A Return to Eden

Can science save Iraq's ancient marshlands?

Marsh Arab villages were often built on the water – with a household for every group of islands. Over time, these islands were reinforced and gradually built up with reeds and mud. Canoes are the main form of transportation. Rob Fitzpatrick / © CSIRO Land and Water

Australian expertise is part of an international effort to assess and remediate the once magnificent Mesopotamian marshlands that were systematically devastated under Saddam Hussein's regime. **Clare Peddie** reports on the exciting findings of Dr Rob Fitzpatrick's soil science expedition to Iraq, and on the glimmers of hope emerging from one of the world's worst environmental tragedies.

When Dr Rob Fitzpatrick was called to go to Iraq last year, he was overjoyed. And yet for many Australians the very idea of going anywhere near the Middle East at present – let alone war-torn Iraq – would have been near abhorrent. Even Fitzpatrick's friends and colleagues were surprised by his unshakable enthusiasm for the expedition.

Fitzpatrick, however, was confident he would be safe – and anyway, he didn't want to miss this opportunity for the world. Very few scientists had set foot in Iraq's southern marshlands – believed to be the location of the biblical Garden of Eden – in the years since the Iran–Iraq War.

According to Fitzpatrick, 'You could say we know more about Mars than we know about the soils of the Iraq marshlands since they were drained and burned'.

In the war-affected years the landscape was intentionally transformed from paradise to desolate wasteland. The huge marshlands area now more closely resembles the surface of Mars than the beautiful 'riverine wilderness' described by Gavin Young in *National Geographic*, back in 1976.

It is almost impossible to comprehend how such a vast area, originally covering 20 000 square kilometres, could have been so efficiently destroyed. And yet the evidence is clear on the ground: it was the combined result of huge dams upstream and engineering works put in place by Saddam Hussein's regime. Expansive drainage canals and 'rivers' with overblown patriotic names like 'Mother of Battles River', 'Saddam River' (or the Main Outfall Drain) and 'Prosperity River' still drain water away from the marshes, straight out into the Persian Gulf.

'There are several reasons for draining soils', says Fitzpatrick, 'one of those reasons is to get rid of people.'

An environmental disaster

The drainage network was first proposed in the 1950s to support irrigation in the north and to reclaim salt-affected agricultural lands. Progress, however, was slow.

Fish caught in the Al Hawizeh Marshes, the last tract of remnant wetland, near the Iran–Iraq border, are for sale at the Al Kahla markets. Rob Fitzpatrick / © CSIRO Land and Water

Further plans to drain the marshlands were drafted in the 1970s and 1980s, but remained on the drawing board until after the first Gulf War. In the meantime, the marshlands were in the middle of a combat zone, and large areas dried out simply as a result of military activities.

While the Western world largely accepted the Iraq government's line about drainage to support agriculture, some suspected Saddam had more sinister motives. Details gleaned from interviews with refugees, and technical plans leaked to dissident groups, indicated that Saddam's engineers started work on a much larger scale around 1991. This was eventually confirmed by startling satellite images.

The Marsh Arabs are trying now to live alongside the many engineered drains and canals constructed since the 1950s to drain the marshes. Rob Fitzpatrick / © CSIRO Land and Water

The United Nations Environment Program (UNEP) Division of Early Warning and Assessment published a selection of NASA's images in 2001. They showed that 90 per cent of the marshlands had already been lost and that the rest were in serious danger. Confirming suspicions, the authors stated that most of the damage was done between 1991 and 1995. They pronounced ecosystem collapse at the year 2000.

'The destruction of the vast Mesopotamian marshlands, a region of global importance for biodiversity and home of the Marsh Arabs, will go down in history along with other human-engineered changes such as the desiccation of the Aral Sea and the deforestation of Amazonia, as one of the Earth's major and most thoughtless environmental disasters.' (UNEP 2001. Partow, H. *The Mesopotamian Marshlands: Demise of an Ecosystem*).

The UNEP report included staggering facts and figures about the full extent of marshland drainage and its impacts. The Main Outfall Drain is 565 km long and the Prosperity River is an amazing 2 km wide, clearly visible from outer space from as early as 1993. Images from Landsat 7, recorded in 2000, depict the Al Hammar Marshes carved into polders by an extensive network of canals and dikes that run north–south and east–west. Virtually every drop of water in the system was drained away to the sea or left to evaporate, leaving the soil completely desiccated and salt-encrusted.

