

# Chapter 2

## Defining and Identifying Cumulative Environmental, Health, and Community Impacts

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### 2.1 Introduction

Cumulative change to the environment is not a new or unfamiliar concept. From governments to concerned citizens, there is a broad appreciation of the singular and cumulative impacts of economic development. These impacts influence the intangible and abstract elements of the natural world such as biodiversity and ecosystem health as well as those components of the environment that directly affect human health and the ability of communities to meet the socioeconomic needs and aspirations of their citizens. Indeed, cumulative impacts are recognised internationally as an outcome of development that must be planned for, regulated, and, when necessary, mitigated (Dixon and Montz 1995; Samarakoon and Rowan 2008; Zhu and Ru 2008; Retief et al. 2009; Sinclair et al. 2009; Wärnäck and Hilding-Rydevik 2009; Kinnear et al. 2013).

In Canada, formal acknowledgement of cumulative impacts can be traced back more than three decades to the initial policy work of the Canadian Environmental Assessment Research Council (Peterson et al. 1987). In 1995, the importance of cumulative effects was recognised and entrenched in legislation when the *Canadian Environmental Assessment Act* (Government of Canada 2012) came into force and required their consideration within all EAs. Subsequent guidance and policy statements (FEARO 1994; Hegmann et al. 1999; CEAA 2013) as well as reviews of the methods and practice of cumulative effects assessment (CEA; Duinker et al. 2012) have advanced the science behind and application of the *Canadian Environmental Assessment Act* as well as non-legislative processes designed to address cumulative impacts in ways that are not directly associated with project approval (Harriman and Noble 2008).

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Despite a long history of practice in Canada and even more extensive experience within other jurisdictions (e.g. the USA; see Kenna 2011), there has been considerable criticism of the processes for addressing cumulative impacts (Ross 1998; Noble 2004, 2009; Duinker and Greig 2006; Gunn and Noble 2011). This was well articulated by Duinker et al. (2012, p. 50) in their comprehensive review of the scientific elements and practice of CEA:

If we do not engage in competent CEA, then the degree to which our activities jeopardize the sustainability of valued ecosystem components will be unknown. Judging that to be an undesirable situation, we conclude that improvements in CEA practice are desperately needed.

The repeated call for improvement in CEA arises from the complexity of defining cumulative impacts. From one perspective, this is an intuitive, easily explained concept that is visibly obvious to most people who live near any of Canada's natural resource industries, or who have an interest in public policy. From a different perspective, that of the industries or governments that are being forced to address cumulative impacts—because of a regulatory response, broad concern about sustainability, land-use conflicts, or control of the use and benefits of natural resources—the problem appears intractable and solutions are elusive. This difficulty arises from our inability to properly quantify impacts or even qualitatively describe the range and scale of the cumulative effects that produce those impacts. The imprecision and uncertainty in identifying cumulative impacts is exacerbated by a decision-making structure, including aspects related to mitigation, that is biased toward socioeconomic benefits (Johnson 2013).

Much of the criticism of current practice is directed at regulatory structures, such as the *Canadian Environmental Assessment Act* (Government of Canada 2012), that are designed to accommodate single proponents and assess individual projects on a site-by-site basis (see Vignette 6.8). Cumulative impacts result from multiple projects that span diverse resource sectors and the impacts can occur regionally over long time periods. Thus, the true cumulative impacts from any one project are difficult for a proponent or even a regulatory agency to consider. Likewise, the calls from some parties to simply limit or identify thresholds for cumulative impacts resulting from many projects are unrealistic given the current focus on economic development and the limitations of EA legislation (AXYS Environmental Consulting 2001; Kennett 2006; Hunter et al. 2009). This is not to say that thresholds are unimportant; an ecosystem that crosses a threshold may begin to degrade rapidly. The problem lies in how to integrate the threshold concept with EA (Johnson 2013).

There has been some work to develop innovative solutions that would be capable of addressing cumulative impacts (Gunn 2009; Gunn et al. 2011). Broad-scale application and testing of these approaches is urgently needed because the cumulative impacts from development are threatening Canada's natural heritage (Fig. 2.1). Nitschke (2008), for example, studied the impacts of 35 years of development across a 410,000-ha area of northeastern BC. He reported changes in the age and structure of forested ecosystems that led to shifts in biodiversity that were not only additive relative to landscape change but also synergistic. Nellemann et al. (2003), Johnson et al. (2005), Boulanger et al. (2012), and Wilson et al. (2012) reported a



**Fig. 2.1** A Landsat Thematic Mapper satellite image (1:100,000 scale) illustrates the cumulative effects (i.e. *nibbling loss*) of forest harvesting, road construction, and petroleum exploration and development across an area of central Alberta (Landsat imagery courtesy of the U.S. Geological Survey). These activities will have both positive (e.g. economic development) and negative (e.g. loss and fragmentation of habitat for species that depend on old-growth forests) impacts for the region

large decline in past or predicted future habitat for caribou and reindeer caused by industrial development that is occurring across the central Arctic. These subspecies have high subsistence and cultural value for Canadians, and particularly for Aboriginal communities. Squires et al. (2010), working in the Athabasca River Basin of central Alberta, reported significant cumulative impacts caused by a range of land-use types, including pulp mill effluent, human population growth, agriculture, and oil sands operations. They found significant decreases in water volume and quality (e.g. concentrations of phosphorus, nitrogen, and sulphate) when comparing the most recent data with data from the previous 20 years. Such changes to the natural environment, including the accelerating development of resources, are having real impacts on the health of citizens and the long-term sustainability of communities (Barth 2013; Jeffery et al. 2013; Kinnear et al. 2013; see Vignette 6.7).

