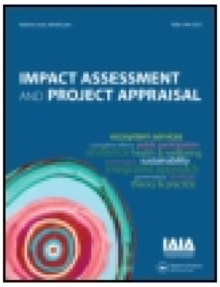

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Strategic approaches to regional cumulative effects assessment: a case study of the Great Sand Hills, Canada

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Strategic approaches to regional cumulative effects assessment: a case study of the Great Sand Hills, Canada

Bram Noble

This paper examines the experience with regional cumulative effects assessment (CEA) in the Great Sand Hills, Saskatchewan, Canada, and the lessons that emerge for better practice. The benefits of a regional approach to CEA are widely discusssed; however, in practice, regional CEA, particularly in Canada, has fallen short of its potential. Part of the reason for this, arguably, is the lack of strategic frameworks to support good practice. Most attempts at regional CEA have been constrained by the strong influence of project-based environmental assessment, and are focused on modeling past and present stressors and responses, rather than on projecting cumulative trends and systematically identifying and evaluating desirable futures. Regional CEA is inherently futures-oriented. This requires a supporting SEA framework, structured scenario-based analysis, a multi-scaled perspective, and an integrated approach to CEA and regional plan development.

Keywords: regional cumulative effects assessment, strategic environmental assessment, ecological integrity, Great Sand Hills, Canada

THE NOTION OF A regional environmental effects assessment is not new to the impact assessment community, and the potential benefits emerging from a regional approach are postulated widely; of particular benefit is the opportunity to better understand, assess and manage the sources of cumulative environmental change (see, e.g., Kennett, 2002; Dube, 2003; Cooper and Sheate, 2004; Harriman and Noble, 2008).

In Canada, several regional environmental studies and related cumulative effects assessment (CEA) and management initiatives have taken place over the past fifteen-plus years and across a range of jurisdictions, including the Northern River Basins Study in the Peace, Athabasca and Slave River Basins in Alberta and the Northwest Territories, the Banff Bow Valley Study in Banff National Park Alberta, and the Oak Ridge's Moraine Area Planning Study in Ontario (see, for example, Hegmann *et al*, 1999; Culp *et al*, 2000; and Quinn *et al*, 2002). All of these studies were based on a premise that a regional approach provides the necessary context to effectively understand and manage cumulative environmental effects beyond what is often possible in project-based environmental assessment; however, none of these past regional initiatives occurred explicitly within the context of a strategic environmental assessment (SEA) framework.

As a result, regional CEA in Canada has largely been restrictive, focused on describing the current state of the environment or modeling system response to past land use changes and current land use pressures, rather than on projecting trends, scenario building, and discerning desirable futures as well (Duinker and Greig, 2006; Noble, 2005; Quinn *et al*, 2002). The need for frameworks to support regional CEA has been recognized for some time in the environmental assessment literature. It was a focus of the

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Canadian Environmental Assessment Agency's research and development priorities from 2000 to 2003, and again in 2006–07, and is currently a national priority of the Canadian Council of Ministers of Environment Environmental Assessment Task Group.[1] The challenge is that experience with regional CEA remains limited, particularly in terms of strategic frameworks to support good practice. It is only recently that an explicit, systematic SEA-based framework for regional CEA has been demonstrated in practice.

In December of 2004, the Government of Saskatchewan called for a regional environmental study (RES) of the Great Sand Hills. Situated in the southwest portion of the province (see Figure 1), the Great Sand Hills is the largest sand dune complex in the region and is of significant ecological importance. The region is also characterized by both large-scale and long-term anthropogenic-induced surface disturbance, in particular natural gas development and livestock grazing. The Great Sand Hills RES was commissioned to provide a strategic assessment of human activities that cumulatively affect the long-term ecological integrity and sustainability of the region and to provide recommendations, in the form of a management plan, to guide future land use activities. The RES was completed in May 2007.[2] Although the RES did not occur under any formal regulatory requirement for SEA, as no such requirement exists in the province of Saskatchewan, the assessment was based explicitly on the principles and framework of SEA — making it the first of its kind in the province and a step forward in regional CEA in Canada.

This paper examines the experience with regional CEA in the Great Sand Hills, Saskatchewan, and the lessons that emerge for advancing current practice. In particular, this paper explores the strategic assessment framework underlying the Great Sand Hills study with a view to understanding how such frameworks guide CEA processes at the regional scale. First, the Great Sand Hills regional context is described, including previous regional planning initiatives. This is followed by an examination of the SEA framework, drawing largely on the final assessment document, the author's involvement with the process, and contributed working papers and consultants' reports. The paper concludes with a discussion of key lessons emerging from the Great Sand Hills experience, and enduring challenges for future regional CEA and management.

