ENGINEERING AND CONSERVATION IN THE SNOWY MOUNTAINS, AUSTRALIA

IAN G. CROOK

New Zealand Wildlife Service, Department of Internal Affairs, Wellington

SUMMARY: The Snowy Mountains Hydro-electric and Irrigation Scheme is an example of resource development in which fundamental, ecological values of a natural environment were largely retained. Co-operation between ecologists and engineers and flexibility in planning, which allowed modifications prompted by economic and social changes during the long period of construction, contributed to its success. This suggests that greater harmony in the thinking of engineers and ecologists is possible, and it could well be promoted through examples such as that provided by the Snowy scheme.

INTRODUCTION

Ecologists and engineers look at natural environments in different ways, and the consequences are not limited to difficulties of communication; ecologists know that a simplistic approach to resource development can lead to unwise use of land and irrevocable damage to natural systems. These things will be difficult to avoid while ecologists and those who develop natural resources think and speak in such widely divergent terms about the same things; and some effort is being made to establish lines of communication. Engineers have expressed interest in ecological aspects of their work (Scott 1972), ecologists are listening to engineering and technological points of view (e.g. Littlewood 1972, Williams 1972), and there is now provision in New Zealand for ecological consultants in the field of resource development (New Zealand Ecological Society 1972). Further progress requires ecologists to show that specific resources can be developed economically without affecting functional stability, scientific values and æsthetic appeal of natural environments. A resource development which goes a long way toward meeting these specifications and provides a valuable example to both ecologists and engineers is the Australian Snowy Mountains Hydro-electric and Irrigation Scheme.

BACKGROUND TO THE SCHEME

Australian rivers discharge, on average, a total of only 280×10^6 acre/ft (345.2×10^9 m^3) of water annually (Australian Water Resources Council 1965). The largest river system, the Murray-Darling, has an average annual yield of 12×10^6 acre/ft (14.8×10^9 m^3) and a catchment of more than 1,072,000km^2 (Barton 1945). About 25 percent of Murray river water comes from 5000km^2 of high mountain catchments in the Australian Alps (Costin 1966). These figures demonstrate the limits of Australia's water resources and the need to develop them fully and protect the small mountain catchments.

There is an increasing demand for electricity in the eastern states of Australia which is being met mainly by coal-fired, thermal power stations; but hydro-electric stations, which can take up load quickly, can produce 'peak load' energy for short periods of high demand much more cheaply. By operating thermal stations on as continuous a basis as possible, and using hydro-stations to provide the 'peak load', an "economic optimum" is achieved (Hardman 1970). Hydro-stations can also cope with sudden changes in power demand by standing by on light load and producing only a small proportion of their potential output ('spinning reserve'). The problem of providing adequate 'spinning reserve' is becoming more acute with the rapid growth in size of thermal units, and the use of the Snowy hydro-stations for this purpose will probably become increasingly important (Hardman 1970).

Between 1886 and 1949 several projects were suggested to develop the water resources of the Snowy Mountains by diverting the eastward-flowing Snowy River through tunnels to the western side of the range where it would join the Murray River or its tributaries (Wigmore 1968). The scheme which was adopted in 1949, and which should be completed in 1975, provides for an annual output of 5000 $\times$ 10^6kWh of electricity and the controlled discharge of two million acre/ft (2.5 $\times$ 10^9 m^3) of water for irrigation of the Murray-Darling basin (Snowy Mountains Authority 1970).

The Scheme consists of 16 large dams and several smaller ones, seven power stations, 137km of tunnels, 790km of heavy duty roads, 1060km of light roads and access tracks and over 160km of 330,000V transmission lines (Hardman 1970). These works are scattered over an area of about 5000km^2, mostly within the 6070km^2 of the Snowy Mountains National Park.

This park was originally designated as the Kosciusko State Park (Kosciusko State Park Act 1944) and responsibility for its "care, protection and management" was vested in a Trust. With the enactment of the N.S.W. National Parks and Wildlife Act (1967) it became the Snowy Mountains National Park and passed into the control of the National Parks and Wildlife Service of the N.S.W. Department of Lands.

THE SNOWY MOUNTAINS

The "Snowy Mountains" is the name of an elevated plateau near the border of Victoria and New South Wales—the highest part of the Great Dividing Range. The plateau is deeply dissected by steep-sided river valleys and its western margin is sharply defined by steep scarp-slopes. For the most part, however, it consists of extensive areas of gently sloping uplands with few conspicuous mountains; the highest is Mt Kosciusko—2231m.

