# GREAT SAND HILLS REGIONAL ENVIRONMENTAL STUDY

Great Sand Hills Advisory Committee
May 2007

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## List of Acronyms

| | |
|---|---|
| AAFC | Agriculture and Agri-Food Canada |
| AEGIS | Altered Ecosystem Generalized Incremental Simulation |
| AGCR | Crested wheatgrass |
| ARC | Alberta Research Council |
| BACI | Before-after-control-impact |
| BAIS | Baird's Sparrow |
| BHCO | Brown-headed Cowbird |
| BMPs | Best management practices |
| BRIN | Smooth Brome |
| CAPP | Canadian Association of Petroleum Producers |
| CCLO | Chestnut-collared Longspur |
| CCSP | Clay-colored Sparrow |
| CDC | Saskatchewan Conservation Data Centre |
| CHSU | Smooth Arid Goosefoot |
| CLUZ | Conservation Land-Use Zoning |
| CMI | Climate Moisture Index |
| CONI | Common Nighthawk |
| COSEWIC | Committee on the Status of Endangered Wildlife in Canada |
| CYR | Saskatchewan Culture, Youth and Recreation |
| DIF | Distance impact factor |
| EA | Environmental Assessment |
| EIA | Environmental Impact Assessment |
| EIS | Environmental Impact Statement |
| ENGO | Environmental Non-Government Organization |
| EPP | Environmental Protection Plan |
| ES1 | Environmental Sensitivity Lands 1 |
| ES2 | Environmental Sensitivity Lands 2 |
| GIS | Geographic Information System |
| GR | Saskatchewan Government Relations |
| GRSP | Grasshopper Sparrow |
| GSH | Great Sand Hills |
| GSHMA | Great Sand Hills Manufacturers Alliance |
| GSHPDC | Great Sand Hills Planning District Commission |
| GSH RES | Great Sand Hills Regional Environmental Study |
| HRSDC | Human Resources and Social Development Canada |
| HIS | Habitat Suitability Index |
| HOLA | Horned Lark |
| IPCC | Intergovernmental Panel on Climate Change |
| LSD | Legal subdivision |
| LBCU | Lon-billed Curlew |
| LUPU | Small lupine |
| MAGO | Marbled Godwit |
| NGO | Non-Government Organization |
| NWSEP | National Water Supply Expansion Program |
| PET | Potential evapotranspiration |
| PFRA | Prairie Farm Rehabilitation Administration |
| PPAs | Prime Protection Areas |
| PP or 2P | Proven and probable gas reserves |
| PPP or 3P | Proven, probable and potential gas reserves |
| PPT | Precipitation |
| PRVI | Chokecherry |
| RAER | Representative Area Ecological Reserve |
| RECD | Regional and Economic Cooperative Development |
| REDA | Regional Economic Development Authority |
| RES | Regional Environmental Study |
| RMs | Rural Municipality |
| RM #110 | Rural Municipality of Piapot |
| RM #139 | Rural Municipality of Gull Lake |
| RM #141 | Rural Municipality of Big Stick |
| RM #169 | Rural Municipality of Pittville |
| RM #171 | Rural Municipality of Fox Valley |
| RM #229 | Rural Municipality of Miry Creek |
| RM #230 | Rural Municipality of Clinworth |
| RM #231 | Rural Municipality of Happyland |
| ROC | Receiver Operating Characteristics |
| RSF | Resource Selection Functions |
| SAC | Scientific Advisory Committee |
| SAF | Saskatchewan Agriculture and Food |
| SARA | Species at Risk Act |

| | |
|---|---|
| SAVS | Savannah Sparrow |
| SCADA | Supervisory Control and Data Acquisition |
| SE | Saskatchewan Environment |
| SEA | Strategic Environmental Assessment |
| SHRO | Beaked annual skelton-weed |
| SIR | Saskatchewan Industry and Resources |
| SIAST | Saskatchewan Institute of Applied Science and Technology |
| SPIGEC | Saskatchewan Petroleum Industry/ Government Environment Committee |
| SPP | Summer precipitation proportion |
| SPPI | Sprague's Pipit |
| SPSS | Statistical Package for the Social Sciences |
| SPTO | Spotted Towhee |
| SWA | Saskatchewan Watershed Authority |
| TEACUP | Total Economic Activity under Current Productivity |
| TLEs | Treaty Land Entitlements |
| VECs | Valued Ecosystem Components |
| UPSA | Upland Sandpiper |
| VUOC | Six weeks fescue |
| WEDA | Western Economic Diversification |
| WEME | Western Meadowlark |

## Preface

On behalf of the Scientific Advisory Committee, we are pleased to submit the final report for the Great Sand Hills Regional Environmental Study.

Commissioned as an independent scientific authority, our mandate was to oversee the design and implementation of a Regional Environmental Study for the Great Sand Hills that focused on a strategic assessment of human activities that affect the ecological integrity or sustainability of this globally significant regional ecosystem.

This study is one of the largest, most complex, and most truly interdisciplinary research projects to be attempted for any region. Our goal was to present the methods and results in a form that is generally comprehensible and user-friendly. We acknowledge, however, that the complexity of this study made translation into common language challenging; hence, the reader will encounter some fairly technical concepts and terminology. Nevertheless, we made a concerted effort to present our recommendations clearly to policy makers and the public. Essentially, our recommendations focus on sustaining the ecological integrity of the Great Sand Hills and are grounded in the realities of natural, social and economic capital for the region. The recommendations are based on the weight of evidence from natural and social sciences studies, which consistently confirm that sustainability of human activity in the Great Sand Hills is reliant on the sustainability of ecosystem elements and processes that are not significantly perturbed by human activities. We ask that our recommendations be considered not singly but in their entirety.

While we have made every effort to insure that our recommendations take into consideration current policy and practice, it is inevitable that changes will occur that affect our recommendations. For example, in July of 2008, as proposed in the recent 2007 provincial budget, both the Large Corporation Capital Tax and Corporation Capital Tax Resource Surcharge have been proposed for elimination. Such changes will affect the impact that industry has on the region in relation to government revenues, industry perception(s) of the business climate in the region, and the on-going operating costs and associated profits of industry. In turn, there may be a suite of impacts to the local economy. Therefore, on-going economic re-assessment and valuation—combined with social and ecological studies—are critical for continued progress toward sustaining the natural, human, and economic capital of the study area.

We greatly appreciate the commitment and contribution of the many researchers, staff, contractors, and students who participated in this intense two-year study. In developing our recommendations, we benefited from the experience and insights of numerous individuals representing a wide range of interests throughout the Great Sand Hills and beyond. We also benefited from substantial contributions contained within pre-existing studies and plans. We hope that our efforts will contribute to serving the natural, economic and social sustainability of the Great Sand Hills in perpetuity.

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Dr. David Gauthier
Chair, Scientific Advisory Committee

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# GREAT SAND HILLS REGIONAL ENVIRONMENTAL STUDY
## – EXECUTIVE SUMMARY –

## INTRODUCTION

The Great Sand Hills (GSH) of Saskatchewan are nationally and internationally significant as one of the largest remnants of native grassland in Canada—an island of mixed-grass prairie and shrubland in a sea of intensive agriculture. The GSH have remained essentially intact with high ecological integrity because their sandy soils and rugged terrain are not conducive to cultivation and because urban and industrial development in the region are minimal. The GSH are located within the physiographic region known as the third prairie level, Alberta High Plains or Alberta Plateau Region. The GSH are the largest of the sand dune complexes within the region, dominated by aeolian landforms where sand deposits were laid down by glacial meltwaters and subsequently modified and reworked by wind. The sand dunes include both stabilized and active dunes of varying shape and height, interspersed with areas of sand flats. The great expanse of native vegetation, combined with the rugged terrain, provides diverse habitats for many species.

The GSH Study Area (see below) is sparsely populated with 6,709 residents in 2001, of which approximately 60% resided within the jurisdiction of settlements. Ranching, gas development, and recreation are the major human activities in the area. The provincial Crown owns over 85% of the land within the heart of the GSH—the Review Area (see below)—of which most is under grazing lease and additionally protected under *The Wildlife Habitat Protection Act*. All of the Review Area is believed to have high potential for natural gas development, an important source of revenue for the province and the communities surrounding the GSH. In 2001 the labour force participation rates in the GSH area were higher than the Saskatchewan average with the majority of reporting settlements and Rural Municipalities (RMs) exceeding the Saskatchewan median family income. The majority of the labour force is engaged in occupations associated with the primary industry—agriculture, including farming and ranching—which accounts for 60-80% of all employment in the region and reflects some of the highest concentration of agricultural employment in Saskatchewan.

The only First Nation with a reserve near the GSH is the Nekaneet, located 121 km southwest of Swift Current and occupying 5,602 ha of land. At least part of the Great Sand Hills lies within the Qu'Appelle Treaty, signed in 1874, and the area itself is of considerable historic, cultural, spiritual, and economic significance to many First Nations, including the Saskatchewan Treaty 4 First Nations and the Blackfoot Confederacy of Alberta, as well as numerous other First Nations groups in Saskatchewan and North Dakota.

Concerns over impacts of economic development in the GSH, and conflicts among ranchers, the gas industry, and environmental conservation interests, have been of public concern for many years. In 2004 the Great Sand Hills Land Use Review Committee presented a report, subsequently accepted by the Government of Saskatchewan, calling for increased protection of environmental resources of the GSH and for a Regional Environmental Study (RES). The Great Sand Hills Representative Area Ecological Reserve (RAER) was designated in March of 2005, closely following a commitment by Government to undertake an RES. A Scientific Advisory Committee (SAC) was assembled by the Minister of Environment to conduct the RES, which was to involve a strategic assessment of human activities that affect the ecological integrity and sustainability of the area. Furthermore, the RES would serve as a comprehensive evaluation of natural, social, and economic capital of the GSH region under alternative future scenarios of conservation and development.

This report outlines the methodology and results of the RES and provides strategic recommendations to guide human activities in the GSH so that the long-term ecological integrity of the area is maintained while a corresponding level of environmental, socio-cultural, and economic benefits are realized. The basic research approach of the RES, following the general philosophy of Strategic Environmental Assessment, is scenario analysis. Rather than showing what will be, a scenario shows what could be if particular trends and rates of change (for example, in land use or development) take place over time. By comparing multiple, alternative future scenarios, decision-makers, scientists, and the general public are able to obtain a vivid picture of the consequences of different policies, management plans, or courses of action. Such comparisons allow decisions to be based not only on what has happened in the past, but on potential future trends.

The GSH RES focuses on two nested regions, a Study Area and a Review Area. The Study Area is delineated by 8 RMs (Piapot, Big Stick, Fox Valley, Happyland, Clinworth, Miry Creek, Pittville, Gull Lake) that surround the GSH and are the focus of the social and economic baseline studies. This area covers 10,016.47 $km^2$ or approximately 1.71% of Saskatchewan's total landmass. The natural capital baseline studies focus largely on the Review Area, contained within the Study Area and delineated by the spatial extent of the dunes and grasslands of the GSH. The Review Area is 2028.9 $km^2$ (783.4 $mi^2$) of native prairie overlaying a more or less continuous surface deposit of unconsolidated sands. The area is sensitive to erosion if heavily disturbed. Currently the area is considered to have a high degree of ecological integrity, although invasive non-native plants are an increasing concern.

The GSH RES commenced with a baseline assessment (Part 2 of this report), which characterized the current and cumulative natural, social, and economic conditions of the GSH region that are consistent with its sustainability. This included an assessment of changes in selected baseline components over time. The baseline assessment was followed by an analysis of three alternative future scenarios. The scenario analysis phase examined the implications of alternative levels of human activity within the GSH, as indicated by deviation from current baseline conditions. The scenario projections focused on those human activities that have the greatest potential for surface disturbance and, therefore, for affecting the ecological integrity and sustainability of the GSH—namely those activities associated with gas development and ranching.

Recommendations associated with implementation of the preferred scenario included consideration of mitigation measures and monitoring requirements for maintaining the ecological integrity and sustainability of the GSH. The alternative scenarios considered in the RES, along with the assumptions and conditions of each, are detailed in Part 3. Recommendations consistent with the preferred scenario are discussed in Part 4. Each phase of the RES considered the input of affected stakeholders, interests, and First Nations.

## BASELINE ASSESSMENT

Natural gas development has been ongoing in the GSH since the early 1950s, with the most intense development occurring since 1980. Current gas production from known reserves in production in the area is estimated at over 180 billion cubic feet (BCF), and proved, probable, and possible reserves are estimated at nearly 670 BCF. There are currently 132,370 ha of gas leases in the region and an additional 7,996 ha of leases for gas exploration, together representing approximately 70% of the GSH land base. On over 1,400 surface leases with single and multiple well heads per pad there are more than 1,500 gas wells. Most well pad surface leases are developed in the west and southwest portion of the Review Area. Vertically drilled wells, typically with one well head per pad on a surface lease, represent 84% of the total well inventory. This development occurs in densities of up to 8 wells and 8 well pad surface leases per section in the Review Area. Lower-impact directional and slant drilling have occurred in some places, constrained, in part, by topography, reserve depth, cost, and the willingness of industry. In those areas where directional and slant drilling has occurred, there are cases where 8 wells per section have been sustained across only 1–4 well pads.

Activities associated with gas development have resulted in disturbance of native habitat at drilling sites, disturbance of habitat during pipeline construction, and an overall increase in human activity in the region. Although many of the individual disturbances associated with gas development are minimal in extent, and even positive for some disturbance-obligate species, gas development and maintenance activities cannot be considered independently of the impacts of roads and trails used for drilling and maintenance. In much of the gas-developed areas of the western GSH, for example, as well as in isolated patches on the eastern boundary, there are 2–3 $km/km^2$ of roads and trails, in many places exceeding 3 $km/km^2$. At the current scale of development, the cumulative impact of well pads and associated roads and trails for servicing infrastructure are overarching concerns in relation to sustaining the ecological integrity of the GSH, particularly in terms of the implications for biodiversity, habitat fragmentation, and the spread of non-native species.

Over 40% of participants in the RES baseline community social survey indicated some form of dependency on income from the gas industry, either in the form of wages from gas industry employment or from revenue generated from gas wells on their property. Approximately 85% welcomed gas development in the region and over two-thirds supported an increase in development of the gas industry, noting the positive impacts and benefits to regional communities and households. Indices of resource dependency and specialization in the GSH are higher than for many rural areas of the province, suggesting that the region is vulnerable to external market changes and government policies and initiatives both locally and beyond.

Livestock grazing has exerted a long-term and widespread influence on the landscape and integrity of the GSH. Ranching is considered by most respondents to be an ecologically acceptable activity in the GSH and acts as a cohesive influence for sustaining rural communities through support of local businesses and socially through helping retain population. The total current economic value of ranching in the GSH represents approximately

$45 million annually in revenues, rents, income, and sales to the local and regional economy. Total potential economic contribution of ranching is projected to be over $716 million in the next 15 years. However, many RES survey participants recognized the potential for environmental disturbance (e.g., dugouts and damaged pastures due to overgrazing) produced by ranching. Focal species habitat modeling suggested that although grazing is ubiquitous across the GSH, the most notable footprint is the over-concentration of animals around livestock watering holes. This concentration of animals has resulted in extensive vegetative trampling and soil erosion, poor range health, and an extensive network of permanent trails.

Baseline predictions of range health for the GSH suggest that 5% of the landscape is in an "unhealthy" condition, 42% in a "healthy, but with problems" condition, and 53% in a "healthy" condition. All three anthropogenic disturbances (gas well activity, roads and trails, and livestock watering holes) resulted in reductions of range health, but unhealthy conditions were most frequently associated with areas surrounding livestock watering holes. Reductions in range health around livestock watering holes were most pronounced within 250 m of the site. Reductions in range health due to gas well pads and roads and trails, while significant, are not as broad or as large in effect, with only slight decreases in range health within a 100-m buffer. Moderate reductions in range health in the vicinity of well pads appear to be partly due to aggregation of livestock. However, when considering the additive impacts of gas well pads and roads/trails and the sheer number of well pads and length of roads and trails, the cumulative reduction in range health from gas development is substantial.

In terms of focal species (i.e., the bird and plant species selected for detailed analysis in the RES), gas development itself does not appear to reduce occurrence; however, associated road and trail development does have negative impacts. Gas development activities at well pads produced no significant adverse impacts on the 8 rare and traditional-use plants considered in the baseline. However, most rare and traditional-use plants were not common in areas that coincide with current gas development, so it would be incorrect to conclude that expansion of gas activity would not result in significant impacts. Gas development is also associated with marginal increases in prevalence of crested wheatgrass, a non-native species that can lead to erosion of ecological integrity through reductions in native plant cover.

The presence of roads/trails has a significant, adverse impact on some rare plants, with the occurrence of species affected up to 100–300 m from roadsides. The greatest threat to many species, however, may be from livestock trampling or competition from non-native plants. The non-native and invasive plants, crested wheatgrass and smooth brome, increase substantially along roads and trails. The impacts of roads and trails are also negative for a number of native grassland birds, although several species appeared to be positively associated with gas well pads, which may reflect selection for structure (e.g., perch sites) or enhanced habitat conditions for disturbance-evolved species. For livestock watering holes, all but one native focal species with significant responses decreased in occurrence near watering holes, while non-native plants increased in occurrence.

In addition to the overarching concern of surface disturbance, a number of direct and indirect interactions among Valued Ecosystem Components (VECs) and driving forces of change are of concern in the GSH. A total of 25 priority VEC linkages were identified from the baseline assessment as significant to address in scenario analysis or to consider in management recommendations. Fourteen of these linkages and impacts relate in some way, either positively or negatively, to activities associated with gas development and various aspects of the natural, social, and economic environment. The key VEC linkages and impacts include the following:

- Employment in the primary sector dominates the region, more so than many other rural areas of Saskatchewan. Activities associated with gas exploration and development are a significant source of secondary employment in the region, either in the form of wages from gas industry employment or from revenue generated from gas wells on ranchers' properties. Approximately 40% of baseline social survey participants report having some form of secondary income or direct employment from the gas industry.
- Gas exploration and development is a major economic land use within the broader GSH region. The market value of over $500 million annually (exclusive of government revenues, at fall 2006 prices) suggests that gas development may contribute to the economic prosperity of the region.
- Gas exploration and development has not contributed significantly to human population stability in the Study Area RMs. Notwithstanding expansion in gas activity since 1980, the regional population has continued to decline. No significant long-term correlation exists between levels

or distribution of gas development and population change. Gas development, and its current pattern of hiring and investment, is apparently not a sufficient activity to maintain population or recover declining population.

• The regional population decline is attributed primarily to the loss of youth in search of education, income, and employment opportunities not currently available in the GSH. Overall, employment within the region is down over the last 25 years. There are no direct policies or programs in the Study Area to address population decline, nor are there regional or local policies or programs to support income and employment diversification.

• Some gas exploration and development industry firms have invested in excess of $171 million in the GSH region in land acquisition, bonuses, and infrastructure development. However, the firms that are the infrastructure investors are extra-regional, many of them extra-provincial, with much of the capital, profits, labour, and materials coming from outside the region. The result is a large investment, but little long-term financial benefits accrue to the people of the GSH.

• Gas exploration and development is seen as contributing positively to social conditions in the GSH through generating tax revenues to RMs and land owners, providing employment opportunities, and funding community activities. Gas development is also seen as negatively affecting social conditions through negative impacts on quality of life and deterioration of highway/road infrastructure by use of heavy equipment.

• Gas exploration and development, specifically drilling gas wells, has a short-term requirement for surface water resources. The water is typically taken from a landowner's dugout or slough. While isolated incidents of gas contamination of water sources have been reported due to pipeline leaks, there is no evidence of significant, adverse effects on the supply or quality of water for drilling. However, industry initiatives to manage impacts on water quality are largely self-regulated, and provincial and regional policies are perceived as either lacking or not sufficiently enforced at the local level.

• Although expansion of gas exploration and development is largely supported by social survey participants, there is widespread, local public perception that the GSH area is being affected adversely from road development, chemical spills, and damage to species habitat due to gas activity.

• Gas exploration and development, when considered cumulatively with associated roads and trails, negatively affects land cover and biodiversity, measured in part by focal species occurrence. The exceptions are disturbance-obligate focal species or those whose natural distribution is found primarily within gas-disturbed areas. Range health decreases near gas disturbance sites. However, the impact on land cover is less than that of cattle watering holes.

• Environmental assessment of gas exploration and development activities is a concern. The industry is relied on to implement and monitor best management practices. There is a noted dissatisfaction with governance, particularly the corporate capital tax, among oil and gas producers, and concern with regard to constraints to maximizing gas development.

• The coordination and complexity of governance and land-use regulations and policies are of concern. RM bylaws often reflect provincial policy, but they are not always consistent. Responsibilities over decision-making concerning land use and access are fragmented and sometimes contradictory. An overriding concern is the need for clear designation, zoning, and management of competing lands uses.

• The GSH are of significant cultural and spiritual significance to both the Treaty 4 and Treaty 7 First Nations, and they are concerned over the disturbance and removal of artifacts. Gas exploration and development is perceived as negatively affecting First Nations cultural and spiritual values of the GSH. An indefinite moratorium on gas development is called for by elders of both Treaty 4 (File Hills Qu'Appelle) and Treaty 7 (Blood Tribe).

• Current land cover in the GSH is considered an important source of medicines by First Nations. First Nations elders perceive development in the GSH to negatively affect medicine sources and the biodiversity of the region, and call for enhanced levels and scope of protection, particularly in current ES1 zoned areas.

• There are more than 200 heritage resource sites of archaeological significance within the GSH Review Area. These sites are most often discovered through the process of gas development. Gas exploration and development activities, including well pads and pipelines, have significant adverse impacts on heritage resources in terms of archaeological site disturbance.

• Terrain sensitivity models indicate that the topography and landscape within the GSH are highly sensitive to current anthropogenic disturbance. Disturbance is greater adjacent to livestock watering holes. On the other hand, recent research indicates no soils highly sensitive to acid deposition in the GSH.

• Land cover and water resources have a limited carrying capacity, and local perception and understanding suggest that ranching activity is not likely to increase significantly beyond current conditions.

• Governance issues in the GSH are related to the complexity and coordination of legislation first, and gaps or omissions in the legislation second. Information exchange among government departments needs improvement, especially regarding the sharing of ecological data. There is also an overall lack of enforcement mechanisms for environmental and regulatory violations and limited government coordination of efforts for data collection and monitoring for biodiversity protection.

• The current governance framework and land tenure for the GSH is perceived by First Nations as unduly restricting their access to traditional lands. First Nations currently do not see themselves as adequately represented in decision-making concerning GSH land use and future management.

## SCENARIOS

As part of the baseline assessment of natural capital, we used the site-selection algorithm, MARXAN, to highlight biodiversity hotspots and other areas of conservation importance within the GSH Review Area. MARXAN minimizes the total "cost" of a potential reserve design by identifying the smallest overall area needed to meet planning goals and by selecting planning units that are clustered rather than dispersed. In the scenario analysis phase, we used results from MARXAN to identify "core biodiversity areas," which were incorporated into the preferred scenario.

Roads and trails are a reasonable surrogate for anthropogenic surface disturbance in the GSH because they are used for most human activities. We stratified the GSH into a "highly-developed" area that contains substantial road and trail footprints and a "less-developed" area with fewer roads and trails. On average the GSH has approximately 1.5 $km/km^2$ of roads/trails. We defined highly-developed areas as those having at least 1.9 $km/km^2$ (average density plus 0.5 standard deviation) and less-developed areas as having less than 1.9 $km/km^2$. We restricted MARXAN analyses for selection of core biodiversity areas to the less developed zone, because this area is relatively more pristine and will be more practical to maintain in a condition of high ecological integrity.

Final biodiversity features targeted in MARXAN site-selection analyses included: 1) seven focal species of plants and birds from an identified grassland guild; 2) four focal species that were independent of other species; 3) absence of two non-native species; and 4) Sharp-tailed Grouse leks. We varied planning goals (i.e., the percent of a species, predicted suitable habitat included within a reserve design) according to global and provincial species status and rarity within the GSH. Although our site-selection exercises were restricted to the less-developed areas, we set goals based on habitat availability across the entire GSH, forcing MARXAN to meet those goals in the less-developed zone. We explored goal sets that varied from 20% to 65% averages, with subsequent discussions determining that the 30% goal be used, since it provided the clearest delineation of discrete core biodiversity areas.

We assessed trends in surface disturbances from 1979 to 2005 for three anthropogenic disturbances: 1) roads/trails; 2) gas well surface leases (i.e., well pads); and 3) livestock watering holes. Annual rates of change were determined from past trends and used to guide spatial modelling of future scenario landscapes in the year 2020. Our three scenarios varied in intensity and location of gas development and livestock watering holes. One of the three scenarios is the preferred scenario that minimizes human impacts on core biodiversity areas. We summarized current and future levels of gas well pads, roads/trails, and livestock watering holes, as well as changes to range health and two focal species (beaked annual skeleton-weed and the non-native crested wheatgrass), for each of 37 identified core biodiversity areas. Vulnerability of each core biodiversity area was ranked based on potential increases in surface disturbance from each scenario, i.e., potential changes in density of well pads, roads/trails, and livestock watering holes, as well as percent change in focal species habitat. Those core biodiversity areas with the greatest increase in surface disturbance were ranked as highly vulnerable, whereas those areas with low or even no change in surface disturbances were ranked low. In contrast, focal species vulnerability ranks were based on changes in habitat distribution, with those areas seeing the greatest loss of native species or gains in non-native species ranked as most vulnerable. Vulnerability ranks were used to summarize threats for core areas and prioritize conservation needs.

The three alternative future scenarios were defined as follows:

- Scenario 1: development of proven and probable gas reserves (2P); well spacing of up to 8 wells per section and up to 8 well pad surface leases/section; roads to each well pad; no new restrictions on livestock grazing; no new reserves or wetland protection.
- Scenario 2: development of proven, probable, and possible gas reserves (3P); well spacing of up to 8 wells per section and up to 8 well pad surface leases/section; otherwise same as Scenario 1.
- Scenario 3 (preferred scenario): 2P gas development, well spacing of up to 8 wells per section but only up to 2 well pad surface leases/section; new conservation protection or ecological reserves established in "core biodiversity areas"; new gas well drilling and both mineral and surface leases limited (see below) and no new watering holes in core biodiversity areas; wetlands protected.

From a 2005 baseline of 1,463 surface leases (1,559 gas wells), we projected an additional 1,446 well pads by 2020 (96/yr) for scenario 1 and 1,887 well pads by 2020 (126/yr) for scenario 2. Estimates were conservative because spatial simulations restricted future gas development from the RAER. Regardless of restriction due to RAER status, rates of gas development were forecast approximately twice (96–126 well pads/yr) that of historic trends (53–54 well pads/yr). (Note: the Recommendations section of this Executive Summary and Part 4 of this report presents our recommended specific conditions for uses of core biodiversity areas.) With those conditions within the core biodiversity areas and holding maximum well-pad density at 2 per section outside of core biodiversity areas, the preferred scenario resulted in a total of 309 new well pads. Although this represents a substantial reduction (21 well pads/yr) from baseline conditions (96–126 well pads/yr), directional or slant drilling from multi-well sites could be used to offset losses by maintaining a well density of up to 8 per section (i.e., 3 directional or slant wells per vertical well) outside of proposed core biodiversity areas (see Recommendations).

Based on simulations exploring road and trail development at four densities, we estimated that, on average, 420 m (3.8 km/mi$^2$ of total roads/trails) of additional road would be needed to establish each well pad, 1020 m (4.4 km/mi$^2$) for 2 well pads/section, 1,710 m (5.1 km/mi$^2$) for 4 well pads/section, and 2,980 m (6.3 km/mi$^2$) for 8 well pads/section. Locating well pads along existing roads with only short spur roads could substantially reduce total road development.

From a 2005 baseline of 3,175 km of roads and trails, we projected an additional 624 km of new roads to access well pads in scenario 1 and 814 km of new roads to access well pads in scenario 2. Annual rate of increase in kilometres of road was approximately twice that of historic (1979–2005) baseline rates, which would be necessary to match forecasted rates of increase in gas wells. Because new roads were modeled as a function of modeled locations of new gas well pads, the regions of the Review Area that saw the greatest increase in roads were the west, central, south, and northwest areas. By reducing gas development within core biodiversity areas and holding maximum well-pad density at 2 per section outside of core biodiversity areas, the preferred scenario resulted in a total of only 110 km of new roads. This represented an increase of 7 km/yr, a substantially lower rate of increase than baseline scenarios of 42 and 54 km/yr.

From a 2005 baseline of 507 livestock watering holes, we projected an additional 75 water holes (5/yr) by the year 2020 for scenarios 1 and 2. Locations of future watering holes were assumed to be available for areas further than 1,200 m from existing watering holes. We predicted that the "healthy" class of range health would decline for 6.2% and 7.3% of the landscape for scenarios 1 and 2, respectively, while the "healthy, but with problems" category would increase over 5.1% of the landscape for scenario 1 and 5.9% of the landscape for scenario 2. We predicted that "unhealthy" conditions would increase in baseline scenarios 1 and 2 by an additional 1.2% and 1.4% of the landscape, respectively. In contrast to the more ubiquitous distribution of new watering sites in the two baseline scenarios, the preferred scenario excluded watering holes from core biodiversity areas, resulting in a reduction of 24 watering holes or a total of 51 new sites. This represented an average increase of 3.4 new watering holes/yr from a baseline rate of 5/yr without considering core biodiversity areas. We predicted range health conditions in the Review Area under the preferred 2020 scenario as 50.9%

"healthy," 44.1% "healthy, but with problems," and the remaining 5% of the landscape as "unhealthy." Compared to range health conditions estimated for the 1979 landscape and those predicted for 2005, the preferred scenario reduced trends in degradation of range health, while both of the baseline scenarios were projected to increase degradation of range health.

For the two focal species we selected as primary indicators in scenario assessments—crested wheatgrass and beaked annual skeleton-weed—future landscapes showed continued loss of the rare native beaked annual skeleton-weed and an expansion in the distribution of the exotic plant, crested wheatgrass. Differences among scenarios suggested substantial benefits of the preferred scenario, whereas differences between scenarios 1 and 2 were marginal, with scenario 1's lower rate of anthropogenic disturbance resulting in slightly greater extent in beaked annual skeleton-weed and a smaller extent in crested wheatgrass. Scenario 1 and the preferred scenario resulted in a reduction in the rate of loss for beaked annual skeleton-weed and a gain in crested wheatgrass when compared to past trends. Further conservation action along with restoration and management, which were not considered in any of our scenarios, could potentially reverse negative trends and, for example, result in gains in habitat for beaked annual skeleton-weed and a reduction in the extent of crested wheatgrass.

When considering all species used in MARXAN site selection, the core biodiversity area with the highest biodiversity rank was an area in the southeast in an arm of the Review Area that contains a glacial tunnel valley complex. The presence of this geologically unique feature of the environment and associated high levels of biodiversity suggest that protection of this area is critical to the natural capital of the GSH. The RAER had a low overall biodiversity ranking, although this partly reflected our selection of focal grassland species that were not already well represented in the RAER. As we did not conduct field work in wetlands due to time constraints, or model wetland species and habitats, conservation ranks for some small wetland-based core biodiversity areas may be artificially low.

All conservation and sustainable development plans have costs as well as benefits. Whereas the benefits of conservation have been often difficult to quantify, costs can be summarized more readily in economic terms. The opportunity cost of implementing our preferred scenario includes, most prominently, a reduction in revenues from gas development, since we are recommending limited gas development in the identified core biodiversity areas.

Our economic analysis of the opportunity costs associated with implementation of the preferred scenario shows that the costs would be considerable, but slightly less than the costs already associated with designation of the current RAER. The total opportunity cost of implementing the preferred scenario, considering gas development alone, is approximately $32 million in lost revenues to Government (i.e., royalties, corporate taxes, mineral lease rentals, and surface lease payments) plus an additional $53 million in contributions to the local economy over the period of 2007–2021.

## RECOMMENDATIONS

The recommendations presented in this RES report (see Part 4) focus on sustaining the ecological integrity of the Great Sand Hills and are grounded in the ecological realities of natural, human, and economic capital for the GSH region. Our methods focused on integrating biodiversity information in strategic environmental assessment on landscape and regional scales.

### Governance and Institutional Arrangements

Existing institutional arrangements in the GSH region are not as effective as they should be. Information exchange among government departments needs improvement, especially regarding the sharing of ecological data. There is a need to establish a greater consensus and a clearer vision amongst government departments and agencies about the nature of and need for activities and land uses that are consistent with the principles of sustainability, and to communicate this vision to GSH stakeholders and First Nations. From our discussions with stakeholders and First Nations, there is considerable recognition of potential land-use conflicts and the need to resolve differences before they escalate to nonproductive or destructive levels.

Both the provincial government and the GSH Planning District Commission have generally been able to adapt to the demands of managing the GSH in the last 10 years, particularly in terms of promoting environmentally-sensitive development, but efforts are hampered by shortages of staff and other resources. Capacity building, both in terms of human development and physical infrastructure, is needed in the GSH region. At present, the lack of financial, human, and infrastructure resources combined with a lack of baseline data limits the overall effectiveness of governance and the scope of viable management options.

Two common issues were raised by stakeholders and

First Nations with respect to legislation affecting governance in the GSH. First, the scope of the legislation is inadequate to address the current mix of land uses and interests in the region. This is sometimes due to outdated legislation or legislation that has been conceived too narrowly to cover the range of relevant issues encountered in current management, as is the case with *The Provincial Lands Act*. Second, legislation and management mechanisms lack sufficient enforcement, making it difficult for responsible authorities to prevent or curb undesirable activity.

At present, government is criticized by the gas industry for failing to provide a clear and timely development approvals process, a situation that can be attributed partly to the controlling influence of the RMs. There is also confusion around the purpose and powers of the GSH Planning District Commission, and a strong call to amalgamate the bylaws of RMs, coordinate the mandates of government departments, and simplify the development process in the GSH. The most common suggestion to improve governance is to establish a central, higher-level governing body with decision-making power, supported by an effective and balanced network of interests focused on long-range planning.

## Environmental Assessment

The environmental assessment (EA) program in Saskatchewan has been in existence since the mid 1970s. Legislation formalizing what had been learned in practice was put in place in 1980 with the creation of *The Environmental Assessment Act*. In the spirit of strategic environmental assessment, this Regional Environmental Study (RES) of the GSH focused on understanding the environmental limitations and opportunities for development in this ecologically sensitive area. The Scientific Advisory Committee (SAC) believes that such regional landscape-based approaches will help Saskatchewan realize its vision for sustainability, by providing insight into the complex nature of development decisions and integrating ecological and socio-cultural interests with the desire for economic development before irreversible decisions and actions are taken.

Nonetheless, the SAC's review of the assessment process and its historical application in the GSH revealed some serious concerns. Our concerns lie not within the Act itself, but in the changing way that the Act has been applied over the last 20 years, especially with respect to cumulative environmental effects. For example, in the GSH as each gas development project came on stream, the proponents were not required, as part of their EA, to consider their impacts as additive to those of other projects already approved. The SAC believes that it is imperative that this trend be reversed.

We summarize our detailed recommendations as follows:

*Specific Recommendations: Reserve Area (Core Biodiversity Areas)*

- The current level and distribution of protection of biodiversity in the GSH is inadequate. In order to represent viable examples of grassland vegetation and associated focal species habitat, additional areas in the south and west of the Review Area require protection. We recommend that all 35 sites identified as core biodiversity areas in this study be provided a level of protection equal to that of the current Representative Area Ecological Reserve.
- The Saskatchewan Government should pursue avenues to achieve Ecological Reserve designation for core biodiversity areas using appropriate means, including but not limited to mineral rights buy-backs and land trades.
- Until such time as an Ecological Reserve designation is achieved, those areas should receive elevated statutory conservation protection so as to be protected from further surface disturbance and should be immediately subject to the following conditions: 1) no new mineral or surface leases are allocated; 2) existing leases are grandfathered; 3) no more than one gas well pad per section is permitted: 4) where gas development has already occurred, any new development must occur on existing well pads; 5) no further development of roads; 6) activities will be conducted only within the confines of existing pads, roads, and trails; 7) reclamation and monitoring are applied to the highest practical standard; 6) ranching operations are allowed only to the extent that they support and do not compromise the maintenance of the natural ecological system and its components.
- Saskatchewan Environment (SE) in consultation with other provincial government departments, Rural Municipalities, First Nations and local leases should, as quickly as practical, develop and implement a land management plan for the Representative Areas Ecological Reserve and the 35 core biodiversity areas in the Review Area.

*Specific Recommendations: Non-Reserve Areas*

• New well pads, watering holes, and associated roads/trails in the Non-Reserve Area of the Review Area should be restricted according to ecological information.

*Specific Recommendations: Land-use Zoning*

• The boundaries of ES1 and ES2 zoning designations should be altered to correspond with the boundaries identified in this study for Reserve and Non-Reserve Areas, respectively.

*Specific Recommendations: Fire Ecology*

• Government should take the lead role in introducing fire to the landscape with a pilot fire education program to show fire as a natural process and to show producers how the introduction of controlled fire can promote range health. We recommend continued experimentation with prescribed fire as a means of restoring and maintaining range health in the GSH. We also recommend that a programme be established to compensate local ranchers to conduct prescribed burning to reduce encroachment of shrubby vegetation in grasslands. This programme could be funded by government, ENGOs, and other private donors.

*Specific Recommendations: Wide-ranging Species*

• Key species were not considered in this Regional Environmental Study, because data were inadequate to consider them rigorously, including wide-ranging mammals that require vast areas larger than the GSH to maintain viable populations. Among these species is the pronghorn antelope. We recommend that research be undertaken to better understand the requirements of wide-ranging species, such as pronghorn antelope, that use the GSH on a permanent or seasonal basis.

*Specific Recommendations: Surveys and Databases*

• We recommend increased funding of Saskatchewan Conservation Data Centre (CDC) to support sufficient staffing for maintaining up-to-date, high-quality, and relevant databases.
• Ord's kangaroo rat has not been systematically surveyed in the GSH. We recommend surveys of sites predicted to support this species, recording presence or absence, updating habitat models, and protecting sites with confirmed occupancy. Additional systematic surveys of non-habitat should be considered to ensure accuracy of predictions of non-habitat.
• An organized inventory and ongoing monitoring of wetlands in the GSH is needed.

*Specific Recommendations: Communications Plan*

• We recommend a communication plan for landowners and lessees through a partnership of government (local and provincial), industry, and academia that highlights best management practices for biophysical surveys and a permitting plan for research activity on leased land.

*Specific Recommendations: Governance*

• The Province of Saskatchewan should define its provincial interests in the GSH and take responsibility to ensure that rules, regulations, and policies of the Rural Municipalities in the GSH are consistent with the province's rules and regulations concerning land management in the area.
• The SAC strongly endorses the need for Government, in consultation with stakeholders and First Nations, to find effective mechanisms for the early resolution of land-use conflicts. Government should promote the joint participation of different stakeholders and First Nations in the decision-making processes in regard to the GSH as a way to identify different interests and promote consensus.
• The various roles of government departments and agencies in planning and decision-making in the GSH, as well as current legislation and land-use plans, need to be clarified to all stakeholders. We recommend strengthening the character and mandate of the Great Sand Hills Planning District Commission to play a more direct, and centralized role in land-use planning, regulation, and decision-making in the Great Sand Hills. Among our specific recommendations is for the Commission to adopt the structure of a corporate board with governance and management responsibilities and decision-making authority.
• A follow-up mechanism for reviewing best management practices should be established for

the GSH through the GSH Planning District Commission. Environmental monitors should be responsible to the local municipalities through the Commission. The Commission itself should employ a full-time senior Environmental Manager to oversee environmental monitoring activities and auditing of best management practices in the GSH. The position would be funded jointly by the provincial government and the Commission membership. The Environmental Manager should have the mandate to review industry and government environmental monitoring data and programs in the GSH, and to release to the public an annual follow-up report that documents the "state of best management practice compliance and performance" in the GSH.

• A centralized information/resource system should be established to house annual monitoring reports, industry EPPs, RM bylaws, regulations, and community economic profiles and investment/infrastructure profiles concerning the GSH region. This information would be housed and managed by the GSH Planning District Commission, and made available to its members and to outside parties as determined appropriate by the Commission.

• We recommend that the GSH Planning District Commission receive a sustained funding commitment, the balance of which is sourced by the provincial government. Such funding would be directed toward: 1) a paid Executive Secretary position for the Commission; 2) a paid Environmental Monitor Coordinator position for the Commission; 3) funding long-term ecological monitoring and data sharing; and 4) meeting regular Commission operating costs. Special funding arrangements also should be established on a cost-shared basis with the RMs, industry, and other members as appropriate, to support Commission special research initiatives, monitoring, and development projects.

### *Specific Recommendations: Acts and Regulations*

• The final report and recommendations of the GSH RES should be subjected to a full review pursuant to *The Environmental Assessment (EA) Act*. The body and recommendations of the RES report should contribute to the scientific foundation of an eventual Regional Sustainability Plan focused on the maintenance of ecological integrity within the GSH.

• The EA process should be modified to include consideration of the cumulative effects of all land-use projects in order that a more realistic assessment of the impacts of human activities on the ecological capacity of GSH can be determined.

• The SAC recommends that further guidance and decision support criteria be developed for determining "development" under section 2(d) of *The Environmental Assessment Act*.

• The SAC identified a number of concerns and recommendations in relation to monitoring gas activities and associated best management practices in the GSH. For those gas development activities that do trigger the full environmental impact assessment process under section 2(d) of *The Environmental Assessment Act*, a formal post-approval follow-up mechanism is necessary. The objectives for a follow-up program under the Act should be to: 1) verify that proposed environmental and socioeconomic mitigation measures have been implemented; 2) verify that implemented impact mitigation measures are working as intended; 3) verify the accuracy of project impact predictions; and 4) identify and manage unanticipated environmental and socioeconomic impacts.

• Government should review the purpose and effectiveness of the current *Provincial Lands Act* and revise, replace, or update the Act to address current land activities in the GSH and new interests on Crown land.

• Both government agencies and First Nations are concerned that while *The Heritage Property Act* is successful in the protection of "built heritage," there is inadequate attention to the designation and protection of heritage properties based on aesthetic or First Nations' spiritual or cultural values. *The Heritage Property Act* should be amended to clearly provide for the protection of heritage sites based on aesthetic and cultural grounds, and ensure that joint management of such resources occurs, where applicable, with the affected First Nations.

### *Specific Recommendations: Reducing Impacts*

• Gas mineral lease holders should be required to use directional/slant drilled wells. Specifically, multi-well pads with directional/slant drilled wells or a combination of directional/slant drilled wells with a vertical well on the same pad are recommended.

• Given the sensitive nature of soils in the GSH Review Area, and the serious threat of non-native plant species invasion, it is critical that areas subject to human-caused surface disturbance or exotic plant species invasion undergo reclamation back to a near-native state in a timely fashion. We support the employment of permanent environmental monitors to identify areas for surface reclamation and for special management of non-native plant invasion. A reclamation fund should be created to ensure that proper reclamation activities take place, even if original stakeholders no longer operate in the area. This fund should also support reclamation research projects. Reclamation activities should be overseen by a joint partnership between industry, agriculture, a revitalized Great Sand Hills Planning District Commission, the RMs, the lessees, and the Province.

• Measures capable of decreasing the surface impacts of gas industry activity on the sensitive environment of the GSH and surrounding areas should be examined and put into practice. All relevant technologies toward that end should be employed, and new practices and methods with a high potential to contribute to the reduction of surface disturbances should be investigated.

• In order to maintain an environmentally sound ranching industry, best management practices for range management (including water management) must be consistently implemented by ranchers. The provincial government has an important role to play in working with ranchers to develop, communicate, and assist in implementing best management practices.

• An improved and more transparent process is needed for management of incidents that impact negatively upon the environment during construction, operation, and decommissioning of any development on the land (e.g., distributed water systems, gas wells). Affected RMs and landowners/lessees should be involved with full regard to the constraints of due process.

• Before the approval and construction of any new distributed watering systems in the Review Area, the proponent should make a request to Saskatchewan Agriculture and Food (SAF) and SE. Provincial agencies should provide assistance with location preference and gathering of information on rare and endangered species.

• An environmental assessment process should be required prior to installing distributed watering systems. Overall grazing pressure should be controlled in areas receiving distributed water, such as by use of management-intensive grazing, rotational grazing, or rest-rotation grazing, in order to maintain range health. We also recommend intensive monitoring of the overall and cumulative effects of distributed water systems on the GSH ecosystem. Research and monitoring of distributed watering systems is necessary to make valid predictions about long-term impacts on range health, invasive plants, and sensitive focal species.

• We recommend that fragmentation of natural habitats in the GSH by roads, trails, pipelines, and other linear disturbances be controlled and ultimately reduced, accompanied by intensive monitoring of ecological impacts. Specifically, we recommend a combined approach in which no new roads or other surface disturbance are allowed in the Reserve Area (i.e., existing RAER and 35 new core biodiversity areas), and that best management practices are applied and monitored in the Non-Reserve Area across the GSH Review Area. We also recommend quantification of the use of roads as part of the ongoing monitoring of and adaptive management within the GSH. Management actions that limit road development, both in the form of new conservation areas and best management practices, are likely to have the greatest impact on conserving the biological resources of the GSH.

*Specific Recommendations: Monitoring*

• Within one year of the date of this report, an ongoing environmental monitoring program for the GSH should be designed and implemented.

• Monitoring efforts to date within the Review Area have been fragmentary, inadequate, and primarily focused on the specific activities of gas projects, such as well drilling. To build and maintain the GSH environmental monitoring program, partnerships should be established, first between the primary users (government, industry, agriculture, NGOs) of the area and then with external sources of monitoring expertise, such as the Alberta Biodiversity Monitoring Program.

• A monitoring program should, as a minimum, include the following features: 1) coarse and fine filter monitoring approaches; 2) standardized protocols and rigorous design; 3) centralized monitoring metadata and data storage and access, including data held by industry; 4) dedicated environmental monitors; 5) mandatory cradle-to-grave project monitoring; 6) continued research on response of species to gas development.

*Specific Recommendations: Reclamation*

• Within one year of the date of this report and in order to reflect the latest techniques available, we recommend that the Saskatchewan Government establish an inclusive review process of existing reclamation guidelines that involves appropriate government agencies, industry representatives, stakeholders, First Nations, and industry.

• To ensure the restoration of land subject to surface disturbances irrespective of their cause, we recommend that a reclamation fund be established in the same manner as that proposed for environmental monitoring in the Review Area.

• The Orphan Wells Program needs to be supplemented to cover the broader reclamation of surface disturbances not associated with gas development, including the elimination of pockets of invasive, non-native plant species before they become widely established. As with monitoring, the responsibility for such funding should come from all parties creating surface disturbance; however, the government must take the lead role and allocate for this purpose some of the revenues (e.g. gas royalties, taxes, surface lease payments) generated from the Review Area.

• Environmental monitors (as identified in earlier recommendations) should be used to survey the GSH area for areas requiring surface reclamation or management of non-native plant species invasion; these monitors should also track the progress of reclamation projects.

• We recommend extensive conservation, restoration, and management activities in the GSH, including reclamation of gas line routes and abandoned roads and well pads, as well as eradication of non-native plants wherever feasible.

• Many areas of disturbed soil within the GSH require restoration. Our models suggest that appropriate management and restoration could lead to gains in habitat.

• Only locally adapted native seed sources should be used for reclamation; all seed sources must be carefully scrutinized for contamination by unwanted plant species.

*Specific Recommendations:*
*Sustaining Regional Communities and Economies*

• We recommend that Saskatchewan Agriculture and Food re-evaluate the amount of compensation to agriculture leaseholders for gas surface leases in the Review Area. We suggest that Government look to other jurisdictions for potential examples of more equitable crown lessee compensation policies for gas well pad surface leases.

• We recommend Government consultation with First Nations as part of the GSH RES implementation strategy, and that the consultation processes adopt the principles outlined in *The Government of Saskatchewan Guidelines for Consultation with First Nations and Métis People: a Guide for Decision Makers*.

• We urge that consultation for RES implementation include both Saskatchewan First Nations interests and the interests of the Blackfoot Confederacy of Alberta, who claim the GSH as their traditional territory and as an area of contemporary cultural and spiritual significance.

• To facilitate ongoing consultation and knowledge sharing post-RES implementation, we recommend the establishment of a "Council of Elders and Traditionalists," with whom governments and industry would be able to consult to ensure that proper protocols are followed with regard to issues of development, land use, land access, and heritage resource management, and to ensure that the sacred nature of the GSH is properly addressed.

• Ceremonial sites of particular interest to First Nations should be identified as part of the RES implementation process, based on consultation with Treaty Four and Treaty Seven members or the Councils of Elders and Traditionalists.

• The immediate purpose of First Nations access to the GSH is to engage in spiritual and cultural activities, such as ceremonies and the collection of medicinal plants. Although the SAC cannot recommend access to particular areas, as many are potentially subject to a Crown lessee agreeing to such access, every consideration should be extended to permit First Nations access to land within the GSH for spiritual ceremonies and medicinal plant collection. First Nations membership on the GSH Planning District Commission could facilitate such negotiations.

- A protocol should be established between industry, government, and First Nations concerning the treatment of disturbed heritage sites.
- We recommend that the Government of Saskatchewan, through Regional Economic and Cooperative Development (RECD) in partnership with the local Regional Economic Development Authorities (REDAs) and Western Economic Diversification (WED), develop a series of information sessions, mailings to businesses, and workshops, detailing the specific application procedures and success strategies for Provincial, REDA, and WED programs and initiatives, be offered to the employers of the region. In addition, we recommend that a partnership of government agencies (RECD, REDA, and WED) develop a close working relationship with the GSH Planning District Commission to improve program uptake and increase local adoption of the various labour and employment programs.
- We recommend that the Government of Saskatchewan, through Saskatchewan Finance, grant business tax relief for 3 years to those businesses that are provided provincial or federal support through labour and employment programs and provide new employment opportunities. A progressive income tax structure for new employment also should be created. For those RMs that have indices of economic specialization above 50, for every new job created outside the sector of concentration, an income tax credit of 10% of gross earnings should be provided to each new employee for the first 5 years of employment.
- We recommend that the Government of Saskatchewan, through Saskatchewan Finance, establish a property tax break for 3 years for individuals who are new "non-traditional" sector employees, if during their 5 years of income tax credits for employment in the region (based on the above recommendation), they purchase a new home or a home 20% more expensive than their previous (owned) dwelling.
- The Government of Saskatchewan, through RECD, Saskatchewan Finance, and in partnership with the GSH region banks and credit unions, should establish business loans for those businesses outside the dominant economic sectors (agriculture and gas extraction) with below prime interest rates for new operations/divisions/ ventures that support value added services to the dominant sectors.
- The Government of Saskatchewan, through Saskatchewan Finance, should eliminate corporate taxes for the first 10 years of operations for new businesses in the GSH region, followed by a reduced corporate tax rate (for example, from 42% to 30%). This reduction of tax rates should provide incentives to locate businesses not in the major population centres, but in smaller communities.
- We recommend that the Government of Saskatchewan, through RECD and in conjunction with information sessions from economic development agencies such as WED and the REDA, provide educational workshops to help small manufacturers develop business plans and marketing strategies.
- To further facilitate economies of scale, we recommend that the Government of Saskatchewan, in partnership with the GSH Planning District Commission, create a Great Sand Hills Manufacturers Alliance (GSHMA). The GSHMA would serve as an intermediary between local firms and the gas sector or other large potential contract providers.
- We recommend that Saskatchewan Environment in consultation with other provincial government departments, RMs, and local lessees, implement improved education in best management practices for ranchers.
- We recommend that dedicated environmental monitoring officers be hired for the region with a special focus on members of the ranching communities. These monitoring officers would conduct various environmental surveys (water quality, invasive plants, soils, etc.), monitor the application and use of best management practices in the region, and conduct educational workshops.
- We recommend that one-time baseline assessments of water quantity and quality be established as soon as possible, and that ongoing water quality and quantity comparisons throughout the region be conducted by the environmental monitors. A water quantity and

quality assessment and statement should be completed prior to any on-site gas development.

