

# *3<sup>rd</sup> Australasian Engineering Heritage Conference 2009*

## **THE ENGINEER AS LANDSCAPER AND CULTURAL WARRIOR**

Illustrated lecture by Professor David Dolan

***SUMMARY:** In 1910, American philosopher William James called on governments of all nations to eschew fighting each other, and instead jointly pursue “the moral equivalent of war”— a War Against Nature. Believing the world to be fundamentally hostile to the human struggle for survival, James was inspired by the projects of the great nineteenth-century engineers. He saw their work as a grand cultural endeavour, transcending merely building infrastructure to solve local practical problems.*

*Pipelines, railways, roads, tunnels, bridges and canals tie formerly separate places and people together, creating new political, economic and population zones. The engineers of the Victorian and Edwardian era literally reshaped the landscape and redrew the maps, changing forever the ways we experience, conceptualise and understand the environment. In the context of the British Empire, impressive engineering works were articulated to enhance the credibility of the imperial enterprise.*

*The visual impact on the physical landscape was controversial, but the new spatial and cultural reality they created is reflected in landscape art and popular national imagery. The fame and drama that surrounded C. Y. O’Connor in Australia and New Zealand, and his international peers, made them significant cultural figures in their own right, as influential as literary or visual artists in creating cultural imagery and sense of place.*

### **1. THE ENGINEER AS LANDSCAPER AND CULTURAL WARRIOR**

When we mention engineering heritage, we most often think of structures such as power stations, dams, harbours, pumping stations and pipelines, and road and rail lines with their embankments and tunnels.

The shared engineering heritage of New Zealand and Australia includes the dispersed work of C Y O’Connor, who is particularly famous in my home state of Western Australia (WA) where his name is forever associated with the opening of Fremantle Harbour, the growth of the railway system, and the Goldfields Water Supply Scheme (hereafter referred to by its shorter and colloquial local name “the Pipeline”).

Before coming to the Antipodes and changing some of their landscapes forever, O’Connor’s prior learning experience was in railways in Ireland where he was born and educated. Ireland was then entirely if uneasily under English rule — colonial rule, really: at the time of his birth the Irish Free State was 80 years in the future. O’Connor is important here for what he represents: he was a product and representative of the European and British culture of heroic engineering, which includes such names as the Brunels (father and son), and Ferdinand de Lesseps of Suez fame. As a young professional engineer in Ireland, O’Connor did not have control of major projects: that was to come in Australia and New Zealand. As for so many others, engineers realised that the colonial empire provided challenges and opportunities for work on a larger scale than at “home”, and potentially for fame and glory.

A couple of years ago I was interviewed on ABC radio as part of a discussion about how it was possible for such large-scale projects to be undertaken in the 19th and early 20th centuries. In the angling of the program, there seemed to be an implication that today’s governments are reluctant to undertake comparable infrastructure projects. Whether that is really true as a generalisation, and if so why, is beyond my scope here, although at the end of my talk I will offer some suggestions about negative as well as positive aspects of the heritage of the era of heroic engineering.

My purpose is to discuss a number of cultural implications of these grand 19th century projects of which there are many examples such as O’Connor’s Western Australian pipeline which is generally regarded as much more than a piece of infrastructure, having achieved recognition as a major component of the state’s and indeed the nation’s cultural heritage. For example, when the National Museum in Canberra opened in 2001, the “Golden” pipeline was — as far as I could see anyway — the only representation of WA in the permanent exhibitions.

Such recognition of industrial and engineering heritage is not unusual these days. All around the world, bridges and forts, reservoirs and power stations (the latter only when decommissioned, it seems) are entered on heritage registers and feature prominently in the imagery of tourism and political nationalism. This is of course a relatively recent development. In the early days of heritage listing, the emphasis was on colonial domestic architecture, churches, and public buildings rather than public works. And when we investigate the story of some great examples of engineering heritage, it becomes apparent that what we now greatly admire, and desire to protect, conserve and interpret, was often initially regarded as destructive of aesthetic and heritage values as then understood!

