12 July 2019

Save Foulden Maar Incorporated Society
Kimberley Collins – Chair

To whom it may Concern

Foulden Maar

I adamantly support the Save Foulden Maar Incorporated Society in their efforts to save Foulden Maar for Most Valuable future scientific research, and to bring Foulden Maar and its uniquely invaluable fossils into public ownership. I completely endorse the option to buy the 42 hectares currently owned by Plaman Resources to prevent potential future attempts to use it for commercial purposes.

I was Invertebrate Zoologist to Otago Museum from 1974–1999 and, after retiring, Honorary Curator of Entomology (Otago Museum) from 1999 to the present. I have published over six papers on fossil insects from New Zealand, and in 1983 published the first paper on a complete fossil insect (Dilophus campbelli) in the *Journal of the Royal Society of New Zealand*.

My strong interest in entomology is life-long. My 1974 thesis (Victoria University of Wellington) was on the biosystematics of New Zealand Pompilidae (Hymenoptera), published in part in 1987 as *Pompilidae, Fauna of New Zealand Monograph No. 12*. I have published 1,668 weekly articles in the *Otago Daily Times* in my '*Nature File'* column between 1985 and the present.

When writing journal articles on fossil insects, I read much of the (then) world literature on the subject. This has enabled me to fully appreciate the unique world value of Foulden Maar and its fossils.

I first inspected Foulden Maar in 2000, realising it could well contain fossil insects. In 2002, I collected further samples. At this point I recognised that the small black specks apparent were likely the insect fossils. I published this opinion in my weekly column in the *Otago Daily Times* on 16 December 2002.

Until the discovery of Foulden Maar fossil insects, only six, mostly fragmentary, insect fossils were known from New Zealand. Foulden Maar contains many hundreds and likely many thousands of fossil insects which can be dated with exceptional precision and accuracy. They provide data on the fauna and flora occurring in New Zealand during a previous period of warming.

The fossils provide enormous information to systematics (the study of classification – family trees) and biogeography (the distribution of animals and plants). When the fossils were laid down in Foulden Maar, New Zealand had not long emerged from a period of marine incursion (in the

Oligocene). The fossils in Foulden Maar therefore constitute a record of animals and plants that survived inundation by the sea, by existing on land well above sea level throughout the Oligocene Epoch. At least some of these plants and animals were likely long native to New Zealand, some possibly descendants of forms present in Gondwanaland before it broke up, and New Zealand drifted away from the lands with which it was once contiguous.

These are just some of the many reasons why plant and animals fossils from the early Miocene (which are very rare anywhere in the world) are extremely valuable for solving geological questions of major international importance.

Foulden Maar is consequently a priceless asset to New Zealand and to the world. To needlessly destroy this geological marvel would be an almost unparalleled act of uncivilised vandalism that would earn for New Zealand international contempt.

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University of
HUDDERSFIELD
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5/8/19

To Whom it may Concern,

I fully support Save Foulden Maar Incorporated Society in their efforts to secure funding in order to place Foulden Maar in public ownership and preserve it for scientific research in its entirety and in perpetuity.

I am a Senior Lecturer in Geology and Physical Geography at the University of Huddersfield, UK. Until 2018 I was a Lecturer in Geology at the University of Waikato. I worked on the Foulden Maar sediment during my PhD research at the University of Otago (2009-2014), and have continued to work on the sediments throughout my subsequent career. I have published a number of papers on the sediments in international peer-reviewed journals and given many presentations on results from Foulden Maar at international conferences and as an invited speaker at various institutions. I have an excellent understanding of the current and potential contribution of Foulden Maar to scientific research.

The importance of Foulden Maar in terms of palaeontology cannot be overstated. The preservation of the fossils is astonishing and the top few metres of the sediment have yielded a large amount of new information about the history of New Zealand flora and fauna. The majority of New Zealand insect fossils on record have come from this site. Given that only the top few layers have been investigated for palaeontology, there is no telling how much more information is preserved in deeper layers which might be investigated in the future.

As far as the sediment itself goes, the temporal resolution is extraordinary. Most sediments from this time period (the Oligocene/Miocene boundary) have a sedimentation rate of a few mm per thousand years; 44 mm per thousand years is considered to be high. Foulden Maar has a sedimentation rate of around 1000 mm per thousand years. Furthermore, most sediments are stirred by burrowing organisms and so any layers tend to be disturbed. Because of the lack of oxygen at depth, these organisms were not present at Foulden and annual (in fact, seasonal) layers are preserved through the entirety of the sediment. This is highly unusual even for modern lake sediments; to find this in a sediment of such great age is remarkable. There are very, very few annually resolved records of palaeoclimate older than the oldest recovered ice on Antarctica (about 800,000 years). This is the only such record known from this time period; the best resolution available otherwise is on the order of 5,000-10,000 years.

The time period is also very important: the Foulden Maar sediment was deposited during a period of rapid deglaciation in Antarctica, the causes of which are not yet well understood. This is the only record that can document this time period (and the changes in NZ climate at this time) on human timescales, i.e. over periods of seasons to centuries. The fantastic fossil preservation also means that this sediment contains fossil leaves where cell walls have been preserved. This can be used to estimate atmospheric carbon dioxide changes on short (years to centuries) timescales. Again, this is an unprecedented resolution for this time period. By comparison, a recent study using marine data to reconstruct atmospheric carbon dioxide had only 5 data points representing this 100,000 year period. This is considered to be very high resolution. Meanwhile at Foulden a single study on an 8.5 cm diameter core yielded 62 data points from 19 horizons. Given the richness of the fossils in the deposit, further cores could produce a great deal more data.

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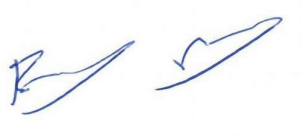
Given our current climatic situation, the more information we have about how the Earth system (and NZ more specifically) has responded to past changes in carbon dioxide and Antarctic ice volume, the better. There are multiple further studies that could be performed on this sediment given time and resources; at present, only a single PhD project has studied the palaeoclimatology of the sediment.

A core has been taken through the sediment at a single site; however, it is now ten years since this was retrieved, and despite our best efforts in terms of careful storage and preservation, such cores deteriorate over time. Thus, if the sediment were to be removed from Foulden Maar, there would be little recourse to stored materials. Further cores at multiple sites would doubtless yield a great deal of important data.

The scientific value of this deposit is very high, and in my view it would be a great loss to both global and New Zealand science if it were removed. It is vital that such resources are preserved for future generations and future science.

Yours sincerely



Bethany Fox

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Office of the Mayor

CITY OF DUNEDIN
NEW ZEALAND

3 July 2019

To Whom it May Concern

THE PRESERVATION OF FOULDEN MAAR

I am writing on behalf of Dunedin City Council in support of the application for funding made by *Save Foulden Maar Incorporated*, so the entirety of Foulden Maar may be purchased and preserved in perpetuity for ongoing palaeontological and climate change research for the good of humanity.

Dunedin has a proud heritage in education, the arts, and the sciences, which continues to this day. As we, at the Dunedin City Council, have so recently learnt from our palaeontologists and geologists, Foulden Maar contains invaluable fossils of exceptional quality which are key to understanding our flora and fauna, providing both an insight into our past and possible future.

We also learnt that the Maar contains 120,000 years of climate change data of incalculable value; that it is the only known site in the world that holds such high-resolution climate records spanning the period of the last major deglaciation of Antarctica, the very situation we are now facing.

These treasures were at risk of destruction by a transnational mining company wanting to mine it for diatomite for use as a stock feed additive on offshore factory farms and feedlots.

On 29 May, the Dunedin City Council voted to preserve Foulden Maar. The motions passed as follows:

1. Recognise the significance of the fossil record at Foulden Maar
2. Support its preservation and protection as a scientific resource
3. Requests options with urgency for giving effect to this

Dunedin and Otago also have a proud heritage of people who have tirelessly fought to preserve what are now considered outstanding features of our region and the South Island, such as the iconic Lake Manapouri and our very own Aramoana at the mouth of Otago Harbour. Foulden Maar is now being talked about in the same way.

From a long-term economic and sustainability perspective, our region would be best served by preserving Foulden Maar, promoting the area as an international centre for scientific, geological and climate research, and encouraging controlled geo-tourism such as at the Messel Pit in Germany. We believe public ownership is the best solution, otherwise Foulden Maar could, in the future again, be at risk of commercial destruction.

To this end, we reiterate our support of the application for funding submitted by the *Save Foulden Maar Incorporated Society*.

Yours sincerely

Dave Cull
Mayor of Dunedin

Dave Hansford, QSM
Nelson

12 July, 2019

To whom it may concern:

I write here to express my impassioned support for measures to protect in perpetuity the paeleontological treasure that is Foulden Maar.

I am a freelance science and environment writer. I have reported on these rounds for nearly 25 years, and sadly, in that time, I have documented too many wrong choices: opportunities to do real and lasting good irrevocably missed.

We must not let Foulden Maar be another one.