• The Government of Saskatchewan, through Saskatchewan Tourism, Saskatchewan Transportation, the Southwest Saskatchewan Tourism Association, the local communities, and the GSHDPC, should create a coordinated and integrated regional tourism plan built upon the foundations of ecologically sensitive tourism and recognition of the economic, social, and historical forces that shape the region, past and present. A historical route, complete with cairns, roadside pullouts, and stops at the various museums, is appropriate for the region.

• The Government of Saskatchewan, through RECD, should develop and implement a "hire local, buy local" policy for gas firms operating in Saskatchewan, and develop a local industry capability assessment framework (similar to the assessment from HRSDC for skilled foreign workers). The GHSPDC and the newly proposed GHSMA would serve as intermediaries facilitating dialogue between the gas industry and local manufacturers.

• We recommend that the Government of Saskatchewan, through SE and under the auspices and direct assessment of the environmental monitors proposed herein, require that "environmental performance bonds" be posted by all gas companies operating in the GSH Study Area. The bond can be cashed in the event of a leak, seep, blow-out, water contamination, or other form of environmental disturbance, to pay for immediate remediation efforts. The bonds may also serve to provide income loss payments to lessees when remediation takes productive land/water out of operational use.

• The SAC recommends that the Government of Saskatchewan, through SIR, conduct a comprehensive assessment of current and projected gas reserves and their economic valuations every 3–4 years.

## CONCLUDING COMMENTS

The Great Sand Hills Scientific Advisory Committee has given careful consideration to issues of ecological integrity of the Great Sand Hills and to the situation faced by local communities. The recommendations of the SAC are designed to contribute towards a sustainable future for the GSH and its communities using a balanced approach founded on principles of sustainable development. Our recommendations are based upon our scientific studies of the past two years and our assessment of past studies and plans for the GSH. All of our recommendations are consistent with our preferred sustainability scenario. We suggest that our recommendations, and the studies on which they are based, be considered in their entirety as an integrated package serving the needs of regional communities and the people of Saskatchewan.

# PART 1

## GREAT SAND HILLS REGIONAL ENVIRONMENTAL STUDY
## – INTRODUCTION TO STUDY –

# Chapter 1: Overview of Regional Environmental Study

## 1.1 GENERAL DESCRIPTION AND CONTEXT OF THE GREAT SAND HILLS REGIONAL ENVIRONMENTAL STUDY

In 2002, the Saskatchewan government called for a review of the 1991 Great Sand Hills Land Use Strategy.[1] Concerns over impacts of economic development on the GSH and conflicts among the interests of ranchers, the gas industry, and environmental conservation interests in the area triggered the review. The review evaluated the Land Use Strategy and made recommendations regarding the future direction of human activities in the region. The Great Sand Hills Land Use Review Committee presented its report in June 2004. The government accepted the report in principle, calling for increased protection and for a Regional Environmental Study. The Great Sand Hills Representative Area Ecological Reserve (RAER) was announced on March 10, 2005 with amendments to *The Ecological Reserves Act* introduced by the Minister of Environment on March 24, 2005. The designation and amendments were designed to lead to improved management of the Great Sand Hills.

In December of 2004, shortly before the designation of the new ecological reserve, the Government of Saskatchewan committed to undertake a Regional Environmental Study of the Great Sand Hills, with the study to be managed by a capable, independent institution. A Scientific Advisory Committee (SAC) was assembled by the Minister to conduct the Regional Environmental Study (RES). The RES was to involve a strategic assessment of human activities that affect the ecological integrity, as well as the sustainability, of the area. Furthermore, the RES would serve as a comprehensive evaluation of natural, human, and economic capital of the Great Sand Hills region under alternative future scenarios of conservation and development. Notably, the RES was designed to identify and meet social, economic, and ecological goals simultaneously and in such a way that benefits to all three categories are realized and are sustained over time. Such integration has been identified as a key factor in the success of any ecosystem management project (Keough and Blahna 2006).

Saskatchewan Environment staff took the lead in assembling the SAC. The current members of the SAC are:

- Chair: Dr. David Gauthier, Vice President (Research and International), University of Regina
- Senior Scientific Advisor: Dr. Reed Noss, Biology Department, University of Central Florida
- Member: Dr. Polo Diaz, Sociology Department, University of Regina
- Member: Dr. Paul James, Director, Environ mental Monitoring Branch, Saskatchewan Environment and Adjunct Professor, Canadian Plains Research Center, University of Regina
- Member: Dr. Bram Noble, Geography Department, University of Saskatchewan
- Member: Dr. Ben Cecil, Head, Geography Department, University of Regina

## 1.2 PURPOSE AND GUIDING PRINCIPLES OF THE REGIONAL ENVIRONMENTAL STUDY

The Regional Environmental Study (RES) provides strategic recommendations to guide human activities in the Great Sand Hills so that the long-term ecological integrity of the area is maintained while a corresponding level of environmental, socio-cultural, and economic benefits are realized. The RES was the result of an objectives-led, integrated, and strategic assessment process, based on the evaluation of a range of development scenarios and predicted environmental impacts for the region (see Figure 1-1-1 for a satellite photo of the Great Sand Hills Region).

The GSH RES adopted an integrated approach to Strategic Environmental Assessment (SEA), where environmental assessment and the integration of socio-cultural and economic impacts unfolded at the same

1. See Chapter 3 for a description and review of previous planning initiatives.

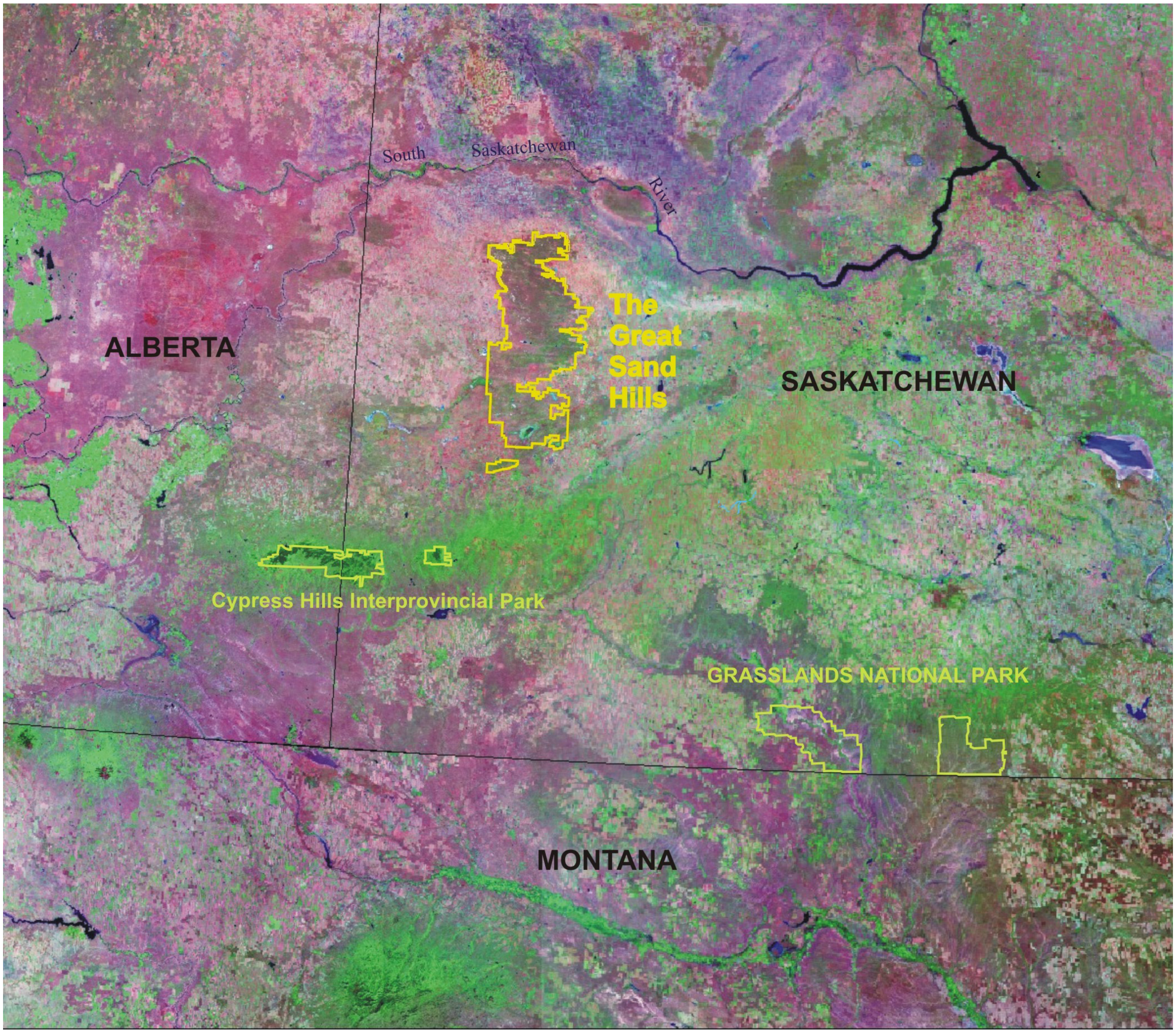



Figure 1-1-1. GSH RES spatial boundaries.

time as the planning and decision-making. Rather than developing a plan that is presented and then measured against various objectives, targets, or regulations, an integrative approach ensures that sustainability criteria are met during the development of the plan. This approach has a number of advantages including increased clarity for the plan objectives and (at least preliminary) evaluation of a broader range of alternatives.

The RES is based on the principles of sustainable development as outlined in the 1996 Bellagio Principles and stated in the RES Terms of Reference. In the context of the current study, these principles include:

- Guiding visions and goals: a clear vision and goals of sustainability and ecological integrity for the Great Sand Hills.
- Holistic perspective: consideration of the Great Sand Hills as an integrated ecological and social system, as well as its component parts.
- Essential elements: consideration of economic development and other activities in the Great Sand Hills region that contribute to social and cultural well-being.
- Adequate scope: adopting a regional approach, large enough to include both local and longer distance impacts and activities that affect the ecological integrity of the region and the well-being of society.
- Practical focus: adequate scoping of a limited number of concerns and issues for analysis.

- Openness: accessible researchers and proven research methods.
- Effective communication: public terms of reference, use of newsletters and websites for regular communication with all interests.
- Broad participation: representation of key interests and affected parties in research design and data collection.
- Ongoing assessment: capacity development for repeated measures and monitoring programs.
- Institutional capacity: clear assignment of responsibilities and provision of support for research and decision-making.

See: http://www.iisd.org/measure/principles/bp_full.asp for further details of the Bellagio Principles.

## 1.3 OVERVIEW OF RES STUDY OBJECTIVES AND ACTIVITIES

The Regional Environmental Study accomplished several tasks in its analysis of potential future scenarios of the Great Sand Hills (GSH). Specifically, this study:

- Characterized the current environmental, socio-cultural, and economic dimensions of the GSH, and trends in these dimensions over recent decades, in the form of a baseline assessment.
- Used the baseline assessment and information on trends to develop alternative future scenarios. The impacts of these scenarios were predicted for the year 2020 by means of a cumulative risk and vulnerability analysis. A preferred alternative was developed, which is intended to balance natural, social, and economic well-being in the spirit of sustainable development.

To facilitate the implementation of the study Saskatchewan Environment (SE) entered into an agreement with the University of Regina to handle all financial and administrative functions. The baseline studies portion of the RES (see Part 2) included a number of specific, detailed analyses of current natural, social, and economic conditions across the GSH as well as past and current trends in land use and other activities. The major categories of this analysis are the following (under the headings of each type of capital).

### 1.3.1 Natural Capital Data/Research Categories

- Climate profiling: Climate variables (temperature, precipitation) were summarized across the region, and climate change was projected into the future.
- Surficial geology, soils, and topography were mapped; a digital elevation model was created at high resolution from LIDAR imagery to provide details of topography and landform.
- Gas reserves: The study documented the amount and extent of known and anticipated natural gas reserves and forecast their development under the Study Area, as well as technological options for accessing them.
- Water (surface and groundwater): The study described regional groundwater resources, including the status and characteristics of aquifers.
- Land cover and land use: The study identified and mapped current land cover (including plant community types) and land use.
- Biodiversity: The study identified and mapped key components of biodiversity including species at risk that occur in the GSH, and undertook focused field surveys to document locations of particular focal species. The distributions of these species were modeled across the region and their responses to land-use activities (i.e., gas development, roads/trails, livestock watering holes) were predicted under three alternative future scenarios.

### 1.3.2 Human Capital Data/Research Categories

- Population and community: The study provided an understanding of aspects of regional and local population and community characteristics.
- Quality of life measures: The study included an assessment of perceptions and measures of quality of life for people living within the GSH region.
- Governance: The study documented the current management structure and decision-making context of the GSH region.
- Heritage Resources: Heritage resources (e.g., archaeological sites), which provide important information about past and current ways of life in the GSH, were thoroughly documented and mapped.
- Aboriginal use and culture: The baseline documented traditional land use and land-use patterns, use values, and Treaty Land Entitlements (past, present, and proposed) primarily through the use of traditional knowledge.

### 1.3.3 Economic Capital Data/Research Categories

- Land-use patterns: The study collected and mapped data to indicate the current distribution of water and land use, grazing and ranching, gas development, recreation and tourism, and other commercial and industrial activity.
- Commercial activity and productivity: Types of business and commercial activity in the region were surveyed as measures of commercial and industrial economic productivity.
- Income and employment: Income and employment data were collected in order to characterize the following:
  - Regional and community employment and unemployment levels.
  - Seasonality of employment.
  - Household income and income sources.
  - Income, occupation, and employment levels by economic sector.

### 1.3.4 Sustainability Scenarios

The basic research approach of the RES, following the general philosophy of Strategic Environmental Assessment, is scenario analysis. A scenario can be defined as "a hypothetical sequence of events constructed for the purpose of focusing attention on causal processes and decision points" (Kahn and Wiener 1967:6). A scenario represents a plausible but unverifiable account of change in a set of conditions over a defined period of time. Rather than showing what will be, a scenario shows what could be if particular trends and rates of change (for example, in land use or development) take place over time. By comparing multiple, alternative future scenarios, decision-makers, scientists, and the general public are able to obtain a vivid picture of the likely consequences of different policies, management plans, or courses of action. Such comparisons allow decisions to be based not only on what has happened in the past, but on potential future trends, which may include a number of surprises (Theobald 2007). When alternative scenarios are mapped in a spatially explicit way, which is possible with geographic information systems (GIS), stakeholders are able to visualize change in real landscapes and engage in discussions that would not otherwise be possible. Nevertheless, because the human mind is limited in the number of scenarios that it can visualize and compare simultaneously, most planners agree that the number of scenarios must be kept small (i.e., 3-5).

To assist our analysis of alternative scenarios we applied software commonly used by conservation planners to select a "portfolio" of sites that meets a given set of planning goals in the smallest area or at the lowest cost or conflict. This approach allows for a systematic evaluation of conservation options and results in an efficient solution. We used the MARXAN site-selection algorithm to develop portfolios of planning units that meet quantitative planning goals for all mappable features of interest in the study (for example, local populations or occurrences of rare species, high-quality habitat for species of interest, intact examples of all biophysical habitat types). MARXAN minimizes total portfolio cost by selecting the smallest overall area needed to meet established goals and by selecting planning units that are clustered rather than dispersed. As will be described in Part 3, we made numerous MARXAN runs, with varying goals, to determine portfolios that meet stated goals for natural, human, and economic capital in the GSH region under each of the alternative future scenarios. Importantly, we were able to identify sites within the GSH that have the most to lose if not protected from development or otherwise managed wisely—i.e., irreplaceable sites. Conversely, we were also able to identify sites that could be developed for economic gain with less threat to biodiversity or ecological integrity. Many of these areas have already been substantially modified by past land-use activities.

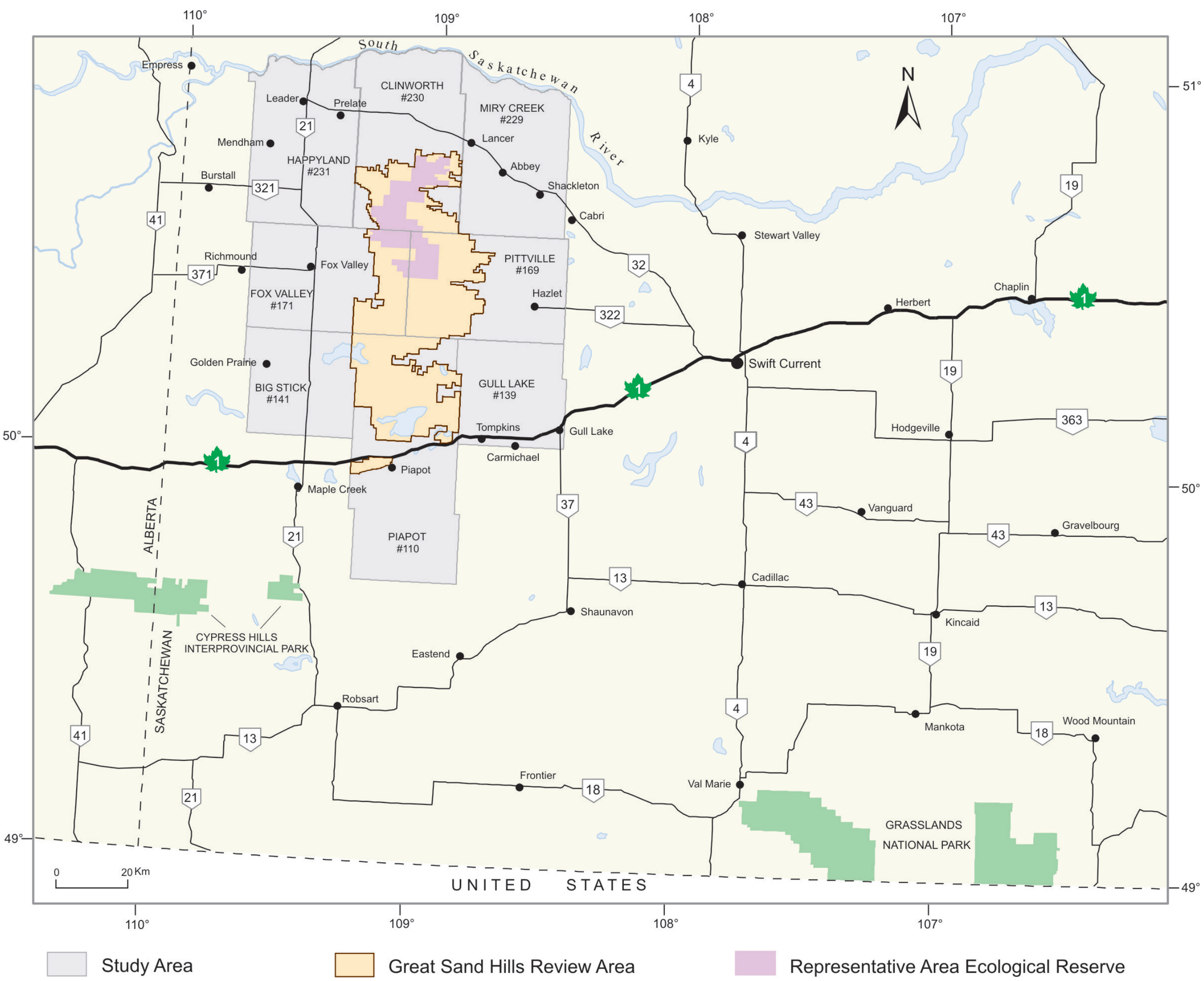
The RES was a collaborative study involving many researchers and discussion with many interest groups, including a variety of stakeholders and First Nations. A project web site was launched in May 2005 at www.se.gov.sk.ca/GSH to communicate news of the study to the public.

## 1.4 RES SPATIAL AND TEMPORAL BOUNDARIES

Spatial and temporal boundaries provide a frame of reference and assist in determining the level of analysis in effects assessment. Regional-based SEA is defined by both ecological and social boundaries, considering geographic relationships, common resources, and activities not only from the perspective of the Valued Ecosystem Components (VECs; See Table1-1-1) but also from the perspective of policies, plans, land uses, and other interests that may interact with any proposed sustainability scenario. In this regard the GSH RES consists of two principal spatial boundaries: a "Study Area" and a "Review Area" (note Figure 1-1-2). The Study Area is delineated by 8 Rural Municipalities (Piapot [110], Big

Table 1-1-1. GSH RES Valued Ecosystem Components.

| Natural capital | Human capital | Economic capital |
|---|---|---|
| regional climate | regional demographics | regional economic base |
| economic geology | regional and community change | regional economic change |
| gas reserves | quality of life | community economic change |
| water resources | local governance | quality of life |
| land cover and biodiversity | Great Sand Hills use and change | economic contribution of government |
| terrain sensitivity | First Nations use and culture<br>governance instruments | |
| soils | | |
| heritage resources | | |



Stick [141], Fox Valley [171]), Happyland [231], Clinworth [230], Miry Creek [229], Pittville [169], Gull Lake [139]) that surround the Great Sand Hills and are the focus of the social and economic baseline studies. This area covers 10,016.47 $km^2$ or approximately 1.71% of Saskatchewan's total landmass.

The natural capital baseline studies focus largely on the Review Area, contained within the Study Area, delineated by the spatial extent of the Great Sand Hills' dunes and grasslands. The Review Area is 1942.5 $km^2$ (750 $mi^2$) of native prairie overlaying a more or less continuous surface deposit of unconsolidated sands. The area is extremely sensitive to erosion if the vegetation is heavily disturbed. The area is considered to have a high degree of ecological integrity at present, although a recent survey of exotic plants found many present (Gerry and Andersen 2003), hence the need for continued vigilance into the future. Ranching, gas development, and recreation are the major human activities in the area. The provincial Crown owns over 85% of the land, of which most is under grazing lease and additionally protected under *The Wildlife Habitat Protection Act*. All of the Review Area is believed to have high potential for natural gas development, an important source of revenue for the province and the communities surrounding the GSH.

When defining spatial and temporal boundaries for the RES, two types of information were considered: the "activity information" and the "Valued Ecosystem Components (VEC) information" (Irwin and Rodes 1992; see Table 1-1-1). The activity information refers to the types of effects that a particular plan option or land-use scenario might generate, such as biodiversity loss or increased economic productivity. VEC information refers to the particular processes that may result from such effects, and include interactions between VECs and the implications for existing policies and land uses. In this regard, the study boundaries for the GSH RES adhere to the following good-practice principles:

- Large enough to include relationships between existing plans and activities, and the affected VECs (Cooper 2003).
- Cross jurisdictional boundaries and allow for interconnections across systems (Shoemaker 1994).
- Respects ecological boundaries (Beanlands and Duinker 1983).
- Adopts different scales for the assessment of different VECs (Shoemaker 1994).
- Set at the point where many ecological effects become insignificant by focusing on a core area or maximum detectable zone of influence (Scace et al. 2002).
- Encompasses both local and regional bounds (Canter 1999).

Temporally, the RES considers the cumulative effects of human activities from the 1950s to present, based on decadal changes, and projects forward to the year 2021 to assess the sustainability of various surface disturbance scenarios.

## 1.5 THE STRATEGIC ENVIRONMENTAL ASSESSMENT PROCESS AS A GUIDE TO THE REGIONAL ENVIRONMENTAL STUDY

The overall objective of the RES was to provide strategic recommendations, in the form of a management plan or plans, to guide human activities in the Great Sand Hills so that the long-term ecological integrity of the area is maintained while economic benefits are realized. The plan was the product of an objectives-led, integrated, and strategic assessment process, based on the evaluation of a range of development scenarios and environmental impacts for the region, so that the development of the area is sustainable.

The overall approach for the RES was based on Strategic Environmental Assessment (SEA) methodology (see Noble 2000, Noble and Storey 2001), which in turn is consistent with empirically validated principles for success in ecosystem management (Keough and Blahna 2006). Strategic environmental assessment is a systematic process for evaluating the biophysical consequences of policies, plans, programs, or proposals to ensure that they are addressed on par with economic and social considerations early in the decision-making process. Strategic Environmental Assessment is an important tool in the progress towards sustainable development because it provides decision makers with information that allows them to make better-informed decisions. Some of its general principles and characteristics follow:

- Is set in the context of a broader regional vision that establishes particular goals and objectives.
- Examines strategies to accomplish these goals and objectives.
- Addresses alternative options and asks which one is preferred.
- Maximizes positive outcomes by selecting the most positive option at an early stage.
- Includes past experience, identifying preferred futures, and forecasts the effects of alternative options.

- Is a proactive rather than a reactive approach.
- Leads to a strategy for action.

The GSH RES, as modeled on the SEA methodology, commenced with a baseline assessment, which included a documentation of past and current trends in land use, and was followed by an analysis of alternative future scenarios and the development of a set of detailed recommendations for maintaining the natural, human, and economic capital of the GSH into the future (Figure 1-1-3). Each phase of the RES considered the input of affected stakeholders, interests, and First Nations and served to inform decisions concerning the future management and integrity of the GSH. Early opportunity for public involvement was ensured through the release and advertising of guidelines for a Terms of Reference for the GSH RES in 2004. A regular communications strategy consisting of a project website and community newsletters was maintained throughout the RES process.

### 1.5.1 Baseline Assessment

The baseline assessment phase served to focus the RES by identifying and characterizing the current and cumulative natural, social, and economic conditions of the Great Sand Hills region that are most important to its sustainability. This included an assessment of changes in selected baseline components over time considering pressures from past and current activities in the region. Emphasis is placed on scoping key stressors, land-use issues, management concerns, linkages between baseline components, and delineation of the key social driving forces of change.

### 1.5.2 Scenario Analysis and Recommendations

The scenario analysis phase examined the implications of alternative levels of human activity within the GSH, as indicated largely by surface disturbance and deviation from the current baseline conditions. Information derived from the baseline assessment was used to project trends in environmental and socioeconomic conditions, assuming rates of land-use, environmental, and economic change developed under each of three scenarios. The projections focused on those human activities that have the greatest potential for surface disturbance and, therefore, for affecting the ecological integrity and sustainability of the GSH—namely those activities associated with gas development and ranching.

Recommendations associated with implementation

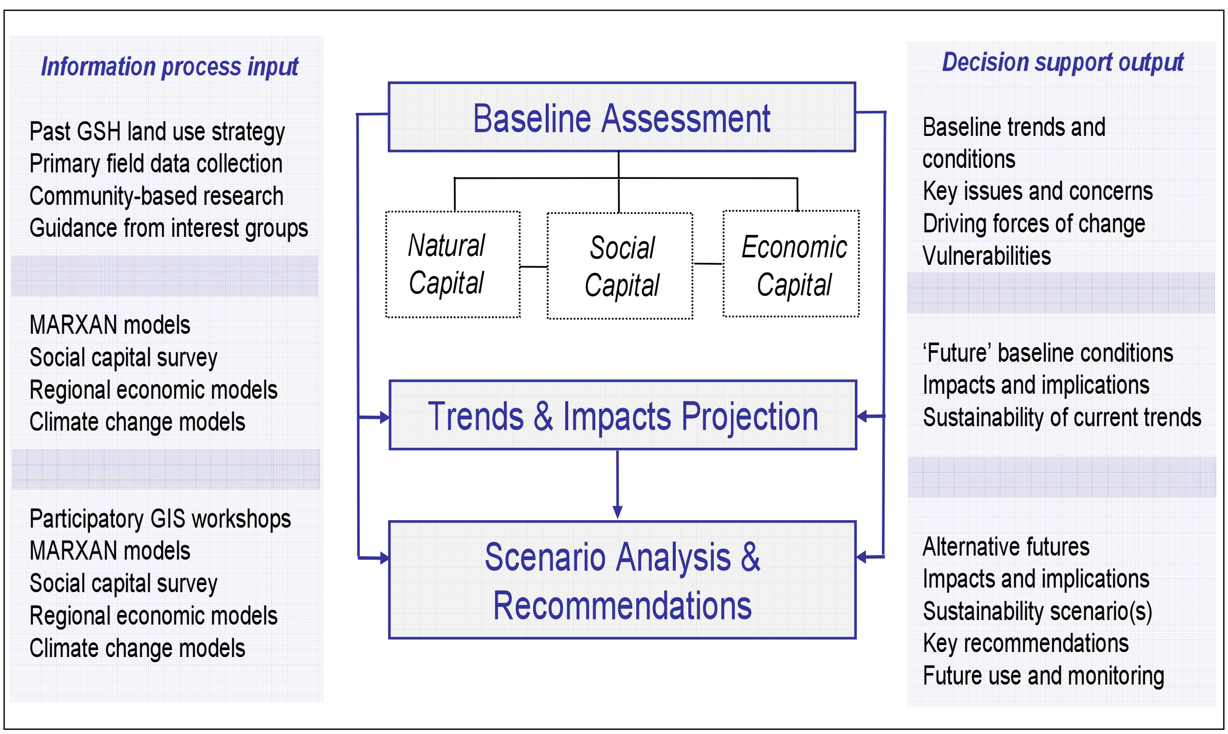



Figure 1-1-3. GSH RES overall framework.

of the preferred scenario included consideration of mitigation measures and monitoring requirements for maintaining the ecological integrity and sustainability of the GSH. The alternatives considered in the RES, along with the assumptions and conditions of each, are detailed in Part 3. Recommendations consistent with the preferred scenario are discussed in Part 4.

### 1.5.3 Guiding Considerations

The following considerations guided the RES:

1. Sustainable Development – The management of the area today should not compromise the ability of future generations to derive the same benefits.
2. Socio-economic and Cultural – Social and economic values are considered as part of the assessment process.
3. Ecological Scale – The primary basis for ecological assessment should be at the coarse or landscape/ecosystem level, including the approach to species at risk.
4. Cumulative Approach – The ecological impacts of human activities to date should be used as the basis for considering the type and extent of future human activities. Information collection and input from stakeholders is therefore important.
5. Human Footprint – The short-term impacts of all human activities should be minimized, especially those that remove vegetation cover. Emphasis should be placed on new or emerging techniques that minimize human impacts. Over the longer term, human activities must not reduce the area's ecological integrity.
6. Protected Areas – Areas considered too sensitive for industrial activity should be highlighted for provincial-level protection. Such areas include sites of cultural significance.
7. Restoration – Areas where the vegetation cover has been significantly altered should be restored to their original plant communities. Invasive, non-native plant species should be controlled and/or eradicated.
8. Monitoring – A program of ecological monitoring should be established within the Study Area, both for short- and long-term human impacts, including monitoring of restored areas. The monitoring program must be based on valued ecological components and include clear identification of objectives, targets, and early warning indicators of undesirable change.
9. Groundwater Conservation – A plan for the long-term conservation of the groundwater resource under the GSH is required.
10. Climate Change – Recommendations for human activities should try to incorporate the potential effects of predicted climate change in the area.

## 1.6 DELIVERABLES

The work that produced this RES was divided into several stages. Initially, it focused on creating a core group of experts (the Science Advisory Committee: SAC) that includes natural and social scientists at universities. The SAC oversaw the creation of a work plan that identified tasks, timelines, and responsibilities for the various milestones of the project, including the production of interim reports. The ultimate deliverable was decided to be an ecosystem-based, integrated, sustainable development plan that addresses future development scenarios and includes the following components:

1. An assessment of the current baseline condition considering pressures from past and current activities in the region.
2. An assessment of alternative future scenarios within the context of the current and projected baseline, where each scenario considers various combinations of the cumulative effects of each of the following activities at varying intensities or rates:
   - Gas development
   - Road construction
   - Cattle grazing

   and, as feasible:
   - Recreation and eco-tourism
   - Other potential development
3. Identification of a strategic direction and preferred scenario, which includes the establishment of potential impact mitigation measures (i.e., "best management practices") and a monitoring and adaptive management framework. The plan would include consideration of Values, Objectives, Indicators, and Targets. For the purposes of the study, "Values" are specific characteristics or qualities of the ecosystem, considered to be important to an interested party. "Objectives" are broad statements describing a desired future state or condition for a specific Value of the ecosystem. "Indicators" are variables that measure the state or condition of a specific Value of the ecosystem, and for which one or

more “Targets” are set. A “Target” is a quantitative or qualitative measure that the management of the ecosystem should maintain or move towards. It can be monitored, evaluated, and if necessary, adjusted over time.

The assessment predictions in this report include not only the ecological, but also the socio-economic and cultural impacts that could occur at various levels of development corresponding to the alternative future scenarios. The impact considerations are presented in a similar way with a range of impact significance/probability highlighted (e.g., Low, Medium, High). The respective definitions/assumptions are outlined for each scenario and a comparative analysis of scenarios highlights the costs and benefits of each in the full range of environmental impacts.

## 1.7 TIMELINES AND STUDY ORGANIZATION

Saskatchewan Environment provided administrative coordination to the study and established the SAC before Christmas 2004. The group’s work plan was approved in early 2005 so that field seasons for that year could be planned (Ultimately, however, contracts for field work in 2005 were delayed). Interim annual reports were produced by the end of that year. Activities in 2006 were undertaken to fill gaps identified through review of the interim reports. Extensive surveys of focal bird and plant species were conducted in summer 2006. This final report was submitted to SE in March 2007.

The following summarizes these dates and key milestones:

| *Date(s)* | *Deliverable(s)* |
|---|---|
| December 2004 | Establish membership of core expert partnership (the SAC) |
| February 2005 | Develop work plan |
| June-October 2005 | First field season |
| December 2005 | Interim reports |
| April-August 2006 | Second field season |
| March 2007 | Final report |

# Chapter 2: Biophysical and Socioeconomic Characteristics of the Great Sand Hills

## 2.1 CLIMATE

The climate of the Great Sand Hills is cold, semi-arid steppe. In some years the cold sub-humid climate from further north shifts into the region, creating moister conditions, whereas in other years the cold, semi-arid climate prevails (Epp and Townley-Smith 1980). Monthly mean temperatures range from approximately -14º C in January to approximately 19 Cº in July. Recorded temperature extremes are -42.8º C, which occurred in January, and 40º C, which occurred in July (Environment Canada Atmospheric Services). The GSH region receives on average 316 mm of precipitation annually—245 mm of rain and 71.4 mm of snow (Environment Canada Atmospheric Services). The prevailing winds are from the west-northwest with a mean annual wind speed of 24 km/h. Monthly mean wind speeds range from 20.5 km/hr in July to 26.4 km/h in January. The strongest recorded wind gust was 140 km/h and the maximum recorded hourly wind speed was 112 km/h (Environment Canada Atmospheric Services). Wind has a major effect on evaporation rates and significantly affects landform features, as revealed by the parabolic dunes, linear lanes between dune clusters, and dune tongues all trending largely east-west (Mollard et al. 1990). High groundwater tables in deep depressions between dunes suggest that there is little external runoff from the dune area and that rain and snowmelt quickly infiltrate to the water table, causing it to rise and stabilize vegetation (Mollard et al. 1990).

The western sections of the GSH tend to be more susceptible to destabilization from prevailing westerly winds. This is indicated by large blowouts and large bare sand patches in this area. Drought conditions also influence dune stability. However, David (1972) suggests that 20–30 years of drought are necessary to produce climate-induced, large-scale dune activity. Climatic conditions have been important factors in producing the physical features of the GSH and in determining the region's biodiversity. Climate also controls and constrains land use. Based on historical evidence, climate-induced changes in the GSH are highly likely, but may occur slowly and somewhat unpredictably, with vegetation change lagging behind climate.

## 2.2 LANDFORMS

The Great Sand Hills are located within the physiographic region known as the third prairie level, Alberta High Plains (Hart and Hunt 1980) or Alberta Plateau Region (Richards and Fung 1969). In Saskatchewan, the third prairie level comprises all lands west of the Missouri Coteau to the western boundary of the province. Regionally, the GSH are part of a larger natural region known as the Bigstick Lake Plain (Barclay and Weichel 1979) which lies between the South Saskatchewan River to the north and Cypress Hills upland to the south. This region consists of glacio-fluvial, glacio-lacustrine, and morainal deposits of undulating to rolling topography. In several areas the glacio-fluvial deposits including outwash and delta plains have been reworked by wind action to form sand dunes and interesting dune complexes.

The GSH area is the largest continuous area of sand dune complexes in souther Canada (David 1977). It is dominated by aeolian landforms where sand deposits were laid down by glacial meltwaters and subsequently modified and reworked by wind. The GSH thus comprise stabilized and active sand dunes of varying shape and height interspersed with areas of sand flats. The GSH name can be misleading by conjuring an image of great relief and topography. The entire north section lies almost entirely between 708.8 m (2325 ft) and 747.0 m (2450 ft) above sea level, a vertical difference of 38.2 m (125 ft). Few individual dunes rise more than 15 m (49.2 ft) above the surrounding plain. The relative ruggedness of the topography is the result of steeply sloping dunes located close together.

Factors of relief, frequency or density of dunes, slope steepness, and the presence of active or stabilized dunes were used to create a detailed classification of landforms by Epp and Townley-Smith (1980). Eight distinctive landforms were then identified within the north section of the GSH:

1. Sand flat: level topography, very low frequency of dunes, very low dunes under 2 m, no moving sand, 3.6% of the north section.
2. Low stabilized dunes: local steep slopes, high frequency of dunes, low dunes under 3 m, no moving sand, 7.8% of the north section.
3. High stabilized dunes: local steep slopes, high frequency of dunes, dunes over 3 m, no moving sand, 57.6% of the north section.
4. Sand flat-low stabilized dunes: local steep slopes, intermediate frequency of dunes, low dunes under 3 m, no moving sand, 14.9% of the north section.
5. Sand flat-high stabilized dunes: local steep slopes, intermediate frequency of dunes, high dunes over 3 m, no moving sand, 5.5% of the north section.
6. Low-high stabilized dunes: local steep slopes, high frequency of dunes, variable dune height, no moving sand, 9.8% of the north section.
7. Active complexes: local steep slopes, variable dune frequency, variable dune height, moving sand, 0.5% of the north section.
8. Intermittent lake beds: flat, no moving sand, 0.2% of the north section.

Much of the central part of the GSH and over half of the total area comprises the high stabilized dunes landform. In this landform, dunes are over 3 m in height and variations are dependent on the extent of level ground between individual dunes and the amount of relief of the dunes.

Active dunes consitute a very small percentage of the total area although they provide the most popular image of the hills. The active dunes occur in four distinct clusters in the Straw Road, Yakowan, Rastad, and Wachiwan areas (see Saskatchewan Environment and Public Safety 1991). These tend to be the highest relief areas within the Hills. The combination of high relief and active dunes create the most spectacular and picturesque of the landscape features of the Hills. All dunes of the GSH are of the parabolic type (David 1998), with a convex slipface pointing downwind and wings pointing upwind. Several variations of this basic form, as well as combinations of these variations into compound dune forms, have been classified by Peter David of the University of Montreal (Wolfe and David 1997).

There are few water bodies within the GSH. The presence of several dry lake and slough beds attests to former conditions of higher precipitation. These shallow water bodies are in fact the surface manifestation of a high groundwater table. The coarse texture of the sandy soil leads to rapid internal drainage of any precipitation. This high degree of infiltration combined with low rainfall and snowfall have prevented the development of a surface drainage system. There are no streams, creeks, or rivers within the GSH.

The Saskatchewan Institute of Pedology has classified the soils of the area as being susceptible to wind erosion, once surface disturbance has taken place. The sparse ground cover, limited organic material, low moisture holding capacity of the soil, and broken topography create a situation of great sensitivity to disturbance. The GSH have been largely uncultivated due to the sandiness of the soil and the sharply divided topography. The land is much more suited to grazing than to cereal crop production. The rugged topography has constrained settlement and major road development with the result that only one grid road crosses the GSH and most ranch homes are located on the periphery. The sensitivity of the GSH to disturbance also presents a constraint to a variety of other social and economic activities including grazing and intensive infrastructure development.

## 2.3 FLORA AND FAUNA

The Great Sand Hills are a unique ecosystem rich in native flora and fauna. The great expanse of native vegetation in the GSH, combined with the rugged terrain, provides diverse habitats for many species of plants and animals. The lack of significant agricultural cultivation, and urban or industrial development, has resulted in an island of relatively intact native prairie surrounded by cultivated lands. Epp and Townley-Smith (1980) produced a list of the vertebrate fauna of the GSH, which reports 5 species of amphibians, 70 species of birds, and 19 species of mammals. No reptiles were found in their study, but have been found in other studies. A number of species occurring in the GSH are protected under federal and/or provincial species-at-risk legislation.

The distribution and status of game species in the GSH are reasonably well documented. Important game species include mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), pronghorn antelope (*Antilocapra americana*), and Sharp-tailed Grouse (*Tympanuchus phasianellus*). As a consequence, hunting is an important recreational activity in the GSH. Interestingly, the natural predators of these ungulates, chiefly grey wolf (*Canis lupus*) and cougar (*Puma concolor*), are occasionally reported within the GSH, but little is known about their status and distribution. We speculate that these animals may have connections to populations further south and west into the U.S., probably through the Cypress Hills, which straddle the Saskatchewan-Alberta border just north of the border with Montana. Field research is needed on these species, especially given increasing evidence of the keystone role they often play in ecosystems (i.e., by controlling prey abundance and distribution in a more "fine-tuned" way than hunting, hence contributing substantially to vegetation health; Ripple and Beschta 2005).

The distribution and density of plant species in the GSH are determined by several factors including climate, topography, aspect, depth to groundwater, soil type, the present state of soil activity (stabilized versus destabilized), and current land use. A detailed inventory of the flora of the GSH was not attempted in this study. However, a new vegetation map has been prepared using satellite imagery, and field surveys were conducted for species of interest (e.g., rare and characteristic species and invasive exotic species). Previous vegetation surveys of the GSH include a sample plant species survey in the 1970s by Epp and Townley-Smith (1980). They developed a list of vascular plants, but did not attempt to map species distribution across the GSH. Deciduous trees found scattered throughout the area are primarily plains cottonwood (*Populus deltoides*) and trembling aspen (*Populus tremuloides*) (Mollard et al. 1990). Both species are indicative of moist habitats. The largest area of plains cottonwoods occurs in the southwestern portion of the area and was designated as a Special Use Zone in the 1991 Great Sand Hills Land Use Strategy. Dense stands of shrubs are also found in the GSH, including sagebrush (*Artemisia cana*), rose (*Rosa sp.*), snowberry (*Symphoricarpos occidentalis*), wolf willow (*Elaeagnus commutata*), creeping juniper (*Juniperus horizontalis*), bearberry (*Arctostaphylos uva-ursi*), chokecherry (*Prunus virginiana*), and Saskatoon berry (*Amelanchier alnifolia*).

The dominant grass species present include needle and thread grass (spear grass; *Stipa comata*), sand reed grass (*Calamovilfa longifolia*), june grass (*Koeleria cristata*), and wheat grasses (*Agropyron* sp.). Blue grama (*Bouteloua gracilis*) is also present but less abundant. A variety of perennial forbs are found in the GSH, with hairy golden aster (*Chrysopsis villosa*) one of the most common. Others include beaked annual skeleton-weed (*Shinnersoseris rostrata*), spiny yellow flax (*Linum rigidum*), wild begonia (*Rumex venosus*), and lance-leafed psoralea (*Psoralea lanceolata*). Lance-leafed psoralea and wild begonia are usually the first to invade active sand surfaces. Six plant species considered rare in Saskatchewan have previously been found in the Great Sand Hills (Epp and Townley-Smith 1980). Great Basin downingia (*Downingia laetq*) was found at Crane Lake and Skull Creek. This plant has not been found anywhere else in Western Canada (Epp and Townley-Smith 1980). Other rare plants include beaked annual skeleton weed (*Shinnersoseris rostrata*), spiny milk-vetch (*Astragalus kentrophyta*), small lupine (*Lupinus pusillus*), and Schweinitz's flatsedge (*Cyperus schweinitzii*). In addition to completing a plant species survey, Epp and Townley-Smith (1980) identified 11 vegetation communities in the GSH according to landscape type and aspect. The major vegetative-landscape units they described were dunes, sand flats, erosion areas, deposition areas, and aspen understory areas.

## 2.4 AIR QUALITY

The quality of air can be described by the amount of foreign gaseous and particulate material present. Monitoring of air quality in Saskatchewan has mainly focused on urban centres and larger facilities that burn fossil fuels or emit particulates from production processes. The main sources of air emissions in the GSH area include gas wells, compressor stations, communities, and motor vehicles. Emissions from these small point sources are not considered to be a threat to plants and animals. However, there is growing concern that increasing emissions from Alberta may be harming the sensitive soils of the GSH, although this is as yet unverified.

## 2.5 SOCIOECONOMIC SETTING

The Great Sand Hills Study Area is sparsely populated with 6,709 residents in 2001, of which approximately 60% resided within the jurisdiction of settlements. The only First Nation with a reserve near the GSH is the Nekaneet, located 121 km southwest of Swift Current and occupying 5,602 ha of land. At least part of the Great Sand Hills lies within the Qu'Appelle Treaty, signed in 1874, and the area itself is of considerable historic, cultural, spiritual, and economic significance to many First Nations, including the Blackfoot Confederacy of Alberta, Saskatchewan Treaty 4 First Nations, as well as numerous other First Nations groups in Saskatchewan and North Dakota.

In 2001 the labour force participation rates in the GSH area were higher than the Saskatchewan average, and the majority of reporting settlements and RMs exceeded the Saskatchewan median family income. The majority of the labour force is engaged in occupations associated with the primary industry—agriculture, including farming and ranching—which accounts for

60–80% of all employment in the region and reflects some of the highest agricultural employment concentration figures in Saskatchewan. From the limited number of ranches that cover over 190,000 ha in the GSH, the total economic value represented approximately $45 million in revenues, rents, income, and sales to the local and regional economy in 2005.

As with many other rural areas in the Prairies, however, the GSH region has a declining population base, threats to its traditional economic activities of farming and ranching, and associated changes in quality of rural community life. Thus, an important figure of the Great Sand Hills is the gas industry, which has become a key contributor to the regional economy and provides indirect income support to local residents and revenues to local, regional, and provincial governments. In 2006 the total value of economic activity from gas wells in the Great Sand Hills region represented just over $1,080,000.

# Chapter 3: Previous GSH Planning Initiatives

Ranching, gas exploration and development, and recreational activities are major uses of the Great Sand Hills area. The provincial Crown owns over 85% of the land, most of which is under grazing lease. All of the GSH area is believed to have high potential for natural gas development, and the existing gas industry is an important source of revenue for the province and municipalities, and provides jobs for communities near the area. Several previous planning or visioning efforts considered various aspects of conservation and development in the region, as reviewed below.

## 3.1 THE 1991 GREAT SAND HILLS LAND USE STRATEGY

The Strategy recommended four zones to guide management and development of the GSH. These were: Prime Protection Area; Special Use Area; Multiple Land Use Area and Facility Area. The 1991 Strategy proposed most of the land base as multiple-use area where most uses, including gas development and ranching, were permitted, subject to provincial and municipal regulatory procedures. There are currently 141.25 (this is the number today which includes the RAER and all of the 1991 PPA areas) sections withdrawn from Crown mineral lands where no mineral development is allowed. In this report, Prime Protection Areas (PPAs) refers to those lands identified in the 1991 Strategy that were subsequently "protected" by withdrawal from Crown mineral lands (known as a Crown mineral reserve).

## 3.2 1992–2002: MUNICIPAL ROLES IN THE GREAT SAND HILLS

The goal and objectives of the 1991 Land Use Strategy have been supported by more recent Rural Municipality (RM) zoning bylaws. The Great Sand Hills Planning District was established in 1994. It included four RMs: Piapot No. 110, Pittville No. 169, Fox Valley No. 171, and Clinworth No. 230. Identical development plans and zoning bylaws were adopted by the RMs. The evolving Great Sand Hills Planning District Commission's role was to give advice to member RMs, based on the Development Plan and Zoning Bylaw, in order to ensure uniform administration of land-use issues amongst member municipalities. The Commission was made up of elected officials from the four RMs and a public representative.

From 1992 to 1998, the RMs and the province expended significant effort to refine the Great Sand Hills Planning District Development Plan and Zoning Bylaw. This work was the basis for the current RM zoning controls, including Agricultural/ Resource (AR), Environmentally Sensitive 1 (ES1), and Environmentally Sensitive 2 (ES2) lands, in the Great Sand Hills Planning District.

### 3.2.1 Provincial Roles in the Great Sand Hills

The provincial departments managing the environment, government relations, aboriginal affairs, agriculture, and industry have all played a role in the management of the area. They each have approval responsibilities for use of the Crown land and its resources.

## 3.3 2002 LAND USE STRATEGY REVIEW: PRECURSOR TO THE CURRENT RES

As a result of growing tensions over land uses, in July 2002 the provincial government confirmed that there would be a review of the Great Sand Hills Land Use Strategy (1991). In initiating this review, the province had two principal objectives: to address land-use interests in the area and to ensure that provincial and municipal policies for the area reflect current realities.

The Great Sand Hills Land Use Strategy Review Committee (the Review Committee), advisory to the provincial government, was established in August 2002 to conduct the review. The Review Committee included representatives from the provincial departments of Environment; Government Relations; Agriculture, Food and Rural Revitalization; and Industry and Resources; the Rural Municipalities of Piapot, Pittville, Fox Valley and Clinworth; and the Great Sand Hills Planning District Commission.

The scope of the review was to consider all land and resource management issues in the planning area and be aware of concerns beyond the limits of the planning area. A large component of the review was to evaluate the effects of the 1991 Great Sand Hills Land Use Strategy. The Review Committee completed an evaluation of the objectives and recommendations in the 1991 Strategy. The Goal for the 1991 Strategy was to maintain the Great Sand Hills as a distinctive landscape for social, cultural, and economic benefits.