The cumulative impacts of human development are now becoming obvious (Fig. 2.1), and policy makers and natural resource professionals are working to develop effective solutions. However, progress in developing better methods for conducting CEA as well as in the planning, policy, and legislation required to address impacts is occurring against a backdrop of increasing industrial activity. In BC, energy development is intensifying in both scope and magnitude. This includes major expansion in the development of coal deposits, petroleum resources, wind energy, and both large- and small-scale hydroelectric facilities (see Box 3.1). An interprovincial committee recently announced a doubling in the known reserves of natural gas, potentially providing a 150-year supply for both domestic use and export (NEB et al. 2013). There are expressions of interest to construct more than five natural gas and two heavy oil pipelines and associated export facilities across coastal BC. The creation of a Ministry of Natural Gas Development in 2013 shows that the province of BC is fully embracing these opportunities as a path to future prosperity. Such twenty-first century developments will occur across landscapes that have a long history of existing and past impacts from forestry, agriculture, mining, and oil and natural gas.

The direct and indirect cumulative impacts of past and present developments have raised concerns among both governments and environmental advocates. More urgent, however, is the requirement to identify the type, rate, and extent of future developments that will not compromise the resilience of ecosystems, nor will compromise the sustainability of communities. As has been witnessed in other jurisdictions, the options for changing the pace of human development decrease over time because of regulatory and tenure inertia and the evolution of a status quo mentality (Timoney and Lee 2001; Aumann et al. 2007). Decisions on land use are a function of the wants of citizens, but are also influenced by market conditions and the transfer of rights to the land in the form of tenures and licences. The window of opportunity for land-use decision making is closing for jurisdictions that are currently developing their natural resources to meet growing global demand. Clearly, there is an urgent need to identify effective methods for understanding and quantifying past and potential future impacts, and then implementing processes for conducting balanced, multi-value decision making.



In this chapter, I explore the fundamental concepts underlying CEA and the range of potential approaches capable of addressing impacts. First, I describe cumulative effects and then differentiate them from cumulative impacts. I continue with a discussion of the rate of development of natural resources in Canada and the relationship between development and the emerging crisis of cumulative impacts. The chapter ends with a review of current methods and approaches for assessing the magnitude and extent of these impacts. This includes current EA legislation and more progressive ideas focused on holistic cumulative effects assessment and management frameworks.

## 2.2 Defining *Cumulative*

The definition of *cumulative* is key to not only understanding and quantifying the scope and magnitude of changes but also developing collaborative frameworks to address the resulting consequences. Although this is an intuitive concept, regulatory agencies, practitioners, and academics have provided multiple definitions of *cumulative impacts* and its consequences (see Duinker et al. 2012 for a review). Common definitions that are quoted from the regulatory processes applied in Canada include:

...any cumulative environmental effects that are likely to result from the designated project in combination with other physical activities that have been or will be carried out. (*Canadian Environmental Assessment Act* (Government of Canada 2012), Section 19(1)(a))

Cumulative effects are changes to the environment that are caused by an action in combination with other past, present and future human actions. (Hegmann et al. 1999, p. 3)

These definitions provide a simple, but limited description of how changes accumulate. In particular, they support the common misperception that *cumulative* means *additive*, and that it results from multiple adjacent or overlapping projects. Although the *death by a thousand cuts* metaphor seems appropriate in this context, cumulative processes are much more complex in reality. Effects that originate within one project or across multiple projects may interact or result in nonlinear net consequences that are a product of time-lags or threshold responses. Consistent with the ideas of Ross (1998) and of Harriman and Noble (2008), we suggest a more inclusive definition that considers a fuller range of changes and their consequences:

*Cumulative* refers to the synergistic, interactive, or unpredictable outcomes of multiple land-use practices or development projects that aggregate over time and space, and that result in significant consequences for people and the environment.

We argue that the definition should consider not only healthy environments but also healthy communities and societies, with the concept of *health* including socio-economic resilience and self-determination (Parlee et al. 2012). Although human health and socioeconomic well-being depend on naturally functioning and resilient ecosystems, it is necessary to explicitly recognise these human dimensions of the environment.

### 2.2.1 *Differentiating Between Effects and Impacts*

For the discussions in this book, we have differentiated between the terms *effect* and *impact*: an effect is a change to the environment (including its human components) and an impact represents the consequences of such changes (Wärnbäck and Hilding-Rydevik 2009). Thus, one might quantify the cumulative effects of some set of development activities as the amount of forest that is converted to an early-successional plant and animal community or the increase in the density of linear features in a landscape. The assessment of impacts will depend on how a landscape is perceived as being changed in the short term and the long term by development such as the creation of roads, seismic lines, well pads, mine sites, or clearcuts.

As is the case for effects, impacts are context-specific. During a CEA, one would not aim to identify and quantify all changes to the environment, human health, or communities. Instead, a series of important environmental attributes or values would be identified and the change in those values might be related to the total effect or some subset of the measured effects. Whether a change is positive or negative depends on the values that have been defined, and the impacts (consequences) of changes in the values. Thus, differentiating effects from impacts allows one to identify both positive and negative impacts of cumulative effects. If we consider, for example, the environment, forest harvesting will have an aggregate effect on the amount of old forest. Early-successional forest types might result in a greater number of moose, a species sought after by Aboriginal, recreational, and guided hunters. This would be a positive impact. Likewise, a higher density of moose associated with these forest types might result in a greater number of predators, which would ultimately result in the decline of woodland caribou (see Box 3.2), a conservation species that is currently receiving provincial and federal protection (Serrouya et al. 2011). Similarly, resource development in a town or region might bring employment and higher wages to residents as well as tax revenues for municipal and provincial governments. The negative impacts might include higher housing costs and civil services that can no longer meet the demand of an increasing and potentially transient population (see Chap. 4). For both examples, decision-makers will need to consider the positive and negative impacts of a single development activity or a set of activities.

