiled forests of tree ferns, cycads, podocarps and southern beech. Alas, humans have not exactly wrought any improvement here!

The Wanderer, a modest, but adequately comfortable ship was our overnight home that night on magical **Milford "Sound."** It is, in fact, a true fiord - glacial in origin and U-shaped, with its entrance to the Tasman Sea deeper than the adjacent sea floor. After a breathtakingly beautiful trip past its vertical rock sides, dripping with waterfalls from hanging valley lakes, we arrived at the mouth of the fiord, its north headland prominent on our right and the Anita Bay lighthouse perched on our left in a greenstone (type of jade) area - just in time for a hot, and very welcome, shipboard dinner. The captain turned the ship around and traveled about half way back up the fiord to sheltered Harrison Cove where we spent the night. There was enough daylight left to take a small craft to the pebbly shore nearby and explore the tree fern - rata forest, photograph the leathery-leaved *Asplenium obtusatum* subsp. *obtusatum* and fend off hordes of hungry sand flies. Sleeping bunk-bed style that night in small cubicles was not the lap of luxury, but getting up at 2:00 AM to a jet-black, star-studded southern sky was ample reward. At 9:00 AM we were back at our bus,

headed once more for the Homer Tunnel.

Scheduling foul-ups by other tour buses headed for Milford Sound found them out of synch with the one-way agreement and found us confronted by several oncoming buses in a space barely minimal for two ordinary cars. There were literally millimeters of clearance as our daring driver maneuvered us through the squeeze and, as we emerged unscathed into the sunlight once more, the entire group erupted in a spontaneous round of applause. Our botanizing locale for the day (Jan.19) was the **Gertrude Valley**, just east of the tunnel in the heart of Fiordland. Steve Newall, a local field enthusiast and *Ranunculus* expert, led us through a low wetland area, to a finger-shaped beech forest (where a colony of the primitive *Huperzia* (*Lycopodium*) *australianum* grew on a moss-covered boulder) and up onto an alpine meadow at 2,600'. At this elevation we reacquainted ourselves with flowering gentians, Mt. Cook "lilies," mountain daisies and all the other high altitude gems that had become a familiar part of our field repertoire. It was also a perfect spot to eat lunch and watch a "snowfall" - a cascade of snow breaking from a high shelf. We found a second species of Maori onion here - *Bulbinella gibbsii* subsp. *balanifera*. Pushing ever onward and upward, our ultimate quarry was finally in view - a waterfall area dotted with clear yellow flowers of *Ranunculus sericophyllus* and pure white blooms of *R. buchananii* - two more rare mountain buttercups evolving in isolation. Quite a delightful sight and worth the effort to see!

The Borland Saddle

By mid-afternoon we were back in Te Anau and had time for a long walk around the lake and the bird reserve, renewing friendship with the takahe, shelducks and other avian residents. The next morning (Jan.20) we headed south to the **Borland Saddle** via Lake Manapouri and New Zealand's largest (700+ megawatt) hydro plant, built underground to avoid despoiling the wilderness character of Fiordland. Access to the Saddle is by a power company maintenance road only recently opened to public use. The beech forest ravines and clearings bordering the road were lush habitats for many *Blechnum* species, great colonies of

Polystichum vestitum, *Hypolepis*, *Hymenophyllum*, *Lycopodium sarmentosum* and *L. fastigiatum*. The lush understory contained flowering shrubs like *Pimelea traversii* (Thymelaeaceae) and *Olearia ilicifolia* (Compositae.). At the top of the road a five-passenger helicopter ferried us in turn (H-E-L-P!) onto the highest part of the saddle (4,440') where the scene was quite other-worldly. There were clouds swirling around our heads, sub-alpine grass scrub and tiered kettle ponds at our feet and views of the Southern Alps stretching to the horizon. Among the new alpine species here were charming plants of a small spaniard, *Aciphylla congesta*, in full bloom, its sharp-tipped shoots forming dwarf, multiple tufts. The compact inflorescences were packed with tiny, white, umbelliferous flowers - a "piercing" charmer!

The Catlins Coast and Return to Christchurch

After an overnight stay in the coastal city of **Invercargill** (an enclave of Scots,) we pushed east on Jan. 20 along the scenic, southern **Catlins Coast** (where the movie "The Piano" was filmed.) First stop of the day was the old whaling station of Waikawa, site of Curio Bay where Jurassic era (180 million years old) volcanic ash buried cycad and kauri (podocarp) tree forebears along a warm flood plain. Now uncovered, the petrified remains of this ancient forest stand out strikingly against the giant kelp and blue surf of the South Pacific.

