Note to readers:

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Human activities affect the operation of physical environment processes, and the results rebound on the human world. The human factor is an important consideration in assessing climate, landform, and ecosystem changes. The physical environment provides resources and a platform to use those resources, but can also be a hazard to people. Therefore human impact as a subject is of special concern to physical geographers. This interest has developed from studying the impacts of the environment on human activities, to understanding the impacts of humans on the environment and attempting to reduce them. There is now overt recognition of the role of the human factor, which is also reflected in an increase in applied work by physical geographers.

The effects of human activities and physical environmental modifications range from being entirely local to global, and can be immediately evident or they may manifest slowly over time and become of concern at some time in the future. The duration of the effects can be short-lived or everlasting. Many examples can be observed in our surrounding landscape. While this chapter describes and discusses only some of the impact of human presence in New Zealand, the conceptual context of humans as agents of environmental change is woven into the examples given.

The subject of human impacts on the physical environment is wide-ranging, complex, and fraught with avenues for opinion, hypothesis, fact, debate, and compassion. People are an agent of change. Although arguably robust, the physical environment is susceptible to external influences wilfully imposed upon it. This area of geography has in the past been dealt with summarily in classic general physical geography texts. More recently, textbooks have alerted the reader to humans as a cause of change to the geosphere, the hydrosphere, and the atmosphere, and in doing so, note that human actions are generally to the detriment of the ‘natural’ systems.

However, a more specific path of investigation and discussion has arisen around the issue of people and the environment. Goudie and Viles (1997) explored the ways people have transformed the Earth by developing a temporal context to the issue, while illustrating the types of impact through global, regional, and local case studies under the headings of ‘Biosphere’, ‘Atmosphere’, ‘Waters’, ‘Land Surface’, and ‘Oceans, Seas, and Coasts’. This approach closely links the impacts of humans to global crises,
while highlighting the need to both appreciate the role humans play in shaping the physical environment and to manage that environment towards sustainability.

Goudie (1997) developed the history of literature concerning the ways humans can and have transformed nature. He pointed out that George Perkins Marsh’s *Man and Nature* (published in 1864) presented insights into the way in which people affected the environment in an expose of the destruction and waste done to the Earth, showing the ‘importance of human life as a transforming power’. Marsh’s treatise is considered to be the primary origin of the conservation movement, and provided a warning for the future through identification of the connections between human actions and environmental changes. However, it was not until about 1970 that this topic became of central concern for many disciplines.

Modern recognition of the damage caused by human actions, the need for conservation of our environment, and the global scale of human impact reflect specific issues such as acid-rain pollution, desertification, and the enhanced ‘greenhouse effect’. This has resulted in the establishment of conservation movements, environmental protection groups, and lobbyists, and an awareness at local through to international government levels of the need for global consideration of human impact and its management to provide for a sustainable future.

In New Zealand, the conservation movement is thought to have evolved from voiced public concerns and political debate over the raising of Lake Manapouri for hydro-power production in the late 1960s (Peat 1994). However, appreciation of the natural splendour of the country, and its importance to New Zealand’s national identity, was evident in early colonial times. Notwithstanding this, New Zealand reflects the footprint of humans as much as the beauty of an isolated pristine wilderness. The latter qualities are said by many (such as the Ministry for the Environment) to indicate high environmental quality.

Human impact on the physical environment is largely accidental but usually adverse (Goudie & Viles 1997). Humans act with intent but often without understanding the impact of their actions. Table 24.1 shows a time-line of environment impact. There is an historical or temporal context to these activities that is clearly linked to the technological capabilities of the populous. Generally, the more advanced the technology, the greater the ability to modify the environment, and the greater the potential impact (see also White et al. 1984).

Early impacts came as a result of the use of fire, while the extinction of animal and bird species is also an early indicator of human impact. Human-induced changes to the environment have increased as our economic basis has changed from hunting to agriculture and the domestication of plants and animals, as well as through technological developments such as irrigation, ploughing, intensive cultivation, and pastoralism. There has been a further increase in human-induced changes with the industrial revolution and urbanisation, accompanied by an intensification of the utilisation of resources. The impact also increases as population grows. The variety of types of impact has also become more extensive over time, while colonisation and adoption of developing technologies to new parts of the world have expanded the spatial impact of human activities.
**Table 24.1 Energy, technology, and environmental impact time-line.**