### 2.2.2 *Relating Effects to Impacts*

Many EAs are structured according to pathways that link the cause, or effect, and the resulting impact, as defined by some set of valued components (VCs; BC EAO 2011) or valued ecosystem components (VECs; Noble 2010). For the province of BC, a VC is a part of the human or natural environment with ecological, economic, social, cultural, or health importance to a proponent, government, or the public, and that must be recognised and maintained through the EA process. Within the federal assessment process in Canada, a VEC represents a biotic or abiotic component of an ecosystem that has scientific, social, cultural, economic, historical, archaeological,

or aesthetic importance. This model requires one to identify the source of an effect and the resulting functional pathway that represents the type of impact or impacts originating from that source. Pathways from multiple sources would reveal an additive or more complex relationship (e.g. interactive, nonlinear) that defines the cumulative impact for the VC or VEC of interest.

Pathways can be useful for defining the mechanistic relationship between sources of effects and the resulting impacts, particularly when describing how these cumulative impacts occur. For the natural resource sector, the most often cited cause of cumulative impacts is what is termed the *nibbling loss*. As the name suggests, this is the additive loss of habitat or some other VC resulting from a cumulative increase in the footprint of human development (Hegmann et al. 1999; Fig. 2.1). *Growth-inducing* effects are more complex to quantify and predict. Here, new development can result in an infrastructure that supports other development that may greatly exceed the cumulative impacts of the first project (Fig. 2.2). Growth-inducing projects include major roads that provide access to new areas or power infrastructure



**Fig. 2.2** The 287 kV Northwest Transmission Line, under construction in this image, will stretch 344 km across an undeveloped but mineral-rich region of northwestern BC (Photo by C. Johnson). The transmission line will provide electricity to planned and future mines as well as an interconnection point for run-of-river hydroelectric development. The right-of-way and associated infrastructure (effects) will have direct impacts on biodiversity and other values. More complex, however, are the indirect economic growth-inducing effects resulting from the provision of inexpensive electricity to large industrial projects. The positive and negative impacts of future resource development will greatly exceed the impacts of the transmission line; however, those impacts are difficult to predict and consider during project assessment and approval

that facilitates energy-dependent industrial activities such as mining. Many projects implemented in a small area over a short time can result in impacts related to a *crowding effect* (Fig. 2.1). The environment may be resilient against some level of activity, but if that level is reached during a too-short period of time, the activity could exceed an ecological or societal threshold for a particular VC. As an example, a body of water may absorb some level of a nutrient or pollutant until a threshold is reached and the water is no longer potable or suitable for a valued population of fish. Similarly, forested landscapes can accommodate some logging, especially when harvest levels and patch sizes are consistent with the natural disturbance regime for that ecosystem (DeLong 2007). However, harvesting beyond that natural regime will fundamentally alter the age-class distribution and size of forest patches in the landscape, creating impacts for plants and animals that depend on these characteristics of the landscape.

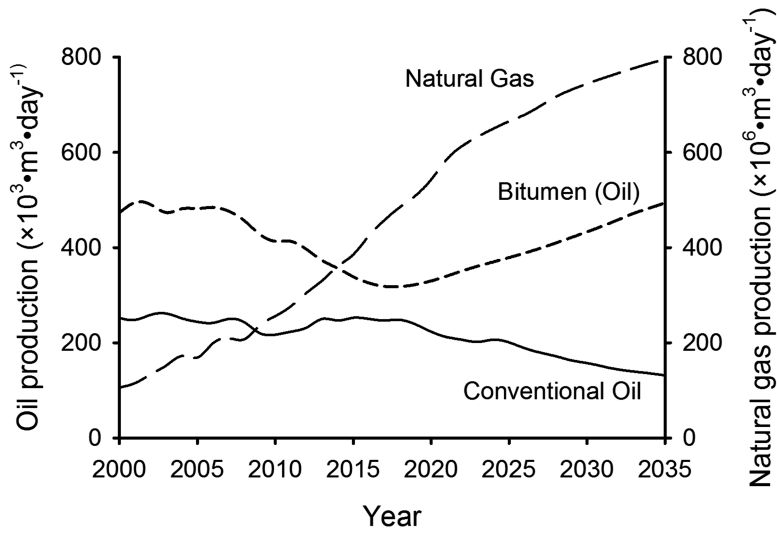
### **2.3 The Need to Address Cumulative Impacts: An Emerging Issue**

There are considerable challenges in assessing past and current cumulative effects and finding solutions to mitigate their impacts, including the restoration of damaged ecosystems (Duinker et al. 2012). Given projected rates of natural resource development, those challenges cannot be neglected. Not only is the accurate prediction of future impacts difficult, preventing the planning of responses, but there has been very little effort on the part of governments to correct ineffective legislative frameworks. If the expected high rates of development are realised, we are quickly approaching a cumulative impacts crisis.