Virtually every drop of water in the marsh system was drained away to the sea or has evaporated, leaving the soil completely desiccated and salt-encrusted. Dr Rob Fitzpatrick surveyed the scene over the dried marshes towards Basra from a Hercules aircraft. Rob Fitzpatrick / © CSIRO Land and Water

Marshland restoration

The Central and Al Hammar marshes were the worst affected. It was thought that while partial restoration (through managed re-flooding) may be possible, there was still a chance to preserve the last tract of remnant wetland, in Al Hawizeh near the Iran–Iraq border. It was recommended that detailed scientific studies be conducted on the ground, incorporating targeted training for local agencies involved in wetland management and restoration.

Further studies released in 2003 showed that just 7 per cent of the original marsh-

Iraq's marshland areas. CSIRO Land and Water

Dr Rob Fitzpatrick samples toxic saline 'mono-sulfidic black ooze' in the re-flooded Al Hammar Marshes (Bani Asad village). Blue-green algae was also evident. Jane Gleason/DAI

lands remained. There were fears they could disappear entirely by 2008.

But some positive signs of recovery emerged as parts of the now-arid marshlands were re-flooded in 2003, for the first time in a decade. It had been a good season, a drought had ended, and the collapse of the Iraqi government left the drainage works unsupervised. Locals took the opportunity to breach embankments and dykes, open floodgates and send water back into the marshes.

In May 2003, the UNEP hosted a special meeting in Geneva to consider the way forward, and in June 2003 a rapid assessment mission was carried out by an interagency team. This group of scientists, engineers, government officials and representatives of the AMAR (Assisting Marsh Arabs and Refugees) Foundation was the first of its kind to enter the marshlands of Iraq for at least 20 years.

The scoping trip began a process of data collection, and helped to develop an action plan for the US Agency for International Development (USAID) Marshlands Restoration Program, making way for a technical team that was due to visit in September/October 2003.

Intense marsh blazes fired the earth into a hard ceramic crust. Rob Fitzpatrick / © CSIRO Land and Water

Recognising that the program's ultimate success would depend on international collaboration, the US Government was keen to involve technical experts from all over the world, including Australia.

With expertise in the understanding of soil and mineral processes in saline, arid and wetland systems, both in Australia and overseas (including Kuwait), Rob Fitzpatrick from CSIRO Land and Water was chosen to lead the Soil and Water Sub-program.

His team was asked to establish the limitations of soil and water resources to agricultural production in both drained and re-flooded areas. The information would be used to develop a set of practical indicators to help the local people interpret signs of soil and water degradation, and to direct efforts to local projects with the best chance of success.

After the trip was postponed several times for security reasons (the bombing of the UN headquarters was a major setback), the Soil and Water team finally set off in February 2004.

Fitzpatrick returned in late February, ecstatic about his experiences, and with more than 70 marshland samples (50 kg in total) – many unique. Scientifically, the trip had been a revelation.

'We ended up finding a whole range of new minerals, new processes going on in the system … quite seriously I'm overwhelmed by it all!' The team is now preparing a series of papers for international journals.

Dr Rob Fitzpatrick and Professor Dakhil Radhi Nedawi (right) of the University of Basra, on a traditional trip along the Prosperity River to sample water. Jane Gleason / DAI

The people of the marshes

The word 'Mesopotamia' means 'between rivers', and it is the southern plain of the region, between the Tigris and Euphrates rivers, that is often referred to as the 'cradle of civilisation'.

Even the earliest settlers were engaged in agriculture some 5000 years ago, using basic irrigation techniques. Then the Sumerians arrived, followed sometime later by the Babylonians. In more recent times, the area has been home to the Ma'dan or Marsh Arabs, Shi'ite Muslims.

The landscape of interconnected lakes, mudflats and wetlands has been gradually modified by human occupation. Some villages were established on the edges of the marshes, others were built on the water – with a household for every group of islands.

The Mesopotamian marshlands have been home to people for 5000 years. Estimates of the number of people living in this part of Iraq before it was disturbed by Saddam Hussein's regime are between 200 000 and 500 000. The marsh people are very protective of their land and property. Anna Presswell

In 2003 displaced locals breached embankments and dykes to reflood the marshlands around their destroyed houses. Rob Fitzpatrick / © CSIRO Land and Water

The 'mudhif' is the centre of the social and cultural system, providing a focus for the community. Dr Rob Fitzpatrick visited a number of these grand arched halls made out of reeds. Anna Presswell

Over time, these islands were reinforced and gradually built up with reeds and mud. Water buffalos also played a central role, providing milk, butter and yoghurt as well as energy and fertiliser (manure).

