

Web of knowledge, web of life, web of wonder



The Kalevala ⁽¹⁾, 'Rune II – Wainamoinen's Sowing'

*Pellerwoinen, thus consenting,
Sows with diligence the island,
Seeds upon the lands he scatters,
Seeds in every swamp and lowland,
Forest seeds upon the loose earth,
On the firm soil sows the acorns,
Spruce-trees sows he on the mountains,
Pine trees also on the hilltops,
Many shrubs in every valley,
Birches sows he in the marshes,
In the loose soil sows the alders,
In the lowlands sows the lindens,
In the moist earth sows the willow,
Mountain ash in virgin places,
On the banks of streams the hawthorn,
Junipers in hilly regions;
This the work of Pellerwoinen,
Slender Sampsa, in his childhood.
Soon the fertile seeds were sprouting,
Soon the forest trees were growing,
Soon appeared the tops of fir-trees,
And the pines were far outspreading;
Birches rose from all the marshes,
In the loose soil grew the alders,
In the mellow soil the lindens;
Junipers were also growing,
Junipers with clustered berries,
Berries on the hawthorn branches.*

(¹) The Kalevala is the national epic poem of Finland compiled by Elias Lönnrot in the nineteenth century from Finnish and Karelian oral folklore. The epic consists of 22 795 verses in fifty cantos. The extract selected to open our story shows a highly developed awareness of forest ecology — an awareness we would expect from a people so dependent on the forest for its livelihood and well-being.

It's October, it's late in the season and it's been a bad year for mushrooms in Finland. Webcaps, a type of mushroom found particularly in the boreal and temperate forests of northern Europe, are no exception.

Webcaps play an important role in these forest ecosystems. They are mycorrhizal fungi that live in symbiosis with the trees, providing nutrients and protection from diseases and receiving sugars in return. However, there is a delicate balance to this symbiosis. When nitrogen levels in the forest floor are low, webcaps provide the necessary nitrogen from both organic and inorganic nitrogen compounds. If nitrogen levels are high, either naturally or due to pollution or fertiliser use, then the trees reduce sugar supply to the webcaps and their growth is degraded. In these conditions, more tree means less mushroom.

For humans, webcaps offer equally varied benefits. Local people of course derive many advantages from the forest ecosystems that they support. From a cultural perspective, many Finns have a deep love

of outdoor activities centred on the country's forests and lakes. Equally, tourism and other services and goods that forests provide have considerable economic worth.

But webcaps aren't just valuable because of their contribution to the surrounding ecosystem. As we will discover, besides their intrinsic beauty, their chemical characteristics have attracted the attention of scientists and craftspeople.

One forest among many

Tuula Niskanen and Aino Juslén are visiting Mariefred Forest in search of the last webcaps of the season.

Situated about 30 kilometres north-east of Helsinki, the most noticeable aspect of Mariefred Forest is the silence. There is no wind, no traffic, no voices. The trees stand close together in a natural, haphazard way, not in regimented rows as in plantations.

Overhead the canopy cover is almost complete with a mixture of spruce, pine, aspen and birch providing

lots of shade. Underfoot, a deep carpet of green mosses sparkles with moisture in the late afternoon light. This living material helps muffle the noise within the forest and provides a calm, relaxing silence. The closed canopy

and moss carpet maintain a cool, moist microclimate that enables a rich diversity of forest fungi, plants and animals to thrive.

Surrounded by a publicly owned Natura 2000 forest

Webcaps get their name from their web-like veil. They belong to a group of mushrooms called *Cortinarius*, a name derived from the Latin word for a veil (*cortina*). Within the known 72 000 species of fungi, over 22 000 are club fungi, and include for example mushrooms, toadstools and puffballs. And among mushrooms, the biggest group is *Cortinarius* with about 2 000 known species.

Some webcaps are edible and some may be pharmacologically active and hence have uses in medicine. Webcaps are most widely used in dyeing, however, as they provide a range of natural colours from pale yellow to deep, dark red. They are not usually eaten because some are deadly poisonous and recognising edible ones requires some expertise.



