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Halting natural resource depletion: Engaging with economic and political power

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Abstract

Globally, fisheries and forestry have been characterised by substantial ecological and economic problems. Both sectors have become notorious for depleting the stocks on which they depend, eroding the value of harvested natural resources over time and having significant negative 'by-catch' impacts on non-target natural resources. Problems of resource overuse and potential ecosystem collapse inherently derive from poor decisions influenced by those with undue or excessive economic, political and labour market power. Solutions to problems of unsustainability of resource management will need to engage with these economic drivers and beneficiaries, and require strategies including better and more independent assessments of the status and condition of resources. Deep-seated problems caused by resource over-commitment need more robust approaches to resource assessment that (1) better account for uncertainty (including uncertainty resulting from stock losses due to disturbance), (2) avoid ratchet effects and (3) provide appropriate ecological parameters for resource harvest. The United Nations framework for environmental and economic accounting methods can help assess the economic and other contributions of different resource-based industries and inform decisions about trade-offs between competing interests. Finally, there is value in examining successful and unsuccessful industry restructuring, in which decisions to transition away from demonstrably unsustainable resource industries have been made.

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Keywords

Ecosystem collapse, environmental accounting, non-target impact, sustained yield

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Introduction

Industries based on natural resources have long attracted substantial controversy and frequently been socially, environmentally and economically divisive (e.g. Demeritt, 2001; Larkin, 1977; Mansfield, 2011). Two of the most controversial resource-based industries worldwide are forestry and fisheries (Ajani, 2007; Costello et al., 2016; Hanich et al., 2014; Harris, 1998; Yaffee, 1994). Both industries are characterised by the vast literature in the scientific, management, policy and economic domains. Despite existing in markedly different terrestrial versus marine environments, fisheries and forestry often have similar sets of underlying ecological and economic problems. Here, some of the ecological and economic problems common to both forestry and fisheries are outlined. This exposition is followed by some potential solutions, adoption of which will be critical to better ecological and economic management. The perspectives in this article are based largely on experiences in Australia, although there are some international perspectives, including from North America and Asia.

Some cross-sector problems

Resource over-commitment

Fisheries and forestry have long been plagued by resource over-commitment (Demeritt, 2001; Larkin, 1977). In the case of fisheries, a large proportion of stocks globally are heavily over-exploited and poorly managed (Costello et al., 2016; Pauly and MacLean, 2003). Resource over-commitment can manifest in many and varied ways and interact with other problems. Sustained yields of fish or trees are set at levels at which more fish or more trees are harvested per unit time than a given ecosystem is capable of producing without medium- to long-term depletion of the target stock or significant erosion of non-target values (Arnason et al., 2009; Puettmann et al., 2008).

A key factor in resource over-commitment is poor stock assessment that does not account for spatial and temporal variations in productivity. For example, estimates of growth rates of trees are based on inventory plots with inherent bias (e.g. see Marvin et al., 2014). This can include bias towards accessible places that can be more productive than elsewhere in the landscape, leading to over-estimates of the amount of available timber (Lindenmayer and Franklin, 2002). Such uncertainty in stock availability can lead to over-exploitation because, in the absence of reliable information, stock managers become over-optimistic about the resource (Burgman, 2005; Lindenmayer and Burgman, 2005).