### 3.3.1 1991 Great Sand Hills Land Use Strategy Evaluation

The Review Committee completed an evaluation of the implementation of the original 1991 Great Sand Hills Land Use Strategy. The committee found that implementation of this strategy was mostly complete. They recognized the tremendous effort by the Great Sand Hills Planning District Commission, the four Rural Municipalities, and the provincial agencies over the previous 12 years. They also acknowledged that a great deal of the success of land-use administration is credited to the local people who have a strong bond and familiarity with the area. Particularly, the committee recognized the work of those who are elected and accountable to represent all of the local interests. It is a time-consuming responsibility to be a member of a municipal council. In an area as complex as the GSH, the duties and responsibilities are all the greater.

The Review Committee recommended that the 1991 Strategy continue to be built upon to address ongoing and evolving issues in the harmonization of processes and procedures that have been adopted by the municipal and provincial governments. It had been found that environmental requirements that were innovative in 1991 were now standard practices. The advance of technology and accumulation of experience meant operational practices often exceeded standards described in the Strategy. The committee's evaluation showed that the objectives and recommendations of the 1991 Strategy have been mostly achieved (35 objectives and 77 recommendations) in the attempt to find balance between environmental preservation and economic development.

The Review Committee arrived at its recommendations through listening to public interests, reading submissions concerning land-use policies, and discussing at length many of the issues and concerns. Common themes regarding consistency, balance, and particularly clarity, emerged during the Strategy review process. Many people were able to agree that a balanced approach that addresses economic, social, and environmental needs was necessary to manage the GSH sustainably. This approach supports the conclusion that some areas in the GSH can be developed, but that other areas warrant an enhanced and clearly defined level of protection.

Information received by the Review Committee through written and verbal presentations, public meetings and workshops, and reference material was examined. The committee's consultations and research identified concerns that range from a general philosophical perspective to specific scientific or technical questions. Concerns were identifiable in major themes: environmental/ecological; ranching/grazing; zoning/land-use administration; and operations (specific to gas development and access to resources). The report provided details of discussion and analyses that were the basis for the committee's recommendations.

The Review Committee discussed what process or administrative model could be used to implement recommendations. It identified six scenarios that were brought forward for further public consultation as the beginnings of possible recommendations. At the public workshops held in May and June 2003, members of the public elaborated further or more specifically on the initial ideas from the committee and also proposed additional scenarios. The six initial options were status quo; status quo plus adjustments; expansion of the 1991 PPAs; enhanced or changed role for formalized structures; multi-use scenario; and start over (true socio-economic and biophysical study).

### 3.3.2 Recommendations and Principles for Implementation

The Review Committee identified the following nine areas of interest and proposed a number of recommendations for each: protected lands—increase size and protection; zoning outside of the additional and existing protected lands; environmental assessment; ecological monitoring; grazing—minimize footprint; gas developments—minimize footprint; conserve wildlife and biodiversity; conserve air and water resources; and administrative procedures. These recommendations are discussed in more detail below.

### 3.3.3 Protected Lands (PLs): Increase Size and Protection

1. Add additional lands to the 1991 PPAs. The committee recommended lands roughly three

times the current PPA area (36.5 sections of Crown land) be identified for protected designation. "Protected land" meant land identified for high levels of management restriction. The committee recommended that these lands or areas should receive designation under provincial legislation to restrict industrial development both on the surface and the subsurface.
2. Establish the additional lands, wherever possible, adjacent to and in combination with those PPAs identified in the 1991 Strategy. There were four areas identified as PPAs in 1991: Yakowan 12 sections; Rastad 21 sections; Wachiwan 1/2 section; and Straw Road 3 sections (see Saskatchewan Environment and Public Safety 1991). Additional lands should be added to each one of these existing PPAs to increase their size.
3. Include ecological representivity in the process of identifying protected lands.
4. Designate surface and subsurface control with provincial-level legislation.
5. Use the new identified lands and 1991 PPAs in combination as benchmarks for ecological monitoring.
6. Confirm the land uses that may be permitted within protected lands.

### 3.3.4 Zoning Outside of the Additional and Existing Protected Lands

1. Clearly identify and define areas outside the additional and existing protected lands.
2. Consider the area environmentally sensitive and not lessen environmental protection planning. Processes established by the Great Sand Hills Planning District Development Plan and Zoning Bylaw should be supported. In the absence of greater scientific understanding, the utilization of ES1 and ES2 zoning should be continued.
3. Continue the practice of coordinating environmental standards with the province.
4. Strive to achieve the most up-to-date environmentally responsible technologies for specific development standards.
5. Support the RMs and Great Sand Hills Planning District Commission with resources (expertise and funding) to improve their abilities to provide good management under an agreed plan of action.
6. Before commencing any development within the municipality, every person shall complete an application for a Development Permit.
7. Saskatchewan Industry and Resources (SIR) should continue to consult with the RM prior to posting the environmentally sensitive subject land in the "Public Notice Sale of Saskatchewan Crown Petroleum and Natural Gas Disposition."

### 3.3.5 Environmental Assessment

1. Conduct an environmental impact assessment, which sets the basis for a comprehensive implementation plan for long-term management for the Great Sand Hills.
2. Include within the environmental impact assessment, among other things, consideration of baseline biophysical information, cumulative impacts, linear developments, ecological disruption tolerances, reclamation potentials, and socio-economic impacts.
3. Involve land users and those with an interest in the environmental impact assessment process.
4. Ensure that existing and new spatial information on roads, trails, dugouts, well pads, and pipelines is collected and centrally deposited and stored for access by the appropriate regulatory agencies and proponents of development.
5. Contribute to the updating of management policies and more refined map delineation in the Great Sand Hills Planning District Development Plan and Zoning Bylaw.

### 3.3.6 Ecological Monitoring

1. Establish a comprehensive program that monitors ecological integrity by establishing appropriate indicators and benchmark areas for future comparisons.
2. Undertake an invasive plant study every five years.
3. Employ qualified Environmental Monitors who report to land owner/manager to oversee developments (enforce provincial and municipal environmental protection plan obligations).
4. Support (either financial or in-kind) small land users to ensure that an equivalent level of management is accorded without imposing onerous requirements that could inhibit advances in stewardship practices on their part (e.g., replacement of dugouts with modern wells and controlled-watering facilities).

### 3.3.7 Grazing–Minimize Footprint

1. Encourage the continued development and implementation of techniques that minimize surface disturbance from grazing.
2. Encourage the completion and implementation of range management plans on a ranch basis, as resources are available.
3. Jointly develop and implement a strategy with industry partners and other agencies to control and/or eradicate invasive, non-native plants.
4. Saskatchewan Agriculture and Food (SAF) should review the compensation payment to ranchers for gas developments on leased lands (consider increased sharing of revenue directed at stewardship initiatives that benefit this sensitive area).

### 3.3.8 Gas Developments–Minimize Footprint

1. Develop and implement a comprehensive access management plan that minimizes surface disturbance (for example, proponents share infrastructure).
2. Encourage the use of special drilling techniques such as multi-pad and/or directional drilling as appropriate to avoid unnecessary environmental damage.
3. Streamline processes by reducing redundancy and creating clarity for reporting in reclamation and enforcement procedures.
4. Encourage reclamation projects that begin to build an information base for successful long-term reclamation.
5. Require the gas industry to complete timely environmental planning. Where lands are deemed inoperable the surface could be protected from surface access or designated as protected lands.

### 3.3.9 Conserve Wildlife and Biodiversity

1. Conduct surveys for rare and endangered species.
2. Establish reclamation standards that include the use of appropriate native plants.
3. Assess the need to increase or decrease hunting opportunities.
4. Ensure that steps are taken to manage the risk of wildfires.

### 3.3.10 Conserve Air and Water Resources

1. Understand the groundwater resources contained within the Great Sand Hills.
2. Develop and implement a water management strategy.
3. Understand the impacts of all forms of air-borne pollution.

### 3.3.11 Administrative Procedures

1. Identify lead and support agencies for each recommendation brought forward.
2. Establish an advisory or formalized administrative board that reflects land user interest and, in the majority, local administration.
3. Establish timelines for follow-up to ensure recommendations brought forward are completed.
4. Establish a communications strategy to ensure area residents and others are kept informed.
5. Make adequate resources available to carry out these recommendations.

The Review Committee did not recommend any single option for implementation. Rather, the committee determined that a combination of options can better serve to manage the ecological sensitivities and complexities of the Great Sand Hills. Further, the committee specified that any decision by government for implementation of their recommendations must address these important principles: longevity; permanence; informed management decisions; local partnerships; public involvement; compliance and enforcement; and dedicated resources.

### 3.3.12 Principle of Longevity

Longevity, or prolonged existence in this case, is the time between land-use and resource management policy reviews and changes. In order to stand the test of time, in addition to the specific recommendations above, the provincial government's implementation decision must include a clear understanding of the roles and responsibilities of administrators and landowners, of proponents and lessees, and of staff personnel and elected officials.

### 3.3.13 Principle of Permanence

Permanence, or the ability to withstand change (particularly policy changes), is important to address. To provide more permanence the committee suggested that the provincial government use current and/or future Acts and Regulations to designate and administer protected lands in the Review Area.

### 3.3.14 Principle of Informed Management Decisions

The committee early on recognized that a contributing factor to conflict in the GSH area was a lack of scientific knowledge regarding the overall ecological impact from a variety of land uses on the ecosystem. Research into natural resource use and impacts from development, gas and ranching, and tourism will strengthen long-term management of the GSH area.

### 3.3.15 Principle of Local Partnership

The committee believed that people most affected by land-use and resource management decisions must be meaningfully involved in those decisions. The committee recommended that government continue with, and strengthen, partnerships with the municipalities for local area management.

### 3.3.16 Principle of Public Involvement

The committee recommended that public involvement continue to be an integral component of decision-making in the Great Sand Hills area. The RMs and provincial governments should add this perspective to their decision processes.

### 3.3.17 Principle of Compliance and Enforcement

The committee recommended that the government address the perceived inability of government to respond effectively to environmental conflicts. There is also an opportunity here to strengthen provincial and municipal enforcement efforts through alignment of roles and responsibilities.

### 3.3.18 Principle of Dedicated Resources

The Review Committee recognized that significant resources are required to implement these recommendations. It will not be possible for the government, the municipalities, or the industries to do this alone. In order to provide the best management for the GSH area, partnerships must be fostered and formed.

### 3.3.19 Summary

In the end, the implementation recommendation recognized the critical partnership between the provincial and municipal (local) authorities for management of the GSH. A combination of the following features was proposed for the future:

- One environmental impact assessment for the area.
- The formation of either an advisory or formalized administrative board.
- A comprehensive implementation plan for the area that will give direction for land use and resource management in the GSH.

Anticipating that government would make a decision to implement these recommendations and principles, the Review Committee considered the following.

In the short-term:

For the additional and existing protected lands, immediately:

- Designate protected lands under provincial legislation.
- Define allowable land uses in regulation.
- Describe environmental practices in regulation.
- Describe enforcement abilities in regulation.

Identify advisory and public interests.

For the interim period prior to government decision and an environmental impact assessment:

- Utilize established directions and approval processes for areas outside new protected lands.
- Conduct an environmental impact assessment.

In the medium-term:

- Clarify roles and responsibilities of provincial agencies and municipal councils.
- Create and formalize a partnership (board) between provincial agencies and municipal councils for management of the Great Sand Hills area.
- Identify the responsibilities of the board to enable management of the Great Sand Hills area.

And, in the long-term:

- Prepare a provincial land-use policy that clarifies the provincial role in development decisions by providing clear direction to municipalities, industry groups, and the public.

## 3.4 SASKATCHEWAN ENVIRONMENT SCOPING DOCUMENT/GUIDELINES

In June 2004 the Government of Saskatchewan officially responded to the report tabled by the Great Sand Hills

Land Use Strategy Review Committee. The government's response indicated that the overall future approach would be one of integrating environmental and economic interests while maintaining a high degree of protection. To achieve this, the existing protected areas were consolidated and increased from 36.5 to 141.25 $mi^2$ (~19% of the area) (Figure 1-1-2). A major outcome of the government response was the creation of the Representative Area Ecological Reserve (RAER) in which no gas leases were to be sold and no gas development would be permitted. In addition, the government called for a Regional Environmental Study (RES) over the following two years that would consider the cumulative human impacts in the area to date and make scientific recommendations regarding future land uses in the area. An impartial, internationally recognized ecological expert or experts would be identified to lead the study. While the study was underway, existing mineral rights would be honoured, but a moratorium on further mineral sales would be in place. Grazing and other permitted land uses would continue uninterrupted.

This RES provides a large-scale assessment of the GSH to define future land uses and delineate future areas for protection. Our intent was to emulate the size and scope of other previous ecosystem-based assessments such as the 20-year forest management plans in northern Saskatchewan. The Review Area, as described earlier, covers 783 $mi^2$ of native prairie (see Figure 1-1-2). Among other things, this RES considered the cumulative impacts to date over the entire area in order to make specific recommendations for the areas where gas development has not yet been approved.

Valued Ecosystem Components (VECs) are those aspects of the environment, physical and human, considered to be important from ecological or public perspectives and likely to be affected by, or to affect, development and decision-making activities. By focusing a baseline assessment on a select number of key VECs, subsequent phases of impact assessment and scenario analysis are also more focused and thus able to deal more effectively and efficiently with those issues and concerns that are most important to the sustainability of the Great Sand Hills. A total of 20 core baseline study VECs are considered in the RES, each categorized according to various "capitals" of the natural, human, and economic environment (Table 1-1-1). The preliminary list of VECs was compiled by the Scientific Advisory Committee through an open scoping process, drawing initially upon previous studies and reviews of the Great Sand Hills including *The Great Sand Hills of Saskatchewan* (Epp and Townley-Smith 1980), *The Great Sand Hills Land Use Strategy* (Saskatchewan Environment and Public Safety 1991), and *The Great Sand Hills Land Use Strategy Review* (Great Sand Hills Land Use Strategy Review Committee 2004). The final list of VECs was compiled as the scoping process and discussions with stakeholders, communities, and First Nations groups unfolded.

# PART 2

## GREAT SAND HILLS REGIONAL ENVIRONMENTAL STUDY

## – BASELINE ASSESSMENT REPORT –

# Chapter 1: Baseline Assessment Purpose and Scope

## 1.1 INTRODUCTION TO THE BASELINE ASSESSMENT

Part 2 of the Regional Environmental Study (RES) characterizes the natural, social, and economic environment of the Great Sand Hills (GSH) in the form of a baseline assessment. A baseline assessment identifies current environmental conditions, trends, and cumulative change for selected study variables or Valued Ecosystem Components (VECs). The study VECs encompass those interactions that are of primary concern to regional ecological, social, and economic sustainability, and to planning and decision making. By focusing on a select number of VECs subsequent phases of assessment and scenario analysis are more focused, providing an effective and efficient means to address those issues and concerns that are of most importance to the sustainability of the region.

A total of 20 VECs, or VEC groupings, are considered in the RES. Each is categorized according to the natural, social, and economic environment (Table 1-1-1). The preliminary list of VECs was compiled by the Scientific Advisory Committee (SAC) through an open scoping process, drawing initially upon previous studies and reviews of the GSH including *The Great Sand Hills of Saskatchewan* (1980), *The Great Sand Hills Land Use Strategy* (1991), and *The Great Sand Hills Land Use Strategy Review* (2004). The final list of VECs was compiled as the scoping process and discussions with stakeholders, communities, and First Nations groups unfolded.

## 1.2 BASELINE STUDY APPROACH AND STRUCTURE

The approach and structure to the baseline assessment follow recent best practice guidelines (e.g., European Communities 2001, Dalal-Clayton and Sadler 2005, Petts 1999) and address three major components:

1. a profile of current and past natural, social, and economic environmental trends and conditions in the GSH Study Area;
2. a summary of key natural, social, and economic issues, concerns, and questions that emerge from the baseline study variables and interactions;
3. identification of significant issues across baseline study components, which are carried forward to trends projection, scenario analysis, and management recommendations for maintaining the ecological integrity of the GSH.

The baseline assessment results summarized in this document are from studies undertaken by members of the GSH RES research team. The results are presented in 7 chapters following the introduction. Chapter 2 (*Physical Environment and Natural Resources*) and Chapter 3 (*Biodiversity Assessment*) summarize the natural capital baseline environment of the GSH. Chapter 4 (*Human Landscape*) and Chapter 5 (*Perceptions of Use and Change*) summarize the social and human capital baseline, followed by Chapter 6 (*Economic Landscape*), which describes the economic baseline of the region. The baseline assessment concludes with Chapter 7 (*Baseline Synthesis*), which identifies the principal human driving forces of change in the region and summarizes the key baseline conditions and linkages to be addressed in scenario analysis and recommendations. The full baseline research reports are available as supporting documentation.

# Chapter 2: Physical Environment and Natural Resources

## 2.1 INTRODUCTION

Situated in the physiographic region known as the third prairie level, part of the larger Bigstick Lake Plain, the GSH Review Area is characterized by undulating to rolling topography, limited surface water resources, and sand dunes and dune complexes. The GSH is largely uncultivated, with the low moisture-holding capacity of the soil and broken topography creating an environment sensitive to disturbance. This sensitivity and rugged topography present a constraint to a variety of human and economic activities, including grazing and infrastructure development. That being said, the GSH is also underlain by large natural gas deposits, resulting in considerable interest in resource development of the region. This Chapter describes the current physical environment and natural resources of the GSH in terms of its geology, water resources, terrain sensitivity, natural gas reserves, and soils.

## 2.2 ECONOMIC GEOLOGY, WATER RESOURCES, AND TERRAIN SENSITIVITY

Information reported in this section from Penner et al. (2005) provides the necessary baseline to characterize the long-term geological, hydro-geological, and hydrological environments in the GSH area and is used to support environmental, socio-cultural, and economic components of the RES.

### 2.2.1 Methods

The main study approach adopted by Penner et al. (2005) entailed: i) synthesizing available baseline data for each of economic geology, water resources, and terrain sensitivity; ii) air photo terrain mapping of surficial geology, soil texture, and topography and integrating this information with previously mapped data; iii) Geographic Information System (GIS) integration of the data and development of terrain sensitivity maps, and iv) validation based on air-photo interpretation, assessment of landscape temporal change, field verification, GIS modeling, and a review of environmental sensitivity studies conducted in similar terrain.

Other sources of information included personal contacts with government officials and others having first-hand knowledge of the GSH Study Area. Primary sources of data include Saskatchewan Environment, Saskatchewan Industry and Resources, Saskatchewan Research Council, Saskatchewan Watershed Authority, and Agriculture and Agri-Food Canada (AAFC)-Prairie Farm Rehabilitation Administration (PFRA) and the Saskatchewan Land Resources Unit. Results from previous studies carried out by J.D. Mollard and Associates Ltd. were also reviewed and incorporated in the study. A 1990 report titled "Air Photo Terrain Mapping and Evaluation, Great Sand Hills Area, Saskatchewan" is particularly pertinent. That study includes a map showing the relative sensitivity of terrain to disturbance from past GSH use activities as well as some GSH unique local features interpreted from 1:80,000 3-D air photos. Wherever possible, digital geospatial data were acquired and imported into a GIS. Where digital data were not available, relevant maps and data were digitized for use in a GIS. Although much of the required baseline data was available from existing studies, some primary data collection and analysis was carried out. This included air photo terrain mapping of the Study Area. New temporal data were also created from analysis and interpretation of historical air photos.

### 2.2.2 Results

#### *2.2.2.1 Economic geology*

The main natural resources of economic interest in the GSH are aggregates, sodium sulphate minerals, and oil and gas reserves. There are very few gravel pits with coarse aggregates, with only one pit in the area containing significant volume. Aggregate resources are restricted almost entirely in the Study Area south of Township 17. A considerable volume of graded sand and fine gravel exists, but few proven coarse gravel deposits suitable for producing traffic gravel or asphalt pavement. Detailed field reconnaissance and backhoe testing is needed to properly evaluate total aggregate resources in the Study Area. There is also a low potential to import coarse aggregates from sources outside the Study Area. Sodium sulphate deposits are found in RMs 110, 168, 169, and 171. Two mines that formerly operated in the area have ceased operations. The mining of sodium sulphate in the Study Area is not competitive because it can be produced more cheaply in the United States as a by-product of the production of copper arsenite. Under current market conditions, the mining of sodium sulphate in the Study Area is not considered a viable option.

Oil and gas resources have been exploited in the area since the early 1950s and are an important economic industry for the area. Gas is by far the dominant product. Potential oil reservoirs are restricted to the southeast corner of the Study Area and southwest of the Study Area. Gas production has expanded considerably in the western side of the GSH over the past 25 years. A high density of gas wells bounds the west side of the GSH, suggesting the limits are regulatory rather than geological. An estimated 10,000 million $m^3$ of gas and 3 million $m^3$ of oil remain (December 2003 estimates). Saskatchewan Industry and Resources states that reserves have so far not been estimated for areas outside of known pools in the GSH. Gas reserves are known to exist in the Study Area beyond the borders of the existing pools; hence the potential for new gas pool discoveries is high. There is low potential for oil production to expand beyond the current pool boundaries.

#### *2.2.2.2 Water resources*

Surface water is limited in spatial extent, temporal occurrence, and duration due to low rainfall, high evaporation rates, irregular spring runoff, and high soil permeability. Nearly all streams and lakes are ephemeral and most natural catchments are saline basins. The major uses of surface water are: irrigation 86%, domestic 6%, industrial 2% (livestock, oil recovery), municipal 2% (urban distribution, tank load), and other 4% (wildlife, recreation). Most irrigation projects are small back-flood systems capturing spring runoff and flooding relatively small areas; very few irrigation projects have been constructed in recent years. Five potential groundwater aquifers exist in the GSH; surficial aquifers are also present over a large part of the central area of the GSH as well as in the dune areas south of Bigstick Lake and east of Crane Lake. Considerable good quality, high-yielding groundwater sources exist in a number of buried tunnel valley aquifers. Deep non-potable groundwater is used for enhanced oil recovery in the GSH, generally from a depth of 300–450 m. Land-use activities in the GSH can potentially affect recharge supply and water quality in high recharge potential areas, the rate of recharge corresponding to the annual precipitation. Bedrock aquifers are part of a larger regional set of bedrock formations. Their recharge is a function of regional climate systems and controlled by factors outside of the GSH.

Major water-use categories in the GSH are: irrigation 4% (agriculture); industrial 82% (intensive livestock, oil recovery, and mineral recovery); municipal 14% (urban distribution, tank load, community, commercial facility, recreation). One glacial aquifer is the source of groundwater for a single licensed irrigation project.

There is no written record available of water use by the ranching industry; however, no substantial changes in grazing pressure have occurred over the past 50–60 years. The number of head of cattle was higher in the past, but average live weight has increased, thus the total grazing pressure is unchanged. A significant herd reduction occurred during the drought of the 1980s and the herd has not yet recovered to pre-drought levels. The grazing capacity of the GSH limits the herd size, which is near or at capacity. There is increasingly efficient use of pastureland due to enhanced pasture management from fencing and grazing rotation and the installation of water pipeline distribution systems, which tap to a single well or dugout and distribute water through up to 21 km of pipeline buried at a shallow depth (50 cm). Water is pumped to troughs along the pipeline system. This is a more efficient system of delivery of water, resulting in more uniform grazing throughout the pastures. Good quality troughs reduce water loss from leakage and water evaporation and the system eliminates the need for cattle to wade into dugouts, resulting in improved of water quality. The use of dugouts is still common in GSH, especially where the water table in surface aquifers is shallow. Where the water table is deeper, wells are used. In the past it was common to draw water from water-table dugouts using windmills. Today, solar-powered pumps are used to move water through the shallow pipeline distribution systems; about 10 gallons (45 l) of water per day per head of cattle are used.

For human settlements, records of water use extend from the mid-1970s to the present with data available for nine communities. Water use is stable for six of the nine: Abbey, Hazlet, Lancer, Prelate, Sceptre, and Gull

Lake; water use has risen slightly in Cabri, Leader, and Fox Valley. The water supply is at risk during droughts for Abbey, Fox Valley, Hazlet, Lancer, and Sceptre because they all rely on shallow groundwater wells. No data are available for water use by rural residents and farm operations; however, with a long-term trend of decreasing population, overall water use by rural residents and farm operations is likely lower than 30–40 years ago.

For drilling gas wells, there is a short-term requirement for surface water (about 0.5 $dam^3$/well). This water is usually taken from the landowner's dugout or slough; no adverse affects on the supply or quality have been reported for this use (see, however, section 5.2.2, or see Table 2-5-4). Water is also used in the industry for water flood-recovery techniques using non-potable water drawn from deep bedrock aquifers with high total dissolved solids.

Overall, the sustainability of water resources in the GSH is subject to tremendous year-to-year variability depending on precipitation. In the core of the GSH, surface water is largely non-existent and even a single year of below-normal precipitation can jeopardize water supplies in reservoirs and dugouts. An estimate of total groundwater volume is 12 million $dam^3$ in the GSH with an annual recharge rate of 0.5 million $dam^3$/year. The current active groundwater allocation under Saskatchewan Watershed Authority licenses is 2,200 $dam^3$/year—less than the total groundwater estimates for the area, and lower than the annual recharge rate.

#### *2.2.2.3 Terrain Sensitivity*

Five sand-dune regions cover about 1,500 $km^2$ of the GSH Review Area; most are medium to fine dune sand. Prevailing dune-forming winds blow from the west to the east and the rate of active dune advance is 1–5 m/yr, averaging 3 m/yr. Dune-forming soils have the highest sensitivity while soils susceptible to wind drifting have an intermediate sensitivity. Larger areas of high sensitivity terrain occur in the southern part of the GSH Review Area and in Townships 15 and 16. Areas rated as extremely high and very high wind-erosion potential correspond to areas of higher terrain sensitivity, as do areas of active and large stable dunes. Compared to 1945 air photos, there are more active dunes now than there were then. An increased degree of ground disturbance is occurring adjacent to dugouts located in low, moderate, and high sensitivity areas as classified by a terrain sensitivity model. The model is primarily a predictor of the sensitivity of exposed mineral soil to wind erosion. Results from the model suggest that terrain within the core GSH area is high to very high sensitivity, whereas much of the area surrounding the core area is rated as moderate to low sensitivity.

## 2.3 GAS RESERVES, DEVELOPMENT, AND PRACTICES

Below the GSH, natural gas reserves are located in the Milk River and Second White Specks sandstone and shale formations of Upper Cretaceous age (approx 85 mya) (Penner et al. 2005). Most gas development has occurred since 1980 in the Hatton field, which encompasses the western half of the GSH. The Abbey-Lacadena field, north and east of the GSH, started drilling from 2002. On Crown lands, gas companies initiate development by leasing natural gas rights from Saskatchewan Industry and Resources, or if freehold rights, from a private individual or company. Saskatchewan Industry and Resources receive, review, and approve a gas company's application for a license to drill, operate, and produce. Subsequent to environmental review and approval, negotiation of a surface lease for access, and the issuing of a municipal development permit, drilling is undertaken. Within the baseline assessment, this study focused on: i) current gas leases and development in-place; ii) defining the known gas reserves and future development potential in the GSH; iii) review of coal bed methane potential, and; iv) management practices particularly as they relate to reducing surface disturbance.

### 2.3.1 Methods

Current Petroleum and Natural Gas (P&NG) lease ownership, well records, and well pad surface leases were documented by the Canadian Plains Research Center (CPRC), University of Regina. This public information was accessed on-line from the Geological Atlas of Saskatchewan. Professional consultants were contracted to provide an independent assessment of specific technical aspects. J.D. Mollard and Associates Ltd. reviewed economic geology, which included gas reserves and current production based on a review of literature and contact with Saskatchewan Industry & Resources. GLJ Petroleum Consultants Ltd. (2006) undertook an in-depth estimate by proven, probable, and potential gas reserves classification on developed and undeveloped lands. Proven (90%), probable (50%), and possible (10%) reserve lands are categorized by their likelihood of commercial development. Reserve estimates were determined from existing wells using decline analysis and analogy. Well density and development were forecast over 15 years for step-out and infill development. Golder Associates Ltd. (2006) were contracted to review gas technology and management practices and thereby provided the Scientific Advisory Committee with an environmental perspective of the industry in the GSH. Surface disturbance is of particular concern with respect to the ecological integrity of the GSH. To potentially reduce the number of well pad surface leases and associated roads and trails, the investigation concentrated on directional and slant drilling whereby multiple wells are drilled and operated from a single well pad surface lease. Chinook Directional Services and On Management Ltd. recommended a typical design for directional drilling. CPRC further worked with On Management Ltd. and GLJ Petroleum Consultants Ltd. to characterize existing directional and slant wells on-site and to determine their current ownership. Follow-up interviews were conducted by CPRC with directional and slant well owners of the City of Medicine Hat and Canadian Natural Resources Ltd. (including Anadarko Canada Corporation). The interviews confirmed background and experiences to date in the use of directional and slant drilling and their ongoing operations.

### 2.3.2 Results

The gas well logs of the Milk River Formation indicate a gas-bearing zone 125–150 m in thickness consisting of upper and lower shaley sections and a central portion of interbedded thin shale beds, siltstone, and fine to very fine grained sandstones. In the central portion of the zone, the reservoir deteriorates in quality from west to east. Comparatively, the Second White Specks Formation is limited to the most southern portion of the GSH Study area and consists of an interval of repeated interbeds of fine to very fine sandstones, siltstones, and shales (GLJ Petroleum Consultants Ltd., 2006).

Earliest gas production started in the 1950s. For the period 1995–2005, gas production in the Hatton field was estimated at 6,034,544 dam$^3$ (213 billion cubic feet [BCF]) with a small volume of water at 274 dam$^3$ (1.72 million barrels). Comparatively, the Abbey–Lacadena field commenced production in 2003 and its production for the period of 2003–2005 was 1,004,115 dam$^3$ (35.5 BCF) and water production was 74 dam$^3$ (0.47 million barrels) (Penner et al. 2006). Today, the Milk River formation accounts for most of the gas production in the GSH, estimated at approximately 25.4 million cubic feet per day (MMCFD) (719 dam$^3$ per day) compared to the Second White Specks Formation where production is approximately 1.9 MMCFD (53 dam$^3$ per day) (GLJ Petroleum Consultants Ltd., 2006).

Based on locations of gas and exploration leases extracted from the Geological Atlas of Saskatchewan V.8 (2005), currently there are approximately 132,370 ha (330,926 ac) of gas leases and an additional 7,996 ha (19,989 ac) of leases for gas exploration. Together these areas represent 66% and 4%, respectively, of the GSH. Ownership of the gas leases comprises 23 companies with predominate holdings by ConocoPhillips (including Burlington Resources Canada Ltd.), Canadian Natural Resources Ltd. (including Anadarko Canada Corporation), EOG Resources Canada Inc., ARC (Sask) Energy Trust, and the City of Medicine Hat.

There are 1,460 gas wells with reserves assigned to the Milk River formation and 99 gas wells with reserves assigned to the Second White Specks formation of the GSH (GLJ Petroleum Consultants Ltd., 2006). Most wells are located along the western half of the GSH Review Area and extract gas from the Hatton field. Little or no gas production yet occurs along the eastern and northern perimeter. Individual well life is typically up to 50 years of production. Approximately 84% are vertical wells and typically drilled to intersect gas-bearing sandstone layers to depths over 400 m. Directional and slant drilling account for approximately 16% overall and are exclusive to the Milk River formation of the GSH Review Area. Avoidance of sensitive environmental features like dunes and species-at-risk habitat led to directional and slant drilled wells. Beginning in 1988, slant and directional drilling in the GSH Study Area was used with a horizontal displacement of up to 1,000 m and a ground to reservoir depth of 485 m (On Management Ltd., personal communication, November 2006).

For projects requiring an Environmental Impact Statement (EIS), the resulting approval for directional and slant drilling correspond to the project and carry over any change of ownership of the gas lease. Early designs by EOG Resources Canada, Inc. (Twp 15 & 16, Rge 24, W3M) typically included one vertical well and two directional and slant-drilled wells from a single well pad surface lease at a density of two gas well pad surface leases per section. In 2005 Canadian Natural Resources Ltd. (including Anadarko Canada Corporation) undertook (Twp 14 Rge 23 W3M and Twp 14 Rge 24 W3M) an innovative approach of one well pad per section using up to six directional and slant drilled wells with typical horizontal displacement of

500 m and one vertical well per pad surface lease. This design is coupled with a remote operating system that reduces the frequency of field visitation (Canadian Natural Resources Ltd., personal communication, November 2006).

Cumulative production estimated from all existing wells and both zones is 184 BCF (5.2 $dam^3$). Ultimate gas reserves, including proved, probable, and possible (3P), are estimated at 600 BCF (17.0 million $dam^3$) in the Milk River Formation and 69.4 BCF (1.97 million $dam^3$) in the Second White Specks Formation. Development is proposed for 3P reserves over a 15-year period of drilling up to 2,568 new wells in the Milk River formation and 109 new wells in the Second White Specks Formation. More conservatively, proved and probably (2P) ultimate reserves are estimated at 512 BCF (14.5 million $dam^3$) in the Milk River formation and 66.5 BCF (1.9 million $dam^3$) in the Second White Specks Formation. Again, development over a 15-year period will result in 1,745 new wells in the Milk River Formation and 79 new wells in the Second White Specks Formation (GLJ Petroleum Consultants Ltd., 2006). The 15-year period includes both infill and stepout well development. Optimum development for extraction of gas is estimated at eight wells per section spacing in the Milk River formation. In the Second White Specks formation, well density is recommended by GLJ Petroleum Consultants Ltd. as follows: one well per section where reserves are expected to exceed 500 MMCF (14.2 million $dam^3$) and two wells per section where reserves are 100-500 MMCF (2.8-14.2 million $dam^3$) from the initial well (GLJ Petroleum Consultants Ltd., 2006). At current prices a commercial gas well is defined in the Milk River formation as yielding at least 60 MMCF (1.7 million $dam^3$) per well recoverable raw gas reserves. Comparatively, a commercial gas well in the Second White Specks formation is economic above 100 MMCF (2.8 million $dam^3$) per well.

Based on a review of well logs, the only known presence of coal seams is within the Belly River Formation. Here, coal seams in Townships 12 to 14, Ranges 22 to 24 W3M, are estimated to be up to 6.1 m (20 ft) in thickness and they are found at 91–122 m (300–400 ft) depth. With the shallow depth and expected low pressures and gas content, potential for coal bed methane is considered to be low (GLJ Petroleum Consultants, 2006).

### 2.3.3 Discussion

From an industry perspective, gas production in the GSH is considered relatively low but consistent and long term, with well life of up to 50 years. The reserves are shallow and drilling success is good. Water content can limit production and overall production appears to decline from west to east.

Gas development has concentrated along the western and central portion of the GSH Study Area. Limiting factors beyond gas prices have included land-use zoning, accessibility by roads and trails, and location of infrastructure including compressor stations, pipelines, and flow lines. A moratorium on new Crown mineral lease sales is in effect during the GSH Regional Environmental Study. Exclusive of zoning, existing gas leases, and the Representative Area Ecological Reserve, the unleased lands represent approximately 23,712 ha (58,178 ac) or approximately 12% of the GSH Study Area. These lands are principally zoned as Environmentally Sensitive 1 and development is restricted. For much of these lands along the eastern periphery, the potential gas reserves are unknown but believed to be present in lower volumes not considered commercially viable at today’s gas prices.

Approximately 70% of the GSH has petroleum and natural gas leases with over 1,500 gas wells capable of production. Without consideration of the Representative Areas Ecological Area and current land-use zoning, future growth of up to 2,677 new wells will come from infill developments on existing leases and stepout developments on new leases. Industry, provincial and municipal governments and landowners share a common goal to reduce surface disturbance. There are currently an estimated 1,327 active well pad surface leases within the GSH Review Area. The number of well pad surface leases and the associated roads and trails to service the infrastructure of wells and flow lines are over-arching concerns. The cumulative effect of an increasing density of well pad surface leases progressively fragments a landscape. Single vertical wells on a well pad surface lease with associated trails and roads are developed in densities currently of up to eight wells and eight well pad surface leases per section in the GSH. Vertical wells currently represent 84% of the total well inventory. Alternative practices of directional and slant drilling result in multiple wells per well pad surface lease and thereby reduce the amount of roads and trails as well as length of flow lines installed. Use of directional and slant-drilled wells on-site date from the late 1980s and reach depths of 485 m with a horizontal displacement or reach of up to 1,000 m. Slant-drilling costs range up to twice those of vertical wells, whereas directional-drilled wells are 1.4 times the cost of vertical wells (City of Medicine Hat, personal communication, November 2006).

A shortage of slant contractors with this specialized drilling equipment and their availability during winter drilling period in the GSH results in relatively higher costs. With fewer well pad surface leases per section, there is lower cost for surface leases and reduced length of flow lines, as well as more trails and roads shared in common among wells (City of Medicine Hat, personal communication, November 2006). Directional drilling is more effective at higher ground elevations, as it creates more opportunity for a suitable angle and thus a longer horizontal displacement or reach to be achieved (Chinook Directional Services Ltd., personal communication, September 2006). Having control of adjacent lands is helpful for designing and implementing directional and slant drilling (On Management Ltd. personal communication, September 2006). The nature of land control in the GSH has a company acquiring its gas leases over multiple land sections. For at least the City of Medicine Hat and Canadian Natural Resources Ltd. (including Anadarko Canada Corporation), companies are expected to continue to undertake directional and slant drilling as per their design in the Environmental Assessment-approved Project Areas. There are current examples of directional and slant drilling where the number of wells per section is sustained at up to 8, with the number of well pad surface leases reduced to 1–4 per section.

In summary, considerable gas development has already occurred in the GSH. Review of reserves indicates that development by both infill and step-out drilling will continue for another 15 years. Production of existing wells could extend up to a total life of 50 years. Use of best management practices to reduce the number of well pad surface leases and associated roads and trails per section is occurring, with about 16% of the wells drilled to date. An opportunity exists now to apply innovative management practices to gas development and thereby reduce surface disturbance.

## 2.4 RELATIVE SENSITIVITY TO ACID DEPOSITION AND CRITICAL LOADS OF SOILS IN THE GREAT SAND HILLS

Alberta is now the largest producer of acidifying emissions in Canada and up to 70% of those enter Saskatchewan (McDonald et al. 1996). Given the potentially sensitive nature of the soils in the Great Sand Hills, there is growing concern that acid deposition may be causing damage. As part of the GSH Regional Environmental Study, the short and long-term impacts of acid deposition on the soils of the region were assessed by establishing benchmark sites, studying the soils, rating the soils for their relative sensitivity to acidic deposition by using empirical methods, and calculating site-specific critical loads of acid deposition using the Alberta Research Council (ARC) soil acidification model (Turchenek et al. 2006). More specifically, the study:

- Reviewed the Saskatchewan Soil Survey Reports # 100, 169, 171, and 230 published by the Saskatchewan Institute of Pedology and selected appropriate areas within which to establish benchmark sites;
- Established a minimum of 60 benchmark soil sampling sites within the area, identifying GPS locations, describing soil profiles, taking soil samples from the top two horizons for chemical analysis, and recording a digital photo of each soil profile and its adjoining vegetation;
- Analyzed soil samples collected from the upper 30 cm of the soil profile for several physical and chemical parameters such as texture, pH, exchangeable ions, and soluble ions. These were required for rating soils for their relative sensitivity and for simulating acidification by application of the ARC model;
- Rated soils for their sensitivity to acid deposition using empirical methods such as that of Holowaychuk and Fessenden (1987) or another appropriate method;
- Calculated site-specific critical loads of acid deposition using the ARC acid deposition model, a steady state mass balance model and an empirical mineralogical-based method; and
- Produced a GIS map and data layer of soil sensitivity to acid deposition for the Great Sand Hills Study Area.

Four sensitivity assessment and modeling approaches were applied in the examination of the soils of the Great Sand Hills Study Area, with general results as follows:

1. Sensitivity assessment according to the western Canadian system of Holowaychuk and Fessenden (1987) and Wiens et al. (1987) resulted in a low sensitivity rating for the 0–20 cm surface soil layer at all sites.
2. Critical load assessment by the empirical method known as the Skokloster approach resulted in a wide range of critical loads. Low critical loads, suggesting relatively high sensitivity, characterize soils with no carbonate in the assessment layer, provided that the soil layer was not

more than 20–25 cm thick. Assessment of a whole soil profile would have resulted in high critical load assignments due to calcareousness in subsoils at almost all sites.

3. The Steady State Mass Balance (SMB) approach treats the soil as a single compartment to a depth of 0.75 m. The SMB assessment resulted in all soils of the region being considered to have generally low sensitivity to acid deposition, with critical loads of 1 kmol/ha/yr ($H^+$) or higher.

4. Application of the ARC model, the most sophisticated of the assessment methods applied, resulted in characterization of all soils having low sensitivity to acid deposition. However, under application of a relatively stringent critical chemical criterion, soils classified as orthic brown in the Antelope, Hatton, and Birsay soil associations or as non-calcareous Orthic Regosols in the Antelope association were assigned to a moderate sensitivity category.

In general, there appear to be no soils of high sensitivity to acid deposition in the GSH Study Area. Some Antelope, Hatton, and Birsay soils are moderately sensitive according to some of the sensitivity and critical load assessment criteria. The Antelope soils with no near-surface calcareousness fall into the moderate sensitivity category and are the most sensitive relative to other soils. These are not associated with any specific soil map units, nor with soils of sand dunes, but are with relatively gentle terrain occurring between dune areas or in relatively more extensive eolian and fluvial plains. The extent of these soils was roughly estimated to be about 20% of the GSH. The critical loads suggested for moderate sensitivity soils are 0.2–0.5 kmol/ha/yr ($H^+$) relative to a 100-yr time period, and 0.5–1.0 kmol/ha/yr ($H^+$) relative to a 50-yr period.

An additional study was carried out in the laboratory by adding known amounts of acids ranging from 0–320 kmol/ha to 14 of the soil samples and the resultant pH of the soil solution was measured. The data were analyzed and a correlation with r = 0.81 calculated between the base saturation of soils and the number of years required to acidify the soils to different pH levels. A summary of these results is given in Table 2-2-1.

Measures of current loading of acidic deposition in the Great Sand Hills region and ground truthing of the results from the ARC mathematical model and the analysis presented above would be useful in the future.

## 2.5 FUTURE CLIMATE AND RELATED VEGETATIVE COVER CHANGES IN THE GREAT SAND HILLS OF SASKATCHEWAN

### 2.5.1 Introduction

Current general circulation models predict significant warming for the interior of North America. An increase of approximately 1.4°C over 59 years has already occurred on the prairies (Environment Canada 2006) with extreme conditions, such as the 1987–88 drought, producing annual temperatures 2–4°C warmer than average along with greatly decreased precipitation (Wheaton and Arthur 1989). Global climate change is expected to have far-reaching effects both on natural and human ecosystems; the GSH and the people that depend on the area for their livelihoods will not escape. Whereas the potential impacts of climate warming are being extensively discussed, however, models linking climate to changes in natural and agro-ecosystem structure are few.

Vandall et al. (2006) and Thorpe et al. (2001) modeled future climates for the Saskatchewan prairie ecozone and predicted vegetation responses in the 2050s climate.

Table 2-2-1. Number of years required for acidification of soils to pH = 5 and 6 at different levels of acidic loadings using an analytical method in the laboratory.

| | | |
|---|---|---|
| | Acidic Loadings (keq $H^+$/ha/yr) | Total number of years |
| | pH = 5 | pH = 6 |
| 0.125 | 432 | 104 |
| 0.25 | 216 | 52 |
| 0.5 | 108 | 26 |
| 1.0 | 54 | 13 |
| Average initial pH of the soils was 6.66 | | |

Vandall et al. (2006) modeled the climatic envelopes of U.S. vegetation types in the Great Plains and used them to estimate the most probable vegetation types under predicted future climates that are currently beyond the range of climates found in the Canadian prairies. They show a general trend for the Dry Mixed Prairie zone of southern Saskatchewan to shift toward the dry U.S. Northern Mixed Prairie zone by the 2050s. They also note a gradual reduction in tree and shrub cover for the aspen parkland and mixed prairie, as well as a change in the structure of grasslands, from the cool-season grasses that currently dominate in the northern Great Plains, to the warm-season grasses that tend to dominate in the southern Great Plains (Epstein et al. 1997) and in sandier soils.

Thorpe et al. (2001) looked more closely at sand dune areas within the Great Plains, examining sand dune areas within the U.S. as analogues for the 2050s climate of sand dune areas in the Canadian Prairies. They found the sand hill areas in the 14–16 inch precipitation zone in Nebraska and Colorado to be the closest U.S. analogue for the 2050s climate of the driest Canadian sand dunes areas, including the GSH of Saskatchewan. Grassland is a major vegetation type in both regions, with abundant blue grama (*Bouteloua gracilis*), needle and thread (*Stipa comata*), sand reed grass (*Calamovilfa longifolia*), and sand dropseed (*Sporobolus cryptandrus*) in both, but with a large number of other mostly warm season grasses abundant only in the U.S. analogue. Shrubland and prostrate shrubland are major vegetation types in the Canadian areas, but not in the U.S. analogue; many of the shrubs and trees common in the Canadian dunes are not present in these sand hills, and appear not to be adapted to a warmer climate. Also, silver sagebrush (*Artemisia cana*) grassland is important in the GSH, whereas sand sage (*Artemisia filifolia*) prairie is important in these U.S. sand hills. Thorpe et al. (2001) suggest that the 2050s GSH climate would be capable of supporting the vegetation currently found in the U.S. analogue areas, and that the current vegetation in the GSH is likely to shift in that direction. A model by Wolfe (1997) for areas within this same region suggests that a shift to a drier climate could also result in increased sand dune activation.

Here we model the fine scale local effects of changing global climate for the GSH, and how landcover and vegetation changes are likely to occur within the area during the next 50 years. We thought it was important to obtain some prediction of these changes so that 1) the future scenarios examined in the Great Sand Hills Regional Environmental Study (GSH RES) could be better informed (see Part 3), and 2) the people of the area would have some basis for considering potential adaptation responses to climate change.

We chose potential changes in vegetative communities caused by climate change as the indicators to track over time, because these communities are viewed as an integrator of "higher level" climate variables and "lower level" soil variables. In addition, the majority of animals in the GSH prefer certain plant communities above others, so that predicted future changes in vegetation would assist with predictions about the populations of animals dependent upon them. This rationale could also be extended to livestock grazing by the ranchers in the GSH, and to how local people perceive their future.

### 2.5.2 Methods

The vegetative capability of an ecosystem, in terms of vegetation zone and community development, is essentially dependent on climate and soils, such that the vegetation that can be supported by a particular soil type will change with changing climate factors. In this context, vegetation development at the broad scale of vegetation zones is largely governed by an ecosystem's climate moisture index (CMI; Hogg 1994 and 1997, Thorpe 1999, Vandall et al. 2006), described by mean annual precipitation (PPT) minus mean annual potential evapotranspiration (PET). Climate-driven transition thresholds can also be fairly reasonably established for extant vegetation communities within these vegetation zones according to CMI values. The structure of vegetation communities can also be further defined by summer precipitation proportion (SPP, Vandall et al. 2006)—the portion of PPT received during June through August. This factor can be employed to model future conditions capable of potentially supporting communities not presently found within the ecosystem. A strong correlation can be identified between CMI values and vegetative capability at the broader scale of vegetation zonation, and a significant statistical correlation with SPP can be determined at the finer scale of vegetation community development, providing means for modeling potential future changes to the vegetation component of a particular ecosystem according to modeled future climatic envelopes (Hogg 1994 and 1997, Thorpe 1999, Vandall et al. 2006). These approaches make the assumption that vegetation quickly reaches an equilibrium with climate, an assumption that is violated when dispersal limitations cause substantial time lags in vegetation response or when other factors (e.g., changes in fire regimes, invasions of non-native species) disrupt vegetation stability.

The Saskatchewan Environment/Canadian Plains Research Center ecological climate impact model *AEGIS* (Altered Ecosystem Generalized Incremental Simulation) has been developed to model the impact of changing climate on the vegetative capability of the ecosystem according to shifts in CMI using the entire Saskatchewan Prairie Ecozone with its five major vegetation zones as the spatial baseline. The third generation of this model, reworked in terms of processing structure and refined to the level of modeling vegetation type and community development through the incorporation of a logistic regression approach (Vandall et al. 2006), was applied to model the vegetative impact of future climate on the GSH region for this study. This version of the model is fully flexible in terms of spatial scale and resolution, which are governed simply by the datasets used. Consequently, it may be applied to any area for which the relevant coextensive ecological and climate data are available.

In modeling potential future climate impact, land cover data describing the present (baseline) vegetative capability and vegetation conditions for the GSH were supplied by the 2005 GSH landcover classification derived from SPOT5 imagery acquired specifically for the study. This dataset describes the land surface for the Study Area in 18 land cover classes as of the end of August 2005 at 10-m resolution (Appendix A).

The baseline climatic regime is described by data acquired from the Canadian Climate Impacts and Scenarios Project (http://www.cics.uvic.ca/scenarios/index/cgi), representing the climate period 1961–1990 at a resolution of approximately 0.14 degrees latitude and longitude. The calculation of the baseline PET was carried out by Thorpe (Vandall et al. 2006) according to the Jensen-Haise method, following the approach used by Hogg (1994). We then further interpolated this dataset to 1-km resolution to provide for less abrupt vegetative transitions within the model.

Future modeled climatic regimes were also obtained from the Canadian Climate Impacts and Scenarios Project, representing potential climate conditions for the 2040–2069 period (nominally referred to as the 2050s), and reworked as change factors for application to the baseline climate variables. These regimes have been provided by three separate climate models: the Australian CSIROMk2b, modeling the Intergovernmental Panel on Climate Change (IPCC) B1 potential future atmospheric chemistry scenario; the British HadCM3, modeling the B2 scenario; and the Canadian CGCM2, modeling the A2 scenario. These climate models and scenarios were selected because the models are internationally considered as "state of the art" and the scenarios represent a range of potential results based on possible future atmospheric conditions as published by the IPCC in its report of 2000.

Three separate runs of the model were conducted, simulating vegetative impact on the GSH Study Area over the future 50-year period according to the three potential future climatic regimes. Although the CGCM2 A2 and HadCM3 B2 data represent warmer/drier and cooler/moister futures, respectively, as compared to the median CSIROMk2b B1 results, the differences in impact on the relatively small GSH area were minimal. Consequently, only the median CSIROMk2b B1 climate data and resulting impact on vegetation conditions have been incorporated in this report.