Photo: *Cortinarius semisanguineus*
© Gordon McInnes

In his famous story, 'Tale of the Forest Folk' (translated by Tim Steffa and published by Otava, Helsinki , 1994), Finnish novelist Veikko Huovinen (who died in 2009) described the regeneration of a forest after a tragic, accidental fire at the turn of the nineteenth century. Having worked as a forester, Huovinen knew well the process of succession and climax of forest ecosystems:

'allowed to develop in peace and quiet, untouched by the axe for one hundred and thirty years, [a forest] reaches a kind of equilibrium governed by a certain regularity. It slowly begins to reach the climax stage, in which each tree and plant species is represented in its particular niche and to a degree determined by its ecological character and biotic vitality'.

to the north and agricultural land, other small forests and scattered dwellings on the other sides, Mariefred Forest is an example of the fairly old boreal forest that has been steadily disappearing in southern Finland. Almost two-thirds of Finland is forest land and five per cent of all land is protected. Much of

the forest and most of the protected areas lie in the less populated northern parts of the country, however. In the south, commercial forestry and conversion to arable land has reduced forest cover and less than two per cent is protected.

Mariefred Forest is an exception. Under the government's Metso

Natura 2000 is the network of nature protection areas established across the European Union by the 1992 Habitats Directive. Its aim is to ensure the long-term survival of Europe's most valuable and threatened species and habitats. For more information see: http://ec.europa.eu/environment/nature/index_en.htm.



Photo: Mariefred Forest © Gordon McInnes

Programme the owner receives a subsidy for 10–20 years in return for maintaining the natural values of the forest and not selling the trees for timber. As a result, the forest has a hope of reaching climax — the state of equilibrium that ecosystems may achieve if left undisturbed. At the same time, researchers will be able to gather valuable data, and the public will be able to continue collecting berries and mushrooms and enjoying its tranquillity.

Finns and their forests

The value that Finns put on their forests can hardly be overstated. Forests play a crucial role in Finland's culture, recreational pursuits, economy and, of course, its

environment. The need for sustainable development of these prized resources is obvious.

Forest covers about two-thirds of Finland's land area. Almost one in five Finns owns forest directly through purchase or inheritance. Tar burning was the first sign of commercial use of forest and remained the only sign until Finland's forest industry started to develop 150 years ago. This industry, being highly competitive and profitable, helped Finland develop from an economy dependent on the land into a prosperous, post-industrial society focused on knowledge and information services. At its peak, forest industries accounted for up to 80 per cent of Finland's export income. That figure is now around 20 per cent. However, tens of thousands of Finnish families still depend on forest for their incomes and employment.

All Finnish forests are freely accessible for outdoor activities such as trekking and picking wild berries and mushrooms. This is captured in the concept of Everyman's Right (Jokamiehenoikeudet

in Finnish, www.environment.fi/everymansright). Hiking and hunting are very popular and most Finns love spending time at summer cottages in forests and by lakes. The long history of feeling at home in the forests is seen in the work of many well-known Finnish artists, including Pekka Halonen, Fanny Churberg and Akseli Gallen-Kallela.

Little did we know

Tuula Niskanen grew up in Helsinki but like many Finns her family had a summer cottage where they spent holidays. In the forest beside the lake in Kisko she developed

a love for plants and nature that guided her subsequent choice of studies. Researching webcaps for 10 years, first for her master's degree and then for her doctorate, Tuula has helped catalogue over 200 webcap species in Finland and considers that there may be as many as 400 more.

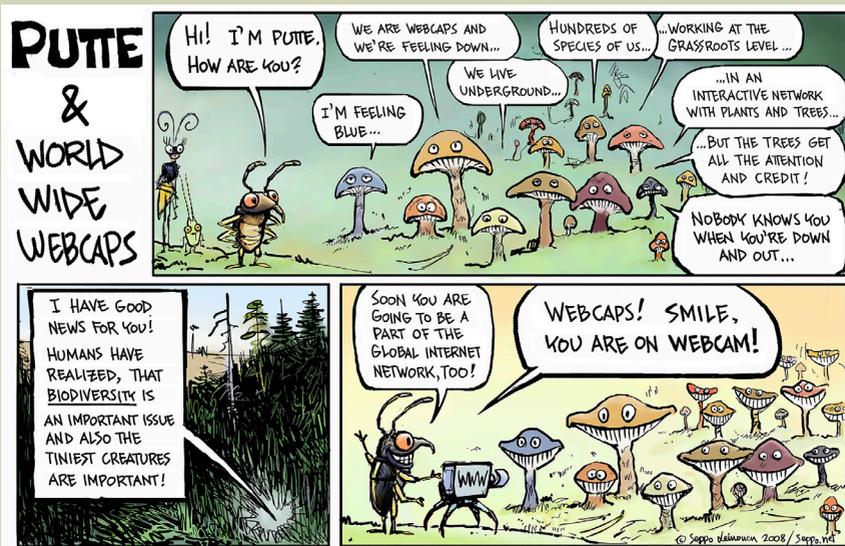
Aino is the co-ordinator of the PUTTE Programme at the Finnish Environment Institute (SYKE). Born in the small village of Tiihala, almost 200 kilometres north of Helsinki, she spent much of her youth in the forests of the family's home town Nokia, where she enjoyed trekking, camping and evenings around