I recently interviewed two noted paeleontologists — Daphne Lee and Nic Rawlence — for a *New Zealand Geographic* story on this site and its treasures. Rarely have I encountered such an open-and-shut case for protection and wisdom.

The unique chronology and circumstances of deposition at Foulden Maar have left us one of the clearest, most high-resolution pictures of Zealandia as it looked and functioned 23 million years ago.

Foulden Maar is the only known site in the country to offer us this priceless glimpse of a menagerie and flora dramatically different in some respects, but surprisingingly familiar in others.

It has yielded two of just five orchid fossils known worldwide. It has preserved in breathtaking clarity one of the earliest galaxiid fishes. Prior to work at Foulden Maar, we had maybe seven pre-ice age fossil insect specimens. This site has yielded, at time of writing, 266 — such a trove that international experts are clamouring to help classify them.

So perfect are the fossils from the diatomaceous strata that we can clearly see the individual facets of insects' compound eyes — not just the intricate structure of a leaf, but the tiny scale insect that lived on it.

Revelations like Foulden Maar come along as rarely as the unique circumstances that created it. To allow these treasures to be destroyed, simply to support the insupportable — intensive battery farming — would be nothing less than barbarous.

Future generations would spit our names, and they would be right to do so. Other nations moved to protect their paleontological treasures decades ago: the Chengjiang Fossil Site in China and the Messel Pit in Germany — another maar site — both have UNESCO World Heritage protection. Foulden Maar deserves nothing less.

I urge anybody with the power and jurisdiction to do so to ensure that Foulden Maar is promptly and thoroughly protected for the lasting benefit of knowledge, enlightenment and sheer delight.

Yours Sincerely,

Dave Hansford, QSM

ENVIRONMENT AND CONSERVATION ORGANISATIONS OF NZ INC.

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Phone/Fax 64-4-385-7545

Friday 12 July 2019

To whom it may concern,

Keep the Museum out of the Mincer:

Protect Foulden Maar in perpetuity

Introduction to ECO and its interest in this matter

The Environment and Conservation Organisations of NZ (ECO) is the national alliance of 45 groups with a concern for the environment and conservation. We were established in 1971-72. Some of our member bodies are themselves federations or multiple groups. Many are area-based, some are focused on specific species or activities or impacts, some are not actually environmental groups but share our concerns.

ECO has followed issues of conservation and environmental management and practice, law and policy since its formation in 1971-2. We have member groups from all around New Zealand. We take an interest in both national and global matters and of course many local issues.

We support Te Tiriti o Waitangi, and ensuring that the "voice" of the environment is heard.

We have a long standing interest in and engagement with the systems, institutions, incentives and drivers of activities and impacts on the environment and with appropriate public policy responses.

ECO is a member of the International Union for the Conservation of Nature, IUCN, which is an expert body with both government and non-government membership and six Commissions of experts.

In this submission, we draw on the expertise of several members of ECO's Executive committee including that of ecological economist Cath Wallace, formerly of Victoria University of Wellington and on scientific expertise of a variety of others.

The significance and values of Foulden Maar

We recall distinguished scientist and film-maker, Jaques Cousteau, visiting New Zealand and travelling to the West Coast fossil-containing limestone caves which were proposed to be mined for input into cement making despite public outcries.

Cousteau tartly remarked that**: "there are not many countries that would put their museums through a mincer."** Were he alive still, we would expect him to make the same assessment about any plans to further mine Foulden Maar.

Foulden Maar contains a unique record of life extraordinarily preserved. There is no substitute for it. Once lost, the information it contains is lost irreversibly. It is a Taonga that can provide insights into may aspects of evolution of life and adaptation of species and ecosystems as conditions changed.

Foulden Maar holds **intrinsic value**, that is, value for its own sake. It also holds for people what economists call existence value, bequest value, and option value. These are all in situ "passive use" values.

Existence value is the name for the value humans derive from keeping something intact and its counterpart is the value of the loss that we would otherwise feel if that thing were destroyed.

Bequest value is the value that people put on passing on intact to the future something – in this case honouring the forbearance of those in the past and honouring our responsibility to hand taonga to the future. Kaitiakitanga captures some of this meaning and more.

Option value is the value of not foreclosing options for deriving future benefits, including knowledge, from retaining something intact.

Each of these three sources of value can and do accrue to many people, but it is non-rival (ie shared in common) value and benefits, not private value or benefit. Rival, or private benefit means that if one person benefits, then others cannot share that benefit.

When benefits are non-rival, they are shared and typically confer much greater total value when summed across each of the benefiting populations than private benefits do.

These non-rival benefits can continue as a stream of benefits indefinitely as long as – in this case - the fossil deposits remain in place or are examined in a non-destructive way. Thus the benefit stream continues in perpetuity.

Extractive value typically confers primarily private benefits to a few over a limited term of a few years or a few decades. Those who few who mine a mineral deposit by providing labour, technology or capital may gain some significant comparatively

short-term benefits. Communities may derive short-term multiplier effect benefits, but these are necessarily limited by the extent and term of the mining. They will not last. Moreover, it is common that environmental costs associated with mining are externalized so that these costs are shared but the benefits are privatized.

The public policy issue here is that the diffuse but large total net benefits from non-extractive use are non-market benefits that accrue to all, whereas the extractive market benefits may be substantial for a few, but the rest are worse off. The losses however are usually not counted or registered in the market. Hence, public policy and collective responses are required.

In the case of Foulden Maar, regulations to protect the taonga are needed, and these require some form, in this case, of protected area classification and management. We reproduce as Appendix One, the Protected Areas classification system of IUCN1, the International Union of Nature and Natural Resources, the authoritative global body on protected areas classification and management.

In the case of Foulden Maar, ECO suggests that the appropriate classification is either Ia) or III. Such designations can be made under the Conservation Act 1987 and the Reserves Act 1977.

The Reserves Act 1977 provides for geological and/or scientific reserves. This Act is administered by the Department of Conservation. The most appropriate permanent protection would be gained via Section 21 of the Reserves Act for establishing Scientific Reserves that allow for carefully controlled scientific study. See relevant excerpts from the Reserves Act 1977 in **Appendix Two**.

ECO is grateful for the work of all who have staved off any expansion of mining of Foulden Maar, particularly local residents, conservation organisations and scientists and their associations.

We urge central and local government and community to work with the land-owners to protect Foulden Maar, this vital geological museum. In particular, we recommend that this taonga be protected in perpetuity and that the ancient record it contains be protected under the Reserves Act 1977, with the blessing if it can be given, of Tangata Whenua.

Respectfully,

Cath Wallace

Co-chair of ECO

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[1] https://www.iucn.org/theme/protected-areas/about/protected-areas-categories/category-ia-strict-nature-reserve

Appendix 1

IUCN's Classification of Protected Area Categories

IUCN protected area management categories classify protected areas according to their management objectives. The categories are recognised by international bodies such as the United Nations and by many national governments as the global standard for defining and recording protected areas and as such are increasingly being incorporated into government legislation.

IUCN provides **Guidelines for applying protected area management categories** including IUCN WCPA best practice guidance on recognising protected areas and assigning management categories and governance types. See https://www.iucn.org/theme/protected-areas/about/protected-areas-categories/category-ia-strict-nature-reserve

Ia Strict Nature Reserve: Category **Ia** are strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphical features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring more...

Ib Wilderness Area: Category **Ib** protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition. more...

II National Park: Category **II** protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational, and visitor opportunities. more...

III Natural Monument or Feature: Category **III** protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value. more...

IV Habitat/Species Management Area: Category **IV** protected areas aim to protect particular species or habitats and management reflects this priority. Many Category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category. more...

V Protected Landscape/ Seascape: A protected area where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.more...

VI Protected area with sustainable use of natural resources: Category **VI** protected areas conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area more...

Category Ia: Strict Nature Reserve

Protected areas that are strictly set aside to protect biodiversity and also possibly geological/geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring.

Category Ia differs from the other categories in the following ways:

Category Ib	Category Ib protected areas will generally be larger and less strictly protected from human visitation than category Ia: although not usually subject to mass tourism they may be open to limited numbers of people prepared for self-reliant travel such as on foot or by boat, which is not always the case in Ia.
Category II	Category II protected areas usually combine ecosystem protection with recreation, subject to zoning, on a scale not suitable for category I.
Category III	Category III protected areas are generally centred on a particular natural feature, so that the primary focus of management is on maintaining this feature, whereas objectives of Ia are generally aimed at a whole ecosystem and ecosystem processes.
Category IV	Category IV protected areas protect fragments of ecosystems or habitats, which often require continual management intervention to maintain. Category Ia areas on the other hand should be largely self-sustaining and their objectives preclude such management activity or the rate of visitation common in category IV. Category IV protected areas are also often established to protect particular species or habitats rather than the specific ecological aims of category Ia.
Category V	Category V protected areas are generally cultural landscapes or seascapes that have been altered by humans over hundreds or even thousands of years and that rely on continuing intervention to maintain their qualities including biodiversity. Many category V protected areas contain permanent human settlements. All the above are incompatible with category Ia.
Category VI	Category VI protected areas contain natural areas where biodiversity conservation is linked with sustainable use of natural resources, which is incompatible with category Ia. However large category VI protected areas may contain

category Ia areas within their boundaries as part of management zoning.