Next we explored a modern podocarp forest at **Lake Wilkie**. The trail wound down a fern-rich ravine to a wide waterfall before ending at the lake. Beautiful tree ferns here towered over colonies of *Blechnum*, *Grammitis* and *Asplenium*. A brief detour to Florence Hill Lookout on a high bluff above the ocean offered riveting views of Tautuke Beach and across the Foveaux Strait separating New Zealand's South Island and Stewart Island. Lunch was at **Papatowai Beach** where we found fruiting specimens of the glossy five-finger shrub, *Pseudopanax arboreum* and pollen-shedding specimens of *Podocarpus totara*. Mats of hound's tongue fern, *Phymatosorus diversifolius* clung to tree branches spreading out over the beach. There is lots of deer husbandry in this part of New

Zealand. To overcome the gamey flavor of venison, ranchers have crossed red deer with American Wapiti (elk) and the resulting meat, is, indeed, tender and delicious. But the toll on New Zealand's landscape is extreme when paddocks replace podocarps. Vegetarianism, anyone?

Another detour to **Purakaunui Falls** in a red "pine" area (*Dacrydium cupressinum* - a podocarp) yielded an interesting *Blechnum discolor* with incompletely dimorphic leaves. Finally we arrived in **Dunedin** on the east coast of the South Island, our overnight stop in a city known as the "Edinburgh of the South." Settled by Scotch Presbyterians during the Otago gold rush of the 1860's, it enjoys a beautiful location at the inner end of Otago Harbor and a large, hillside botanical garden famous for its collection of native flora and its large rock garden. After touring this steep garden we were ready for a dinner cruise on a small craft, euphemistically named the "Monarch," to **Taloroa Headland** on the **Otago Peninsula** northeast of the city. This is a seabird sanctuary home to nesting Royal Albatrosses, common Spotted and rare Stewart Island Shags (Cormorants,) Yellow-Eyed and Erect-Crested Penguins and more. Southern fur seals, dolphins and whales are frequently seen here as well. Marring this promising excursion was some very threatening weather, an entrapping sand spit and a bad case of seasickness for the writer.

The next morning (Jan. 21) there was a final foray on the Otago Peninsula to Cor Fluit's garden and aviary. This private garden featured a rare, ancient subspecies of *Helichrysum selago* among many beautifully grown New Zealand native plants. But, the special treat here was a serendipitous find of two specimens of *Tmesipteris tannensis*, a relative of the whisk "fern," *Psilotum*, in a fern-filled corner. It was the Devonian era (350 million years ago) relic I had hoped to see in New Zealand (its only native home) and was disappointed to learn of its now endangered status following habitat destruction and overcollecting (largely for North American herbaria.) It is normally an epiphyte of tree fern leaf bases, dangling 6-18" down from its perch, but here in the Fluit's garden it was on the ground, growing in mulch made from tree fern "bark." These tiny fork "fems" (so-called

for their forked fertile leaves, each bearing a pair of fused sporangia on the upper surface) were my three-scream treat, and best of all, my pictures came out perfectly.

The last leg of our tour - back to Christchurch - was along Coast Highway 1, through the popular retirement community of Palmerston and past Shag Point, where it is thought the Maoris may have first arrived in New Zealand. The Maoris, who replaced New Zealand's indigenous tribes soon after arriving ca 400 A.D., are a people whose past is unknown; their language has similarities with Japanese; their culture is polynesian (probably Hawaiian;) and their appearance is most like that of Alaskan Eskimos. An interesting lunch stop at **Moeraki Beach** provided a final geologic wonder - large, perfectly spherical boulders on the sand which eroded out of mudstone cliffs bordering the shore. They formed during the Paleocene (60 million years ago) when concretions of calcite mineral in ground water crystallized around organic "nuclei" under conditions of equal surrounding pressure and subsequent dehydration and shrinkage. It was a real show-stopper end to a terrific trip. Plant lovers beware! Because New Zealand is so botanically important and unique (even though its area is no greater than the state of Colorado,) you will need more time than you imagine to get a satisfying sampling of its natural riches.

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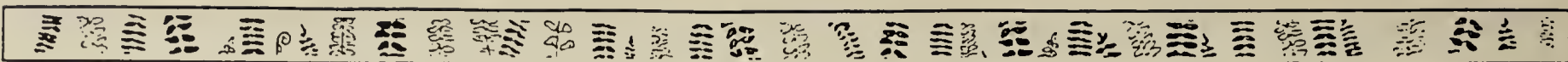
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