Metso was started in 2000 to safeguard biodiversity in Finland's forests. Metso is the Finnish acronym for the Forest Biodiversity Programme of Southern Finland and also the Finnish word for capercaillie (wood grouse), which has been adopted as the emblem for the Programme. More information is available at: www.ymparisto.fi/default.asp?contentid=274911&lan=fi&clan=en.



Photo: Capercaillie (*Tetrao urogallus*)
© P. Rassi

The PUTTE Programme was initiated within Metso to help improve the knowledge base and meet several targets set under the Convention on Biological Diversity. It focuses on the most poorly known groups of organisms, particularly invertebrates and fungi. PUTTE produces scientific publications and identification books. It also promotes public awareness about Finnish plants and animals and their status and threats, through books, active contact with the public, information on the Internet and cartoons: www.environment.fi/putte.



a fire with friends or family, telling stories, singing and cooking.

Tuula and her colleagues have found 146 webcap species new to Finland, including at least 12 not seen elsewhere

and hence new to science. This research has made a major contribution to the understanding of these mushrooms in Finland and other Nordic countries, giving her great pleasure. This knowledge has been partly



Photo: *Cortinarius gentilis* (left), *semisanguineus* (middle two) and *sommerfeltii* (right)
© Gordon McInnes

captured in *Funga Nordica*, a Nordic handbook for the identification of fungi, which Tuula helped compile.

In search of webcaps in Mariefred Forest

Walking through Mariefred Forest, Tuula spots several types of webcap as well as some edible cantarells and inedible mycenae. Although she knows the forest and has spent many days in others across Finland searching for

new species, her excitement is infectious. She plucks a webcap from the moss, examines it closely, smells its odour and announces its name. Then she darts further into the forest, finds another webcap then another and repeats the identification process.

First, *Cortinarius semisanguineus*, then *Cortinarius gentilis*, then *Cortinarius sommerfeltii*. The first has a dark brown cap, blood red gills and a pale brown



Photo: *Cortinarius semisanguineus*
© Kare Liimatainen



Cortinarius gentilis
© Kare Liimatainen

stem; the next looks quite like the first but the stem is redder and the gills red-brown; the third is slightly different again.

Tuula does not find anything she does not immediately recognise so it's unlikely there will be any new species to

As a taxonomist Tuula is one of perhaps fewer than 6 000 specialists worldwide dedicated to describing, naming and classifying all species on the planet before they (the species and the taxonomists) disappear. Estimates of the total number of species vary between 10 and 100 million with less than two million discovered and named so far. Since taxonomy is seen by most people as rather dull, repetitive, routine and poorly paid, it is difficult to attract, train and retain such specialists. Hence expanding knowledge of the millions of species in existence, as well as their role within ecosystems and their potential benefits to people, is proving difficult. We now risk losing species before we know that they exist let alone what their properties are.

For more information see, for example: www.cbd.int/gti/problem.shtml.

DNA sequencing techniques have developed into routine, readily available and relatively cheap laboratory methods, allowing taxonomists to distinguish species. Using such techniques, Tuula has determined that two specimens classified as belonging to one species on the basis of visual inspection were actually different species, *Cortinarius semisanguineus* and *Cortinarius aff. semisanguineus*.

For a general introduction to DNA sequencing see: www.wiley.com/college/pratt/0471393878/student/animations/dna_sequencing/index.html.

For specific details of the particular technique used by Tuula see: <http://dx.doi.org/10.1016/j.mycres.2008.10.006>.

add today. Nevertheless, the webcaps are stored carefully in her mushroom-motif basket for further analysis by microscope and DNA sequencing, if needed, back in the laboratory.