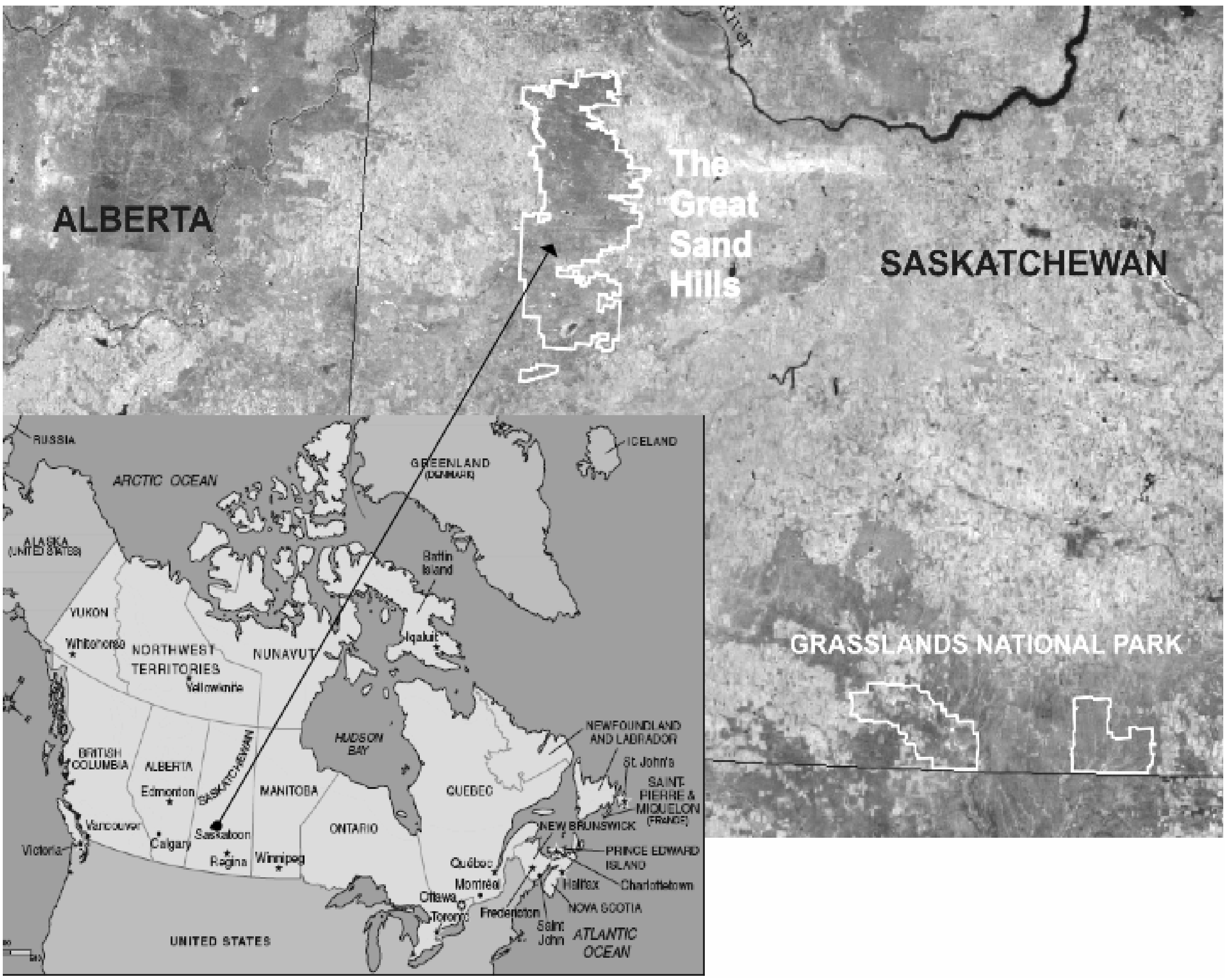

Figure 1. The Great Sand Hills, Saskatchewan, Canada

Regional context to the case study

The Great Sand Hills is approximately 1,942 km^2 of native prairie overlaying a more or less continuous surface deposit of unconsolidated sands, with five dune complexes that total 1,500 km^2. Characterized also by open grasslands and patches of trees and shrubs, the region is home to several game species and endangered, threatened, and sensitive species, many of which are largely dependent on the sand dunes. The rugged topography of the region poses a constraint to most human activity, with the exceptions of natural gas development and livestock grazing.

Natural gas has been exploited in the Great Sand Hills since the early 1950s, and intensively since the 1980s. With more than 23 gas companies currently operating in the region and approximately 1,500 gas wells (see Figure 2), production is estimated at over 180 billion cubic feet, with proven, probable, and possible[3] reserves estimated at nearly 670 billion cubic feet (GLJ Petroleum Consultants Ltd, 2006). Gas leases and land leased for gas exploration account for approximately 70% of the area. The cumulative impacts of gas well pads and associated roads and trails to service the infrastructure are of significant concern.

Livestock grazing, the social fabric of the region, has exerted a much longer-term and widespread influence on the landscape. Ranching is considered by many to be an ecologically acceptable activity (Nelson *et al*, 2006), and is relatively ubiquitous across the region. Of concern, however, are the cumulative effects associated with cattle watering holes and cattle congregation — the result of which is a network of permanent trails and vegetative trampling and erosion (Scientific Advisory Committee, 2007).

In addition to its ecological and economic importance, the Great Sand Hills is of historical and spiritual significance and is considered to be the traditional territory of numerous First Nations groups in Saskatchewan, Alberta and North Dakota,