Even though the present modeling process incorporates refinements in the area of simulating vegetation type and community transitions, it remains a coarse representation. Over the future 50-year period through which the model was run, the process shows the baseline vegetative capability and vegetation conditions for the GSH being changed to classes both within and beyond current capabilities and conditions. We created two classes to capture the conditions of future vegetative capability: "Desiccation" describes the state to which all presently disturbed soils (e.g., cultivation) change to, reflecting greatly reduced productive capability through the protracted drying of the ecosystem; "U.S. northern mixed prairie (dry)" describes the vegetation community analogue to which all areas of extant native vegetation eventually shift to during the period modeled. It presently exists in drier regions of the northwestern U.S. Great Plains. It is important to emphasize that the U.S. northern mixed prairie (dry) class describes conditions of vegetative *capability* within the GSH and not necessarily the actual development of this vegetation community during the modeled period, due to the limitations of equilibrium modeling assumptions noted above.

#### *2.5.2.1 Model operation*

Modeled climate variables for the 2050s time period, supplied by the climate models and converted to annual change factors, were applied to the baseline climate in annual increments within the model. At each annual climate increment, the resulting change in the CMI is tested against the predefined transition threshold values for vegetative capability for each 10-m cell of the baseline land cover dataset. Each class was modeled to transition into a single class only. For some vegetative classes, a small portion of the area could also shift into another class, however this is beyond the present capabilities of the model. When a transition threshold value is surpassed, the land cover value for vegetative capability is changed for that data cell. At each annual increment, the PET value is also tested for each cell. If this value exceeds a predetermined value (in this case 760 mm PET) the process is diverted to the logistic regression model and tested for transition to a selection of vegetation community classes not presently existing within the ecosystem. These transitions are described in Table 2-2-2.

### 2.5.3 Results

With respect to the local climate of the GSH, our model predicts substantive changes over the 50-year period (Figures 2-2-1 through 2-2-5). Currently, mean annual temperatures range from 4.6°C in the south of the Study Area to 3.4°C in the north (Figure 2-2-1). Our 50-year trend indicates an average increase of 3°C across these zonal belts. Mean annual precipitation also follows a north-south gradation, currently ranging from 370 mm in the south to 340 mm in the north (Figure 2-2-2). These values are predicted to increase by about 15 mm per year. The proportion of this precipitation that falls during the summer is predicted to decrease by about 4% over the 50-year simulation period (Figure 2-2-3). Despite the modest increase in mean annual precipitation, the marked increase in mean annual temperatures results in dramatic increases in mean annual potential evapotranspiration (Figure 2-2-4) and concomitant decreases in the GSH climate moisture index (Figure 2-2-5). Mean annual potential evapotranspiration in the south will jump from about 695 to 920mm, a change of 32%, and in the north from about 650 to 830mm, a change of 28%. Respective climate moisture indices will change from about –325 to –535mm (65% decrease) in the south and from about –310 to –460mm (48% decrease) in the north.

Despite these dramatic predicted changes in local climate over 50 years, the modeling of vegetative cover from our model predicts little to no changes for the first

Table 2-2-2. Modeled land cover transition thresholds and succession land cover types

| Land Cover | Transition Threshold | Succession Land Cover |
|---|---|---|
| Cultivated | < -400 CMI | Desiccation |
| Hay/Alfalfa | < -420 CMI | Desiccation |
| Shallow alkaline water | < -420 CMI | Alkali flat |
| Vegetated wetland | < -380 CMI | Wet meadow |
| Open water | < -360 CMI | Shallow alkali water |
| Bare soil | < -400 CMI | Desiccation |
| 25% re-vegetated | < -440 CMI | Bare sand (GSH) |
| 50% re-vegetated | < -420 CMI | 25% re-vegetated |
| Grassland | > 760 PETAnn | U.S. Northern Mixed Prairie (dry) |
| Silvery grassland | < -400 CMI | 50% re-vegetated |
| Wet meadow | < -450 CMI | Alkali flat |
| Juniper | < -420 CMI | Grassland |
| Mixed shrub | < -400 CMI | Grassland |
| Sagebrush | < -450 CMI | Grassland |
| Trees | < -360 CMI | Mixed shrub |
| Bare sand (Cultivated) | < -380 CMI | Desiccation |

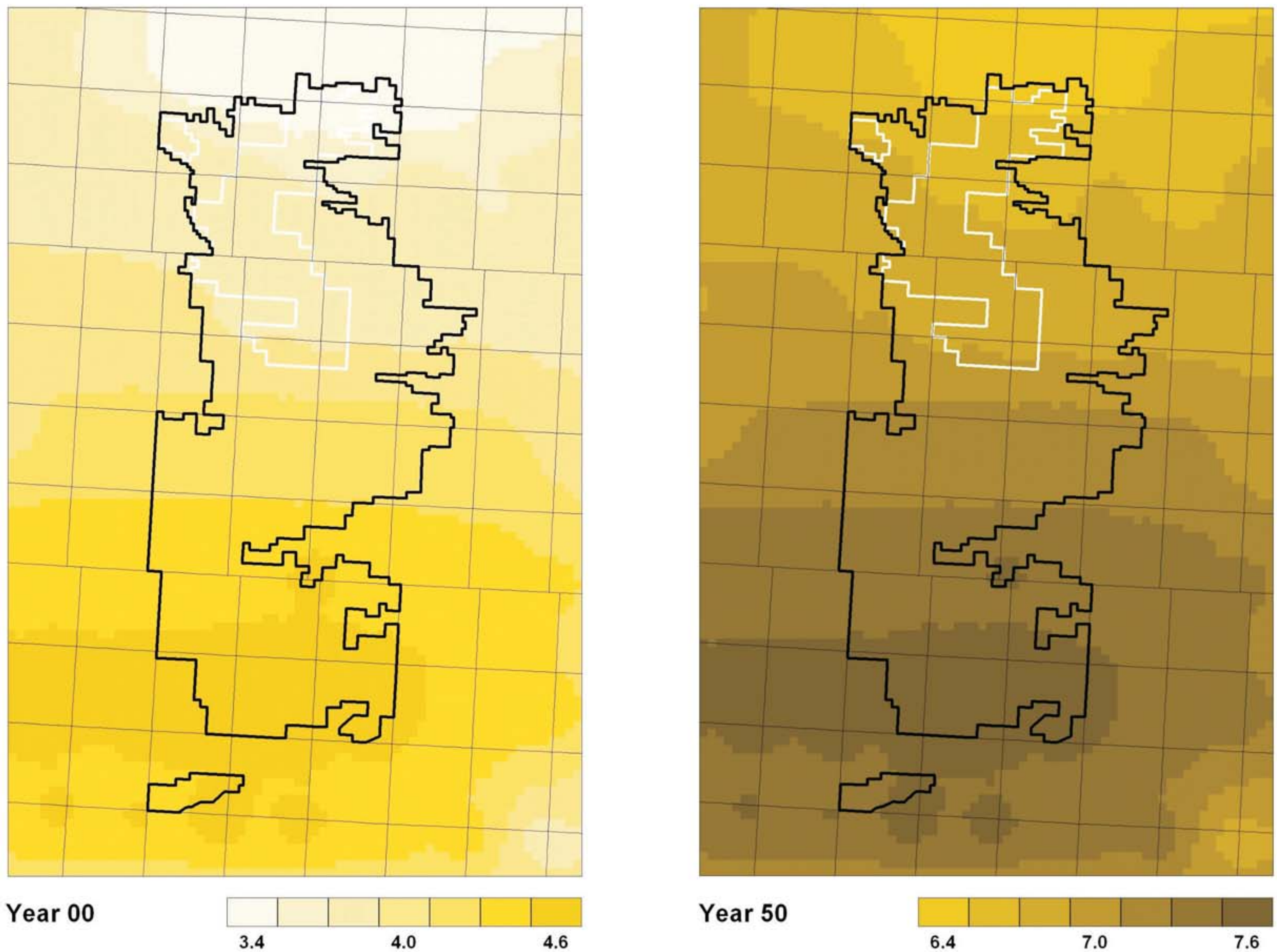



Figure 2-2-1. Mean annual temperature (degrees C) in the Great Sand Hills under current conditions (left) and after 50 years of modelled climate change (right). The Review Area is outlined in black and the Representative Area Ecological Reserve is outlined in white.

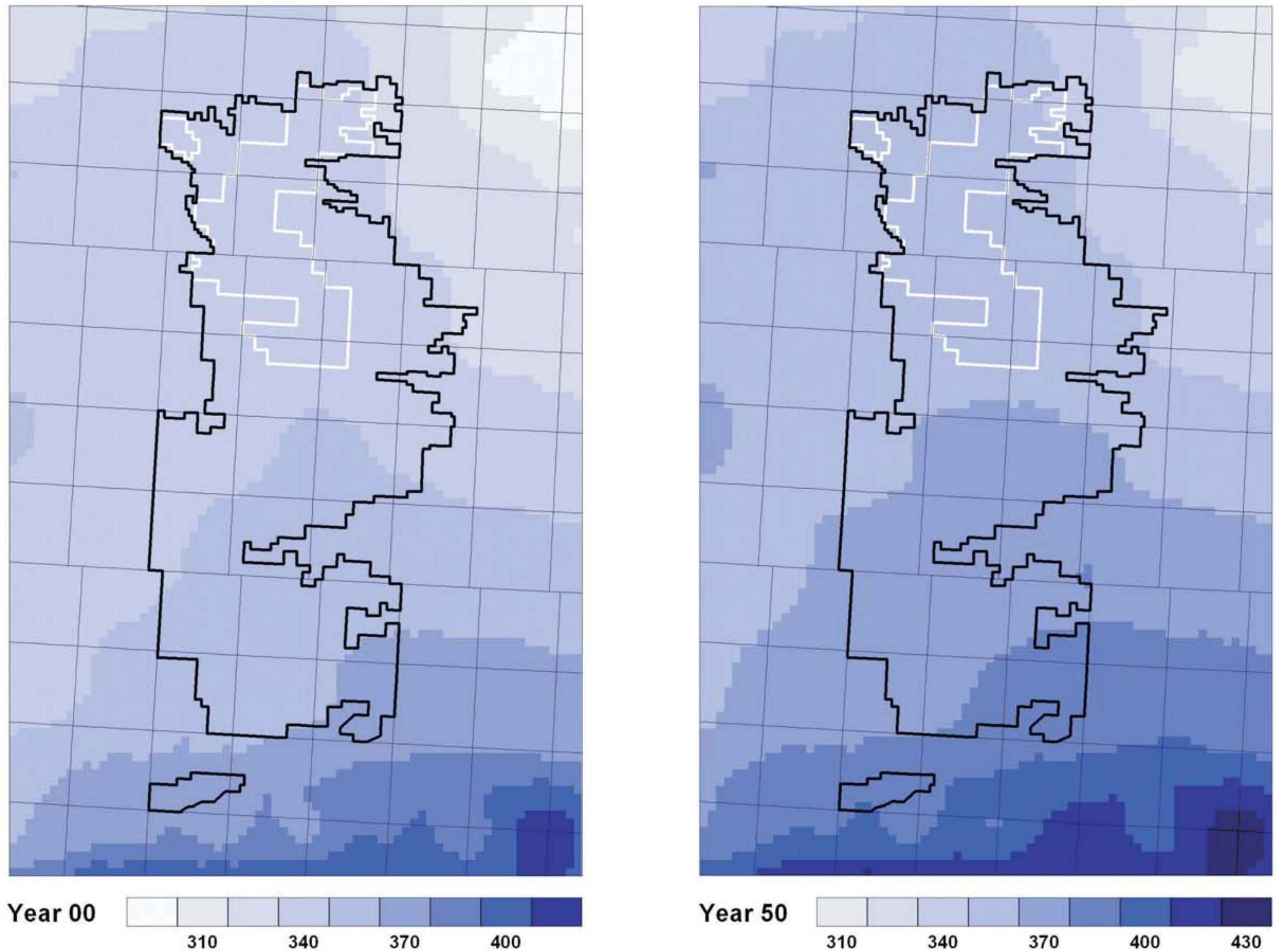



Figure 2-2-2. Mean annual precipitation (mm) in the Great Sand Hills under current conditions (left) and after 50 years of modelled climate change (right) The Review Area is outlined in black and the Representative Area Ecological Reserve is outlined in white.

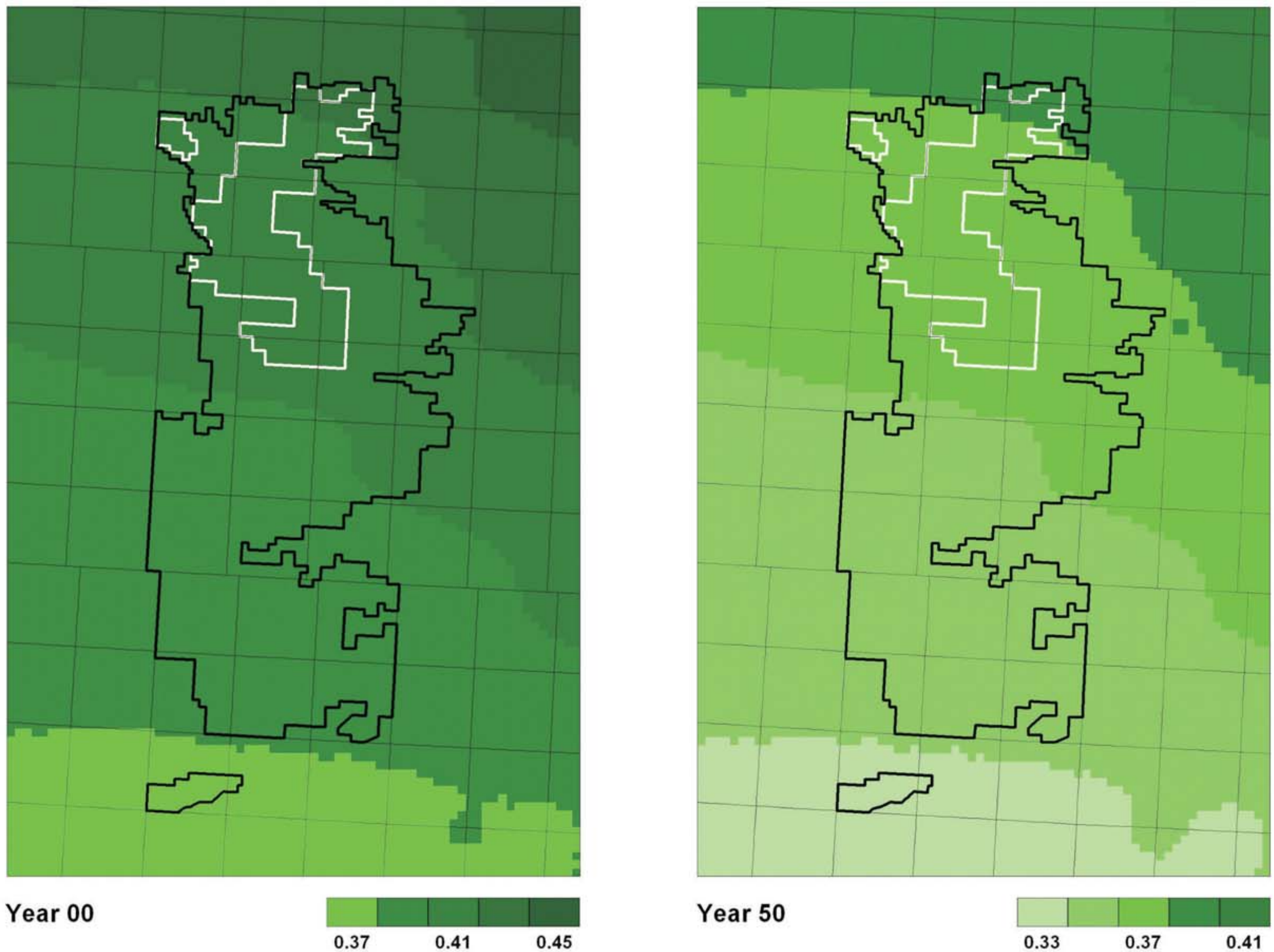



Figure 2-2-3. Summer precipitation proportion in the Great Sand Hills under current conditions (left) and after 50 years of modelled climate change (right). The Review Area is outlined in white.

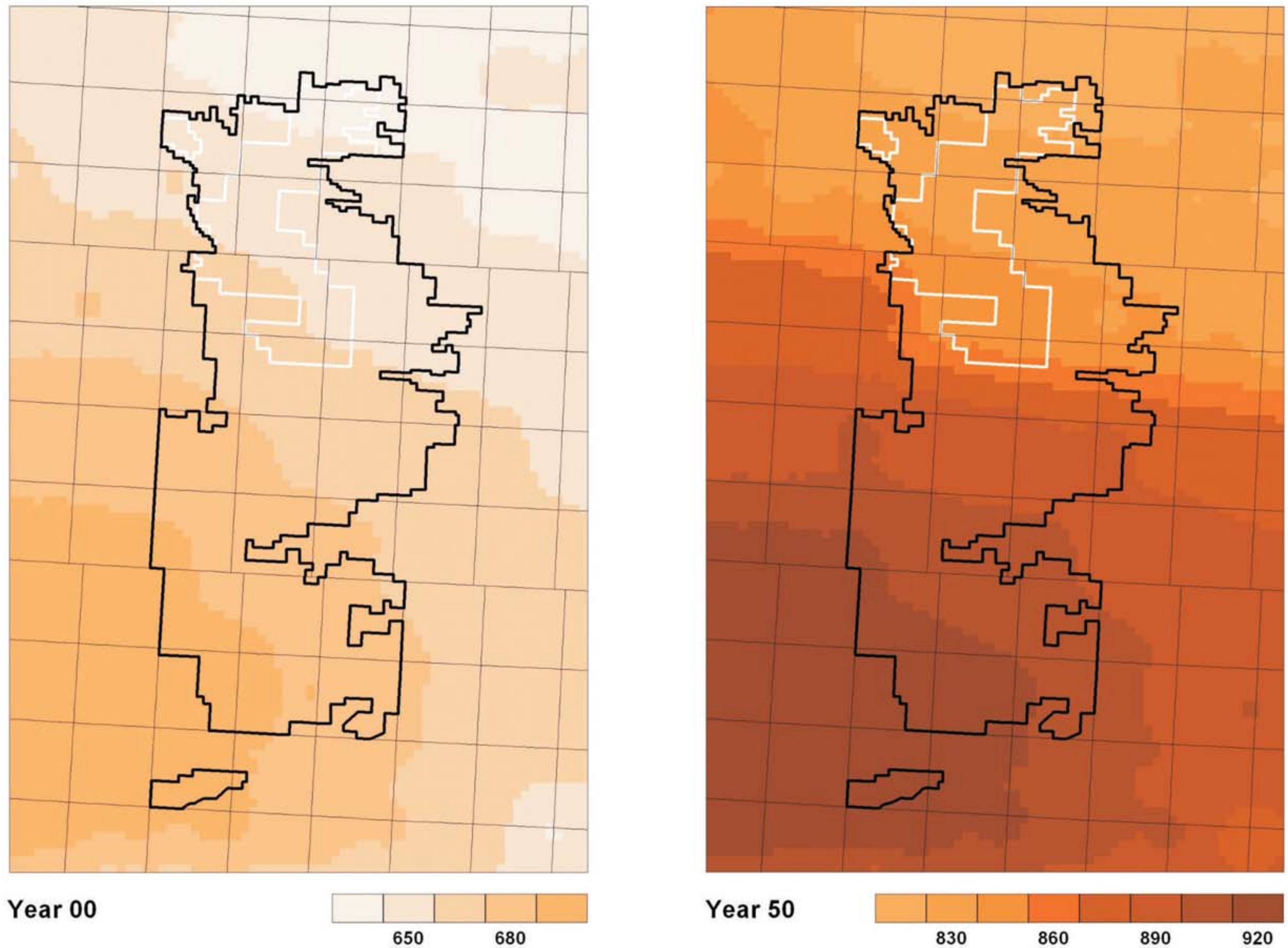



Figure 2-2-4. Mean annual potential evapotranspiration (mm) in the Great Sand Hills under current conditions (left) and after 50 years of modelled climate change (right). The Review Area is outlined in black and the Representative Area Ecological Reserve is outlined in white.

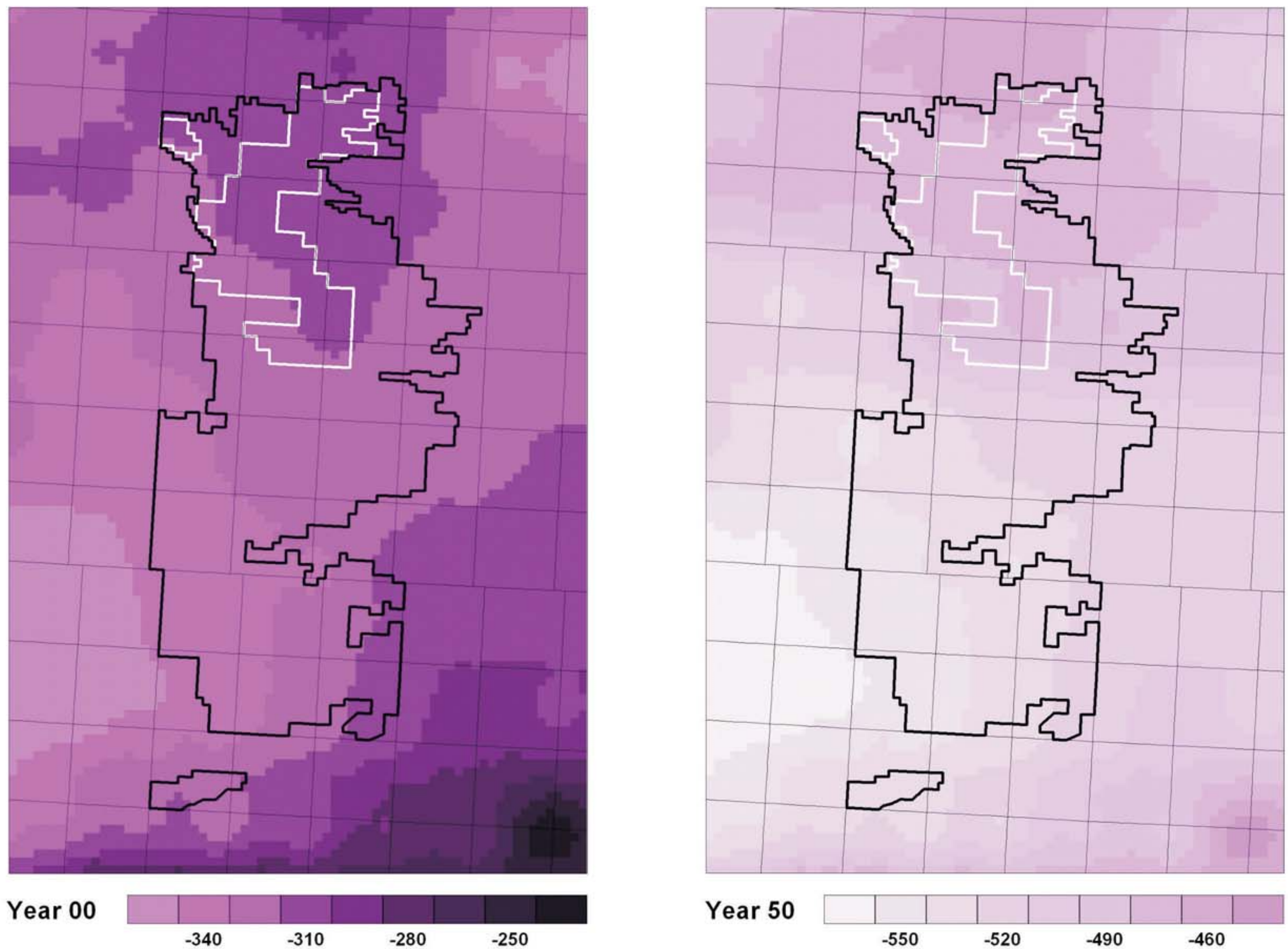



Figure 2-2-5. Climate moisture index (mm) in the Great sand Hills under current conditions (left) and after 50 years of modelled climate change (right). The Review Area is outlined in black and the Representative Area Ecological Reserve is outlined in white.

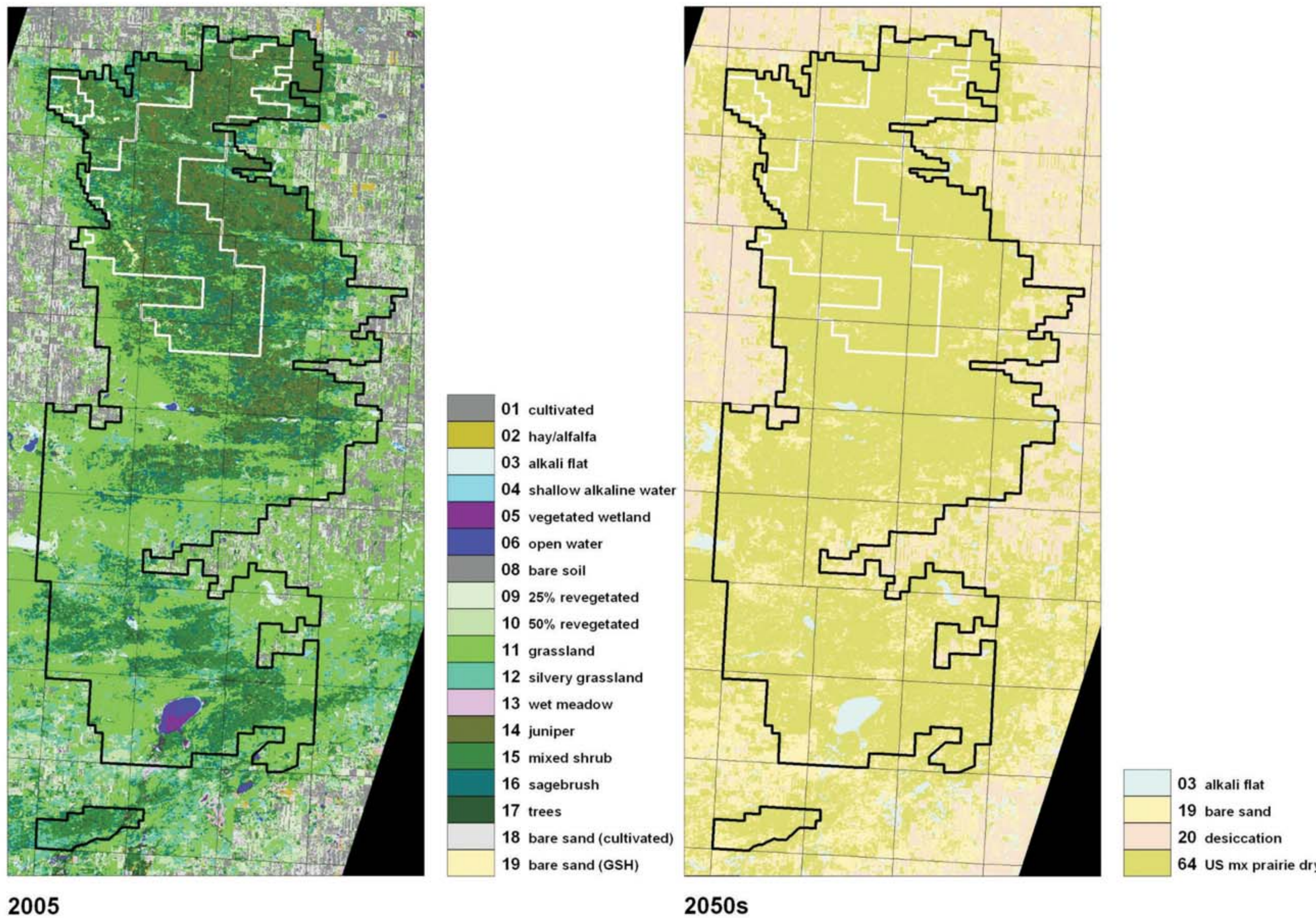



Figure 2-2-6. The Great Sand Hills Landcover Classification – as produced from SPOT5 imagery in 2005 (left) and after 50 years of modelled climate change (right). The Review Area is outlined in black and the Representative Area Ecological Reserve is outlined in white.

15 years, but beyond this, extensive changes in vegetative cover over the following 35 years (Figure 2-2-6). Consideration of these changes can be broken down into four broad categories: shrubland areas and grassland areas (Figure 2-2-7), and cultivated areas and wet areas (Figure 2-2-8).

In shrubland areas (Figure 2-2-6), trees, mixed shrub, sagebrush, and juniper revert to grassland, and eventually to U.S. Northern Mixed Prairie (dry). Few changes occur with sagebrush and juniper cover for the first 25–30 years; however, within 35–45 years, shrubland is predicted to change entirely to U.S. Northern Mixed Prairie (dry) (Figures 2-2-6 and 2-2-7).

In grassland areas, silvery grassland dries and shifts to 50% re-vegetated, which in turn changes to 25% re-vegetated and finally reverts to increased areas of bare sand. Current grassland (dry mixed prairie) in turn shifts towards the U.S. Northern Mixed Prairie (dry) type, and within 30 years this land cover type dominates the entire GSH region (Figures 2-2-6 and 2-2-7).

In cultivated areas, mostly around the perimeter of the GSH Study Area (Figure 2-2-6), grain crops and hay crops, as well as areas with bare soil and sand, are predicted to undergo desiccation within 25-30 years and shift to a new unproductive class, Desiccation (Figure 2-2-8).

In wet areas, open water dries up, leading to an increase in shallow alkaline water, which in turn evaporates, leading to an increase in alkali flats. Vegetated wetlands also shift to drier wet meadows, which in turn revert to alkali flats. Within 30 years, most wet classes have disappeared and are replaced by alkali flats (Figure 2-2-8).

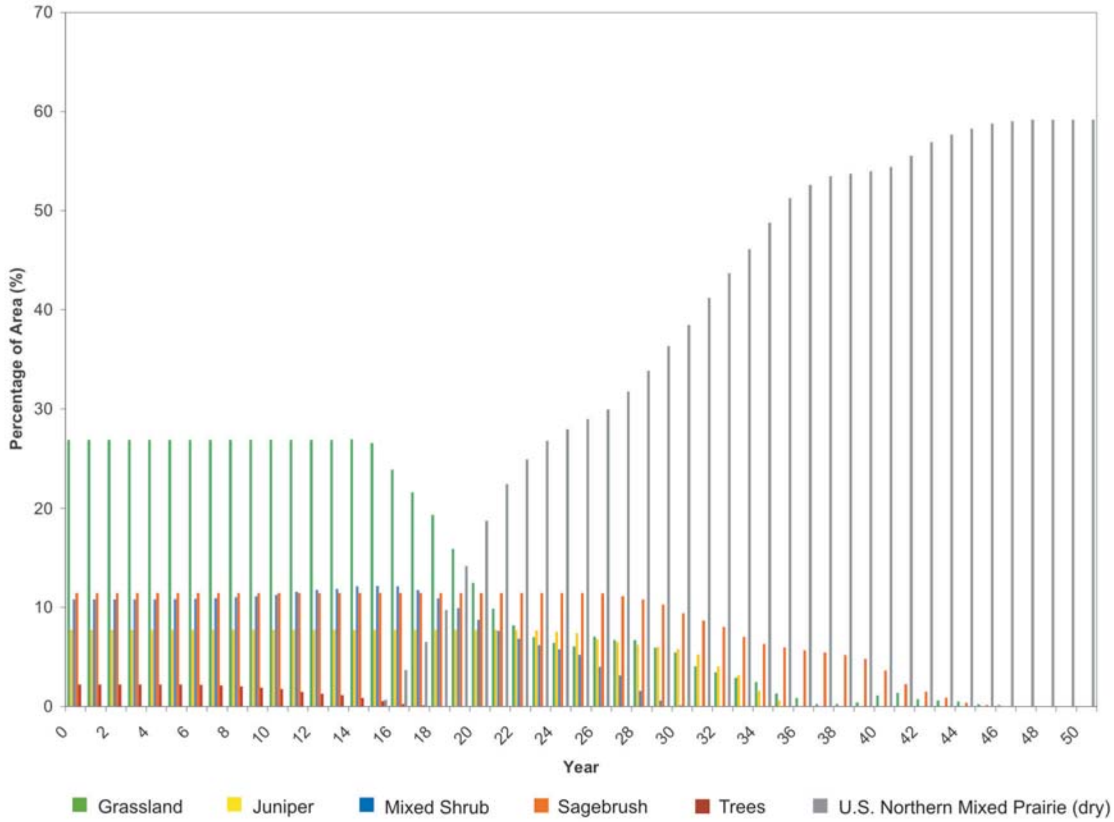
### 2.5.4 Discussion

We modeled 50 years of changing climate and associated potential vegetative shifts for the GSH based on landcover classes from the 2005 GSH landcover classification, current and future CMI values, selected vegetative community thresholds, the vegetation shifts anticipated by Thorpe et al. (2001), and the dune activation anticipated by Wolfe (1997). Our model predicts the following changes in vegetative classes of the GSH:

**Trees:** The trees class includes bluffs of trembling aspen (*Populus tremuloides*) and plains cottonwood (*Populus deltoides*), both of which are often surrounded by tall shrubs including water birch (*Betula occidentalis*) and willow (*Salix spp.*). Both species of poplar are associated with moist habitats, and poplar forests are not a major vegetation type in the Nebraska and Colorado Sand Hills. A reduction in poplar cover and tall shrub cover is expected with the predicted climate.

**Sagebrush:** This class of grassland with frequently scattered silver sagebrush (*Artemisia cana*) is found in only the driest of the Canadian Sand Hills regions (Thorpe et al. 2001) but is not found in the Colorado and Nebraska Sand Hills. There sand sagebrush (*Artemisia filifolia*) is a major vegetation type in the driest zones. The distributions of both species of sagebrush overlap in Badlands National Park in South Dakota, although they occur under different conditions: the silver sagebrush/western wheatgrass (*A. cana* / *Agropyron smithii*) community is closely associated with creeks, drainages, and depressions, whereas the sand sagebrush/ sand reed grass (*A. filifolia* / *Calamovilfa longifolia*) community occupies sand hills and high sand ridges (Von Loh et al. 1999). With climatic warming in the GSH, a similar pattern could emerge: silver sagebrush is likely to gradually decrease and could become limited to areas with high moisture availability as it declines; as sand sagebrush disperses northward, new sand sagebrush communities could form on the sand ridges and flats currently occupied by silver sagebrush. Although silver sagebrush increases with grazing (Abouguendia 1990) and is able to recover from other disturbances by sprouting new vegetation, it does not recover entirely from drought (Ellison and Woolfolk 1937). Sand sagebrush has similar disturbance-associated characteristics, yet thrives in hot, dry climates; overgrazing and fire maintain the sand sage prairie in the Colorado Sand Hills (Ramaley 1939). With a climate analogous to that of the Colorado and Nebraska Sand Hills, a sand sage prairie community, once developed, is likely to persist within the future climate envelope of the GSH.

**Juniper:** This community is dominated by creeping juniper (*Juniperus horizontalis*) with sparse grasses. It is found mostly in depressions and flats, and is known to be limited to the northern area of the GSH. Based on the juniper-dominated sites during the 2006 GSH Survey, at the majority of the sites needle-and-thread grass (*Stipa comata*) and June grass (*Koeleria macrantha*) are the dominant grasses. Sand reed grass (*Calamovilfa longifolia*), sedges (*Carex spp.*), and wheat grasses (*Agropyron spp.*) were also present



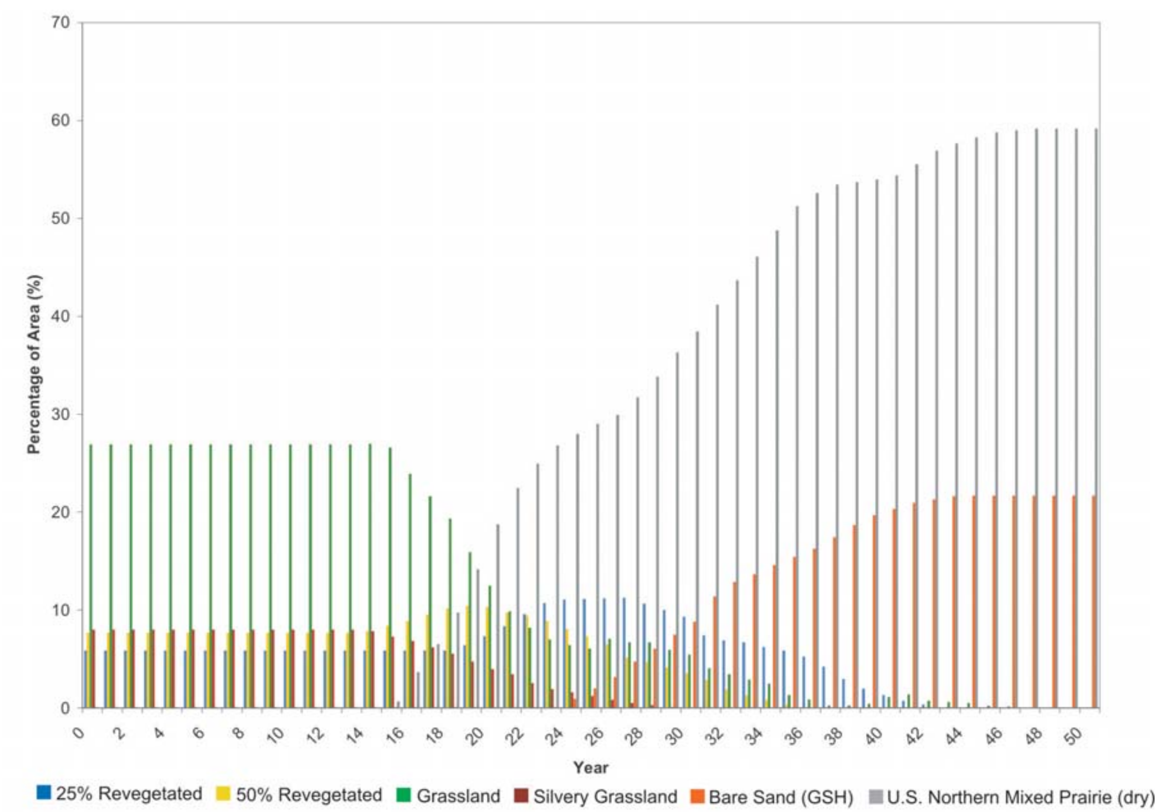




Figure 2-2-7. Vegetation succession in shrubland (top) and grassland (bottom) during 50 years of modelled climate change.

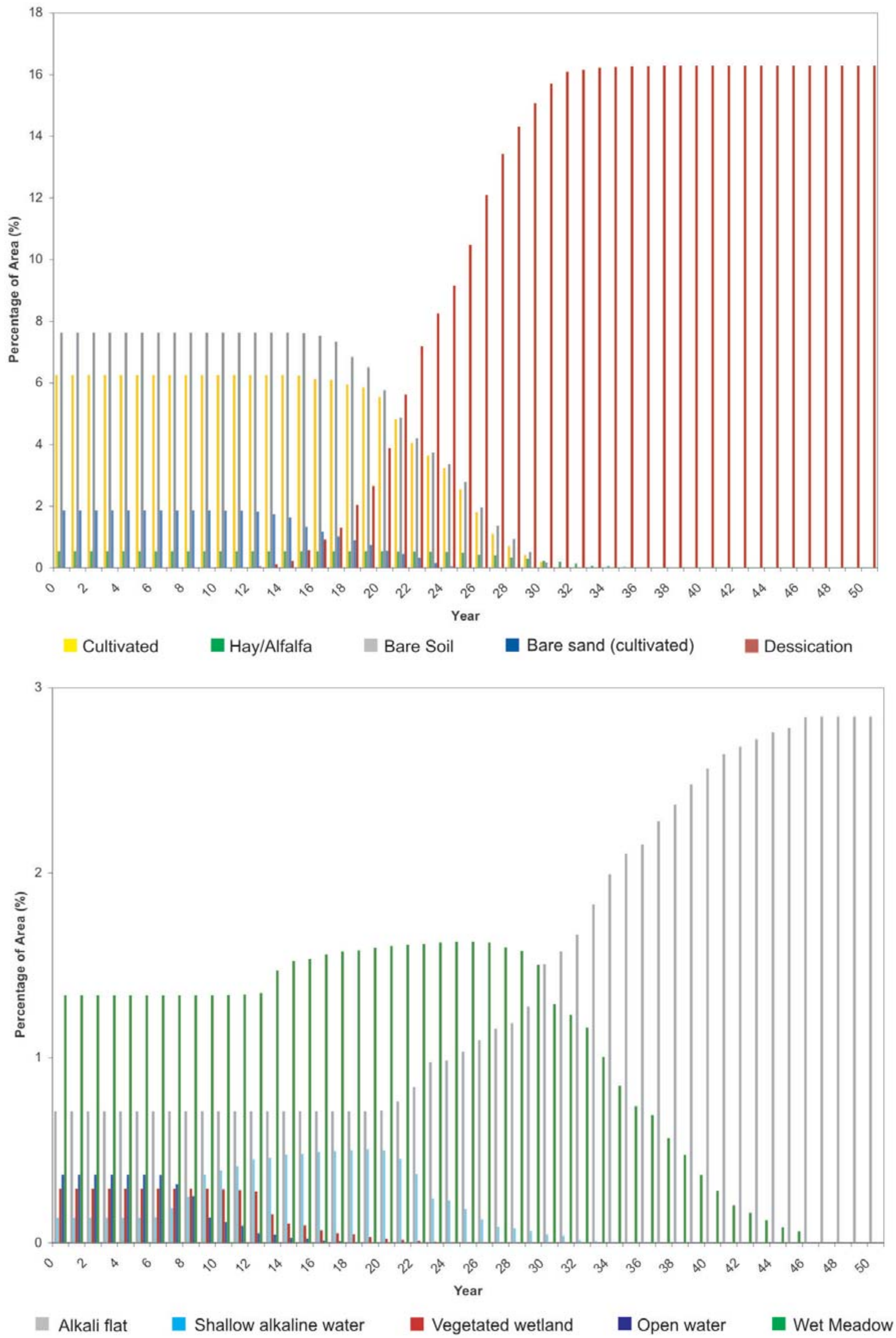



Figure 2-2-8. Vegetation succession in cultivated (top) and wet areas (bottom) during 50 years of modelled climate change.

at most sites. During the 2005 surveys, creeping juniper was also found with little bluestem (*Andropogon scoparius*) at some sites (S. James, pers. obs). Similar creeping juniper-dominated communities with sparse grasses are described with xeric to subxeric moisture regimes in Coenen (2003), whereas creeping juniper-dominated communities with little bluestem are described on relatively more mesic sites in Von Loh et al. (2000). Creeping juniper (or any prostrate shrubland) is not found in the U.S. analogue, is likely not adapted to the climate, and is expected to decrease with increasing warm and dry conditions in the GSH. With decreasing juniper cover, an increase in sand reed grass, little bluestem, and other warm season grasses already present is expected, and a transition to grassland is probable.

**Mixed Shrub:** This class consists of all shrubland within the GSH, with the exception of Sagebrush, and is found most often near poplar bluffs and in depressions. It is most often a mix of western snowberry (*Symphoricarpos occidentalis*), rose (*Rosa spp.*), chokecherry (*Prunus virginiana*), and juniper (*Juniperus horizontalis* and *Juniperus communis*); however, stands of wolf willow (*Elaeagnus commutata*), willow (*Salix spp.*), and water birch (*Betula occidentalis*) are also likely to occur within this class. With the exception of rose, none of these species is found in the Nebraska or Colorado Sand Hills (Thorpe et al. 2001). This land cover class is likely to decrease with climatic warming. Arrival of southern shrubs could create a new shrub class with less coverage overall.

**Grassland:** The grasslands of the GSH are currently mixed grass prairie with a needle and thread grass-wheatgrass–june grass association, with patches of sand reed grass and little bluestem, as well as other warm season grasses. Thorpe et al. (2004) found dominance by C4 grasses increased with annual growing degree days. With a shift from the current climate to warmer, drier conditions, a shift from C3 to C4 dominated grasslands is expected. With such a large component of native warm-season (C4) grasses, the GSH has the potential capacity to adjust to climate change with a rapid response from existing warm season grasses (Thorpe et al. 2001). Most of the current dominant grasses will continue to be abundant, but a shift towards increasing proportions of native warm-season species is expected: needle and thread grass, western wheat grass (*Agropyron smithii*) and June grass are expected to decrease in relative production with mean annual temperature, whereas blue grama (*Bouteloua gracilis*) and sand reed grass are expected to increase (Epstein et al. 1998). A gradual arrival of southern warm-season grasses—sand bluestem (*Andropogon halii*), switch grass (*Panicum virgatum*), sandhill muhly (*Muhlenbergia pungens*), sand love grass (*Eragrostis trichodes*), hairy grama (*Bouteloua hirsuta*), blowout grass (*Redfieldia flexuosa*), and Scribner panicum (*Dicanthelium oligosanthes*)—is also likely to occur (Thorpe et al. 2001), along with the potential for new dominant warm-season species. For the sand hills of northeastern Colorado, Ramaley (1939) describes a climax grassland community of needle and thread grass–sand bluestem–sand reed grass. Sullivan (1994) describes the Nebraska Sand Hills grasslands as having north-facing slopes dominated by needle and thread grass, south-facing slopes dominated by sand reed grass, hilltops dominated by both, and dry upland sand dunes dominated by sand bluestem. With time the GSH could also develop these communities. More grassland areas are also likely to occur, as trees and mixed shrub areas decline, although some grassland areas are likely to transition to 50% re-vegetated grassland as dune activation occurs.

**Silvery Grassland:** This class consists of grassland patches dominated by Pasture Sage (*Artemisia frigida*) and /or Silver-leaved Psoralea (*Psoralea argophylla*). Pasture sage is common in disturbed areas (Epp and Townley-Smith 1980) and increases with grazing (Abouguendia 1990), and areas occupied by this class are often heavily grazed. With increasing aridity, this class is likely to transition to the 50% re-vegetated class, to a greater extent than grassland, as existing disturbed areas within this class may be susceptible to erosion.

**50% Re-vegetated:** This class is found on sandy soils, most often on dunes that are beginning to stabilize, and consists of areas that are 50% re-vegetated, 50% bare sand. The vegetation is a mix of grasses, including sand reed grass and often lance-leaved psoralea (*Psoralea lanceleota*). With increasing potential for dune activation with increased aridity (Wolfe et al. 2001), the amount of this class is likely to remain the same or increase. This class is likely to transition towards the 25% re-vegetated class, whereas some areas of grassland (especially those on the crests of stabilized dunes or on the edges of disturbed areas) are likely to transition towards this class.

**25% Re-vegetated:** This class is found on sandy soils, most often on the edges of active dunes or other sand disturbances as the first stage of stabilization, and consists of areas that are 25% re-vegetated, 75% bare sand. On dunes, the vegetation is most often dominated by lance-leaved psoralea, but also includes sand reed grass. With increasing potential for dune activation with increased aridity (Wolfe et al. 2001), the amount of this class is likely to remain the same or increase. This class is likely to transition towards the bare sand (GSH) class, and the 50% re-vegetated class is likely to transition towards this class.

**Bare sand (GSH):** This class consists of bare sandy soils, with no vegetation, and includes active dunes and disturbed areas such as trails, saltlicks, watering sites, and other livestock disturbances. This land cover type is expected to increase with the reactivation of dunes under drought conditions and with a probable increase in erosion of disturbed areas, whether caused by humans, animals, or fire.

**Bare soil:** This class consists of brown productive soils at the edge of GSH Review Area and south. It also includes ploughed bare fields and cattle disturbances (at dugouts, etc.) on brown soils within the Review Area. With climatic warming, a decrease in the suitability of land for cultivation is expected, as soil becomes unproductive, with an increased probability of erosion. This produces a new class of bare soil: Dessication.

**Bare sand (Cultivated):** This class consists of sandy soils outside of the GSH Review Area, including ploughed fields and disturbed areas with little to no vegetation. With climatic warming, this class is also expected to shift towards Dessication.

**Cultivated:** This class consists of cultivated lands with ripe grains on the edges of the Great Sand Hills Review area. It includes summer fallow fields, standing crop, and cut crop. This vegetative class is expected to decrease with climatic warming due to decreased suitability of the land for cultivation under hotter, drier conditions and the shift from productive to dessicated soils.

**Hay/Alfalfa:** This class consists of deep green moist vegetation, mostly alfalfa (*Medicago sativa*). This vegetative class is expected to decrease with climatic warming due to decreased suitability of the land for cultivation under hotter, drier conditions and the shift from productive to dessicated soils.

**Open water:** This class consists of dugouts, lakes, and any areas of deep open water where light penetration to the floor was minimal. With a hotter, drier climate, this class is expected to dry to shallow alkaline water, although a small portion may shift instead toward vegetative wetland.

**Shallow Alkaline Water:** This class consists of shallow water with an alkali bottom. With changing climate and hotter drier conditions, this class is expected to dry to alkali flats.

**Alkali Flat:** This class consists of white-crusted dry alkali flats with no vegetation. This cover type is expected to increase with drier climate, as shallow alkali water dries to alkali flats.

**Vegetated Wetland:** This class consists of green moist vegetation, e.g. Great Bulrush and Prairie bulrush (*Scirpus spp.*), Baltic Rush (*Juncus balticus*), etc. With increasing aridity the cover of this class is likely to decrease as vegetated wetlands shift towards wet meadows.

**Wet Meadow:** This class includes moist grassland dominated by foxtail grass (Hordeum jubatum) and other moist vegetation. With increasing aridity the cover of this class is likely to decrease, potentially shifting towards alkali flats.

Changing climate will drive vegetation transitions, increase the potential for dune activity, erosion, and fire, and alter species distributions across the GSH. The similarities of the predicted GSH 2050s climate to the current climate of the Nebraska and Colorado Sandhills led Thorpe et al. (2001) to suggest that, with warming, a gradual migration northward of southern warm season grasses, forbs, and shrub species will occur, along with an overall reduction of shrubland and a decline in many of the current tree and shrub species. Our models also indicate an overall reduction in the current distribution of tree and shrub species and a shift to a new type of grassland dominated by warm season species. We modeled only existing vegetative classes; however, we expect that within the large areas that become U.S. Northern mixed prairie (dry), some southern warm season species could establish, including those present in Thorpe et al.'s (2001) U.S. analogue: sand sage, inland ceanothus (*Ceanothus americanus*), leadplant (*Amorpha* *canescens*), sand cherry (*Prunus besseyi*). Many factors will affect the rate at which a shift in the vegetation will occur, however. The current vegetation may remain intact, requiring some form of disturbance before a change in species composition will occur (Thorpe et al. 2001). As well, species will vary in dispersal rates, and the dispersal of southern species northward may be impeded by the high fragmentation of native habitats with agricultural lands in between. The disruption of communities during transitions, and changing climatic conditions, could also increase the opportunity for invasions by weedy and non-native plant species, creating new communities without current analogues.

