A Peaty Archive

THE PATTERNED FENS OF THE GREAT SANDY REGION

For much of colonial history, wallum ecosystems were regarded as wastelands, and many patterned fens have been lost to clearing for urban and tourist development, exotic pine plantations or sand mining. But since the 1960s, the subtle beauty and high biodiversity values of wallum have inspired many conservation battles to keep it from further destruction. This is the Dutgee patterned fen complex opposite the Cooloola sand blow, in the Cooloola Recreation Area. *Photo: Patrick Moss*

Palaeoecologist **Patrick Moss** is reading the past from the peaty bottom of globally unique wetlands in subtropical Queensland.

The World Heritage-listed Fraser Island has many standout features: rainforests growing on sand, the greatest concentration of perched (rain-fed) lakes in the world, diverse wallum (heathland) communities and the most genetically pure dingo population, to name a few. But one of its most distinctive ecosystems is hardly known and was discovered (scientifically) less than two decades ago.

In 1996, when a meeting of the Convention on Wetlands of International Importance (the Ramsar Convention) was held in Brisbane, an English expert on fens, Richard Lindsay, took a tour to Fraser Island and identified from the air the 'new' ecosystem – patterned fens. This was a surprising find, for almost all patterned fens occur in the northern hemisphere at mid to high latitudes (in cold environments). There were no other patterned fens known in the subtropics anywhere else in the world.

Since then, 20 patterned fen complexes covering 521 hectares have been identified across the Great Sandy region, the northernmost at Wathumba, Fraser Island, and the most southerly near Lake Cooloola. The largest complexes are in the Cooloola Recreation Area along the Noosa River, south west of

The fen-building spreading rope rush (*Empodisma minus*) is impressively hardy, tolerating waterlogging, drought, nutrient-poor soils and extremely acid water (to pH 2.5). It thrives in fens and bogs and along wet creek banks from coastal to alpine environments, and is widespread across coastal eastern Australia and New Zealand. It is an 'ecosystem engineer', responsible for the creation of many fens and bogs in Australia and New Zealand. The peat in these systems forms mainly from its dense mat of horizontal rhizomes (underground stems), which hold water like a sponge, up to 15 times their dry weight. The plant is able to resprout after fire. *Photo: Lui Weber*

FENS, MIRES AND PEATLANDS

The Great Sandy region has both types of patterned fens: string-flark (ridge-pool) systems and string mires (also known as 'aapa', a Finnish term). String-flark fens consist of at least ten pools, up to two metres wide and half a metre deep, which are separated from one another by ridges about 50 centimetres higher than the pools. String mires are long parallel channels of water separated by ridges. Both fen types result from interactions between groundwater and spreading rope rush, the main peat-forming plant in this system.

In most other patterned fens, which are extensive in the mid to high latitudes of the northern hemisphere, various sphagnum mosses are the main peat-forming plants.

Peat-forming systems include mires (fens and bogs), mangrove swamps and the peat forests of South East Asia. They cover over three percent of global land area and account for about 60 percent of all wetlands. Over millions of years and under the right conditions, peatlands will turn into lignite coal. Victoria's brown coals, which contain well preserved wood, flower and leaf fossils, were formed 20 to 50 million years ago from extensive peatlands, probably similar to the modern day peat forests of Borneo.

The Moon Point or Puthoo fen complex on Fraser Island has string-flark systems (ridges and pools) (in the foreground) and string mires (in the background at top). Groundwater flows from the high dunes (in the far right) and the strings form more or less at right angles to the flow of water. ***Photo: John Sinclair***

There are no other patterned fens known in the subtropics anywhere else in the world.

This is a flark in the Moon Point patterned fen complex, showing the dominant plant, spreading rope rush, growing on the ridges. ***Photo: Patrick Moss***

the township of Rainbow Beach, and at Moon Point on Fraser Island. More recently, patterned fens have been found further south in Noosa National Park, Mooloolah River National Park on the Sunshine Coast, and the northern part of Moreton Island, suggesting they have a close relationship with the wallum community characteristic of this broader region.

Because these fens are globally unique, a distinctive component of the Great Sandy region, and prime habitat for rare wildlife, I have embarked on studies to investigate how they formed, the role of groundwater and vegetation, and the impacts of sea-level changes and fire patterns.