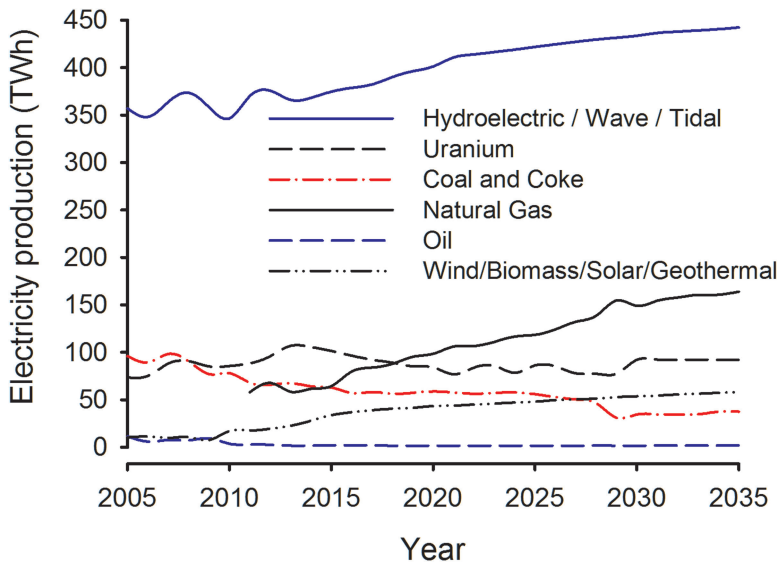
Canada's economic history was defined by the development and export of natural resources, from beaver pelts to masts for sailing ships. The global economy and government policy ensure that Canada's history continues to determine the country's future, albeit with some diversification. Globally, Canada is ranked fourth in the export of electricity, sixth in crude oil production (third in reserves), fifth in natural gas exports, and ninth in CO<sub>2</sub> emissions from energy consumption (CIA 2013). New technologies and practices, combined with expanding export markets, suggest that the development of hydrocarbons will not decrease in the future, but rather will increase. The National Energy Board projects a 75 % increase in Canadian oil production by 2035. In situ oil sands will account for the majority of the new production (*bitumen*; NEB et al. 2013; Fig. 2.3).

Over the same period, the production of natural gas will increase by 25 %—but these are mainly nonconventional sources consisting of tight gas. This gas occurs in rock with low permeability in which extraction requires hydraulic fracturing (fracking) of the rock–gas matrix. Electricity generation is predicted to increase by 27 % (NEB 2013; Fig. 2.4).





**Fig. 2.3** Projected development of oil and natural gas reserves in Canada (data from NEB et al. 2013)



**Fig. 2.4** Projected production of electricity in Canada, by source (data from NEB 2013)

The impacts of individual energy development activities on a given site, such as installation of a pumping station, well, or seismic line, are potentially large, but typically occur over a small area. Of more concern is how the rapid development of conventional and renewable energy resources has the potential to fragment landscapes across extremely large areas, creating impacts for threatened or rare plant

and animal species as well as for human communities (Dana et al. 2009; Naugle 2011). McDonald et al. (2009) predicted that the cumulative impacts of future energy development (2009–2030) in the USA would affect more than 20.6 million ha. Across western North America (including BC and Alberta), Copeland et al. (2011) estimated that new and existing energy development could directly or indirectly affect up to 96 million ha. The largest impacts are expected across the boreal forest, followed by shrublands and grasslands.

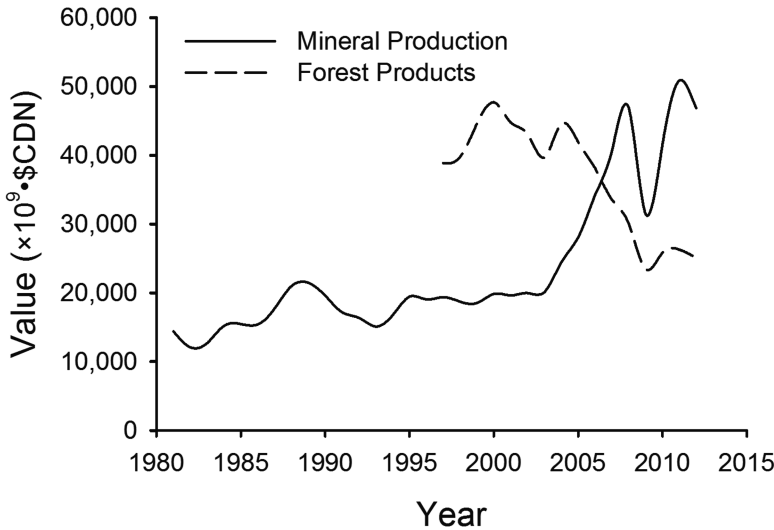
The cumulative human impacts are also substantial. Air and water pollution reduce environmental quality and thus the quality of the environment for human use (Tenenbaum 2009). Many of these impacts are still not fully understood (Dana et al. 2009). Hydraulic fracturing for natural gas reserves, for example, uses large volumes of water and creates proportionally large amounts of pollution, resulting in unknown long-term consequences for human communities that depend on the affected water resources (Colborn et al. 2011; Souther et al. 2014). From a socio-economic perspective, the rapid growth of emerging centres of energy development can overrun the available municipal and health services (Kinnear et al. 2013). There is also a risk of communities suffering through boom and bust cycles that depend on unpredictable fluctuations in the global demand for local commodities (Barth 2013). In some cases, such dynamics are beyond the control of even the best-meaning and most well-prepared local government (Gramling and Freudenburg 1990).