A second issue leading to resource over-commitment is that resource allocation often does not make provision for the losses of stock that invariably result from key stochastic events like natural disturbances (e.g. cyclones and extreme temperatures that can kill trees or fish) (Burgman et al., 1994a) or other factors that may not have been anticipated, such as new information on a threatened species that demonstrates a need for increased levels of protection (e.g. see Heinsohn et al., 2015). Failure to account for stochasticity or other factors means that estimates of sustained yield do not have sufficient 'ecological margin' to accommodate these impacts on the stock available for harvesting. As an example, the Mountain Ash forests of Victoria, south-eastern Australia, are fire-prone ecosystems, in which high-severity wildfire is important for natural regeneration (Smith et al., 2013). These ecosystems are also extensively logged for paper and timber production (Flint and Fagg, 2007). Yet, the organisation responsible for scheduling of logging in these forests (VicForests) makes no provision in its estimates of sustained yield for the loss of forest stock due to fire (Forest Industry Taskforce, 2016, personal communication). Major wildfires in 2009 badly damaged more than 52,000 ha of Mountain Ash forest in the Victorian Central Highlands (Burns et al., 2015), but environmental accounting analyses (Keith et al., 2016) indicate that there has been little change in sustained yield allocation since these fires. The maintenance of pre-disturbance rates of cutting leads to an increased harvesting intensity of the reduced area of unburned green forest, essentially committing to overharvesting of the remaining resource (Lindenmayer et al., 2015a). A lack of flexibility in sustained yield in Mountain Ash forests – that was set under the Regional Forest Agreement process almost two decades ago in 1997 (Department of Agriculture and Water Resources, 2016) – has contributed to an unsustainable harvesting regime (Lindenmayer et al., 2015b).

Another driver of the problem of resource over-commitment can be institutional 'gaming' in which the level of stock availability and associated levels of direct employment are deliberately over-stated. This may be to secure the status and influence of a given institution with government or for other reasons, such as leverage in negotiations over access to resources. The autobiography of former Australian Prime Minister Gillard (2014) provides a sobering expose of this kind of problem in the context of bitter arguments over the fate of forests in Tasmania, with conservation, organised labour and industry groups arguing about harvesting of forests which, in reality, could not be logged because potentially available timber simply did not exist. In this case, the relevant organisation, Forestry Tasmania, significantly over-stated the amount of timber and deceived conservation, union and industry groups, as well as State and Federal Governments (Gillard, 2014).

Resource over-commitment leading to stock collapse has been best documented in fisheries and follows a familiar pathway across many different fish stocks. The pathway has eight stages (Talbot, 1993): (Stage 1) A new fishery or a new method of harvesting an existing stock is discovered. (Stage 2) The new resource is rapidly developed with little or no regulation. (Stage 3) Major fishing effort results in over-capitalisation of the equipment used to harvest the resource. (Stage 4) Fishing capacity outstrips the potential of the fishery to sustain harvesting levels. (Stage 5) The fishery is depleted and the level of harvest begins to decline. (Stage 6) Fishing effort is intensified to offset the decline in the harvest. (Stage 7) Intensive fishing effort continues to service investments made on over-capitalised equipment. (Stage 8) The fishery is depleted to levels below which it is uneconomic to harvest or the fishery is fully collapsed. In some cases, attempts to manage the fishery occur in Stages 6 and 7, such as putting in place quotas and economic subsidies or reducing the fishing capacity of the fleets (Talbot, 1993). However, management efforts at Stages 6 and 7 are often belated and ineffective, particularly given uncertainty about the resource, the lack of information on the ecology of the target species and the fact that the industry with vested interests will lobby hard to protect those interests (Talbot, 1993). In addition, subsidies at these stages may mean that a given fishing industry becomes artificially profitable, and fishers remain in the industry and continue to over-invest to obtain a greater share of a dwindling resource (Harris, 1998).

Some forestry industries can be characterised by some similar kinds of stages to those listed above for fisheries, even though it should be easier to gauge the status of forest stocks. For example, native forest harvesting in Australia is a highly capital-intensive industry using heavy machinery that costs a large amount of money to purchase and run (PricewaterhouseCoopers, 2016). Such efficient machinery-based harvesting may not only employ relatively few people (PricewaterhouseCoopers, 2016) but also outstrip the capacity of the available resource to sustain cutting levels (comparable to Stage 4 of fisheries collapse above). In addition, significant amounts of timber and pulpwood need to be harvested and hauled on a continuous and ongoing basis to service the financial repayments for the capital equipment (comparable to Stage 7 above). Moreover, logging may be continued even though it is highly uneconomic to do so (Stage 8 above). For example, in East Gippsland in Victoria, VicForests has admitted in a submission to State Cabinet that logging is not profitable and nor has it been for many years losing USD5.5 millon per annum (after the distribution of corporate overheads) (VicForests, 2013). However, the high levels of subsidy to maintain logging operations were kept secret from taxpayers through the use of commercial-in-confidence submissions to senior politicians in the Cabinet of the Victorian Government.

