Kākāpō Recovery

Dear Reader, Andrew Digby, <http://andrewdigby.com/> , had been helping me with this article, which we had published a while ago. On October 2, 2020, he sent some additional corrections which are included in this revision.

Tony Noerpel

“Learn how to see. Realize that everything is connected to everything else.” Leonardo DaVinci.

“Even if expense were no object, none of these [biosphere] services could be performed at such scales and with such efficacy by any anthropogenic means. Our dependence on biosphere services is literally a matter of survival, and that’s why the integrity of the biosphere matters.” Vaclav Smil

Another journal article was published on June 2, 2020, by Gerardo Ceballos, Paul R. Ehrlich, and Peter H. Raven in the Proceedings of the National Academy of Science, reminding us we are causing a major extinction event [Ceballos]. The rate of extinction is approximately 100 times faster than the background rate and accelerating. The authors summarize

“*The ongoing sixth mass extinction may be the most serious environmental threat to the persistence of civilization, because it is irreversible. Thousands of populations of critically endangered vertebrate animal species have been lost in a century, indicating that the sixth mass extinction is human caused and accelerating. The acceleration of the extinction crisis is certain because of the still fast growth in human numbers and consumption rates. In addition, species are links in ecosystems, and, as they fall out, the species they interact with are likely to go also. In the regions where disappearing species are concentrated, regional biodiversity collapses are likely occurring. Our results reemphasize the extreme urgency of taking massive global actions to save humanity’s crucial life-support systems*.”

70% of all individuals of vertebrate species have disappeared over the 50 years since 1970 [WWF] and wild mammal biomass has declined 83% during the Holocene [Bar-On]. About 75% of all flying insects in national parks in Germany disappeared in 27 years [Hallmann] and similar declines have been observed in a protected rainforest in Puerto Rico [Lister]. In intensively farmed areas, earthworm biomass has been reduced by about 88% compared to organically farmed acreage [Blakemore]. Wetlands have been reduced by 84% [Diaz]. Elephant populations have been reduced by 98% [Chase]. North American birds have suffered the loss of 3 billion individuals, mostly due to loss of habitat [Rosenberg]. Manatees, whales and salmon used to thrive in the Chesapeake Bay [Lotze]. We are destroying the habitability of our planet [Diaz].

Today, though, I want to discuss a parrot that we have driven to the brink of extinction and are trying desperately to save. The kākāpō (from Māori: “night parrot”), is native to New Zealand and once inhabited both the North and South main islands in large numbers. Kākāpō is a flightless bird, the largest parrot in existence and one of the world’s longest living birds with a mean live expectancy of 60 years. It is nocturnal, herbivorous, and ground dwelling, though they do spend a lot of time in trees. They have poor eye sight but huge olfactory glands and a remarkable sense of smell.

A kākāpō has fine yellow-green plumage, and a distinct facial disc resembling an owl. Its scientific name is the “owl-faced, soft feathered parrot (Strigops habroptilus). It has a large grey beak, short legs, large feet, and relatively large wings for a flightless bird. Males are larger than females. Males weigh on average about 4.5 lbs. but can be as heavy as 9 lbs. and are from 23 to 25 inches long. Females average about 3 lbs. A male named Sirocco is shown in Figure 1. Sy Montgomery in her book Kākāpō Recovery describes them as “Sweet-smelling, beautiful, big, soft, trusting and playful.” [Montgomery]

Kākāpō are so colorful and uniquely beautiful that thousands of birds were killed by Europeans and sold to museums and collections around the world. This large supply of dead birds became a treasure for geneticists attempting to estimate past populations.

The kākāpō is considered to be a "habitat generalist" [Wiki]. Before human settlement, they thrived in nearly all climate conditions in New Zealand, including dry, hot summers on the North Island and cold winter temperatures in the sub-alpine areas of the South Island and they survived through the glacial/interglacial cycles of the Pleistocene. Kākāpō seem to have preferred forests with mild winters and high rainfall, but were not exclusively forest-dwelling. In recent decades and in order to save the species, kākāpō was transferred to a predator-free, uninhabited and tiny islands, such as Whenua Hou/Codfish Island, Anchor Island, and Hauturu-o-Toi/Little Barrier Island. There they have adapted well to these new environments. This is a sad reminder that kākāpō might survive human-caused climate change if they can survive loss of habitat, over exploitation and predation from invasive species first.

There were two waves of population declines. The Maori arrived in New Zealand in approximately 1280 CE bringing with them Maori dogs and kiore rats. The kākāpō was historically important to these people, appearing in many of their traditional legends and folklore; however, it was also heavily hunted and used as a resource by Māori, both for its meat as a food source and for its feathers, which were used to make highly valued pieces of clothing. The hunting of kākāpō for food seems to have begun around 1500 CE after other large flightless birds such as the Moa had been hunted into extinction. Kākāpō were also occasionally kept as pets. The dogs easily hunted down the sweet smelling birds and the rats ate the underground chicks and eggs.