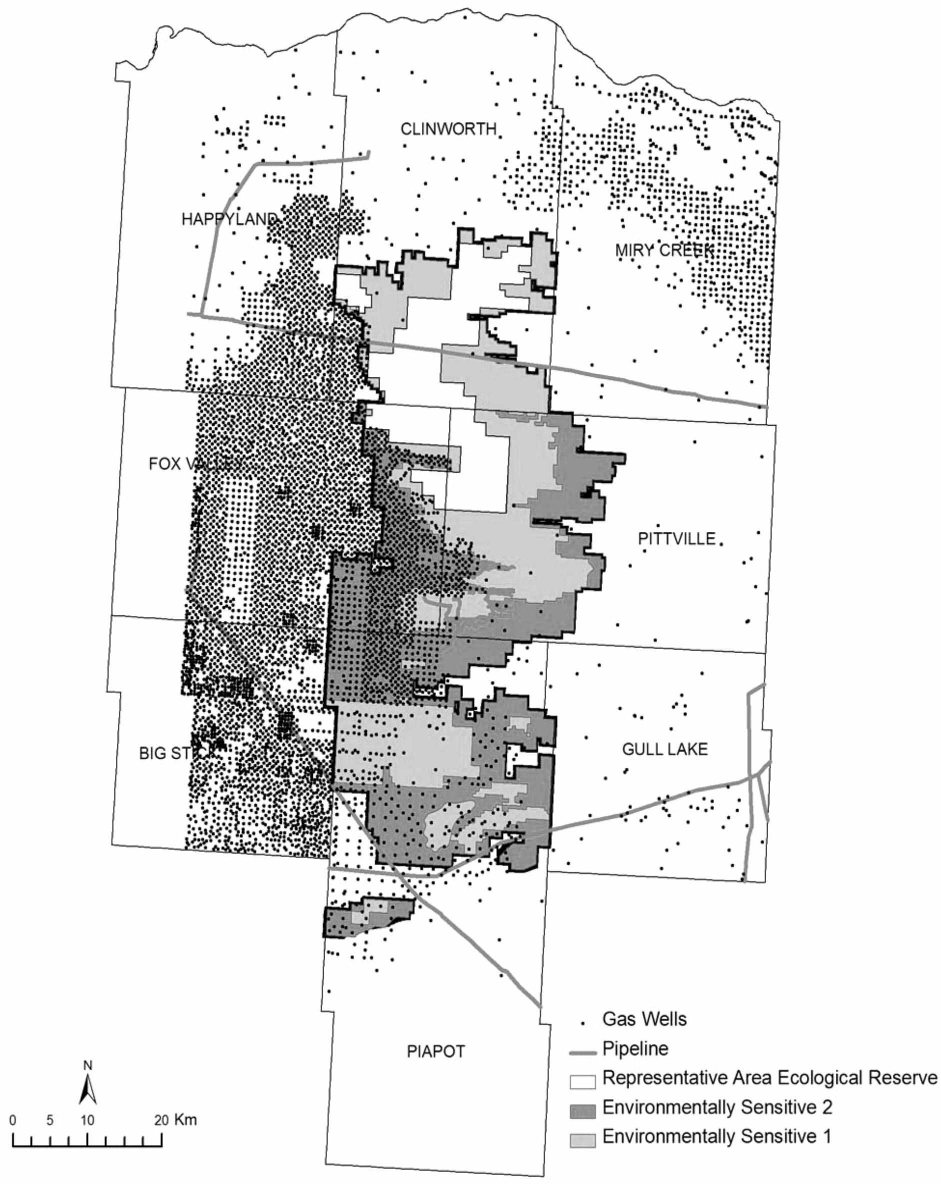

Figure 2. Natural gas well sites and major pipelines
Source: Scientific Advisory Committee (2007: 118)

USA (Peters *et al*, 2007). There are over 200 known sites of archaeological significance within the region, most of which have been discovered through surface disturbances associated with natural gas development (Gauthier and Galenzoski, 2006).

Overview of regional land use planning initiatives

Regional land use planning in the Great Sand Hills commenced in 1991 with the Great Sand Hills Land Use Strategy. The result was a series of land designations, including lands to be protected from gas development (Environmentally Sensitive 1 lands) and lands open to further gas development subject to industry environmental protection plans (Environmentally Sensitive 2 lands); these are indicated in Figure 2.

In the years following the Strategy, tensions over land use and environmental impacts continued to grow, as did the gas industry. It was not that the provincial *Environmental Assessment Act* did not apply in the region, but that as each individual gas project came on stream, proponents were not required to consider their impacts as additive to those of other projects already approved, currently operating, or likely to come on stream in the future. Further, of the 1,500 gas wells currently in the region, only five proposals had triggered the *Environmental Assessment Act* and undergone full environmental assessment (MacFarlane, 2006).

In 2002, the provincial government commissioned an independent review of the Strategy. A number of recommendations emerged, including enhanced protection in certain areas and to “start over” with a “true socioeconomic and biophysical study” (Minister of Environment, 2004). The Government of Saskatchewan subsequently established a Representative Area Ecological Reserve (RAER) in the northern portion of the Great Sand Hills in which no new gas development would be permitted, and called for a regional assessment of cumulative human impacts in the Great Sand Hills.

The province released a formal scoping document in 2004, calling for an assessment that would provide strategic recommendations, in the form of a management plan, to guide human activities in the Great Sand Hills. The overall objective of the assessment was to ensure that the long-term ecological integrity of the area is maintained while economic benefits are realized. The assessment was to be objectives-led and integrated, consider a range of development scenarios and environmental impacts for the region, and be based on SEA methodology (Government of Saskatchewan, 2004).

An independent Scientific Advisory Committee[4] was appointed by the Minister of Environment to oversee the administration and implementation of the assessment process, and to make recommendations concerning the assessment outcomes.

The overall objective of the Great Sand Hills cumulative effects assessment was to ensure that the long-term ecological integrity of the area is maintained while economic benefits are realized

The Great Sand Hills SEA framework

The overall approach to regional CEA in the Great Sand Hills was based on a structured SEA framework (after Noble and Storey, 2001) and underlying SEA principles and characteristics, which in turn are consistent with validated principles for success in ecosystem management (see Keough and Blahna, 2006; Scientific Advisory Committee, 2007: 8). The assessment was guided by the 1996 Bellagio Principles of sustainability and also by a number of additional underlying objectives important to good-practice regional CEA, including (Scientific Advisory Committee, 2007: 10):

- integration of socioeconomic and cultural values as part of the assessment process;
- use of multiple assessment scales, including a coarse or landscape scale as the basis for ecological assessment;
- consideration of the cumulative ecological impacts of human activities to date as the basis for considering the type and extent of future activities;
- minimizing human footprint in the short term, while focusing also on emerging techniques for longer-term solutions;
- protection of sensitive areas from development, including areas of cultural significance, and restoration of already disturbed areas to their original plant communities; and
- facilitating short- and long-term monitoring of human impacts and restoration areas based on clear objectives, targets, and early warning indicators of undesirable change.

The spatial scale of the assessment was multi-tiered, considering biophysical, socioeconomic and cultural boundaries, common resources and geographic relationships, as well as the reach of existing policies, plans, land uses and interests that have the potential to affect any proposed land use scenario for the region.