Reduced value of the kinds of resources harvested over time

Many fisheries and forestry industries undergo a temporal decline in the quality of product that is obtained from harvesting. In fisheries, this is sometimes known as 'fishing down the food chain' (Pauly et al., 1998). When a given fish stock collapses, fishing effort will often be switched to another (less lucrative) species, and the series of stages in the depletion of a new stock (see above) recommences (Talbot, 1993). For example, in eastern Canada and USA, the Spiny Dogfish was a much loathed by-catch in the Atlantic Cod fishery – dubbed the 'cockroach of the sea'. When the Atlantic Cod fishery collapsed, the dogfish was renamed 'Cape Shark', and it too was heavily exploited (Harris, 1998; Kurlansky, 1999). Indeed, catches were not regulated until many years after scientists called for reduction and better regulation of harvesting. Other fish stocks, previously regarded as 'junk fish' and discarded as by-catch (monkfish, flounder and skate) have been targeted and also have been, or are at risk of being, over-fished (Kurlansky, 1999).

Some forestry industries are characterised by a terrestrial equivalent of fishing down the food chain. When a new forest stock is discovered, the highest value trees are those first extracted and rapidly depleted. The almost complete removal of stands of Red Cedar from native forests in New South Wales is an example (Boland et al., 2006; Vader, 2002). Sawlogs from other, less valuable tree species then become the target of harvesting operations. In other forestry examples (and unlike fishing down the food chain), logging may be confined to a given species but the value of the products derived from that one species may decline over time. For instance, many tree species need to be above a certain age to be sawlogs (Burgman et al., 1994b). However, when a sawlog resource is depleted because recurrent cutting cycles are rapid and the interval between logging operations is short, harvesting may then be switched to pulp logs that are the high volume, low-value feedstock for paper manufacturing (Ajani, 2007). Indeed, the volumes of pulpwood that need to be moved to pulp mills can be substantial to ensure that financial payments on

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expensive harvesting machinery can be met (see above). Short cutting cycles mean that the overall age of a forest remains young and few areas can grow old enough to produce sawlogs; the forest industry then becomes a pulp-driven industry (not a sawlog industry as is often claimed) (Ajani, 2007). Finally, if, for example, consumers of paper become concerned about the lack of sustainability of forest management and will not purchase particular products because they remain unapproved under a given certification scheme (e.g. Forest Stewardship Council), harvesting operations may then switch focus to yet other (non-certified) forest products such as low-value wood for biomass burning, with significant implications for carbon emissions (Keith et al., 2014; Macintosh et al., 2015).

'By-catch' or spillover effects

Fisheries and forestry have long been associated with significant by-catch or spillover effects. That is, harvesting has significant impacts on other entities in the ecosystem that is being fished or logged. In the case of fishing, non-target species are often caught and discarded (but then die). By-catch can include not only fish but also other organisms such as seabirds, turtles, dolphins and seals (Løkkeborg, 2011; Robertson, 2000). Other impacts of fishing that could be considered as 'ecological by-catch' include the impacts of 'ghost nets' (abandoned fishing equipment) (Wilcox et al., 2014) and damage to the sea bottom as a result of some kinds of trawling (e.g. Freese et al., 1999). Some seabird populations may never fully recover from depletion as a result of animals taking baited hooks used in longline operations (Løkkeborg, 2011; Robertson, 2000).

'By-catch' effects in forestry include as follows: (1) the direct mortality during logging operations of animals (Tyndale-Biscoe and Smith, 1969) and non-target plants (such as non-merchantable understory trees and ground cover) (Blair et al., 2016; Ough and Murphy, 1996), (2) significant carbon emissions generated by cutting forests (Keith et al., 2014) and (3) impaired water quality and yields from logged catchments (Viggers et al., 2013). Such 'by-catch' effects can persist for prolonged periods after harvesting (Vertessy et al., 2001). For example, water yields from logged catchments can take up to 150 years to recover to levels characteristic of uncut catchments (Vertessy et al., 2001).