The rate of dune activation with increasing aridity is also uncertain. Wolfe et al. (2001) highlight the sensitivity of the sand dunes in the Great Sand Hills to drought and cumulative moisture stress. Widespread sand dune formation and activity across the region last occurred during the late 18th century, when a drought in the late 1790s followed lower than average precipitation throughout the 1700s (Wolfe et al. 2001). These authors suggest that the current trend towards a warmer and drier climate could cause a shift from the current stabilization of sand dunes to increased levels of dune activation; however, a long-term shift towards increased aridity would be necessary to cause widespread dune activity.

With dune destabilization the GSH will have an increase in areas of bare sand, and we expect our re-vegetating types are also likely to shift in that direction. We also expect that, with any stress, a portion of the grassland cover will shift to silvery grassland or 50% re-vegetated, rather than the shift of the entire class to U.S. Northern Mixed Prairie (dry) that we modeled. This will lead to the persistence of the re-vegetated classes and eventually to a slight increase in bare sand and a slight decrease in U.S. Northern Mixed Prairie (dry). Though not modeled, areas that are disturbed within the new grassland class (U.S. Northern Mixed Prairie (dry)) are also expected to shift towards the re-vegetated and bare sand classes, again leading to the persistence of these classes with increasing aridity.

Increased aridity could also increase the erosion of roads and trails, sites that experience cattle disturbances (watering sites, cattle trails, etc.), and sites of gas development. The role of the Representative Area Ecological Reserve within the GSH with its reduced human disturbance may prove to be instructive here.

Changes in vegetative types that occur could be beneficial to some species. An increase in dune activity would create the potential for an increase in species associated with active dunes and bare sand, many of which are currently rare, including the federally listed smooth arid goosefoot (*Chenopodium subglabrum*) and Ord's Kangaroo rat (*Dipodomys ordii*). With an increase in grassland and decrease in shrubland, there would also be more habitat suitable for open grassland species. In the Focal Species Modeling for the GSH RES (see Chapter 3), Baird's Sparrow (*Ammodramus bairdii*), Chestnut-collared Longspur (*Calcarius ornatus*), Grasshopper Sparrow (*Ammodramus savannarum*), Horned Lark (*Eremophila alpestris*), Long-billed Curlew (*Numenius americanus*), Marbled Godwit (*Limosa fedoa*), Savanna Sparrow (*Passerculus sandwichensis*), Sprague's Pipit (*Anthus spragueii*), Upland Sandpiper (*Bartramia longicauda*), and Western Meadowlark (*Sturnella neglecta*) all had higher occurrences in grassland and herbaceous habitats than in the shrub and dune habitat types examined. An increase in grassland areas could be beneficial to the populations of these species, especially for those considered at risk.

Climate change and changing vegetative cover will also affect grazing and livestock production. A shift to a hotter, drier climate may lower the water table (Thorpe et al. 2001), reducing water availability for livestock at traditional dugout watering sites. This may lead to an increase in the development of cattle watering systems based on deeper, more secure sources of water. An increase in shallow buried pasture pipeline development under these conditions is likely, and while it will secure a better source of water for livestock, it also creates the potential to increase the number of watering sites, as well as the potential for erosion, invasive species, and poor range health associated with each (James 2006). With respect to grassland productivity, Thorpe et al. (2004) predict only a modest change in grazing capacities with climate change. In comparing the current productivity of the GSH with the U.S. analogue for the 2050s, the herbaceous forage yield and grazing capacity are higher in the Nebraska and Colorado Sand Hills despite a drier climate (Thorpe et al. 2001). Although this could be due to a difference in measurement techniques, this could also be due to an increase in the suitable land for grazing (more grassland and less woody cover) and the greater proportion of warm season grasses balancing out the effects of drier climate. A drier, hotter climate will also increase the potential for prairie fires. Over the long term fire may be beneficial to range health and producers; however, in the short term uncontrolled fires could have catastrophic effects on the livelihoods of the landowners and producers affected.

As with any predictive modeling exercise, we cannot account for all of the variables that will likely play a role in shaping the future land mosaic of the GSH. Most important of these will be the human response to the changing climatic conditions. Changes in land cover set off by climate change can be either moderated or exacerbated by the resultant changes in the human management of the GSH ecosystem and its surrounding landscape matrix. For example, converting cropland to grassland in the matrix may help to support the ecological integrity of the GSH, reducing surface disturbance throughout the GSH may slow the reactivation of the dunes, and the human-assisted introduction of already adapted plant species from the south may prevent the loss of range productivity. The key to maintaining the future sustainability of the GSH will be careful planning based on the best possible information; it is in this light that we hope this report will be taken.

# Chapter 3: Biodiversity Assessment

## 3.1 INTRODUCTION

The Great Sand Hills of Saskatchewan represent a large remnant of native northern mixed-grassland habitat with provincial, national, and continental significance (Gauthier and Wiken 2003). The sand dune formations common to the area, in particular, provide habitat for many species that are considered rare or declining in Saskatchewan and Canada. These species include the Endangered Ord's kangaroo rat (*Dipodomys ordii*), the Threatened slender mouse-ear cress (*Halimolobos virgata*), and Species of Special Concern smooth arid goosefoot (*Chenopodium subglabrum*). The first two species are largely dependent on sand dunes, an uncommon habitat that has become rarer since the early 20th century due to changes in climate (Wolfe et al. 2001, Hugenholtz and Wolfe 2005).

Beyond sand dunes, the GSH are also characterized by wetlands, lakes, extensive open grasslands, and a patchy network of shrubs (sagebrush, juniper, chokecherry, etc.) and trees (most notably aspen and cottonwood). This mosaic of grasslands, dunes, wetlands, shrubs, and trees, largely patterned from the hummocky terrain derived from Pleistocene and Holocene deposits, provides more than 2,000 km$^2$ of contiguous native habitat. The sandy soils and rugged terrain characteristic of the GSH are not conducive to cultivation. Given the extent and diversity of native habitats, the GSH is an important refuge for game species, including Sharp-tailed Grouse (*Tympanuchus phasianellus*), white-tailed and mule deer (*Odocoileus virginianus* and *O. hemionus*), and pronghorn antelope (*Antilocapra americana*). Native non-game species are also well represented. With this combination of unique landscape elements (i.e., sand dunes), known occurrences of Endangered, Threatened, and sensitive species, important game species, and more generally a refuge of natural heritage, the GSH constitute a biologically significant landscape at regional, national, and international scales. Sustaining the biodiversity of the GSH is critical to securing its ecological integrity.

Despite relatively pristine conditions compared with surrounding areas, the GSH have been influenced by large scale (GSH-wide) and long-term (ca. 100 yrs) livestock grazing and the more recent (past few decades) development of natural gas reserves. Such activities have the potential to alter habitat conditions, through direct disturbances and fragmentation, and affect populations of native and non-native flora and fauna. Although grazing is ubiquitous across the GSH, the most notable footprint of livestock grazing occurs with the concentration of animals around watering holes. This results in a network of permanent trails and extensive vegetative trampling and erosion surrounding these sites. In addition to these localized disturbances, livestock grazing also has the potential to modify vegetation structure and composition at larger landscape scales. In addition to livestock grazing, the GSH have also experienced extensive exploration and development of natural gas reserves, particularly in the west and south. Such activities have resulted in the disturbance of native habitat at drilling sites and during pipeline construction, road/trail development for drilling and maintenance activities, and an overall increase in human activity.

To assist our analysis of baseline biodiversity conditions in the GSH, we used patterns of road and trail density to define "developed" and "less developed" cores (Figure 2-3-1), where "developed" refers to areas with higher concentration of industrial and agricultural activity as represented by higher road and trail density. Although many of the individual disturbances associated with gas development are relatively minimal in extent, at the current scale of development the cumulative effect of such activities may be substantial. Understanding current impacts of stressors resulting from human activities, as well as future threats within the GSH, will lead to more informed land-use decisions, particularly at scales relevant to management (160-ac parcels) and for larger regional contexts (10–2000 km$^2$) relevant to the maintenance of biodiversity and ecological processes. Although dramatic changes in livestock grazing are unlikely over the next two decades (see however, James 2006), additional gas development is likely over significant areas of native habitat within the GSH.

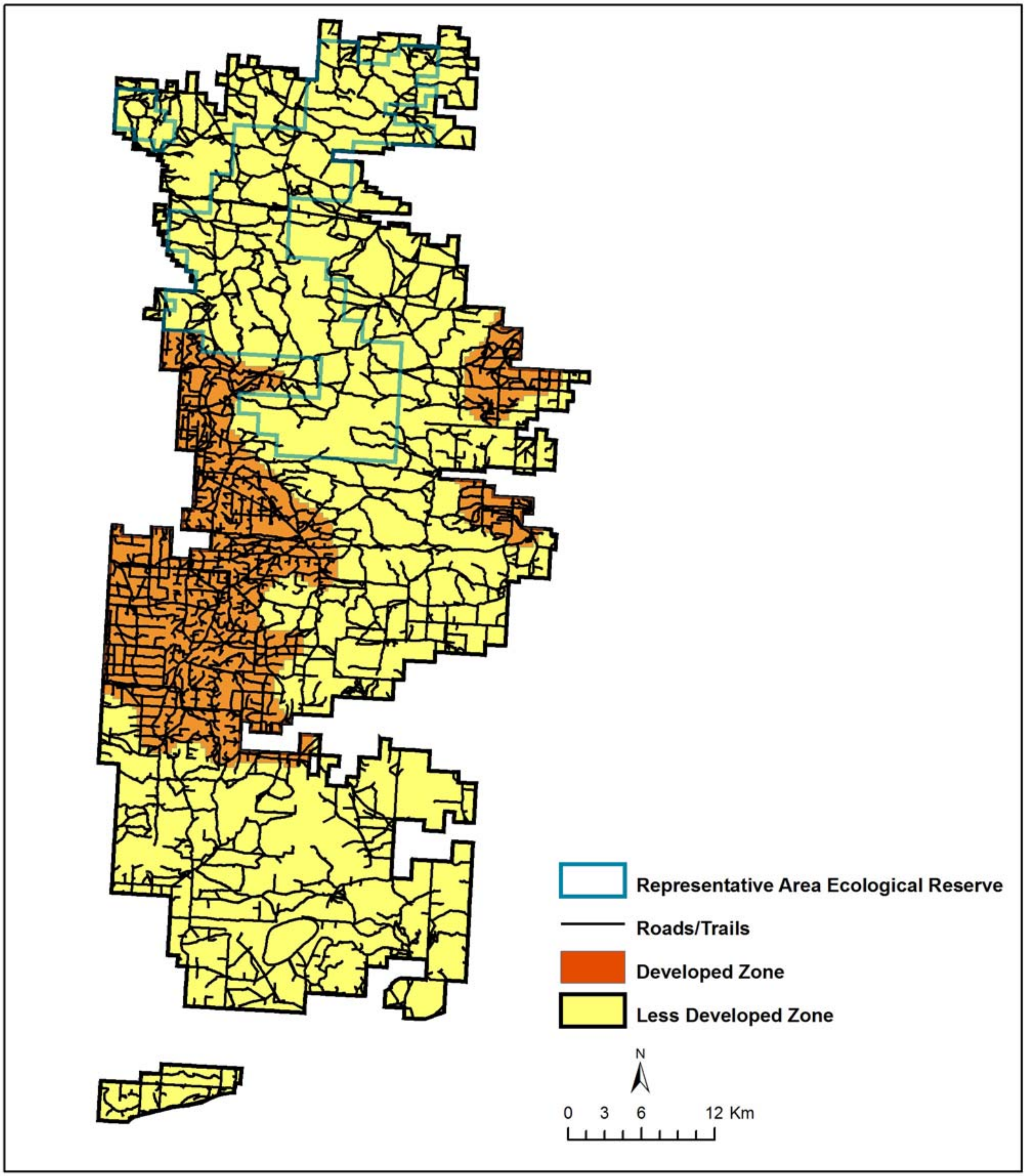



Figure 2-3-1. Classification of the Great Sand Hills for conservation planning. Differentiation of developed and less developed zones was based on patterns of road and trail density (threshold = 1.88 km/km$^2$ [mean + ½ standard deviation]). Only developed patches greater than 23 km$^2$ (9 sections) were classified as developed. Likewise, small islands of less developed sites were merged into developed polygons to prevent checkering of the landscape. Developed areas have higher degrees of concentration of industrial and agricultural activity.

## 3.2 BASELINE MARXAN ANALYSIS

The MARXAN site-selection algorithm (Ball and Possingham 2000, Possingham et al. 2000) was applied to identify areas of the GSH with high biodiversity value. The MARXAN program is widely used in conservation research and planning to explore options for regional biodiversity protection (McDonnell et al. 2002, Ardron 2003, Maanen et al. 2006). The MARXAN algorithm was supported by the Conservation Land-Use Zoning (CLUZ) program (Smith 2005), an ArcView GIS (ESRI 1999) extension that simplifies MARXAN file preparation and display of results.

MARXAN uses the "simulated annealing with iterative improvement" algorithm to select areas of high value for conservation. Minimizing the "cost" of conservation while maximizing attainment of conservation goals in a compact set of planning units is accomplished through the Objective Cost Function:

Cost = Area + Feature Penalty + Boundary Length

where Cost is the objective (to be minimized), Area is the number of hectares in all planning units selected for the portfolio, Feature Penalty is a cost imposed for failing to meet biodiversity feature goals, and Boundary Length is a cost determined by the total boundary length of all selected planning units. MARXAN minimizes total cost by selecting the smallest overall area needed to meet conservation goals and by selecting planning units that are clustered rather than dispersed. It does this by changing the planning units selected and re-evaluating the Cost function through multiple iterations. We performed 1,000,000 iterative attempts in MARXAN to find the minimum-cost solution per simulated annealing run and performed 100 such runs for each alternative conservation scenario we explored.

An array of approximately 16-ha (40-ac) square planning units were created for the MARXAN analyses. Although this is the size of a quarter-quarter section Legal Sub Division (LSD), the planning units were not intended to align with legal boundaries. After adjusting the planning units array to the Review Area boundary and incorporating the RAER boundary there were a total of 13,626 planning units; most were 16 ha but some were smaller because of being split by either the Review Area or RAER boundary.

Table 2-3-1 lists the 77 biodiversity features used in MARXAN analyses, their abundance within the Study Area, and the proportion of their distribution that is within the RAER. Many features have little or none of their distribution within the RAER, leaving them vulnerable to increased surface disturbance or other threats elsewhere in the GSH. Features include: (1) 26 rare species from Conservation Data Centre element occurrences polygons or 2006 field season observations; (2) 23 biophysical habitats including Saskatchewan enduring features, vegetation classes derived from SPOT imagery, topographic features, and surface watercourses; and (3) 28 focal species and range health models (as described later in this chapter). A data table (not shown) was created for use in MARXAN containing the amount of each feature that occurred in each planning unit.

MARXAN runs were made for all features combined, except the "other" focal species models (for reasons explained later), and for each of the three feature groups separately, to examine similarities and differences in biodiversity patterns among the groups. As an example of these patterns, MARXAN results for capturing 50% of all features are shown in Figure 2-3-2, in which planning units that are more essential for meeting biodiversity goals are shown as being selected more frequently among 100 portfolios, each of which was the most efficient of 1,000,000 iterations. The process of highlighting planning units that are selected more frequently by MARXAN is called Sum Runs. For example, the total area of the planning units selected in 50% or more of the 100 scenarios (i.e., Sum of runs ≥ 50) was over 102,000 ha (this includes the 37,000-ha RAER), or approximately 50% of the Review Area. The proportion of total feature abundances held in those planning units is given in Table 2-3-1; the average proportion is 63% (range 44–100%). Capturing an average 63% of biodiversity features in 50% of the Study Area demonstrates the efficiency of MARXAN. As found in other studies, MARXAN solutions based on a "blank slate" landscape (i.e., no RAER or other protected areas) are more efficient because fewer features are "over-represented." The implication of working from a "blank slate" landscape in the GSH, however, would be de-designation of a legally protected area, which we considered unrealistic.

Figures 2-3-3 through 2-3-5 show results for separate MARXAN runs for capturing 50% of the rare species, biophysical habitats, and focal species feature groups respectively; percentages of features captured in these analysis are given in Table 2-3-1. Planning units selected in ≥ 50% of the 100 portfolios totaled 44,900 ha for the rare species run, 103,500 ha for biophysical habitats, and 96,000 ha for focal species.

Rare species data came from two sources: the Saskatchewan Conservation Data Centre and lek sites of Sharp-tailed Grouse observed by GSH RES bird survey crews during 2006 summer field surveys. Both of these

Table 2-3-1. Biodiversity features used in baseline MARXAN analyses (MARXAN Target = Y), with total amount in the Review Area, amount in the RAER, percent protected within the RAER, and percent captured in planning units selected in ≥50% of portfolios for MARXAN analyses of 50% goals for rare species (RS), biophysical habitats (BP), focal species (FS), and for all three feature groups combined (COMB). MARXAN Target = N (not targeted in MARXAN analyses) for (a) field observations of G3S3 and higher or listed species that were either too few in number for focal species modeling or were not made at survey sites (i.e., opportunistic), or (b) 'other' species models that did not meet criteria.

| | | Review | | % of feature | | | | |
|---|---|---|---|---|---|---|---|---|
| FEATURE | MARXAN Target | Area (ha) | RAER (ha) | RAER | COMB | RS | BP | FS |
| Rare Species | | | | | | | | |
| *CDC element occurrence* | | | | | | | | |
| American White Pelican | Y | 7529 | 0 | 0 | 61.0 | 48.2 | 35.2 | 57.7 |
| Burrowing Owl | Y | 9 | 0 | 0 | 100 | 77.8 | 66.7 | 66.7 |
| Common Poorwill | Y | 7817 | 5552 | 71.0 | 73.2 | 71.0 | 73.5 | 77.7 |
| Ferruginous Hawk | Y | 73 | 0 | 0 | 60.3 | 49.3 | 47.9 | 34.2 |
| Long-billed Curlew | Y | 1102 | 151 | 13.7 | 79.9 | 42.5 | 74.5 | 78.1 |
| Migratory bird concentration | Y | 1644 | 0 | 0 | 46.9 | 64.4 | 30.5 | 29.7 |
| Piping Plover | Y | 6 | 0 | 0 | 100 | 50.0 | 50.0 | 0 |
| Olive-backed pocket mouse | Y | 4012 | 0 | 0 | 64.2 | 51.1 | 32.9 | 12.7 |
| Ord's kangaroo rat | Y | 808 | 281 | 34.8 | 69.3 | 42.9 | 68.8 | 61.6 |
| Beaked annual skeleton-weed | Y | 1497 | 875 | 58.5 | 84.0 | 68.9 | 78.4 | 66.0 |
| Bur ragweed | Y | 1615 | 668 | 41.4 | 82.0 | 45.8 | 94.6 | 84.0 |
| Lemmon's alkalai-grass | Y | 7117 | 0 | 0 | 60.9 | 52.9 | 34.7 | 52.9 |
| Low milk-vetch | Y | 537 | 0 | 0 | 83.8 | 53.3 | 37.6 | 12.1 |
| Narrow-leaved water-plantain | Y | 50 | 0 | 0 | 100 | 100 | 44.0 | 0 |
| Nodding umbrella-plant | Y | 50 | 50 | 100 | 100 | 100 | 100 | 100 |
| Prairie dunewort | Y | 315 | 0 | 0 | 98.7 | 62.2 | 0 | 1.0 |
| Sand dune wheatgrass | Y | 5 | 0 | 0 | 100 | 100 | 100 | 0 |
| Six-weeks fescue | Y | 202 | 152 | 75.2 | 75.2 | 75.2 | 75.2 | 75.2 |
| Sleepy catchfly | Y | 50 | 0 | 0 | 100 | 56.0 | 0 | 0 |
| Small lupine | Y | 922 | 273 | 29.6 | 72.7 | 44.8 | 66.8 | 41.9 |
| Smooth arid goosefoot | Y | 2791 | 1875 | 67.2 | 85.4 | 77.7 | 77.9 | 72.3 |
| Spiny milk-vetch | Y | 1395 | 803 | 57.6 | 76.3 | 62.4 | 85.4 | 61.1 |
| Upright narrow-leaved pondweed | Y | 2886 | 0 | 0 | 76.4 | 61.0 | 38.8 | 56.1 |
| Wedge-scale saltbush | Y | 96 | 0 | 0 | 89.6 | 85.4 | 0 | 0 |
| *2006 Field season observations* | | Count | Count | | | | | |
| Sharp-tailed Grouse leks | Y | 18 | 5 | 27.8 | 50.0 | 33.3 | 50.0 | 38.9 |
| American White Pelican | N | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ferruginous Hawk | N | 23 | 4 | 17.4 | 69.6 | 17.4 | 69.6 | 52.2 |
| Golden Eagle | N | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Loggerhead Shrike | N | 26 | 1 | 3.9 | 26.9 | 15.4 | 46.2 | 26.9 |
| Long-billed Curlew | N | 33 | 2 | 6.1 | 57.6 | 6.1 | 60.6 | 42.4 |
| Northern Harrier | N | 25 | 0 | 0 | 36.0 | 8.0 | 32.0 | 32.0 |
| Piping Plover | N | 1 | 0 | 0 | 100 | 0 | 100 | 100 |
| Sage Thrasher | N | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sprague's Pipit | N | 95 | 9 | 9.5 | 47.4 | 10.5 | 56.8 | 29.5 |
| Bur ragweed | N | 3 | 1 | 33.3 | 100 | 66.7 | 100 | 33.3 |
| Carolina whitlow-grass | N | 4 | 0 | 0 | 75.0 | 25.0 | 50.0 | 25.0 |
| Cinquefoil | N | 2 | 0 | 0 | 50.0 | 0 | 50.0 | 50.0 |

| Table 2-3-1. Continued | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Review | | | % of feature | | | | |
| FEATURE | MARXAN Target | Area (ha) | RAER (ha) | RAER | COMB | RS | BP | FS |
| Rare Species | | | | | | | | |
| *CDC element occurrence* | | | | | | | | |
| Common moonwort | N | 5 | 1 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| Golden currant | N | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Low pussytoes | N | 2 | 0 | 0 | 50.0 | 0 | 50.0 | 50.0 |
| Narrowleaf cottonwood | N | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Narrow-leaved water-plantain | N | 1 | 0 | 0 | 100 | 100 | 0 | 100 |
| Nodding umbrella-plant | N | 1 | 1 | 100 | 100 | 100 | 100 | 100 |
| Pursh's milk-vetch | N | 2 | 0 | 0 | 50.0 | 0 | 50.0 | 50.0 |
| Rough pennyroyal | N | 4 | 1 | 25.0 | 75.0 | 25.0 | 75.0 | 100 |
| Slender mouse-ear cress | N | 6 | 0 | 0 | 0 | 0 | 16.7 | 16.7 |
| Smooth spike-primrose | N | 1 | 0 | 0 | 100 | 0 | 100 | 100 |
| Spiny milk-vetch | N | 5 | 0 | 0 | 60.0 | 20.0 | 40.0 | 40.0 |
| Biophysical habitat types | | | | | | | | |
| *Enduring features** | | ha | ha | | | | | |
| AFHB | Y | 8572 | 0 | 0 | 55.1 | 14.9 | 57.4 | 22.8 |
| AFUA | Y | 6443 | 0 | 0 | 49.4 | 18.1 | 52.2 | 35.7 |
| ALKB | Y | 8835 | 382 | 4.3 | 53.9 | 4.5 | 56.3 | 27.5 |
| ALUA | Y | 19591 | 2599 | 13.3 | 44.9 | 16.0 | 47.2 | 40.3 |
| AMHB | Y | 699 | 0 | 0 | 66.3 | 0 | 66.4 | 68.6 |
| AMHD | Y | 5205 | 0 | 0 | 55.6 | 0 | 58.0 | 52.5 |
| AMKD | Y | 9542 | 0 | 0 | 69.8 | 0 | 67.2 | 84.7 |
| REHB | Y | 59489 | 0 | 0 | 53.0 | 0.6 | 54.8 | 45.4 |
| REHD | Y | 78280 | 34294 | 43.8 | 47.4 | 44.9 | 47.8 | 50.5 |
| *SPOT vegetation types* | | | | | | | | |
| Alkali flat | Y | 1171 | 25 | 2.1 | 62.3 | 5.9 | 59.9 | 29.6 |
| Bare sand GSH | Y | 309 | 209 | 67.6 | 78.0 | 78.6 | 76.4 | 77.3 |
| Grassland | Y | 63909 | 3834 | 6.0 | 57.6 | 7.9 | 58.2 | 55.1 |
| Juniper | Y | 30680 | 11721 | 38.2 | 44.4 | 39.1 | 44.4 | 45.0 |
| Mixed shrub | Y | 31254 | 7381 | 23.6 | 45.3 | 28.3 | 47.6 | 42.6 |
| Revegetated 25% | Y | 2563 | 111 | 4.3 | 54.9 | 6.2 | 54.5 | 41.0 |
| Revegetated 50% | Y | 8337 | 891 | 10.7 | 54.8 | 14.9 | 55.5 | 47.6 |
| Sagebrush | Y | 37540 | 9699 | 25.8 | 45.2 | 28.7 | 45.4 | 44.0 |
| Silvery grassland | Y | 13966 | 798 | 5.7 | 59.2 | 9.4 | 59.7 | 51.8 |
| Trees | Y | 7448 | 2413 | 32.4 | 45.1 | 35.1 | 46.2 | 41.6 |
| Vegetated wetland | Y | 713 | 2 | 0.3 | 59.5 | 74.3 | 48.4 | 19.8 |
| Wet meadow | Y | 448 | 1 | 0.2 | 50.7 | 8.9 | 50.9 | 23.4 |
| *Other* | | | | | | | | |
| Toe slopes and swales | Y | 45652 | 12197 | 26.7 | 50.9 | 28.9 | 52.4 | 48.2 |
| Surface watercourses (metres) | Y | 55836 | 0 | 0 | 72.9 | 9.4 | 66.1 | 57.3 |
| Focal species models | | | | | | | | |
| *Grassland guild* | | | | | | | | |
| Baird's Sparrow | Y | 66996 | 2349 | 3.5 | 59.5 | 5.8 | 59.2 | 56.6 |
| Chestnut-collared Longspur | Y | 45407 | 878 | 1.9 | 64.1 | 4.1 | 64.1 | 62.1 |
| Grasshopper Sparrow | Y | 78826 | 2176 | 2.8 | 59.6 | 5.9 | 59.0 | 57.5 |

| Table 2-3-1. Continued | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Review | | | % of feature | | | | |
| FEATURE | MARXAN Target | Area (ha) | RAER (ha) | RAER | COMB | RS | BP | FS |
| Rare Species | | | | | | | | |
| *CDC element occurrence* | | | | | | | | |
| Marbled Godwit | Y | 55496 | 1184 | 2.1 | 62.5 | 4.8 | 59.8 | 59.9 |
| Savannan Sparrow | Y | 63152 | 1233 | 2.0 | 61.3 | 4.4 | 60.9 | 58.2 |
| Sprague's Pipit | Y | 95393 | 6503 | 6.8 | 56.6 | 9.8 | 56.6 | 53.5 |
| Prairie dunewort | Y | 41869 | 824 | 2.0 | 61.9 | 3.4 | 58.3 | 59.9 |
| *Shrub guild* | | | | | | | | |
| Clay-colored Sparrow | Y | 108740 | 32504 | 29.9 | 45.2 | 32.7 | 46.3 | 43.8 |
| Spotted Towhee | Y | 37659 | 9070 | 24.1 | 44.5 | 28.6 | 45.9 | 43.1 |
| Chokecherry | Y | 106309 | 30945 | 29.1 | 45.1 | 31.9 | 46.6 | 43.8 |
| Six-weeks fescue | Y | 76790 | 22942 | 29.9 | 45.9 | 32.4 | 47.7 | 44.0 |
| *Independent species* | | | | | | | | |
| Ord’s kangaroo rat | Y | 521 | 257 | 49.3 | 72.0 | 59.1 | 71.9 | 65.7 |
| Beaked annual skeleton-weed | Y | 13113 | 207 | 1.6 | 60.3 | 6.1 | 57.0 | 58.3 |
| Low milk-vetch | Y | 90984 | 15841 | 17.4 | 53.7 | 19.0 | 53.9 | 52.6 |
| Smooth arid goosefoot | Y | 37027 | 5534 | 14.9 | 50.6 | 20.2 | 51.8 | 47.7 |
| *Invasives absence* | | | | | | | | |
| Crested wheatgrass | Y | 106875 | 30701 | 28.7 | 45.4 | 30.6 | 48.3 | 43.9 |
| Smooth brome | Y | 136199 | 25478 | 18.7 | 53.5 | 20.7 | 53.9 | 51.5 |
| *Range health* | | | | | | | | |
| Moderate range health | Y | 86169 | 6947 | 8.1 | 55.8 | 11.6 | 53.1 | 51.9 |
| High range health | Y | 106007 | 29770 | 28.1 | 45.6 | 30.4 | 48.8 | 44.1 |
| *Other* | | | | | | | | |
| Brown-headed Cowbird | N | 79900 | 22265 | 27.9 | 46.0 | 31.3 | 47.7 | 43.8 |
| Common Nighthawk | N | 32469 | 10488 | 32.3 | 47.5 | 34.5 | 48.2 | 46.5 |
| Horned Lark | N | 75916 | 2476 | 3.3 | 60.1 | 5.9 | 58.9 | 56.6 |
| Long-billed Curlew | N | 81597 | 2669 | 32.7 | 59.0 | 6.1 | 60.0 | 55.7 |
| Upland Sandpiper | N | 89459 | 14426 | 14.7 | 53.2 | 17.7 | 53.5 | 51.4 |
| Small lupine | N | 81424 | 24103 | 29.6 | 47.4 | 32.3 | 49.3 | 46.0 |
| Windflower | N | 103916 | 26923 | 25.9 | 48.2 | 28.4 | 48.4 | 46.8 |
| Canadian thistle absence | N | 159415 | 28366 | 17.8 | 52.4 | 20.1 | 52.7 | 50.3 |
| Kentucky bluegrass absence | N | 127088 | 24326 | 19.1 | 51.5 | 21.5 | 51.5 | 50.3 |

* Enduring features are specific rock, soil and land-form types that are very stable over long periods of time, and are likely to support characteristic plant and animal communities. Enduring features are defined based on four specific factors:
• the origin of the parent material: this relates to the method by which material such as soil, gravel or rocks was deposited (i.e. wind, water, glacial melt water)
• soil development: how soils were formed through various factors like climate, soil organisms, the nature of the parent material, the topography of an area, and time
• surface form: physical landscape features such as eskers or potholes
• slope: refers to the steepness or grade of the surface terrain.

Soil Development

| | |
|---|---|
| # | Rock |
| A | Brown Chernozemic |
| B | Dark Brown Chernozemic |
| C | Black Chernozemic |
| D | Dark Gray Chernozemic or Dark Gray Luvisolic |
| F | Gray Luvisolic |
| G | Brown Solonetzic |
| H | Dark Brown Solonetzic |
| M | Eutric Brunisol |
| P | Dystric Brunisol |
| R | Regosol |
| U | Gleysolic |
| W | Water |
| X | Fibrisol |
| Y | Mesisol |

Surface Form

| | |
|---|---|
| B07 | Bog Peat Plateau |
| B14 | Bog Flat |
| B16 | Bog Blanket |
| D | Dissected |
| F01 | Fen Northern Ribbed |
| F13 | Fen Horizontal |
| H | Hummocky |
| K | Knoll & Kettle |
| L | Level |
| M | Rolling |
| R | Ridged |
| U | Undulating |
| T | Terraced |
| W | Water |

Origin of Parent Material

| | |
|---|---|
| A | Alluvial |
| B | Bog |
| E | Eolian |
| F | Fluvioglacial |
| L | Lacustrine |
| M | Morainal |
| N | Fen |
| O | Organic Undifferentiated |
| R | Rock |
| U | Undifferentiated |
| W | Water |
| 23 | Mesic Woody forest |

Slope

| | |
|---|---|
| A | 1–3% |
| B | 4–9% |
| C | 10–15% |
| D | >16 |

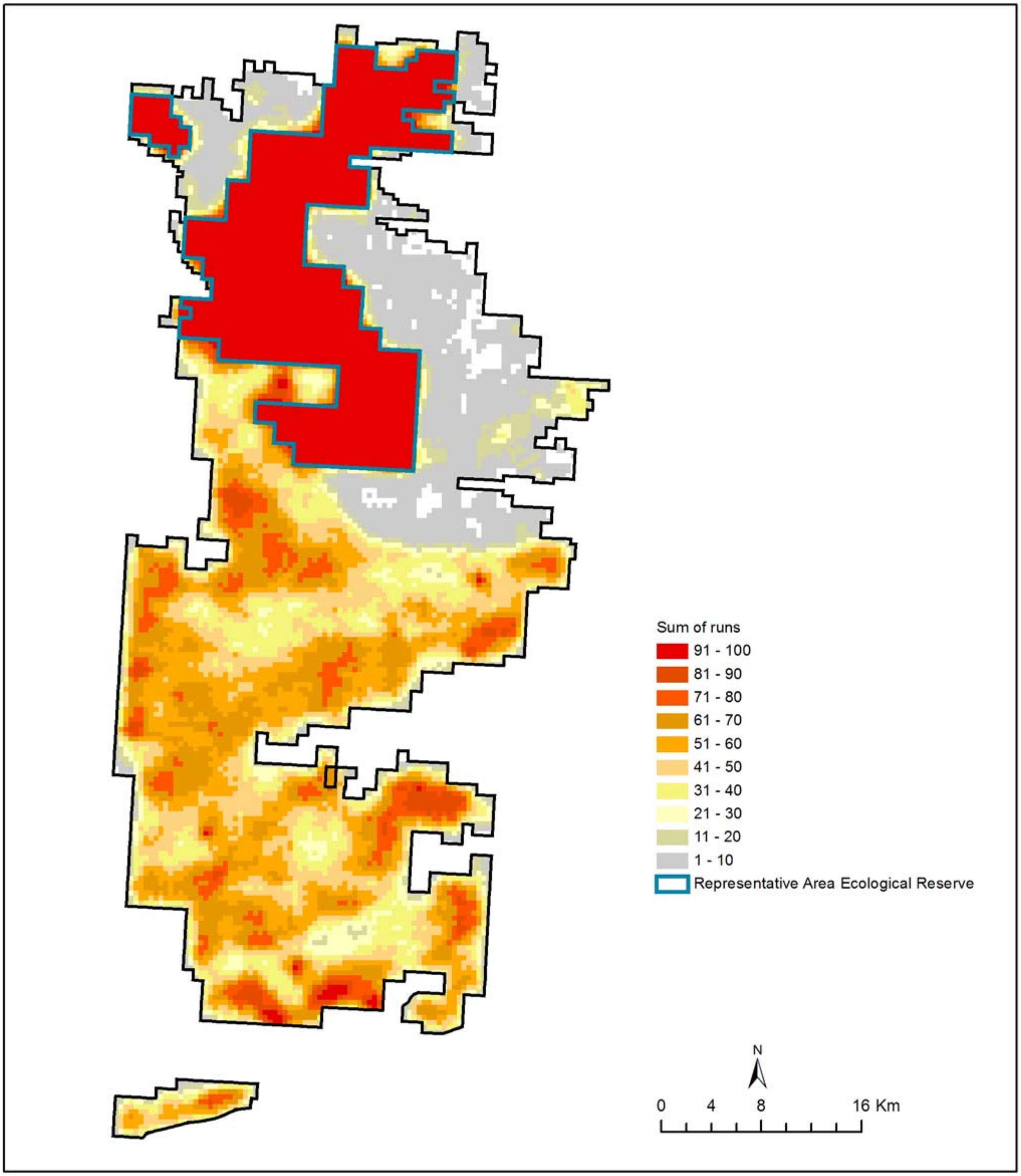



Figure 2-3-2. MARXAN results of 50% goals for all three biodiversity feature groups: rare species, biophysical habitats, and focal species.

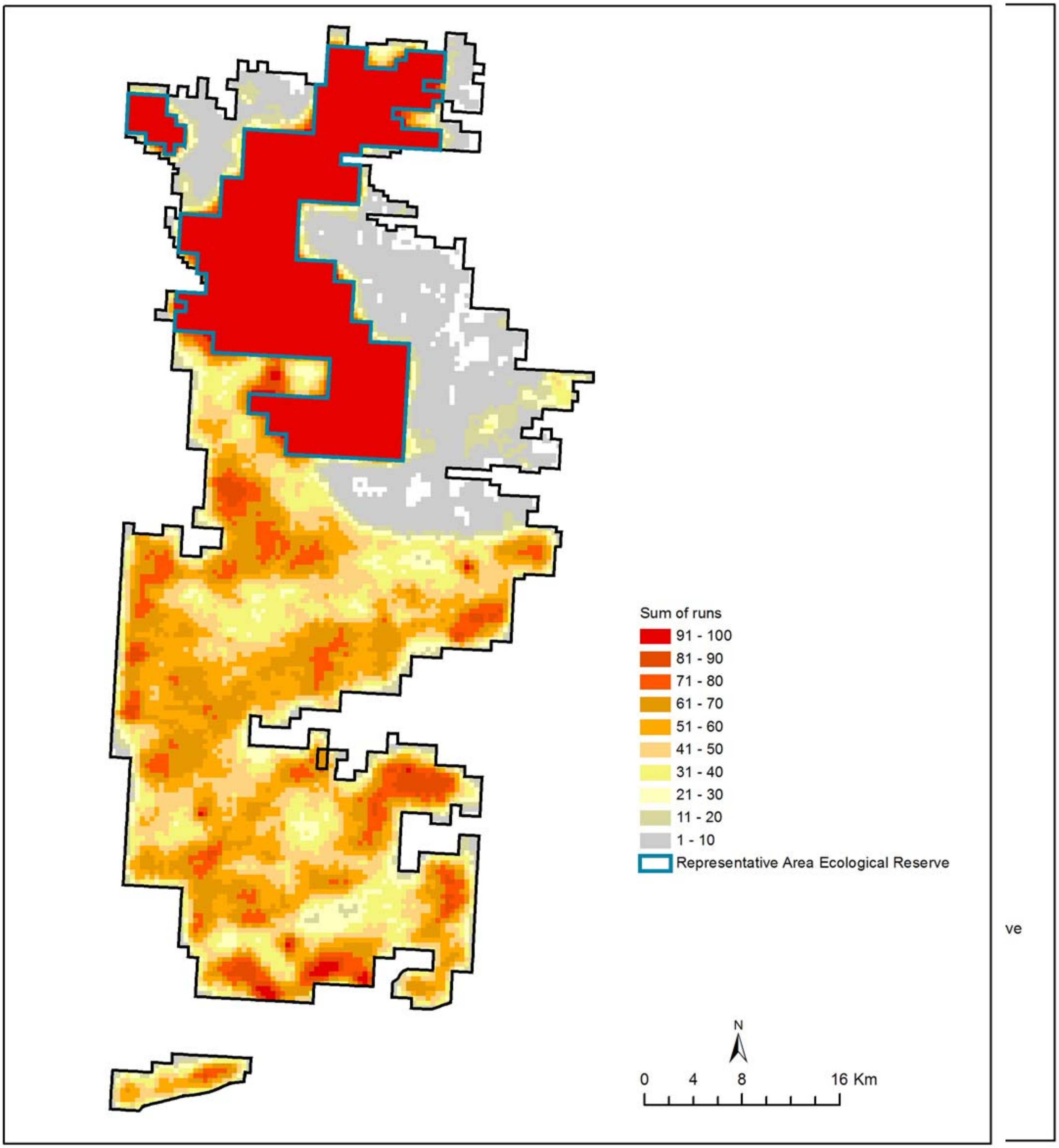



Figure 2-3-2. MARXAN results of 50% goals for all three biodiversity feature groups: rare species, biophysical habitats, and focal species.

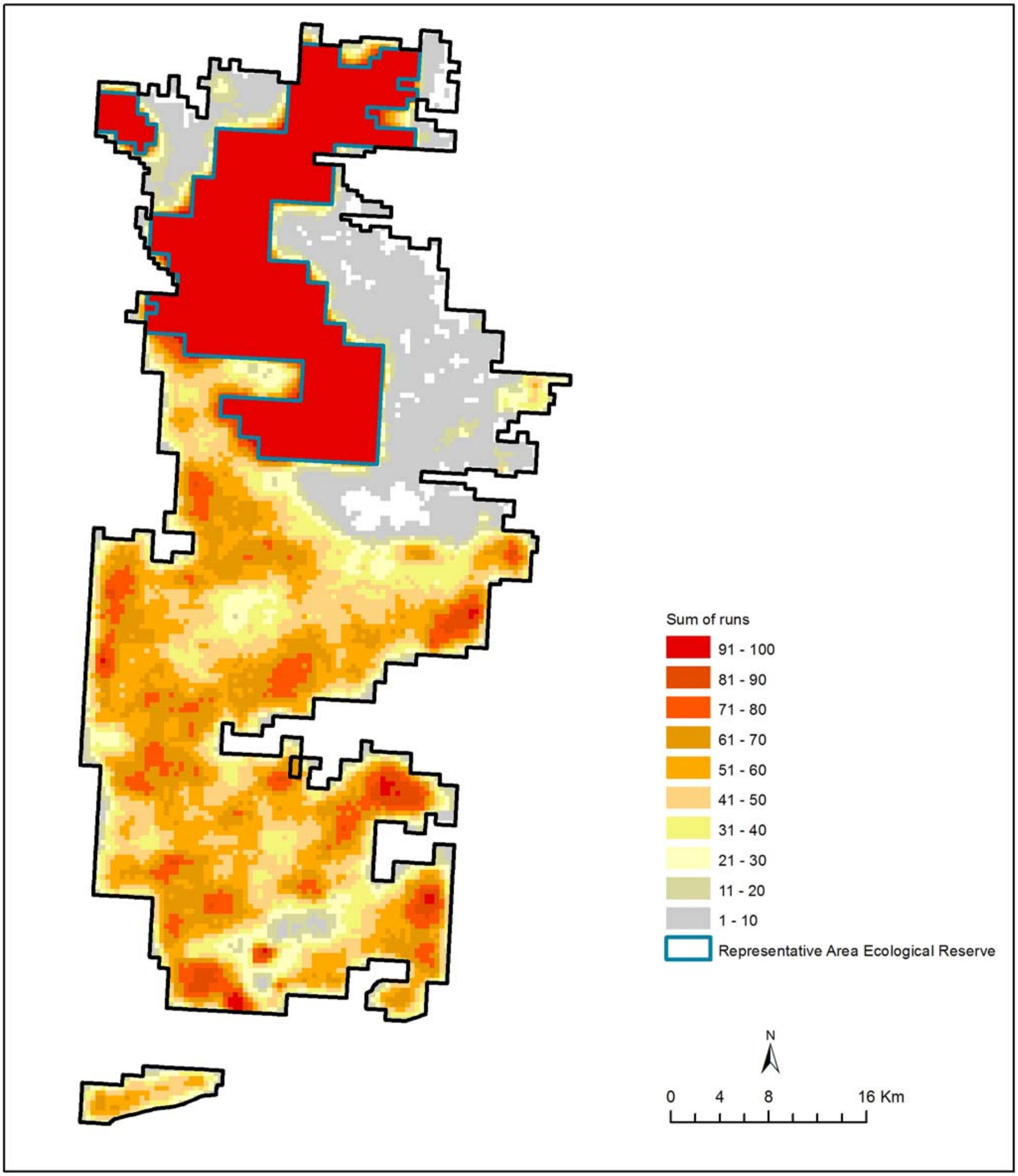



Figure 2-3-4. MARXAN results of 50% goals for the biophysical features group: enduring features, vegetation classes, surface watercourses, and topographic toe slopes and depressions.

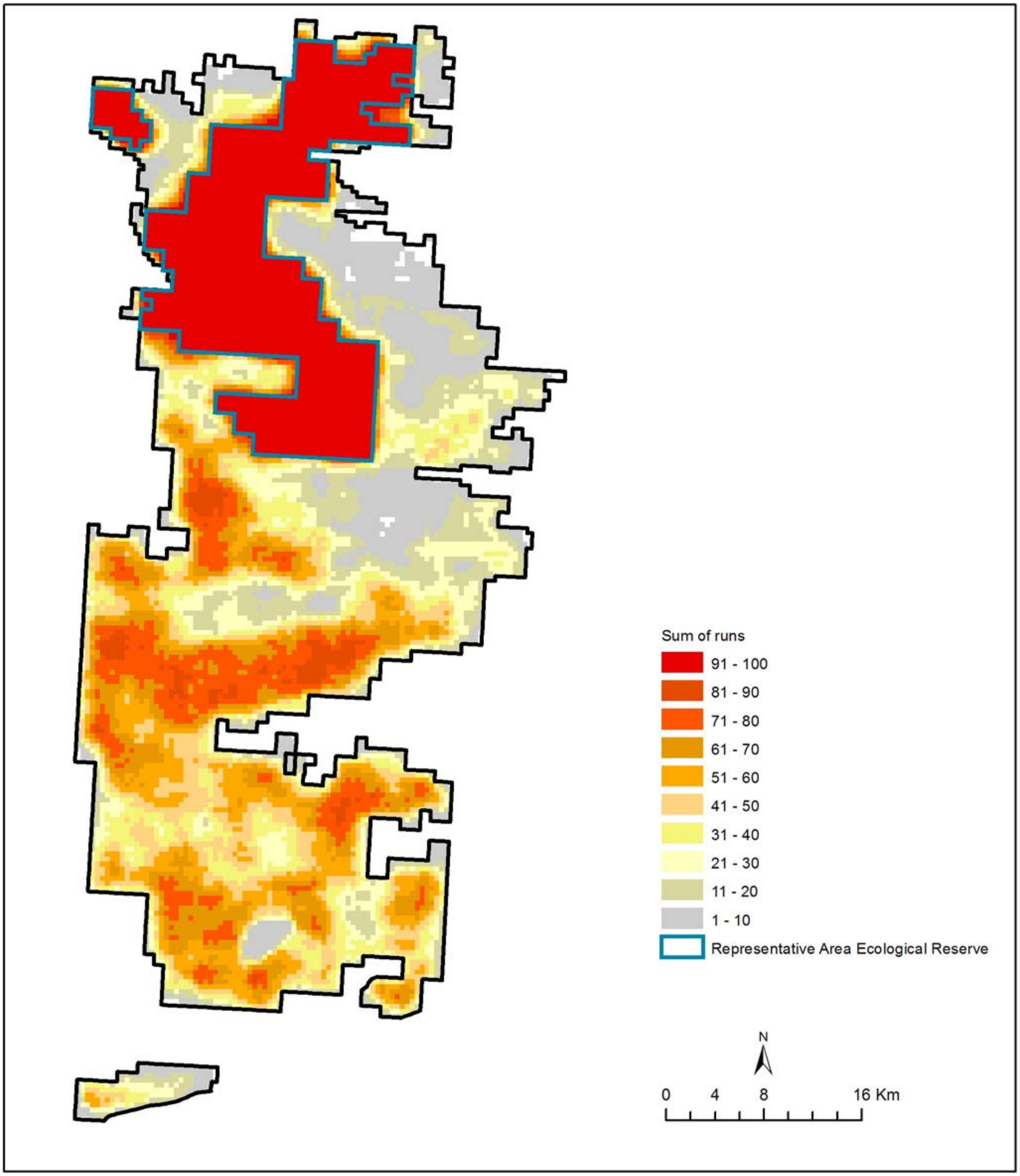



Figure 2-3-5. MARXAN results of 50% goals for the focal species group: eight bird species, six plant species, one mammal (Ord's kangaroo rat), absence of two invasive plant species, and two range health models.

data sets represent opportunistic and incomplete inventories of species and there is little confidence in their ability to serve as reliable surrogates for biodiversity across the GSH. This is reflected in the great difference between the patterns of biodiversity importance shown in the rare species run compared to the combined run. In contrast, the biophysical habitat and focal species data sets cover the entire Review Area and are based upon more objective methods; these two feature groups drive the biodiversity patterns revealed by MARXAN. The focal species hotspot patterns shown later in this chapter (Figure 2-3-16 and 17) are reflected in the focal species MARXAN results shown in Figure 2-3-5.

The frequent selection of planning units in the southern portion of the Review Area is likely due to regional vegetation patterns (shrubland versus grassland), and the location of the RAER in the shrubland-dominated north. The RAER does capture various types of shrub-dominated vegetation and habitat for shrub-associated focal species, but capturing grassland vegetation types and associated focal species habitat requires MARXAN to include extensive areas in the south and west.

## 3.3 BIRD AND PLANT SURVEYS

As part of characterizing the natural ecosystems of the GSH and to provide indicators of its ecological integrity for current conditions and future projections, field surveys of selected species of birds and plants were conducted in 2005 and 2006. The 2005 field surveys were led by ERIN Consulting Ltd. with the objective of documenting distribution and abundance of birds and rare plants across major vegetation communities and land uses in the Review Area. Because the contracting process in the project could not begin before May 2005, ERIN's field work did not begin until late June 2005, at the end of the primary survey period for breeding birds and plant reproduction. This resulted in limited sampling time to meet objectives and yielded partial results (ERIN Consulting Ltd. 2006) based on sampling across a minimal range of vegetation communities and spatial extent within the GSH study region. To fill further information needs, additional field work was required. In 2006 selected birds, rare plants, and range quality were quantified within a framework for establishing baseline conditions and assessing effects of current human activities and future development scenarios on biodiversity. A summary of the 2006 field research objectives, methods, and brief overview of results follow; detailed analytical methods and results that use these data for focal species modeling are provided later in this chapter.

### 3.3.1 Methods

The primary objectives were to determine habitat affinities of focal grassland birds, bird species of conservation concern (and one mammal), and rare plants and to assess the effects of human-related surface disturbance—gas development, grazing, and roads/trails—on probability of occurrence of those species and on range quality.