The alternative to oil, natural gas, and coal, and to their associated impacts, is renewable energy. In 2011, approximately 19 % of global energy consumption was supplied by renewable sources (REN21 2013). The USA and many Canadian provinces have made the further development of renewable energy sources a legislated priority (e.g. *British Columbia Clean Energy Act*; Government of BC 2010). Thus, the development and use of solar, wind, hydropower, biomass, and geothermal energy is likely to grow substantially through the twenty-first century as a response to efforts to reduce CO<sub>2</sub> emissions (Fig. 2.4). Even these so-called green sources of energy can, however, result in significant environmental and human impacts (Johnson and Stephens 2011). Wind turbines, for example, are a known cause of mortality for migrating and resident bat and bird populations (Kuvlesky et al. 2007; Pruett et al. 2009). Utility-scale solar energy facilities require large amounts of space and can greatly change the thermal environment of the site (Kaygusuz 2009; Hernandez et al. 2014). For both sources, the required access roads fragment landscapes and further reduce habitat for species that depend on interior forest conditions or undisturbed habitats. The health risks of wind turbines are still being debated, but there are substantive concerns from communities about the impacts of turbine noise and energy transmission on the quality of life of adjacent home owners (Bakker et al. 2012; Jeffery et al. 2013; Groth and Vogt 2014). Development projects in Ontario, for example, have been redesigned or canceled as a result of community concerns and protests. Hydroelectricity has a long history of development in North America, but there are significant impacts for affected river systems, downstream water users, and of course communities that are lost or moved as a response to the impoundment of water (Rosenberg et al. 1997; Zhang and Lou 2011). Micro-hydroelectric projects have a smaller effects footprint, but the distribution of many

small facilities leads to a large cumulative impact that results from both the generation sites and the infrastructure for energy and road transportation (Watkin et al. 2011; Bracken and Lucas 2013; Box 3.1).

In addition to energy, Canada’s more traditional natural resources (i.e. minerals and forests) are also highly sought after. In 2012, minerals accounted for 21 % of the country’s total exports and more than 330,000 Canadians were employed by that resource sector (NRCAN 2012, 2013a; Fig. 2.5). Leading commodities include potash (\$7.0 billion), coal (\$6.4 billion), gold (\$5.6 billion), iron ore (\$5.3 billion), copper (\$4.5 billion), and diamonds (\$2.0 billion). These totals do not include the \$3.9 billion spent domestically on exploration and associated costs, with record years in the most recent decade (NRCAN 2012). Globally, Canada is one of the top five producers of aluminium, cadmium, cobalt, nickel, platinum, sulphur, titanium, tungsten, and uranium (USGS 2012). The export of forest products is second only to China, and contributed \$25.3 billion to Canada’s economy (NRCAN 2013b; Fig. 2.5).

As is the case for energy development, mining and forestry can result in significant cumulative impacts to natural and human systems. This depends, however, on the extent and magnitude of the effects. Forestry can be a sustainable industry if trees are harvested at a rate that allows for regeneration and if a sufficient area of forest is maintained to support biodiversity and other values associated with natural or old-growth forest types (DeLong 2007). Mines may have a relatively small footprint if most of the extraction occurs underground, and the surface can be reclaimed to a more natural state following closure of the mine (Latimer 2012; but see also Raab and Bayley 2012). Both of these industries can, however, have perva-



**Fig. 2.5** Economic benefits of mineral production and the export of forest products from Canada (data from NRCAN 2013a, b)

sive cumulative impacts (Fig. 2.1). In particular, forestry results in the development of extensive road networks that may create other impacts, such as the degradation of streams and rivers (Forman and Alexander 1998; Ercelawn 2000; Jones et al. 2000). Mining has a footprint effect with a high magnitude that can exacerbate impacts from adjacent mines or other industrial activities, particularly for surface and near-surface mining. Across the South Peace Region of BC, for example, many areas have had past and recent coal development, as well as oil and natural gas extraction, wind farms, and a long history of forestry. Nitschke (2008) quantified the broad-scale impacts to biodiversity in that region. Woodland caribou, an endangered species across much of BC, have lost considerable amounts of habitat because of the cumulative impacts of those developments (Johnson et al. 2015; see Box 3.2).

Although Canada is a rich country with considerable experience and capacity to regulate the development of natural resources, there is much evidence to recommend improvements in how we address the impacts associated with industrial activities (Timoney and Lee 2001). Nationally, Canada ranks 104th out of 146 countries in its efforts to reduce environmental stresses according to the environmental sustainability index (Esty et al. 2005). When Boyd (2001) compared 25 environmental indicators across the 29 countries in the Organization for Economic Cooperation and Development, Canada ranked 28th. The inherent difficulties in quantifying and managing cumulative impacts and the potential growth in key resource industries suggests that the challenges of maintaining Canada's environments and communities will become more difficult in the future.

The challenges of managing cumulative impacts become even more apparent when considering some of Canada's most vulnerable and disenfranchised communities (Parlee et al. 2012). Across much of the country, Aboriginal peoples are attempting to assert their right to resources and land in the face of past, present, and unprecedented future levels of activity. In BC, these struggles occur in the context of unsettled land claims in which treaty rights or the assertion of Aboriginal title has not yet secured traditional activities or access to twenty-first century resources (see Box 3.6; Vignette 6.6). The BC and federal EA processes do not provide adequate mechanisms for First Nations to have their concerns about cumulative environmental, cultural, and social impacts considered and addressed (FNEMC 2009; Booth and Skelton 2011a). Recognising these deficiencies in legislation and process, Plate et al. (2009) recommended review and improvement of CEA methods, the full inclusion and consideration of oral Aboriginal knowledge when assessing past impacts, and the use of planning or regional assessment processes to set thresholds for these impacts. Booth and Skelton (2011b) also recognised the importance of regional land-use planning or proactive CEAs to support Aboriginal peoples during the review of development projects.

The failure to proactively and meaningfully consider Aboriginal peoples' interests in decision making will undoubtedly result in court challenges that require the provincial and federal governments to reactively address the cumulative impacts of past decisions that now infringe on constitutionally protected Aboriginal rights and title. In BC, there is now precedent for such litigated outcomes. Following a challenge by the West Moberly First Nations, the BC Supreme Court required the



province to halt coal development and restore a population of woodland caribou that had declined as a result of cumulative impacts (Box 3.2). This finding may force the province to consult Aboriginal peoples more closely on cumulative impacts when they are reviewing resource development permits and tenures (Findlay and Walton 2010).