European colonization began in 1769 and during the nineteenth century settlers brough a host of predators including big black climbing ship rats and the even bigger Norwegian brown rat, both of which are bigger and tougher than the kiore rat. Whalers brought cats to eat the stowaway rats and settlers brought pigs, deer, goats, sheep, rabbits and ferrets and stoats to eat the rabbits. By the mid-1900s kākāpō were thought to have been wiped out. In 1894, conservationist Richard Henry led an effort to save the birds by relocating several hundred of them to Resolution Island in Fiordland, which at the time was predator-free. Unfortunately, stoats arrived within six years, eventually destroying the relocated population. Two papers which studied the genetic diversity of both current and historic populations (using museum samples) conclude that Polynesian hunting and habitat destruction could have led to population fragmentation even though records suggest the kākāpō remained locally abundant in less intensively settled areas [Bergner] [Dussex]. This would have made the species vulnerable to the deleterious effects of inbreeding and genetic drift. By introducing mammalian predators and further reducing habitat, Europeans caused a rapid decline in population in an already depauperate (in this case lacking in genetic diversity) species.

The historic population may have been 1,000,000 individuals prior to the arrival of the Maori [Digby] [Dussex] and is currently only 209 [NZDOC] As shown in Figure 2. Both Maori and European settlements impacted the kākāpō population. An important message is that while the recent increase from a minimum of 50 individuals in 1995 to the current 209 individuals is a positive sign, it is by no means a recovery of a species once numbering hundreds of thousands or millions, and which is still very much threatened. Cat control was implemented in 1982 to arrest the decline in kākāpō numbers shown in Figure 2. The population has recently been increasing with the intensive effort of the Kākāpō Recovery Programme [krp].

Conservation and evolutionary biologist are studying how species respond to population declines, often associated with loss of genetic diversity, inbreeding and accumulation of deleterious mutations. These can lead to a reduction in fitness and subsequently contribute to extinction. Because kākāpō passed through this genetic bottleneck, in which the world population was reduced to only 50 birds, they are extremely inbred and have low genetic diversity. This results in lower disease resistance and fertility problems. 40% of kākāpō eggs are infertile and many males have never produced offspring [White].

The ecologist Warder Clyde Allee was the first to recognize the link between population size of a species and individual fitness. For example, a species with a small genome may be more highly vulnerable to fungal, bacterial or viral infection. And in fact, in 2012, an outbreak of the fungal disease aspergillosis was discovered in kākāpō. In total 48 kākāpō were flown by helicopter to veterinary hospitals around New Zealand for CT scan diagnosis and intensive treatment that usually lasted for several months. Dunedin's Wildlife Hospital has treated 12 birds. The relationship Allee discovered is called suitably the Allee effect. As we drive species such as kākāpō, elephants, rhinos, whales, amphibians and others towards smaller population sizes, we are making them increasingly vulnerable to extinction even if we change our exploitive behavior, i.e., cease hunting them, and establish habitat reserves and clean up the environment. And some of the damage we cause to habitat, such as introduced invasive predators or vast pools of plastics in the oceans cannot be undone within less than a few generations.

Currently there are many wonderful people, NGOs, and academic and government organizations around the world attempting to save species like kākāpō and other endangered species and this takes time, energy, money, manpower and resources. And all we are doing is what nature was once perfectly capable of doing without our help and much more effectively. As we continue recklessly misbehaving as a species ourselves, and as more and more of the Earth’s biodiversity becomes threatened, we will have to spend increasing resources and energy undoing our damage and, in many cases, we will fail because species will have passed Allee limits without us realizing it.

Special thanks to conservation biologist Andrew Digby, Kākāpō Recovery Programme’s lead scientist for providing me with lots of reading material and patient help [krp]. For anyone wanting to learn more, I recommend the article by Rebekah White [White], a young adult book Kākāpō Rescue: Saving the World’s Strangest Parrot by Sy Montgomery, with illustrations by Nic Bishop [Montgomery] and Alison Ballance book “Kākāpō: Rescued From The Brink Of Extinction” [Balance].

The two papers describing this genetic sequencing are by Laura M. Bergner, Nicolas Dussex, Ian G. Jamieson, and Bruce C. Robertson published in 2015 [Bergner] and by Nicolas Dussex, Johanna von Seth, Bruce C. Robertson, and Love Dalén published in 2018 [Dussex]. This work has been funded by the Genetic Rescue Foundation, Kākāpō Recovery Programme, Ngai Tahu, Department of Conservation, Otago University, Duke University and New Zealand Genomics Ltd. and other individuals and organizations.