The biophysical scale of assessment was based primarily on the spatial extent of the Great Sand Hills’ dunes and grasslands, with the exception of climate and acid deposition studies, which considered also broader intra-regional influences. The socio-economic boundary was based on a much larger area of eight regional municipalities that encompass the review area (as shown in Figure 2). The cultural boundary (First Nations study area) extended well beyond the Great Sand Hills and into the neighbouring province of Alberta, as no First Nations group currently occupies the region but many have historical contemporary cultural ties. Temporally, the RES considered the cumulative effects of human activities and natural change from the 1950s, the beginnings of gas development in the region, and projected forward to 2020, at which time gas reserves would be fully tapped.

The assessment framework consisted of three main phases: a baseline that characterized the current and cumulative biophysical, economic, and social conditions of the region; the identification of historic trends in land use and associated cumulative change (conceptualized as 'surface disturbance'); and development, projection, and assessment of alternative land use scenarios together with recommendation of a preferred scenario and guidelines for implementation, mitigation, and monitoring. These phases of the assessment framework are illustrated in Figure 3, and each is described in greater detail below. So as to limit the discussion, attention is focused primarily on the biophysical components of the assessment framework.

Phase I: Baseline assessment

The baseline phase characterized the current biophysical, socioeconomic, and cultural environment of the region; identified broad-scale cumulative change; and collected data for identification of stressors, trends projection, and scenarios. The underlying objectives of the baseline were to identify those human activities in the region that have the greatest potential for surface disturbance and, therefore, for affecting ecological integrity and sustainability, and to identify key issues and concerns associated with those Valued Ecosystem Components[5] (VECs) that are of importance to human development, regional sustainability, and planning and decision-making.

The scope of the baseline was defined initially by a terms of reference prepared by the provincial government, and then tailored to the specific context of the region. As the baseline assessment unfolded, VECs were identified through an open scoping process involving members of the scientific advisory committee, regional stakeholders and First Nations, and guided by previous land use planning initiatives. A total of 20 VECs were identified for consideration in the baseline assessment (see Table 1), many of which are regional aggregates of local environmental indicators. Multiple first-, second- and third-order linkages between VECs were also identified to be of importance for regional environmental management. More than half of the first-order linkages were in some way, positively or negatively, associated with natural gas activities (Scientific Advisory Committee, 2007).

Interviews and focus groups were conducted with more than 250 local community members and other interests. A variety of primary and secondary-source biophysical data were collected for baseline construction, including soil and terrain analysis. Biophysical assessment focused on spatial analysis and sensitivity mapping of species and habitats, delineation of surface disturbance patterns across the region, and establishing statistical and spatial relationships between disturbed sites and species occurrence. The health and distribution of various biodiversity features (focal species, soil types, and

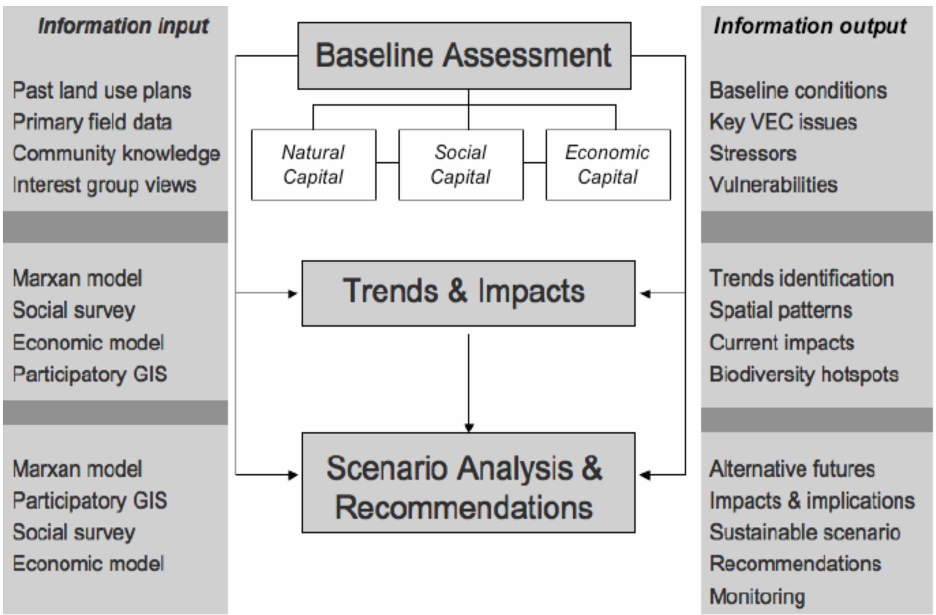

Figure 3. Great Sand Hills strategic assessment framework
Source: Adapted from the Scientific Advisory Committee (2007: 9)

Table 1. Great Sand Hills assessment VECs

regional climate	soils	local governance
economic geology	land use and change	governance instruments
natural gas reserves	regional economic base	regional demographics
water resources	regional economic change	quality of life
land cover and biodiversity	community economic change	First Nations use and culture
terrain sensitivity	economic contribution of government	heritage resources

vegetation), including species known to be of cultural importance to First Nations, were identified and mapped for the purposes of delineating biodiversity 'hot spots' and other areas of conservation importance.

Baseline estimates of range health, for example, identified almost half of the review area to be in an 'unhealthy' condition or 'healthy, but with problems' (Scientific Advisory Committee, 2007: 156). All three sources of disturbance (roads and trails, gas well sites, cattle watering holes) were found to be associated with areas of poor rangeland health, with the unhealthiest conditions associated with cattle watering holes. Range health was less problematic near gas well sites; however, gas well sites could not be considered independently of the cumulative effects of well access roads. In much of the gas intensive areas there is upwards of three kilometres of road per square kilometre of land; 93% of roads and trails established between 1979 and 2005 are within a one-mile radius of gas well pads established during that same period (Scientific Advisory Committee, 2007: 156).