## 2.4 Assessing Cumulative Effects and Impacts

Cumulative effects are identified through a broad set of approaches known generically as CEA. The methods are diverse, and VC/VEC specific (see Duinker et al. 2012), but CEA generally refers to a systematic and repeatable approach for assessing the relative strength and significance of cumulative environmental change. Although the term CEA explicitly refers to *effects*, such assessments focus on measuring cumulative environmental impacts (see Sect. 2.2.1). During the assessment process, the results of a CEA are used to determine if a project or series of projects have significant cumulative impacts, and can guide efforts to prevent or mitigate impacts.

Hegmann et al. (1999, p. 3) stated that CEA is “environmental assessment as it should always have been: an Environmental Impact Assessment done well.” This speaks to not only the importance of cumulative impacts, relative to the individual impacts from a single project, but also the overwhelming emphasis in Canada on the EA process. As we will discuss in the rest of this chapter, existing regulatory requirements limit the consideration of the full range of impacts as well as the processes that could be developed to address those broader impacts.

A CEA can follow two broad approaches that address either individual projects or the region over which a number of projects have or may occur. The majority of our experience in Canada is with *stressor* or *project-based* CEA (Dubé 2003). These assessments are a response to regulatory review and approval for an individual project and are focused on assessing the cumulative impacts associated with a particular set of effects. These impacts are identified for each VC based on the assumptions that all relevant VCs will be considered and that the mechanisms defining the effect–impact pathways are understood. Also, the range of stressors is confined to the CEA study area for a particular development proposal, thus the spatial and temporal scales of the impacts must be defined carefully. Without such a consideration, it is possible to inadvertently exclude impacts that occur across large regional areas or that become significant over long time periods. For example, chronic health impacts resulting from a project may not be well understood initially, but may become apparent following long-term exposure or through the development of more sensitive diagnostic methods. The primary steps in most project-based CEA (Noble 2010) are:

1. Identify the VCs for a particular project.
2. Determine past, present, and reasonably foreseeable future activities and their associated effects.

3. For each effect, identify the pathway for how it affects the VC and the hypothesised impacts for that VC.
4. Develop a model or method for effect and impact measurement.
5. Quantify the potential impacts of all activities related to the listed VCs.
6. Determine the significance of the impacts.
7. Identify appropriate measures for environmental management and mitigation for all impacts judged to be significant.

In contrast, *effects-based* or *regional* CEA focus on the regional impacts of a series of development projects rather than single stressors or project-specific effects and their associated impacts. This shift in both method and philosophy arises from the recognition that CEA should extend beyond the scope of any one project or proponent (Dubé 2003). Regional CEA provides greater flexibility to consider broader spatial and temporal scales and a wider scope of VCs, and is less concerned with the potentially complex mechanisms embodied in the effect–impact pathways (Noble 2010). Regional studies are more closely aligned with broad-scale sustainability targets. Thus, regional CEA is flexible and responsive to regional needs, and facilitates approaches for cumulative impacts management that engage broader communities and that emphasise proactive planning (Johnson 2011).

Regional studies of cumulative impacts are recognised and even *encouraged* within the *Canadian Environmental Assessment Act* (S.4(1); Government of Canada 2012). The dominant model for CEA, however, remains project-based. This is likely the result of a lack of government leadership, since no one industry or proponent can be expected to plan for regional impacts unrelated to their activities. Also, regulations are a key driver of EA, but necessarily focus on projects and proponents.

## 2.5 Regulatory Requirements for Cumulative Effects Assessment

The cumulative impacts of resource development are one of the largest emerging challenges for natural resource, health, and planning professionals as well as for communities that are attempting to accommodate rapidly expanding industrial sectors (Krausman and Harris 2011; Naugle 2011; Kinnear et al. 2013). In addition, there is an expanding scope of values and increasing appreciation of the holistic nature and complexity of ecological systems (see Chap. 3). Ecosystem services, for example, are now recognised as more than an abstract set of metrics that can be used to measure environmental change; they are increasingly seen as real services that influence the health and well-being of humans (Costanza et al. 1997; Carpenter et al. 2009). In reality, however, much of the contemporary work that has focused on understanding cumulative impacts, including the application and critiques of CEA, has occurred in response to EA legislation (Dixon and Montz 1995; Duinker and Grieg 2006). Much of that legislation has focused exclusively on a subset of discrete environmental values, with socioeconomic and health impacts a consideration only when they relate directly to environmental change.

Legislative requirements for CEA vary across Canada. The *Canadian Environmental Assessment Act* (Government of Canada 2012) is federal legislation that applies to all projects that meet specific requirements relative to the involvement and responsibilities of the federal government. This includes projects: that affect fish and fish habitat, migratory birds and their habitat; that have cross-border effects (provincial and national) or that affect Aboriginal people; that occur on federal land or cause changes to the environment as a result of a decision by the federal government; and projects that are regulated by the Canadian Nuclear Safety Commission or the National Energy Board.

Cumulative effects assessment may vary considerably among projects reviewed as a requirement of the *Canadian Environmental Assessment Act* (Government of Canada 2012). Criteria for defining the approach and level of effort include (CEAA 2013):

- The type of project;
- The magnitude of the anticipated potential cumulative impacts;
- The health or status of VECs that may be affected by the cumulative environmental effects;
- The potential for mitigation; and
- The level of concern expressed by Aboriginal groups or the general public.

Most provinces and territories in Canada have separate legislation that considers the environmental and socioeconomic impacts of resource development proposals. Some of these legislative frameworks have provisions for assessing the cumulative impacts. For example, the *BC Environmental Assessment Act* (Government of BC 2002) was amended in 2010 to formally recognise cumulative effects. Proponents can voluntarily consider these cumulative effects, but whether this is required is at the government's discretion. There have therefore been examples of projects that included a CEA, but there is no formal guidance on the scope or type of CEA that is acceptable to the BC Environmental Assessment Office (Haddock 2010).