One of the most striking features of the traditional village are the grand arched halls made out of reeds. The 'mudhif' is the centre of the social and cultural system, providing a focus for the community.

Estimates of the number of people living in this part of Iraq before it was disturbed by Saddam Hussein's regime are between 200 000 and 500 000. It's believed some 100 000 to 200 000 of these people are now displaced within Iraq. Another 100 000 are living as refugees outside the country, mainly in Iran (40 000).

Even though it has become virtually impossible to continue to lead a traditional lifestyle, about 10 000 people have stayed. A further 85 000 are settled close-by and hope to return.

'Unfortunately a lot of these people are not going to be able to go back into the marshlands and just live on water', explains Fitzpatrick. 'They are going to have to live alongside these dried-up, drained, dusty areas.

'The changes that have taken place – because of the draining, because of the burning, and the unique salt accumulation – mean you could never recreate that wetland. You can't do it because the changes in the soil are irreversible.'

New scientific discoveries

Some of these changes were to be expected. 'It has been a wetland for thousands upon thousands of years; it's a very old wetland. The marshland's reeds have been growing there for a long period of time.'

Beneath wetlands, mangroves and marshes alike, large amounts of organic matter accumulate from decaying vegetation. Soils formed under these conditions contain a lot of sulfidic material (pyrite), which is perfectly safe if left undisturbed. But here, the wetlands have been drained and ancient soils exposed.

'Sulfides within the soil react with the oxygen in the air, forming sulfuric acid. The acid either drains into waterways, or reacts with carbonates and clay minerals in soils and sediments to form sulfates – liberating dissolved iron, calcium, magnesium and other elements such as copper', explains Fitzpatrick.

As the water drains away from the landscape, more salt is leached from the soil, leaving calcic or sodic soils behind on the ridges. Salty water collects in the lower parts of the drained marshlands and then, as the water evaporates in the hot sun, minerals (sulfate salts) are formed as precipitates.

This scenario is typical of drained marshlands, but the salt crusts in the marshlands of Iraq contain strange new minerals, recently seen by Fitzpatrick under a Scanning Electron Microscope (SEM). These are thought to be due to the

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The engineered Prosperity River, west of Al Azair, prevents water from reflooding the Central Marshes. Rob Fitzpatrick / © CSIRO Land and Water

unique chemistry of the region. The marshlands have built up with sediment originally from sedimentary rocks in the mountains of the north, transported downstream by the Tigris and Euphrates rivers.

When the landscape had completely dried out, it was burned. 'Imagine. The reeds would still be there, 12 ft high and dried out in the middle of the desert. Then the earth is fired, as though in a kiln or oven, and basically turned into a ceramic brick', Fitzpatrick says.

With such a tremendous fuel load, the fire would have been very hot. 'Temperatures must have exceeded 300°C, because between 15 and 50 cm of the topsoil at these sites had been irreversibly transformed into hard, cemented (fused) ceramic-like porous fragments.'