The plateau is composed predominantly of granitic and metamorphosed sedimentary rocks ranging in age from Ordovician to Devonian. In its northern part are several areas of Tertiary sands, gravels and clays overlain with basalt (Moye 1955, Gill and Sharp 1957, Diesendorf 1961). The absence of glaciation—only the area above about 1500m in the region of Mt Kosciusko was glaciated during the Pleistocene—and the mainly gentle topography have favoured the development of deep soils. Alpine humus soils predominate in well drained areas and bog and fen peats and a variety of gleyed soils occur in wetter areas (Costin 1954).

The climate is characterised by a well distributed, high precipitation of rain and snow (1800-3000mm per year) and frequent frosts; up to 200 freeze-thaw cycles occur annually (Costin 1967).

The lower altitudes and foothills support several eucalypt-dominated forest types, mainly savannah woodlands and dry sclerophyll forests with some areas of wet sclerophyll forests. These grade into a further series of wet sclerophyll forests in which alpine ash (*Eucalyptus delegatensis*) is prominent and then to the high altitude, subalpine forests which are dominated by snow gum (*Eucalyptus niphophila*). The snow gum forest is commonly reduced to scrub at the higher altitudes and at about 2000m gives way to the tussock grasslands, herbfields, heath and bog and fen communities of the alpine tract. The vegetation and soils of the Snowy Mountains are described by Costin (1954). The flora includes 17 species which are confined to the alpine zone of the Snowy Mountains and there is little doubt that the abundant and diverse fauna includes rare species found in few other places (Costin 1961).

EFFECTS OF THE SCHEME

The Scheme has caused several major changes to the environment. The hydrology of the area has been permanently altered—ground-water communities near water diversion structures being particularly affected (Costin 1966)—and the scenery has been extensively changed by the appearence of a great network of structures. Patterns of access and human settlement have changed, and although several roads have now been closed and construction camps demolished, many unforeseen side-effects persist—such as the unknown but probably adverse effects of domestic cats introduced to settlements. Exotic plants have been accidentally introduced and actively propagated to re-vegetate earthworks. White clover (*Trifolium repens*) and browntop (*Agrostis tenuis*) have been used extensively, and poplars, willows and broom (*Cytisus scoparius*) have been planted. In some places stabilised areas have been recolonised by native species, but in others the exotics persist; broom has spread widely, particularly on road verges.

Some of these effects could not be avoided without prejudicing the Scheme itself. Others, such as the spread of broom and some accidental introductions, possibly could have been, but there were surprisingly few major mistakes with deleterious side-effects and most were corrected during the construction period. The recognition and control of soil erosion caused by construction operations is an example of this.

"Quite a considerable amount" of soil erosion occurred in the plateau region during the early years of construction (Browne 1952). Little attention was then paid to catchment stability and tracked vehicles were driven indiscriminately across country, sideling roads were cut at the bottoms of steep slopes and others were made by pushing soil down equally steep slopes to fill 'wants' and to clear cuttings. Clayton (1955) described the erosion hazard as "very great and very serious"; but the Snowy Mountains Authority set up a soil conservation section which by 1970 had spent nearly four million dollars repairing the early damage and ensuring the stability of later earth-works.

As well as building such things as dams and power stations and causing a multitude of other changes, the Scheme contributed indirectly to further changes in land use during the construction period. The effects of these may be as far-reaching as those of the Scheme itself.

Before the Scheme began, and in the early years of construction, sheep and some cattle grazed the alpine and sub-alpine areas during the summer under a system of "snow leases". Grazing began in the latter half of the 19th century and was accompanied by burning tussock grasses to encourage palatable new growth. The effects of grazing and burning included:

1. Impairment of ground cover caused by selective grazing of alpine herbs which exposed the soil to the effects of frost, wind and water.
2. Impairment of the ability of forested areas to retain water because of changes in ground-cover vegetation.
3. Gullying and lowering of water tables in fens and bogs caused by trampling.
4. Failure of the regeneration of snow gum following burning caused by sheep grazing the new growth.
5. Destruction of peat by fire.
6. Acceleration of soil erosion.
(Australian Academy of Science 1957, Costin 1966).

The Snowy Mountains Authority and the powerful, pastoralist lobby came into direct conflict over the grazing issue and, though the controversy was both heated and protracted, a ban on grazing above 4500ft (1371m) was introduced in 1958. Following further restrictions, sheep and cattle grazing in the Snowy Mountains has now virtually ceased.