Everyone knows that large-scale engineering projects such as railways, highways, ports and water supply schemes changed the appearance of landscapes. The prime mover in all of this has been and is population growth and movement and specifically urbanisation. New and growing — and often sprawling — cities not only permanently change the landscape where they are built, by replacing open land and woodlands and wetlands with buildings and roads and infrastructure, but they also impact on the landscape far beyond their boundaries. As well as accommodation for residential and work purposes, the concentration and number of people demands infrastructure to provide water and sewerage, energy supplies of all sorts, and of course food production and raw materials.

In European countries, the industrial revolution of the 18th and 19th centuries and simultaneous population growth meant not only the steady expansion of existing older cities like London and Paris, but also the birth and sudden growth of vast new cities where there had previously been only small towns or villages: obvious examples are places like Glasgow and Birmingham. The pattern in Australia and some other colonial societies was comparable to the latter scenario. Small indigenous populations were rapidly outnumbered and rendered politically and geographically marginal (at the very least) by hordes of immigrants. The extreme case of this was of course a gold rush, which suddenly brought thousands of people to places like Dunedin or Bendigo or Kalgoorlie where there was no infrastructure and their physical needs could not possibly be met from existing local natural resources.

## **2. SCARS ON THE LANDSCAPE ?**

Then as now, the hasty sprawling of cities old and new was applauded by those who profited from it, and detested by those who had to live with the results of it — and also by those who regretted the loss of rural landscape and habitats. Today, when we have planning commissions and planning laws and a planning profession, we still manage to produce some horribly ugly and environmentally unsustainable urban and suburban developments, when speculative greed and so-called “property rights” are given priority over the long-term public interest. But in England during the industrial revolution and the first part of the 19th century, there were no planning controls: “Go for it, build those tenements and future slums, and decamp with the profits! You’ll be rich and won’t have to live there.”

The irresponsible and environmentally damaging urban and suburban development of the 19th century eventually led to calls for planning controls, and to schemes to do it better, such as the Garden City and City Beautiful movements, and of course the birth of the National Trust which was initially focussed on protecting rural landscapes and places for recreation: “vast outdoor sitting rooms for the urban poor” was one founder’s phrase.

Heritage preservationists, as they – or we – are often called in the USA, are generally impatient with bleating about “property rights” heard from some developers whenever communities try to restrain the destruction of heritage or even excessive subdivision. Let us quickly put some historical context around this. Nineteenth century English property owners fought the first planning laws all the way to the Privy Council, just as some employers fought the Eight Hour Day, ship-owners mocked the introduction of the Plimsoll line, American landlords refused to build fire escapes, and slave-owners fought abolition.

Because the emergence of urban and regional planning as a practice and a profession was a reaction against the horrors of uncontrolled development, it is fair to say that modern and contemporary planning and its results— the towns and suburbs most of us now live in— are indirect and evolved products of the industrial revolution.

Coming back to the more specific works of engineers, it was the railways with their bridges and cuttings that were seen as the greatest destroyer of nature and rural scenery. Remember that at this time, especially pre-Darwin, Nature had literally divine status as God’s handiwork which humanity should study and learn from, and there was widespread nostalgia for the fast-fading feudal traditions of rural life.

Mention of Darwin reminds us that the construction of railways also challenged the conventional religious beliefs about life on Earth and the age of the planet. It was during the excavation of railway cuttings that the best preserved and thus most influential dinosaur fossils were discovered. Geologists began to realise that the Earth was more than a few

thousand years old, and that life forms had changed, and this inspired various scientific hypotheses including eventually Darwin and Wallace's Evolution by Natural Selection. The creationists, then the Christian mainstream rather than a rump as today, could suggest that God had faked the fossils and planted them to challenge our faith, but such notions became increasingly untenable.

