De Silva, S. S., Perera, M. K. and Maitipe, P., 1984. The composition, nutritional status and digestibility of the diets of *Sarotherodon mossambicus* from nine man-made lakes in Sri Lanka. *Environ. Biol. Fishes* **11:** 205–219.

De Silva, S S., Subasinghe, R. P., Bartley, D. M. and Lowther, A., 2004. Tilapias as alien aquatics in Asia and the Pacific: a review. FAO Technical Paper No. 453, Rome.

Ehrlich, P. R., 1989. Attributes of invaders and the invading processes: vertebrates. Pp. 315–328 *in* Biological Invasions: A Global Perspective ed by J. Drake, F. di Castri, R. Groves, F. Kruger, H. Mooney, A. Rejmánek and M. Williamson. Wiley, New York.

Eviner, V. T. and Chapin, F. S. III., 2003. Functional matrix: a conceptual framework for predicting multiple plant effects on ecosystem processes. *Annu. Rev. Ecol. Syst.* **34:** 455–485.

García-Berthou, E., 2007. The characteristics of invasive fishes: what has been learned so far? *J. Fish Biol.* **71 (Suppl. D):** 33–55.

Holway, D. A. and Suarez, A. V., 1999. Animal behaviour: an essential component of invasion biology. *TREE* **14:** 328–330.

Krishna Murthy, V., Dhananjaya Reddy, Y., Manohar Reddy, R., Bhaskar, M. and Govindappa, S., 1984. Changes in brain acetylcholinesterase activity and behaviour of freshwater fish in acid polluted environment. *Environ. Ecol.* **2:** 79–82.

Landau, M., 1992. Introduction to Aquaculture. John Wiley and Sons, New York.

Lévêque, C., 2002. Out of Africa: the success story of tilapia. *Environ. Biol. Fishes* **64:** 461–464.

Lodge, D. M., Taylor, C. A., Holdich, D. M. and Skurdal, J., 2000. Nonindigenous crayfishes threaten North American biodiversity. *Fisheries* **25:** 7–20.

Lovell, T., 1998. Nutrition and Feeding of Fish. Kluwer, Boston.

Lovett, G. M., Canham, C. D., Arther, M. A., Weathers, K. C. and Fitzhugh, R.D., 2006. Forest ecosystem responses to exotic pests and pathogens in eastern North America. *Bioscience* **56:** 395–405.

Mackenzie, R., Jackson, P. and Cotterell, E., 2001. Control of Exotic Pest Fishes — An Operational Strategy for Queensland Freshwaters 2002–2005. Department of Primary Industries, Queensland.

Maddern, M. G., Morgan, D. L. and Gill, H. S., 2007. Distribution, diet and potential ecological impacts of the introduced Mozambique mouthbrooder *Oreochromis mossambicus* Peters (Pisces: Cichlidae) in Western Australia. *J. Roy. Soc. W.A.* **90:** 203–214.

Maitipe, P. and De Silva, S. S., 1985. Switches between zoophagy, phytophagy and detritivory of *Sarotherodon mossambicus* (Peters) populations in twelve man-made Sri Lankan lakes. *J. Fish Biol.* **26:** 49–61.

McKaye, K. R. and Marsh, A., 1983. Food switching by two specialized algal-scraping Cichlid fishes in Lake Malawi, Africa. *Oecologia* **56:** 245–248.

McKaye, K. R., Ryan, J. D., Stauffer, J. R. Jr., Lorenzo, J., Lopez, P., Vega, G. I. and van den Berghe, E. P., 1995. African tilapia in Lake Nicaragua: ecosystem in transition. *Bioscience* **45:** 406–411.

Merrick, J. R. and Schmida, G. E., 1984. Australian Freshwater Fishes: Biology and Management. Griffin, Adelaide.

Morgan, D. L., Gill, H. S., Maddern, M. G. and Beatty, S. J., 2004. Distribution and impacts of introduced freshwater fishes in Western Australia. *N. Z. J. Mar. Freshwat. Res.* **38:** 511–523.