#### *3.3.1.1 Site selection*

A case-control stratified random sampling design was employed to measure bird and plant communities in four major grassland types (Juniper grassland, Shrubby grassland, Herbaceous grassland, and Disturbed grassland—predominantly grasslands associated with active dune complexes), with and without one of three types of surface disturbance impacts (cattle watering sites, gas wells, and roads and trails). Sites were paired, so that for each site with an impact in a given type of grassland, a second control site without the impact but in the same type of grassland was surveyed nearby (~200–1000 m from impact site). Ten paired sites were selected for each impact in each grassland type for a total of 240 sites (Table 2-3-2). The location of most sites was determined by computer-assisted selection prior to field sampling using the 2005 GSH landcover classification (Appendix A) and updated GIS information on the locations of cattle watering sites, gas wells, and roads/trails. All site locations were finalized when they were initially visited by the bird survey teams to ensure that the site had the specified impact and that the paired sites matched each other with respect to grassland type. In some cases, sites were moved or replaced with alternate random sites to meet the sampling objective. Six pairs of sites that had been visited for bird surveys could not be used for plant surveys because the property lessee would not grant access after bird sampling was completed; this was due to a perceived increased risk in fire during an unusually dry season. Six pairs of alternate sites (of the same vegetation type and impact as the originals) were selected and surveyed for plants; no bird surveys at these new sites were possible. Figure 2-3-6 shows the distribution of sampling sites. Each survey was centred on a point (GPS location) with a surrounding 100-m radius plot for bird surveys and 50-m radius plot for plant surveys. Plant survey plots were always centred on the impact, whereas bird survey plots were occasionally moved a short distance to ensure that the entire plot was visible and audible to the observers.

| Table 2-3-2. Stratification and sample sizes for bird and plant sampling in Review Area. | | |
|---|---|---|
| Grassland Type[1] | Disturbance Type | Sample Size |
| *Herbaceous Grassland* | Cattle<br>Road / Trail<br>Gas | 10<br>10<br>10 |
| *Shrubby Grasslands* | Cattle<br>Road / Trail<br>Gas | 10<br>10<br>10 |
| *Juniper Grasslands* | Cattle<br>Road / Trail<br>Gas | 10<br>10<br>10 |
| *Disturbed (Dune) Grasslands* | Cattle<br>Road / Trail<br>Gas | 10<br>10<br>7[2] |
| Subtotal-1 | | 117 |
| 2nd-level impact assessment | Paired<br>(at disturbance, far from disturbance) | 117+ 117 |
| Subtotal-2 | | 234 |
| Disturbed Grasslands | No Impact | 6[2] |
| Subtotal-3 | | 240 |
| Detectibility assessment | Repeated surveys (sites x 2) | 480 |
| Grand Total | | 480 |

1. Grassland types (derived from 2005 GSH landcover classification from SPOT 5 Imagery): 1) Herbaceous Grassland: grasslands + silvery grasslands + 50% revegetated, 2) Juniper Grassland: dominantly creeping juniper, 3) Shrubby Grassland: mixed shrub + sagebrush, 4) Disturbed Grassland: bare sand + 25% revegetated (predominantly grasslands associated with active dune complexes).
2. Only 7 paired sites were pre-selected in the disturbed grassland with a gas disturbance, bringing the total number of study sites to 234. Additional paired sites were not found on site for this grassland type and disturbance. Six disturbed grassland sites without disturbance were added.

### *3.3.1.2 Bird surveys*

Point-count surveys focused on a suite of 13 bird species, selected as indicators of grassland integrity—positive, generalist, and negative (Table 2-3-3)—and which could be measured using standard point-count methods (Hutto et al. 1986). In addition to these 13 focal species, observations of bird species of conservation concern (Table 2-3-4) were recorded wherever they were heard or seen within the Review Area. The preliminary lists of species and sampling methods were reviewed by regional experts (Steve Davis, April 2006 and Glenn Sutter, March 2006, personal communication) and revised according to their recommendations to produce the final lists.

Surveys were conducted from 16 May to 4 July 2006, the primary bird breeding period in southwestern Saskatchewan. Two replicate surveys were conducted at each of the 240 survey sites in order to account for detection variation; all sites were sampled first between 16 May and 15 June and then again, in the same order, between 8 June and 4 July. Visitation to sites was made in a pattern so as to avoid temporal bias in sampling relative to vegetation type and region within the Review Area.

Two teams, each with one experienced observer knowledgeable in the identification of the local birds by sight and sound, conducted point-count surveys. Each team visited approximately half of the sites distributed throughout the Review Area. At each site, replicate surveys were conducted by the same experienced observer. Prior to the initiation of the bird sampling, there was a training session to develop a high level of accuracy and consistency in data recording among observers. Observers thoroughly reviewed identification of songs, calls, and behaviors and spent five days training for

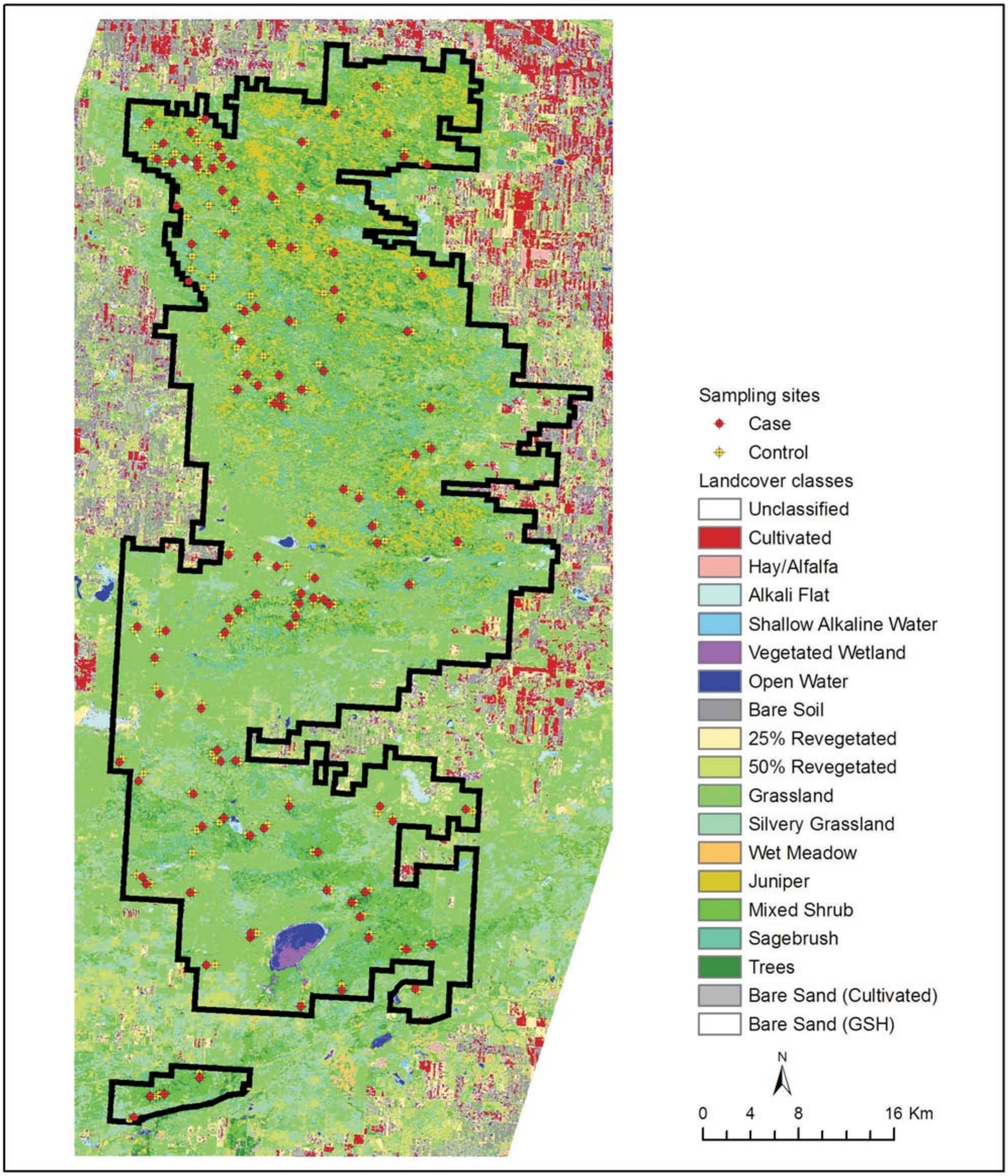



Figure 2-3-6. Distribution of case (impact) and control sampling sites in the Review Area overlaid on the vegetation classification of 2005 SPOT5 imagery (Saskatchewan Environment).

Table 2-3-3. Focal bird species targeted in point count surveys and summary of results.

| Common Name | Scientific Name | Global | Prov | COSEWIC | Count[1] | Mean (SD[2]) | Mean (SD[3]) | Pres[4] |
|---|---|---|---|---|---|---|---|---|
| Horned Lark | *Eremophila alpestris* | G5 | S5B, S5M, S5N | (not listed) | 111 | 0.5 (0.89) | 1.8 (0.83) | 62 |
| Spotted Towhee[5] | *Pipilo maculatus* | G5 | S5B | (not listed) | 11 | 0.05 (0.23) | 1.1 (0.32) | 10 |
| Yellow-breasted Chat[5] | *Icteria virens* | G5 | S4B | (not listed) | 0 | NA | NA | NA |
| Clay-coloured Sparrow | *Spizella pallida* | G5 | S5B | (not listed) | 461 | 1.9 (1.51) | 2.5 (1.2) | 182 |
| Brewer's Sparrow | *Spizella breweri* | G5 | S4B | (not listed) | 5 | 0.02 (0.14) | 1.0 (0.0) | 5 |
| Lark Sparrow[5] | *Chondestes grammacus* | G5 | S5B | (not listed) | 5 | 0.02 (0.14) | 1.0 (0.0) | 5 |
| Savannah Sparrow | *Passerculus sandwichensis* | G5 | S5B | (not listed) | 59 | 0.3 (0.61) | 1.4 (0.70) | 42 |
| Grasshopper Sparrow | *Ammodramus savannarum* | G5 | S4B | (not listed) | 56 | 0.2 (0.62) | 1.5 (0.73) | 37 |
| Baird's Sparrow | *Ammodramus bairdii* | G4 | S4B | Not at Risk | 107 | 0.5 (0.98) | 2.1 (1.02) | 51 |
| McCown's Longspur[6] | *Calcarius mccownii* | G4 | S4B | (not listed) | 0 | NA | NA | NA |
| Chestnut-collared Longspur | *Calcarius ornatus* | G5 | S5B | (not listed) | 68 | 0.3 (1.08) | 3.2 (1.97) | 21 |
| Western Meadowlark | *Sturnella neglecta* | G5 | S5B | (not listed) | 211 | 0.9 (0.87) | 1.4 (0.68) | 149 |
| Brown-headed Cowbird | *Molothrus ater* | G5 | S5B | (not listed) | 176 | 0.7 (1.05) | 1.5 (0.97) | 104 |

1. Sum of counts for adult males within 100-m radius plots (after detection analysis applied) for 240 plots
2. Mean (standard deviation) of counts for 240 plots
3. Mean (standard deviation) of counts for plots that recorded at least one individual
4. Number of plots with at least one individual recorded
5. Suggested addition as a species associated with shrub and dense thicket (Dr. Glenn Sutter, pers. comm.)
6. Suggested addition as a prairie specialist species (Dr. Glenn Sutter, pers. comm.)

visual and auditory determination of a 100-m radius plot in a range of terrains until they could accurately determine whether birds were inside or outside the plot. For the first three days of surveys, observers surveyed together to ensure consistency in technique and identification between observers. The 100-m radius distance was confirmed visually several times a day. During a point count, if the location of an individual bird inside or outside the plot was in question, the distance was always confirmed immediately following the point count. If the identity of a species was in question, it was also always confirmed immediately following the point count.

At each site, data on: 1) GPS location, 2) weather—temperature, cloud cover, precipitation, and wind speed, and 3) time of start and stop of count were recorded. During the 5-minute point count, all individuals of the focal species (Table 2-3-3) heard or seen were recorded. Each observation included 1) estimated location inside or outside the 100-m radius plot, 2) timing of observation in one of two periods: within the first 3 minutes (to provide data comparable to Breeding Bird Survey protocol) or in the last 2 minutes of the period, 3) breeding behavior, 4) type of vocalization, 5) juvenile status, and 6) sex of each individual when possible. Birds of conservation concern (Table 2-3-4) were also recorded if they were observed within, outside of, or flying over a survey plot, but in a separate database along with their GPS location and information on their vocalizations, age, sex, breeding behavior, activity, and associated landcover type.

#### *3.3.1.3 Plant surveys*

Rare and traditional use plants, vegetation cover, and range assessment surveys were conducted at the 240

| Table 2-3-4. Rare bird species recorded in point counts and any time they were observed in the Review Area. | | | | | | | |
|---|---|---|---|---|---|---|---|
| Common Name | Scientific Name | Global | Prov | COSEWIC | Count[1] | Pres[2] | Oppor[3] |
| Trumpeter Swan | *Cygnus buccinator* | G4 | S1B | Not at Risk | 0 | 0 | 0 |
| Sharp-tailed Grouse[4] | *Tympanuchus phasianellus* | G4 | S5B, S5N | (not listed) | 4[4] | 4 | 14 |
| American White Pelican | *Pelecanus erythrorhynchos* | G3 | S3B | Not at Risk | 1 | 1 | 0 |
| Double-crested Cormorant | *Phalacrocorax auritus* | G5 | S4B | Not at Risk | 5 | 5 | 0 |
| Northern Harrier | *Circus cyaneus* | G5 | S5B, S4M, S2N | Not at Risk | 10 | 10 | 15 |
| Ferruginous Hawk | *Buteo regalis* | G4 | S4B, S4M | Special Concern | 8 | 7 | 16 |
| Golden Eagle | *Aquila chrysaetos* | G5 | S3B, S4M, S3N | Not at Risk | 0 | 0 | 1 |
| Prairie Falcon | *Falco mexicanus* | G5 | S3B, S3M, S3N | Not at Risk | 0 | 0 | 0 |
| Piping Plover | *Charadrius melodus circumcinctus* | G3T3 | S3B | Endangered | 0 | 0 | 1 |
| Willet[5] | *Catoptrophorus semipalmatus* | G5 | S5B, S4M | (not listed) | 17 | 13 | 6 |
| Upland Sandpiper | *Bartramia longicauda* | G5 | S5B, S5M | (not listed) | 77 | 68 | 51 |
| Long-billed Curlew | *Numenius americanus* | G5 | S4B, S4M | Special Concern | 45 | 39 | 33 |
| Marbled Godwit[5] | *Limosa fedoa* | G5 | S5B, S5M | (not listed) | 25 | 22 | 10 |
| Burrowing Owl | *Athene cunicularia* | G4 | S2B | Endangered | 0 | 0 | 0 |
| Short-eared Owl | *Asio flammeus* | G5 | S3B, S2N | Special Concern | 0 | 0 | 0 |
| Common Nighthawk | *Chordeiles minor* | G5 | S5B, S5M | (not listed) | 42 | 37 | 10 |
| Common Poorwill | *Phalaenoptilus nuttallii* | G5 | S3B | Data Deficient | 0 | 0 | 0 |
| Loggerhead Shrike | *Lanius ludovicianus excubitorides* | G4T4 | S4B | Threatened | 12 | 11 | 15 |
| Sage Thrasher | *Oreoscoptes montanus* | G5 | S1B | Endangered | 1 | 1 | 0 |
| Sprague's Pipit | *Anthus spragueii* | G4 | S4B | Threatened | 205 | 147 | 95 |

1. Sum of counts for all individuals observed (heard or seen) at point count plot (after detection analysis applied) for 240 plots, including birds outside the 100-m radius and irrespective of behavior (i.e. flying, perched).
2. Number of plots with at least one individual recorded.
3. Opportunistic observations (presences), i.e. number of observations with at least one individual recorded that were made away from point count plots any time or location within the Review Area.
4. Numbers refer only to leks; number of birds observed at a single site ranged from 5 to 23 (mean = 14 + 6.1, n = 14).
5. Suggested addition as priority shorebird species for prairie pothole region (Dr. Steve Davis, pers. comm.).

sites within the GSH Review Area from 22 May to 4 August 2006. Two sampling periods were defined: 22 May to 19 June and 19 June to 4 August. Initially, the strategy was to sample all sites twice to encompass a temporal range of detection for different species—greater probability to observe plants with limited timing of reproduction (flowers and fruits being key characteristics for identification)—and to conduct range assessment in the more appropriately timed second period. Logistically, however, it proved impossible to complete the full set of sites in the first period. Sites searched early in the first survey period were searched again at the end of the second period, whereas those visited for the first time after 19 June were not revisited, i.e. all sites were surveyed during the second sampling period, while only some were also surveyed in the first.

The rare plant surveys focused on a suite of 77 species (Table 2-3-5) compiled from a list of sensitive plant species known to occur in the Study Area, the SKCDC element occurrence records from the GSH, and the SKCDC list of vascular plants for the Mixed Grassland ecoregion. An initial list was reviewed by Nature Saskatchewan botanists and revised according to their knowledge to produce the final list. Two teams each with two experienced botanists skilled in identification of local plant species conducted the surveys. At each site, a walking survey of the entire plot and a hands-and-knees transect survey across the plot was carried out. Upon completion of both types of surveys, the botanists worked together to record:

*Site characteristics and survey details:* The date, start and end time of survey, observers, GPS location, and photos of the site were recorded during each survey period. During the second sampling period, the identity and cover of dominant grasses, forbs, and shrubs, as well as the dominant land-cover types, were recorded.

*Rare plant species characteristics:* The number of individuals and the number of groups of each species and their distribution, stage in flower or fruit, GPS location, and photos of the plant and its identifying characteristics were recorded. Microhabitat information was also collected on the location of each rare species population, including the landform, aspect, slope, soil type, and associated species.

*Range health:* The alteration of the plant community due to disturbance; the reduction or absence of expected vegetation layers; the presence, distribution, and cover of invasive and noxious species; the degree of soil erosion; the amount of human-caused bare soil; and the expected amount of litter were scored using the Saskatchewan Grassland Range Health Assessment (Appendix C), which was based largely on an assessment methodology developed in Alberta (Appendix D). An expert in range assessment, Zoheir Abouguendia, advised on using a *Stipa*-wheatgrass-june grass community as the reference condition for the Herbaceous Grassland type. For Shrub, Juniper, and Disturbed (dune) grassland types, the abundance of plant species known to be "increasers" (plants that respond positively to cattle grazing) and "decreasers" (plants that respond negatively to grazing) as well as the vigor of the plants was used as the reference. The increasers and decreasers for the region were determined from a reference guide (Abouguendia 1990), using the Brown Soil zone. One range health assessment was done at each site, during the second sampling period.

*Plant species traditionally used by First Nations:* The presence or absence of a set of plant species known to have value to First Nations groups (Table 2-3-6) was recorded at each site when observed during either of the two sampling periods.

### *3.3.1.4 Ord's kangaroo rat observations*

All signs of Ord's kangaroo rat (*Dipodomys ordii*) observed at survey locations or opportunistically anywhere within the Review Area were recorded. Each observation included a GPS location, type of observation (i.e. tracks, den or individual), photographs with photo documentation, and any additional comments.

### *3.3.1.5 Data entry and accuracy*

Point-count observations, site details, observations of bird species of conservation concern, and Ord's kangaroo rat observations were transferred from hardcopy forms into a PDA and then from the PDA to an Access database at the end of each survey day. All data were checked and confirmed daily by two people. Plant survey data were entered directly into PDAs in the field and then transferred to an Access database at the end of each day. The plant data were proofed and edited at the termination of the field study. All GPS points were taken with a positional accuracy of less than or equal to +/- 6 m.

| Table 2-3-5. Rare plant survey list for 2006 surveys in the Review Area, including species listed with: Global, Saskatchewan (Prov), and National (COSEWIC) conservation status. EO/CDCMG and LSP indicate from which database the species was listed (EO = Saskatchewan CDC Element Occurrence records for study area, CDCMG = Saskatchewan CDC list of vascular plant species in Mixed Grassland Ecoregion, LSP = List of sensitive plant species in Great Sand Hills). | | | | | | |
|---|---|---|---|---|---|---|
| Division Name<br>Family Name<br>Scientific Name | Common Name | Global | Prov | COSEWIC | EO/CDCMG | LSP |
| **Coniferophyta (Gymnosperms)**<br>**Cupressaceae (Cypress Family)**<br>*Juniperus scopulorum* | Rocky Mountain juniper | G5 | S1 | not listed | CDCMG | |
| **Magnoliophyta (Angiosperms)**<br>**Alismataceae (Water-Plantain Family)**<br>*Alisma gramineum* | narrow-leaved water plantain | G5 | S3 | not listed | EO/CDCMG | LSP |
| **Apiacea (=Umbelliferae) (Parsley or Carrot Family)**<br>*Osmorhiza depauperata* | blunt-fruited sweet-cicely | G5 | S3S4 | not listed | EO | LSP |
| **Asteraceae (=Compositae) (Aster or Sunflower Family)**<br>*Ambrosia acanthicarpa* | bur ragweed | G5 | S2 | not listed | EO/CDCMG | LSP |
| *Crepis atribarba* | dark hawk's-beard | G5 | S1 | not listed | CDCMG | |
| *Erigeron compositus* | compound fleabane | G5 | S3? | not listed | CDCMG | LSP |
| *Picradeniopsis oppositifolia* | opposite-leaf false bahia | G5? | S1 | not listed | CDCMG | |
| *Psilocarphus elatior* | tall woolly-heads | G4Q | S1S2 | Special Concern | CDCMG | |
| *Senecio integerrimus var. scribneri* | Scribneri's entire-leaf ragwort | G5T1T3 | S1 | not listed | CDCMG | |
| *Senecio pseudaureus* | thin-leaved ragwort | | 0 | | | LSP |
| *Shinnersoseris rostrata (=Lygodesmia rostrata)* | beaked annual skeleton-weed | G5? | S2 | not listed | EO/CDCMG | LSP |
| *Stephanomeria runcinata* | rucinate-leaved skeleton-weed | G5 | S1S2 | Not at Risk | EO/CDCMG | |
| *Tetraneuris acaulis var. acaulis* | stemless tetraneuris | G5T5 | S1 | not listed | CDCMG | |
| **Boraginaceae (Borage Family)**<br>*Cryptantha celosioides* | clustered oreocarya | G5 | S1 | not listed | CDCMG | |
| *Cryptantha minima* | small cryptanthe | G5 | S1 | Endangered | EO/CDCMG | |
| **Brassicaceae (=Cruciferae) (Mustard Family)**<br>*Halimolobos virgata* | slender mouse-ear cress | G4 | S1 | Threatened | EO/CDCMG | |
| *Rorippa tenerrima* | slender yellow-cress | G5 | S1 | not listed | CDCMG | |
| Caryophyllaceae (Pink Family)<br>*Arenaria congesta var. lithophila* | rocky ground sandwort | G5T3T5 | S3 | not listed | CDCMG | LSP |
| *Silene antirrhina* | sleepy catchfly | G5 | S1S2 | not listed | EO/CDCMG | |
| *Stellaria subvestita X S. longipes* | hairy long-stalked stitchwort | | S2 | not listed | | LSP |
| **Chenopodiaceae (Goosefoot Family)**<br>*Atriplex powellii* | Powell's saltbush | G4 | S1 | not listed | CDCMG | |
| *Atriplex truncata* | wedge-scale saltbush | G5 | S1 | not listed | EO/CDCMG | LSP |

| Table 2-3-5. Continued | | | | | | |
|---|---|---|---|---|---|---|
| Division Name<br>Family Name<br>Scientific Name | Common Name | Global | Prov | COSEWIC | EO/CDCMG | LSP |
| *Atriplex x aptera* | four-wing saltbush | GNA | S1 | not listed | CDCMG | |
| *Chenopodium incanum* | hoary goosefoot | G5 | S1? | not listed | CDCMG | |
| *Chenopodium subglabrum* | smooth arid goosefoot | G3G4 | S2 | Special Concern | EO/CDCMG | LSP |
| *Corispermum orientale* | villose bugseed | | S2 O | | | LSP |
| *Suaeda moquinii* | shrubby seepweed | G5 | S1 | not listed | CDCMG | |
| **Crassulaceae (Stonecrop Family)**<br>*Sedum lanceolatum* | lance-leaved stonecrop | | S3 | | | LSP |
| **Cuscutaceae (Dodder Family)**<br>*Cuscuta coryli* | hazel dodder | G5 | S1? | not listed | CDCMG | |
| **Cyperaceae (Sedge Family)**<br>*Carex crawei* | crawe's sedge | G5 | S1 | not listed | CDCMG | |
| *Cyperus schweinitzii* | Schweinitz's flatsedge | | S2 | | | LSP |
| *Eleocharis parvula var. anachaeta* | dwarf spike-rush | G5TNRQ | S1 | not listed | CDCMG | |
| **Euphorbiaceae (Spurge Family)**<br>*Chamaesyce serpens* | round-leaved spurge | G5 | S1 | not listed | EO/CDCMG | LSP |
| **Fabaceae (=Leguminosae) (Legume or Bean Family)**<br>*Astragalus kentrophyta var. kentrophyta* | spiny milk-vetch | G5T4 | S1 | not listed | EO/CDCMG | LSP |
| *Astragalus lotiflorus* | low milk-vetch | G5 | S3 | not listed | EO/CDCMG | LSP |
| *Astragalus purshii var. purshii* | Pursh's milk-vetch | G5T5 | S2 | not listed | CDCMG | LSP |
| *Astragalus spatulatus* | tufted milk-vetch | G5 | S2S3 | not listed | CDCMG | LSP |
| *Lupinus argenteus ssp. Argenteus* | silvery lupine | | S3 | | | LSP |
| *Lupinus pusillus ssp. pusillus* | small lupine | G5T5 | S3 | not listed | EO/CDCMG | LSP |
| **Juncaceae (Rush Family)**<br>*Juncus interior* | inland rush | | S2 | | | LSP |
| *Juncus tracyi* | mud rush | G5 | S1 | not listed | EO | |
| **Juncaginaceae (Arrow-grass Family)**<br>*Lilaea scilloides* | flowering quillwort | G5? | S1 | not listed | CDCMG | |
| **Liliaceae (incl. Amaryllidaceae) (Lily Family)**<br>*Allium geyeri* | geyer onion | G4G5 | S1 | not listed | CDCMG | LSP |
| **Loasaceae (Loasa Family)**<br>*Mentzelia albicaulis* | white-stemmed evening-star | G5 | S1 | not listed | CDCMG | |
| **Lobeliaceae (Lobelia Family)**<br>*Downingia laeta* | Great Basin downingia | G5 | S1S2 | not listed | EO/CDCMG | LSP |
| **Nyctaginaceae (Four-o'clock Family)**<br>*Mirabilis linearis* | narrow-leaved umbrella-wort | G5 | S2 | not listed | CDCMG | LSP |
| *Tripterocalyx micranthus* | small-flowered sand-verbena | G5 | S1 | Endangered | CDCMG | |

| Table 2-3-5. Continued | | | | | | |
|---|---|---|---|---|---|---|
| Division Name<br>Family Name<br>Scientific Name | Common Name | Global | Prov | COSEWIC | EO/CDCMG | LSP |
| **Onagraceae (Evening-Primrose Family)**<br>*Boisduvalia glabella* | smooth spike-primrose | G5 | S2 | not listed | EO/CDCMG | LSP |
| *Camissonia andina* | upland evening-primrose | G4 | S1 | not listed | CDCMG | |
| *Camissonia breviflora* | short-flower suncup | G5 | S1 | not listed | EO/CDCMG | LSP |
| *Oenothera flava* | low yellow evening-primrose | G5 | S3 | not listed | EO/CDCMG | LSP |
| **Ophioglossaceae (Grape-Fern Family)**<br>*Botrychium campestre* | prairie dunewort | G3G4 | S1 | not listed | EO/CDCMG | |
| *Botrychium lunaria* | common moonwort | G5 | S1 | not listed | CDCMG | |
| Poaceae (=Gramineae) (Grass Family)<br>*Alopecurus carolinianus* | Carolina foxtail water-foxtail | G5 | S1 | not listed | CDCMG | |
| *Andropogon hallii* | sand bluestem | | S1/S3 | | | LSP |
| *Aristida purpurea* | red three-awn grass | G5 | S1 | not listed | CDCMG | |
| *Hordeum brachyantherum spp. brachyantherum* | meadow wild barley | G5T5 | S1 | not listed | EO | |
| *Leymus cinereus* | giant wild-rye | G5 | S1S2 | not listed | CDCMG | |
| *Munroa squarrosa* | false buffalo grass | G5 | S1 | not listed | CDCMG | |
| *Puccinellia lemmonii* | Lemmon's alkali-grass | G4 | S1? | not listed | EO/CDCMG | LSP |
| *Sporobolus neglectus* | small dropseed | G5 | S1 | not listed | CDCMG | |
| *Vulpia octoflora* | six-weeks fescue | G5 | S2 | not listed | EO/CDCMG | LSP |
| **Polemoniaceae (Phlox Family)**<br>*Linanthus septentrionalis* | northern desert-gold | G5 | S1S2 | not listed | CDCMG | |
| *Navarretia leucocephala ssp. Minima* | lesser navarretia | G4T4? | S3 | not listed | CDCMG | LSP |
| *Phlox alyssifolia* | blue wild phlox | G5 | S2 | Not at Risk | CDCMG | |
| **Polygonaceae (Buckwheat Family)**<br>*Eriogonum cernuum var. cernum* | nodding umbrella-plant | G5T5 | S1 | not listed | EO/CDCMG | |
| **Potamogetonaceae (Pondweed Family)**<br>*Potamogeton strictifolius* | upright narrow-leaved pondweed | G5 | S2 | not listed | EO/CDCMG | LSP |
| **Primulaceae (Primrose Family)**<br>*Dodecatheon conjugens* | cylindric-fruited shooting star | G5 | S3 | not listed | CDCMG | LSP |
| **Ranunculaceae (Buttercup Family)**<br>*Clematis occidentalis var. grosseserrata* | western purple virgin's bower | | S2 | | | LSP |
| *Delphinium bicolor* | low larkspur | | S2S3 | | | LSP |
| *Thalictrum occidentale* | western meadow-rue | | S2 | | | LSP |
| **Ruppiaceae (Ditch-grass Family)**<br>*Ruppia cirrhosa* | widgeon-grass | G5 | SNR | not listed | CDCMG | LSP |

| Table 2-3-5. Continued | | | | | | | |
|---|---|---|---|---|---|---|---|
| Division Name<br>Family Name<br>Scientific Name | Common Name | Global | Prov | COSEWIC | EO/CDCMG | LSP |
| **Salicaceae (Willow Family)**<br>*Populus angustifolia* | narrowleaf cottonwood | G5 | S1 | not listed | EO/CDCMG | LSP |
| *Populus x brayshawii* | hybrid cottonwood | GNA | S1 | not listed | EO/CDCMG | LSP |
| **Scrophulariaceae (Figwort or Snapdragon Family)**<br>*Collinsia parviflora* | blue-eyed mary | | S2 | | | LSP |
| *Mimulus guttatus* | large yellow monkeyflower | G5 | S2 | not listed | EO/CDCMG | LSP |
| **Violaceae (Violet Family)**<br>*Viola nuttallii var. vallicola* | yellow violet | G? | not ranked | | | LSP |

Table 2-3-6. Selected plants used by Blackfoot, Cree, and other First Nations Groups for medicinal, ceremonial, and other purposes.

| Common Name | Scientific Name (Family) | Use | PRES[1] |
|---|---|---|---|
| chokecherry | *Prunus virginiana* var. *virginiana* (Rosaceae – Rose family) | medicine/food | 115 |
| Saskatoon berry | *Amelanchier alnifolia* (Rosaceae – Rose family) | | 8 |
| windflower | *Anemone multifida* (Ranunculaceae – Crowfoot family) | medicine | 34 |
| western meadow-rue | *Thalictrum occidentale* (Ranunculaceae – Crowfoot family) | aroma | 0 |
| purple meadow-rue | *Thalictrum dasycarpum* (Ranunculaceae – Crowfoot family) | food | 0 |
| meadow death camas, poison sego lily, lobelia | *Zygadenus venenosus* (Liliaceae – Lily family) | medicine | 0 |
| sweetgrass | *Hierochlöe odorata* (Gramineae – Grass family) | ceremonial | 0 |
| wildrye | *Elymus cinereus* (Gramineae – Grass family) | ceremonial | 0 |
| nodding onion | *Allium cernuum* (Liliaceae – Lily family) | food | 0 |
| black hawthorn | *Crataegus douglasii* var. *douglasii* (Rosaceae – Rose family) | food | 0 |
| wild rose/meadow rose | *Rosa blanda* var. *blanda* (Rosaceae – Rose family) | food | 0 |
| white milkwort | *Polygala alba* (Polygalaceae – Milkwort family) | medicine | 0 |
| Dawson's angelica | *Angelica dawsonii* (Umbelliferae – Carrot family) | ceremonial | 0 |

1. Only presence at each sample plot was recorded.
Notes:
• All plants and uses were identified based on secondary sources. Primary information concerning plants used by First Nations, their location and uses could not be obtained from the focus groups and interviews. An attempt to verify use and significance with First Nations for the Great Sand Hills area should be made when and if possible.
• This is not a comprehensive list of all plants used by First Nations in Saskatchewan and the Blackfoot. The emphasis is on plants known to be used for ceremonial or medicinal purposes, with only selected food plants identified. Additional plants for dyes, horse feed etc are not included. Only those plants that could be crosschecked and verified against other sources (e.g.: Cota-Sánchez 2006; Leighton 1986; Johnston 1987) are included.

#### *3.3.1.6 Data preparation and summary for focal species analysis*

All GPS data were projected from geographic coordinates (Datum: WGS84) to the Saskatchewan standard NAD 1983 CSRS98 UTM Zone 13N. Data from point-count surveys for focal species and species of conservation concern were summarized for subsequent modeling as follows. For focal birds (Table 2-3-3), only records of adult males perched (not flying over) within the 100-m radius plot were used. Observations of species of conservation concern at case-control sites were not limited to the 100-m radius plot or to birds perched in the plot (i.e., observation could be of individuals in flight over plot, as were 100% of Sprague's Pipit observations). These datasets were then summarized to account for variation in detection for each species at each plot by finding the highest count of individuals between surveys 1 and 2; the count data were then transformed into binary format (presence-absence) for logistic regression analysis (see following section on focal species). Some species in both groups did not have sufficient number of observations (from case-control point-count sites) to be used in subsequent modeling.

### 3.3.2 Results

Analysis, results, and discussion on relationships of selected bird and plant species and range assessment with vegetation type, soil, the three impacts, as well as spatial modeling of the species' occurrence probabilities are provided later in this chapter. The results for birds and plants are summarized briefly in the following two sections.

#### *3.3.2.1 Birds*

The majority of birds observed during point counts were heard and not seen. Clay-colored Sparrow was the most abundant and Brewer's Sparrow and Lark Sparrow the least abundant species recorded in point-count surveys (Table 2-3-3). Although Chestnut-collared Longspur was not among the most abundant species, birds tended to occur in higher numbers than other species when they were observed (Table 2-3-3). No McCown's Longspur or Yellow-breasted Chat were seen or heard within the Review Area.

Of the bird species of conservation concern, Sprague's Pipit was the most abundant species recorded at both point counts and opportunistically (Table 2-3-4); all individuals heard or seen were of birds in flight, i.e. no Sprague's Pipits were observed perched. No Trumpeter Swans or Common Poorwills—and just one Burrowing Owl—were heard or seen within or outside the Review Area by any of the bird observers. A total of 18 Sharp-tailed Grouse lek sites were recorded (Table 2-3-4).

#### *3.3.2.2 Plants*

Twenty rare plant species were recorded in plant surveys (Table 2-3-7). This list contains 14 species from the original list of 77 known or potential rare plant species for the area (Table 2-3-5); an additional 6 rare species not on the initial list were also documented. Four species were recorded at more than 30 plots: *Astragalus lotiflorus*, *Vulpia octoflora*, *Lupinus pusillus*, and *Botrychium campestre*, whereas the majority of other species were found at only a few sites (Table 2-3-7). At least one traditional-use plant was found at over half of the sites visited (Table 2-3-6), suggesting that the GSH has considerable value for traditional-use plants. The most common traditional-use species was chokecherry (*Prunus virginiana*); windflower (*Anemone multifida*) and Saskatoon berry (*Amelanchier alnifolia*) were also recorded. Five of 8 expected non-native and invasive species were recorded in plant surveys (Table 2-3-8). Of these, Kentucky bluegrass and crested wheatgrass were most prevalent, recorded at 89 and 82 plots, respectively, of the 240 sample plots.

## 3.4 FOCAL SPECIES RESPONSE TO LIVESTOCK GRAZING AND GAS DEVELOPMENT

In the following section we describe the selection of focal species for assessing baseline environmental conditions and potential impacts of livestock grazing and gas development in the Great Sand Hills. Specifically, we consider the effects on the probability of occurrence of selected flora and fauna of three common anthropogenic activities: 1) gas well pad sites; 2) livestock watering holes; and 3) roads and trails. We predict response curves across distances from individual impacts as well as the distribution of the species across the Great Sand Hills in a geographical information system (GIS) to express impacts spatially. This analysis allows identification of biodiversity hotspots, and is essential for subsequent conservation planning exercises.

Table 2-3-7. Rare plant species found during the 2006 plant surveys in the Review Area. Global, Saskatchewan (Prov), and National (COSEWIC) conservation status are indicated. EO/CDCMG and LSP indicate from which database the species was listed (EO = Saskatchewan CDC Element Occurrence records for study area, CDCMG = Saskatchewan CDC list of vascular plant species in Mixed Grassland Ecoregion, LSP = List of sensitive plant species in Great Sand Hills).

| Family Name<br>Scientific Name | Common Name | Global | Prov | COSEWIC | PRES[1] |
|---|---|---|---|---|---|
| **Asteraceae (=Compositae) (Aster or Sunflower Family)** | | | | | |
| *Ambrosia acanthicarpa* | bur ragweed | G5 | S2 | not listed | 3 |
| *Antennaria dimorpha*[2] | low pussytoes | G5 | S2 | not listed | 2 |
| *Shinnersoseris rostrata (=Lygodesmia rostrata)* | beaked annual skeleton-weed | G5?[3] | S2 | not listed | 10 |
| **Brassicaceae (=Cruciferae) (Mustard Family)** | | | | | |
| *Draba reptans*[2] | Carolina whitlow-grass | G5 | S2?[4] | not listed | 4 |
| *Halimolobos virgata* | slender mouse-ear Cress | G4 | S1 | Threatened | 6 |
| **Chenopodiaceae (Goosefoot Family)** | | | | | |
| *Chenopodium subglabrum* | smooth arid goosefoot | G3G4 | S2 | Special Concern | 18 |
| **Fabaceae (=Leguminosae) (Legume or Bean Family)** | | | | | |
| *Astragalus kentrophyta* var. *kentrophyta* | spiny milk-vetch | G5T4 | S1 | not listed | 5 |
| *Astragalus lotiflorus* | low milk-vetch | G5 | S3 | not listed | 105 |
| *Astragalus purshii* var. *purshii* | Pursh's milk-vetch | G5T5 | S2 | not listed | 2 |
| *Lupinus pusillus* ssp. *pusillus* | small lupine | G5T5 | S3 | not listed | 53 |
| **Grossulariaceae (Currant Family)** | | | | | |
| *Ribes aureum*[2] | golden currant | G5 | S2 | not listed | 3 |
| **Lamiaceae (=Labiatae)(Mint Family)** | | | | | |
| *Hedeoma hispida*[2] | rough pennyroyal | G5 | S3 | not listed | 4 |
| **Onagraceae (Evening-Primrose Family)** | | | | | |
| *Boisduvalia glabella* | smooth spike-primrose | G5 | S2 | not listed | 1 |
| **Ophioglossaceae (Grape-Fern Family)** | | | | | |
| *Botrychium campestre* | prairie dunewort | G3G4 | S1 | not listed | 33 |
| *Botrychium lunaria* | common moonwort | G5 | S1 | not listed | 5 |
| **Plantaginaceae (Plantain Family)** | | | | | |
| *Plantago elongata (=Alisma gramineum)*[2] | narrow-leaved water plantain | G4 | S2S3 | not listed | 1 |
| **Poaceae (=Gramineae) (Grass Family)** | | | | | |
| *Vulpia octoflora* | six-weeks fescue | G5 | S2 | not listed | 78 |
| **Polygonaceae (Buckwheat Family)** | | | | | |
| *Eriogonum cernuum* var. *cernuum* | nodding umbrella-plant | G5T5 | S1 | not listed | 1 |
| **Rosaceae (Rose Family)** | | | | | |
| *Potentilla bipinnatifida*[2] | plains cinquefoil | G5? | SNR | not listed | 2 |
| **Salicaceae (Willow Family)** | | | | | |
| *Populus angustifolia* | narrowleaf cottonwood | G5 | S1 | not listed | 1 |

1. Number of plots with at least one individual recorded.
2. These species were not among the focal 77 rare species, but were recorded when found because they were considered by the botanists to be rare.
3. "?" denotes inexact numeric rank in Global status
4. "?" denotes that the species is not yet ranked in Saskatchewan.

| Table 2-3-8. List of non-native and potentially invasive plants searched for in range assessments and the number of plots of 240 plots in which their presence was recorded. | | |
|---|---|---|
| Scientific Name | Common Name | PRES[1] |
| *Acroptilon repens* | Russian knapweed | 1 |
| *Agropyron cristatum* | crested wheatgrass | 82 |
| *Bromus inermis* | smooth brome grass | 32 |
| *Carduus nutans* | nodding thistle | 0 |
| *Cirsium arvense* | Canadian thistle | 7 |
| *Euphorbia esula* | leafy spurge | 0 |
| *Poa pratensis* | Kentucky bluegrass | 89 |
| *Rhamnus cathartica* | common buckthorn | 0 |
| 1. Only presence at each sample plot was recorded. | | |

### 3.4.1 Methods

#### *3.4.1.1 Focal species designation and data sources*

Given the wide diversity of habitats in the GSH, there are numerous candidate species for consideration in environmental assessment. Most frequently, large-bodied, charismatic mammals, such as pronghorn antelope, gray wolves, grizzly bears, or mountain lions, are chosen as a focal, flagship, or umbrella species for conservation reserve design (Noss et al. 1996, 2002, Carroll et al. 2001). It is assumed that protection of such species shelters or simultaneously benefits other species of conservation interest (Ryti 1992, Lambeck and Murphy 1994, Launer and Murphy 1994, Sergio et al. 2006). Many of the large mammals, carnivores in particular, also have relatively low recruitment rates, making them sensitive to population decline due to environmental stochasticity and/or anthropogenic disturbances (Russell et al. 1998, Purvis et al. 2000). However, detailed knowledge of large mammal distributions and how populations are affected by natural gas development and livestock ranching is currently lacking for the GSH and throughout grassland areas of North America where most large-bodied mammals have been extirpated. Although GIS-based habitat suitability indices (HSI) provide an alternative means for spatially projecting anthropogenic impacts (Li et al. 2002), no HSI from environmentally similar habitats are known. Reliability of some HSIs also has been questioned (Roloff and Kernohan 1999). Instead, this RES considers a number of focal species in the GSH using well-studied species of vascular plants and birds at scales appropriate for impact assessment and conservation planning. These include a number of rare or sensitive species, non-native and likely invasive species (indicators of reduced ecosystem integrity), range health measures, and traditional-use plants identified in the literature as used by the Blackfoot and Cree Nations.

Numerous sources of information were used to develop distributional models for plant, bird, and mammal species in the GSH. These sources included (1) Saskatchewan Sharp-tailed Grouse lek records (past and present); (2) Saskatchewan Conservation Data Centre (Saskatchewan Environment) element occurrence records; (3) recorded presence/absence of selected plant and bird species from the 2006 field season; and (4) range health assessments collected during the 2006 field season at the same sites where species information was collected. The first source of data represented hard copy annual records of Sharp-tailed Grouse leks in southern Saskatchewan from Saskatchewan Environment. Active leks were visited annually from 1969 to 1999 (not all leks were followed for every year), male and female bird attendance noted, and location to the section or quarter section recorded. This information was entered into a Microsoft Access database for further use. In addition to these historic lek records, leks were recorded during 2006 field surveys. For the second source of data, element occurrences of species locations from the SKCDC were mapped for areas within the GSH Review Area where an element occurrence represented a georeferenced observation of a population, species, or ecological community of conservation or management interest (http://www.biodiversity.sk.ca/). A single element occurrence may be documented by one or multiple specimens or by observations taken from the same population over multiple years. The original database was provided in the spring of 2005 and an updated database in July 2006; there were no new records for the Review Area in the updated database. The third and fourth sources of information represented data gathered during the 2006 field season, as described earlier in this chapter. For the third source, presence/absence of selected plant and bird species was recorded at the 240 sample locations. In addition, the presence of Ord's kangaroo rat was noted at each sample site, as well as other locations where it was observed during travels. Finally, the fourth source of data represented an assessment of range health using the same locations where presence/absence of plant and bird species was recorded. Assessments of range health followed current protocols for Saskatchewan (see above).

*3.4.1.2 Species occurrence modeling*

Presence-absence of 14 bird and 12 plant species (Table 2-3-9) was used from the 2006 field dataset to estimate probability of species occurrence for each 0.01-ha pixel in the GSH. Logistic regression models were developed in the program STATA (StataCorp 2005) for each species using presence-absence (0/1) as the response and environmental and anthropogenic disturbance variables available in a GIS as predictors. Environmental variables included the proportion of regosolic soils and landcover types (i.e., vegetation or habitat) in 50-m (plants) or 100-m (birds) moving windows. Regosolic soil data were selected from the primary soil class (soil_cl1) attribute field of the "sk_sis_gerry" shapefile. All regosolic polygons were converted into a 10-m raster file using the same extent and cell size as the 2005 SPOT remote sensing classification. We chose regosolic soils over other possible soil variables such as soil texture and organic matter because preliminary analyses suggested that the presence of this soil type explained the presence or absence of many focal species as well or better than other available variables (most were correlated). This was particularly true for vascular plants, but also for some species of birds. Although these data were coarse in resolution, they provided further stratification of the Study Area into two broad regions of the GSH, with regosolic soil areas having much smaller vegetation patch sizes and a greater diversity of habitats (especially treed and juniper habitats). Eight landcover types from the 2005 SPOT 5 remote sensing classification(Appendix A) were grouped to create six landcover categories for our modeling purposes. These included grassland, herbaceous, mixed shrub, sagebrush, juniper, and disturbed habitat totaling 92.5% (1,878-km$^2$) of the Review Area. In contrast to the field sampling program that used four broad landcover types (see above), two of the classes (herbaceous grassland and shrubby grassland) were separated to improve predictions of focal species. Herbaceous grassland was divided into the grassland and herbaceous (silvery grassland + 50% revegetated) categories, whereas shrubby grassland was separated into either mixed shrub or sagebrush categories. Examination of these landcover types within the 50-m and 100-m moving windows suggested that sample sizes were sufficient to allow further separation. Because of the unit sum constraint (proportional data sum to 1), the grassland category (the most common habitat) was removed and used as a reference category for comparison to avoid perfect colinearity (i.e., $n - 1$ categories are needed to predict the remaining category). For each of the three human disturbances (natural gas well pads, cattle watering holes, and roads/trails), grids were generated in ArcGIS (ESRI 2005) depicting the distance from impact in metres for each 0.01-ha pixel in the landscape. Using distance grids, a disturbance impact factor (DIF) for each anthropogenic disturbance was estimated in ArcGIS (ESRI 2005) based on a distance decay model having the form,

(eqn. 1)

$$DIF = \exp\left(\frac{-x}{d}\right)$$

where *DIF* was the distance impact factor, *x* one of five scale parameters chosen *a priori* (50, 100, 250, 500, 1000 m) and *d* the distance in metres for the pixel of interest. Resulting grids scaled from 1 (greatest impact) to 0 (least impact), with sharper declines in the index for the smallest scaled *x* parameter (Figure 2-3-7). As well as using *DIF* variables, straight line distance was also used as a potential predictor variable. Assumed advantages of *DIF* variables over a straight line distance included intuitive scaling of variables (1-high to 0-low) and resulting coefficients (negative coefficients represented negative associations with impact for *DIF*, compared to positive associations for straight line distance) and the direct application of non-linear responses. Straight line distance assumes that there is a similar change in species occurrence per unit of distance regardless of how far away from the actual impact. It is likely that change in

Table 2-3-9. Fourteen bird and 12 plant species used in presence-absence modeling to predict their probability of occurrence with respect to environmental and human disturbance variables.

| | Scientific Name | Common Name | Presence[1] |
|---|---|---|---|
| Focal Birds | | | |
| | *Ammodramus bairdii* | Baird's Sparrow | 51 |
| | *Molothrus ater* | Brown-headed Cowbird | 104 |
| | *Calcarius ornatus* | Chestnut-collared Longspur | 21 |
| | *Spizella pallida* | Clay-colored Sparrow | 182 |
| | *Ammodramus savannarum* | Grasshopper Sparrow | 37 |
| | *Eremophila alpestris* | Horned Lark | 62 |
| | *Passerculus sandwichensis* | Savannah Sparrow | 42 |
| | *Pipilo maculatus* | Spotted Towhee | 10 |
| | *Sturnella neglecta* | Western Meadowlark | 149 |
| Birds of Special Concern | | | |
| | *Anthus spragueii* | Sprague's Pipit | 147 |
| | *Chordeiles minor* | Common Nighthawk | 37 |
| | *Numenius americanus* | Long-billed Curlew | 39 |
| | *Limosa fedoa* | Marbled Godwit | 22 |
| | *Bartramia longicauda* | Upland Sandpiper | 68 |
| Rare Plants | | | |
| | *Astragalus lotiflorus* | low milk-vetch | 105 |
| | *Botrychium campestre* | prairie moonwort | 33 |
| | *Chenopodium subglabrum* | smooth arid goosefoot | 18 |
| | *Lupinus pusillus* spp. *pusillus* | small lupine | 53 |
| | *Shinnersoseris rostrata* | beaked annual skeleton-weed | 10 |
| | *Vulpia octoflora* | six-weeks fescue | 78 |
| Traditional Use Plants | | | |
| | *Prunus virginiana* var. *virginiana* | chokecherry | 115 |
| | *Anemone multifida* | windflower | 34 |
| Non-native and Potentially Invasive Plants | | | |
| | *Poa pratensis* | Kentucky bluegrass | 89 |
| | *Agropyron cristatum* | crested wheatgrass | 82 |
| | *Bromus inermis* | smooth brome | 32 |
| | *Cirsium arvense* | Canada thistle | 7 |

1. Number of 240 survey plots in which at least one individual was recorded. Detectability was incorporated into presence values by assigning presence of a species at a plot when the species was observed in either or both replicate surveys.