The formation of fens

In the taxonomy of wetlands, a fen is a form of mire, which is a peat-forming wetland, distinguished from other peat systems – such as mangrove swamps and the peat swamp forests of South East Asia – by lack of a forest canopy. Mires generally derive from mosses or sedges that form peat due to water-logging, which slows their decomposition by creating a highly acidic and oxygen-poor environment. Of mires, there are bogs (fed mostly by rainwater) and fens (fed mostly by groundwater) of many types, depending on where and how they formed: blanket bogs, raised bogs, flat fens, sloping fens and patterned fens among them. Patterned fens also come in varieties: string-flark (ridge-pool) systems and string (aapa) mires, both of which can be found in the Great Sandy region (hopefully, the pictures will help you navigate through the quagmire of terms).

Although the fens of the Great Sandy region are unique, patterned fens are by no means rare in the world. They are extensive in the boreal and subarctic region of the northern hemisphere, possibly linked to the cold conditions that favour the growth of sphagnum moss, a very important peat-forming species. They are much rarer in the southern hemisphere, occurring on the New Zealand South Island, Tierra del Fuego and the Falkland Islands, with some localised examples in the Tasmanian highlands.

It is thought that most patterned fens are formed by biological rather than geological processes in three steps. First, there is a gradual differentiation in the surface of a pre-existing wetland (usually one with sphagnum moss), which leads to peat accumulating at different rates in different places, resulting in a mosaic of flarks (pools) and ridges. These pools eventually coalesce to form large open-water lakes, and the patterned structure disappears.

The process of patterned fen formation in the Great Sandy region is thought to be different but is as yet poorly understood. The fens there do not form large lakes, and they either start within lake systems (vegetation starts growing in a lake, gradually filling it in) or form when highly acidic, anaerobic groundwater differentially affects the growth of fen-forming vegetation, which leads to the production of flarks and ridges or strings and ridges as peat accumulates. Adjacent water bodies (Hervey Bay, Tin Can Bay and the Noosa River) and alterations in sea level affecting the Fraser Island and Cooloola freshwater lenses may also be influential by affecting the groundwater that feeds the fens.

The main plant responsible for the patterned fen complexes in south east Queensland, forming the ridges and base of the flarks and strings, is the spreading rope rush or wire rush (*Empodisma minus*). Well adapted to life in low-nutrient and oxygen-poor

The wallum of southern Queensland and northern New South Wales, which hosts the world's only known subtropical patterned fens, is celebrated for its wildflowers. Besides the main fen-forming plant – spreading rope rush – other important or common fen plants include lemon scented tea tree, sprengelia (*Sprengelia sprengeloides*, below right), common sundew, red fruit saw sedge, pouched coral fern, coral fern, willow guinea flower, coral heath (*Epacris microphylla*, shown below left) and swamp bankia (*Banksia robur*, shown above). All are adapted to low nutrient, acidic, waterlogged conditions. The fens provide habitat for some distinctive birds, such as the eastern ground parrot and Lewin's rail, and probably for several migratory waders. The New Holland honeyeater shown in the swamp banksia is an occasional visitor lured by nectar.

habitats, it grows as wiry clumps to about 30 centimetres high and has a dense layer of fine roots and rhizomes to a depth of about 10 centimetres, which decay into peat at the base of the root layer. Because fen water is highly acidic (a pH of 4.3 to 4.8) and low in oxygen, decomposition is slow. Initial research suggests it takes 50 to 100 years for the plant roots to decay into a fresh peat (in which the root structures are still present) and several hundred years to form a decomposed peat (an organic rich black soil with little or no plant structure). Peat in some of the Great Sandy fens is probably more than five metres deep, suggesting considerable age.

Fire occurs within patterned fen complexes – every seven to 15 years on average since 1977 at Moon Point. The main impact appears to be reduced vegetation cover. While peat fires overseas are the cause of great concern because they can burn for months and release huge volumes of greenhouse gases, it seems the rhizomes of spreading rope rush prevent ignition and protect the base of the fen from damage, facilitating post-fire regeneration of the fen vegetation. Aerial photographs back to 1958 show that the patterned fen complexes have been extremely stable for decades, although it appears that the forest around some of the fen complexes has thickened.

Environmental archives

Because the peat base of fens is partially decayed vegetation from the past several thousand years, the patterned fens of the Great Sandy region are a valuable botanical and fire archive. By analysing fossil pollen and charcoal fragments, we can work out how ecosystems have responded to past climatic changes and the history of fire regimes as well as how the wetlands were formed. This is critical information for the future conservation of the fens and other Great Sandy ecosystems.