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Category Ia: Strict Nature Reserve

Protected areas that are strictly set aside to protect biodiversity and also possibly geological/geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring.

Primary objective

To conserve regionally, nationally or globally outstanding ecosystems, species (occurrences or aggregations) and/or geodiversity features: these attributes will have been formed mostly or entirely by non-human forces and will be degraded or destroyed when subjected to all but very light human impact.

Other objectives

- To preserve ecosystems, species and geodiversity features in a state as undisturbed by recent human activity as possible;
- To secure examples of the natural environment for scientific studies, environmental monitoring and education, including baseline areas from which all avoidable access is excluded;
- To minimize disturbance through careful planning and implementation of research and other approved activities;
- To conserve cultural and spiritual values associated with nature.

Distinguishing features

The area should generally:

- Have a largely complete set of expected native species in ecologically significant densities or be capable of returning them to such densities through natural processes or time-limited interventions;
- Have a full set of expected native ecosystems, largely intact with intact ecological processes, or processes capable of being restored with minimal management intervention;
- Be free of significant direct intervention by modern humans that would compromise the specified conservation objectives for the area, which usually implies limiting access by people and excluding settlement;
- Not require substantial and on-going intervention to achieve its conservation objectives;

- Be surrounded when feasible by land uses that contribute to the achievement of the area's specified conservation objectives;
- Be suitable as a baseline monitoring site for monitoring the relative impact of human activities;
- Be managed for relatively low visitation by humans;
- Be capable of being managed to ensure minimal disturbance (especially relevant to marine environments).

The area could be of religious or spiritual significance (such as a sacred natural site) so long as biodiversity conservation is identified as a primary objective. In this case the area might contain sites that could be visited by a limited number of people engaged in faith activities consistent with the area's management objectives.

Role in the landscape/seascape

Category Ia areas are a vital component in the toolbox of conservation. As the Earth becomes increasingly influenced by human activities, there are progressively fewer areas left where such activities are strictly limited. Without the protection accompanying the Ia designation, there would rapidly be no such areas left. As such, these areas contribute in a significant way to conservation through:

- Protecting some of the earth's richness that will not survive outside of such strictly protected settings;
- Providing reference points to allow baseline and long-term measurement and monitoring of the impact of human-induced change outside such areas (e.g., pollution);
- Providing areas where ecosystems can be studied in as pristine an environment as possible;
- Protecting additional ecosystem services;
- Protecting natural sites that are also of religious and cultural significance

What makes category Ia unique?

Allocation of category is a matter of choice, depending on long-term management objectives, often with a number of alternative options that could be applied in any one site. The following box outlines some of the main reasons why Category Ia may be chosen in specific situations vis-à-vis other categories that pursue similar objectives.

Issues for consideration

- There are few areas of the terrestrial and marine worlds which do not bear the hallmarks of earlier human action, though in many cases the original human inhabitants are no longer present. In many cases, category Ia areas will therefore require a process of restoration. This restoration should be through natural processes or time-limited interventions: if continual

intervention is required the area would be more suitable in some other category, such as IV or V.

- There are few areas not under some kind of legal or at least traditional ownership, so that finding places that exclude human activity is often problematic.

- Some human actions have a regional and global reach that is not restricted by protected area boundaries. This is most apparent with climate and air pollution, and new and emerging diseases. In an increasingly modified ecology, it may become increasingly difficult to maintain pristine areas through non-intervention.

- Many sacred natural sites are managed in ways that are analogous to 1a protected areas for spiritual and cultural reasons, and may be located ***within*** both category V and VI protected areas.

Appendix Two

Reserves Act 1977: - Provisions relating to Geological and Scientific reserves

3 General purpose of this Act

(1) It is hereby declared that, subject to the control of the Minister, this Act shall be administered in the Department of Conservation for the purpose of—
(a) providing, for the preservation and management for the benefit and enjoyment of the public, areas of New Zealand possessing—
(i) recreational use or potential, whether active or passive; or
(ii) wildlife; or
(iii) indigenous flora or fauna; or
(iv) environmental and landscape amenity or interest; or
(v) natural, scenic, historic, cultural, archaeological, biological, geological, scientific, educational, community, or other special features or value:

4 Minister may require reports as to land to be reserved or otherwise protected

(1) The Minister may from time to time, in order to decide whether any land should be reserved or otherwise protected, cause inquiries or general surveys to be made regarding any land which may possess scenic, historic, cultural, archaeological, biological, **geological, or other scientific features or interest**, or indigenous flora or fauna, or wildlife, or recreational or natural environment interest:

21 Scientific reserves

(1) It is hereby declared that the appropriate provisions of this Act shall have effect, in relation to reserves classified as scientific reserves, for the purpose of protecting and preserving in perpetuity for scientific study, research, education, and the benefit of the country, ecological associations, plant or animal communities, types of soil, geomorphological phenomena, and like matters of special interest.

49 Taking of specimens

The Minister may from time to time, by writing under his or her hand, and subject to such conditions as he or she may impose in that behalf, grant any qualified person who in the Minister's opinion has the necessary credentials a right to take specified specimens of flora or fauna or rock mineral or soil from a reserve for scientific or educational purposes, provided the taking of such specimens does not unduly deplete the number of any species, damage ecological associations, or damage the values of the reserve:
provided that nothing in this section shall authorise the doing of anything with respect to fauna that would contravene anything in the Wildlife Act 1953 or in any regulations or Proclamation or notification under that Act.

59 Powers in respect of scientific reserves

(1) Where the Minister has issued a notice under section 21(2)(b) prohibiting entry to a scientific reserve or to any part of such a reserve, he or she may from time to time authorise the administering body, or the Commissioner where there is no administering body, to issue to any person who in the opinion of the administering body or the Commissioner, as the case may be, has the necessary credentials or qualifications a permit affording access to the reserve or to that part for scientific study or for control and management purposes, upon such

terms and conditions as the administering body or the Commissioner, as the case may be, may determine.

5th July 2019

To Whom It May Concern:

The 42 ha property near Middlemarch, Otago, containing the majority of the Foulden Maar is currently held by the Australian company, Plaman Resources, which has recently gone into receivership. The company had floated plans that could have seen the entirety of the diatomite deposit infilling the Maar mined away. From a scientific perspective Foulden Maar is a globally significant maar lake deposit containing a ~120,000-year-long annual record of infill (mostly varved diatomite) from the early Miocene (approximately 23 million years ago). Numerous plants, flowers, insects and freshwater fish have been described from this deposit and enable geological research into New Zealand climate in the Miocene. The detail available from the deposits is exceptional and is the best record of Miocene freshwater environments in New Zealand. This is an extremely valuable scientific resource and of relevance to all New Zealanders interested in our biological and geological history. This has been recognised financially via research funding support to investigate this site. This research has yielded nearly 40 peer-reviewed scientific articles and several postgraduate student research theses. The site was one of the first to be included in the New Zealand Geopreservation Inventory as "Middlemarch diatomite-bearing leaf fossils." and now as "Foulden Maar terrestrial and freshwater fossils in diatomite" see https://services.main.net.nz/geopreservation/. Attached is a summary document covering the significance and scientific outputs related to Foulden Maar.

The climate record at this site is also globally unique and has not yet been fully utilised. It is preserved to its full extent only in the central and deepest/thickest part of the diatomite deposit. The climate record is important as:

1. Foulden Maar is the world's only known annually layered record of climate and environment from the earliest Miocene. It can be investigated down to individual years and seasons, allowing us to see changes on human timescales, such as El Niño events. Other records of the time period have at best millennial resolution (i.e. a single subsample represents an average of at least 1000 years, and there is no way to look at any changes or events that take place over shorter timescales). The Foulden Maar thus is our only way of understanding human-timescale events during this period of geological history.

2. Foulden Maar also includes an unparalleled record for atmospheric carbon dioxide. There is no other place in the world where you have the potential of linking global climatic events to changes in the carbon cycle. This is highly relevant to the modern interaction between Antarctic ice extent, global temperatures and rising carbon dioxide levels. The presence of well-preserved fossil leaves also allows us to estimate atmospheric carbon dioxide changes. Again, this is very unusual for a deposit this old,

and this combined with the annual resolution allows us to pinpoint the rate of change of atmospheric carbon dioxide at a level of detail which is almost unknown elsewhere.

3. During this period of the Miocene, large parts of the Antarctic ice sheet melted for reasons that have not previously been well understood. The Foulden Maar represents a unique opportunity to investigate the causes of this ice-sheet loss and the effects that the warming had on New Zealand on human timescales.

