Centring Indigenous knowledge systems to re-imagine conservation translocations

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Abstract

1. Conservation translocations—particularly those that weave diverse ways of knowing and seeing the world—promise to enhance species recovery and build ecosystem resilience. Yet, few studies to date have been led or co-led by Indigenous peoples; or consider how centring Indigenous knowledge systems can lead to better conservation translocation outcomes.
2. In this Perspective—as Indigenous and non-Indigenous researchers and practitioners working in partnership in Aotearoa New Zealand—we present a novel framework for co-designing conservation translocations that centre Indigenous peoples and knowledge systems through Two-Eyed Seeing.
3. We apply this framework to Aotearoa New Zealand's threatened and under-prioritised freshwater biodiversity. In particular, we highlight the co-development of conservation translocations with Te Kōhaka o Tūhaitara and Te Nohoaka o Tukiauau that are weaving emerging genomic approaches into local mātauraka (Māori knowledge systems), including customary practices, processes and language.
4. We envision the Two-Eyed Seeing framework presented here will provide a critical point of reference for the co-design of conservation translocations led or co-led by relevant Indigenous peoples elsewhere in the world to ultimately build more resilient biocultural heritage.

1. Torutoru noa iho kā hinoka kua puta mai i kā iwi taketake e pā ana ki te nekeneke o kā momo tata korehāhā. Tēnā pea mā te mātauraka o kā iwi taketake, ka whakahaumako i te whāomoomo o te pūnaha hauropi.
2. Kua hakaia he pou tarāwaho e mātou hei hoahoa i kā hinoka neke momo tata korehāhā. Ko te kako o tēnei pou tarāwaho ko te arotahika ki kā mātauraka o kā iwi taketake kia āwhina i ēnei mahi.
3. Mai i te whakakotahitaka o kā rarauka huika ira ki kā momo mātauraka Māori — mai i kā mahika kai, tae ana ki te reo — ka whakahākai mātou i tēnei pou tarāwaho ki kā momo tata korehāhā i kā wai o Te Kōhaka o Tūhaitara me Te Nohoaka o Tukiauau.
4. Ko te tūmanako ka whakahākaitia tēnei pou tarāwaho e kā iwi taketake me kā kairangahau o te ao whānui ki te hāpai i te whāomoomo o kā koiora mai i ō rātou whenua.

Keywords

biocultural diversity, conservation genomics, conservation translocations, customary harvest, ecosystem resilience, freshwater biodiversity, Indigenous knowledge, mātauranga, species recovery, Two-Eyed Seeing

Note—for this Perspective, we have used the Kāi Tahu dialect 'k' in place of the northern 'ng' (underlined in text). This reflects local pronunciation and does not necessarily change the meaning of the word (i.e., where underlined, ng and k are interchangeable).

Introduction

Researchers, practitioners and communities around the world are exploring creative strategies to enhance resilience in threatened species (Suding et al., 2015). Combined with growing awareness that the fate of our biological diversity is closely tied to cultural and linguistic diversity, many are looking beyond Western science to bring together diverse ways of knowing and seeing the world (e.g., Mercier, 2018; McAllister et al., 2019; Wehi, Beggs, & McAllister, 2019). Mi'kmaq Elder Dr Albert Marshall describes the Mi'kmaq principle of *Etuaptmumk* or 'Two-Eyed Seeing' as 'learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of Western knowledges and ways of knowing ... and learning to use both these eyes together, for the benefit of all' (Marshall, 2004; Bartlett, Marshall, & Marshall, 2012; Kutz & Tomaselli, 2019). Indeed, Indigenous communities sustain a vast portion of the world's remaining biodiversity through knowledge systems (knowledge-practice-belief complexes) that are carefully and iteratively adapted to local landscapes over generations, and often millennia (Reed, Brunet, Longboat, & Natcher; Gadgil, Berkes, & Folke, 1993; Garnett et al., 2018; Ginsberg, Chieza, Frank, Rands, & Vilutis, 2019). Yet—despite promising dialogue—Indigenous knowledge, process and practices often remain side-lined from conservation decision-making (Box 1; Reed et al.; IUCN, 2016; Mistry & Berardi, 2016).

< Box 1 >

Conservation translocations—that is, the movement of organisms from one location to another for conservation benefit—promise to build resilience across threatened populations, species and ecosystems (Seddon, 2010). While translocations to enhance biodiversity are not novel, nor unique, to Western science (e.g., Ross et al., 2018; Silcock, 2018), few publications reflect on how Indigenous-led approaches could inform conservation translocations (Leiper et al., 2018). In this Perspective, as Indigenous and non-Indigenous scientists and practitioners working in partnership under Aotearoa New Zealand's Tiriti o Waitangi (Treaty of Waitangi, 1840)—a critical founding document that frames the relationship between Māori (Indigenous peoples of Aotearoa New Zealand) and the British Crown—we consider Two-Eyed Seeing in a conservation translocation context. In particular, we reflect on how conservation translocations can be enhanced by decentring Western perspectives to co-develop approaches that centre Indigenous people, knowledge, process and practises.

Why translocate?

Threatened species often exist as small, fragmented populations, which puts them at risk for increased inbreeding and reduced genetic diversity (Frankham, 2005). Over time, this can limit their ability to respond—or adapt—to a changing environment (de Villemereuil et al., 2019). Thus, conservation strategies generally seek to build resilience such that populations can respond to future change; in part by promoting large, genetically diverse metapopulations (Frankham et al., 2017; Galla et al., 2019). Evidence-based conservation translocations can build resilience by increasing genetic, biological and functional diversity (Parker, 2008; Polak & Saltz, 2011; Seddon, Griffiths, Soorae, & Armstrong, 2014; Malone et al., 2018).