Of particular concern, given the overall focus of the RES on the maintenance of ecological integrity, was that of the 77 biodiversity features identified in the baseline analysis (including 26 rare species), many were found to have little or none of their distribution within the current ecological protected area (the RAER), leaving them vulnerable to disturbances (Scientific Advisory Committee, 2007: 155).

Phase II: Impacts and trends identification

In phase two of the assessment, concentrated biodiversity areas were delineated using a site selection algorithm, Marxan, based on species and habitat data collected during the baseline. Marxan is decision-support software that uses an optimization algorithm (see Ball, 2000) to aid in the selection of a system of spatially cohesive sites to meet biodiversity targets.[6] The Marxan algorithm seeks to minimize the total 'cost' of a potential conservation area by identifying the smallest overall area needed to meet conservation goals and by selecting land units that are clustered (Scientific Advisory Committee, 2007).

The analysis and selection of biodiversity conservation areas focused on lesser-disturbed areas in the southern and eastern parts of the Great Sand Hills, as the objective was to identify areas for protection that have not experienced significant disturbance but were at risk to cumulative effects. A total of 37 core biodiversity areas — those with the most to lose if not managed — were identified, representing various levels of biological irreplaceability.[7]

Trends in surface disturbance were then assessed across the landscape using retrospective analysis of aerial photography and land use and vegetation/species databases. Rates of change were established for each of the three main sources of stress in the region. In 1979, for example, there were 76 gas well surface leases in the Great Sand Hills. By 2005, 1,391 new wells (more than 50 wells per year) had been established. Associated with the increase in gas well development was a growth in roads and trails, which had increased from 2,497 km in 1979 to approximately 3,175 km by 2005, with new roads and trails 153 times more likely to be built in association with a new gas well pad than elsewhere in the region (Scientific Advisory Committee, 2007). In contrast, cattle watering holes during this period increased at an average annual rate of only five new watering holes per year, and with no obvious spatial pattern of association. Annual rates of change in development and associated patterns of surface disturbance were used to build statistical models to quantify status quo trends in future scenarios, and a Geographic Information System (GIS) was used to project these future growth rates and spatial patterns of disturbance across the regional landscape.

Parallel to the ecological and spatial analysis was a regional economic assessment, a telephone-based social survey to assess local perceptions of current impacts of ranching and gas activity, and a series of participatory GIS workshops with key

Emphasis was placed on developing a set of plausible accounts of cumulative change. Instead of showing what 'will be', scenarios focused on alternative futures or what 'could be' under various trends, land use patterns, and rates of change

stakeholders to identify goals that participants have for the region, including preferred land use patterns and designations.

Phase III: Scenario analysis and recommendations

The third phase of the assessment comprised development and analysis of alternative land use scenarios and land use designations. Scenario-based approaches are fundamental to regional CEA, and to understanding cumulative change associated with regional land use and planning decisions (see Duinker and Greig, 2007). Emphasis was placed on developing a set of plausible accounts of cumulative change in a set of conditions over a specified period of time, rather than focusing on a fixed prediction about the most likely future impacts. Instead of showing what ‘will be’, scenarios focused on alternative futures or what ‘could be’ under various trends, land use patterns, and rates of change; see Table 2. This approach allowed decisions to be based not only on past trends, but also on potential future trends, which may include a number of surprises (Theobald, 2007).

In this way, the cumulative consequences of land use scenarios could be assessed and attention focused on achieving the most desirable outcomes and the means necessary to achieve those outcomes. Scenario analysis was primarily biophysical in nature, concentrating on cumulative effects on range health, biodiversity and ecological integrity. Species, range, and biodiversity responses to disturbances under each scenario were modeled according to the statistical and spatial relationships determined in the baseline and trends analysis phases.

The first two scenarios were based on past trends in development and represented two variations of the future; the main difference between the scenarios was a more ambitious natural gas development agenda under the second, such that all proven, probable, and possible reserves would be developed by the end of the projection period. Under the first scenario, from a 2005 baseline of 1,443 surface leases, an additional 1,446 well pads (96 per year) were projected for proven and possible gas reserves, and an additional 624 km of roads to access those new well pads. Under the second scenario, an additional 1,887 well pads (126 per year) were projected for proven, possible, and potential reserves (see Figure 4), along with an additional 814 km of new access roads. Cattle watering holes were projected across the region based on historic patterns and a rate of five new watering holes per year (Scientific Advisory Committee, 2007).

Table 2. Great Sand Hills future land use scenarios

	Scenario A. Business as usual	Scenario B. Enhanced development	Scenario C. Conservation approach
Natural gas activity			
Extent of natural gas development	Proven and probable reserves	Proven, probable, and possible reserves	Proven and probable reserves
Maximum allowed well pad density per land section	8	8	2[a]
Road development	Roads to each well pad follow least-cost path	Roads to each well pad follow least-cost path	Roads to each well pad follow least-cost path
Location restrictions	No new development in current ecological reserve	No new development in current ecological reserve	No new development in current ecological reserve and restricted development in new core biodiversity areas identified in baseline assessment
Livestock grazing			
Rate of development	5 new watering holes per year[b]	5 new watering holes per year	5 new watering holes per year
Minimum distance from existing watering sites	1,200 meters	1,200 meters	1,200 meters
Location restrictions	None	None	No new watering sites in current ecological reserve or in new core biodiversity areas identified in baseline
New core biodiversity areas			
Upland locations	No protection outside existing ecological reserve	No protection outside existing ecological reserve	Current ecological reserve plus minimum 40 acre planning/ protection parcel selection based on core biodiversity areas
Wetland and water bodies	No further protection	No further protection	Current ecological reserve plus additional land section with at least 40 acres in wetland or lake

Notes: [a] To reduce the number of well pad surface leases and associated roads and trails, directional and slant drilling are possible where multiple wells are drilled and operated from a single well pad surface lease
[b] Determined based on historic rate of development and assuming no projected increase in ranching activity under current animal unit restrictions and given current land-based capacity

Source: Based on Scientific Advisory Committee (2007: 176)

The third scenario was predicated on a conservation-based approach and consistent with the RES objectives of maintaining ecological integrity and sustainability. It was designed to conserve biodiversity through the protection of biodiversity hot spots identified in the baseline and impact analysis phase, and by further reducing surface disturbance outside the core biodiversity areas. Under this scenario, gas development was limited in the core biodiversity areas and well pad density held to a maximum outside core areas. This resulted in a total of 309 new well pads (see Figure 4) and 110 km of new service roads (Scientific Advisory Committee, 2007). Total natural gas production could be sustained through increased use of directional drilling technologies. New cattle watering holes were restricted from the core biodiversity areas, thereby reducing growth to approximately three new watering holes per year.