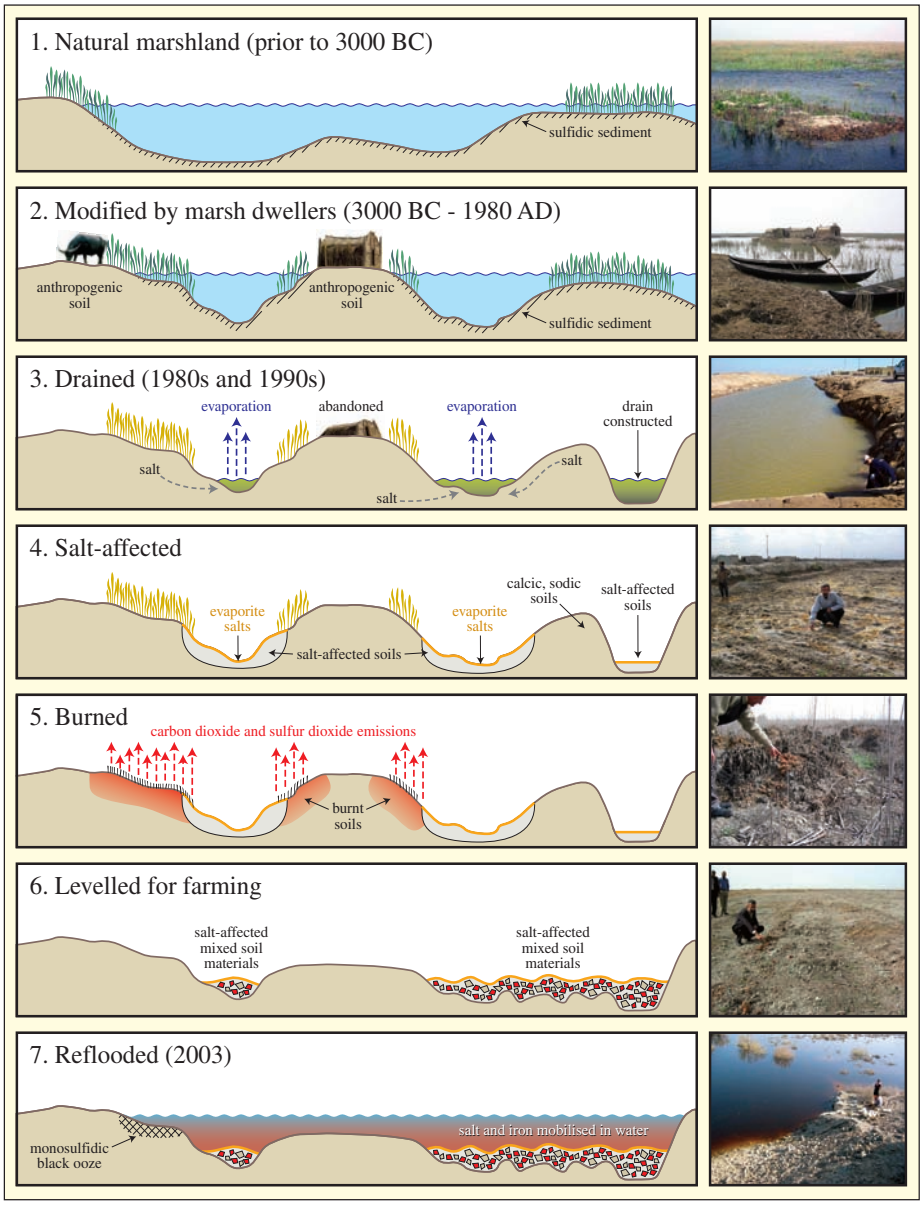
Holding one of the prized specimens, about the size of a man's fist and reddish-brown in colour, Fitzpatrick continues, 'When this was underwater it was a beautiful living sediment', turning the strange, crumbling sample in his hands. 'Then you dry it out, oxidise it and burn the hell out of it; you would think all the pyrite would have oxidised, and it has – but under the microscope it looks exactly the same, burnt and preserved, as if cast in stone!'

Fitzpatrick could not believe it until he probed the structures using x-rays in the SEM. Pyrite (FeS_2) had been converted to the iron oxide maghemite (Fe_2O_3) releasing sulfur dioxide gas, but retaining the same shape. The conditions had to be just right with the pyrite 'framboids' coated in organic matter and heated to above 300°C in a carbon dioxide reducing atmosphere.

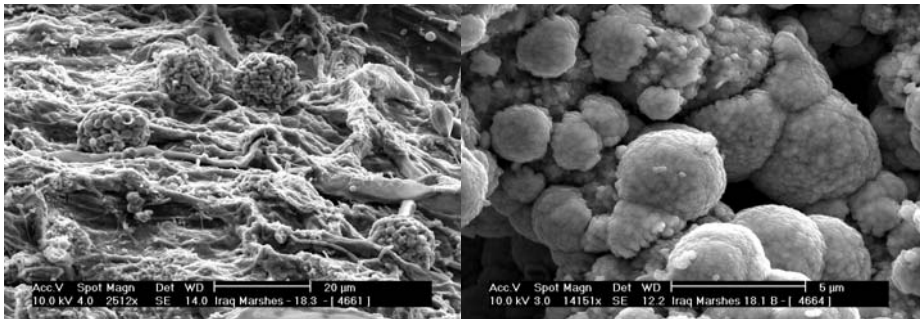
He is visibly excited by the discovery. 'These reactions have never been studied before; it is something you wouldn't normally see.' He says he feels like Neil Armstrong stepping out onto the moon, walking around and taking a few samples back home. Here is a landscape unknown to science – and he is the first soil scientist to explore it.