The International Union for Conservation of Nature (IUCN) Species Survival Commission (SSC) classifies conservation translocations according to their primary objective. For example, *population reinforcement* can increase resilience of existing populations by decreasing inbreeding and increasing genetic diversity. Translocations may also seek to re-establish species where they have been lost from an ecosystem entirely (*population restoration*). These may be particularly important in fragmented landscapes where habitat rehabilitation does not guarantee that biodiversity will return naturally (e.g., the “build it, and they will come” Field of Dreams hypothesis; Palmer, Ambrose, & Poff, 1997; Bond & Lake, 2003; Sudduth, Hassett, Cada, & Bernhardt, 2011). C*onservation introductions* may also be performed outside of natural ranges, either to prevent focal species extinction (*assisted colonisation*) or to replace ecological function (*ecological replacement*). Out-of-range translocations such as these are increasingly considered in the context of climate change; for instance, where a species’ present range is predicted to become unsuitable (Chauvenet, Ewen, Armstrong, & Pettorelli, 2013; Bay et al., 2018). *Mitigation translocations* further seek to move populations to new habitat—either within or outside the species current range—in response to impending local extirpation (e.g., due to urban development or habitat loss).

To increase the likelihood of success, best-practice guidelines such as those developed by the IUCN / SSC Conservation Translocation Specialist Group (CTSG) provide a comprehensive overview of considerations relating to conservation translocations (IUCN / SSC CTSG Guidelines for Reintroductions and Other Conservation Translocations; herein, ‘the CTSG guidelines’). These evidence-based considerations include comprehensive risk assessment, multidisciplinary teams, existing baseline knowledge, multigenerational population monitoring, iterative management and documentation (Weeks et al., 2011; IUCN/SSC, 2013; Moehrenschlager, Shier, Moorhouse, & Stanley Price, 2013).

Evidence-based conservation translocations are challenging for many under-studied species

Case-by-case evaluations of the benefits and risks of conservation translocations are routine for many terrestrial species (e.g., Seddon, Armstrong, & Maloney, 2007; Parker et al., 2015; Lloyd, Hostetter, Jackson, Converse, & Moehrenschlager, 2019), plants (e.g., Godefroid et al., 2011) and some recreationally or commercially-valued species (Dunham, Gallo, Shively, Allen, & Goehring, 2011; Anderson et al., 2014). However, comprehensive evaluations—and as a result, evidence-based protocols—are more challenging for many invertebrates, marine and freshwater fish (Box 2; Fischer & Lindenmayer, 2000; Seddon, Soorae, & Launay, 2005). The discrepancy across taxonomic groups is reflected in the CTSG database of annually published case studies ('Global Re-introduction Perspectives'; http://publications.iucn-ctsg.org/ead). Despite commendable efforts to incorporate a diverse taxonomic breadth, charismatic terrestrial vertebrates remain highly overrepresented: at the time of writing, 168 of the 351 global case studies focus on birds or mammals, compared to 34 fish and 29 invertebrate case studies across marine and freshwater systems combined. Indeed, while Aotearoa New Zealand is globally renowned for evidenced-based bird translocations to offshore predator-free islands, only two of its 22 conservation translocations listed in the CTSG database relate to freshwater species (Armstrong et al. 2015).

Whether these taxonomic trends—which are conservative estimates, at best—reflect lower rates of reporting or fewer translocations overall is unclear. Regardless, we anticipate these trends can partially be attributed to the complex and varied motivations that underlie translocations (Brichieri-Colombi & Moehrenschlager, 2016). For example, terrestrial conservation translocations generally centre around enhancing conservation outcomes for specific focal species (e.g., Braidwood, Taggart, Smith, & Andersen, 2018), whereas marine conservation translocations tend to be ecosystem-driven (Swan, McPherson, Seddon, & Moehrenschlager, 2016). Excluding Cochran-Biederman, Wyman, French and Loppnow (2015)—who reviewed correlates of success relating to native freshwater fish reintroductions—to our knowledge, a comprehensive review for all freshwater conservation translocations is lacking; but examples in this Perspective and elsewhere suggest that ecological, rather than species, considerations tend to be prioritised (Germano et al., 2015). Indeed, there is ample scope to bridge the gap between ecosystem restoration and threatened species recovery for conservation translocations in general (Franklin, 1993; Lindenmayer et al., 2007; Hughes, Inouye, Johnson, Underwood, & Vellend, 2008; Tilman, Isbell, & Cowles, 2014; Hughes, Grabowski, Leslie, Scyphers, & Williams, 2018)

< Box 2 >

Indigenous-led approaches build more resilient biocultural heritage

Whereas Western science has often prioritised an 'either-or' approach to ecosystem restoration and threatened species recovery, Indigenous-led approaches are more likely to integrate both (Long, Tecle, & Burnette, 2003; Hudson et al., 2016; Kutz & Tomaselli, 2019). For example, in Kakadu Country, Australia, traditional wetland burning forms an integral part of contemporary land management to maintain and enhance local resources, including habitat heterogeneity and culturally significant species such as almangyi (long-necked turtle *Chelodina rugosa*) (McGregor et al., 2010). In Hawai'i, the Nā Kilo 'Āina Program (NKA) seeks to build resilient socio-ecological systems through Indigenous-based frameworks to improve the 'well-being of 'āina, Hawai'i's biocultural landscapes and seascapes' (Sterling et al., 2017; Morishige et al., 2018). These frameworks incorporate biocultural monitoring, customary management and social mechanisms that are informed by native

Hawaiian knowledge systems (e.g., Huli ‘Ia, a platform for recording ‘place-based cycles of productivity’ as they relate to seasonal indicators and lunar cycles; Winter et al., 2018). Further, ample evidence demonstrates that Indigenous knowledge systems are highly sensitive and adaptable to novel challenges such as climate change (Berkes, 2009; Ginsberg et al., 2019). For instance, Skolt Sámi in Finland have taken adaptive measures to preserve Atlantic salmon *Salmo salar* numbers in response to rising water temperatures and reduced catch rates, including by increasing harvest of pike to reduce predation pressure (Nakashima, McLean, Thulstrup, Castillo, & Rubis, 2012; Pecl et al., 2017; Mustonen & Feodoroff, 2018).