Most areas recovered naturally when grazing and burning ceased (Carr and Turner 1959, Costin *et al.* 1959), but measures such as re-seeding, mulching and construction of adsorption banks and paved waterways were necessary in some places, particularly around the summit of Mt Kosciusko. Restoration costs in that area were as high as $1000 per acre [*ca.* $2500/ha] (Kosciusko State Park Trust 1963).

Since the Snowy Mountains became a State Park there has been an enormous increase in their use for recreation, and the Scheme has contributed to the increase by encouraging visitors onto the new roads with an active public relations campaign. Development of tourist facilities and the rising popularity of snow sports completed this picture, and during 1970 more than two million people used the Park (Mr M. Jarrett pers. comm.).

Initially, at least, the Snowy Mountains Authority encouraged ecological research. This culminated in the production of a great weight of evidence on the adverse effects of grazing at high altitudes (Australian Academy of Science 1957); but research, aided by the new accessibility of the area, continued, and the Scheme aroused the interest of conservationists. This resulted in pressure being applied for establishment of a 'primitive area' of about 18,000ha centred on the summit of Mt Kosciusko (Australian Academy of Science 1961). The 'primitive area' issue was opposed by the Snowy Mountains Authority which had planned extensive engineering work there. A compromise was reached in 1963 which the Australian Academy of Science was said to consider "reasonable" (Anon. 1963), and the upper Snowy works were finally abandoned on economic grounds (Snowy Mountains Authority 1968).

The 'primitive area' encompasses features which are of great importance to scientists and nature conservation in Australia:

"1. It is the only extensive alpine area in the whole mainland continent of Australia . . .
2. It includes, within a few miles of traverse, the highest mountains in the continent, with an unmatched altitudinal sequence from 1500 to 7300ft [457-2231m].
3. Within it are well-defined moraines, cirques, polished pavements, glacial varves, and a series of glacial lakes, unique in the Australian mainland.
4. It contains the best development of alpine flora of the mainland . . .
5. It is watered by permanent alpine streams, some containing the original fauna and flora as yet unaltered by the introduction of trout or by stream diversion." (Australian Academy of Science 1961)

PRESENT MANAGEMENT OF THE SNOWY MOUNTAINS NATIONAL PARK

The Australian Academy of Science (1962) stated that:

> ". . . for an area of its size and unique natural features, which should be the outstanding National Park of the Commonmonwealth [of Australia] the standard of development achieved has been disappointing."

Much has since been done to correct the deficiencies. The Park is now divided into a series of land-use zones: primitive areas, areas of scientific or historic interest, development areas (for tourist and sporting facilities), hydro-electric areas, etc. Although their pattern was dictated to a large extent by the Scheme and its associated network of roads, the principle itself provides a firm policy for long-term management of the Park; and it is enforced by a staff which is large and well-equipped by New Zealand standards. The staff is also active in the control of introduced plants and animals, biological surveys, public education, construction of tourist facilities and many other activities related to the Park as a recreation area.

DISCUSSION

The Snowy Mountains Scheme has become an integral part of its surroundings. Engineers recognised this when they began to combat soil erosion in the high altitude catchments, and awareness of its broader environmental relationships is implicit in the following statement of the first Commissioner of the Snowy Mountains Authority:

> "The planning and construction of major hydro-electric developments involve many activities other than the purely technical . . . It can . . be said that the most frustrating and exasperating problems are not the technical ones" (Hudson 1955).

Some ecologists may, at first sight, be inclined to regard it as simply a mass of concrete and steel impinging itself on a natural landscape. Such an attitude would be unconstructive if greater harmony between engineering and conservation interests is being sought. It would also ignore such beneficial aspects of the Scheme as the cessation and repair of damage caused by livestock and the direct and indirect roles the Scheme may have played in advancing research and interest in the area to its present stage of development as a National Park.

On the other hand, if both ecologists and engineers recognise the Scheme as part of the whole environment, some progress toward a common viewpoint can be made.

The Scheme and Functional Stability of the Snowy Mountains

Catchment stability, and therefore a stable environment from the point of view of the ecologist, is an essential part of management of an area for water supply. However, some erosion will continue even though accelerated erosion is minimised or even stopped; and suspended sediments completely fill most man-made reservoirs in a centruy or two (Hubbert 1969). The maximum rate of siltation in any of the Snowy reservoirs is less than 0.025 percent of its total capacity per year (Diesendorf 1961). This indicates that the Scheme has a very long life expectancy and that the need to maintain a stable environment will continue for a similarly long period.