In the future, new geological techniques will become available which will allow us to extract even more information about climate, environment and ecology from Foulden Maar and thus preservation of a continuous and full sequence of the layered diatomites is critical; the centre of the deposit is by far the most significant location for scientific research.

While industrial excavation at the site can expose new scientific information the pace and scale of a currently economic mining operation would make it difficult to realise the full scientific value of fossils exposed under any sort of NZ paleontological research 'business as usual' scenario as fossil preservation and study is slow and labour intensive. Although other infilled Maar craters, such as Hindon Maar, exist in the Otago region no other site in New Zealand or elsewhere globally preserves this time sequence and suite of fossil plants, fish and insects (and potentially birds and reptiles). During the recent mining proposal we also became concerned that lowering the water table (pumping the pit) during deep extraction could have cause any intact/preserved portion of the deposit to dry out. While currently lacking data to model this, if it occurred it could cause irreparable damage to the in situ fossils and layering hence destroying the scientific value of the entire site.

The Geoscience Society of New Zealand has consistently submitted a recommendation that at this unique site a significant and representative portion of these deposits should be retained in perpetuity, so that the scientific value of this resource remains for future public science and educational use. Public purchase of the land when it comes up for sale in the receivership process would be a good way to preserve this even if only a small part of the land from the edge to centre of the Maar was ultimately retained for science and education. The geoscience value of the site could be preserved in harmony with pastoral/agricultural/ecological restoration use of the land surface.

Yours sincerely

Dr Jennifer Eccles

GSNZ President

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8 July 2019

To Whom It May Concern,

It is my pleasure to write this letter in support of the attached proposal for funding submitted by Save Foulden Maar Incorporated.

Like many New Zealanders, I was shocked to learn of the proposal to mine Foulden Maar for diatomite. As a result, I publicly stated my opinion that it is wrong to destroy valuable scientific knowledge for the sake of a mining operation for an animal food product which does not appear to have proven benefit. This is particularly so in the face of global challenges such as climate change and biodiversity loss – Foulden Maar's fossil trove gives many insights to scientists relevant to these challenges.

Indeed, Foulden Maar contains a detailed climate record which is unique to the Southern Hemisphere. By protecting Foulden Maar, we ensure that this critical data remains intact so that it may help future generations to understand and cope with the current and future impacts of climate change. As new technologies and approaches to the study of past climates are developed, there is no telling what the data contained in Foulden Maar could reveal.

Furthermore, the exquisite fossil record represented at Foulden Maar gives an invaluable history of New Zealand biota and informs our understanding of the modern conservation challenges faced by extant biodiversity. This is particularly important given that New Zealand has the highest level of threatened species in the world, with more than 4,000 listed by the Department of Conservation as being threatened or at-risk of extinction.

I was surprised to learn that Foulden Maar is not already a scientific reserve. To this end, I fully support the efforts of Save Foulden Maar Incorporated to protect it in perpetuity for scientific research and the good of humanity by whatever means possible.

It is imperative New Zealand and New Zealanders are proactive in taking on the responsibility to protect our unique natural heritage with seriousness and urgency.

Yours faithfully,

Rt Hon Helen Clark,

Former Prime Minister of New Zealand; ONZ; PC.

5th July 2019

Kimberley Collins
Chair
Save Foulden Maar Charitable Trust

To whom it may concern

I am writing in support of the Save Foulden Maar Incorporated Society and their work to preserve a valuable scientific resource for the future by bringing Foulden Maar into public ownership. I fully endorse the option to purchase the 42 hectares previously owned by Plaman resources so that the site can be made safe from any future attempts to use it for commercial purposes.

I am a member of the Otago community and I am an environmentalist and climate activist. I am very concerned about the effects of the current climate and ecological crisis on our wildlife and ecology. I understand that Foulden Maar contains a rich fossil record that provides a continuous undisturbed resource stretching back over the last major deglaciation of Antarctica and is the only known site in the world to do so.

This information is invaluable to scientists studying the effects of climate change on the world today. I believe that it must be kept safe from the threat of destruction by mining so that it can be investigated by without any constraints of time or access. We have a responsibility to preserve the site and protect the potential for future scientific discovery that may assist us in adaption to climate change.

Please give every consideration and assistance to the Save Foulden Maar Incorporated Society.

I am happy to discuss this further and can be contacted using the details below.

Yours sincerely,
Jenny Olsen

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Dunedin 9014

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Twizel 7944
Canterbury

12th July 2019

To Whom it May Concern,

This letter is in support of funding applications by the Save Foulden Maar Incorporated Society to purchase the land that Foulden Maar sits on, to bring it into public ownership. This land purchase would prevent any diatomite mining on the land in the future, and protect and preserve this important fossil site for future generations.

I am a climate scientist, currently working in the energy industry, modelling climate and the NZ energy system decades into the future. I have worked on various climate research projects over the past 30 years, including microclimate modelling with the Topoclimate South project, and have contributed to the Lake Ohau Climate History project - a project using sediment cores from the Lake Ohau lake bed for palaeoclimate reconstruction.
(https://www.victoria.ac.nz/antarctic/research/research-prog/loch)

Foulden Maar is one of New Zealand's pre-eminent fossil sites that provides a unique window into New Zealand's geological past and the evolution of our unique biodiversity, and it should not be mined for animal fodder. The fossils retrieved to date from Foulden Maar represent only a tiny part of the potential fossil record at the site. In the face of human-induced climate change, we have no mandate to destroy one of the few sites that could offer unique insights to how our climate has changed over millenia.

This is not the first time this site has been at risk of being destroyed by mining, and it is vital that it is purchased and made into a reserve so that its scientific value can be preserved.

Yours faithfully,

Dr Jen Purdie

List of fossil species described from Foulden Maar and of publications and conference abstracts on the geology and paleontology of Foulden Maar

10 May 2019

Foulden Maar is now upgraded to international significance (A category) in the Geoscience Society of New Zealand Geopreservation Inventory

The unique finely laminated diatomite deposit preserved in Foulden Maar, near Middlemarch, Otago is of major international geological and paleontological significance.

Foulden Maar holds perhaps the most important fossiliferous terrestrial lake deposits of latest Oligocene – earliest Miocene age in the Southern Hemisphere. Firstly, it contains the best-preserved plant, insect and fish fossils of earliest Miocene age in New Zealand. Secondly, it holds the best-resolved record of the mid-latitude terrestrial climate in the Southern Hemisphere during a period of elevated global temperatures.

The scientific importance of Foulden Maar is shown by the number of peer-reviewed scientific papers on aspects of its geology and paleontology that have been published in national and international journals, most in the past 10 years. In addition, 3 PhD theses and several MSc and Honours theses have been based on research at Foulden Maar. Scientific research is continuing and we expect several papers a year to be published for the foreseeable future.

The laminated diatomite deposit that infills the subcircular volcanic crater formed by explosive phreatomagmatic eruptions is of limited spatial extent. It occupies an area of c. 1000 × 800 m. In June 2009, a Marsden Grant from the Royal Society of New Zealand enabled a research team from the University of Otago, GNS Science and The University of Adelaide to retrieve a 183 m-long core by drilling through the central and deepest part of the deposit. Detailed and ongoing study of this core has revealed a thickness of c.120 m of finely laminated diatomite overlying >63 m of volcaniclastic sediments (Kaulfuss 2017). Radiometric dating of volcanic rocks adjacent to the maar and from volcanic clasts within the core shows that the volcanic crater formed c. 23 million years ago. Thus, the lake sediments infilling the crater were deposited very close to the Oligocene–Miocene boundary, a key time in Earth History spanning a period of major deglaciation on Antarctica (Fox et al. 2017).

Paleontological Significance

Foulden Maar contains an extraordinary array of exquisitely preserved plant, fish, spider and insect fossils reflecting the anoxic conditions on the floor of the lake. A summary of the major fossil discoveries is provided in a review paper published in Lee et al. (2016) in the journal *Alcheringa.* The abstract in this invited review paper summarises the importance of Foulden Maar as a site of international significance.

Abstract: "This paper highlights the biodiversity and palaeoecology of the 23-million-year-old Foulden Maar, the first *Konservat-Lagerstätte* deposit described from New Zealand and a key site for reconstructing early Miocene Southern Hemisphere terrestrial ecosystems. The 1000-m-diameter, ca 200-m-deep Foulden Maar volcanic crater lake was a closed system with anoxic bottom waters, capturing and preserving in exquisite detail organisms from the lake and adjacent rainforest. The fossils include numerous leaves, flowers with in situ pollen, fruits, seeds, fish and arthropods. Surrounding Foulden Maar was an evergreen, Lauraceae-dominated

notophyll vine forest with a diverse understorey, lianes, epiphytes and mistletoes. Diverse pollination and seed dispersal modes are evident. Fish include larval to adult stages of articulated specimens of *Galaxias*, some with preserved soft tissue and a species of eel resembling *Anguilla*. The arthropod fauna comprises ca 20 families in the orders Araneae (spiders), Plecoptera (stoneflies), Odonata (dragonflies), Isoptera (termites), Hemiptera (true bugs), Diptera (true flies), Coleoptera (beetles), Trichoptera (caddis flies) and Hymenoptera (wasps, ants and bees), representing faunas typical of soil, leaf litter, forest floor or freshwater habitats. Many fossil taxa have close relatives in the extant New Zealand biota; others are now locally extinct. Coprolites containing quartz sands sourced from outside the lake indicate the presence of volant birds, presumably waterfowl. The Foulden Maar *Lagerstätte* is crucial for reconstructing Miocene lake and forest ecosystems in New Zealand, particularly the terrestrial arthropod component."