The significance of Indigenous-led approaches extends to species that are often underrepresented in Western science and conservation management (Noble et al., 2016; Sato, Price, & Vaughan, 2018). For example, Gunditjmara communities of the Budj Bim landscapes in southeast Australia have managed the declining, culturally-significant kooyang (short-fin eel *Anguilla australis*) for millennia, including through complex aquaculture systems (Gunditjmara People & Wettenhall, 2010; McNiven, Crouch, Richards, Dolby, & Jacobsen, 2012). Gunditjmara communities have led restoration of wetland habitat and stream connectivity to re-establish migratory pathways (e.g., Framlingham Aboriginal Trust & Winda Mara Aboriginal Corporation, 2004; Noble et al., 2016). In the Khong province of southern Laos, local communities along the Mekong River have developed freshwater fisheries management systems that have improved freshwater stocks compared to areas managed entirely by national government (Baird, 2007). These include measures—such as size-selective harvest; establishment of Fish Conservation Zones; and restrictions on catching methods—that are grounded in local ecological knowledge, including comprehensive taxonomic systems and understanding of foraging or migratory behaviour (Baird, 2007). In Aotearoa New Zealand, Māori are revitalising traditional harvesting methods for kōura (freshwater crayfish *Paranephrops* spp.) as a monitoring tool and for customary management (Kusabs, Hicks, Quinn, & Hamilton, 2015; Whaanga, Wehi, Cox, Roa, & Kusabs, 2018).

The inclusion of Indigenous knowledge in Western science and conservation management enables more nuanced insights (Wehi, Whaanga, & Roa, 2009). For instance, Seri Indian knowledge holds that the diversification of spiny-tailed iguana *Ctenosaura hemilopha* spp. in the Sea of Cortez pre-dated human migration—in contrast to prevailing Western thought that species diversification was human-mediated—and this knowledge has since been observed in a recent phylogeographic study (Davy, Méndez de la Cruz, Lathrop, & Murphy, 2011). Examples such as this represent a promising start toward Two-Eyed Seeing in a conservation translocation context; and there is ample scope to build on the inclusion of Indigenous knowledge by centring this knowledge alongside Indigenous peoples, processes and practices. For example, in Aotearoa New Zealand, mātaurak̲a (Māori knowledge systems) describe historical translocations of culturally significant species—including kōura, tuna (eel *Anguilla* spp.), kākahi (freshwater mussel *Echyridella* spp.), pūpū whakarongotaua (kauri snail *Placostylus ambagiosus*) and toheroa (clam *Paphies ventricosa*)—that have informed phylogeographic studies and increasingly, contemporary conservation translocations (McDowall, 2011; Ross et al., 2018; Michel, Dobson-Waitere, Hohaia, McEwan, & Shanahan, 2019; Daly, Trewick, Dowle, Crampton, & Morgan-Richards, 2020; McEwan, Dobson-Waitere, & Shima, 2020).

Centring Indigenous knowledge systems in conservation translocations through Two-Eyed Seeing

Indigenous and non-Indigenous researchers and practitioners are increasingly working at the interface of Indigenous knowledge systems and Western science to build more resilient biocultural heritage (e.g., Long et al., 2003; Dobbs et al., 2016; Clapcott et al., 2018; Delevaux et al., 2018; Lyver et al., 2018; Bond, Anderson, Henare, & Wehi, 2019). However, published and grey literature indicates that contemporary conservation translocations are rarely Indigenous led or co-led (e.g., http://publications.iucn-ctsg.org/ead; Leiper et al., 2018). Given the broad scope of conservation translocations (i.e., translocations where the primary objective is a 'measurable conservation benefit at a population, species or ecosystem level'; IUCN/SSC, 2013), we see a clear opportunity to extend existing frameworks such as the CTSG guidelines through Two-Eyed Seeing.

As more conservation translocations are Indigenous led or co-led, we envision this will be reflected in both the defined objectives and indicators of success. Where success indicators in CTSG case studies tend to focus on the conservation status of target species (e.g., an improvement in a species' national threat ranking), we anticipate co-designed success-indicators will capture a wider breadth of biocultural outcomes (Sterling et al., 2017; Mooney & Cullen, 2019). Further, conservation translocations that are intended to enable or enhance sustainable customary practices are well placed to incorporate long-term monitoring and iterative management (Herse et al., 2020). In Aotearoa New Zealand, frameworks that are grounded in mātauraka—such as the Cultural Health Index (CHI)—are recognised as robust measures of waterway health (Harmsworth, Young, Walker, Clapcott, & James, 2011). The CHI generally assesses three key components: site status (e.g., significance to tākata whenua; people of the land); values associated with food and natural resources (e.g., presence of culturally significant species, changes in biodiversity and whether people would return to harvest at the site); and cultural stream health, including riparian vegetation, catchment land-use and water quality (Tipa & Teirney, 2006). Measures such as these could be readily adapted to assess conservation translocation success. For example, we are actively co-developing translocations of the culturally significant species kēkēwai (freshwater crayfish *Paranephrops zealandicus*) for customary harvest at Tūhaitara Coastal Park. For kēkēwai, a key objective is to establish self-sustaining populations that are resilient to future change; and one success indicator is sustainable customary harvest. However—beyond this species-specific target—additional indicators of success are signalled in a 200-year vision for the wetland, including the revitalisation of mātauraka, tikaka (customary processes and practices) and te reo Māori (Māori language).

As outlined in national and international treaties and agreements (e.g., Box 1), we contend there is a responsibility to ensure Indigenous communities with local authority are at the decision-making table when co-developing conservation translocations; particularly when translocating culturally significant species. That is, the first—and ongoing—step toward any conservation translocation should be building trusted relationships between relevant Indigenous and non-Indigenous researchers, practitioners and communities. Below, we capture these ideas in a novel framework (Fig. 1) that can be readily extended to suit relevant local contexts (e.g., see Fig. 2). Indeed, our intent is for this framework to inspire a wealth of local conservation translocation strategies that are responsive to diverse ways of knowing.