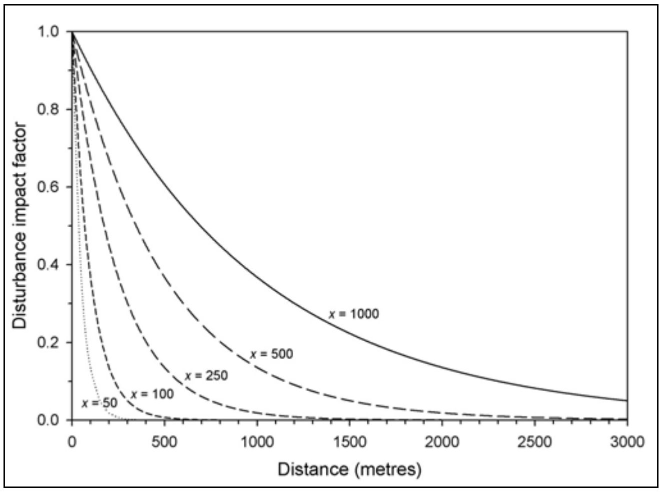



Figure 2-3-7. Exponential decay functions used to assess the impact of gas well pads, cattle watering holes, and roads and trails on species distribution. Resulting index, called the disturbance impact factor (*DIF*), is scaled from 1 at the disturbance (0-m) to 0 at increasingly greater distances for larger parameter *x* values. Approximately 95% of the *DIF* was eroded at 3 times the parameter *x* value (i.e., when $x = 50$ the DIF was approximately 0.05 at 150 metres).

occurrence is more substantial near the impact, as represented by the exponential decay models.

For each species, univariate analyses were used to determine significance of regosolic soils and *DIF* values (or straight line distance). Significant variables (only 1 scale for each impact type) were added to a base model containing land-cover variables. For each model, coefficients and significance were recorded, overall model significance verified with likelihood ratio (LR) $\chi^2$ values, amount of deviance explained noted, and predictive accuracy assessed using Receiver Operating Characteristic (ROC) area under the curve, sensitivity, specificity, and percentage correctly classified. For ease of interpretation, coefficients are reported for predicting the probability of occurrence as odds ratios (likelihood of a change in occurrence over a one unit change in the variable). Values >1 indicate that species occurrence increases as the variable unit increases (i.e., an odds ratio of 2 would be interpreted as twice as likely to occur between a value in the variable of 0 and 1), while values <1 indicate that species occurrence declines as the variable unit increases (i.e., an odds ratio of 0.5 would be interpreted as one-half as likely to occur between a value in the variable of 0 and 1). To estimate sensitivity, specificity, and percentage correctly classified for models, optimal cutoff probabilities were estimated by assessing sensitivity and specificity values across all observed probability of occurrence values. Where both sensitivity and specificity values were at their highest, the probability of occurrence was recorded and that value was used as the optimum cutoff probability (i.e., equalize predictive success of both presences and absences simultaneously). A model was considered "excellent" when the model LR $\chi^2$ probability was <0.001, percentage deviance >20%, and ROC scores >0.8 and good when LR $\chi^2$ probability was <0.001, percentage deviance >15%, and ROC scores >0.75.

To generate spatial predictions of species occurrence in a GIS the logistic regression model,

(eqn. 2)

$$\Pr(y = 1 \mid x) = \frac{e^{LP}}{1 + e^{LP}},$$

was calculated using the raster calculator function in ArcGIS Spatial Analyst extension (ESRI 2005), where the probability of outcome 1 (species being present) is estimated from a set of *x* independent variables. The linear predictor (*LP*) represented the summed value of the product of coefficients and pixel values for all variables. Resulting grids ranged in value from 0 (the species is not likely to occur) to 1 (the species is likely to occur) for each 0.01-ha pixel. However, because the field sampling protocol only sampled grassland, herbaceous, mixed shrub, sagebrush, juniper, and disturbed habitats, no estimates were made for wetland types, treed sites, and agricultural lands. Using optimum probability cutoff values, species occurrence maps were reclassified into binary habitat (1- predict species to occur or greater than the cutoff probability threshold) and non-habitat (0- predict the species to be absent or lower than the cutoff probability threshold) maps for ease of subsequent assessments of focal species and MARXAN analyses to identify sites of high conservation value.

### *3.4.1.3 Resource selection function (RSF) for Ord's kangaroo rat*

Because Ord's kangaroo rat observations were made outside of the 240 stratified-random survey sites, a separate analysis using presence-only data was required (i.e., knowledge of absences was not complete). Resource selection functions (RSF) provide an approach for dealing with presence-only data (Manly et al. 2002). Here random sampling is used to characterize availability of resources and subsequently compared with the sample of use (presence-only) locations. Logistic regression is used to estimate coefficients of the RSF model,

(eqn. 3)

$$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k),$$

where $w(x)$ is the resource selection function for a vector of predictor variables, $x_i$, and $\beta_i$'s the corresponding selection coefficients. Because data on Ord's kangaroo rat absences are not available, the model for this species is based on an assessment of available resources (random or pseudo-absences), and resulting RSF predictions represent only the relative probability of occurrence. Pseudo-absences were generated for the GSH at a sampling intensity of one location/km$^2$ and no closer than 300 m from a known Ord's kangaroo rat location, for a total of 2,029 locations. Because the ratio of random or available locations to known use locations is an artifact of the pseudo-absence sampling intensity, the model constant (i.e., $\beta_0$) is dropped in the RSF. Predictor variables used to predict the relative probability of occurrence for Ord's kangaroo rat were the same as those used to describe other focal species (i.e., landcover, regosolic soils, and distance functions for gas well pads, roads/trails, cattle watering holes). 50-m radius (7,830-m$^2$) moving windows were used to represent landcover and soils, since this scale matched nighttime (when animals are most active) home range territories of Ord's kangaroo rats (Gummer and Bender 2005) and further matched the scale of plant surveys and field assessments of landcover. To present results on equivalent scales to other focal species (presence-absence models of occurrence), RSF values were scaled between 0 and 1 using the transformation,

(eqn. 4)

$$w_t(x) = \frac{w(x)}{1 + w(x)},$$

where $w_t(x)$ is the re-scaled RSF and $w(x)$ the original RSF prediction from equation 3. Relative probability of occurrence was predicted spatially for each pixel in the GSH using the raster calculator function in Spatial Analyst ArcGIS (ESRI 2005) and equations 3 and 4 for the Ord's kangaroo rat RSF model. To classify kangaroo rat habitat from the RSF model a $w_t(x)$ of 0.5 was used as a cut-off value for predicting presence.

### *3.4.1.4 Range health modeling*

Range health estimates from the 2006 field dataset, as described earlier in this chapter, were used to estimate range health conditions for each pixel in the GSH. Because range health scores were on a percentile scale and observations were positively skewed, an arcsin square-root transformation of the form,

(eqn. 5)

$$RH_t = a\sin\left(\sqrt{\frac{RangeHealth}{100}}\right) \times \left(\frac{180}{\pi}\right),$$

was used to normalize range health scores. Using transformed range health values ($RH_t$), a linear regression model predicting range health was estimated based on the same environmental and human impact variables used for species occurrence modeling. Model selection followed the same univariate to multivariate procedure as described in the species occurrence modeling. Tests for normality (skewness and kurtosis) and constant variance were performed to ensure appropriate distribution of data in the linear regression model. Model significance and percentage of variation explained ($R^2$) was recorded.

Transformed range health scores were predicted in a GIS using the raster calculator function in ArcGIS (ESRI 2005) and the linear regression equation. To re-scale the values to percentiles (0–100 scale), a back transformation was calculated in raster calculator using the equation,

(eqn. 6)

$$RangeHealth = \left(\sin\left(\frac{RH_t}{180}\right) \times \pi\right)^2 \times 100,$$

where $RH_t$ represented the transformed range health predictions for each landscape pixel from equation 5 and *RangeHealth* the predicted value of range health using the original 0–100 scale. As well as estimating raw range health scores, categories of range health were estimated for each pixel based on three pre-defined thresholds following the methods of Adams et al. (2005). These categories and thresholds included unhealthy (<50), healthy, but with problems (50–74), and healthy (>74).

*3.4.1.5 Species habitat inter-relationships and selected indicator species*

Pearson correlations ($r$) were estimated among resulting species occurrence grids by querying predicted occurrence values for random pixels (5% of pixels) and estimating correlation values using the program STATA (StataCorp 2005). Correlation values >0.7 were used to determine species guilds (species with similar habitat/community). Guilds were illustrated by use of a constellation diagram of selected species and correlation values. A final set of species was derived from these diagrams by choosing one or a few indicators from each guild and combining these with independent species (species not globally correlated with other species) to balance conservation reserve efforts in the MARXAN analyses.

*3.4.1.6 Focal species hot spot assessments*

Using reclassified binary (i.e., 0: non-habitat,1: habitat) species habitat maps, we assessed the importance of individual 0.01-ha pixels for focal native flora and fauna, as well as areas of greater concentration of invasive plants. This hot spot analysis was estimated in ArcGIS (ESRI 2005) by summing binary species habitat maps in spatial analyst for five separate taxonomic and conservation groupings: (1) rare and traditional use plants; (2) rare birds and birds of special concern; and (3) species guilds based on species habitat interrelations assessed as described above. Results were expressed in predicted richness of species for each pixel in the landscape. Hotspots were mapped and scaled between blue colours for low richness and red colours for high richness. Patterns were interpreted and used for assessing patterns in MARXAN analyses.

*3.4.1.7 Gap analysis of the RAER and remaining regions of the Great Sand Hills Review Area*

The current conservation value of the Representative Area Ecological Reserve (RAER) was assessed using predicted species occurrence models (maps). For each species the optimal cutoff probability for classifying species occurrence was estimated using sensitivity and specificity values following model estimation. Using cutoff values, species occurrence maps were reclassified into habitat (1- predict species to occur or greater than the cutoff probability threshold) and non-habitat (0- predict the species to be absent or lower than the cutoff probability threshold) conditions. Amounts of habitat for each species were summed for the GSH Review Area excluding the wetland, water, treed, and agricultural habitats that were not surveyed or modeled and were minor in extent (7.5%). Amounts of habitat for each species inside and outside the RAER were summarized to determine the overall current protection status of focal species.

### 3.4.2 Results

*3.4.2.1 Sharp-tailed Grouse and Saskatchewan Conservation Data Centre observations*

In total, 3,209 unique lek and year records from southwestern Saskatchewan were entered into a Microsoft Access database. Locations of leks were summarized by section (often more than one lek per section) and imported into ArcGIS. The SKCDC database consisted of 104 element occurrences in the Review Area. The records included one ecological feature (Migratory Bird Concentration Site), nine animals, and 15 plants (Table 2-3-10). Limitations were found in the use of historic Sharp-tailed Grouse lek locations and element occurrence data for assessments of human disturbance. These data sources were collected opportunistically in the field over many years (1969–1999 for lek observations and 1956–2005 for element occurrence records) without any formal study design or control for effort (in space or time). As 50% of natural gas development in the GSH has occurred since 1992, use of historical sources of data for assessing recent landscape change was questionable. Furthermore, the element occurrence locations were represented as polygons, not point locations, with size of the polygon representing the precision of location. Thirty-six percent of the records were at a level of precision of ≥1 $km^2$ and 62.2% at ≤80 ha (Figure 2-3-8). Initial

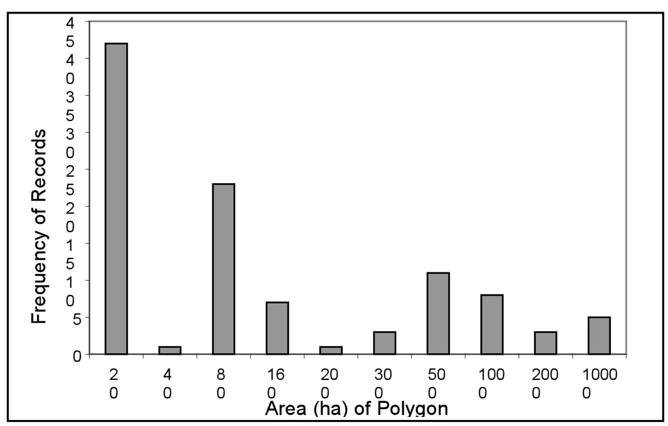



Figure 2-3-8. Polygon area (i.e., spatial representation/accuracy) of 107 Saskatchewan Conservation Data Centre element occurrence records for the Great Sand Hills, Saskatchewan.

Table 2-3-10. Summary of element occurrences in the Great Sand Hills, Saskatchewan. Data from the Saskatchewan Conservation Data Centre, July 2006.

| Scientific Name or Element | Common Name | N[1] | Status[2] | | |
|---|---|---|---|---|---|
| | | | Global | COSEWIC | PROV |
| Migratory Bird Concentration Site | Migratory Bird Concentration Site | 2 | GNR | | S3 |
| *Pelecanus erythrorhynchos* | American White Pelican | 2 | G3 | NR | S3B |
| *Athene cunicularia* | Burrowing Owl | 3 | G4 | E | S2B |
| *Phalaenoptilus nuttallii* | Common Poorwill | 1 | G5 | DD | S3B |
| *Phalacrocorax auritus* | Double-crested Cormorant | 1 | G5 | NR | S4B |
| *Buteo regalis* | Ferruginous Hawk | 20 | G4 | SC | S4B |
| *Numenius americanus* | Long-billed Curlew | 2 | G5 | SC | S4B |
| *Perognathus fasciatus* | olive-backed pocket mouse | 3 | G5 | | S3 |
| *Dipodomys ordii* | Ord's kangaroo rat | 7 | G5 | SC | S2 |
| *Charadrius melodus circumcinctus* | Piping Plover | 2 | G3T3 | E | S3B |
| *Shinnersoseris rostrata* | beaked annual skeleton-weed | 10 | G5?[3] | | S2 |
| *Ambrosia acanthicarpa* | bur ragweed | 7 | G5 | | S2 |
| *Puccinellia lemmonii* | Lemmon's alkali-grass | 1 | G4 | | S1? |
| *Astragalus lotiflorus* | low milk-vetch | 7 | G5 | | S3 |
| *Alisma gramineum* | narrow-leaved water plantain | 1 | G5 | | S3 |
| *Eriogonum cernuum* var. *cernuum* | nodding umbrella-plant | 1 | G5T5 | | S1 |
| *Botrychium campestre* | prairie dunewort | 1 | G3G4 | | S1 |
| *Elymus lanceolatus* ssp. *psammophilus* | sand-dune wheatgrass | 1 | G5T3 | | S2 |
| *Vulpia octoflora* | six-weeks fescue | 5 | G5 | | S2 |
| *Silene antirrhina* | sleepy catchfly | 1 | G5 | | S1S2 |
| *Lupinus pusillus* ssp. *pusillus* | small lupine | 11 | G5T5 | | S3 |
| *Chenopodium subglabrum* | smooth arid goosefoot | 9 | G3G4 | SC | S2 |
| *Astragalus kentrophyta* var. *kentrophyta* | spiny milk-vetch | 4 | G5T4 | | S1 |
| *Potamogeton strictifolius* | upright narrow-leaved pondweed | 1 | G5 | | S2 |
| *Atriplex truncate* | wedge-scale saltbush | 1 | G5 | | S1 |

1. Number of records.
2. Status or rank provides information on the risk of extinction of a species as designated by different government agencies or nongovernmental organizations for different spatial scales (i.e. global, national, provincial) using different sets of criteria. Provincial ranking indicates the species' risk of extirpation in the province. For example, a rank of S2 signifies "Rare; 6 to 20 occurrences in Saskatchewan or few remaining individuals. Imperiled; may be susceptible to extirpation because of some factor of its biology." National status of "wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada" is defined by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). For example, Endangered (E) status is defined as a "species facing imminent extirpation or extinction," Special Concern (SC) status is given to a "species that is particularly sensitive to human activities or natural events but is not an endangered or threatened species," Data Deficient (DD) is "a species for which there is inadequate information to make a direct or indirect assessment of its risk of extinction," and Not at Risk (NR) is "a species that has been evaluated and found to be not at risk."
3. "?" denotes inexact numeric rank in Global status.

examination for a number of species of the SKCDC data with large sample sizes suggested a strong positive association with roads and trails, which was assumed to be caused by biases in observer effort rather than actual preference for roads and trails by rare species (Figure 2-3-9). Statistical modeling of species responses to human disturbance (i.e., impact assessment) and subsequent spatial predictions of species occurrence at small scales (0.01 ha pixels) were therefore deemed inappropriate due to limitations in spatial accuracy, temporal period, and a general bias in distribution of records. These data were used instead as a regional *post-hoc* filter for selection of conservation reserve sites. New (2006) Sharp-tailed Grouse lek records were considered a superior source of data for conservation planning.

### *3.4.2.2 Models of bird occurrence and baseline impacts*

The probability of occurrence across the GSH was estimated for 14 species of birds. Sprague's Pipit, Brown-headed Cowbird, and Spotted Towhee showed no significant response to direct human disturbance; their distributions were explained by general habitat conditions (Table 2-3-11). Sprague's Pipit occurrence was significantly higher in grassland habitats (reference category), and particularly rare in juniper, sagebrush, and disturbed grasslands. Sprague's Pipit also was 2.4 times more likely to be found off than on regosolic soils, suggesting that the small grassland patches characteristic of regosolic soils were avoided. Brown-headed Cowbird and Spotted Towhee were more likely to be found in non-grassland habitats, particularly in the mixed shrub, sagebrush, and disturbed habitats (Table 2-3-11). Five species—Baird's Sparrow, Chestnut-collared Longspur, Grasshopper Sparrow, Horned Lark, and Marbled Godwit—responded significantly to livestock watering holes (Table 2-3-11), with only Chestnut-collared Longspur positively associated with livestock watering holes (Figure 2-3-10). Scales of influence were broad for all species except Horned Lark, which dramatically decreased in occurrence within 100 m of a watering hole. Road and trail impacts were significant for five species: Baird's Sparrow, Chestnut-collared Longspur, Clay-colored Sparrow, Common Nighthawk, and Savanna Sparrow (Table 2-3-11). Baird's Sparrow, Chestnut-collared Longspur, and Savanna Sparrow were negatively associated with roads and trails, while Clay-colored Sparrow and Common Nighthawk were positively associated (Table 2-3-12). Scales of influence for Clay-colored Sparrow and Common Nighthawk were similar in magnitude with increased presence of birds in a 100–150 m buffer (Figure 2-3-11). Local decreases in occurrence for Baird's Sparrow, Chestnut-collared Longspur, and Savanna Sparrow also occurred in a 100–150 m zone.

Impacts of gas well sites were significant for Chestnut-collared Longspur, Clay-colored Sparrow, Grasshopper Sparrow, Horned Lark, Long-billed Curlew, Savanna Sparrow, Upland Sandpiper, and Western Meadowlark. Excluding Clay-colored Sparrow, gas well sites were positively associated with the occurrence of these birds (Figure 2-3-11). Zone of influence was narrow for Upland Sandpiper with a 50-m scale, whereas the remaining species demonstrated wide zones of influence (Figure 2-3-11).

All birds showed significant habitat (landcover) relationships. Baird's Sparrow, Chestnut-collared Longspur, Grasshopper Sparrow, Horned Lark, Long-billed Curlew, Marbled Godwit, Savanna Sparrow, Sprague's Pipit, Upland Sandpiper, and Western Meadowlark all had higher occurrence in grassland and herbaceous habitats (Table 2-3-11). Of these species, Marbled Godwit occurrence was the only species significantly more likely to occur in herbaceous sites than grassland sites. Regosolic soils were negatively associated with 6 of 9 grassland birds (Baird's Sparrow, Grasshopper Sparrow, Horned Lark, Marbled Godwit, Savanna Sparrow, and Sprague's Pipit), suggesting that the small patches of grassland on regosolic soils were not large enough to attract these area-sensitive species. In contrast to these open grassland and herbaceous specialists, occurrences of Brown-headed Cowbird, Clay-colored Sparrow, Common Nighthawk, and Spotted Towhee were higher in shrub-dominated habitats common to regosolic soils (Table 2-3-11).

Although all species occurrence models were significant, Brown-headed Cowbird, Common Nighthawk, Long-billed Curlew, and Upland sandpiper were weak in deviance explained and predictive accuracy (Table 2-3-11). These four species also were the only of the 14 species of birds to fail our standards for model significance (LR $\chi^2$ <0.001), deviance (>20% for excellent and >15% for good). and predictive accuracy (ROC >0.8 for excellent and >0.75 for good). Because of low predictive accuracy, caution should be used in the application and interpretation of the models for these four species. This limitation notwithstanding, predictions of species occurrence for each landscape pixel (excluding the wetland, treed, and agricultural pixels) were estimated for each bird species (Appendix B). Spatial patterns of species occurrence suggested broad overlap in distribution.

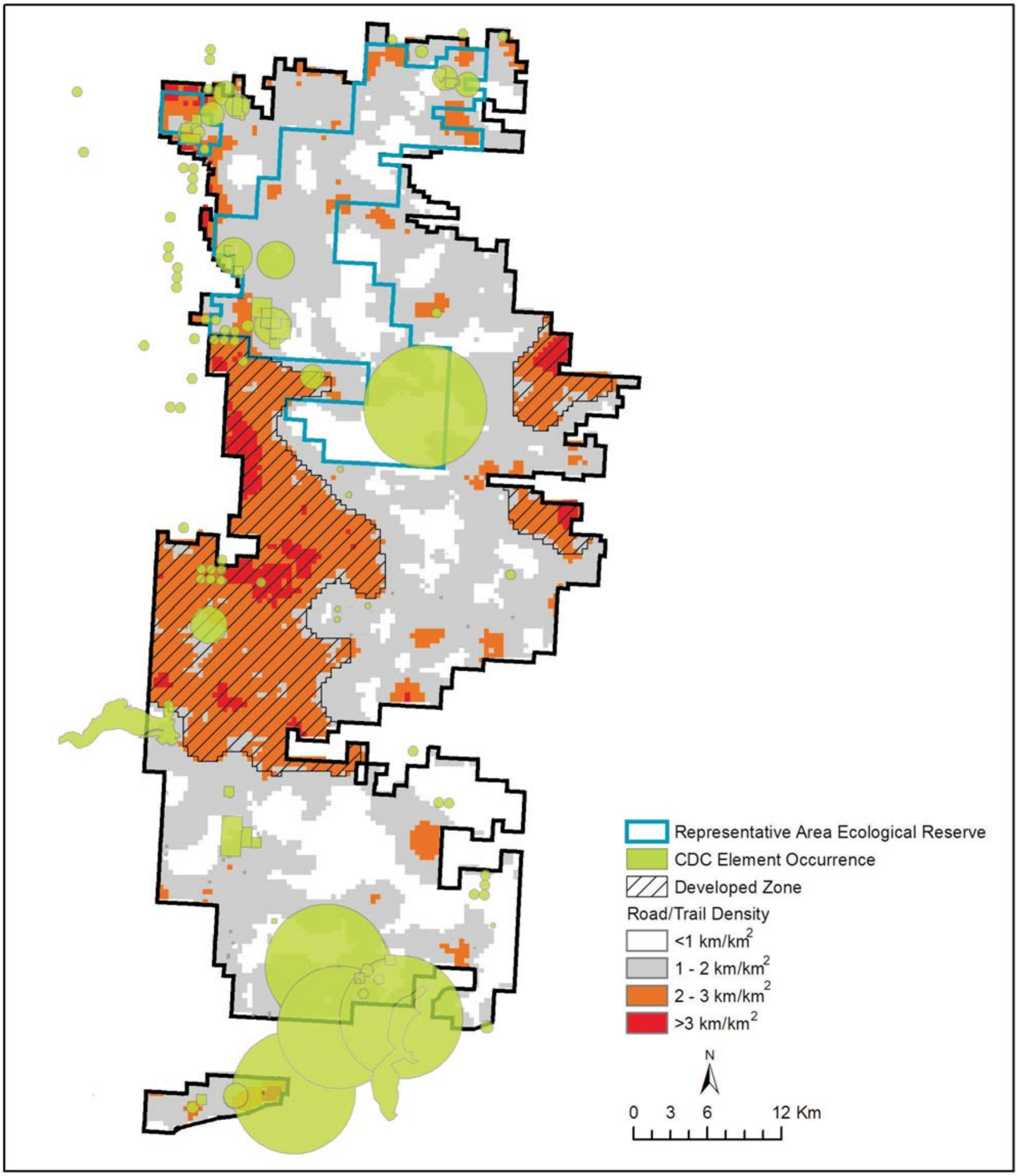



Figure 2-3-9. Patterns of element occurrences (polygons) for the Great Sand Hills, Saskatchewan. Data from the Saskatchewan Conservation Data Centre, Saskatchewan Environment, July 2006. Polygon size is relative to the spatial accuracy or representation of records. Road and trail density, the RAER, and classified developed zone are shown for context.

Table 2-3-11. Odds ratio and significance (p<0.1 indicated by superscript § symbol) of environmental (soils and landcover) and human disturbance (cattle, roads and trails, and gas well pads) variables describing the probability of occurrence for 14 bird species (4 letter codes) in the Great Sand Hills, Saskatchewan. Where perfect avoidance of categories was observed (indicated by 'none' below), observations were removed and model subsequently estimated. Grassland habitats were used as the reference category (due to the unit sum constraint) in landcover types. Odds ratio and significance of landcover types are in comparison to grasslands. Other habitat (agriculture, wetlands, etc.) is not reported here, but was used as an offset. Model significance, explanation, and predictive accuracy are presented.

| Variable | | BAIS | BHCO | CCLO | CCSP | CONI | GRSP | HOLA | LBCU | MAGO | SAVS | SPPI | SPTO | UPSA | WEME |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Soils:* | regosol | 0.23$^{\S}$ | 2.15$^{\S}$ | | 3.11$^{\S}$ | 4.01$^{\S}$ | 0.37$^{\S}$ | 0.21$^{\S}$ | | 0.06$^{\S}$ | 0.36$^{\S}$ | 0.41$^{\S}$ | | | |
| *Landcover type* | | | | | | | | | | | | | | | |
| | herbaceous | 0.25$^{\S}$ | 2.27 | 0.15$^{\S}$ | 2.60 | 3.83 | 0.61 | 0.85 | 0.93 | 8.08$^{\S}$ | 0.30$^{\S}$ | 0.19$^{\S}$ | *none* | 0.81 | 1.31 |
| | mixed shrub | 0.03$^{\S}$ | 7.02$^{\S}$ | 0.001$^{\S}$ | 53396$^{\S}$ | 2.14 | 0.05$^{\S}$ | 0.08$^{\S}$ | 0.03$^{\S}$ | 1.28 | 0.05$^{\S}$ | 0.14$^{\S}$ | 316$^{\S}$ | 0.34$^{\S}$ | 0.32$^{\S}$ |
| | sagebrush | 0.0004$^{\S}$ | 5.82$^{\S}$ | 0.07 | 22.5 | 1.23 | 0.43 | 0.09$^{\S}$ | 0.35 | 2.8 E-06 | 0.003 | 0.05$^{\S}$ | 489$^{\S}$ | 0.72 | 0.04$^{\S}$ |
| | juniper | 0.0003$^{\S}$ | 1.65 | *none* | 34.2§ | 4.66 | 0.01$^{\S}$ | 0.16 | 0.16 | *none* | <0.001$^{\S}$ | 0.02$^{\S}$ | 9.03 | 1.30 | 0.34 |
| | disturbed | 0.007$^{\S}$ | 7.84$^{\S}$ | 0.002 | 3.55 | 9.61$^{\S}$ | 0.09 | 1.53 | 0.30 | 1.70 | 0.008$^{\S}$ | 0.03$^{\S}$ | 509$^{\S}$ | 0.15$^{\S}$ | 0.13$^{\S}$ |
| *Human disturbance* | | | | | | | | | | | | | | | |
| | cattle | 0.30 | | 0.18$^{\S*}$ | | | 0.28 | 0.34$^{\S}$ | | 0.10$^{\S}$ | | | | | |
| | (response) & scale | (-)500m | | (+)dist | | | (-)1km | (-)50m | | (-)250m | | | | | |
| | Roads and trails | 0.46 | | 0.15$^{\S}$ | 2.49$^{\S}$ | 2.02$^{\S}$ | | | | | 0.41$^{\S}$ | | | | |
| | (response) & scale | (-)50m | | (-)50m | (+)50m | (+)50m | | | | | (-)50m | | | | |
| | gas | | | 0.11$^{\S*}$ | 0.09$^{\S}$ | | 0.52$^{\S*}$ | 2.21 | 0.60$^{\S*}$ | | 0.61$^{\S*}$ | | | 2.38$^{\S}$ | 8.28 |
| | (response) & scale | | | (+)dist | (-)1km | | (+)dist | (+)250m | (+)dist | | (+)dist | | | (+)50m | (+)1km |
| *Constant* | | 6.62$^{\S}$ | 0.15$^{\S}$ | 18.6$^{\S}$ | 0.69 | 0.02$^{\S}$ | 3.22 | 1.68 | 0.76 | 0.76 | 3.84 | 19.2$^{\S}$ | 0.001$^{\S}$ | 0.48 | 1.55 |
| *Model significance* | | | | | | | | | | | | | | | |
| | $LR\chi^2$ | 106.3 | 35.7 | 59.6 | 121.7 | 24.0 | 59.5 | 68.0 | 28.3 | 47.1 | 93.2 | 71.3 | 19.5 | 17.0 | 66.8 |
| | *p*-value | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | 0.018 | <0.001 |
| *Model fit/explained* | | | | | | | | | | | | | | | |
| | % Deviance | 42.8 | 10.9 | 46.9 | 45.9 | 11.7 | 28.8 | 24.8 | 13.2 | 35.9 | 41.9 | 22.2 | 25.4 | 5.9 | 21.0 |
| *Model accuracy* | | | | | | | | | | | | | | | |
| | ROC | 0.91 | 0.72 | 0.94 | 0.92 | 0.74 | 0.87 | 0.83 | 0.75 | 0.88 | 0.91 | 0.81 | 0.86 | 0.64 | 0.79 |
| | cutoff prob. | 0.2859 | 0.4403 | 0.1919 | 0.7791 | 0.1766 | 0.1579 | 0.2415 | 0.1639 | 0.1493 | 0.2580 | 0.5874 | 0.0950 | 0.2910 | 0.6410 |
| | sensitivity | 84.7% | 63.5% | 81.0% | 84.1% | 67.6% | 78.4% | 74.2% | 69.2% | 81.8% | 83.3% | 74.2% | 80.0% | 58.8% | 72.5% |
| | specificity | 84.3% | 64.0% | 83.2% | 84.5% | 67.5% | 79.3% | 74.2% | 68.7% | 81.8% | 83.8% | 74.2% | 80.1% | 58.8% | 72.5% |
| | correctly classified | 84.6% | 63.8% | 82.9% | 84.2% | 67.5% | 79.2% | 74.2% | 68.8% | 81.8% | 83.8% | 74.2% | 80.1% | 58.8% | 72.5% |

*indicates that variable was a straight line distance away from human footprint. Note that the sign/direction of response is opposite to that of the decay distances (odds ratio > 1 represents a negative relationship with the disturbance, while odds ratio < 1 represents a positive relationship with the disturbance). Species codes: BAIS: Baird's Sparrow, BHCO: Brown-headed Cowbird, CCLO-Chestnut-collared Longspur, CCSP: Clay-colored Sparrow, CONI: Common Nighthawk, GRSP: Grasshopper Sparrow, HOLA: Horned Lark, LBCU: Long-billed Curlew, MAGO: Marbled Godwit, SAVS: Savanna Sparrow, SPPI: Sprague's Pipit, SPTO: Spotted Towhee, UPSA: Upland Sandpiper, WEME: Western Meadowlark.

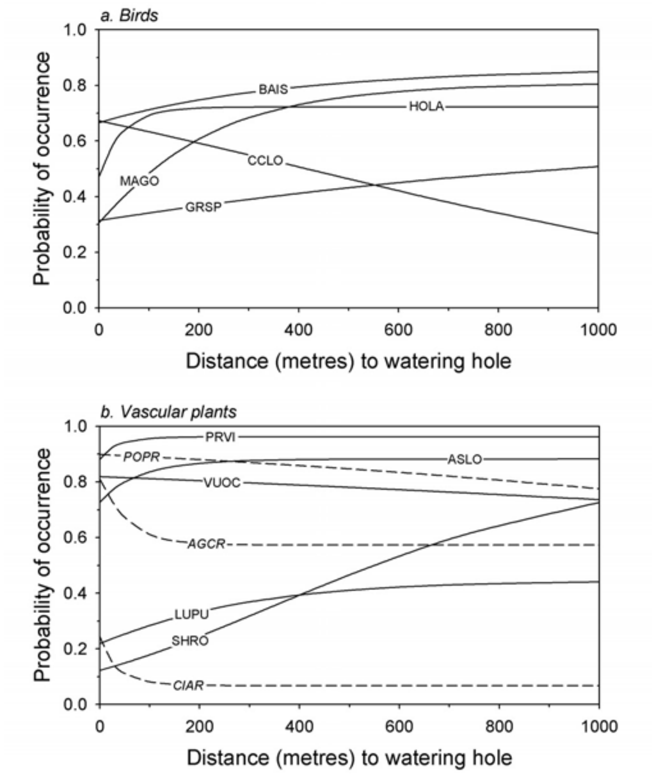



Figure 2-3-10. Predicted probability of occurrence for five species of birds (BAIS: Baird's Sparrow; CCLO: Chestnut-collared Longspur; GRSP: Grasshopper Sparrow; HOLA: Horned Lark; and MAGO: Marbled Godwit) and eight species of vascular plants (PRVI: chokecherry, POPR: Kentucky bluegrass, VUOC: six-weeks fescue, LUPU: small lupine, SHRO: beaked annual skeleton-weed, CIAR: Canada thistle, and ASLO: low milk-vetch) based on distance to cattle watering holes. Habitat conditions were assumed to be that where the species was most prevalent (landcover type and regosolic soils), while other significant disturbance factors were assumed to be at a distance of 1 km. Non-native plants are represented by italic code names and dashed lines.

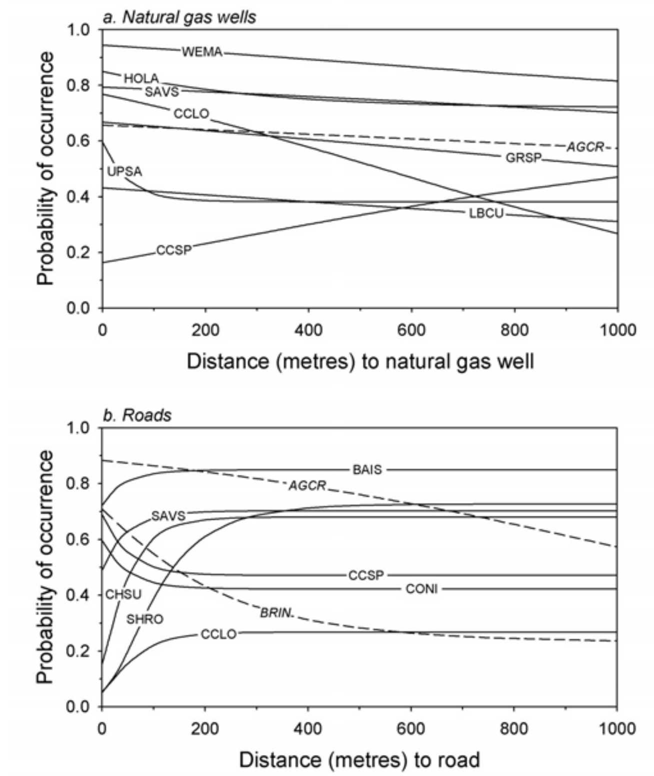



Figure 2-3-11. Predicted probability of occurrence for ten species of birds (BAIS: Baird's Sparrow; CCLO: Chestnut-collared Longspur; CCSP: Clay-colored Sparrow; CONI: Common Nighthawk; GRSP: Grasshopper Sparrow; HOLA: Horned Lark; LBCU: Long-billed Curlew; SAVS: Savanna Sparrow; UPSA: Upland Sandpiper, and WEME: Western Meadowlark) and four plants (AGCR: crested wheatgrass, BRIN: smooth brome, CHSU: smooth arid goosefoot, and SHRO: beaked annual skeleton-weed) based on distance to a gas well (a) or road or trail (b). Habitat conditions were assumed to be that where the species was most prevalent (landcover type and regosolic soils [except CCSP was assumed for grassland]), while other significant disturbance factors were assumed to be at a distance of 1 km. Non-native plants have italicized code names and dashed lines.

### *3.4.2.3 Models of rare and traditional use plant occurrence and baseline impacts*

We estimated the probability of occurrence for two traditional use plants and six rare plants (Table 2-3-13). Of the eight species, we did not detect a significant response to anthropogenic disturbance for windflower (*Anenome multifida*) and prairie dunewort (*Botrychium campestre*). Instead, habitat explained the occurrence of windflower (8.8 times more likely in juniper habitats) and prairie dunewort (most likely in grassland and juniper habitats off of regosolic soils). Probability of occurrence for five of the remaining species (*Astragalus lotiflorus*-low milk-vetch, *Lupinus pusillus*-small lupine, *Prunus virginiana*-chokecherry, *Shinnersoseris rostrata*-beaked annual skeleton-weed, and *Vulpia octoflora*-six-weeks fescue) varied significantly based on distance to livestock watering holes (Table 2-3-13). Of these species, only six-weeks fescue was positively associated with livestock watering holes and marginally, at that, with small gains in occurrence over a 1000-m distance (Figure 2-3-10). Remaining species decreased in occurrence near livestock water holes. Chokecherry and low milk-vetch both responded at local scales around watering holes with occurrences decreasing within a 150–m buffer (Figure 2-3-10). In contrast,

Table 2-3-12. Odds ratio and significance (p<0.1 indicated by superscript § symbol) of environmental (soils and landcover) and human disturbance (cattle, roads and trails, and gas well pads) variables describing the probability of occurrence of four invasive plant species in the Great Sand Hills, Saskatchewan. Where perfect avoidance of categories was observed (indicated by 'none' below), observations were removed and model subsequently estimated. Grassland habitats were used as the reference category (due to the unit sum constraint) in landcover types. Odds ratio and significance for landcover variables were therefore in comparison to grassland habitats. Model significance, explanation, and predictive accuracy are presented in the bottom of table.

| Variable | *Agropyron cristatum* | *Bromus inermis* | *Cirsium arvense* | *Poa pratensis* |
|---|---|---|---|---|
| *Soils* | | | | |
| regosol | 0.23§ | | | |
| *Landcover type* | | | | |
| herbaceous | 4.71§ | 0.71 | 0.02 | 0.71 |
| mixed shrub | 4.52§ | 11.27§ | 3.27 | 7.87§ |
| sagebrush | 1.10 | 5.56§ | none | 0.67 |
| juniper | 0.16 | 0.01§ | 0.51 | 0.71 |
| disturbed | 0.08§ | 0.06 | 0.72 | 0.14§ |
| *Human disturbance* | | | | |
| cattle | 3.20§ | | 4.51§ | 0.39§* |
| (response) & scale | (+)50m | | (+)50m | (+)dist |
| Roads and trails | 0.18§* | 8.21§ | | |
| (response) & scale | (+)dist | (+)250m | | |
| gas | 0.70§* | | | |
| (response) & scale | (+)dist | | | |
| *Constant* | 2.27§ | 0.03§ | 0.02§ | 1.12 |
| *Model significance* | | | | |
| $LR\chi^2$ | 73.6 | 42.3 | 5.6 | 38.7 |
| p-value | <0.001 | <0.001 | 0.467 | <0.001 |
| *Model fit/explained* | | | | |
| % Deviance | 23.9 | 22.5 | 9.4 | 12.2 |
| *Model accuracy* | | | | |
| ROC | 0.81 | 0.83 | 0.73 | 0.73 |
| cutoff prob. | 0.3535 | 0.1525 | 0.0267 | 0.3720 |
| sensitivity | 74.4% | 75.0% | 57.1% | 64.0% |
| specificity | 74.1% | 75.0% | 57.1% | 64.2% |
| correctly classified | 74.2% | 75.0% | 57.1% | 64.2% |

*indicates that variable was a straight line distance away from human footprint. Note that the sign/direction of response is opposite to that of the decay distances (odds ratio > 1 represents a negative relationship with the disturbance, while odds ratio < 1 represents a positive relationship with the disturbance).

Table 2-3-13. Odds ratio and significance ($p<0.1$ indicated by superscript § symbol) of environmental (soils and landcover) and human disturbance (cattle, roads, and gas well pads) variables describing the probability of occurrence for six rare plant and two medicinal/food/ceremonial plant species in the Great Sand Hills, Saskatchewan. Where perfect avoidance of categories was observed (indicated by 'none' below), observations were removed and model subsequently estimated. Grassland habitats were used as the reference category (due to the unit sum constraint) in landcover types. Odds ratio and significance for landcover variables were therefore in comparison to grassland habitats. Model significance, explanation, and predictive accuracy are presented in the bottom of table.

| Variable | *Anenome multifida* | *Astragalus lotiflorus* | *Botrychium campestre* | *Chenopodium subglabrum* | *Lupinus pusillus* | *Prunus virginiana* | *Shinnersoseris rostrata* | *Vulpia octoflora* |
|---|---|---|---|---|---|---|---|---|
| *Soils* | | | | | | | | |
| regosol | | | none | | 2.08§ | 5.51§ | none | 13.3§ |
| *Landcover type* | | | | | | | | |
| herbaceous | 1.51 | 0.25§ | 0.001§ | 7.63§ | 2.80 | 1.21 | 33.9§ | 2.10 |
| mixed shrub | 0.89 | 0.37§ | 0.07§ | 5.52 | 1.73 | 37.2§ | 0.54 | 2.35 |
| sagebrush | 1.89 | 0.01§ | 0.14§ | 6.44 | 1.28 | 59.0§ | 0.04 | 9.44§ |
| juniper | 8.75§ | 3.60§ | 1.04 | <0.001 | 1.94 | 5.33§ | <0.001 | 2.78 |
| disturbed | 0.027§ | 0.05§ | 0.07§ | 60.6§ | 1.49 | 1.94 | 31.2§ | 3.91§ |
| *Human disturbance* | | | | | | | | |
| cattle | | 0.36§ | | | 0.35§ | 0.29§ | 0.01§ | 0.62§* |
| (response) & scale | | (-)100m | | | (-)250m | (-)50m | (-)1km | (+)dist |
| Roads and trails | | | | 0.09§ | | | 0.02§ | |
| (response) & scale | | | | (-)50m | | | (-)100m | |
| gas | | | | | | | | |
| (response) & scale | | | | | | | | |
| *Constant* | 0.14§ | 2.08 | 0.87 | 0.04 | 0.14 | 0.08§ | 0.44 | 0.04 |
| *Model significance* | | | | | | | | |
| LR $\chi^2$ | 20.4 | 60.5 | 27.4 | 39.6 | 11.9 | 103.7 | 35.3 | 54.9 |
| *p*-value | 0.002 | <0.001 | <0.001 | <0.001 | 0.155 | <0.001 | <0.001 | <0.001 |
| *Model fit/explained* | | | | | | | | |
| % Deviance | 10.4 | 18.4 | 16.0 | 31.6 | 4.7 | 31.2 | 46.5 | 18.2 |
| *Model accuracy* | | | | | | | | |
| ROC | 0.72 | 0.79 | 0.78 | 0.90 | 0.66 | 0.85 | 0.96 | 0.76 |
| cutoff prob. | 0.1346 | 0.4885 | 0.1877 | 0.1203 | 0.2565 | 0.4722 | 0.0999 | 0.3784 |
| sensitivity | 64.7% | 72.4% | 66.7% | 83.3% | 60.4% | 82.6% | 90.0% | 64.1% |
| specificity | 65.1% | 74.1% | 66.9% | 82.4% | 60.4% | 81.6% | 91.1% | 64.8% |
| correctly classified | 65.0% | 73.3% | 66.9% | 82.5% | 60.4% | 82.1% | 91.1% | 64.6% |

*indicates that variable was a straight line distance away from human footprint. Note that the sign/direction of response is opposite to that of the decay distances (odds ratio > 1 represents a negative relationship with the disturbance, while odds ratio < 1 represents a positive relationship with the disturbance).

beaked annual skeleton-weed and small lupine responded at broader scales with changes in occurrence occurring across a 1-km and 500-m zone, respectively (Figure 2-3-10).

Only smooth arid goosefoot (*Chenopodium subglabrum*) and beaked annual skeleton-weed responded significantly to the presence of roads and trails (Table 2-3-13). Smooth arid goosefoot decreased dramatically within 150 m of a road or trail, whereas beaked annual skeleton-weed decreased dramatically across a 300–400-m zone (Figure 2-3-11). No significant response to gas well sites was detected for any of the eight rare and traditional use plants assessed. This does not mean that such impacts are unlikely to occur. Rather, because the distributions of most species (except prairie moonwort), did not overlap the area of current gas development, conclusive judgment on the impact of gas development on these species is not possible at this time. Further research, for example applying a before-after-control-impact (BACI) experimental design, is needed to address the question of potential impacts of gas development on rare plants and other species.

Habitat and soils were significant predictors of every rare and traditional use plant. Windflower and low milk-vetch were most likely to occur in juniper habitat at 8.8 and 3.6 times more likely, respectively, than the reference habitat of grassland (Table 2-3-13). Occurrence of smooth arid goosefoot was highest in disturbed habitat (61 times more likely than grassland) followed by herbaceous sites (7.6 times more likely than grassland). Chokecherry occurrence was greatest in sagebrush (59 times more likely than grasslands) and mixed shrub (37 times more likely than grassland) habitats after accounting for the preference of regosolic soils (5.5 times more likely on regosolic soils than off) (Table 2-3-13). Neither beaked annual skeleton-weed nor prairie moonwort occurred in any sites on regosolic soils, suggesting unsuitability of these soil environments. Off of regosolic soils, prairie moonwort was most likely in grassland and juniper habitats (>7 times more likely than remaining habitats), whereas beaked annual skeleton-weed was most likely in herbaceous (34 times more likely than grassland) and disturbed (31 times more likely than grassland) habitats (Table 2-3-13). In contrast to the previous species, six-weeks fescue was closely associated with regosolic soils (13.3 times more likely on regosolic soils than off). After accounting for soil preferences, the occurrence of six-weeks fescue was highest in sagebrush (9.4 times more likely than grassland) and disturbed (3.9 times more likely than grassland) habitats (Table 2-3-13). No significant relationship was found between habitat (landcover) and small lupine presence, although a positive association with regosolic soils (2 times more likely) was evident (Table 2-3-13).

Excluding small lupine, all focal plant models were significant overall (Table 2-3-13). Only smooth arid goosefoot, beaked annual skeleton-weed, and chokecherry met pre-defined objectives for "excellent" model performance, whereas low milk-vetch and six-weeks fescue met our secondary model performance of "good." Regardless of limitations, predictions of probability of occurrence for each landscape pixel (excluding the wetland, treed, and agricultural pixels) were estimated for each traditional use and rare plant species (Appendix B). Spatial patterns of species occurrence suggested broad overlap in distribution.

### *3.4.2.4 Models of invasive plant occurrence and baseline impacts*

The probability of occurrence was estimated for the four most common non-native and presumed invasive plant species of the GSH. This included crested wheatgrass (*Agropyron cristatum*), smooth brome (*Bromus inermis*), Canada thistle (*Cirsium arvense*), and Kentucky bluegrass (*Poa pratensis*). All four species had high frequency of occurrence in mixed shrub habitats (at 4.5, 11, 3.3, and 7.9 times more likely in mixed shrub than in grasslands, respectively), suggesting that mixed shrub habitats were highly susceptible to plant invasion (Table 2-3-12). Besides mixed shrub sites, herbaceous habitats were also more likely to contain crested wheatgrass (4.7 times more likely than grasslands), while sagebrush habitats were more likely to contain smooth brome (5.6 times more likely than grasslands) (Table 2-3-12). Only crested wheatgrass responded significantly to regosolic soils, being 5 times more likely to be found off of regosolic soils than on regosolic soils. As a general rule, disturbed and juniper habitats were less likely to contain non-native plants than remaining habitat types. Excluding crested wheatgrass, non-native species were also less likely to occur in herbaceous habitats (Table 2-3-12).

Specific to anthropogenic disturbances, crested wheatgrass, Canada thistle, and Kentucky bluegrass responded positively and significantly to the presence of livestock watering holes (Table 2-3-12). Crested wheatgrass and Canada thistle both increased substantially within a 100-m zone around watering holes, whereas Kentucky bluegrass had a more gradual, but persistent increase in occurrence nearer to watering holes (Figure 2-3-10). Relationships with roads and trails were evident for smooth brome and crested wheatgrass (Table 2-3-12). Smooth brome increased dramatically within a 400–500-m zone along roads/trails, whereas crested wheatgrass had a more consistent response across a broader scale (Figure 2-3-11). Only crested wheatgrass demonstrated a significant relationship with distance to gas wells (Table 2-3-12). The response, however, was rather weak, displaying only small increases across a 1-km distance (Figure 2-3-11).

Crested wheatgrass, smooth brome, and Kentucky bluegrass models were significant overall (Table 2-3-12). Only crested wheatgrass and smooth brome, however, met pre-defined objectives for model performance (excellent and good categories). Regardless of limitations, predictions of species occurrence for each landscape pixel (excluding the wetland, treed, and agricultural pixels) were estimated for each non-native plant (Appendix B). Patterns of occurrence for non-native species were more diffuse than for rare birds and native plants, reflecting the widespread influence of livestock and roads/trails.

### *3.4.2.5 Ord's kangaroo rat model and baseline impacts*

Ord's kangaroo rat (*Dipodomys ordii*) observations (dens and tracks) were noted at 28 survey locations and opportunistic sites during the 2006 field season. Distribution of Ord's kangaroo rat was explained by regosolic soils, disturbed habitats, and livestock watering holes. Holding other factors constant, Ord's kangaroo rat was more likely to occur on regosolic soils than off and more likely to occur in disturbed habitats than the reference habitat of grassland (Table 2-3-14). Ord's kangaroo rat was also positively associated with livestock watering holes (assuming other environmental conditions were satisfied), with increases in presence largely within 150 m of a watering hole. Assuming a threshold classification probability (relative values) of 0.5 (<0.5 = non-habitat; ≥0.5 = habitat), we predict 520 ha (or about 0.26% of the Review Area) of potential Ord's kangaroo habitat in the GSH Review Area (Appendix B). Much of the predicted distribution was in the northwest portion of the Review Area, although a number of smaller and more isolated sites were predicted throughout the GSH. Further validation of these small and isolated sites is necessary. For our conservation assessment purposes, however, these areas are assumed to be potential habitat, since false positive (predicting presence when the species is absent) errors are less of a concern than false negative (predicting absence when the species is present) errors.

### *3.4.2.6 Models of range health and baseline impacts*

Range health was related to regosolic soils, habitats, and the three anthropogenic disturbances tested (Table 2-3-15). The final model explained 43% of the variation in the data (adjusted $R^2$) and was significant overall ($F$ [1,

Table 2-3-14. Odds ratio (exp($\beta$)), standard error (S.E.) of odds ratio, and significance ($p$) of resource selection function (RSF) coefficients describing Ord's kangaroo rat (*Dipodomys ordii*) distribution in the Great Sand Hills, Saskatchewan.

| Variable | exp($\beta$) | S.E. | $p$ |
|---|---|---|---|
| *Soils* | | | |
| regosol | 173 | 3.65 | <0.001 |
| *Landcover type** | | | |
| disturbed | 13017 | 5.86 | <0.001 |
| herbaceous | 15.3 | 6.43 | 0.143 |
| Mixed shrub | 2.56 | 6.75 | 0.623 |
| sagebrush | 0.22 | 17.2 | 0.593 |
| juniper | 0.34 | 13.0 | 0.677 |
| *Human disturbance* | | | |
| Cattle (50m) | 3210 | 32.9 | 0.021 |

*Grassland habitats were used as the reference category (due to the unit sum constraint) in landcover types.