The Scheme and Scientific Values

Few, if any, detailed studies of the ecology of the Snowy Mountains had been completed before the Scheme began. It was not until 1958, nine years after its inception, that scientists prepared a submission to the Federal Government favouring establishment of a natural reserve where scientific and nature conservation values would be paramount. The compromise agreement with the Snowy Mountains Authority was reached five years later and the proposed works in the 'primitive area' near the summit of Mt Kosciusko were not finally abandoned until *18 years* after the Scheme began. This demonstrates the danger of too rapid implementation of resource development proposals and planning not flexible enough to allow for independent research or economic and social changes which are bound to occur as such a development proceeds.

The Scheme and Aesthetic Appeal

The attractiveness of an area is largely a matter of personal opinion, but the Australian Academy of Science (1961) suggested that the majority of people who visit the Snowy Mountains would agree that well-designed power stations, dams and the like add to the interest of heavily forested mountain scenes. In addition, the structures of the Scheme cover only a small proportion of the Park, and the Snowy Mountains Authority made an effort to ensure that major structures had a "pleasing" appearance by establishing an independent advisory group on the æsthetics of such structures in 1958. This group not only advised but also adjudicated in disputes between the Snowy Mountains Authority and other organisations.

However, the Snowy Mountains Authority considered that "when the interest is from the viewpoint of scenery, it cannot be agreed that proposed works should be abandoned or any location other than the most economical one adopted" (Snowy Mountains Authority, cited by Australian Academy of Science 1961). Possibly as a result of this policy there are features of the Scheme, such as transmission lines sited in prominent places, which detract from the beauty of the Park.

The Scheme and Modification of the Environment

The Scheme has involved many changes in the environment of the Snowy Mountains. Ecologists, occupied with ensuring overall stability of this modified environment and preserving major scientific values, perhaps overlooked some of the "smaller" changes caused by the Scheme. For example, in New Zealand, broom is an aggressive weed (Smith 1903, Cumberland 1944), but the attitude of the Snowy Mountains Authority to exotic species was uncritical; they were considered either to blend fully with the surrounding landscape (Snowy Mountains Authority 1965), or to "afford a pleasing contrast, emphasising the essentially native nature of the vegetation over the whole area" (Clayton 1967). More caution might have been shown if greater understanding between ecologists and engineers had allowed appreciation of the sometimes far-reaching effects of such "small" matters. The problems of domestic cats and plants introduced with settlements could similiarly have been, at least, reduced (cats have also been introduced into townships built for tourist accommodation), and considerations other than economic ones may have influenced the siting of such things as transmission lines.

CONCLUSIONS

1. The Snowy Mountains Scheme shows, by example, that resources can be developed with-

out destroying other, less tangible assets in the same environment; and that maintenance of environmental stability, scientific values and æsthetic appeal of the natural environment does not necessarily conflict with the economics of resource development.

2. In the absence of planning which recognises these values, the time lag between inception and completion of such a large project can be used by ecologists to ensure they are preserved; but if time is "wasted" in negotiations over issues which may, as the Scheme shows, not be real sources of conflict, details of more peripheral deleterious changes to the environment may be overlooked.

ACKNOWLEDGMENTS

I thank Mr D. J. Wimbush of C.S.I.R.O. for the information he provided and Mr W. Steele and Mr M. Jarrett (N.S.W. National Parks and Wildlife Service) for their generous assistance in the field. I am particularly grateful to my wife, Mrs Gillian Crook, for her contributions to all stages of the production of this paper.

ANON. 1963 *Sunday Telegraph*, Sydney, 27 October p.18.

AUSTRALIAN ACADEMY OF SCIENCE 1957. *A report on the condition of the high mountain catchments of New South Wales and Victoria.* Australian Academy of Science, Canberra.

AUSTRALIAN ACADEMY OF SCIENCE 1961. The future of the Kosciusko summit area: a report on the proposed primitive area in the Kosciusko State Park. *Australian Journal of Science* 23: 391-399.

AUSTRALIAN ACADEMY OF SCIENCE 1962. *Report to the National Parks Committee* (Unpublished) Canberra, p.70.

AUSTRALIN WATER RESOURCES COUNCIL 1965. *Rewiew of Australia's water resources 1963.* Department of National Development, Canberra.

BARTON, J. H. O. 1945. *A short history of the River Murray works.* Government Printer, Adelaide.

BROWNE, E. R. 1952. David Memorial Lecture. Cited by CLAYTON, E. S. 1955. Soil conservation in relation to water resources. In: *Water resources of Australia—their control and development* p.74. New South Wales University of Technology, Sydney.