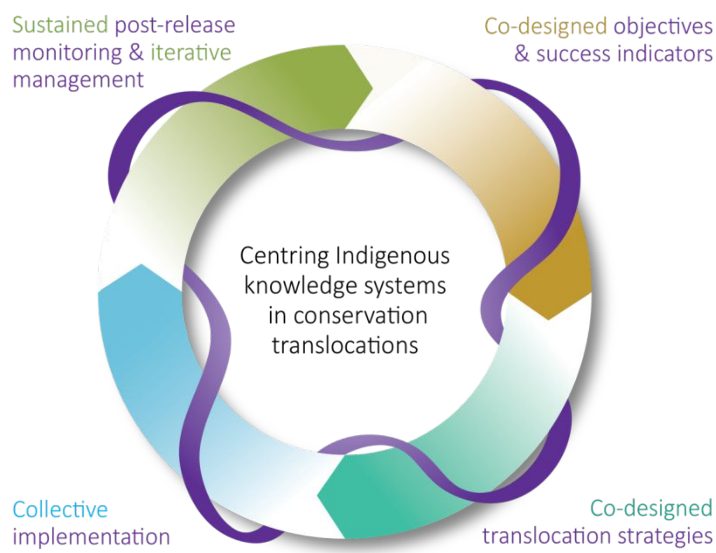

Figure 1. A novel framework for re-imagining conservation translocations through Two-Eyed Seeing. The main circle—comprised of key conservation translocation steps (purple text) based on IUCN / SSC guidelines—represents the centring of Indigenous knowledge, practice and values, while the purple weave around it represents Western science. The coloured (non-purple) text reflects ways in which Indigenous-led approaches can enhance each key step. At the centre, lies genuine partnership where relationships—built on mutual trust and respect—and collective decision-making are embedded throughout. For an example of how this framework can be reflected locally, see Fig. 2.

Can we re-imagine freshwater conservation translocations? Aotearoa New Zealand as a case study.

There is growing recognition that conservation translocations may be critical for enhancing resilience in freshwater biodiversity (Eikaas & McIntosh, 2006; Pavlova et al., 2017; Blanton, Cashner, Thomas, Brandt, & Floyd, 2019). For example, in the Murray-Darling Basin of Australia, post-European habitat fragmentation has impeded population connectivity for a freshwater fish, contributing to its recent and rapid decline (Brauer & Beheregaray, 2020). If these patterns are widespread—as indicated by a comprehensive review in Lindenmayer and Fischer (2007)—actions to restore population connectivity and prevent further species declines are urgently needed (Cowx & Portocarrero Aya, 2011; Pavlova et al., 2017). As per the examples described above, Indigenous-led approaches can be readily extended to freshwater conservation translocations. For instance, United States Native American Tribes and Canadian First Nations have co-led freshwater reintroductions and restoration of fish passage in the Columbia River Basin (US Columbia Basin Tribes & Canadian First Nations, 2014).

In Aotearoa New Zealand, freshwater conservation translocations are being explored through Indigenous-led or co-led approaches. Māori (Indigenous peoples of Aotearoa New Zealand) maintain a profound understanding of local landscapes and humankind's place through mātaurak̲a, at the centre of which lies whakapapa (genealogy) (Mead, 2003; Black, 2014). Embedded within these relationships is a paradigm of responsibility and reciprocity that is integral to kaitiakitak̲a (trusteeship). Katiakitak̲a is a way of managing the environment through traditional Māori worldviews (Marsden, 2003; Walker, Wehi, Nelson, Beggs, & Whaanga, 2019). It is also a guiding principle of mahik̲a kai (literally 'the working of the food'). Mahik̲a kai is itself is an expression of te Ao Māori (the Māori world) and steeped in a rich body of language, knowledge and practice (Phillips, Jackson, & Hakopa, 2016). By its very nature, mahik̲a kai acts to maintain the health of the entire ecosystem through strategies including cultural health monitoring; selective harvest of specific size classes; translocations to establish new populations and augment existing ones; rāhui (restrictions on access or harvest); and customary fishing reserves such as mātaitai or taiāpure (Tipa, 2013; Hudson et al., 2016; Awatere et al., 2017). Practises such as these ensure natural resources are maintained and enhanced to sustain future generations. For example, mahik̲a kai species are generally translocated according to specific objectives related to cultural vitality (Williams, 2012). Evidence of how mahik̲a kai-centred approaches can restore and enhance biodiversity is beginning to enter the conservation literature, such as customary management of tītī (sooty shearwater *Puffinus griseus*) (Moller, 2009), transdisciplinary research projects on īnak̲a (whitebait *Galaxias maculatus*) management in the Waikōuaiti River catchment (Carter, 2019) and Māori co-led translocations of kākahi (freshwater mussel) (Michel et al., 2019; McEwan et al., 2020).

In the face of new challenges (e.g., climate change) and emerging technologies (e.g., genomic data), we are increasingly asking whether—and if so, how—different populations should be mixed (Allendorf, Hohenlohe, & Luikart, 2010; Weeks et al., 2011; Harrisson, Pavlova, Telonis-Scott, & Sunnucks, 2014). For example, the potential to characterise adaptive variation has reignited debate over the benefits and risks of mixing disparate populations (e.g., Ralls et al., 2018; Borzee et al., 2019; Burridge, 2019; Kolodny et al., 2019). We anticipate that bringing together Indigenous and Western knowledge systems through Two-Eyed Seeing will enable more nuanced decisions for questions such as these. For instance, in Aotearoa New Zealand, conservation policy around moving individuals between catchments has generally followed precautionary principle—that is, in the absence of evidence, cross-catchment translocations are actively discouraged to avoid mixing populations that may be locally adapted. However, for species such as kēkēwai (freshwater crayfish), mātauraka directly challenges this line of thought. Evidence of historical translocations to establish or supplement kēkēwai along Kāi Tahu travel routes (McDowall, 2011; Monk, 2017) is also observed in preliminary genomic data (Rayne et al. unpublished data). We are combining mātauraka relating to historical translocations with genomic approaches to characterise adaptive variation to inform contemporary conservation translocation decisions. These decisions are further informed by primary industry, including the KEEWAI freshwater crayfish farming manual—the product of a partnership between Te Rūnanga o Ngāi Tahu, forestry company Ernslaw One and aquaculture company KEEWAI (Hollows, 2016). With expertise ranging across kēkēwai physiology, ecology, management and biosecurity, the manual represents a wealth of knowledge intended for use by iwi Māori and the wider public. Thus—even for under-studied species such as kēkēwai—there is ample evidence that could inform translocation policy in Aotearoa New Zealand's freshwater ecosystems, provided that Western-trained researchers and practitioners are open to multiple ways of knowing.