<table>
<thead>
<tr>
<th>Time zone</th>
<th>Global population</th>
<th>Daily energy use per person (kJ)</th>
<th>Energy source</th>
<th>Technological discoveries</th>
<th>Environmental impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 million to 5000 years BC</td>
<td>&lt;10 million</td>
<td>8–21</td>
<td>Food, human muscle</td>
<td>Tool production, fire</td>
<td>Local and short-term; animal kills and vegetational change</td>
</tr>
<tr>
<td>5000 BC to AD 1800</td>
<td>10 million – 1 billion</td>
<td>50–100</td>
<td>Animals, agricultural crops, wind, water, coal</td>
<td>Cultivation, building, transport, irrigation</td>
<td>Local and longer term; natural vegetation removal, soil erosion, urban air pollution</td>
</tr>
<tr>
<td>1800 to 1950</td>
<td>1 billion – 4 billion</td>
<td>210</td>
<td>Fossil fuels, electricity, steam</td>
<td>Industry</td>
<td>Local, regional and permanent; major landscape changes, air and water pollution common</td>
</tr>
<tr>
<td>1950 to present</td>
<td>&gt;4 billion</td>
<td>1250</td>
<td>Internal combustion engine, electricity, nuclear, fossil fuels</td>
<td>Industry, cultural globalisation</td>
<td>Local, regional, global; permanent and perhaps irreversible, acid rain, global warming</td>
</tr>
</tbody>
</table>

Goudie & Viles 1997

**How are these impacts manifest in New Zealand?**

There are two major periods of human influence on the New Zealand landscape. The first period is from the initial human contact by Polynesians through to the arrival of European influences and colonists. The major difference in the impacts of these two main groups of people is due to the technology available to them. The first colonists to New Zealand used fire and stone tools in providing living spaces and food. They were mainly hunter-gatherers who increasingly used agricultural practices. Their economic base was mainly subsistence within hapu (or sub-tribe), with some exchange of resources within regional iwi (or tribe). The concept of bartering for goods was understood by the Maori at the time of contact with Europeans. Because of the need to live off the land and to provide for their immediate future from the local surroundings, a rudimentary application of sustainability was also evident.

In contrast, the European visitors, initially whalers and seafarers, and then colonists, brought with them post-industrial tools and practices, and an economic system that saw the environment as a provider of resources for bounty, sale, and widespread use. Resources were taken from New Zealand to be used in Britain and Europe, and the new colonies of the Americas, Asia, and Australia. Because new resources continued to be found, there was a feeling of limitless abundance of wood for export, food, and land for settlement.

Both the level of technology and the economic base of the communities were controlling factors of the type and magnitude of human impact on the New Zealand
environment. Maori used fire to burn bush and forest vegetation, clearing land for farming and making it easier to hunt birds for food. Although methods of transport were limited to travel by foot or canoe, most of the country has evidence of Polynesian occupation dating from about AD 800. The main changes brought about by this settlement were to the ecosystems, with changes to the vegetation cover and the extinction of bird species the most obvious.

However, there were also changes to the landscape brought about by earthworks. Pa (fortified villages) were built into hillsides, requiring sometimes massive earthworks. The ditches and earth walls are visible in many locations. Less visible but still evident are areas cleared for cultivation. For example, the raised terraces along the Kaikoura coast north of the Clarence River were used to grow kumara and other vegetables, with individual plots marked out by rock walls. These gardens can be seen in aerial photographs.

Streams, estuaries, and lagoons were also modified to an extent to provide water and access to the coast. For example, the present-day outlet of Ahuriri Estuary near Napier is not a natural feature. The natural outlet is reported to have been located approximately 4 km to the north and was unstable and often closed. The new outlet was created artificially by digging a channel across the beach and allowing the outflow to scour it to a navigable width. The estuary was named Ahuriri after Tu Ahuriri, who created the stable entrance. This landform and process modification was planned, with an identified outcome (a stable channel outlet to the sea). However, the modification of the process regime, especially the tidal hydraulics, caused further unplanned modifications and is thought to be a major factor in causing instability of the adjacent beaches of Westshore (Kirk & Single 1999).

There are parallels to Ahuriri in the example of the Port of Timaru. Two major differences are the scale of the project, and the equipment used to carry out the work. The Timaru harbour engineers designed a breakwater to provide a sheltered anchorage. From observations of coastal processes along the South Canterbury coast, including the northward drift of sediment along the beach during storms, they knew that the breakwater would probably impede the transport of gravels along the beach. However, the magnitude, the spatial context, and the duration of the impact were not known, nor considered as relevant to the decision to construct the port. The ongoing effects of the interrupted coastal sedimentation processes are still visible, and have led to the problem of erosion at Washdyke (just north of Timaru), and the mainly beneficial gain of the sandy sheltered beach of Caroline Bay (in the lee of the harbour) (Kirk 1992b).