Biblical literalists could regret the discovery of fossils in cuttings, but the strongest objection to railways in the landscape was that their alignments and bridges were an eyesore, and destroyed magnificent scenery. In the late 1850s, John Ruskin lamented:

“Wherever I look or travel in England or abroad, I see that men, wherever they can reach, destroy all beauty. They seem to have no other desire or hope but to have large houses and to be able to move fast. Every perfect spot which they can touch, they defile.” He then gives a couple of examples in a footnote: “Thus, the railroad bridge over the Fall of Schaffhausen, and that round the Clarens shore of the Lake of Geneva, have destroyed the power of two pieces of scenery of which nothing can ever supply the place, in appeal to the higher ranks of European mind.” (Modern Painters, volume IV, p329).

During the following decades, there were numerous campaigns, some more successful than others, to keep railways out of scenic places such as the Lake District. In the 20th century, as new highways took the place of new railways as the perceived destroyers of landscape aesthetics, the National Trust and other groups campaigned to limit their visual impact also. The architect Sir Herbert Baker whose massive building projects changed colonial landscapes in India and Africa, took a major role in a successful campaign to prevent ribbon development along English country roads and to limit the sprawl of rural villages. These controls have been of enormous benefit to the tourist industry in the UK, so I was horrified to discover, where I was last there in 2004, that the dark forces are still at it, lobbying for the abandonment of defined edges for rural villages, to encourage ‘development’.

The Ruskinian perception of railways as destructive of landscape values had little resonance in 19th century Australia, presumably because the colonists (unlike the indigenous people) had no cultural attachment to a land which they found largely hostile. In Europe the view of railway works as destructive had to contend with the perception of them as heroic, but in Australia and even more in North America, the heroic interpretation carried the day. The heroic interpretation has never really been challenged in Australia, and now the time has come that we regard these bridges, like pumping stations and dam walls and old military sites, as items of historical importance, to be admired and protected as part of our heritage. In this sense, the idea of the engineer as landscape artist has retrospectively triumphed in our own time.

The most famous railway image in American art is *The Lackawanna Valley* of 1855 by George Inness, in the National Gallery in Washington DC. What image of railways in the landscape does it offer? You can see the artist is having a bet both ways. The large busy roundhouse and the speeding smoking train are pushed into the far and middle distance respectively. Closer to the artist's and thus the viewer's position is a watching figure reclining under the sole tree that has survived in the area. He is reminiscent of the “staffage”, the shepherds or mythological figures in classical landscapes, who transmogrify into Aborigines in early Australian colonial landscapes. The observer within the painting does not seem to be distressed, and might be assumed to be favourably impressed, with the wonders of modern technology coming his way.

American art historians have generally seen this painting as expressing a positive attitude to railways in the landscape, quite the opposite of Ruskin's hatred. Perhaps they have been influenced by the fact that the painting was actually commissioned by the Lackawanna Railroad Corporation whose presence in Pennsylvania it depicts — even celebrates? I have stood and looked at this painting for a long time on several occasions over the last thirty years, and am always struck by the prominence in the foreground of the stumps of felled trees. The artist is emphasising that this area is cleared woodland. The railway is not shown to be the direct cause of this, unlike the mines and the woodlines that fed them were the cause of denudation (apparently temporary) of areas around many mines. But Ruskin, and Wordsworth whom he cited in this matter, would have been appalled by Inness's imagery, and seen it as recognition of the destruction expedited by the railways which inter alia supported and encouraged the conversion of forests to agricultural and other uses.

Most of us today would be depressed by the sight of these tree stumps. But if we project back in our own history, we can imagine another interpretation. We know only too well that in Australian political rhetoric, as in the works of our Heidelberg school artists, “clearing the land” was celebrated as economic and social progress. Streeton may have changed his tune later, but this ideology of “If it moves, shoot it; if it doesn't, chop it down” survived well into the 20th century, and still has its adherents. In populist politics, clearing the land was nation-building, it meant creating farms and homes for aspirational citizens, as for example in the often ill-fated group settlements in various parts of Australia

in the post-World War One era. And although railway building had begun in Australia in the 1850s, the 1920s were its high-point all over that continent.