In an Aotearoa New Zealand context, whakapapa is central to realising biodiversity outcomes

In Aotearoa New Zealand, a complex system of genealogical relationships exists in the form of whakapapa (Collier-Robinson, Rayne, Rupene, Thoms, & Steeves, 2019). Although whakapapa is generally defined as genealogy, it encompasses much more than that; whakapapa acts as a knowledge system that describes and contextualises the origins and order of all things in the Māori world in relation to the individual (Tau, 2001). It explains the relationships between whānau, iwi and hapū (families, tribes and sub-tribes); and therefore which landscapes and natural resources they have intergenerational connections to (Te Rito, 2007). In doing so, whakapapa binds tākata whenua (people of the land) to the mountains, rivers, coasts and other landscapes—linking the health of the people with that of the environment. For example, Kāi Tahu are connected to the landscapes of Te Waipounamu (South Island of Aotearoa New Zealand) through whakapapa.

Like humans, species have whakapapa that connects them to their natural environment and to other species (Ataria et al., 2018; Collier-Robinson et al., 2019). Just as it has guided how mahika kai and taoka (treasured) species were managed in the past, whakapapa can—and should—inform contemporary translocation strategies. Indeed, when considering out-of-range translocations, the knowledge embedded within whakapapa can aid in identifying ecologically and culturally suitable sites. For example, whakapapa describes the ecological needs of kākahi (freshwater mussel), including interconnections with the sand, rocks, gravel and aquatic vegetation (Best, 1982; 1986; Rainforth, 2008). If whakapapa is understood thoroughly, we can build the right environment to protect and enhance every living thing. Therefore, when co-developing conservation translocations in an Aotearoa New Zealand context, whakapapa should be central to all decision-making (Fig. 2).

Figure 2. Freshwater conservation translocations under a Kāi Tahu lens. In this illustration, produced by Kaaterina Kerekere (KEdesign), line art refers to whakapapa (genealogy) and the terminology of whakapapa, while kōwhaiwhai (patterns) symbolise the development, movement and pathways of mātauraka (Māori knowledge systems) and practice. The main design sits within a sphere, reflecting Te Pō, Te Ao Mārama me Te Ao Hurihuri (three layers of the Māori world). In the layers of line work beneath the main illustration, the bold circles represent genetic markers, referring to Western knowledge systems and practice. Combined with the kōwhaiwhai (patterns), these repetitive layered designs depict the weaving together of mātauraka and Western knowledge. Within the sphere are tuna (eel), kōwaro (Canterbury mudfish), kēkēwai (freshwater crayfish) and kākahi (freshwater mussel), representing Aotearoa New Zealand's freshwater biodiversity. The colours make reference to the relationships between light, water and land—reflection and refraction, the blending and movement of light and water. Reproduced with permission.

Examples for co-developing conservation translocations through mātauraka and Western science: Te Nohoaka o Tukiauau and Tūhaitara Coastal Park

As an example of how our framework can be applied to enhance conservation translocations, we focus on two Māori led and co-led restoration projects in the tribal region of Kāi Tahu in Aotearoa New Zealand. At Tūhaitara Coastal Park and Te Nohoaka o Tukiauau, we are exploring how weaving genomic data into mātauraka and revival of customary practice could inform translocation policy to enhance resilience in kēkēwai (freshwater crayfish) and kōwaro (Canterbury mudfish *Neochanna burrowsius*) populations.

Along the eastern coast of Te Waipounamu (the South Island) stretches nearly 600 hectares of indigenous coastal, freshwater and terrestrial habitat (Fig. 3a). The site—known as Tūhaitara Coastal Park—was gifted to the people of Aotearoa New Zealand as an outcome of a Waitangi Tribunal settlement between Te Rūnanga o Ngāi Tahu (TRoNT) and the Crown. A charitable organisation, Te Kōhaka o Tūhaitara Trust, was established in 1998 to oversee the management and rehabilitation of the Tūhaitara Coastal Park. The Trust is run by six trustees, three of whom are appointed by TroNT. Tūhaitara Coastal Park includes the culturally significant Tūtaepatu Lagoon, once connected to the ocean and rich with mahika kai. Near the lagoon lies the burial site of the founder of the nearby settlement: Turakautahi. For the past two decades, Te Kōhaka o Tūhaitara Trust has led the restoration of indigenous biodiversity and the co-development of recreational, cultural and community opportunities toward a two hundred-year vision for the future.

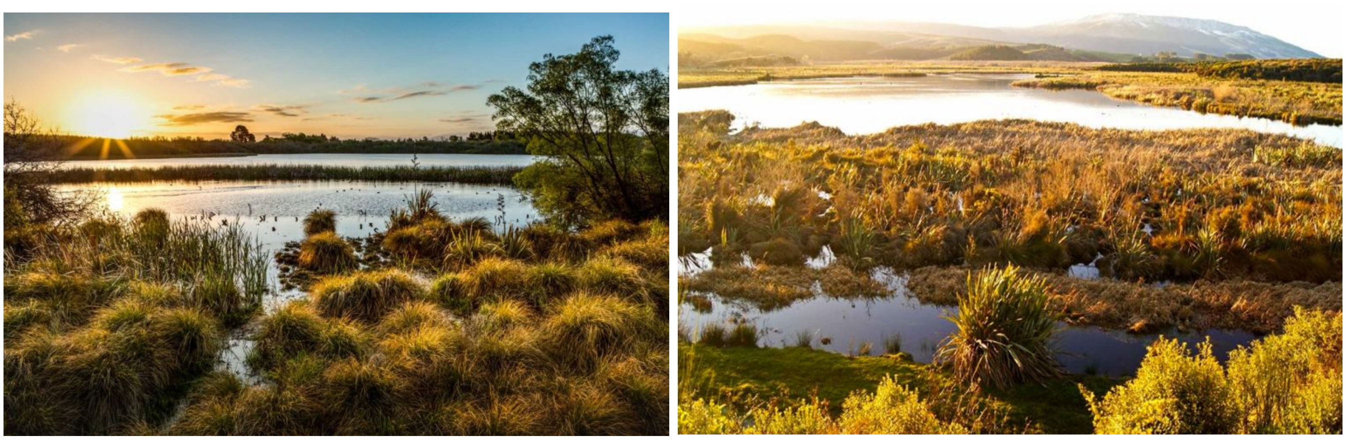

Figure 3. Since being returned to Kai Tahu through the Ngāi Tahu Claims Settlement Act (1998), Tūhaitara Coastal Park (a) and Te Nohoaka o Tukiauau (b) have undergone extensive ecosystem rehabilitation to revive biocultural diversity. Photo 3a: David Baird (David Baird Photography). Photo 3b: Glen Riley (Coordinator, Te Nohoaka o Tukiauau).