Tuula is most interested in extending knowledge of webcaps, their diversity and their role in forest ecosystems. She is first and foremost a taxonomist, fascinated by the collection, analysis and classification of webcaps.

Small wonders beneath their caps

Tuula's enthusiasm does not stop at her research work. She is also interested in the practical side of her discoveries.



Photo: Tuula Niskanen (with basket) and Aino Juslén in Mariefred Forest
© Gordon McInnes

When she discovered from her DNA sequencing that one of these mushrooms producing deep red dyes was in fact two different species producing two different shades of dye, she informed Riikka Räisänen, a chemist at the University of Helsinki. Tuula and Riikka had met through their attendance in the monthly meetings of the Finnish Mycological Society, the professional body promoting the study of fungi in Finland.

Riikka grew up in the country, in Mäntsälä, a municipality 50 km north of Helsinki and surrounded by forest. In her youth she spent lots of time in the forest collecting plants and fungi. Like Tuula, she is interested in webcaps, but more in the chemistry and uses of the dyes they produce than in their biological diversity. For her doctorate, she studied the dyes produced by *Dermocybe sanguinea* (also known as *Cortinarius sanguineus*) and their retention by wool and synthetic fibres.

In her work at University of Helsinki, she developed a course for secondary school students integrating biology, chemistry, art and craft lessons based on

the collection, study and use of webcaps for dyeing textiles.

Where Tuula is most interested in researching and extending knowledge on webcaps, Riikka is more concerned with practical applications and in the integration of a range of disciplines and skills. They therefore complement each other well through a common interest in the availability and diversity of webcaps. They both recognise that scientific study of various species and the ecosystem goods and services they provide is essential for understanding, managing and conserving biological diversity better in the twenty-first century.

Learning biology, chemistry and art in the forest

Riikka initially developed her course for a secondary school in collaboration with a chemistry teacher and a textiles teacher. She has subsequently provided training and advice to 100 teachers, extending the course to more schools and students.

Many students now start her course with a field trip to collect and identify webcaps. Imagine their excitement on a day out



Photo: Riikka Räisänen with sample materials © Gordon McInnes

of the classroom when they are set free to collect different types of mushroom knowing that some are good to eat, some are poisonous and some provide natural dyes, even some fluorescent ones. However, before they can extract and use these natural dyes, they are trained to recognise the various trees, flowers, mosses, lichens, fungi, birds and insects in the forest.

They also learn a little about the interaction and interdependencies of these various species as producers, consumers and decomposers, and the role of webcaps and

other mycorrhizal fungi in promoting tree growth.

Their escape to the forest teaches them, if they did not know already, a little biology and ecology before they return to school for some chemistry. Back in their classes, they isolate the coloured pigments from the webcaps and identify them using simple chemicals, equipment and classification methods. They learn that the webcaps produce a range of anthraquinone dyes, which are found in a variety of other organisms from bacteria through lichens, other fungi and plants to insects. They provide natural colours from pale

yellow to almost black that are brighter than other popular dyes and fade less in the light. The students then learn to create printing and dyeing designs in their art class, produce the dyed materials and create final products according to their chosen design in their crafts class.

And it's not just young students being introduced to webcaps and their creative uses. Many adults in Finland use webcaps to dye products for their own use or for sale. Large numbers come

together in the Finnish Guild of Dyers to share information on their craft and learn from each other. All have access to a range of websites to support their hobbies and professional interests, for example the virtual craft place (www.kaspaikka.fi/engl/index.html) and Textile Education and Research in Europe (www.texere.u-net.dk). The complex web of connections, in which webcaps play numerous valuable roles in human and natural systems, thus extends all the way to the world wide web.



Photo: Example materials coloured with *Cortinarius* dyes © Gordon McInnes



Photo: Nuuksio National Park © Gordon McInnes

The veil has been lifted

With the help of a small and little understood mushroom, this story has linked a small forest ecosystem, the goods and services provided by that ecosystem, and the work of three highly motivated researchers extending knowledge and awareness of these goods and services, including the use of the mushroom in the teaching of chemistry, biology, arts and crafts to an increasing number of Finnish students. It

has lifted the veil on the little *Cortinarius* and its contribution to the web of life we call biodiversity.

Acknowledgements

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