'These drained burnt soils defy classification,' he explains. 'New criteria, based on properties defined in this study, will need to be submitted to the international bodies. We have discovered new soil types.'

The burnt earth is now unsuitable for growing crops. The high concentration of cemented ironstone fragments (more than 60 per cent) restricts plant root growth and increases permeability – like trying to grow crops in gravel, the water and nutrients leach away. But the local farmers have tried, knocking over the petrified ridges



Iraq's marshlands have suffered largely irreparable damage from draining, drying, burning, levelling and re-flooding. This conceptual model shows the various stages of the soil-landscape history. Adapted from Fitzpatrick, R.W. 2004



Some of Fitzpatrick's SEM images. Left: Soil material from lower soil/sedimentary layers of drained marshland revealing abundant pyrite 'framboids' and microorganisms (bacteria, algae) including diatoms with variable intensities of iron-rich cell-wall mineralisation. Right: Maghemite structures in burnt marsh soil are formed by the process of burning in a carbon dioxide reducing atmosphere.

Professor Abdul Jabbar Hassan, University of Basra, inspects an abandoned saline field. The locals tried farming here: now they want to re-flood it. Rob Fitzpatrick / © CSIRO Land and Water

and valleys, levelling fields, and ploughing the gravely fragments into the earth.

These altered soils also create problems when they are re-flooded. The minerals re-dissolve and toxic saline 'mono-sulfidic black ooze' is formed. The black ooze de-oxygenates the water, suffocating aquatic plants and animals.

Fitzpatrick is striving to have the Iraq marshlands recognised as a significant 'Geohazard Area' by the 'Geohazards Working Group', which comprises representatives from the four major geoscience unions of the world.

Productive agriculture

The team's soil and water research promises to support some productive and sustainable agriculture in the Iraqi marshlands. In some cases, soil and water degradation can be reversed; in others, the best thing to do is simply to fence off an area and leave it alone.

'We have developed a system farmers can use to recognise the various soil types that can be used to grow crops and which ones to avoid', says Fitzpatrick.

'I had a genuine feeling that these guys could see we were trying to help them. I felt really safe with them, no doubt about it. But we could not have done this job at all if we did not have the AMAR Foundation as partners.' Everywhere the technical team went, they were escorted by representatives from the AMAR Foundation.

'The marsh people are very protective of their land and property', explains Fitzpatrick. 'They trust no one, except the people from the AMAR Foundation.'

Fitzpatrick was also fascinated by the amount of work that could be achieved in such a short space of time. 'I was surrounded by this incredible infrastructure, with CSIRO, and then the big consultancy company, Development Alternatives Inc. (DAI) – with competent managers like Dr Peter Reiss and Jane Gleason, project associates (Gabriel Bayram), bodyguards, and the AMAR Foundation. And I was just driven around, with a crew behind me.' He says it was like a dream. 'I was in control – 'sample here, sample there, no we won't go there ...' I felt really privileged.

In some parts of the re-flooded Al Hammar Marshes the traditional island way of life has been maintained, but the water is often contaminated. Rob Fitzpatrick / © CSIRO Land and Water

A jubilant Fitzpatrick returned to work in Adelaide announcing that it was one of the best things he had ever done. There was a great buzz in the tearoom as Fitzpatrick shared stories of his adventures with fellow scientists – the pedologists, mineralogists, hydrologists and chemists were all enthralled.

Dr Rob Fitzpatrick with a Romanian soldier, who had kindly offered to mind the team's vehicles while they took some samples, near Al-Chibayish. Rob Fitzpatrick / © CSIRO Land and Water

'It was a magical experience', says Fitzpatrick. 'The potential to do a lot more really good science and work over there is really spectacular.'

The USAID Iraq Marshlands Restoration Program will continue to help restore the ecosystem through improved management and strategic re-flooding, whilst also providing social and economic assistance to the local population.

In conjunction with the two-year USAID effort, the UNEP recently announced a multi-million dollar project to support the sustainable development and restoration of the Iraqi Marshlands, funded by the Government of Japan.

More information:

Fitzpatrick, R.W. (2004). Changes in soil and water characteristics of some natural, drained and re-flooded soils in the Mesopotamian marshlands: Implications for land management planning. CSIRO Land and Water, Client Report 2004. www.clw.csiro.au

UNEP. (2001). Partow, H. The Mesopotamian Marshlands: Demise of an Ecosystem. United Nations Environment Programme, Kenya.

USAID Iraq Marshlands Restoration Program: www.iraqmarshes.org

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