Further south on the Taieri Plains, Te Nohoaka o Tukiauau (the Sinclair Wetlands) Trust seeks to protect and enhance the Te Nohoaka o Tukiauau wetlands (Fig. 3b) by reconnecting people back to the land via education and hands-on experience. At Te Nohoaka o Tukiauau (the dwelling place of Tukiauau), in the early 18th century, a Kāti Māmoe chief—Tukiauau—and his people took temporary refuge on Whakaraupuka (Ram Island) to establish their nohoaka (dwelling place). The name of Tukiauau remains attached to the wetlands; and the swamp complex an important food basket and precious taoka (treasure) for later peoples. The Taieri Plains wetlands were drained during European Pākehā settlement—including the culturally and ecologically significant Tatawai Lake—leaving just two of the original lakes (Waihola and Waipori) and their adjacent swamps. The water from these wetlands was diverted through the nearby settlement, displacing tākata whenua (people of the land) from their land and natural resources. This led to an intergenerational loss of knowledge, customary process and practises that is still being recovered today. In 1998, the property was returned to Kāi Tahu as part of the Ngāi Tahu Claims Settlement Act (1998). Since 2011, the wetlands have been managed by the Te Nohoaka o Tukiauau Trust comprising up to eight volunteer Trustees, including representatives of Te Rūnaka o Ōtākou, and Tatawai Whenua Tapu Trust.

Tūhaitara and Te Nohoaka o Tuikauau wetlands provide valuable habitat for numerous species, including freshwater fish and invertebrates. At Te Nohoaka o Tukiauau, in addition to supporting wildlife, the wetlands provide plant materials for food, weaving, and clothing. At both sites, initial efforts have included restoration of indigenous habitat to support species above and in the water. For example, at Tūhaitara Coastal Park, a network of small ponds ('biota nodes') have been created near Tūtaepatu Lagoon. Ultimately, the biota nodes will be connected toward a 200-year vision of continuous habitat that supports metapopulations of taoka (treasured) and mahika kai species. Until then, the nodes will enable early translocations of freshwater species such as kōwaro, kēkēwai and kākahi (freshwater mussel). These species once lived in the silty channels of the wetlands; where they provided food for humans and freshwater predators, filtered sediment and processed waste (Phillips, 2007; Noble et al., 2016; Thoms, 2016; Vaughn, 2018). However, as of recent decades, they exist outside Te Nohoaka o Tukiauau and Tūhaitara in increasingly small and isolated populations (Thoms, 2016).

As part of strategies to revitalise mahika kai at both wetlands, we are co-developing evidence-based conservation translocations to reintroduce or augment threatened freshwater species. For example, conservation translocations have previously been attempted to enhance recovery of the critically endangered kōwaro. However, little regard has been given to the potential for translocations to disrupt locally adapted populations. Although conservation genomic approaches to characterise adaptive variation can help to identify appropriate source populations for translocation, these generally require relevant ecological data. Where relevant ecological data are lacking in Western science, other knowledge systems may provide even more holistic ecological data. Kāi Tahu hold extensive records from the 19th century with mātauraka—including traditional ecological knowledge—that has been passed down from tūpuna (ancestors). To inform conservation translocations of kōwaro into Tūhaitara Coastal Park, we are weaving this mātauraka into a genotype–environment association study that includes present day ecological data and whole genome resequences for kōwaro populations across their contemporary range (Collier-Robinson et al., 2019). As described above, similar approaches are being applied to conservation translocations of kēkēwai; and eventually other species such as kākahi. For each conservation translocation, source populations will ultimately be identified and selected by mana whenua (those with local authority) using the best available evidence in the form of both mātauraka and Western science.

To assess the long-term effects of conservation translocations on genomic diversity and fitness (i.e., survival and reproductive success), we are co-developing monitoring strategies that combine genomic and non-genomic data. Crucially, these monitoring strategies centre around transferring knowledge—both mātauraka and Western science—across generations. For example, at Te Nohoaka o Tukiauau, rakatahi (youth) are working with cultural experts from Te Rūnaka o Ōtākou, He Waka Kōtuia and freshwater ecologists to monitor local tuna (eel) populations (Fig. 4; Ka Hao te Rakatahi, 2019). Part of this research seeks to compare the efficacy of hīnaki (traditional eel nets) and Western fyke nets, while learning the wetland ecology; tuna lifecycle; and the practices and language associated with mahika kai. At Tūhaitara Coastal Park, local schools, university groups and organisations are responsible for managing and monitoring their allocated biota nodes. For example, tamariki (children) have been involved from early riparian planting; invertebrate monitoring; through to translocations of freshwater species such as kōwaro (Fig. 5). By engaging local people—young and old—as stewards of the knowledge, language and practices associated with these places, Te Kōhaka o Tūhaitara and Te Nohoaka o Tukiauau Trusts intend to maintain these ecosystems and their biocultural diversity long into the future.

Figure 4. Tuna (eel) monitoring with rakatahi (youth) at Te Nohoaka o Tukiauau. All identifiable individuals have consented to the use of this image. Photo: Paulette Tamati-Elliffe.

Figure 5. LCR collecting DNA samples for kōwaro (Canterbury mudfish) with tamariki (children) at Tūhaitara Coastal Park. All identifiable individuals have consented to the use of this image. Photo: Ashley Overbeek.

Conclusion

The biodiversity crisis calls on all of us—including Indigenous and non-Indigenous researchers, practitioners and communities—to work together at the interface of Indigenous knowledge systems and Western science (Artelle et al., 2019; Diaz et al., 2019). Here, we have focused on Aotearoa New Zealand's freshwater biodiversity as a case study for re-imagining conservation translocations through Two-Eyed Seeing. For example, at Te Nohoaka o Tukiauau and Tūhaitara Coastal Park, the revival and intergenerational transfer of knowledge, customary practices and language represents a powerful approach that will lead to diverse ecosystems renowned for sustainable practice, community involvement and as important K̲āi Tahu mahik̲a kai. By layering genomic data into existing mātaurak̲a, we can co-design more nuanced conservation translocation decisions for culturally significant freshwater fish and invertebrates. We anticipate approaches that centre Indigenous knowledge, people, processes and practices through Indigenous governance, or genuine co-governance, can be extended to enhance conservation translocation outcomes elsewhere; particularly for our most threatened and least prioritised species.