Importantly, the economic value of other attributes of ecosystems that are affected by resource harvesting is rarely calculated (Powers, 1998; Puettmann et al., 2008). As an example, the value of water produced from forests and used for human consumption relative to the costs of impaired water yields resulting directly from logging water catchments is rarely considered. Indeed, assessing the relative values of different natural assets can provide critical information for guiding decision making associated with resource management (United Nations, 2012; Vardon et al., 2016). For instance, economic and environmental accounting can make it clear what the relative value-added values of particular industries are in terms of their contribution to GDP and other general (albeit less than perfect) measures of economic performance (Keith et al., 2016). Such comparative calculations are now occurring in the Central Highlands of Victoria where there is a direct price signal on water, in part as a result of the construction of a desalination plant for the city of Melbourne (Viggers et al., 2013). Analyses using the United Nations System of Economic and Environmental Accounting protocols (United Nations, 2012) show that the value-added value of water derived from Melbourne's water catchments in the Central Highlands on a per hectare per year basis is up to 72 times that of the timber and woodpulp generated from the same catchments (USD2033 vs USD29 per ha per year) (Keith et al., 2016). The value-added value of nature-based tourism in the same forests is USD353 per ha per year or approximately 12 times that of timber and pulpwood (Keith et al., 2016). In both cases, employment levels in the water and tourism industries far outstrip direct levels of employment in the native forest logging industry (Keith et al., 2016; PricewaterhouseCoopers, 2016).

Risks of ecosystem collapse associated with overharvesting

Marine and forest ecosystems subject to intense resource extraction are at risk of ecosystem collapse (Kirby, 2004; Valiente-Banuet and Verdu, 2013; reviewed by Lindenmayer et al., 2016). The major changes in animal communities and ecosystem structure following overharvesting of Atlantic Cod stocks are well documented (Harris, 1998; Myers et al., 1997), including the recently quantified collapse of cod stocks in the Gulf of Maine fishery (Pershing et al., 2016). There are many parallels in forest ecosystems (Lindenmayer et al., 2016). For example, recurrent logging, coupled with altered fire regimes, is threatening the persistence of tropical rainforest in parts of south-east Asia (Van Nieuwstadt et al., 2001) and boreal forest in northern Canada (Payette and Delwaide, 2003). Analyses by Burns et al. (2015) indicate that Mountain Ash forests in Victoria are susceptible to collapse as a consequence of widespread clear-cutting, recurrent fire and post-fire (salvage) logging. These forests are now classified as critically endangered under the ecosystem assessment protocol developed by the International Union for the Conservation of Nature (IUCN) (Burns et al., 2015). The great pine forests of northern America are thought to be vulnerable to collapse as a result of the recent crossing of the Rocky Mountains in Canada by the Mountain pine beetle epidemic that has ravaged the Lodgepole Pine forest of British Columbia (Lindenmayer et al., 2016). This epidemic is now threatening all pine species in the rest of Canada (Cullingham et al., 2011). This new threat is believed to have been the direct result of more than 60 years of forestry practices that have targeted Lodgepole Pine and recent climate warming that has increased the survival of pine beetles in winter (Raffa et al., 2008).

Some cross-sector solutions

Better management of fisheries and forestry industries can undoubtedly have major positive environmental and economic benefits. For example, Costello et al. (2016) suggest that better fisheries management would not only assist the recovery of more than 90% of currently depleted fish stocks but also significantly boost profits generated from harvesting those stocks. Indeed, Arnason et al. (2009) estimate that there is USD50 billion of economic benefits lost annually as a result of poor fishing practices and overfishing.

Effective ways of tackling the many problems inherent in the fishing and forestry industries have long exercised the minds of scientists, economists, resource managers and policy makers. The author of this article is not so deluded as to consider that a short treatise such as this one will succeed where veritable mountains of past articles and recommendations have failed. Nevertheless, the following commentary provides some possible (part) solutions to some problems that plague fishing and forestry, but they are far from a panacea and will not likely resolve all economic and ecological problems in either or both sectors.