In Ontario, cumulative effects are considered as a matter of policy rather than explicitly within the context of legislation. According to the Ontario Ministry of the Environment's *Statement of Environmental Values*, the Ministry must: "...consider the cumulative effects on the environment; the interdependence of air, land, water and living organisms; and the relationships among the environment, the economy and society" (Government of Ontario 2014). In Alberta, the *Land Stewardship Act* (Government of Alberta 2009) provides a statutory framework by which the provincial government can develop regional plans that manage cumulative effects. Planning is occurring across seven broad regions and includes a consideration of the impacts associated with water quality and supply, pollutant emissions, and habitat loss. Plans are approved by the provincial Cabinet and are meant to provide policy direction for the regions, thereby supporting finer-scale decision making.

Although there are legislative tools at various jurisdictional levels to consider cumulative impacts, and although these sometimes require formal CEA, much of the emphasis is placed on measuring and addressing changes to the environment resulting from individual projects. The *Canadian Environmental Assessment Act* (Government of Canada 2012), for example, focuses exclusively on the environment. There is no consideration of socioeconomic or human health impacts that are not a

direct function of some change in the environment caused by project activities. In contrast, the BC Environmental Assessment Office often considers a fuller range of impacts, including the economic benefits of a project (BC EAO 2011; Pockey 2011). One must be cautious, however, when tax benefits and employment statistics become the standard by which impacts are measured. Where environmental change, community resilience, and human health cannot be assigned monetary value, the consideration of project revenues may result in underestimation of the negative impacts to less tangible or quantifiable VCs. As Hegmann et al. (1999) recognised, there needs to be a better consideration of and more effective methods for considering the influence of environmental impacts on socioeconomic systems as well as the impacts of cumulative socioeconomic changes on the environment (see Chap. 4). We suggest that such improvements in the process are also required to better consider the impacts of development, including environmental change, on human health (see Chap. 5).

## 2.6 Alternatives to Regulation

There have been strong criticisms of the effectiveness and even the role of project-specific EA in efforts to address cumulative impacts (Burris and Canter 1997; Baxter et al. 2001). Many have argued that cumulative impacts are inadequately represented in existing legislative frameworks or, at a more fundamental level, not served well by the structure and application of the EA process (Creasey 1998; Kennett 1999; Davey et al. 2002). Cumulative impacts are not immediately associated with the time and place of a proposed development and, therefore, it may be difficult to define the extent or magnitude of an impact (McCold and Saulsbury 1996). With the exception of regional studies, which are acceptable under the *Canadian Environmental Assessment Act* (Government of Canada 2012), there is no requirement for a strategic vision that would encompass spatial and temporal domains that exceed the footprint of the proposal that triggered the assessment. Furthermore, EA in Canada and beyond (Dixon and Montz 1995), including the formal requirement of a CEA, is a reactive proponent-driven process. An EA considers the impacts of individual projects rather than multiple projects that may span large areas, jurisdictional boundaries, and considerable time periods. The CEA is a secondary consideration and occurs only after direct project impacts are considered.

These are not only issues for regulators and concerned citizens. Often, a proponent will view the process of developing a meaningful CEA as intractable. Even within certain industrial sectors, there is little sharing of the strategic business interests, data, and knowledge that would make such an assessment possible. This problem is magnified by cross-sectoral gaps in communication and relationships. Furthermore, working with various levels of government, including Aboriginal peoples, can be challenging if a transparent and consistent decision-making process is the goal. Each of these governments can bring unique interpretations of the significance of impacts or even the importance of VCs and the bounds of the study area (Pockey 2011). Overlapping assessments and permit-granting processes further



complicate project review, and this has obvious costs for businesses and uncertainty for resource-dependent communities.

Many have recommended a tiered decision-making framework as a solution for the current failings of EA in Canada (Conacher 1994; Creasey 1998; Kennett 1999; Davey et al. 2002; Duinker and Greig 2006; Gunn 2009). Such a framework would be implemented at a regional scale and would evaluate current levels of cumulative impacts using standardised metrics that are consistent across resource sectors. Linked to this understanding of regional impacts would be targets for acceptable or desirable levels of future development. For Aboriginal peoples, the development of a strategic vision of development for their traditional territories would lead to more inclusive and effective involvement in the assessment process (Plate et al. 2009). Targets could be based on any number of environmental, socioeconomic, cultural, or health criteria. Thus, the environmental impacts of individual projects could be considered within the context of existing and future impacts. Such a framework would have many of the qualities of effective strategic land-use planning (Booth and Halseth 2011). As noted by Bardecki (1990, p. 322), “Assessing and managing cumulative impacts is planning.”

### ***2.6.1 Regional Environmental Assessment***

Regional environmental assessment (REA), also referred to as regional CEA, and in Canada, as Regional Strategic Environmental Assessment (RSEA), is a general type of accounting and guidance framework that would accommodate and inform individual project approvals within a broader and more holistic understanding of current and acceptable levels of impacts (Conacher 1994; Bonnell and Storey 2000; Gunn 2009). Regional environmental assessment is recognised globally as well as within the *Canadian Environmental Assessment Act* (Government of Canada 2012). The World Bank (1999) defines REA as:

An instrument that examines environmental issues and impacts associated with a particular strategy, policy, plan, or program, or with a series of projects for a particular region (e.g., an urban area, a watershed, or a coastal zone); evaluates and compares the impacts against those of alternative options; assesses legal and institutional aspects relevant to the issues and impacts; and recommends broad measures to strengthen environmental management in the region. Regional EA pays particular attention to potential cumulative impacts of multiple activities.