Climate Record

Detailed analysis of the laminations in the diatomite shows that they are annual varves that provide a c. 120,000-year record of annual climatic fluctuations at a time when the Earth's climate was warmer than today (Lindqvist & Lee 2009; Fox et al. 2015, 2017). The unique preservation of plant material in the Foulden Maar core allows unprecedented detailed investigations of otherwise enigmatic climatic variables, such as rainfall and atmospheric CO_2. These include ENSO and other climate cycles, some of which are still under investigation by an international team of climate scientists.

No other pre-Quaternary terrestrial deposit in the Southern Hemisphere contains such a high-resolution mid-latitude climate record and we know of no other potential sites in New Zealand, or elsewhere, that might yield such a record. This level of annual resolution is more than 10× that studied in marine deep-sea cores which are the other main source of paleoclimate records for the earliest Miocene.

Because of the global significance of the paleontological and climate records preserved in Foulden Maar, the status of this site has now been upgraded to "International Significance" (A Category) in the Geoscience Society of New Zealand Geopreservation Inventory.

We note that it is currently vulnerable to significant modifications by human actions by mining, or, potentially over a longer time period of years to decades to vulnerable to complete destruction by human actions (in this case, mining of the entire resource which would result in the formation of a deep lake and prevent any further access for scientific research).

Foulden Maar is the type locality for a growing number of fossil plant and animal taxa and as such the site should be preserved in perpetuity (Table 1). To date, we have identified about 100 different species of plant macrofossils representing 35 plant families (mostly leaves, but also fruits, seeds and wood) and have collected 40 flowers, many with *in situ* pollen, representing 15 plant families. Fossil flowers with associated pollen are extraordinarily rare globally. The plants include extremely rare fossil orchids, mistletoes, fuchsias and a host of other taxa that link NZ to Australia, New Caledonia and South America. There are several fish including the oldest freshwater eel fossil in the Southern Hemisphere. Finally, we have now collected 4 spiders, and 266 different insects representing 21 families and 9 orders. Many more plant, fish and arthropod fossils remain to be described.

Foulden Maar represents one of the few opportunities to reconstruct a complex and highly detailed Miocene rainforest and lake ecosystem from New Zealand that includes significant, now extinct, Australian, New Caledonian and South American elements. However, despite the rich fossil diversity that has been recovered to date, the site has barely been examined and most collecting trips to the maar reveal new, often beautifully preserved fossils with important biogeographic and taxonomic implications. To lose such an important fossil site would be a tragedy both for New Zealand and the wider paleontological community.

In summary, the rich and extraordinarily well-preserved fossil leaves, flowers, insects, and freshwater fish have greatly advanced our knowledge of the history of New Zealand's unique terrestrial biota. Foulden Maar is as important to our understanding of the origins of New Zealand's biota as the UNESCO Messel World Heritage Site in Germany, is to understanding the history of Europe's biota.

The 183-m-long core retrieved from the central part of the lake holds the most finely resolved terrestrial climate record known for the earliest Miocene of the Southern Hemisphere. This core is currently held in refrigerated storage at the University of Otago, but in time (years to decades) it is likely to degrade to such an extent as to be unusable for further scientific research. We expect future research to require freshly cored material that spans the full thickness of the diatomite sequence.

Table 1. Foulden Maar is currently the type locality for 27 species of plants and pollen, nine species of insects and one species of fish. These taxa are all endemic to New Zealand and have been found nowhere else in the world.

Plants (including diatoms and novel pollens)
Encyonema jordaniforme Krammer
Fouldenia staminosa Bannister, D.E. Lee & Raine
Davallia walkeri Conran, U. Kaulfuss, Bannister, Mildenhall & D.E. Lee
Podocarpus travisiae Pole
Dendrobium winikaphyllum Conran, Bannister & Lee
Earina fouldenensis Conran, Bannister & Lee
Laurelia otagoensis Conran, Bannister & Lee
Laurophyllum maarensis Bannister, Conran & D.E. Lee
Laurophyllum microphyllum Bannister, Conran & D.E. Lee
Laurophyllum waipiata Bannister, Conran & D.E. Lee
Laurophyllum taieriensis Bannister, Conran & D.E. Lee
Laurophyllum calicarioides Bannister, Conran & D.E. Lee
Laurophyllum sylvestris Bannister, Conran & D.E. Lee
Laurophyllum lacustris Bannister, Conran & D.E. Lee
Laurophyllum vulcanicola Bannister, Conran & D.E. Lee
Laurophyllum otagoensis Bannister, Conran & D.E. Lee
Litseopsis nova-zelandiae Bannister, Conran & D.E. Lee
Malloranga fouldenensis D.E. Lee, Bannister, J.I. Raine & Conran
Euphorbiotheca mallotoides D. E. Lee, Bannister, J.I. Raine & Conran
Astelia antiquua Maciunas, Conran, Bannister, R.Paull & D.E. Lee
Euproteaciphyllum alloxylonoides R.J.Carp., Bannister, D.E.Lee & G.J.Jord.
Euproteaciphyllum pacificum R.J.Carp., Bannister, D.E.Lee & G.J.Jord.
Fuchsia antiqua D.E.Lee, Conran, Bannister, U.Kaulfuss & Mildenh.
Luzuriaga peterbannisteri Conran, Bannister, Mildenh., & D.E.Lee

Liliacidites contortus Mildenh. & Bannister
Dicyclopsodites leei Mildenh., Kennedy & Prebble
Akania gibsonorum Conran, U.Kaulfuss, Bannister, Mildenh., & Lee

Insects
Stolotermes kupe Kaulfuss, Harris & Lee
Waipiatatermes matatoka Engel & Kaulfuss
Taieritermes krishnai Engel & Kaulfuss
Otagotermes novazealandicus Engel & Kaulfuss
Pterotermopsis fouldenica Engel & Kaulfuss
Rhytidoponera waipiata Kaulfuss & Dlussky
Rhytidoponera gibsoni Kaulfuss & Dlussky
Myrmecorhynchus novaeseelandiae Kaulfuss & Dlussky
Austroponera schneideri Kaulfuss & Dlussky

Fish
Galaxias effusus Lee, McDowall & Lindqvist

Table 2. Peer-reviewed publications on Foulden Maar (in chronological order from most recent)

1. Conran JG, Kaulfuss U, Bannister JM. Mildenhall DC, Lee DE 2019. An *Akania* (Akaniaceae) inflorescence with associated pollen from the early Miocene of New Zealand. *American Journal of Botany* 106: 1–11.
2. Harper MA, van de Vijver,B, Kaulfuss U, Lee DE 2019. Resolving the confusion between two fossil freshwater diatoms from Otago, New Zealand: *Encyonema jordanii* and *Encyonema jordaniforme* (Cymbellaceae, Bacillariophyta). *Phytotaxa* 394: 231–243.
3. Kaulfuss U, Conran JG, Bannister JM, Mildenhall DC, Lee DE 2019. A new Miocene fern (*Palaeosorum*: Polypodiaceae) from New Zealand bearing in situ spores of *Polypodiisporites*. *NZ Journal of Botany*, doi: 10.1080/0028825X.2018.1560336
4. Reichgelt T, Kennedy EM, Conran JG, Lee WG, Lee DE 2019. The presence of moisture deficits in Miocene New Zealand. *Global and Planetary Change* 172: 268–277.
5. Selden P & Kaulfuss U 2018. Fossil arachnids from the earliest Miocene Foulden Maar Fossil-*Lagerstätte*, New Zealand. Alcheringa.
6. Engel MS, Kaulfuss U 2017. Diverse, primitive termites (Isoptera: Kalotermitidae, *incertae sedis*) from the early Miocene of New Zealand. Austral Entomology 56(1): 94–103.
7. Fox BRS, D'Andrea WJ, Wilson GS, Lee DE, Wartho J-A. 2017. Interaction of polar and tropical influences in the mid-latitudes of the Southern Hemisphere during the Mi-1 deglaciation. *Global & Planetary Change* 155: 109–120.
8. Jones DA, Wilson GS, Gorman AR, Fox BRS, Lee DE, Kaulfuss U 2017. A drill-hole calibrated geophysical characterisation of the 23 Ma Foulden Maar stratigraphic sequence, Otago, New Zealand. New Zealand Journal of Geology and Geophysics 60(4): 465–477.
9. Kaulfuss U 2017. Crater stratigraphy and the post-eruptive evolution of Foulden Maar, southern New Zealand. New Zealand Journal of Geology and Geophysics 60(4): 410–432.
10. Conran JG, Bannister JM, Mildenhall DC, Lee DE 2016. *Hedycarya* (Monimiaceae) macrofossils and associated *Planarpollenites* pollen from the early Miocene of New Zealand. American Journal of Botany 103(5): 1–19.
11. Reichgelt T, D'Andrea WJ, Fox BRS 2016. Abrupt plant physiological changes in southern New Zealand at the termination of the Mi-1 event reflect shifts in hydroclimate and pCO_2. Earth and Planetary Science Letters 455, 115–124.
12. Fox BRS, Wilson GS, Lee DE 2016. A unique annually laminated maar lake sediment record shows orbital control of Southern Hemisphere mid-latitude climate across the Oligocene–Miocene boundary. Geological Society of America Bulletin 128(3–4): 609–626.