Box 1: Conservation treaties and agreements reflect a shift toward biocultural approaches

Conservation biology is entangled with the marginalisation of Indigenous communities from ancestral lands and natural resources (Wehi & Lord, 2017). Yet, there is growing recognition that the inclusion of Indigenous rights and knowledge in conservation policy, research and practise is central to realising biodiversity aspirations (Gavin et al., 2018; Artelle et al., 2019; Bridgewater, Rotherham, & Rozzi, 2019; Moola & Roth, 2019). The United Nations Convention on Biological Diversity calls on signatories to preserve biological diversity, including for sustainable use, and to maintain equitable sharing and use of genetic resources (United Nations, 1992; United Nations, 2015a; United Nations, 2015b; IUCN, 2016); although the extent to which global treaties such as the above Convention have realised meaningful legislative change is debatable (Koutouki, 2011). A number of countries—Aotearoa New Zealand, the United States of America and Canada included—have yet to sign the Nagoya Protocol, which is arguably the most pertinent to recognising Indigenous sovereignty over biodiversity. Nonetheless, treaties and agreements such as these can provide platforms for conservation policy, research and practise to realise Indigenous needs and aspirations.

Te Tiriti o Waitangi (the Māori version of the Treaty of Waitangi, 1840) is a critical founding document of Aotearoa New Zealand. The original document affirms and protects the tino rakatirataka (self-determination) of iwi Māori; and further upholds the rights of both Māori as tākata whenua (people of the land) and non-Māori as tākata Tiriti (people of the Treaty). Historical and ongoing breaches of Te Tiriti o Waitangi over the past 250 years have significantly eroded mātauraka (Māori knowledge systems) and sought to separate Māori from the natural environment (e.g., Ngāi Tahu Settlement Claims Act 1998, Ruru, O'Lyver, Scott, & Edmunds, 2017; Wehi & Lord, 2017). In particular, the Waitangi Tribunal report, Ko Aotearoa Tēnei (This is New Zealand) into the WAI 262 claim found that Māori, and Māori cultural values, have been side-lined 'from decisions of vital importance' to te Ao Māori (the Māori world) (Waitangi Tribunal, 2011). Although the Crown has yet to respond to Ko Aotearoa Tēnei, many Māori and non-Māori have moved toward 'an era of growth and partnership' since the Waitangi Act (1975) and the establishment of the Waitangi Tribunal (Walker, 1990; Collier-Robinson et al., 2019). For example, the Ngāi Tahu Claims Settlement Act (1998)—a product of negotiations between Te Rūnanga o Ngāi Tahu (the Kāi Tahu tribal council) and the Crown—has paved the way for partnerships between Kāi Tahu and non-Māori (e.g., Whakaora Te Waihora; Te Kōhaka o Tūhaitara Trust; Te Nohoaka o Tukiauau; Whakamana te Waituna; Whakaora Healthy Harbour).

Box 2: Freshwater conservation translocations: underwater, and out of mind?

Freshwater ecosystem restoration often proves challenging due to dynamic and degraded habitat (Reid et al., 2019). Many freshwater conservation translocations are further complicated by limited biological or ecological data, and social challenges—for example, reconciling conservation outcomes for threatened species with commercial or recreational harvest of introduced predators (e.g., trout *Salmo trutta*) (McIntosh et al., 2010). Further, measuring freshwater conservation translocation success is difficult—partially due to challenges monitoring translocated individuals, but also due to a general lack of post-translocation monitoring (Lintermans, Lyon, Hammer, Ellis, & Ebner, 2015). As a result, estimated success rates of freshwater conservation translocations are low, both globally (Palmer, Hondula, & Koch, 2014) and locally in Aotearoa New Zealand (O'Brien & Dunn, 2007; Aldridge, 2008; Pham, West, & Closs, 2013). Although mitigation translocations are increasingly common, these are generally performed by contracted companies and rarely observe best-practice guidelines. Instead, most published empirical evidence relating to freshwater translocations is restricted to North America, or to commercially or recreationally valued species. While these studies can inform freshwater conservation translocations elsewhere, the extensive heterogeneity of freshwater systems limits the degree to which lessons-learned can be extended to other species or catchments (Olden, Kennard, Lawler, & Poff, 2011).

For the reasons described above, freshwater species tend to have fewer comprehensive evaluations, protocols and empirical evidence to inform conservation translocations compared to terrestrial vertebrates. In Aotearoa New Zealand, challenges related to freshwater conservation translocations are further exacerbated by non-responsive legislation (Fig. I): while the National Threat Classification System considers 76% of freshwater fish and 26% of freshwater invertebrates to be Threatened with or At Risk of extinction, the only legally protected indigenous freshwater species is the long extinct upokororo (grayling *Prototroctes oxyrhynchus*) (Dunn et al., 2018; Grainger et al., 2018). With a significant proportion further listed as Data Deficient under national and international (IUCN) threat classification systems, the decline of many freshwater species likely remains undocumented or poorly addressed (Betts, 2016; Nelson et al., 2019).

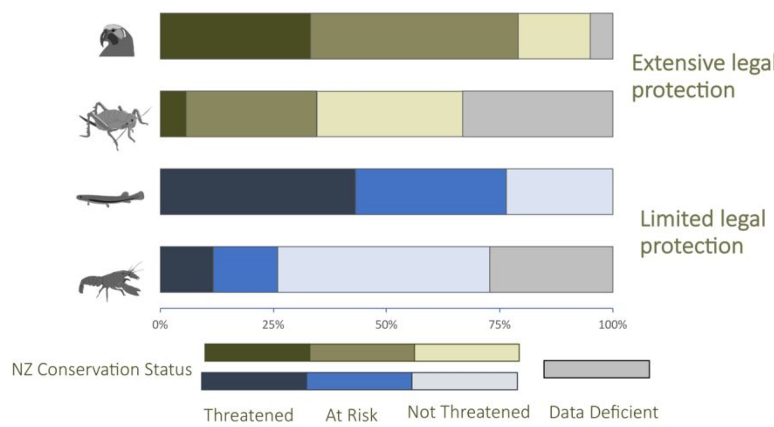

Figure I. Aotearoa New Zealand's freshwater fish (represented by kōwaro) and invertebrates (represented by kēkēwai) share a similar percent of threatened species with terrestrial biota (vertebrates represented by kākā; and invertebrates by wētāpunga) according to the National Threat Classification System; but this is not reflected by their legal protection (data from Ministry for the Environment; https://data.mfe.govt.nz/tables/).