Better and more transparent stock assessment with greater flexibility and environmental margin in sustained yield

Arguably one of the most important ways to better manage fisheries and forestry industries is to conduct more robust and realistic stock assessments. This must include quantification of levels of uncertainty in the size and spatial and temporal variability in stocks (Hanich et al., 2014). This is crucial as it has long been recognised that over-commitment of resources lies at the heart of unsustainable harvesting practices that ultimately become uneconomic harvesting practices (Demeritt, 2001; Pauly and MacLean, 2003; Puettmann et al., 2008; Talbot, 1993).

A further (and critical) part of transparent stock assessment must be for management agencies, policy makers and other industry lobby groups to dispense with the concept of maximum sustained yield in fisheries (Rosenberg, 2003) and its equivalent – the regulated forest – in forestry (Lindenmayer and Franklin, 2002). Maximum sustainable yield is the amount of a renewable natural resource that can be taken while ensuring the indefinite availability of that resource. Optimum catch, later called maximum sustainable yield, was estimated for a Scandinavian fishery in the early 1930s (Rosenberg et al., 1993). The underlying ecological principle of the optimum catch concept is density-dependent population growth. As a population is reduced by harvesting, per capita net population growth increases, until the point is reached at which the population cannot compensate for additional mortality caused by harvesting. The harvesting rate that equals net population growth will, in theory, provide the maximum yield in perpetuity. Calculations in fisheries management that rely on catch per unit effort are based on density-dependent compensation in a growing population. Total catch and catch per unit effort increase, up until a point where population growth balances harvesting effort. If the number of fishing boats reflects harvesting effort, the catch per boat can be measured. Boats can be added until the catch per unit effort plateaus, at which point a fishery will be running at maximum efficiency, without compromising future returns from the resource.

The term ‘sustainable forestry’ dates back to at least 1713 in Germany, when von Carlowitz discussed issues of sustainable wood production for the local timber industry in an early textbook on forestry (Schuler, 1998). Similar developments occurred in France in the 1660s (Brown, 1883). Faustmann (1849, cited by Ludwig, 1993) used the concept of sustainable forestry to calculate a forest rotation period that would maximise economic benefits. The ‘regulated’ forest or ‘normal’ forest has long been a focus of forest management (Davis et al., 2001; Oliver and Larson, 1996). In the simple case of a single commercial tree species, uniform site conditions and a single silvicultural system, the prescription can be reduced to (after Davis et al., 2001):

$$\frac{\text{Total area}}{\text{rotation age}} = \text{area in each age class}$$

resulting in roughly equal areas in each age class. This management strategy led to maximum economic benefit and output of forest products that could theoretically sustain over time (e.g. Leuschner, 1990). The ultimate objective was the perpetual, even flow of wood products for an industry (Lindenmayer and Franklin, 2002).

The major problem with the maximum sustainable yield concept in fisheries and the regulated forest concept in forestry is that both ignore uncertainty. Uncertainty may arise from measurement error, natural variation that affects the distribution and abundance of the resource or a lack of understanding of the ecology of the species. Such considerations are further complicated by uncertainties in the volumes and values of products of different kinds. For example, a fixed return per unit effort from a fixed number of fishing boats will never be achievable, simply because fish populations fluctuate naturally and fishing success is inherently variable (Larkin, 1977; Rosenberg, 2003). In forests, if disturbances and unpredictable environmental variation such as wildfires, diseases and random variation in juvenile survival are not accounted for in forecasts, it is likely that the resource will be over-exploited. In an Australian forestry context, it is unrealistic to expect managed natural forest to have a balanced distribution of size and quality classes producing an even flow of different forest products. This is because in Australia and in many other places in the world, fires are virtually certain within the rotation times of most forest types (McCarthy et al., 1999).

An alternative to the maximum sustainable yield and the regulated forest strategies is to track the availability of the resource through time. For example, fisheries managers may regulate the harvest of a fixed proportion of the population, rather than a fixed number of fish, or harvest only when the population exceeds a specified size.