The Port of Timaru—a case study

The Port of Timaru, on the east coast of the South Island of New Zealand, lies on a coastline that is a near-continuous steep mixed sand and gravel beach. The town of Timaru is directly landward of the beach and is sited on a basalt rock formation overlain with loess cliffs approximately 10 m high. Work on the port infrastructure started in 1878, with the construction of solid concrete block breakwaters on a line northeastwards from the shore. By 1887 the main
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A breakwater wall was 700 m long. Throughout the construction period, gravels built up on the south side of the breakwater and sand accumulated in Caroline Bay to the north of the harbour, until sediment movement into the harbour necessitated the construction of a lee wall between Caroline Bay and the ship berths. Gravel has continued to accumulate south of the breakwater at an annual rate of about 60,000 m$^3$, creating a reclaimed area of over 80 ha, while the annual accumulation of fine sands in Caroline Bay is approximately 30,000 m$^3$. These areas of shoreline progradation are seen in Figure 24.1.

Figure 24.1 also shows the shoreline change north of Caroline Bay. During the period since harbour construction, the mixed sand and gravel barrier beaches at Waimataitai and Washdyke have retreated substantially. By about 1930 the barrier beach enclosing a lagoon at Waimataitai breached and disappeared. The beach at Washdyke has retreated over 400 m at an average annual rate of 3.32 m for the period 1865–1987, and indications are that the retreat will continue until the barrier beach breaches and Washdyke Lagoon is lost.

Even before the construction work on the breakwater commenced, it was noted that gravels moved from south to north along the steep narrow beach at Timaru. It was hypothesised that this was due to the dominance of waves approaching from a southerly direction and breaking at an angle to the shore. It had also been noted that the coastline between Oamaru and Banks Peninsula was subject to chronic erosion. Erosion of a coast is a reflection of a deficit of sediment. Sediment is lost naturally from the beach by abrasion of individual sediment particles, washover of sediment to landward, and longshore transport of sediment. These processes all occur in the vicinity of Timaru and include a strong net northward drift of beach and nearshore sediment. The construction of the harbour breakwaters effectively cut off the supply of sediment from the south to the beaches north of the harbour, causing accretion south of the breakwater and accelerating the natural erosion at Waimataitai and Washdyke.

![Figure 24.1 Shoreline changes around the Port of Timaru as they relate to its development. (Tierney 1977)](image)
The examples above illustrate planned modifications to the physical environment with some unplanned additional impacts. Other early European modifications of the New Zealand landscape were carried out without thought of the consequences but have resulted in the appearance of much of the countryside as it is today. Major physical transformations to the landscape resulted from early deforestation and timber milling. The timber was used for building and fuel, and also exported. The cleared land was either left to revert to secondary scrub and bush growth, or planted in pasture grasses for stock.

Mining has also been a significant contributor to changes in the landscape. Early gold finds in Central Otago, West Coast, and Coromandel resulted in an influx of people who rapidly set about rearranging the landscape in their search for wealth. Major operations such as sluicing and mill screening created moon-like land surfaces, stripped of vegetation and soil, and diverted river channels. With the removal of the gold and the reason for the population being there, these areas were left to local plant succession. On the West Coast between Kumara and Hokitika, scrub and bush hide a scarred, incised land of reworked gravel deposits, reworked riverbeds, abandoned canals used to direct sluice waters, and mining tills. South of Westport, surface coal mining has led to similar transformations of the topography. Mine shafts also penetrate into the hills of the West Coast and Coromandel, while the waste products of mining operations have polluted both rivers and groundwater.

The impact of forestry and mining operations are now recognised, and all consents to mine and mill forest include conditions directing the return of the environment to a 'natural' state. However, debates on the societal and economic costs and benefits of such operations show that in trying to manage resource use in a sustainable manner we have yet to compose totally acceptable solutions.

Agriculture has been a major component of New Zealand's economic output for most of the last 150 years. However, agricultural practices have had many impacts on the physical environment. The clearing of land and planting of introduced pasture grasses is the most obvious impact. Other impacts are also relevant, including clearing of the native vegetation, which has caused destabilisation of soils and hillslopes. Erosion in many rural areas is high, as are associated sediment yields in streams and rivers. The fertility of soils has also been radically changed by the introduction of fertilisers and artificial nutrients. The efficient use and conservation of soil resources is a key issue in local and global environmental sustainability, while soil conservation in New Zealand has been a component of environmental management since the 1930s.