To access these archives, we use specialised peat corers, which we drive into a wetland to various depths to extract sediment cores 50 centimetres long and 100 millimetres in diameter. We wrap these cores in a PVC pipe and take them back to the laboratory, where we process them in small sections by several techniques (sieving, deflocculation and chemical removal) to concentrate the pollen grains and charcoal fragments. We then peer through a microscope to identify the pollen grains and count charcoal fragments. From this, we determine the vegetation types that existed at various times, which in turn provides evidence of environmental alterations that may represent responses to climate change (such as rainforest expanding or contracting due to changes in rainfall) or human impacts (such as expansion of eucalypt forest in response to increased burning by people).

Preliminary research at the Rainbow Beach and Moon Point complexes suggests the fens have developed over thousands of years. They were present at least 5000 and perhaps as long as 12,000 years ago. The sediments from Moon Point provide a record of past environments extending back at least 35,000 years. They suggest that a lake was present from 35,000 to 12,000 years ago, prior to fen development, perhaps similar to the perched lakes on Fraser Island today.

One of the surprising results from Moon Point was a significant change in vegetation, with a rainforest community surrounding a lake system being replaced by the patterned fen community and surrounding eucalypt forest that dominates the region today. There was also a substantial increase in burning around 35,000 years ago, which may have been a factor in the transition to eucalypt forest. Similar vegetation changes occurred on North Stradbroke Island and the Atherton Tableland in far north Queensland around the same time. On the Atherton Tableland these changes around 35,000 to 45,000 years ago have been linked to the arrival of people, which may also be the case on Fraser Island, although further research is required to distinguish the relative influences of people and climate.

The sediments also show that patterned fens have had a high degree of resilience to alterations in burning patterns and to past periods of climate change, implying they may be able to adapt to at least some aspects of future climate change. But their future is threatened by sea-level rise, which could flood the fens or alter the underlying freshwater lens, the source of groundwater on which the fens rely. Learning much more about the fens – how they formed and how they are likely to respond to future changes in sea levels, fire and climate – is essential for us to try to secure their future survival. ■

DR PATRICK MOSS is a senior lecturer in physical geography at the University of Queensland. Through pollen and charcoal analysis, he is investigating the vegetation that existed in late Quaternary times (the last 100,000 years) in north and southeast Queensland and in the Eocene (around 50 million years ago) in Canada's Okanagan highlands. His current research focus, with colleagues from the University of Queensland, University of Massachusetts-Boston, Queensland University of Technology, University of Adelaide and the International Mire Conservation Group, is the patterned fens of the Great Sandy region. It has received support from the Burnett Mary Regional Group.

Patterned fens host some rare specialised frogs and fish. This includes wallum 'acid' frogs, so named because they breed only in the acidic, nutrient-poor wetlands of coastal sandy soils, free from competition by related frog species. All are threatened by habitat loss from urban and resort development, pine plantations and sand mining. The Cooloola sedgefrog (*Litoria cooloolensis*) (left), confined to southeast Queensland, is listed by the IUCN as endangered. Its numbers at Brown Lake, North Stradbroke Island, plummeted after someone introduced exotic mosquito fish. The wallum sedgefrog (*Litoria olongburensis*) (middle), found from Fraser Island to Woolgoolga, NSW, is listed nationally as vulnerable. It lays its eggs singly in water at the base of sedges, hidden from fish. The wallum froglet (*Crinia tinnula*) (right), listed by the IUCN as vulnerable, is the least rare of the wallum specialists, but because it grows only 18 millimetres long it is easily overlooked. Its tinkling call can often be heard after rain, even by day. *Photos: Todd Burrows (wallum froglet), Aaron Payne*

Wallum frogs and kids

HOLLY BRYANT

Introducing children to the delights and plights of four rare specialist wallum frogs (three are shown above) is one way to inspire an interest in wallum. Wildlife Queensland is expanding its wildlife education programs into schools, and one exciting 2014 project is to mentor school children participating in the Sunshine Coast Kids in Action Conference by helping them to get to know their local wallum frogs. The conference, with the theme of 'our coast', will involve delegates from 30 local schools. No adults will present at the conference, for it is based on a peer-teaching model of learning, with students taking responsibility for their own learning and presenting all workshops and activities. I will have a role as a mentor to support them and their teachers – for example, by providing information and taking field trips. In such ways, Wildlife Queensland hopes to inspire the next generation of wallum conservationists.

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