A fundamentally important aspect of better managing fisheries and forestry industries must be to avoid the ratchet effect (*sensu* Ludwig, 1993), which typically characterises industries that exploit irregular or fluctuating natural resources. Ludwig (1993) suggested that because many of the utilitarian values of natural systems are limited, a conflict between human objectives and conservation of resources is inevitable, unless human use rates are also limited. During periods of relatively stable environmental conditions and with few changes in technology, harvesting rates tend to stabilise at positions determined by bio-economic systems that presume a steady state. A sequence of good years may encourage investment in infrastructure and capital. In sequences of poor years, an industry will appeal to government or the general population for help, as investments and jobs are at stake. The appeals then elicit direct or indirect subsidies. The ratchet effect is caused by the lack of inhibition in economic investment during good periods and strong pressure not to disinvest during poor periods. The long-term outcome is a heavily subsidised industry that over-harvests the biological resource on which it depends (Talbot, 1993). Thus, enhanced stock assessment is also critical for guiding appropriate levels of economic investment in a given industry, in part because over-investment can be one of the underlying drivers of overharvesting. The results of stock assessment (and the data and modelling which underpin such assessments) need to be made available to all stakeholders to increase the level of transparency in decision making. This has often not been the case – the opaque stock assessments of Atlantic Cod by the Canadian Department of Fisheries and Oceans is a clear case of a lack of transparency in stock assessment (Harris, 1998). In an Australian fisheries context, data on fisheries management strategies in

NSW, including catch reporting, are up to 10 years out of date (Hanich et al., 2014). A comparable case from the forestry sector is the example of deceptive stock assessment and reporting by Forestry Tasmania in debates over timber availability in that State (Gillard, 2014).

An important additional issue associated with enhanced stock assessment must be to ensure more conservative levels of harvest in a given resource-based industry with sufficient 'ecological margins' that can accommodate events and 'shocks', such as major disturbances, new scientific information and other factors. There are useful examples of where this is done very effectively, such as the kangaroo harvesting industry. In that case, harvest levels are set each year based on detailed aerial survey data (that accommodates uncertainty in population estimates), information on climate conditions such as rainfall in the preceding years (which affects reproduction) and simulation modelling of animal life history and associated population dynamics. The annual harvest quota is then set well under a possible maximum sustained yield and the actual cull is yet further under the quota (Department of the Environment, 2016b; Lindenmayer and Burgman, 2005). In the context of forestry resources, simulation models and other related approaches can be used to predict how much of a given resource is likely to be lost to disturbances and should therefore not be included in estimates of sustained yield to ensure that overharvesting does not occur. For example, in the wet forests of south-eastern Australia, simulation modelling suggests that 45% of the forest estate will be damaged by wildfire over a nominal rotation time of 80 years and hence should not be included as available timber stock for logging (M McCarthy, personal communication, 2016).

A further part of stock assessment must include a formal assessment of the risk of ecosystem collapse (Burns et al., 2015), either as a direct result of harvesting or the interaction of harvesting with other factors, such as climate change, invasions of exotic species, fire or disease. The IUCN recently developed a formal protocol for assessing the status of ecosystems (see Keith et al., 2013), which has similarities to the long-standing approach to assessing the conservation status of individual species (e.g. as critically endangered, endangered and vulnerable of least conservation concern).

Finally, better understanding of fish and forest stocks demands that they are better monitored, including mapping of where particular stocks occur and in what condition. Such assessments and associated statistically based mapping of stock and forest condition in the USA in the 1920s were critical to triggering the recognition of overharvesting and strengthened conservation strategies (Demeritt, 2001). The appalling past record of resource monitoring (Lindenmayer and Likens, 2010) needs to be rectified if better stock management is to occur, both in fisheries and in forestry. Monitoring must be conducted by independent parties and the resulting datasets made widely available (Pielke, 2007).