Whatever we think of some of the intended and unintended consequences, there is no denying that in O'Connor's time, engineers could be culture heroes. An example is John Whitton, a Yorkshireman who in 1852 at age 33 became I. K. Brunel's successor as Resident Engineer on the Oxford, Worcester and Wolverhampton Railway. In 1856 he was recruited as chief engineer of the New South Wales (NSW) Railways, and became known as "the man who conquered the mountains" in recognition of his greatest work: the railway across the great dividing range. Jim Haynes has written: "In the building of this railway, the colony truly came of age. No longer a quaint colonial backwater, the colony of NSW now had an engineering marvel to impress the world, along all the strange plants, animals and natural wonders."

Australia's most famous railway painting is Arthur Streeton's *Fire's On, Lapstone Tunnel* of 1891 in the Art Gallery of NSW. It does not actually depict a train, but shows an incident during the creation of a tunnel in the Blue Mountains, focusing on the drama, heroism and danger of railway building. The flurry of activity outside the tunnel mouth is because a man had just been killed in an explosion within. The tunnel mouth and associated workings are a wound in the landscape, the rest of which is depicted in Streeton's usual aestheticised style.

In closing this part of the talk, it can be noted that although we now admire many older engineering works as part of our heritage, new works can be controversial. The desire to preserve sensitive landscapes and habitats prevented the construction of certain proposed hydro-electric dams in Tasmania in the 1980s, and today there are fierce debates about the siting of wind-farms, and to the further expansion of industrial plants in the world's largest ancient rock art site — the Burrup Peninsula in north-western Australia.

### 3. REVISIONING THE LANDSCAPE

In 2007 I spoke to your previous conference in Perth about "The Engineer as Artist" so I am not proposing to tackle this theme in terms of the aesthetic qualities of engineers' designs, appreciating or critiquing the shape and structural logic of the Eiffel Tower or the Sydney Harbour Bridge: that had been done a lot. Nor am I now looking into the work of engineers as architects, though they existed in most colonial societies, although that would make a good topic for another time. Today, we are investigating the idea that the works of the great engineers not only changed the appearance of the landscape and cityscape, but actually changed the way everyone else saw them, just as artists change the way we see the world by creating and imposing new images.

We see what we learn to see, and it is well established that the 19th century landscape painters, in Australia and elsewhere, showed people new and different ways of seeing the landscape, including drawing attention to aspects and places not previously much looked at or admired. Well known examples of this are J M W Turner's paintings of the European Alps, Eugen von Guerard in New Zealand and Australia, and local Impressionists everywhere who subsequently departed from the earlier colonial vision.

I mentioned the Eiffel Tower earlier, so will return to it very briefly to further explicate this theme. John Berger and Robert Hughes, among others, have discussed how this landmark edifice not only changed the look of Paris, but gave millions of people their first experience of a plan view of a city. Previously, this view had been available only to the very few who went up in hot-air balloons. Suddenly, the tower allowed people who had for years known the city only as a ground-level maze to actually see it laid out like a street map. The impact of this on art has been elaborated elsewhere, so I need not expound it here.

My argument is that engineers, through the impact of their work, were as influential as literary or visual artists in creating new imagery and evolving sense of place. The most obvious example of this, especially in Australia, is the experience of railway travel, which in the mid 19th century replaced horseback or stage coach. On or behind a horse, you covered only a few miles a day, with frequent stops to water or change horses, and for passengers to use dining and lavatory facilities at inns. On a train, you covered greater distances in a day, with long periods of continuous movement (and of course occasional stops for no apparent reason, in the middle of nowhere).