13. Lee DE, Kaulfuss U, Conran JG, Bannister JM, Lindqvist JK 2016. Biodiversity and palaeoecology of Foulden Maar: an early Miocene *Konservat-Lagerstätte* deposit in southern New Zealand. Alcheringa 40(4): 525–541.
14. Conran JG, Lee DE, Kaulfuss U 2015. Fossil flowers: gaining glimpses of an ancient forest. e-Science Oct 2015 (Issue 15): 45–53. Retrieved 20 Feb 2013 http://escience.realviewdigital.com/?iid=129651#folio=45
15. Kaulfuss U, Dlussky GM 2015. Early Miocene Formicidae (Amblyoponinae, Ectatomminae, ?Dolichoderinae, Formicinae, and Ponerinae) from the Foulden Maar Fossil Lagerstätte, New Zealand, and their biogeographic relevance. Journal of Paleontology 89(6): 1043–1055.
16. Fox BRS, Wartho J, Wilson GS, Lee DE, Nelson FE, Kaulfuss U 2015. Long-term evolution of an Oligocene/Miocene maar lake from Otago, New Zealand. Geochemistry, Geophysics, Geosystems 16(1): 59–76.
17. Conran JG, Lee WG, Lee DE, Bannister JM, Kaulfuss U 2014. Reproductive niche conservatism in the isolated New Zealand flora over 23 million years. Biology Letters 10(10): 20140647.
18. Conran JG, Bannister JM, Mildenhall DC, Lee DE, Chacón J, Renner SS 2014. Leaf fossils of *Luzuriaga* and a monocot flower with in situ pollen of *Liliacidites contortus* Mildenh. & Bannister sp. nov. (Alstroemeriaceae) from the early Miocene. American Journal of Botany 101(1): 141–155.
19. Kaulfuss U, Harris AC, Conran JG, Lee DE 2014. An early Miocene ant (subfam. Ambyloponinae) from Foulden Maar: the first fossil Hymenoptera from New Zealand. Alcheringa 38(4): 568–574.
20. Kaulfuss U, Lee DE, Barratt BIP, Leschen RAB, Larivière M-C, Dlussky GM, Henderson IM, Harris AC 2014. A diverse fossil terrestrial arthropod fauna from New Zealand: evidence from the early Miocene Foulden Maar fossil *Lagerstätte*. Lethaia 48(3): 299–308.
21. Mildenhall DC, Kennedy EM, Lee DE, Kaulfuss U, Bannister JM, Fox B, Conran JG 2014. Palynology of the early Miocene Foulden Maar, Otago, New Zealand: diversity following destruction. Review of Palaeobotany and Palynology 204(1): 27–42.
22. Mildenhall DC, Kennedy EM, Prebble JG, Shepherd CL 2014. A distinctive diporate pollen grain (Apocynaceae?) from the Late Oligocene–Early Miocene of New Zealand. New Zealand Journal of Geology and Geophysics 57(2): 264–268.
23. Conran JG, Lee DE, Bannister JM 2013. Fossil orchids in New Zealand underpin evolution in the family. e-Science Feb 2013 (Issue 4): 10–11. Retrieved 20 Feb 2013 http://escience.realviewdigital.com/?iid=73253#folio=10
24. Lee DE, Bannister JM, Kaulfuss U, Conran JG, Mildenhall DC 2013. A fossil *Fuchsia* (Onagraceae) flower and an anther mass with *in situ* pollen from the early Miocene of New Zealand. American Journal of Botany 100(10): 2052–2065.
25. Reichgelt T, Kennedy EM, Mildenhall DC, Conran JG, Greenwood DR, Lee DE 2013. Quantitative palaeoclimate estimates for early Miocene southern New Zealand: evidence from Foulden Maar. Palaeogeography, Palaeoclimatology, Palaeoecology 378(1): 36–44.
26. Bannister JM, Lee DE, Conran JG 2012. Lauraceae from rainforest surrounding an early Miocene maar lake, Otago, southern New Zealand. Review of Palaeobotany and Palynology 178(1): 13–34.
27. Carpenter RJ, Bannister JM, Lee DE, Jordan GJ 2012. Proteaceae leaf fossils from the Oligo–Miocene of New Zealand: new species and evidence of biome and trait conservatism. Australian Systematic Botany 25(6): 375–389.
28. Lee DE, Conran JG, Lindqvist JK, Bannister JM, Mildenhall DC 2012. New Zealand Eocene, Oligocene and Miocene macrofossil and pollen records and modern plant distributions in the Southern Hemisphere. Botanical Review 78(3): 235–260.
29. Kaulfuss U, Wappler T, Heiss E, Larivière M-C 2011. *Aneurus* sp. from the early Miocene Foulden Maar, New Zealand: the first Southern Hemisphere record of fossil Aradidae (Insecta: Hemiptera: Heteroptera). Journal of the Royal Society of New Zealand 41(4): 279–285.
30. Maciunas E, Conran JG, Bannister JM, Paull R, Lee DE 2011. Miocene *Astelia* (Asparagales: Asteliaceae) macrofossils from southern New Zealand. Australian Systematic Botany 24(1): 19–31.
31. Conran JG, Kaulfuss U, Bannister JM, Mildenhall DC, Lee DE 2010. *Davallia* (Polypodiales: Davalliaceae) macrofossils from early Miocene Otago (New Zealand) with *in situ* spores. Review of Palaeobotany and Palynology 162(1): 84–94.
32. Kaulfuss U, Harris AC, Lee DE 2010. A new fossil termite (Isoptera, Stolotermitidae, *Stolotermes*) from the early Miocene of Otago, New Zealand. Acta Geologica Sinica 84(4): 705–709.

33. Lee DE, Bannister JM, Raine JI, Conran JG 2010. Euphorbiaceae: Acalyphoideae fossils from early Miocene New Zealand: *Mallotus–Macaranga* leaves, fruits, and inflorescence with *in situ Nyssapollenites endobalteus* pollen. Review of Palaeobotany and Palynology 163 (1–2): 127–138.
34. Conran JG, Bannister JM, Lee DE 2009. Earliest orchid macrofossils: early Miocene *Dendrobium* and *Earina* (Orchidaceae: Epidendroideae) from New Zealand. American Journal of Botany 96(1): 466–474.
35. Conran JG, Bannister JM, Lee DE 2009. Earliest fossil *Dendrobium* and *Earina* from early Miocene NZ. New Zealand Native Orchid Group Journal 112: 17–20.
36. Lindqvist JK, Lee DE 2009. High-frequency paleoclimate signals from Foulden Maar, Waipiata Volcanic Field, southern New Zealand: an early Miocene varved lacustrine diatomite deposit. Sedimentary Geology 222(1): 98–110.
37. Harris, A.C., Bannister, J.M. & Lee, D.E. 2007. Fossil scale insects (Hemiptera, Coccoidea, Diaspididae) in life position on an angiosperm leaf from an Early Miocene lake deposit, Otago, New Zealand. Journal of the Royal Society of New Zealand, 37(1): 1–13.
38. Lee DE, McDowall RM, Lindqvist JK 2007. *Galaxias* fossils from Miocene lake deposits, Otago, New Zealand: the earliest records of the Southern Hemisphere family Galaxiidae (Teleostei). Journal of the Royal Society of New Zealand 37(3): 109–130.
39. Bannister JM, Lee DE, Raine JI 2005. Morphology and palaeoenvironmental context of *Fouldenia staminosa*, a fossil flower with associated pollen from the early Miocene of Otago, New Zealand. New Zealand Journal of Botany 43(2): 515–525.
40. Pole MS 1996. Plant macrofossils from the Foulden Hills Diatomite (Miocene), Central Otago, New Zealand. Journal of the Royal Society of New Zealand 26(1): 1–39.
41. Pole MS 1993. Miocene broad-leaved *Podocarpus* from Foulden Hills, New Zealand. Alcheringa 17(3): 173–177.
42. McDowall RM 1976. Notes on some *Galaxias* fossils from the Pliocene of New Zealand. Journal of the Royal Society of New Zealand 6(1): 17–22.
43. Couper RA 1960. Plant microfossils from the Middlemarch Diatomite (Appendix to Coombs et al.: Age relations of the Dunedin Volcanic Complex and some paleogeographic implications, part 2). New Zealand Journal of Geology and Geophysics 3(4): 578–579.