Better mitigate of by-catch or spillover effects

The non-target impact of forestry and fisheries is an issue of increasing concern to many people. A raft of approaches attempt to limit these impacts, such as taxes on products derived from fisheries and harvested forests, codes of practice and harvesting prescriptions, and independent (third party) certification of products derived from fisheries and forestry industries (e.g. the Marine Stewardship Council and Forest Stewardship Council certification schemes). Credible industry responses to, and the adoption of recommendations from, scientific work on non-target effects is a critical part of obtaining and maintaining a social licence to continue harvesting. For example, analyses indicate that the by-catch of seabirds can be dramatically reduced in the longline fishery through the adoption of appropriate practices, such as setting lines at night (Løkkeborg, 2011). Similarly, some of the negative impacts of forest harvesting can be mitigated through the adoption of more environmentally sensitive logging regimes (Gustafsson et al., 2012). Economic analyses can be important in these cases. In a recent example, the costs of recommended management strategies to conserve the critically endangered Leadbeater's Possum in the wet ash forests of Victoria were found to exceed that value-added value of the native forest industry based on those same forests (Department of the Environment, 2016a).

Tackling issues of economic and political power

Fisheries and forestry share the common issue that key policy and management decisions about the amount, type and location of harvesting are heavily influenced by people and institutions with economic power and vested interests (Ajani, 2007; Harris, 1998; Puettmann et al., 2008). The management of both resources is also driven by historical norms and decisions made in the past that have placed particular individuals, some representatives of organised labour (e.g. unions such as the Construction, Forestry, Mining and Energy Union in Victoria), professional organisations (e.g. Institute of Foresters of Australia), certain government agencies, and particular companies in a position of power (Ajani, 2007; Harris, 1998). As an example from the wet forests of Victoria, former Premier Jeff Kennett would not sign the Regional Forest Agreement for the Central Highlands region if it affected the flow of pulpwood to the paper manufacturer Australian Paper (Premier of Victoria, 1995). Archival documents show that the letter signalling the premier's intention was preceded by correspondence from the paper manufacturer demanding long-term access to public forests for pre-set volumes of low-cost pulpwood (Schultz, 1980). This correspondence was brokered by high-level operatives in the Victorian Government who recommended that the forest industry be guaranteed resource access, with government agencies thereby acting as an arm of industry (Love, 1995).

Everyone protects their interests, but those with power have the ability to enact or resist change to further their own positions. Economic and political power is the fundamental driver of most of the problems discussed in this article, and any solution or set of solutions will fall short unless it engages with these economic drivers and beneficiaries. For example, the suggestion in the preceding section for improved transparency in stock assessments can only be achieved if the sources of economic and political interest are made clear and are widely recognised (Pielke, 2007). This should include a transparent presentation of the levels of direct and indirect subsidies that are used to maintain a given resource-based industry. Any audit of resource availability and assessment of the extent of industry subsidies need to be performed by independent people or organisations who are not paid by the industry or unions, nor from professional bodies and government agencies with vested interests. A useful illustration of this approach comes from the forests in Tasmania in which a wood flow modeller, independent from the forest industry and government, was engaged to assess the future availability of timber and pulpwood in that State. This was documented in a biography of the former Australian Prime Minister (Gillard, 2014), and it revealed that there was significantly less available timber than initially proposed by the relevant State Government agency. Similar approaches have been successfully applied overseas. A prominent example is the implementation of the Northwest Forest Plan in the Pacific northwest of the USA, in which an independent panel of experts fully assessed the scientific basis for best practice forest management of the extensive areas of Douglas Fir forests in the States of Washington and Oregon (Stankey et al., 2003).

Another way to engage with those with political and economic power is to employ, as discussed above, economic and environmental accounting techniques to reconcile the value-added values of different (and often competing) resource-based industries to determine their relative contributions to GDP at regional, State and/or National scales (Vardon et al., 2016). This includes levels of actual employment relative to those claimed by particular industries (e.g. see Keith et al., 2016; PricewaterhouseCoopers, 2016). Such accounting procedures make clear the economic benefit that can be generated from natural resources, including publicly owned natural resources, such as public native forest and oceans supporting fish stocks. Environmental and economic accounting can also facilitate trade-offs and impacts on employment and economic activity as a consequence of different decisions on resource use. An application of economic and environmental accounting (*sensu* United Nations, 2012) in the context of the contested wet forests of the Central Highlands of Victoria was described above (see also Keith et al., 2016). Such an accounting approach could be expanded to fully access the value-added values of different kinds of products that are generated from a given industry, such as the value-added value of a sawlog-based industry relative to that based on pulpwood and paper manufacturing or biomass burning. Importantly, an environmental and economic accounting approach also allows a de facto form of stock assessment as it is dependent on appraising the extent and condition of different kinds of natural assets (e.g. forests) in a given area. In the case of the wet forests of the Central Highlands of Victoria, the formulation of the environmental and economic accounts revealed that there was very limited sawlog resource remaining within the study area (Keith et al., 2016), thereby suggesting a bleak prognosis for the native forest timber industry and the associated levels of profitably and employment associated with that industry (see also PricewaterhouseCoopers, 2016).