Even today, when we have air-conditioned fast cars and (sometimes) good highways, there is still a difference between the physical and visual experience of road and rail travel. Roads go up and over hills, imposing varying levels of effort on car engines and transmissions, so as a driver or passenger you are directly experiencing the rise and fall of the land. But because trains cannot climb steep hills, railway lines more often go through cuttings and embankments and tunnels on a relatively flat track. There are exceptions to this, especially in the past with such dramatic devices as the famous old zig-zag in the Blue Mountains, but it is a fair generalisation to say that roads go on the ground and trains go on,

through and above it. A train passenger who is dozing or reading a book can go through mountains and over wide rivers without even noticing. One who looks out the window sees the land rise and fall while barrelling along without a bump or change of pace— insulated from the terrain, but seeing it and experiencing it aesthetically.

The contrast with pre-railway era road travel is extreme. In previous centuries, there had always been some road bridges, but these were limited in span. In most cases, when a stagecoach came to a river, there were two choices. Put it on a barge or punt, and ferry it across; or unload everyone and everything, put them on a boat, and then onto another coach when the river was crossed. This was time consuming, and slowed the journey down greatly. It also meant that the travellers experienced the river crossing as a quite different affair from the on-road travelling, although both could be equally rough and jolting.

But with railways, once the huge investment had been made in engineering works, formerly impassable barriers were flown over, often without a change of pace. Crossing a river several hundred metres wide could add an hour or two to a coach journey; but a train on a steel bridge was across it in a minute or less. This is not just about speed, or the perception of speed which has pre-occupied many writers about the way early railways were experienced — it is about the homogenising and smoothing of the travel experience across varied terrain.

As well as speed, the traveller's isolation from the surrounding landscape was heightened by the side-effects of the technology, especially when viewed from outside. At times, the train passed in a blur of speed, and at times it was wrapped in a steam and smoke cloud of its own making. The most famous image of this is J M W Turner's *Rain, Speed and Steam*.

Ruskin claimed that fast train travel was not really travel at all: you were just being sent like a parcel from one place to another without actually experiencing the places you passed through. I am taking a different line, and suggesting that you may experience the places en route, but in a different way: more visual and less physically interactive. It might be taken as a variant of that cultural studies cliché “the tourist gaze”.

Ruskin also objected to railways because much of the travel they facilitated was, in his opinion, to no good purpose. To paraphrase and generalise one of his famous grumpy remarks, he said that the train made it possible for every fool in the suburbs to be in town in 20 minutes, and for every fool from the town to be in the suburbs. Which leads us to tourism, and on to the way engineering projects changed the relationship, and in a sense the relative location as well as the identity, of places.

#### **4. CHANGING THE RELATION OF PLACES**

Railways, and also the new large iron steam-powered ships pioneered by super-engineer Ismbard Kingdom Brunel, permitted the rise of popular tourism for the middle classes. It was of course Thomas Cook who realised the potential of railways and steamers to cheaply, reliably and regularly move large numbers of people together, so he invented the package tour. It took another century until we got jumbo jets and other planes big enough for mass tourism to take to the air.

Mass train travel, and the safe operation of railways in general, required a structured system of time. Until the mid-19th century, local time ruled everywhere and there was no consistency. The need to schedule trains was the chief motivation of the development of standardised time as we know it, and the redrawing of national and international maps into time zones which transcend political boundaries.

Once large numbers of people can and do travel, we perceive the world as smaller, and exotic places as closer. When we hear of a civil war in Sri Lanka or a terrorist atrocity in Indonesia, many of us know the places where it is happening and identify with it to a degree once unimaginable.

Transport links and their components such as bridges and tunnels, but also pipelines whether for water or fuel, change the relationship of places. We can obtain, and worry about depending upon, supplies of all sorts from far away. On an Australian farm in the first half of the 19th century, if you needed a piece of furniture urgently, you made it yourself, or found a local craftsman. By the end of the 19th century, you looked in a catalogue (delivered by mail, most of the way on a train) and ordered what you want, which was then sent out (again, most of the way by train) a few days later.