Figure 1. A male named Sirocco on Maud Island. Photo: Mike Bodie, Department of Conservation. 16 October 2009 Source <https://www.flickr.com/photos/docnz/4015891720/>



Figure 2. Kākāpō population in New Zealand showing breeding years. By KimvdLinde, Canley - Own work, data from Department of Conservation Te Papa Atawhai Monitoring and Reporting System, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=6496732>

[Balance] Alison Balance, Kākāpō: Rescued From The Brink Of Extinction, 2010, Craig Potton Pub.

[Bar-On] Yinon M. Bar-On, Rob Phillips, and Ron Milo, The biomass distribution on Earth, PNAS, Aril 13, 2018, [www.pnas.org/cgi/doi/10.1073/pnas.1711842115](http://www.pnas.org/cgi/doi/10.1073/pnas.1711842115)

[Bergner] Bergner, L. M., Dussex, N., Jamieson, I. G., & Robertson, B. C. (2016). European Colonization, Not Polynesian Arrival, Impacted Population Size and Genetic Diversity in the Critically Endangered New Zealand Kākāpō. The Journal of Heredity, 107(7), 593–602. <http://doi.org/10.1093/jhered/esw065>

[Blakemore] Robert J. Blakemore Critical Decline of Earthworms from Organic Origins under Intensive, Humic SOM-Depleting Agriculture, Soil Syst. 2018, 2, 33; <https://doi.org/10.3390/soilsystems2020033>

[Ceballos] Gerardo Ceballos, Paul R. Ehrlich, and Peter H. Raven, Vertebrates on the brink as indicators of biological annihilation and the sixth mass extinction, PNAS, June 2, 2020, [www.pnas.org/cgi/doi/10.1073/pnas.1922686117](http://www.pnas.org/cgi/doi/10.1073/pnas.1922686117)

[Chase] Michael J. Chase, Scott Schlossberg, Curtice R. Griffin, Philippe J. C. Bouché, Sintayehu W. Djene, Paul W. Elkan, Sam Ferreira, Falk Grossman, Edward Mtarima Kohi, Kelly Landen, Patrick Omondi, Alexis Peltier, S. A. Jeanetta Selier and Robert Sutcliffe, Continent-wide survey reveals massive decline in African savannah elephants,

[Diaz] Sandra Díaz, Josef Settele, Eduardo Brondízio, Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 6 May 2019, available at the IPBES website.

[Digby] personal communications

[Dussex] Nicolas Dussex, Johanna von Seth, Bruce C. Robertson and Love Dalén, Full Mitogenomes in the Critically Endangered K¯ak¯ap¯o Reveal Major Post-Glacial and Anthropogenic Effects on Neutral Genetic Diversity, Genes 2018, 9, 220; <http://doi.org/10.3390/genes9040220>

[Hallmann] Caspar A. Hallmann, Martin Sorg, Eelke Jongejans, Henk Siepel, Nick Hofland, Heinz Schwan, Werner Stenmans, Andreas Mueller, Hubert Sumser, Thomas Hoerren, Dave Goulson, Hans de Kroon, More than 75 percent decline over 27 years in total flying insect biomass in protected areas, PLoS ONE 12 (10): e0185809. <https://doi.org/10.1371/journal.pone.0185809> , 2017.

[krp] <https://www.doc.govt.nz/our-work/kakapo-recovery/what-we-do/history/>

[Lister] Bradford C. Lister and Andres Garcia, 2018. Climate-driven declines in arthropod abundance restructure a rainforest food web. PNAS, 115 (44): E10397-E10406. [www.pnas.org/cgi/doi/10.1073/pnas.1722477115](http://www.pnas.org/cgi/doi/10.1073/pnas.1722477115)

[Lotze] Heike Lotze, “Historical reconstruction of human-induced changes in the U. S. Estuaries”, Oceanography and Marine Biology: An Annual Review, 2010, 48, 267-338.

[Montgomery] Sy Montgomery and Nic Bishop, Kakapo Recovery, saving the world’s strangest parrot, Houghton, Mifflin, Harcourt, 2010.

[NZDOC] New Zealand Department of Conservation <https://www.doc.govt.nz/nature/native-animals/birds/birds-a-z/kakapo/>

[White] Rebekah White, <https://www.nzgeo.com/stories/decoding-kakapo/>

[Wiki] <https://en.wikipedia.org/wiki/Kakapo>

[WWF] World Wildlife Fund, “Living planet report 2018” (World Wildlife Fund, 2018).