Conference abstracts

1. Reichgelt T, D'Andrea WJ, Valdivia-McCarthy AC, Fox BRS 2018. Early Miocene CO_2 reconstructions based on multiple plant species. AGU Fall Meeting, December 2018, Washington DC, USA.
2. Lee DE, Kaulfuss U, Conran JG, Bannister JM, Lindqvist JK, Vanner MR, Reichgelt T, Kennedy EM, Mildenhall DC 2018. Diverse Oligocene-Miocene paleoenvironments and complex forest ecosystems in southern Zealandia. In: Sagar M, Prebble J ed. Abstract Volume: Geosciences 2018, Napier, New Zealand. Geoscience Society of New Zealand Miscellaneous Publication 151A. p 123.
3. Reichgelt T, Kennedy EM, Conran JG, Lee DE 2017. Paleobotanical evidence for Miocene summer moisture deficits in southern New Zealand. GSA abstracts with programs Vol. 49, No. 6. In: Organising Committee ed. GSA Annual Meeting in Seattle, Washington, USA, 22–25 Oct 2017, Geological Society of America. Pp. doi: 10.1130/abs/2017AM-301233.
4. Kaulfuss U, Lee DE, Lindqvist JK 2017. Sedimentology and paleoecology of two Miocene maar-*Lagerstätten* in New Zealand. In: Organising Committee ed. 2017 International workshop on *Konservat-Lagerstätten*, Cork, Ireland 15–16 Jul 2017. Programme book. Cork, Ireland, IWKL Organising Committee. Pp. 18–19.
5. Valdivia-McCarthy ADC, Reichgelt T, D'Andrea WJ, Fox BRS 2017. Suborbital-scale CO2 reconstructions from the earliest Miocene based on fossil leaves. GSA Annual Meeting, October 2017, Seattle, USA.
6. Reichgelt T, D'Andrea WJ, Fox BRS 2017. Fossil leaves record a short-lived disruption of the carbon cycle at the Paleogene–Neogene boundary. Climatic and Biotic Events of the Paleogene Meeting, September 2017, Utah, USA.
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July 19th, 2019

From: Jennifer Shulzitski
Extinction Rebellion Ōtepoti Dunedin
Email: dunedin@extinctionrebellion.nz
Phone: 022-415-7073

Re: Save Foulden Maar Incorporated Society

To Whom It May Concern:

I am writing to urge action to preserve one of New Zealand's Scientific Treasures in perpetuity - Foulden Maar. I agree with scientists that it has merit as a highly detailed and intact fossil record of worldwide status. It is a "one of a kind" location in the Southern Hemisphere as a record for glaciation in Antarctica and its value of 120,000 years of the climate record (at a time when we are preparing for a much warmer planet) merit immediate protection from mining and extractive commercial entities.

I am a scientist with professional experience in biology, long term monitoring programs, and conservation. I have worked for Northern Arizona University, the National Park Service, and the U.S. Geological Survey – Biological Resources Division. I have also worked in outdoor education and as an environmental activist with Turtle Island Restoration Network in San Francisco, California. I am a mother of three young children, and we cherish outdoor experiences connecting with nature, rejuvenating our souls. My grandfather was an avid rockhound, and we have micromineral collections as family heirloom. We grew up looking for fossils in the Rocky Mountains, marveling at our ancestors and reveling, heads spinning, trying to understand the age of the planet. Foulden Maar tells of New Zealand's origins. Foulden Maar roots Kiwis in their sense of place and in their connection to the land.

Foulden Maar provides an extraordinarily detailed record of Zealandia's unique fossil record, preserved with incredible resolution. Pollen grains, insect scales, and orchids are amongst the treasures for national and international specialists. Already three prestigious Marsden grants have been awarded to study at this site of significance, and to date a teaspoon in a rugby field has been properly analyzed. The possiblities for scientific discovery are staggering, with new species left to be uncovered providing crucial links in telling the story of the evolution of life on our planet. In Asia and in Europe, similar sites are treated as museums, and we must do the same with Foulden Maar.

In addition, Foulden Maar is a source of data for climate science. Foulden Maar contains 120,000 years of the climate record beginning 23 million years ago. The year to year clarity of the data is incomparable in the Southern Hemisphere. Foulden Maar's record captures the glaciation record, as well as warmer, wetter periods. Understanding the ecosystem and species assemblage at this time may provide crucial data for climate change modeling, as we enter a transformative period, since carbon dioxide has exceeded 415 ppm for the first time in human history.

The New Zealand people deserve and expect our most unique and iconic treasures to endure for future generations. The Dunedin City Council and Mayor stood beside the people in rejecting calls for commercial mining, and we support permanent protection to thwart future exploitation. I speak for myself, my family, my peers in the scientific community, and the membership of Extinction Rebellion Ōtepoti Dunedin.

Sincerely and with kind regards,

Jennifer Shulzitski

Karearea
NZ falcon

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NEVILLE PEAT

4 July 2019

PROTECTION OF FOULDEN MAAR FOSSIL SITE

I write in support of the fundraising efforts and advocacy of the Save Foulden Maar Charitable Trust to protect in perpetuity the landmark geological site on Foulden Hill Station near Middlemarch.

I have ancestral and literary links to the area. My family farmed at nearby Garthmyl last century and I have visited the fossil site in the course of researching two books – the award-winning natural history book *Wild Dunedin* (1995, new edition 2014) co-authored with scientist Brian Patrick, and the creative non-fiction title, *The Falcon and the Lark* (1992), which is wholly set in the Strath Taieri. In the *Wild* series and numerous other natural history titles featuring southern New Zealand landscapes, flora and fauna I have emphasised up front the geological history and the importance of the fossil record. The Foulden Hill fossil site, as the campaign to save them has compellingly protrayed, is of national and international significance – a natural and scientific treasure trove. In *Wild Dunedin*, I describe the fossil leaves as 'breathtakingly intact and coloured in autumn hues. There are no trees of their species left. They are all extinct.' (Photo attached)

For my nature writing and nature conservation work, including six years leading the Orokonui Ecosanctuary project as trust chair, I was made a Member of the New Zealand Order of Merit (MNZM) in the 2018 New Year Honours, 'for services to conservation'.

As a natural heritage feature, the Foulden Hill site is too precious to be destroyed by quarrying of diatomite. It forms part of ancient inland Otago, which survived the drowning of much of New Zealand in the Oligocene period. Its superbly and finely preserved fossils open up a window on our ancient flora and fauna. It deserves to be protected in perpetuity by covenant or reserve designation that would not necessarily mean the withdrawal of pastoral farming on the immediate surrounding land.

Thank you in advance for any financial support you might be able to provide towards protecting Foulden Maar and its fossil beds.

Sincerely

Neville Peat

Neville Peat

E ngā rakātira o te Nature Heritage Fund

Esteemed leaders of the Nature Heritage Fund

We are a group of mana whenua and connect through whakapapa to this whenua. We are deeply concerned about the future of Foulden Maar. Several of these maar exist within the rohe of Puketeraki rūnaka. They are a result of past volcanic processes which are characteristic of the north Dunedin City landscape. This landscape is our whenua tīpuna, and the significance of these mauka to us is embedded in the landscape through the names of our ancestor's in waka traditions such as the Araiteuru.

We write this letter in support of the application from Save Foulden Maar Incorporated to the Nature Heritage Fund, to secure funding in order to purchase 42 hectares of Foulden Maar and place the site in public ownership.

We are deeply offended and extremely disappointed that this outstanding natural feature may become commodified and sold as an additive to stock food on factory farms and feedlots. Equally disturbing is the very real possibility that it could also end up as a fertiliser on palm oil plantations. Any commercial mining activity is an absolute affront to the unique 23-million-year-old lens into the past that this deposit offers. Neither do we consider it necessary that science expound and appropriate the totality of that past; it is enough that this fascinating and rare feature of our unique biodiversity exists in our landscape.

The future of Foulden Maar must not be decided upon within the limited paradigm of market-driven commercial viability. Its future must be a value driven process, in which the community, present and future, has the opportunity to fully appreciate its significance and worth. Anything other than public ownership and protection of the site would be antithetical to that outcome.

The effort to save Foulden Maar from commercial exploitation has highlighted how these kinds of geologically significant natural features are not well protected through current legislative and regulatory processes. There has been little recognition by local government of geological significance under RMA process. We trust that Foulden Maar will set a precedent and become a catalyst for the protection of other such invaluable sites (Hindon Maar Complex).

As tangata and mana whenua, we recognise there is a current and rapidly escalating future climate crisis. We have begun processes to understand the changes necessary in our engagement with the economy and resource utilisation to avert climate disaster. Minimal foresight is necessary to recognise that the agribusiness petrochemical intensive food production systems supported by the mining of Foulden Maar, heavily reliant on CO2 outputs, are creating the very climate crisis we seek to avert.