The big change in the time taken to transport goods overland occurred with trains. In the 1850s, my great-grandfather paid off his farm in the Clare Valley in South Australia by operating a bullock dray carrier service between Clare and Adelaide. A round trip took him three weeks. When the railway was built, the train trip took six to eight hours each way. Today, a car or delivery truck does the one-way trip by road in two or three hours. The gap between that and the

time taken by the train, is very much less than the gap between the train's time and great-grandfather's bullock dray. Similarly, in Western Australia where I now live, the completion of the railway moved Kalgoorlie closer to Perth, by a greater margin than it was later moved closer again by the introduction of air services.

The cultural map of our countries was shaped by the distribution of technologies. As another South Australian example, the Barossa Valley, settled by German immigrants in the 1850s, remained a centre of Germanic traditional arts and crafts well into the 20th century. In fact, traditional styles survived there long after they had gone out of fashion in the Fatherland. Art historians attribute this to the fact that the railway did not go through to the Barossa until the first decade of the 20th century, so those communities remained relatively isolated and self-sufficient, hardly affected by changes in fashion in the cities and other regions.

Ruskin had seen what was happening from the very start, and understood that the changes were cultural, not merely functional: "The iron roads are tearing up the surface of Europe;.. their great net is drawing and twitching the ancient frame and strength together, contracting all its various life, its rocky arm and rural heart, into a narrow, finite, calculating metropolis of manufactures." (Modern Painters, II, p6)

## **5. REDRAWING THE POLITICAL MAP AND CONQUERING THE WORLD**

Many great engineering projects were undertaken for political reasons. Both at the time, and in historical retrospect, a government's sponsorship of infrastructure is often cited as a measure of its historical importance. Failure to undertake necessary or beneficial projects is commonly taken as indicative of weakness, waste of opportunities, and irrelevance.

Governments which spend millions, or these days billions, on vast engineering projects must be sure they will keep control of them in the future. The creation of large-scale engineering works is only possible if you have political control of the place and the resources; and when completed, the existence of the infrastructure demands continuing or even increased control. Dams, railways, electricity supply, pipelines (think of oil in the middle east and Russia) and harbours are perceived as obvious targets for strikers, rogue capitalists, and terrorists. The need to maintain control over engineering infrastructure both in the building and operational phases has often led to re-drawing of the political map. The most celebrated examples of this have been shipping canals. De Lesseps built the Suez Canal and the French Empress Eugenie officially opened it in 1867, and for the next ninety years at least it was the focus of political manipulations and even wars between Egypt, England, and other powers.

The extreme case of re-drawing the political map involves the far more expensive and ambitious Panama Canal. De Lesseps and others tried but failed to build a sea-level canal through Nicaragua or Colombia. In 1903, the USA stepped in, as they wanted to be able to move their navy between their east and west coasts, and control inter-oceanic traffic. US interests funded the canal, and to secure it fomented war and revolution to create the breakaway nation-state of Panama, with a Canal Zone which remained US-controlled until very recently.

In O'Connor's case, the Forrest government's support for the Pipeline was motivated largely by the need to lock the economically important goldfields into the colony and state of WA. In the lead-up to federation, there was talk of secession and a new state of "Aurelia". The colonial government built the Pipeline and the railway, and thereafter the goldfields were literally tied to Perth and Fremantle, and connections with Esperance diminished. At the next level up, the participation of WA in the newly federated nation of Australia was secured by the commitment to build the transcontinental railway which functionally, and visibly on the maps, tied the west to the east.

At the start of the 21st century, in Australia we are seeing political claim and counterclaim as the eastern states and the Commonwealth restructure control of the Murray River system; and everywhere there are tensions as cities come to increasingly depend on water from rural areas. From time to time (usually at election times) politicians propose grand new engineering schemes such as canals or more pipelines to move fresh water, and we even hear of proposals for "reverse pipelines" to remove salty ground water from agricultural regions affected by salinity.