Moyle, P. B. and Light, T., 1996. Biological invasions of fresh water: empirical rules and assembly theory. *Biol. Conserv.* **78:** 149–161.

Noorjahan, C. M., Dawood, S. S. and Nausheen, D., 2003. Impact of dairy effluent on biochemical constituents of fish *Oreochromis mossambicus*. *J. Ecotox. Environ. Monitor.* **13:** 227–231.

Oliveira, R. F., Almada, V. C. and Canário, A. V. M., 1996. Social modulation of sex steroid concentrations in the urine of male cichlid fish *Oreochromis mossambicus*. *Horm. Behav.* **30:** 2–12.

Popma, T. and Masser, M., 1999. Tilapia Life History and Biology. Southern Regional Aquaculture Centre Publication No. 283, Texas.

Price, T., Qvarnström, A. and Irwin, D. E., 2003. The role of phenotypic plasticity in driving genetic evolution. *Proc. Roy. Soc. Lond. B* **270:** 1433–1440.

Reddiex, B. and Forsyth, D. M., 2006. Control of pest mammals for biodiversity protection in Australia. II. Reliability of knowledge. *Wildl. Res.* **33:** 711–717.

Sax D. F., Stachowicz, J. J., Brown, J. H., Bruno, J. F., Dawson, M. N., Gaines, S. D., Grosberg, R. K., Hastings, A., Holt, R. D., Mayfield, M. M., O'Connor, M. I. and Rice, W. R., 2007. Ecological and evolutionary insights from species invasions. *TREE* **22:** 465–471.

Schoener, T. W., 1971. Theory of feeding strategies. *Annu. Rev. Ecol. Syst.* **2:** 369–404.

Somanath, V., 2003. Impact of tannery effluent on bioenergetics of fishes. *J. Ecotox. Environ. Monitor.* **13:** 161–173.

Strayer, D. L., Eviner, V. T., Jeschke, J. M. and Pace, M. L., 2006. Understanding the long-term effects of species invasions. *TREE* **21:** 645–651.

Vitousek, P. M., 1990. Biological invasions and ecosystem processes: towards and integration of population biology and ecosystem studies. *Oikos* **57:** 7–13.

West-Eberhard, M. J., 2003. Development Plasticity and Evolution. Oxford University Press, Oxford.

Nauru — Opportunity in loss

SASCHA FEARY[1]

[1]Centre for Biodiversity and Restoration Ecology, School of Biological Sciences, Victoria University, P.O. Box 600, Wellington, New Zealand

THE nation of Nauru lies 72 km south of the equator in the Pacific Ocean. Until the discovery of phosphate deposits on the island at the beginning of the 19th century Nauru was covered in dense tropical rainforest which was tended in a traditional form of agroforestry by the indigenous Nauruans. From the forest came fruits such as pandanus, fibre, and timber such as the Tomano or Pacific Mahogany. Aquaculture was performed in the Buada Lagoon, fish, such as tuna were caught from the steep ring reef, and Noddy birds were caught as they came in from the ocean to roost in the evenings.

Over millennia rich deposits of phosphate formed between the coral pinnacles that form the substrate of

the island. The development of superphosphate fertilizer in the late 19th century made phosphate rock a valuable commodity. Nauru, an island which was erstwhile largely ignored by the colonial powers, was thrown into the world marketplace (Weeramantry 1992).

Today the 13,500 inhabitants rely almost entirely on imported foods as most of the trees and birds are gone, as is almost all of the cheaply extractable phosphate (Quanchi 2007). Additionally, around 40% of the fringing reef has died due to sediments from mining and sewerage outflow, affecting local fisheries (NCCC 1999).

The people of Nauru have not given up hope for the future of life on the island. In 1997, the Nauru Rehabilitation Corporation (NRC) was established by the Nauruan government to begin work on rehabilitating the mined areas of the island according to the Nauru Australia Cooperation (NAC) Rehabilitation and Development Feasibility Study (RDFS) of 1994. The process of restoration was not adequately described in the RDFS and as the NRC lacks the ecological expertise necessary to develop the plan further it is unable to fulfill its brief (Clodumar, pers. comm.). There are opportunities for the knowledge and skills of ecologists and conservation biologists to provide real benefits for the people of Nauru, while employed in research which benefits their own disciplines.