Social and economic implications were examined within the context of the various intensities of land use and conservation associated with each scenario, and also relative to the resulting biophysical impacts. For example, an economic cost model was used to analyze the impact of new biodiversity conservation areas in terms of foregone natural gas revenues. The social survey initiated during the trends and impacts phase posed a number of 'what if' scenarios concerning the status quo, increased, and decreased levels of natural gas and ranching activity. The goals and priorities identified during the participatory GIS workshops, such as areas delineated by First Nations to be of spiritual or traditional use significance, were used to interpret the cultural implications of each scenario.

Assessment output and current status

A preferred conservation-based scenario was identified that delineated particular sites of enhanced biodiversity protection and best-practice management for activities on lands outside those protected sites. The vulnerability of core biodiversity areas was ranked based on potential increases in surface disturbance, and used to summarize threats and prioritize conservation needs for areas with the highest biodiversity representation. Over 60 recommendations for implementation, future planning, assessment, and environmental monitoring activities were identified, along with specific targets, thresholds, and objectives for select ecological components. The intent is that such recommendations, and the RES itself, would inform and guide future project-based development, land use zoning, and decision-making in the region. At the time of writing this paper, the

Figure 4. Sample regional scenario output for gas well projections
Source: Scientific Advisory Committee (2007: 187)

planning and assessment document had received formal public review and was under internal government review in preparation for plan and recommendations implementation.

Lessons and observations for practice

The Great Sand Hills RES was to roll up nearly 15 years of regional environmental planning in an ecologically sensitive area, and to provide a strategic direction for cumulative environmental effects management and future land use. The RES thus required a process that was unlike previous planning initiatives in the region, and a framework that could support futures-oriented CEA and management. In the sections that follow, a number of observations are ventured concerning 'good' regional CEA based on lessons learnt from the Great Sand Hills experience. The intent is not to be prescriptive, but rather to extract from the case a number of characteristics that ensured procedural success of the RES as a framework for regional CEA. The observations should help inform future regional CEA practices in Canada, and are likely to be applicable to regional CEA frameworks in general.

SEA-driven process

It is generally accepted that a regional approach to CEA allows for a better understanding of ecological relationships and provides an opportunity for a wider range of roles and stakes to be integrated in planning and assessment (see, for example, Hegmann *et al*, 1999; Creasy, 2002; Duinker and Greig, 2006). However, an increase in assessment scale from the individual project to the region is, by itself, insufficient to ensure an understanding of the sources or drivers of cumulative change and to proactively manage regional land use and cumulative environmental effects. Adopting a regional approach to CEA requires more than simply expanding the assessment boundaries to encompass a broader geographic area; it represents a different way of approaching the interrelationships between environment and development.

Many regionally based initiatives in the Great Sand Hills and elsewhere in Canada have come before the RES, all of which were aware of cumulative effects but none of which were strategically based. The result has been regional studies that lack a clear strategic direction, demonstrate limited cumulative 'impact assessment', and default to traditional project-driven approaches to understanding cumulative effects and regional environmental change. What was different about regional CEA in the Great Sand Hills is the grounding of the process in an SEA framework. This enabled CEA to occur beyond the constraints of individual project-based initiatives, many of which are not subject to any form of impact assessment, in order to address the nature and underlying sources of cumulative change and to identify desirable futures and outcomes. Having such a strategic framework in place is critical to ensuring an effective regional CEA process.

Futures-oriented assessment

'Good' regional CEA is inherently futures-oriented, and requires the creation and evaluation of alternative development scenarios (Duinker and Greig, 2006). As a strategic process, this means less emphasis is placed on generating accurate cumulative impact predictions and more attention is given to identifying possible futures and the means to shape regional outcomes (Partidario, 2007). Simply put, the objective is to ensure that planning and assessment occurs within the context of desirable rather than the most likely outcomes.

In this regard, the Great Sand Hills approach to regional CEA was to systematically evaluate the cumulative effects of multi-sector land uses and surface disturbances under different future scenarios, including a desired conservation-based scenario. With no existing plan or specific set of development activities being proposed for assessment, the focus was on creating images of the future state of development, natural change, and cumulative change in the region. Scenarios were focused on alternative visions of the future, asking 'what if' questions concerning development and conservation. Emphasis was placed on exploring the consequences associated with alternative futures, identifying a preferred future based on ecological, social, and economic objectives, and devising the means to achieve it.

Thus, the RES managed to move forward in the Great Sand Hills where other processes have stopped short — identifying desirable futures for protecting the ecological integrity of the region while maintaining a sustainable level of human activity.

Structured effects assessment framework

Identifying future scenarios and subsequent cumulative outcomes at the regional scale is a complex spatial–temporal exercise. Thus, as Therivel and Ross (2007) suggest, strategic and regional approaches

Identifying future scenarios and subsequent cumulative outcomes at the regional scale is a complex spatial–temporal exercise. An important ingredient for the success of the CEA was an integrative and highly structured analytical model

to CEA are likely to benefit from more complex causal chain or modeling approaches. Conventional techniques — namely expert judgment — although useful when data are limited, are less effective when used alone in identifying the subtleties of cumulative effects, particularly path dependencies and non-linear relationships at the broader regional and strategic scales.