If today's politicians are more hesitant than John Forrest or Teddy Roosevelt to embark on grand engineering schemes to solve specific problems, it may be because we have learnt a few lessons over the last hundred years. Some of the impressive, and indeed successful, schemes of the past have had unintended consequences, solving problems in one place but creating problems elsewhere. Obvious examples include salinity and loss of habitat due to deforestation and over-irrigation in Australia, and there are human and environmental disaster stories world-wide associated with oil pipelines, high dams, nuclear meltdowns, pollution and toxicity, etcetera, etcetera.

In the heroic era of engineering, there was insufficient understanding of the interconnectedness of ecosystems. There was often also scant concern for minorities and indigenous peoples. It needs to be recognised that some scientists and

conservationists were issuing warnings at that time, but they were barely heard in the populist clamour for progress and problem-solving. The failure of understanding is encapsulated in the essay *The Moral Equivalent of War* by US philosopher William James. This essay was not published until the year of his death, 1910, but he had been influential for many decades previously.

The main theme of James's argument is commendable, inasmuch as he called upon governments of all nations to eschew fighting each other, and instead jointly pursue grand and often dangerous civil endeavours. He wanted to engage the energy of youth and the skills of the experienced to exploit the resources of the world, to raise standards of living everywhere. As well as fishing fleets and mining, he cited the building of roads, tunnels, canals and skyscrapers. To achieve this concentration of effort, he advocated a form of civil conscription, instead of putting young people into the military, hence "the moral equivalent of war".

The problem in James's formulation is that he sees these grand endeavours as "a war against nature", a better activity than war against other peoples. James and many others of his time had a Darwinian view of the world and nature as fundamentally hostile to the human struggle for survival and progress. Rather than thinking in terms of working with nature, they saw nature as an enemy to be conquered, and gave little thought to the possibilities for collateral damage to the environment and society.

Two years later, in 1912, the imperialist geographer Dr Marion Newbiggin reviewed the achievements of the 19th century and earlier times in a book tellingly entitled *Man and his Conquest of Nature*. Newbiggin used similar aggressive language, referring to: "man's age-long struggle with Nature,,, to render permanent his hold upon shifting Nature.... His modes of attack upon Nature have been as manifold as is Nature herself, and everywhere the fortunes of the fight have varied with the natural conditions."

Robert Stafford has described the popular late 19th and early 20th century view of the world as consisting of: "undisciplined nature, uncivilised peoples, primitiveness, limitlessness, and bizarre extremes. Implicit in the challenge of these strange continents, however, lay opportunity, excitement, the illusion of infinite resources, exotic fields for personal and national expression. The disposition... was aggressively interventionist. While the scientists often expressed regret at the destruction of native peoples and natural environments, the majority viewed this process as inevitable, and the European right to drastic modification of peoples, species, and entire biotas as unquestionable".

There was even an interplanetary example of the alleged ability of intelligent beings to change whole worlds and defy climate change: the greatest scientific myth of all time, the Canals of Mars. Linear markings observed on Mars were widely believed, between 1895 and the 1920s, to be a vast network of artificial canals bringing water from the melting polar caps to the pitiless deserts which comprise most of its surface. This implied a great global project only possible if there was a unified polity and no wars. This interpretation (based on extrapolation from faulty astronomic observations) was wrong, but it was then widely believed including by many eminent scientists, and was enormously influential.

We now know that the map and the view of Mars was not created by a race of older wiser canal-building Martian pacifists, but I hope I have shown some of the various ways in which the great Earthly engineers of the late 19th and early 20th centuries changed the view, understanding, and indeed the map of our planet. O'Connor and his peers deserve our respect, and their work deserves to be preserved as our heritage. We are going to need some more great engineers and brave politicians if we are to survive on Earth, and the lesson we must learn from the successes and failures of O'Connor's era is that we must not think in terms of War against Nature, but of working with nature and the highest cultural values.