The denuded karrenfield of coralline rock which makes up the interior of the island post mining provides many examples for ecological research. For instance, the coral pinnacles create a landscape of islands of different sizes at greater or lesser distances from remnant areas of vegetation. Different areas of pinnacles have been exposed during different periods of mining allowing different time periods for colonization (Weeramantry 1992). Colonization is occurring; the oldest areas are covered with well developed vegetation, while the newest are stripped to bare rock. Despite regenerating for decades, the two topsoil deposits accumulated during mining are species poor and sparsely covered with acacia and little else.

Of particular interest are the issues of cadmium contamination and climate alteration consequent to mining. Cadmium once associated with the phosphate has been distributed throughout the environment accumulating in soils and vegetation (Blake 1992; Kirk 2000; Manner, Thaman and Hassal 1984; NCCC 1999). The long term effects of this ecologically and sociologically have not been explored. Neither have the effects of the removal of vegetation on the local climate. The island was once covered in dense rainforest, and rain was a regular and common phenomenon. Today, the interior of the island bakes under the equatorial sun and receives less rainfall than is necessary to support rainforest communities (Department of Economic Development and Environment 2003; Kirk 2000; Gowdy and McDaniel 1999). While I was on the island earlier this year, I was told that until a week before my arrival the island had not received substantial rain for a period of three years (Barker, pers. comm.). The consequences of these kinds of changes for the ecology of the island are considerable.

Also of interest are the sociological aspects of conservation. Nauru was rapidly transformed environmentally and socially. Today, barely anyone enters the interior of the island except the Noddy bird hunters and those employed to extract the remaining phosphate. From a society with highly evolved traditional systems of ecological knowledge which guided their agroforestry and aquaculture practices (to give two examples), Nauruan society is now highly urbanized. Nauruans have become reliant on external resources which are becoming less affordable as product and transportation costs increase. Nauru presents a opportunity to successfully employ the principles of Integrated Conservation and Development Projects (ICDP's) as conflicts between biodiversity conservation goals and development potential are minimal. This is due to indigenous recognition of the need for re-establishment of rainforest to provide ecosystem services, and because levels of endemism on the island are low (NCCC 1999).

Akin to Easter Island/Rapanui, Nauru provides a warning about the societal effects of unmitigated environmental degradation. However, Nauru also provides an opportunity to rectify environmental abuse, to develop skills and knowledge of how to reconfigure the relationship between humanity and the environment in a manner that is sustainable and conserves the biological and cultural values of our world.

REFERENCES

Barker, X. Acting Director of the University of the South Pacific in Nauru. Personal Communication. 9th September, 2008

Blake, C. 1992. Environmental distribution of heavy metals on Nauru, Central Pacific, and possible relationships to human health. B.App.Sci. Honours Report, University of New England, Northern Rivers, Lismore, New South Wales, Australia

Clodumar, V. CEO, Nauru Rehabilitation Corporation. Pers. Comm. 12th September, 2008.

Department of Economic Development and Environment. 2003. First National Report of the Republic of Nauru to the United Nations Convention to Combat Desertification. Republic of Nauru.

Gowdy, J. M., and C. N. McDaniel. 1999. The physical destruction of Nauru: An example of weak sustainability. Land Economics **75:** 6.

Kirk, A. R. 2000. The Republic of Nauru. The Blue Pacific Series. Capital Letters Publishing, Masterton, NZ.

Manner, H. I., Thaman, R. R., and D. C. Hassall. 1984. Phosphate mining induced vegetation changes on Nauru Island. Ecology **65:** 11.

NCCC. 1999. Climate Change Response. Nauru National Committee on Climate Change. Nauru.

Quanchi, M. 2007. Troubled times: Development and economic crisis in Nauru. Pp. 249–64 in Security and development in the Pacific Islands: Social resilience in emerging States. ed by M. A. Brown. Lynne Rienner Publishers, Boulder, CO, USA.