In its layers of diatomite, Foulden Maar is the only known site in the world that holds evidence of climate change spanning the last deglaciation of the Antartica, which is essential for us to understand and plan for the conditions we may confront. Foulden Maar is currently unprotected and vulnerable to profit-driven mining interests. To leave it this way, the people of Aotearoa, tangata and mana whenua, our children and future generations are literally robbed of insight into both our past and future.

We reiterate our support of the work of Save Foulden Maar Incorporated to place the site in its entirety and in perpetuity under public ownership and protection. We strongly urge you to be proactive in protecting this taonga for future generations.

He waka eke noa – We are all in this together

Nā mātou,

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Dominic Karaitiana Clucas (Ngāi Tūāhuriri, Ngāi Te Rakiamoa)

Natalie Karaitiana (Kāti Taoka) komiti@tro.org.nz

I, tautoko the Foulden Maar kaupapa. Mrs Koa Whitau Kean, Moeraki. (Ngāti Irakehu, Ngāti Hāteatea, Kāti Huirapa, Ngāti Waewae). koawkean3@hotmail.com

Deirdre Carroll (Ngāi Tūāhuriri) deirdrec@psusi.org.nz

Maree Clayton (Ngāi Tūāhuriri)

Kuini Scott (Kai Te Ruahikihiki and Kāti Kuri) kuini.scott@gmail.com

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Moana Wesley (Kāti Taoka)

I Gene Waaka, tautoko this idea. Kai Tahu- Kaati Mamoe- Waitaha- Te Rapuwai (South Island tribes) Kaati Huirapa

Roslyn Nijenhuis (Ngāti Hāteatea)

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Mrs Hīria Moffat (Kāti Huirapa) Ph: 034394746

Stella McQueen

Native Fish Specialist
Science Communicator

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nznativefish@gmail.com

5 July 2019

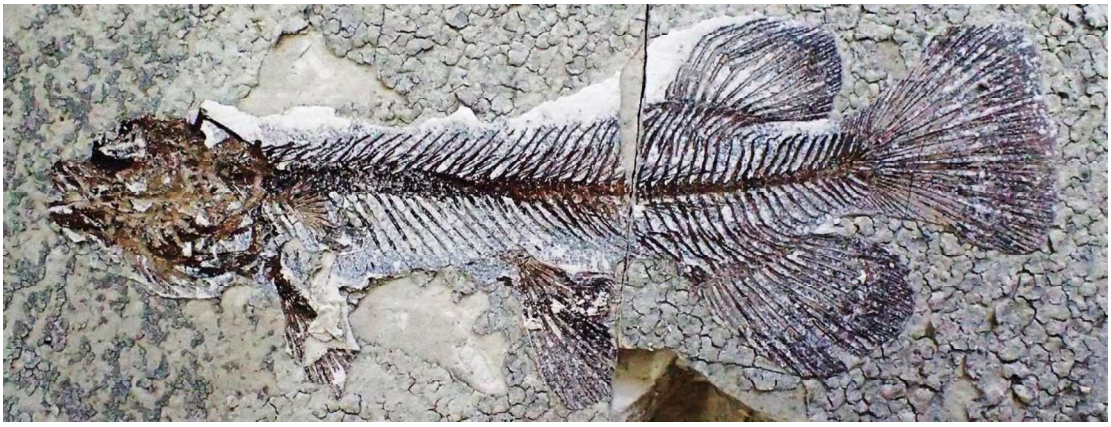
Letter in support of the protection of Foulden Maar for science

I am a freshwater ecologist with a specialty in New Zealand's native fish and an internationally recognised science communicator, bringing native fish biology and ecology to a broad audience through social media, radio, printed articles, workshops and my two books, *A Photographic Guide to Freshwater Fishes of New Zealand* (2013) and *The New Zealand Native Freshwater Aquarium* (2018).

Preserved within the layers of Foulden Maar is an irreplaceable record of the evolution of a single fish species, from a migratory ancestor that favoured flowing waters, to one that was supremely adapted to the quiet lake in which it lived. The existence of such a perfectly preserved, year-by-year evolutionary record of a species is utterly staggering.

That fish, *Galaxias effusus*, is part of the 'whitebait' group, a well-studied family of small, scaleless fishes. *G. effusus* would have looked like a stocky kōkopu with an exceptionally large tail. Its migratory ancestors likely entered Foulden Maar during a rare overflow event, but were then able to establish a landlocked population within the lake, with no need to go to sea as juveniles. It then evolved undisturbed, adapting to conditions within the lake.

It is from a family that is characterised by a cool-temperate Southern Hemisphere distribution, not the warm-temperate to sub-tropical conditions present within the lake. And yet there were other galaxiid species in other lakes and streams around Otago at the same time. We don't know why this family is no longer able to tolerate warmer environments. Further work on this fossil species may be able to answer this, and help us understand the future of this fish family on a warming planet.



Galaxias effusus from Foulden Maar, showing perfect articulation of even the tiniest bones.

Although modern kōkopu are able to form landlocked populations, typically the adults spend their lives in inflowing streams, with juveniles using the lake in place of the sea as rearing habitat. The lack of inflowing streams forced both adults and juvenile *G. effusus* to cohabit, as evidenced by the presence of fossils and coprolites of both stages in the centre of the lake.

This open water would have had no structural habitat and deadly anoxic water below. There would have been few large invertebrates to feed the adult fish, but smaller zooplankton provided plentiful food for juvenile fish. So why were adult fish there? They were probably feeding cannibalistically. The fossil record may yet reveal a competing arms race within the one species, featuring speedy, fast-growing juveniles adapted to feast on zooplankton while avoiding their elders, later maturing into powerful adults primed to snatch mouthfuls of their own young.

Aside from *Galaxias effusus,* the only other fish species present was a freshwater eel (*Anguilla spp.*), known from a single fossil specimen. This is the first record of a freshwater eel in the Southern Hemisphere. Eels are unable to landlock, and would have only been occasional visitors to the lake.

New Zealand's two eel species are not closely related to their geographic neighbours, spread across Asia, India and western Africa, but to the more distant and northerly American and European eels. Prior to the discovery of this fossil, Oceanic and Atlantic eels were thought to have diverged 15 mya. This fossil revises this date to more than 23 mya, unless it represents an earlier radiation and extinction. Unfortunately this specimen is poorly preserved, limiting what can be learned from it. The discovery of other eel specimens at Foulden Maar may yield important information of the phylogeny and radiation of the Anguilla family.

Globally, the loss of the fish fossil record at Foulden Maar would prevent a greater understanding of the phylogeny and evolution of Galaxias and Anguilla. Within New Zealand, freshwater fish fossils have only been found in two regions: inland from Gisborne and several lake deposits in Otago. These lake deposits cover different time periods and contain different species. The loss of one cannot be justified by the existence of others.

Foulden Maar is scientifically priceless in so many ways. Its proposed destruction to produce low-grade, pseudoscientific animal feed is incomprehensible vandalism. This site must be permanently protected for scientific research and education.

Yours sincerely,

Stella McQueen

UNIVERSITY of OTAGO

Te Whare Wānanga o Otago

DEPARTMENT OF ZOOLOGY

4th July 2019

RE: Statement of Support from Department of Zoology - Protection of Foulden Maar

We, the undersigned, write in support of Save Foulden Maar Incorporated Society application for funding to purchase the entirety of Foulden Maar, and bring the land into public ownership, protecting the Foulden Maar site in perpetuity.

As teachers and researchers in the Department of Zoology, University of Otago, we are very aware of the scientific value this precious fossil deposit that gives us a unique window into ancient New Zealand, and it's place in the world, 23 million years ago. It is one of New Zealand's premier fossil sites, containing an annual record of flora and fauna over 120,000 years. The site contains exquisite fossils of fish, aquatic and terrestrial insects, spiders, plants, pollen and fungi. A significant proportion of our research and teaching in the Department of Zoology involves advancing the understanding of the evolution and history of New Zealand's flora and fauna. Foulden Maar will play a central role in advancing that understanding.

To date, only a very small portion of Foulden Maar has been scientifically investigated, with these investigations yielding hundreds of fossils. Foulden Maar is unique – it is the only site of this nature in the Southern Hemisphere that covers this time period, the quality of the fossils is astounding, as is the diversity of the animal and plant community that is represented. The site has already revealed invaluable insights into the evolution of southern New Zealand biota, and will undoubtedly continue to do so if appropriately protected, whilst also allowing for appropriate scientific research.

PROFESSOR GERRY CLOSS

PROFESSOR PHIL BATTLEY

Dr Mark Lockman

PROFESSOR ALISON CREE

PROF GRAHAM WALLIS

H. G. Spencer

PROFESSOR HAMISH SPENCER

DR NIC RAWLENCE

(Assoc. Prof. Y. van Heezik)

Dr. Travis Ingram

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