A primary feature of the Great Sand Hills strategic framework, and important to the success of the regional CEA, was an integrative and highly structured spatial analytical model capable of integrating biodiversity, focal species, land use and climate data and, furthermore, interpolating that data across space and time for each scenario under a range of VEC objectives and targets — the results of which could then be fed to economic and social impact assessment processes. This structured framework and spatial analytical model enabled methodical identification of scenario choice sets; supported explicit analysis of tradeoffs between scenarios to arrive at a 'satisficing' solution; could be repeated under alternative scenarios, at different spatial scales, and for different objectives and targets; and provided quality assurance that the assessment output was derived based on an explicit set of decision rules, thereby addressing the 'fuzziness' of broad regional and strategic impacts and decisions.

Although the degree of structure versus flexibility in SEA-based approaches has been central to debate in recent literature (e.g. Kørnøv and Thissen, 2001; Fischer, 2006; Retief, 2007; Noble and Christmas, 2008), structured and systematic effects assessment frameworks are essential to the success and credibility of strategically oriented regional CEA.

VEC-based, multi-scaled analysis

A multi-scaled approach is essential to gaining a true understanding of regional cumulative effects and being able to devise and inform the practices to effectively manage them. Ross (1998) cautioned that the larger the area covered by CEA the less likely a particular effect is to be identified as significant, because more other sources of effect get captured in the analysis. This may be true when considering the contribution of individual project stressors to cumulative change; however, as a strategically oriented process, regional CEA is not necessarily focused on individual actions but rather on cumulative stressors and VEC responses (Dube, 2003). In other words, the issues of concern in regional CEA are first the VEC conditions or effects, regardless of the individual point source or reasons for impact, and only then are the cumulative contributions of the individual stressors themselves of concern.

A major challenge in adopting such an effects-based approach is that "as the potential scale increases, some more local issues (e.g. noise, townscape) are likely to fall out and others (e.g. climate change, biodiversity) are likely to become more important" (Therivel and Ross, 2007: 382). This is of concern in strategic-based approaches to regional CEA in that not all cumulative processes play out at the same spatial scale. Thus, if broad regional and strategic analyses are to inform the scope of downscale project-based assessment, then localized and point source problems should not be overlooked.

In the Great Sand Hills, a broad regional scale was necessary to understand ecological processes and the cumulative impact of surface disturbance on biodiversity and ecological integrity, as well as to identify regional thresholds of concern. However, at the same time, regional biodiversity was found to be highly concentrated in several localized 'hot spots', each of which has the potential to be affected by the tyranny of smaller-scale, point-specific and project-induced stresses such as spills from gas well facilities, soil compaction, and localized road, infrastructure and cattle watering hole disturbances. In addition, a focus on local scale and site-specific variables and conditions, those typically of concern only in project-based assessment, was necessary to identify the underlying drivers of regional change, to better model future scenarios, and to understand how regional processes and conditions are formed.

In short, if regional CEA is to be meaningful to subsequent scale processes, then multi-scaled analyses are required. This will help ensure that the same issues can be revisited, where needed, not only at different tiers but also at different spatial scales (see João, 2007).

Integrated CEA

Integration has become a popular theme in environmental assessment over the past decade (see Sheate *et al*, 2003). At the most basic level, integration refers to regional CEA unfolding as part of the plan development process. In this way, CEA is able to shape the development of a regional plan by systematically evaluating the cumulative change associated with plan options and objectives.

As an integrated CEA, ecological integrity and sustainability criteria informed the selection of plan options to guide future land use in the Great Sand Hills. Rather than develop and present a plan that would be assessed for potential cumulative effects, the RES integrated CEA as part of the strategic framework for plan development. This provided a means by which environmental and socioeconomic objectives could inform planning and options assessment, and facilitated the early consideration of various stakeholder interests and objectives in scenario development rather than at the stage of plan delivery for final approval. Early opportunity for involvement was ensured with the release of a scoping document prior to RES framework development, on which public feedback was received, and by an ongoing public communications strategy consisting of a website and community newsletters. The result was clarification of stakeholder expectations early in the process, integration of local concerns and values in plan development, and minimization of opposition and conflict once the plan was finalized and presented for public review and approval.

Enduring concerns

Notwithstanding the aforementioned lessons and opportunities, a number of constraints to regional CEA were also evident based on the Great Sand Hills experience. Aside from context-specific challenges of data quality and availability for regional CEA, the Great Sand Hills experience reflects a number of broader issues of concern. These concerns are not new, and have been widely discussed in the academic literature; yet, only little progress seems to have been made in practice. Perhaps there is disconnect from practice, or it could be that the institutional capacity or willingness to address these concerns is just not there. Of particular concern are the following:

- *One-off assessments*: Like regional CEAs and strategic assessments elsewhere in Canada, the RES was initiated outside the regulatory environmental assessment process — in this case as a provincial government response to a prior land use planning commitment. As such, regional CEA is often seen as a 'one-off' (Dube, 2003) with no real mechanism to sustain it as an integral part of regional planning and downstream project assessment. Without the appropriate institutional support, even the most methodologically effective one-off regional CEAs will be of little significance to broader regional and sectoral decision-making and future assessments.
- *Limited tiering*: Closely related to the above is the lack of formal tiering mechanisms. Regional CEA *can* play an important role in downstream development and decision-making; however, to date this does not appear to be the experience in Canada. The intent in the Great Sand Hills is that recommendations emerging from regional CEA, and the RES itself, would inform and guide future development activities, land use zoning, and decision-making. However, like most other jurisdictions in Canada, there does not exist a formal tiered system of policy, plan, and program assessment to effectively carry regional CEA forward from the strategic to the project scale.
- *Inter-agency collaboration*: Essential to regional CEA is government agencies working in partnership to develop a management strategy in areas where future development is likely to occur (AXYS Environmental Consulting Limited, 2000). This requires a common vision and commitment, and clear delineation of roles and responsibilities for implementation of results and recommendations emerging from a regional CEA. A challenge in the Great Sand Hills was that different government agencies expressed different views concerning appropriate land use activities in the region. Further, many of the recommendations emerging from the RES which were deemed necessary to implement the preferred scenario — in particular regulatory issues and those concerning long-term financial or socioeconomic commitments — were beyond the scope and authority of the government agency and environment ministry in charge of the assessment process.