Authors' Contributions

All authors conceived and substantially developed the idea, including Western science perspectives provided by Rayne, McIntosh, Collier-Robinson, Hollows, Thoms and Steeves; and te Ao Māori perspectives provided by Collier-Robinson, Ramsden, Rupene, Tamati-Elliffe and Thoms. Byrnes, Hollows and Tamati-Elliffe contributed knowledge and text associated with each of the two case studies. Rayne led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

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Consent to Participate

Consent to participate in study is not applicable here.

Data Availability Statement

This manuscript does not include any data.

Conflict of Interest

The authors state no conflict of interest.

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Reimagining conservation translocations through Two-Eyed Seeing

Now more than ever, creative solutions that bring together diverse ways of knowing and seeing the world are needed to restore and enhance biocultural diversity (interwoven biological, cultural and linguistic systems).

Mi'kmaq Elder Dr Albert Marshall describes the Mi'kmaq principle of *Etuaptmumk* or Two-Eyed Seeing as 'learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of Western knowledges and ways of knowing ... and learning to use both these eyes together, for the benefit of all'.

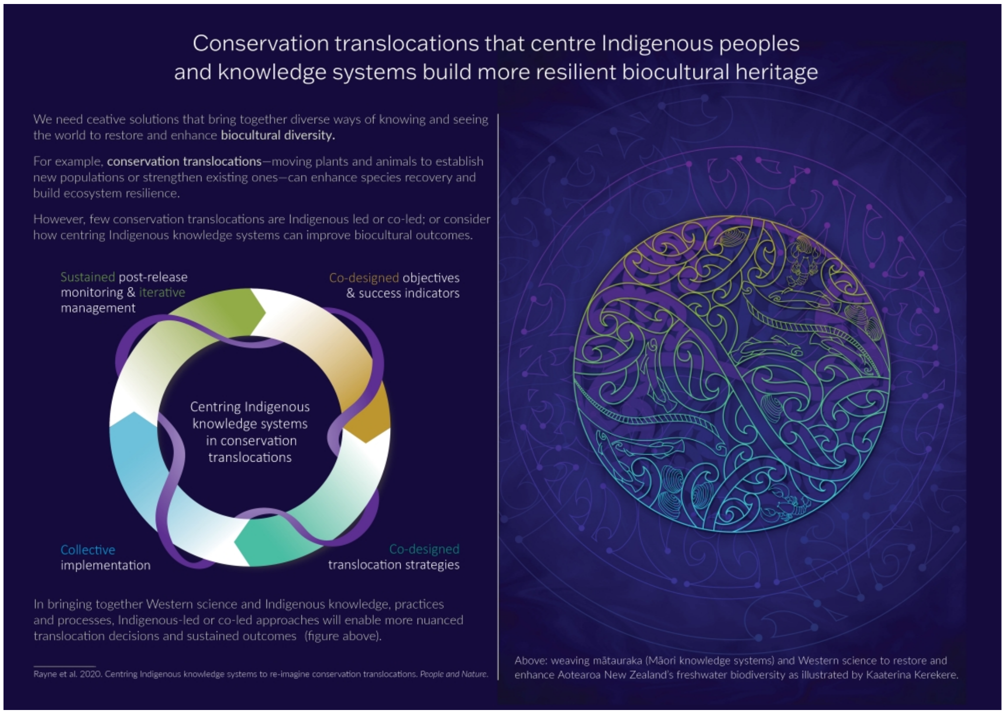
Moving plants and animals to establish new populations or strengthen existing ones ('conservation translocations') can enhance species recovery and build ecosystem resilience. Yet, few studies to date have been led or co-led by Indigenous peoples; or consider how centring Indigenous knowledge systems can lead to better conservation translocation outcomes.

In this Perspective—as Indigenous and non-Indigenous researchers and practitioners working in partnership under Te Tiriti o Waitangi (The Treaty of Waitangi, 1840)—we demonstrate how Two-Eyed Seeing can better inform conservation translocation decisions—such as whether, or how, different populations should be mixed.

We present a new global framework for reimagining conservation translocations by centring Indigenous peoples and knowledge systems; and show how this framework can be readily extended to local contexts. As a case study, we focus on Aotearoa New Zealand's threatened and under-prioritised freshwater biodiversity.

In doing so, we reflect on Māori (Indigenous peoples of Aotearoa New Zealand) led or co-led restoration initiatives: Te Nohoaka o Tukiauau and Tūhaitara Coastal Park. In particular, we highlight the co-development of conservation translocations for culturally significant freshwater species in these wetlands as part of strategies to revitalise biocultural diversity—including customary practices, processes and associated language—for future generations.

In bringing together the strengths of Indigenous and Western ways of knowing through Two-Eyed Seeing, we contend that Indigenous-led or co-led approaches will enable more nuanced conservation translocation decisions and sustained outcomes to ultimately build more resilient biocultural heritage.


Conservation translocations that centre Indigenous peoples and knowledge systems build more resilient biocultural heritage
We need ceative solutions that bring together diverse ways of knowing and seeing the world to restore and enhance biocultural diversity.
For example, conservation translocations—moving plants and animals to establish new populations or strengthen existing ones—can enhance species recovery and build ecosystem resilience.
However, few conservation translocations are Indigenous led or co-led; or consider how centring Indigenous knowledge systems can improve biocultural outcomes.
Sustained post-release monitoring & iterative management
Co-designed objectives & success indicators
Centring Indigenous knowledge systems in conservation translocations
Collective implementation
Co-designed translocation strategies
In bringing together Western science and Indigenous knowledge, practices and processes, Indigenous-led or co-led approaches will enable more nuanced translocation decisions and sustained outcomes (figure above).
Rayne et al. 2020. Centring Indigenous knowledge systems to re-imagine conservation translocations. People and Nature.
Above: weaving mātauraka (Māori knowledge systems) and Western science to restore and enhance Aotearoa New Zealand's freshwater biodiversity as illustrated by Kaaterina Kerekere.