New Zealand's agricultural practices have also led to impacts to the atmosphere. The methane output from sheep and cows is greater in New Zealand than all other anthropogenic changes to the atmospheric composition, and is the subject of ongoing research.

A growing population and a developing technology have placed demands on the provision of power. From early use of wood and coal as fuel for heating and cooking, New Zealand progressed readily to electric power use and its subsequent generation. Hydro, coal-fired, oil-fired, and thermal power generation all have impacts on the physical environment. Hydroelectric schemes in Canterbury, Otago, and Fiordland have, since 1929 at Lake Monowai, caused changes to the landscape and hydrological
regimes. The most recent was the construction of the Clyde Dam on the Clutha River. The dam created Lake Dunstan, a totally artificial lake covering 26.4 km$^2$ with a shoreline of 152 km. This is a deliberate modification of the environment, with planned and predicted impacts to both the physical and human systems of the area.

Not all impacts of hydro-power schemes have been planned. Raising Lake Monowai in Fiordland during the 1920s drowned hundreds of hectares of forest. The remains of the forests give a stark reminder of a lack of knowledge of the processes at work. The impact at Monowai influenced the decision not to raise Lake Manapouri in the early 1970s.

Dams also counteract the natural processes of the rivers they straddle by impeding sediment transport and sediment delivery downstream and to the coast. Dams trap bedload sediment and provide areas of low flow so that sediment can settle and deposit either as a delta, as at the head of Lake Pukaki where the Tasman River enters the lake, or as deposition of fine material onto the bed of the lake itself, such as has occurred significantly in Lakes Waitaki and Roxburgh. The downstream effects can be seen in the Waitaki River, where the bed of the river has been denuded of transportable material as floods carry all available sediment to the coast. No new sediment has been supplied to the riverbed from upstream of the Waitaki Dam, so that erosion of the river banks and the bed itself has occurred, leaving an armouring layer in some areas and exposing other sites to accelerated erosion.

The downstream effect continues, as the river sediment is required to feed the beaches and nearshore of the South Canterbury coast. As fewer gravels travel out of the river, there is less material to nourish the beaches. Beach sediment is transported northward by a strong littoral current due to the oblique approach of southerly storm and swell waves. Beach sediments provide protection to the hinterland from wave attack. Without this sediment, the waves erode material from the base of the cliffs along the Glenavy-Morven area, causing instability and eventual erosion of the cliffs. The cliffs then become a source of sediment for the beaches to the north, ultimately reaching Timaru and contributing to accretion against the breakwater. At the same time, farming practices, irrigation, and drainage of water used in dairying on the coastal fan north of the Waitaki River also contribute to accelerated erosion of the gravel cliffs (Kirk & Hewson 1978).

The previous examples paint a rather bleak picture of detrimental human impact in New Zealand. However, this is not always the case. Through greater understanding of the physical processes and the natural interactions between processes and morphologies, the role of the human agent can be better assessed and managed. Returning to the example of the Port of Timaru, research into the port and adjacent coastal system has provided a means to address and resolve problems of coastal erosion (Kirk 1992b) and to help with port development and maintenance in an environmentally interactive way. Such an approach was used by Kirk (1992a) to design an artificial beach providing protection for the principal breakwater of the Port of Timaru. The concept was to promote accretion of a 'spending' beach seaward of the breakwater, so that wave energy was dissipated across the beach and not onto the breakwater structure. A 150 m long groyne was built near the harbour entrance to trap about 12 ha of northward-moving beach sand and gravel over an eight-year period. Figure 24.2 shows
the completed beach, which is aligned more perpendicular to the dominant swell direction than the breakwater and the beach to the south. The growth of the beach has utilised the existing arrival of sediment from the south and promotes a greater degree of shoreline equilibrium (Kirk 1992a).

Summary

This chapter has considered the impact of human activities on the environment. After discussing the range of types and scale of environmental impacts, the chapter focused on the impacts of Polynesian and European colonists to New Zealand. Many early modifications to the physical environment had unplanned additional impacts. As our understanding of the physical processes and the natural interactions between processes within the physical environment has improved, so too has our ability to manage impacts of human activities.

Awareness of humans as agents of change to the physical environment has enabled us to predict and minimise adverse human impact, where background research and understanding of the natural process regime exists. Where background or baseline knowledge does not exist, 'educated guess' judgments must be made of the impacts of human actions. The effects based New Zealand Resource Management Act imposes such consideration on developers and proposers of new activities in the environment, and provides physical geographers, among others, with an opportunity to fill the role of the informed expert in assessing environmental effect.

Further reading