  Regional CEAs require a degree of inter-agency collaboration not typical of traditional project-based environmental assessments: a collaboration that requires joint commitment and crosses agency boundaries and responsibilities to achieve a common goal.
- *Follow-up and monitoring*: The need for regional CEA follow-up and monitoring is clear, as is the complexity of strategic-level follow-up processes. Environmental monitoring efforts to date in the Great Sand Hills have been fragmentary, and focused primarily on specific activities of the gas industry (through self monitoring and compliance monitoring) rather than also monitoring broad-scale regional environmental change. Emerging from the RES was a recommendation for enhanced coarse and fine-filtered monitoring programs to evaluate ecological change, determine whether the preferred scenario was achieving its objectives, and identify any negative impacts at the local scale that would require mitigation or remediation. However, even for the most basic regional CEA monitoring, capacity is at issue. Currently, for example, there are only 16 government field officers responsible for 62,000 oil and gas wells Saskatchewan-wide, expanding at the rate of 4,000 new wells per year; there are only three monitors in the Great Sand Hills and southwest portion of the province (Scientific Advisory Committee, 2007).

  Further, as suggested by Partidario and Arts (2005: 249), follow-up at the strategic level requires much more than the identification of monitoring indicators; it must also account for the 'splash', 'conformity', and 'strategic' effects of such initiatives. The challenge is that responsibility

Regional CEA is often seen as a 'one-off', with no real mechanism to sustain it as an integral part of regional planning and downstream project assessment. It also requires an exceptional degree of inter-agency collaboration

for monitoring and information sharing, how to follow-up on the strategic initiative itself, and how such information can or should inform subsequent actions or downstream assessment and decision-making processes remains unclear.

Conclusion

To date, regional approaches to CEA in Canada have been restrictive and focused on describing the current state of the environment or modeling system response to past or existing land use pressures, rather than on projecting trends and identifying desirable futures from a range of competing possibilities. Part of the reason, arguably, is that regional assessments have lacked a supportive SEA framework and, further, few such frameworks have been developed and successfully demonstrated in practice.

This paper introduced the SEA framework and approach to regional CEA developed and operationalized for the Great Sand Hills, Saskatchewan, Canada. The Great Sand Hills was a relatively ambitious regional CEA, its framework based on an SEA process and the culmination of planning experiences in the region. The assessment was guided by an overarching vision of regional sustainability and ecological integrity, and extended beyond the existing environmental assessment regulatory process to address the underlying symptoms of regional, cumulative environmental change. The final assessment document reported the current baseline conditions and trends of the region as a product of cumulative natural and anthropogenic-induced change over time, and identified a preferred conservation-based scenario for future land use and development.

Important to the success of the Great Sand Hills approach to regional CEA was its strategic framework, futures-oriented approach to cumulative effects consideration, structured spatial–analytical assessment framework, VEC-based multi-scaled analysis, and an integrated CEA and plan development process. In these regards, the Great Sand Hills experience should present considerable opportunity to learn from practice and improve regional CEA frameworks. That said, as Therevil and Ross (2007: 384) note, “these are the early days for strategic-level CEA” and “we expect strategic-level CEA to improve greatly in the next few years”.

Based on lessons learnt from the Great Sand Hills experience and elsewhere, areas in immediate need of development and better-practice guidelines include institutional support and tiering mechanisms for regional CEA, increased collaboration amongst government agencies and regional stakeholders to develop shared visions and responsibilities for regional assessment and implementation, and methodological and institutional frameworks to support regional monitoring and follow-up of strategic initiatives.

Notes

1. The Canadian Environmental Assessment Agency identified SEA, in particular principles and approaches for regional assessment and tools and methodologies to support good SEA, as a research and development priority for 2007–2008. The Agency’s priority areas can be found at <http://www.ceaa.gc.ca/015/priorities_e.htm>, last accessed 24 April 2008.
2. The Great Sand Hills RES, including web link to the report, was announced in the October 2007, volume 19, number 2 edition of the IAIA Newsletter. The website has since been modified, but a copy of the main assessment document is available at <http://www.environment.gov.sk.ca/>, last accessed 24 April 2008.
3. Proven (90%), probable (50%), and possible (10%) gas reserves are classified based on their likelihood of future commercial development.
4. The Great Sand Hills Scientific Advisory Committee members included Dr David Gauthier, University of Regina (chairperson); Dr Reed Noss, University of Central Florida (senior scientific advisor); Dr Bram Noble, University of Saskatchewan (strategic environmental assessment); Dr Polo Diaz, University of Regina (social capital); Dr Ben Cecil, University of Regina (economic capital); and Dr Paul James, Saskatchewan Environment (government liaison).
5. Valued Ecosystem Components (VECs) were interpreted in the broadest sense in the Great Sand Hills RES to include components of the biophysical, economic, and social environment.
6. See <http://www.ecology.uq.edu.au/index.html?page=27710> (last accessed 24 April 2008) for an overview of Marxan and for a link to Ian R Ball’s PhD thesis (Ball, 2000) which describes the mathematical foundation of the reserve selection algorithm.
7. See *The Great Sand Hills Regional Environmental Study* Chapter 3 (Scientific Advisory Committee, 2007) for a detailed discussion on biodiversity hot spot identification and the Marxan modeling process.

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