A final approach to dealing with excessive or undue influence in resource management is to conduct independent work based on scenario planning (Peterson et al., 2003), in which the ecological, economic and employment implications of particular resource management regimes and associated decisions are projected. This can be important because the effects of resource overuse-triggered ecosystem collapse can be catastrophic not only for biotic communities but also for human communities (Biggs et al., 2009; Walker and Salt, 2012), with far better prospects for industry transition and associated sustained employment if proactive decisions for industry restructuring are made well before problems with resource overharvesting become severe (Harris, 1998; Talbot, 1993).

Better learning in industry restructuring

Fisheries and forestry industries are often the targets of interventions that attempt to restructure them in ways that make them more ecologically sustainable and/or economically viable. Such efforts are often fraught and many have failed, sometimes spectacularly. There is a myriad of reasons for such a poor track record, but they include ill-conceived government intervention that overlooks the science on the extent of resource decline, 'solutions' mis-matched to the problem (e.g. construction of fish processing factories despite there being few fish (see Harris, 1998)), and 'gaming' of recovery efforts such as payouts for participants to exit an industry only to return very soon after (e.g. through using a different company name or other identity (Ajani, 2007)).

It is imperative to document failures in industry restructuring to prevent them from recurring. Indeed, in life sciences (including resource management), more is often learnt from past mistakes than successes (Redford and Taber, 2000). Conversely, there are also some notable successful examples of industry restructuring such as the decisive action by the Norwegian Government to restructure the Cod industry in that nation (see Harris, 1998). These successful interventions need to be used as exemplars to guide other cases where industry restructuring is proposed. The reasons for success also need to be documented, such as the use of permits, rigorous monitoring and stock assessment, mitigation of non-target (by-catch) impacts, and the provision of social licence to operate through independent third-party certification and other factors.

Another key aspect of industry restructuring must be to carefully examine and then document the social and economic outcomes that characterise cases where restructuring has occurred. Powers (1998) has done this in a series of case studies in various terrestrial landscapes in the USA. The study highlights problems in attempting to maintain employment levels in unsustainable resource extraction industries. Interestingly, the book documents how a transition to non-extractive industries based on natural landscapes can often create more robust regional economic conditions characterised by more, longer-lasting and better paid jobs (Powers, 1998). There are numerous other examples of successful economic and environmental transitions away from extractive industries to other kinds of nature-based industries. One of many cases is the replacement of the native forest timber industry in the Otway Ranges of south-western Victoria with tourism infrastructure and subsequent rejuvenation of the economy of that region.

Concluding comments

Fisheries and forestry obviously operate in markedly different environments, but they are characterised by striking similarities in terms of the problems that have undermined their ecological and economic sustainability. Similarly, there are some common ways to tackle at least some of these problems. Problems of resource overuse and potential ecosystem collapse are inherently the ones that are derived from poor decisions that have been influenced by those economic, political and labour market power. Solutions to these problems will involve a range of strategies including better assessing and then more widely communicating the status and condition of a given resource. In particular, deep-seated problems through resource over-commitment using flawed approaches like maximum sustained yield and the regulated forest model need to be replaced with more robust approaches to resource assessment that better account for uncertainty (including uncertainty resulting from stock losses due to disturbance) and provide an appropriate ecological margin (or safe operating space) within which to harvest that resource. In addition, methods such as the United Nations framework for environmental and economic accounting can help assess the economic and other contributions of different resource-based industries and inform decisions about trade-offs between competing interests. Finally, there is considerable value in better assessing successful and unsuccessful industry restructuring, in which decisions to transition away from unsustainable resource exploitation industries have been made.

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