Compared to individual project assessments, REA is outward-looking and strategic, and considers a range of interacting impacts across a region (Harriman and Noble 2008). Failure to look beyond a single development project limits our ability to address the deficiencies of current project-focused EA, and our ability to develop decision-making frameworks that consider cumulative impacts in all of their forms (Baxter et al. 2001; Duinker and Greig 2006).

The benefits of REA are numerous and include: long-term development targets or plans within the context of sustainability; participation of all regulatory agencies

and stakeholder groups; identification of a range of environmental effects and impacts early in the land-use decision-making process; assessment of baseline conditions and data gaps; and development of monitoring and management frameworks that support the documentation of explicitly regional cumulative impacts and the significance of the impacts associated with specific projects (Kennett 1999; Davey et al. 2002; Gunn and Noble 2009a). Regional environmental assessment has been proposed or has shown some success for a number of resource development sectors, and there are a range of technical approaches for understanding large-scale cumulative impacts, especially from the perspective of animal and plant communities (Schneider et al. 2003). Some of the failures of REA result from the unrealised expectation of a one-size-fits-all model. Regional environmental assessment is most successful when it is developed to suit the challenges of land use and development in a specific region (Harriman and Noble 2008).

### **2.6.2 Cumulative Effects Assessment and Management Frameworks**

Some Canadian jurisdictions, recognising the value of integrated project-specific EA and the principles of REA, have developed what are generically known as cumulative effects assessment and management frameworks (CEAMFs). Such frameworks are defined as “an administrative structure that can help decision-makers assess and manage the effects of human use of the land” (AXYS Environmental Consulting 2003, p. 1–6). Cumulative effects assessment and management frameworks are flexible and adaptable to a region’s specific challenges related to cumulative impacts. One could therefore consider CEAMFs as the operational realisation of REAs. Thus, past and current experiences with CEAMFs not only provide lessons for better addressing cumulative impacts but perhaps provide templates for future efforts in other regions of Canada.

Gunn and Noble (2009b) identified and reviewed four Canadian CEAMFs. They concluded that the origin, goals, and development of each framework were unique, but there were some common themes, including land-use planning, development of a vision, coordination among regulatory agencies, policy development, and monitoring of cumulative impacts. The Northwest Territories (NWT) CEAMF, one of the first Canadian frameworks, is a good example of both the potential and failings of this approach. Formed in the late 1990s in response to the rapid development of the diamond mining industry, the NWT CEAMF was composed of a steering committee with representation from the territorial, federal, and First Nations governments and councils, and from non-governmental and industry organisations. The Committee was tasked with making recommendations or providing *refusable advice* to decision-makers on a broad list of initiatives that encompassed ecological integrity, sustainable communities, and economic development. Although the NWT CEAMF Implementation Blueprint identified baseline studies, research, and monitoring as necessary components of cumulative effects management, there was little

progress in this direction (NWT CEAM Steering Committee 2007). Slow progress on such goals reduced the overall legitimacy of the framework (Gunn and Noble 2009b).

Although the attributes of each framework were unique, Gunn and Noble's (2009b) research identified some common themes that can predict the success or failure of this approach. First, a stakeholder-defined regional vision for future development was important for success. This was consistent with broad spatial and temporal perspectives on cumulative impacts that engaged a range of land-use sectors and their associated stakeholders. Second, members of the frameworks often had difficulties linking the strategic nature of CEAMFs to regulatory decisions, and this difficulty was a predictor of failure. Third, translating strategic visions into operational guidance and tracking progress toward meeting goals was difficult, especially when participants were positioned in agencies tasked with project-level decisions.

Despite these difficulties, CEAMFs provide a real opportunity for conducting CEA at meaningful scales and for structuring processes that would guide land-use planning and site-specific decision making for situations that go beyond individual project proposals. These frameworks will have particular value when directed at hotspots where cumulative impacts are especially severe or are expected to occur in the future. Ultimately, however, the limits of past frameworks will need to be addressed. A more complete and fully realised integration of project-based and regional CEA is the starting point. As part of the path that leads to this integration, governments will need to elevate CEAMFs beyond advisory roles and provide them with some legislated authority to influence land-use decision making.

## 2.7 Conclusions

There are profound changes on the horizon for regions of Canada that are hoping to maintain functioning and resilient ecosystems as well as a high quality of life in the context of an accelerating twenty-first century economy (Parlee et al. 2012). These challenges are especially acute for Aboriginal communities who have been disenfranchised by top-down government processes and who may have culturally unique concerns and solutions for managing industrial development. Similar conclusions can be drawn for other regions of the world where rapid resource development is occurring or expected (McDonald et al. 2009; Copeland et al. 2011). Unfortunately, past approaches to address cumulative impacts appear to have been woefully inadequate, and this is not just the Canadian experience (Dixon and Montz 1995; Burris and Canter 1997). Twenty years of retrospective analysis has demonstrated that project-specific approaches for assessing and addressing cumulative impacts are not sufficient, as they cannot meet the basic principles of sustainability: healthy environments, productive economies, and communities that support a high quality of life (Duinker et al. 2012). The reasons for failure are many, but ultimately result from an assessment process that struggles to look beyond the impacts associated with only a single proposed development in isolation from other development

projects (see Chap. 7). The principles of REA offer a starting point for fully considering cumulative impacts across regions and longer (strategic rather than tactical) time periods (see Chap. 8). In Canada, these ideas have been exemplified by CEAMFs. Although these frameworks have not always been successful, and have most often been limited to advisory roles with no authority, at the very least these frameworks provide a mechanism to consider regional scales, multiple resource sectors, and broader participation in land-decision making.

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