EXPONENTIAL GROWTH AND THE EXAMPLE OF MINERAL RESOURCES

It is vital to an understanding of the environmental crisis that everyone appreciates the impact of exponential growth on the environment.

As one ordinarily sees growth, as of babies into adults or of seedlings into trees, it is a linear process, i.e. during the stage of growth, children and trees increase roughly by constant amounts in constant periods of time, an inch or a foot in stature each year, perhaps. A quantity exhibiting exponential growth on the other hand, increases by a constant percentage of the whole in a constant time period. In terms of the accumulation of money, for example, linear growth can be represented by a peasant putting away $10 each year under the mattress; exponential growth by compound interest.

It is useful to look at exponential growth in terms of **doubling times.** It is also necessary to emphasize the apparent suddenness with which exponential growth approaches a fixed limit. With any quantity growing exponentially we are always likely to be startled by a rapidity with which matters appear to go from comfortable, to tolerable, to completely intolerable—whether it be human numbers, or the usage of limited resources, or the pollution of the air, water or soil. The **rate of growth** need not change—what changes as time goes on is the magnitude of the quantity that is being doubled in constant time.

If we are moved to condemn it, we must at the same time realize that exponential economic growth is the feature of our life that has given us the wealth and comforts that we in the technologically advanced countries now enjoy. Nevertheless, its indefinite continuance is the basis of today's environmental crisis.

One example of the effect of exponential growth on a mineral resource is chromium, as studied by Dr. W. H. Behrens recently. It is clearly important to distinguish between the static reserve index (which is what most geologists and economists refer to as the 'reserves') and the exponential reserve index. If usage remained constant, reserves would be depleted linearly and would last for 420 years. If usage increases exponentially **at its present growth rate of** 2.6% p.a., reserves will be depleted in 95 years. If actual reserves are five times present proven reserves, chromium ore will be available for 154 years (assuming the present exponential increase in usage continues). Finally, even if all chromium were perfectly recycled, exponentially growing demand would exceed the 1970 known reserves in 235 years. You may say that the levels of demand postulated in the exponential increased demands are fanciful. They may be, but I can assure you that the under-developed three-quarters of the world fervently hopes they are not, for they aspire to reach the same 'standards of living' (i.e. utilization of resources) that are now found in U.S.A.

Non-renewable resources

Turning to non-renewable resources in general, we know that the earth's crust contains vast amounts of those raw materials that man has learned to mine and transform into useful things. Vast but not infinite. We have seen in the example of chromium how suddenly an exponentially growing quantity approaches a fixed upper limit. This leads us to a very important generalization, as follows: **Given present resource consumption rates** and the projected increases in these rates, the great majority of the currently important

Resource	Static Reserve Index (Years)	Projected Growth of Usage (% p.a.) (av.)	Exponential Reserve Index (Years)	E.R.I. with 5 x Known Reserves (Years)
Aluminium	100	6·4	31	55
Chromium	420	2·6	95	154
Coal	2,300	4·1	111	154
Copper	36	4·6	21	48
Iron	240	1·8	93	173
Lead	36	2·0	21	64
Manganese	97	2·9	46	94
Mercury	13	2·6	13	41
Natural Gas	38	4·7	22	49
Petroleum	31	3·9	20	50
Nickel	150	3·4	53	96
Tungsten	40	2·5	28	72

Exponential Reserve Indices for World Resources of Selected Minerals. From : Donella H. Meadows, Meadows, D.C., Randers, J., and Behrens, W. W. **The Limits of Growth**, London, 1972.

non-renewable resources will be extremely costly 100 years from now. This statement is true regardless of the most optimistic assumptions about undiscovered reserves, technological advances, substitution, or recycling—as long as demands for resources continue to grow exponentially. Examples are even now to hand for resources with the shortest static reserve indices—the price of mercury has increased 500% in the last 20 years, the price of lead 300% in the last 30 years.

Undiscovered reserves

As geologists rightly observe, there are still vast undiscovered reserves of many minerals, and at least some of these occur in places and concentrations that will allow them to be mined economically. But in the face of exponential increase in usage the best figures that are available for world resources are indeed startling (see tabulated figures) if we assume that current trends in increasing demand will continue. The last column shows that this is true even if we assume that there are enormous undiscovered reserves—five times what were known in 1970.