CARR, S. G. M. and TURNER, J. S. 1959. The ecology of the Bogong High Plains. II. Fencing experiments in grassland C. *Australian Journal of Botany* 7: 34-63.

CLAYTON, E. S. 1955. Soil conservation in relation to water resources. In: *Water resources of Australia—their control and development* pp.67-75. New South Wales University of Technology, Sydney.

CLAYTON, E. S. 1967. *Catchment protection in the Snowy Mountains.* Snowy Mountains Authority, Cooma, New South Wales.

COSTIN, A. B. 1954. *A study of the ecosystems of the Monaro region of New South Wales.* Government Printer, Sydney.

COSTIN, A. B. 1961. Scientific aspects of the proposed Kosciusko Primitive Area. Appendix to The future of the Kosciusko summit area: A report on a proposed primitive area in the Kosciusko State Park. *Australian Journal of Science* 23: 397-399.

COSTIN, A. B. 1966. Problems and practice of nature conservation in sub-alpine and alpine ecosystems of Australia. *Proceedings of the Eleventh Pacific Science Congress, Tokyo 1966. Special Symposium No. 4. Ecological basis of nature conservation of alpine and sub-alpine zones.*

COSTIN, A. B. 1967. Alpine ecosystems of the Australasian region. In: *Arctic and alpine environments pp.55-87.* Eds. H. E. Wright Jr. and W. H. Osburn. Indiana University Press.

COSTIN, A. B., WIMBUSH, D. J., KERR, D. and GAY, L. W. 1959. Studies in catchment hydrology in the Australian Alps. I: Trends in soil and vegetation. *Commonwealth Scientific and Industrial Research Organisation Division of Plant Industry Technical Paper No. 13.*

CUMBERLAND, K. B. 1944. *Soil erosion in New Zealand—a geographic reconnaissance.* Soil Conservation and Rivers Control Council, Wellington.

DIESENDORF, W. 1961 (Ed.) *The Snowy Mountains Scheme phase I—the upper Tumut projects.* Horwitz, Sydney.

GILL, E. D., and SHARP, K. R. 1957. The tertiary rocks of the Snowy Mountains, Eastern Australia. *Journal of the Geological Society of Australia* 4: 21-40.

HARDMAN, D. J. 1970. *Snowy Scheme management and administration.* West Publishing Corporation, Sydney.

HUBERT, M. KING, 1969. Energy resources. In: *Resources and man—a study and recommendations.* Ed. National Academy of Sciences, National Research Council. Freeman, San Francisco.

HUDSON, W. 1955. The contribution of hydro-electric power to Australian power resources. In: *Australia's power resources* p.64. F. W. Cheshire, Melbourne.

KOSCIUSKO STATE PARK TRUST, 1963. Preservation of vegetation and prevention of soil erosion within the Kosciusko State Park. *Kosciusko State Park Handbook No. 1.*

LITTLEWOOD, G. E. 1972. Comalco's resource developments in New Zealand and Australia. *Proceedings of the New Zealand Ecological Society* 19: 13-15.

MOYE, D. G. 1955. Engineering geology for the Snowy Mountains Scheme. *Journal of the Australian Institute of Engineers* 27: 287-298.

NEW ZEALAND ECOLOGICAL SOCIETY 1972. *Rules for the registration of ecological consultants.* New Zealand Ecological Society, Wellington.

SCOTT, D. 1972. A possible set of ecological guidelines for engineers. *Proceedings of the New Zealand Ecological Society* 19: 7-12.

SMITH, W. H. 1903. Plants naturalised in the County of Ashburton. *Transactions of the New Zealand Institute* 36: 203-225.

SNOWY MOUNTAINS AUTHORITY 1966. *Sixteenth annual report of the Snowy Mountains Hydro-electric Authority for the year ended 30 June 1965.* Government Printer, Canberra.

SNOWY MOUNTAINS AUTHORITY 1968. *Eighteenth annual report of the Snowy Mountains Hydro-electric Authority for the year ended 30 June 1967.* Australian Government Publishing Service, Canberra.

SNOWY MOUNTAINS AUTHORITY 1970. *Snowy Mountains Story.* Snowy Mountains Hydro-electric Authority, Cooma.

WIGMORE, L. 1968. *Struggle for the Snowy—the background of the Snowy Mountains Scheme.* Oxford University Press, Melbourne.

WILLIAMS, H. R. 1972. Engineering and ecology—what is at issue? *Proceedings of the New Zealand Ecological Society* 19: 5-6.