Comparable Australian data have not yet been compiled. In relation to internal usage we are well off in many minerals but certainly not in all that are needed to sustain a modern industrial state. However, since we export much more of our abundant minerals than we use ourselves Australia must be looked on, for many minerals, merely as part of the world reserves, to be mined for use in Japan, USA and Europe.

Extract from a public lecture, "Is there an Environmental Crisis?", delivered at the Australian National University on April 26, 1972, by Professor F. J. Fenner, Director of the John Curtin School of Medical Research and a Vice-President of the Australian Conservation Foundation.

Reproduced with acknowledgment to A.C.F. Newsletter, Vol. 4, No. 3, June, 1972.

CORELLAS OVER ROTTNEST

Honorary Warden Mr. W. A. Farmer, of Rottnest Island, has sent us the following interesting report:

"Rottnest residents saw for the first time a flock of Corellas [probably Long-billed Corellas, *Ed.*] flying overhead on August 30. They kept at great height and returned to the mainland without landing.

"This contrasted with the mobs of Black Cockatoos which visit Rottnest every few years and are the only visitors who reduce the local ravens to a state of terrified silence. After stripping all cones from the pine trees, the Black Cockatoos decide to depart; but because of their low-flying habits they circle the island for days, distracted by ravens who by then have lost their fear and attack continually. Then, one day, their leader sights the mainland and the black flock disappears."

DUCK SHOOTERS' LICENSES

In the event of a duck shooting season being declared this year, licenses (fee $2.00) will be available—

by post from:

Department of Fisheries and Fauna,
108 Adelaide Terrace, Perth;

by calling at any of the following district offices:

Albany
Bunbury
Busselton
Broome
Carnarvon
Dongara
Fremantle
Geraldton
Jurien Bay
Kalgoorlie
Lancelin
Mandurah
Mt. Magnet
Onslow
Pemberton
Perth
Pingelly
Shark Bay
Wongan Hills
Wyndham;

or the Clerk of Courts at:

Collie
Esperance
Harvey
Katanning
Manjimup
Narrogin
Northam
Wagin.

RED FACES IN ADELAIDE TERRACE

Did you notice our magnificent boo-boo on page 36 of the last issue of S.W.A.N.S. (Vol. 3, No. 2)? If not, then judging by the number of phone calls and letters we have had from our readers, you would appear to be in the minority.

The error was, of course, in the caption under the photograph on that page, for the two birds running alongside the fence are ostriches, not emus. We knew they were ostriches, meant to write ostriches, but in a moment of mental aberration they were titled emus—after all, the story was about emus.

One thing is certain, never again will we write the captions while the rest of the journal is being set at the printers. Meanwhile, there are two very red faces in one office in Adelaide Terrace.

S.W.A.N.S

Vol. 3 No. 3

WINTER, 1972

Issued by direction of the Hon. A. W. Bickerton, M.L.A., Minister for Fisheries and Fauna.

Director of Fisheries and Fauna: B.K. Bowen, B.Sc.

Chief Warden of Fauna: H. B. Shugg, A.A.P.A., A.F.A.I.M.

The support of the public is an essential component in any conservation or reserve management programme—but an informed, educated public is needed to ensure its continuing success.

This publication is designed as a medium by which the various organisations, individuals, and wildlife management personnel may be kept informed of the work being carried out by this department; of departmental policies and directions; and for promoting a better understanding and appreciation of Western Australian wildlife and the role it plays in maintaining a suitable environment in which man can live.

S.W.A.N.S. is published quarterly at the conclusion of each season by:

Extension and Publicity Service,
Department of Fisheries and Fauna,
108 Adelaide Terrace,
Perth, Western Australia 6000.

Editor: A. C. Waldon,
A.A.I.A. (Dip.), M.P.R.I. (Aust.)

Assistant Editor: R. F. Ward

Something to think about....

"Yes, that's it," said the Hatter with a sigh, "it's always tea-time, and we've no time to wash the things between whiles."

"Then you keep moving round, I suppose?" said Alice.

"Exactly so," said the Hatter. "As the things get used up."

"But what happens when you come to the beginning again?" Alice ventured to ask.

"Suppose we change the subject," the March Hare interrupted, yawning.

—*Alice's Adventures in Wonderland.*

Get the point?

No?

See article on page 61.

IN THIS ISSUE....