Table 2-3-15. Estimates of linear regression coefficients (b), standard errors (S.E.), and significance (p) of environmental and human disturbance variables predicting range health (arc-sin square-root transformed values) in the Great Sand Hills, Saskatchewan.

| Variable | *b* | S.E. | *p* |
|---|---|---|---|
| *Soils* | | | |
| regosol | 8.19 | 2.53 | 0.001 |
| *Landcover type** | | | |
| disturbed | 0.81 | 4.72 | 0.864 |
| herbaceous | -12.2 | 4.27 | 0.005 |
| mixed shrub | -5.44 | 3.95 | 0.170 |
| sagebrush | -2.97 | 4.72 | 0.530 |
| juniper | -2.23 | 5.09 | 0.662 |
| *Human disturbance* | | | |
| cattle (250m) | -28.3 | 2.78 | <0.001 |
| gas (100m) | -11.5 | 2.99 | <0.001 |
| roads/trails (50m) | -7.06 | 2.33 | 0.003 |
| *Constant* | 59.9 | 2.39 | <0.001 |

*Grassland habitats were used as the reference category (due to the unit sum constraint) in landcover types.

229] = 18.98, $p<0.001$). Range health was higher on regosolic soils than off, with herbaceous habitats the only landcover type significantly different from the reference category of grassland. Overall, herbaceous areas had lower range health scores. All three anthropogenic disturbances were significant and resulted in reductions in range health, although the spatial scale and magnitude of these responses varied by impact type. For livestock watering holes, reductions in range health were observed out to 750 m, but were most substantial within the first 250 m (Figure 2-3-12). Healthy range conditions were not predicted for herbaceous sites off of regosolic soils until at a distance of 200 m. In contrast, impacts of roads and trails on the same soil and vegetation type did not prove to be as broad in scale or substantial in effect. Reductions in range health for roads and trails were rather trivial when compared to livestock watering holes, with only slight decreases in range health within a 25 to 50–m zone (Figure 2-3-12). For gas well pads, roads and trails were assumed to co-occur, resulting in cumulative impacts that were more similar, but still moderated from livestock watering holes over the first 200 m. Range health was predicted to be in the "healthy but with problems" state adjacent to gas well pads. Unhealthy range conditions, on the other hand, were estimated for areas where livestock watering holes were associated with roads or gas well pads. In the former case, unhealthy range conditions occurred within the first dozen metres, while in the latter case the site was predicted to be in an unhealthy condition within a 50–m radius (Figure 2-3-12). In both situations, range conditions improved to a healthy state after 200 m. Overall, it was apparent that range health conditions on regosolic soils were consistently better, suggesting that regosolic soils were more resilient, livestock access was more limited, or reference communities were not well differentiated between regosolic and non-regosolic soils.

Predictions of range health categories in the GSH suggested that 5% of the landscape was in an "unhealthy" condition, 42% in a "healthy, but with problems" condition, and 53% in a "healthy" condition (Figure 2-3-13). Unhealthy conditions were most associated with areas around livestock watering holes, where overgrazing and trampling have noticeably eroded range health conditions.

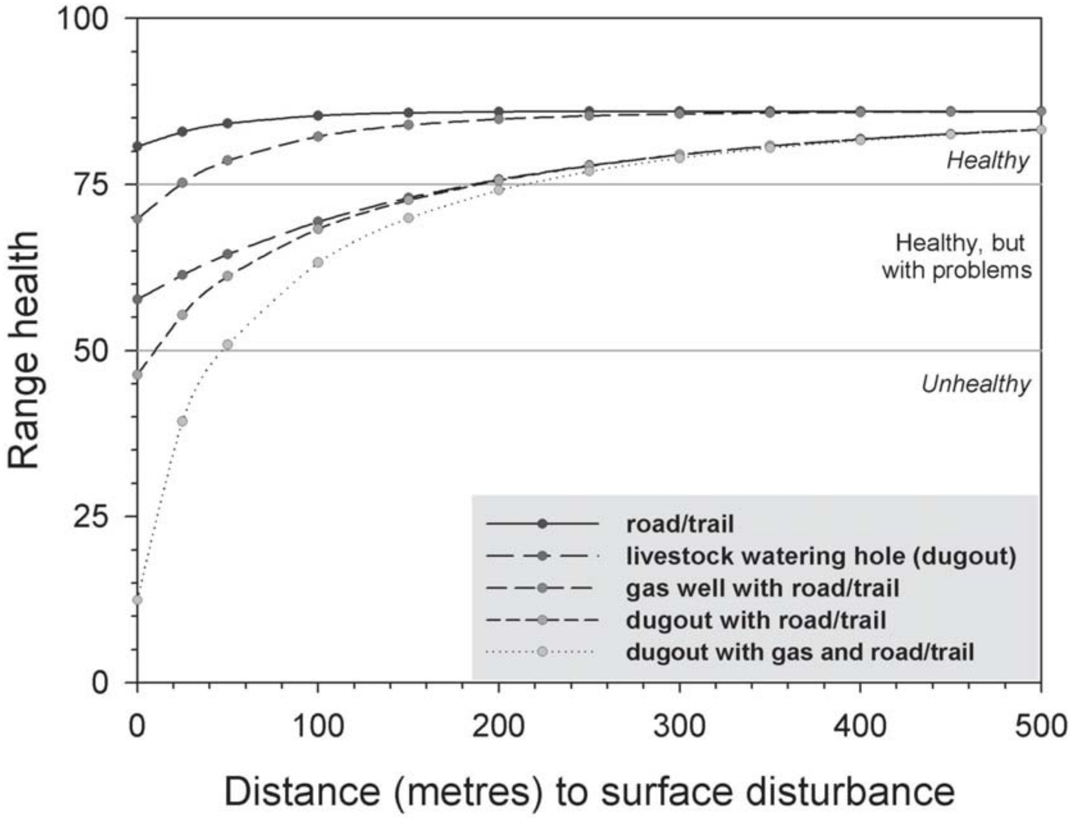



Figure 2-3-12. Predicted responses of range health for herbaceous habitats on non-regosolic soils in the Great Sand Hills of Saskatchewan based on distance from surface disturbance (cattle watering hole, gas well pad, road and trail, or cumulative effect).

### *3.4.2.7. Species-habitat inter-relationships and selected indicator species*

Spatial predictions for focal species indicated that, in some cases, the occurrence of one species could be used to predict the other. Correlation analyses of species occurrence maps suggested the presence of two broad-scale community "guilds" (in this sense, species that respond similarly to habitat conditions). The first guild of 10 species was characterized by grassland species, with Baird's Sparrow and Horned Lark having the most positive connections (Figure 2-3-14). We refer to this guild as the Baird's Sparrow-grassland guild. Only a single plant, prairie moonwort (*Botrychium campestre*), was present in this guild, suggesting that most rare plants were not associated with grasslands and herbaceous habitats. A second, smaller guild of seven species (Figure 2-3-15) was characterized by disturbed and shrub-dominated habitats on regosolic soils. We referred to this group as the chokecherry/Clay-colored Sparrow guild. Here, three plants and four birds were represented.

### *3.4.2.8 Focal species hot spot assessments*

Analyses of focal species hotspots (species richness) revealed that patterns of hotspots in the GSH were largely determined by two taxon and two community guilds. For birds, hotspots appeared in the west and southern parts of the Review Area, largely defined by areas off of regosolic soils (Figure 2-3-16). Vascular plant hotspots were largely exclusive to regosolic soils, but much patchier than bird hotspots due to the more heterogeneous nature of vegetation on regosolic soils.

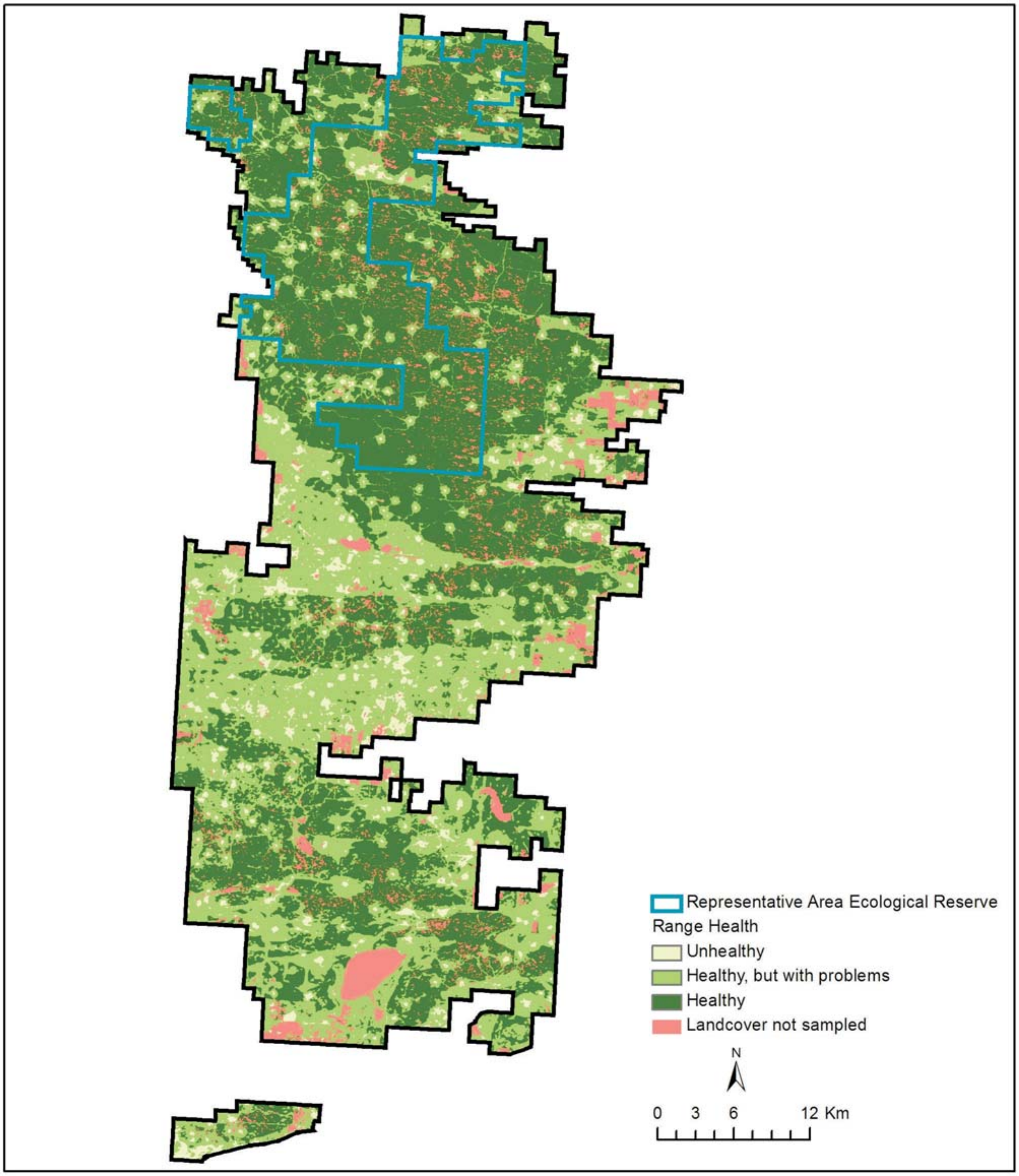



Figure 2-3-13. Predictions of range health (pre-defined categories) based on habitat type, regosolic soils, and distance to cattle watering holes, roads and trails, and gas well sites in the Great Sand Hills, Saskatchewan.

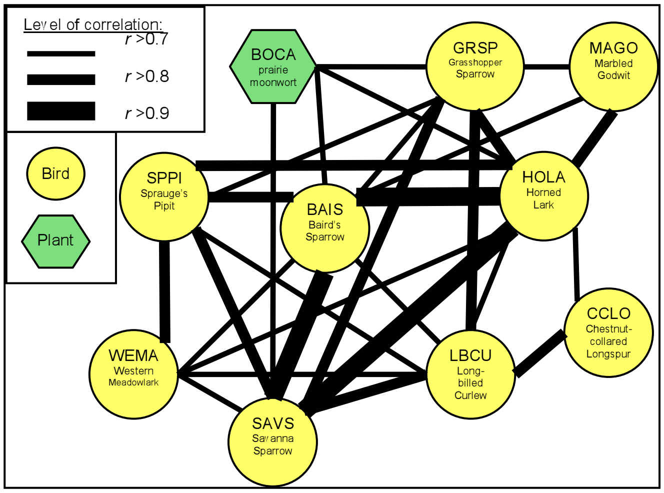



Figure 2-3-14. Baird's Sparrow guild representing open grassland habitats (off of regosolic soils) common to the south and west parts of the Great Sand Hills Review Area.

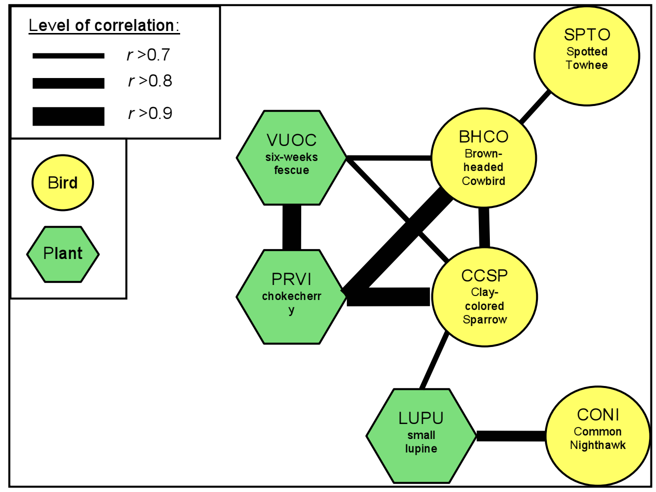



Figure 2-3-15. Chokecherry and Clay-colored Sparrow guild common to shrub-grassland habitats (on regosolic soils) in the north and northeast portions of the Great Sand Hills Review Area.

When birds and plants were combined, hotspots were evident in the west and south, similar to bird hotspots, but also evident as scattered, smaller patches on regosolic soils. These smaller patches represented important areas for plants (Figure 2-3-16) and a few birds associated with shrub habitat, such as the Spotted Towhee and Clay-colored Sparrow. Based on guilds identified in the previous section, the Baird's Sparrow guild resulted in hotspot patterns very similar to bird hotspots, while the chokecherry/Clay-colored Sparrow guild displayed similar patterns to plant hotspots (Figure 2-3-17).

### *3.4.2.9 Gap analysis of the RAER and unprotected regions of the Great Sand Hills*

The Representative Area Ecological Reserve (RAER) contained the greatest concentration (per unit area) of habitat for 9 (Brown-headed Cowbird, Clay-colored Sparrow, Common Nighthawk, Spotted Towhee, small lupine, six-weeks fescue, chokecherry, windflower, and Ord's kangaroo rat) of 23 native species (Table 2-3-16). Species most common to the RAER tended to be those most closely associated with the chokecherry/Clay-colored Sparrow guild. On average species from this guild were 3.1 (±0.5 Std.Dev.) times more likely to occur in the RAER than in the developed zone. The greatest differentiation between the RAER and developed zone was Ord's kangaroo rat, which was 5.6 times more likely to occur in the RAER than the developed zone.

In contrast to species associated with the RAER, 12 native species (Baird's Sparrow, Chestnut-collared Longspur, Grasshopper Sparrow, Horned Lark, Marbled Godwit, Savanna Sparrow, Sprague's Pipit, Western Meadowlark, Long-billed Curlew, Upland Sandpiper, low milk-vetch, and prairie dunewort) had their greatest concentration of habitat in the most developed areas of the GSH (Table 2-3-16; Figure 2-3-1). These species, which largely represent the Baird's Sparrow guild, were more likely to occur in the developed zone (13.4 ±6.9 times more likely) than the RAER (Table 2-3-16).

Areas outside both the RAER and the developed zone (i.e., less developed) contained high concentrations of habitat for two rare plants, beaked annual skeleton-weed and smooth arid goosefoot (Table 2-3-16). In most cases, the less developed zone was intermediate in concentration of species habitat between the RAER and the developed zone.

Finally, for invasive plants the less developed region had the greatest concentration of Kentucky bluegrass and smooth brome, whereas the developed region had the highest concentration of crested wheatgrass. Canada thistle, on the other hand, had its highest concentration in the RAER (Table 2-3-16).

## 3.4.3 Discussion

### *3.4.3.1 Baseline impacts of natural gas and road/trail development on focal species occurrence*

Gas development was associated with a moderate reduction in range health and a marginal increase in crested wheatgrass. Moderate reductions in range

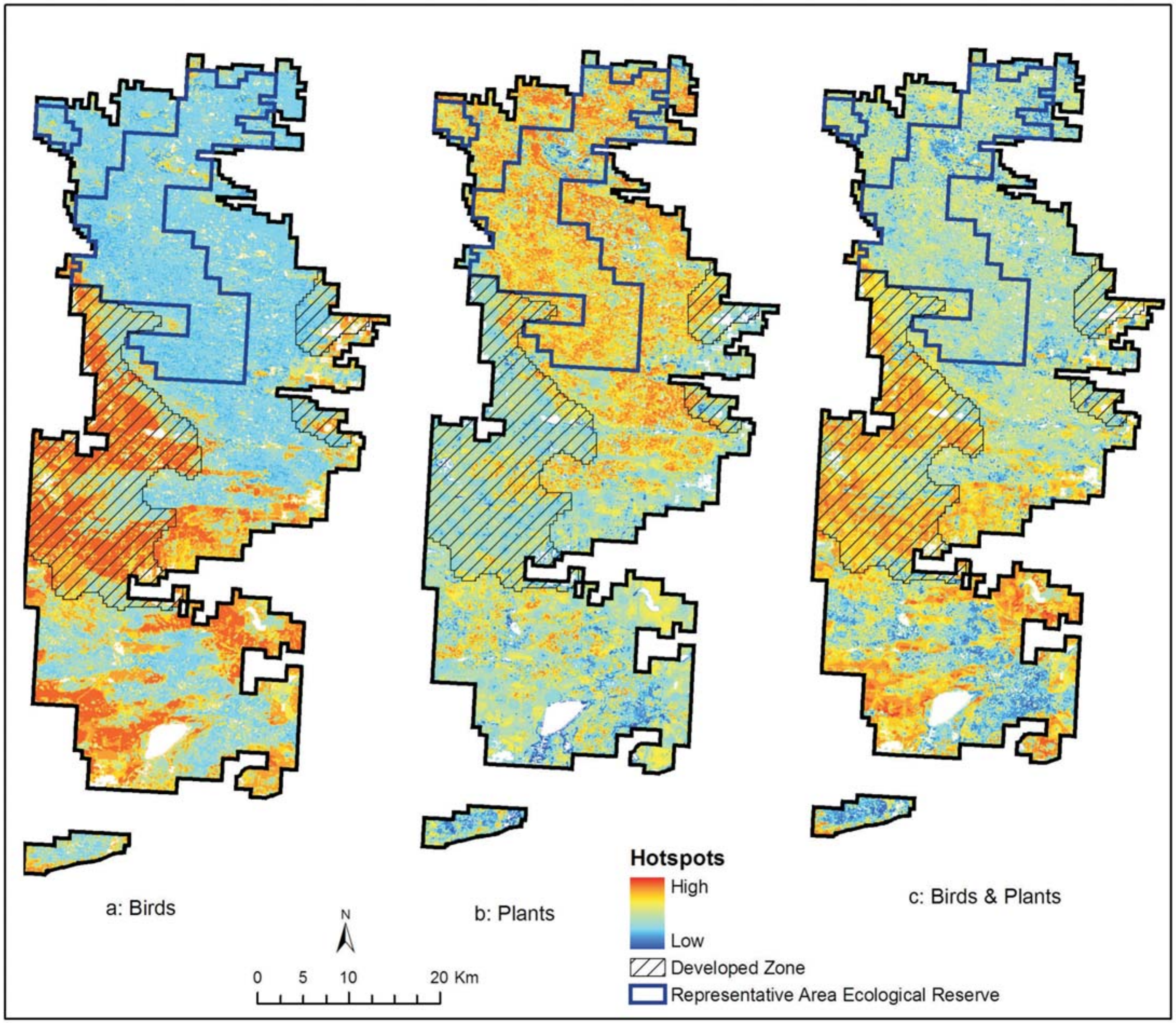



Figure 2-3-16. Patterns of focal species hot spots (richness) for the Great Sand Hills, Saskatchewan by birds (a), plants (b), and combined taxa (c).

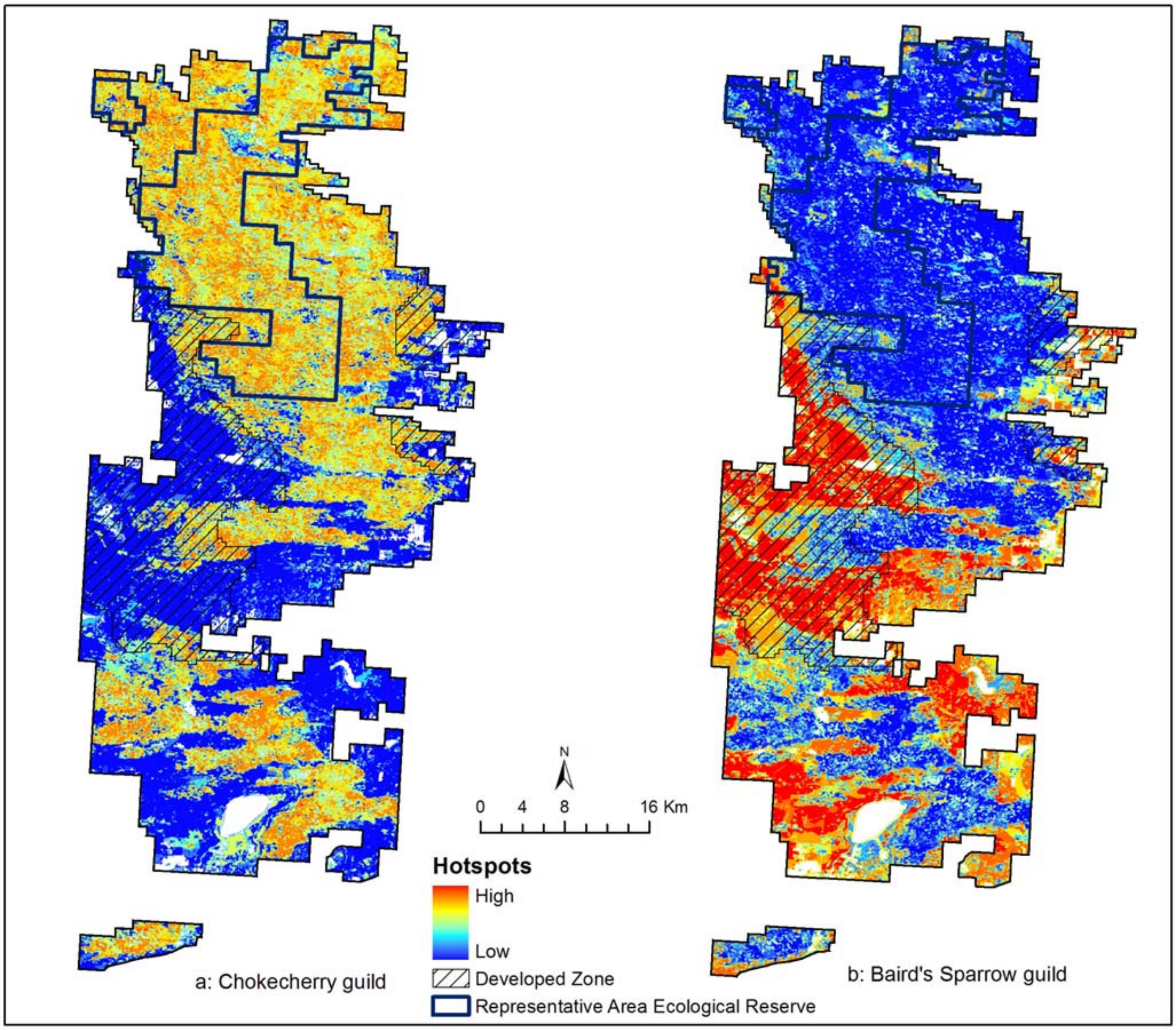



Figure 2-3-17. Patterns of focal species hot spots (richness) for two community guilds (a. chokecherry/Clay-colored Sparrow guild and b. Baird's Sparrow guild) in the Great Sand Hills of Saskatchewan.

Table 2-3-16. Amount of predicted habitat (area and percentage of area) for 27 native and invasive species in the Great Sand Hills, Saskatchewan. Percent of habitat in developed, less developed (but not in the RAER), and Representative Areas Ecological Reserve (RAER) are shown on an individual basis, as well as ranking of importance (per unit area). The zone with the greatest habitat per unit area is underlined. Note that percentages are specific to upland grasslands, shrubs, and disturbed grassland habitats.

| Species | Study area[1] | | Developed[2] | | Less developed[3] | | RAER[4] | |
|---|---|---|---|---|---|---|---|---|
| | Area-km² | % | % area | Rank | % area | Rank | % area | Rank |
| *Focal birds* | | | | | | | | |
| Baird's sparrow | 670 | 35.7 | 60.3 | 1 | 36.0 | 2 | 6.7 | 3 |
| Brown-headed cowbird | 799 | 42.6 | 20.5 | 3 | 43.7 | 2 | 63.8 | 1 |
| chestnut-collared longspur | 454 | 24.2 | 61.6 | 1 | 17.8 | 2 | 2.5 | 3 |
| clay-colored sparrow | 1,088 | 57.9 | 24.4 | 3 | 58.8 | 2 | 93.2 | 1 |
| grasshopper sparrow | 789 | 42.0 | 74.5 | 1 | 41.6 | 2 | 6.2 | 3 |
| Horned lark | 759 | 40.4 | 70.2 | 1 | 40.3 | 2 | 7.1 | 3 |
| savanna sparrow | 632 | 33.7 | 60.9 | 1 | 33.4 | 2 | 3.5 | 3 |
| spotted towhee | 377 | 20.1 | 10.3 | 3 | 21.7 | 2 | 26.0 | *1* |
| western meadowlark | 852 | 45.4 | 76.6 | 1 | 44.7 | 2 | 11.9 | 3 |
| *Birds of special concern* | | | | | | | | |
| Sprague's pipit | 954 | 50.8 | 75.3 | 1 | 52.2 | 2 | 18.6 | 3 |
| common nighthawk | 325 | 17.3 | 7.8 | 3 | 16.7 | 2 | 30.1 | *1* |
| long-billed curlew | 816 | 43.5 | 79.8 | 1 | 41.7 | 2 | 7.7 | 3 |
| marbled godwit | 555 | 29.6 | 50.1 | 1 | 30.4 | 2 | 3.4 | 3 |
| upland sandpiper | 895 | 47.7 | 64.2 | 1 | 43.8 | 2 | 41.4 | 3 |
| *Rare mammals* | | | | | | | | |
| Ord's kangaroo rat | 5.21 | 0.28 | 0.13 | 3 | 0.19 | 2 | 0.74 | 1 |
| *Rare plants* | | | | | | | | |
| low-milk vetch | 910 | 48.5 | 60.3 | 1 | 45.2 | 3 | 45.4 | 2 |
| prairie dunewort | 419 | 22.3 | 42.9 | 1 | 21.2 | 2 | 2.4 | 3 |
| smooth arid goosefoot | 370 | 19.7 | 11.1 | 3 | 23.9 | 1 | 15.9 | 2 |
| small lupine | 814 | 43.4 | 18.6 | 3 | 44.1 | 2 | 69.1 | 1 |
| beaked annual skeleton-weed | 131 | 7.0 | 6.2 | 2 | 9.2 | 1 | 0.6 | 3 |
| six-weeks fescue | 768 | 40.9 | 23.0 | 3 | 39.5 | 2 | 65.8 | 1 |
| *Traditional use plants* | | | | | | | | |
| chokecherry | 1,063 | 56.6 | 29.2 | 3 | 56.3 | 2 | 88.7 | 1 |
| windflower | 1,039 | 55.4 | 40.9 | 3 | 53.7 | 2 | 77.2 | 1 |
| *Non-native plants* | | | | | | | | |
| Canada thistle | 283 | 15.1 | 5.1 | 3 | 17.5 | 2 | 18.7 | 1 |
| crested wheatgrass | 808 | 43.1 | 66.8 | 1 | 44.3 | 2 | 12.0 | 3 |
| Kentucky bluegrass | 607 | 32.3 | 29.0 | 3 | 34.1 | *1* | 30.2 | 2 |
| smooth brome | 515 | 27.4 | 23.4 | 3 | 29.0 | 1 | 26.9 | 2 |

1. Study area does not include wetland (including open water), treed, and agricultural habitats. Total possible area excluding these non-sampled habitats is 1,878-km² (92.5% of review area).
2. Developed zone represents areas (397 km²) having more than 1.88 km/km² (mean + ½ standard deviation) of roads and trails and are outside of the RAER.
3. Less developed zone represents areas (1,132 sq km) having less than 1.88 km/km² of roads and trails and are outside of the RAER.
4. RAER is the Representative Areas Ecological Reserve and has 349 km² in assessed habitat.

health in the vicinity of well sites appear to be caused by congregation of livestock, resulting in increased surface disturbance. A reduction in range health of approximately 10 points was predicted to occur within a 200–m distance of wells. Part of this reduction may be explained by increased presence of non-native species, which reduce range health scores. Marginal increases in crested wheatgrass near gas wells may be explained by this species being common in grassland and herbaceous habitats on non-regosolic soils, where the majority of gas development has occurred. Crested wheatgrass was intentionally planted on some disturbed soils in the GSH, and unlike in some other regions, this plant is considered invasive in Saskatchewan (Hansen and Wilson 2006), and appears to be spreading in the GSH.

Due to sampling limitations (i.e., the coincidence that most rare and traditional use plants in the GSH are distributed outside the area of current gas development), we were unable to document a negative impact of gas development at the well site on rare or traditional use plants. However, any small, isolated population of plants at a site that is being drilled or maintained for monitoring of gas resources is likely to be destroyed or displaced. Under current regulations, such potential impacts are mitigated by movement of well sites away from occurrences of sensitive or rare plants.

No significant relationship between the presence of Ord's kangaroo rat and natural gas wells was observed. However, the limited distribution of available Ord's kangaroo rat habitat and lack of gas wells directly associated with these areas again makes conclusions regarding the impact of gas development tenuous. For a nearby population of Ord's kangaroo rat in Alberta, Gummer and Robertson (2003; in Alberta Ord's Kangaroo Rat Recovery Team 2005) failed to document direct negative effects on Ord's kangaroo rat during winter gas activities.

In contrast to plants and Ord's kangaroo rat, seven of 14 bird species (Clay-colored Sparrow, Grasshopper Sparrow, Chestnut-collared Longspur, Horned Lark, Long-billed Curlew, Upland Sandpiper, Gand Western Meadowlark) responded positively to the presence of natural gas wells. Only Clay-colored Sparrow, however, responded negatively, with the remaining species having mostly marginal increases in occurrence within 1 km of a well. Exceptions to marginal gains in occurrence were Chestnut-collared Longspur (more than doubling in occurrence over a 1-km distance) and Upland Sandpiper (20% gain in occurrence over 150 m). Surprisingly, we were unable to find published information directly assessing the effects of gas development on grassland birds. Increased occurrence of birds at well sites may reflect the selection for structure, such as perch sites, or the possibility that disturbances associated with well sites enhanced habitat conditions for disturbance-evolved species (e.g., those that might have formerly been associated with bison wallows). For example, the Chestnut-collared Longspur is considered a grassland specialist with a preference for sparsely-vegetated grassland and low litter accumulation. These birds avoid excessive woody vegetation; however, during the breeding season, males use isolated shrubs and other elevated perches for singing (Dechant et al. 2003a). The Upland Sandpiper occurs across a range of grassland habitat in early successional stage or moderately grazed prairie, hayfields, and pastures; perch display structures, such as telephone poles, fence posts, or small isolated trees, are an important component of suitable habitat for this species (Dechant et al. 2003b). For Clay-colored Sparrow, the presence of gas wells was associated with a substantial reduction (more than half) in species presence across a 1-km distance. A number of studies have shown Clay-colored Sparrows to be strongly associated with shrubby grasslands and nesting in low-growing shrubs (Dechant et al. 2003c). However, a negative relationship between gas wells, most of which occur outside of this habitat, and this species may be spurious. Because the vast majority of gas wells also have spur roads or trails to access the well for development (drilling) and maintenance, it is practically impossible to differentiate the impact of natural gas wells from that of associated roads/trails. We have considered them here to be cumulative in effect. These and other disturbances may alter distribution and density of shrubs resulting in reduced habitat suitability.

Beyond spur roads/trails, gas development results in an additional network of roads/trails to facilitate access to gas fields and to maintain infrastructure. Understanding how roads/trails in general influence the presence of species is therefore needed. The non-native plants, crested wheatgrass and smooth brome, increased substantially in occurrence along roads and trails. Both species were likely used in past seeding activities. In the mixed shrub habitats most preferred by crested wheatgrass, occurrence increased from an average of 55% 1 km distant from a road/trail to about 89% along road/trail edges. Previous research shows that crested wheatgrass, although it can help stabilize soils, can lead to erosion of ecological integrity through reductions in native plant cover (Heidinga and Wilson 2002, Henderson and Naeth 2005, Waldron et al. 2005). Response of smooth brome was even more dramatic, doubling its occurrence across a 500-m distance in mixed shrub (preferred) habitat. Although both species peaked in mixed shrub habitats, crested wheatgrass was also common in herbaceous habitats, while smooth brome also occurred in sagebrush sites.

For rare plants, the presence of roads/trails resulted in substantial declines in smooth arid goosefoot occurrence over a 100-m distance and beaked annual skeleton-weed occurrence over a 300-m distance. Beaked annual skeleton-weed was most typical of herbaceous and disturbed sites off of regosolic soils, while smooth arid goosefoot (Species of Special Concern, Species at Risk Act) was most common in disturbed grasslands (especially dunes), but also occurred at lower frequencies in herbaceous, mixed shrub, and sagebrush habitats. Little ecological information is available for either species. It has been suggested, however, that the greatest threats to smooth arid goosefoot are competition from invasive plants and trampling from livestock grazing (Anonymous 2002). Livestock grazing is not considered a threat for beaked annual skeleton-weed (Anonymous 2005). The increased presence of non-native plants along roadside edges, as well as slight reductions in range health, may explain the reduced likelihood of both species.

#### *3.4.3.2 Baseline impacts of livestock watering holes on focal species occurrence*

Areas directly surrounding livestock watering holes were found to have unhealthy range conditions, increased occurrence of non-native plants, and a reduction in the occurrence of several sensitive bird and plant species. It was predicted that for herbaceous grassland sites off of regosolic soils, range health did not reach "healthy" conditions until approximately 200 m distant from a watering hole. Considering non-native plants, Canada thistle, crested wheatgrass, and Kentucky bluegrass were all positively associated with cattle watering holes, with Canada thistle and crested wheatgrass both increasing substantially within a 100-m distance from livestock watering holes. Beaked annual skeleton-weed and Marbled Godwit appeared to be the most sensitive species to surface disturbance surrounding livestock watering holes. Marbled Godwit decreased from an average of 80% occurrence at herbaceous sites 1 km distant from livestock watering holes to 30% occurrence at a livestock watering hole. This species tends to be associated with moderately vegetated (or lightly grazed) uplands and a high cover and diversity of wetlands, which are used for foraging (Dechant et al. 2003d). Decreased range condition, and perhaps less wetland cover in the vicinity of watering holes, may result in reduced habitat conditions for Marbled Godwits. Three other birds—Baird's Sparrow, Grasshopper Sparrow, and Horned Lark—were negatively associated with livestock watering holes. Baird's and Grasshopper Sparrow responses were consistent with previous research indicating that minimal soil disturbance and moderate to deep litter are associated with the presence of these species in grasslands (Dechant et al. 2003e, f).

Contrary to initial predictions that the Horned Lark would serve as a reverse indicator of grassland quality, because of its common occurrence in heavily disturbed areas in many regions, this species showed a negative response to livestock watering holes. Both Horned Larks and Chestnut-collared Longspurs (the single bird species with a positive association with watering holes) are species associated with sparse vegetation and relatively intensively grazed grasslands (Dechant et al. 2003a, Dinkins et al. 2003). The reduced probability of occurrence of Horned Lark was relatively narrow and may indicate very poor grassland conditions surrounding livestock watering holes. Beaked annual skeleton-weed decreased from an average of 70% occurrence at herbaceous sites 1 km distant from livestock watering holes to just over 10% next to livestock watering holes. Some native species appeared to benefit from increased amounts of bare soil and a reduction of vegetative structure around livestock watering holes. These included Ord's kangaroo rat and Chestnut-collared Longspur, which is consistent with the natural history of the species and previous research (Gummer and Bender 2005, Dechant et al. 2003a).

It has been suggested that anthropogenic habitats for Ord's kangaroo rat may act as habitat sinks due to increased parasitism by botflies (Gummer et al. 1997). Regardless of whether grazing leads to sink or source habitat for species, it is widely accepted that grazing is an important process opposing plant succession and thereby having the potential to maintain biodiversity by favoring disturbance-obligate species (Huston 1994, Lesica and Cooper 1999). Because accurate spatial data on grazing practices or Animal Unit Months (AUM) were not available or consistent, we were unable to assess the general impact of livestock grazing practices on native and invasive species or range health. We were able to evaluate only the impacts of watering holes.

Range health conditions suggest that areas that encompass greater variability in terrain and habitat, such as vegetative communities on regosolic soils, are likely to be healthier. Potential reasons for such differences include the patchy and restricted distribution of forage (which potentially reduces grazing efficiency), reduced occurrence of invasive species, and/or artifacts related to chosen reference communities. To increase the carrying capacity of livestock in some areas in the GSH, distributed (shallow buried) water systems recently have been installed. Such systems have numerous advantages for the producer, including enhancing water quality and quantity (especially in a drought), ability to cross-fence, greater animal weight gain, and increased distribution of cattle to previously inaccessible areas (James 2006). Because of these advantages, distributed watering systems are now promoted as part of the $60 million National Water Supply Expansion Program (NWSEP) from Agriculture and Agri-Food Canada. It is less clear, however, whether such systems will benefit native flora and fauna by reducing surface disturbance; in terms of cumulative impacts, they could potentially do more harm than good. This is another important topic for new research.

The analyses of livestock watering holes did not fully consider such recent technological advances, since traditional sources of water largely dominated our field samples. However, without adequate control of grazing pressure, such as by use of management-intensive grazing, rotational grazing, or rest-rotation grazing (Watkinson and Ormerod 2001, McCarthy 2003), it is unlikely that distributed water systems will result in improvements in range health, reductions in invasive plants, or maintenance of sensitive focal species. If watering sites are stationary, surface disturbances are likely to accrue over time and possibly be equivalent to traditional water sources. With the potential for a greater number of watering sites with distributed water systems, there will also be a potential for greater surface disturbance. Moreover, higher densities of watering sites may lead to decreases in habitat heterogeneity, since previously inaccessible (or at least less accessible) areas are likely to become more accessible to livestock grazing. Further research and monitoring of distributed watering systems is necessary to make valid predictions about long-term impacts on range health, invasive plants, and sensitive focal species.

#### *3.4.3.3 Focal species hot spot assessments*

Evidence of segregation in species hotspots was found between bird and vascular plant groups. Bird hotspots were found in the southern and western parts of the Review Area, whereas those for vascular plants were concentrated in the northern and eastern parts. Grouping species into guilds further separated hotspot patterns into two distinct areas that correlated strongly with patterns observed in bird and vascular plant hotspots. These results support previous research in conservation planning suggesting that it is important to consider other taxa beyond vertebrates (Fleishman et al. 2000), since patterns of birds were opposite to those of vascular plants. Indeed, species richness hotspots for a variety of taxa often show poor correlation (Pendergast and Eversham 1997, Wolters et al. 2006). Although combining plants and birds helps balance representation of biotic communities in the GSH, it is unknown whether a positive relationship exists between hotspots for the 27 focal species assessed in this study and general biodiversity for the GSH. Previous research suggests caution in assuming that a few indicators or umbrella species can effectively represent other species or biodiversity (Simberloff 1998). Nevertheless, given that we have selected species that are likely to be sensitive to disturbance (SARA listed species, Species of Special Concern in Saskatchewan) within a range of habitats, we feel confident that consideration of our chosen focal species is sufficient for selection of conservation reserves and assessments of anthropogenic activities in the GSH.

#### *3.4.3.4 Gap analysis of the RAER and unprotected regions of the Great Sand Hills*

The Representative Area Ecological Reserve (RAER) contained the greatest concentration of habitat for only 37% (10 of 27) of assessed species, suggesting that the majority of species were better represented elsewhere in the Review Area and highlighting the need for additional conservation areas. Many of the species lacking extensive habitats in the RAER were grassland specialists, best represented by the Baird's Sparrow guild. As many of the large grassland patches in the GSH also have the highest level of development, the relatively few undeveloped grassland patches become even more significant (irreplaceable and vulnerable) for conservation. Although gas development does not appear to reduce the occurrence of our focal species, associated road or trail development appears to have negative impacts. This suggests that management actions that limit road and trail development, both in the form of conservation areas and best management practices, are likely to have the greatest impact on conserving the biological resources of the GSH.

### 3.4.3.5 *Suggested focal species for conservation planning through MARXAN*

Based on model performance and the ecology of species (including removing the *a priori* reverse indicator species, Brown-headed Cowbird and Horned Lark), we concluded that range health, recent Sharp-tailed Grouse leks, and 17 focal species (9 birds, 1 small mammal, and 8 plants) were adequate as potential targets in MARXAN analyses. Specific to focal species, we identified seven species from the Baird's Sparrow grassland guild as targets. These species are Baird's Sparrow, Grasshopper Sparrow, Savanna Sparrow, Chestnut-collared Longspur, Sprague's Pipit, Marbled Godwit, and the only plant in the guild, prairie moonwort. In contrast to the grassland habitats, we also targeted four shrub-associated species from the chokecherry/Clay-colored Sparrow guild. As well as the two species for which this guild is named, this group includes Spotted Towhee and six-weeks fescue. We further targeted four native species (Ord's kangaroo rat, low milk-vetch, smooth arid goosefoot, and beaked annual skeleton-weed) and two non-native plants (crested wheatgrass and smooth brome) independently of other species (for absence in the case of the non-natives).

Examinations of hotspots for the 27 species versus 17 species showed little difference, suggesting that it was not necessary to include the additional 10 species in final MARXAN runs. To equalize importance of habitats in the GSH, one or two species from each of the guilds can be selected as well as the six independent species (native and invasive). When targeting non-native species in MARXAN, the inverse of the probability of occurrence was used to ensure selection of sites that are not excessively invaded by exotics. We found, however, that binary habitat (present) vs. non-habitat (absent) maps based on reported optimal cutoff probabilities could be used to simplify the process of determining MARXAN goals, summarizing habitats for potential conservation areas, and forecasting potential impacts from future development.

# Chapter 4: Human Capital

## 4.1 INTRODUCTION

This chapter provides an overview of the human capital of the GSH RES area. The objective is to develop an understanding of the current and historic baseline of human capital in the Study Area. The focus is on trends and current baseline conditions in relation to a number of components of the human environment, namely: (1) regional population profile; (2) an ethnographic study of the social conditions and concerns that characterize the region and communities; (3) governance instruments and institutional arrangements; (4) heritage resources; and (5) First Nations use and culture.

The Study Area focused on four rural municipalities (RMs) encompassing the GSH Review Area—Fox Valley (RM 171), Clinworth (RM 230), Pittville (RM 169), and Piapot (RM 110)—with an additional four municipalities that bound the core: Happyland (RM 231), Miry Creek (RM 229), Gull Lake (RM 139), and Big Stick (RM 141). The boundaries of the area were defined by the RM boundaries that generally run from Cabri to Gull Lake on the East, the Trans-Canada Highway from Gull Lake to Maple Creek as the southern boundary, then north from Maple Creek to Leader as the western boundary, and from Leader to Cabri as the northern boundary. The 8 RMs encompass 18 settlements, including Burtsall and Cabri. The temporal scale of the study is 1950 to the present or to the 2001 census profile where current data are not available. Our examination of First Nations use and culture encompassed, primarily, the Treaty 4 and Treaty 7 areas.

## 4.2 REGIONAL POPULATION PROFILE

The regional population profile compiled by Black et al. (2006) examined baseline conditions and decadal trends in relation to population distribution and settlement patterns, population change, income, education and employment characteristics, community-based organizations, and household characteristics. The results are summarized below. Information reported in figures and tables are based on Statistics Canada census data.

### 4.2.1 Population

The Study Area is sparsely populated with 6,709 residents in 2001, accounting for 0.7% of Saskatchewan's total population (Table 2-4-1). In 2001, 59.4% of residents in the Study Area resided within the jurisdiction of settlements, of which 48.4% resided in the towns of Gull Lake and Leader. The RMs of Piapot, Fox Valley, Clinworth, Miry Creek, and Gull Lake recorded their largest populations in the 1951 census. Population has declined significantly from 1951 to 2001 (Figure 2-4-1). The RM administrative units that experienced the most significant population decline are Clinworth, Big Stick, and Happyland (Figure 2-4-2). Development of the gas industry has not reversed this population decline. The town of Gull Lake is the only centre in the Study Area to have experienced population growth since 1991.

Table 2-4-1. Populations in the province of Saskatchewan and GSH study area.

| Region | Population | | | | | | Change ('51-01) |
|---|---|---|---|---|---|---|---|
| | 1951 | 1961 | 1971 | 1981 | 1991 | 2001 | |
| Saskatchewan | 831,728 | 925,181 | 926,240 | 968,313 | 988,928 | 978,920 | + 17.7% |
| Study Area | 11,499 | 13,067 | 10,484 | 8,991 | 7,647 | 6,709 | - 41.7% |

Source: Statistics Canada 2001.

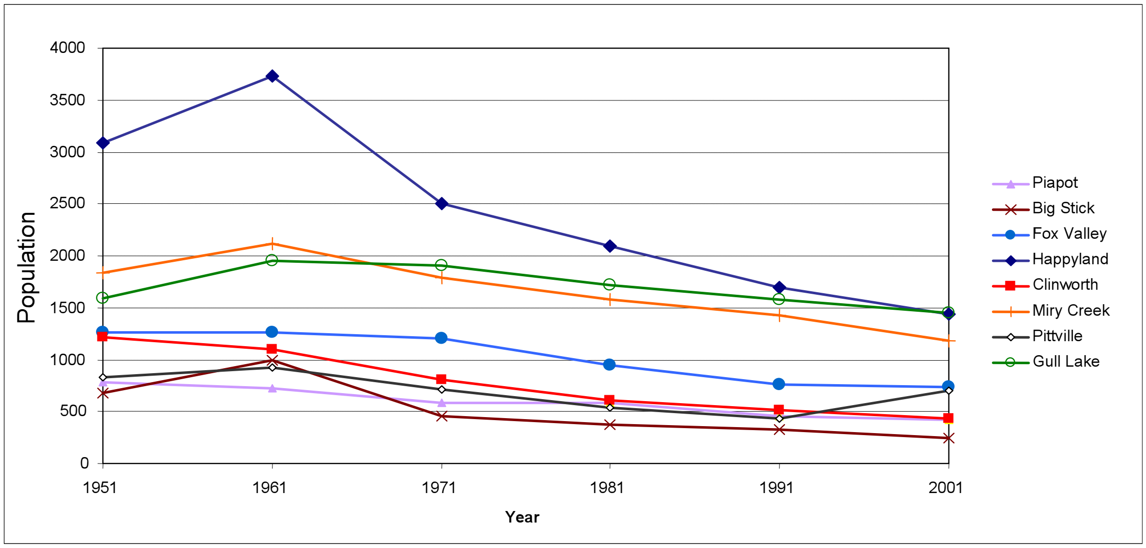



Figure 2-4-1. Regional population trends by RM, 1951–2001.

### 4.2.2 Demographics

Approximately 30% of the population in the Study Area consists of children or young adults (19 and under); 52% are adults of working age (20–64); 18% are seniors (65+ years of age). This compares to provincial statistics of 29% (19 and under), 56% (20–64) and 15% (65+). The median age of residents in Saskatchewan in 2001 was 36.7. Five RMs and eleven settlements had populations of a higher median age. The age distribution of the population varies geographically. RMs and settlements adjacent to the eastern and southern boundaries of the GSH tend to have older-aged populations (e.g., RM of Gull Lake, median age = 43.8 years), whereas RMs and settlements on the western boundary tend to have relatively younger-aged populations (e.g., RM of Fox Valley, median age = 30.5 years). The exception is the settlement of Prelate, in the northwestern region, which, in 2001, reported a median age of 56.5 years.

### 4.2.3 Household and Family Characteristics

Nine out of the twelve reporting settlements and RMs exceeded the Saskatchewan median family income of $40,251 in 2001. The highest incomes are reported in Fox Valley, Burstall, and the RM of Gull Lake. Most households in the Study Area comprise a couple (married or common-law) with children. The following settlements had the highest percentage of one-person households[1]: Village of Piapot (50%), Cabri (42.2%), town of Gull Lake (36.8%), village of Fox Valley (33%) and Leader (32%). The Saskatchewan average for one-person households was 27.6% for 2001.

1. Those people who do not reside with any family members (incl. common-law spouses).

### 4.2.4 Education

Educational attainment in the Study Area is comparable to that of the provincial average (Table 2-4-2).

### 4.2.5 Labour Force Characteristics

Total participation rates are relatively high in the Study Area, with seven of the eight RMs reporting higher participation rates in 2001 than the Saskatchewan average of 67.8%. In the 2001 census, 3,875 people in the Study Area were considered to be in the labour force. The majority of the labour force was engaged in occupations associated with the primary industry (namely agriculture, which includes the subgroups of farming and ranching). In comparison to the provincial average, residents in the Study Area engaged in a higher percentage of occupations associated with primary industries in 2001 (Statistics Canada 2002).

Figure 2-4-3 characterizes the RM labour force characteristics within the Study Area. The RMs of Big Stick and Gull Lake have seen improving employment and participation rates over the last decade. Clinworth has seen a dramatic increase in labour force profile, reaching 100% employment and participation in 2001. The substantial increase within Clinworth is a factor of the recording of these statistics. The number of people

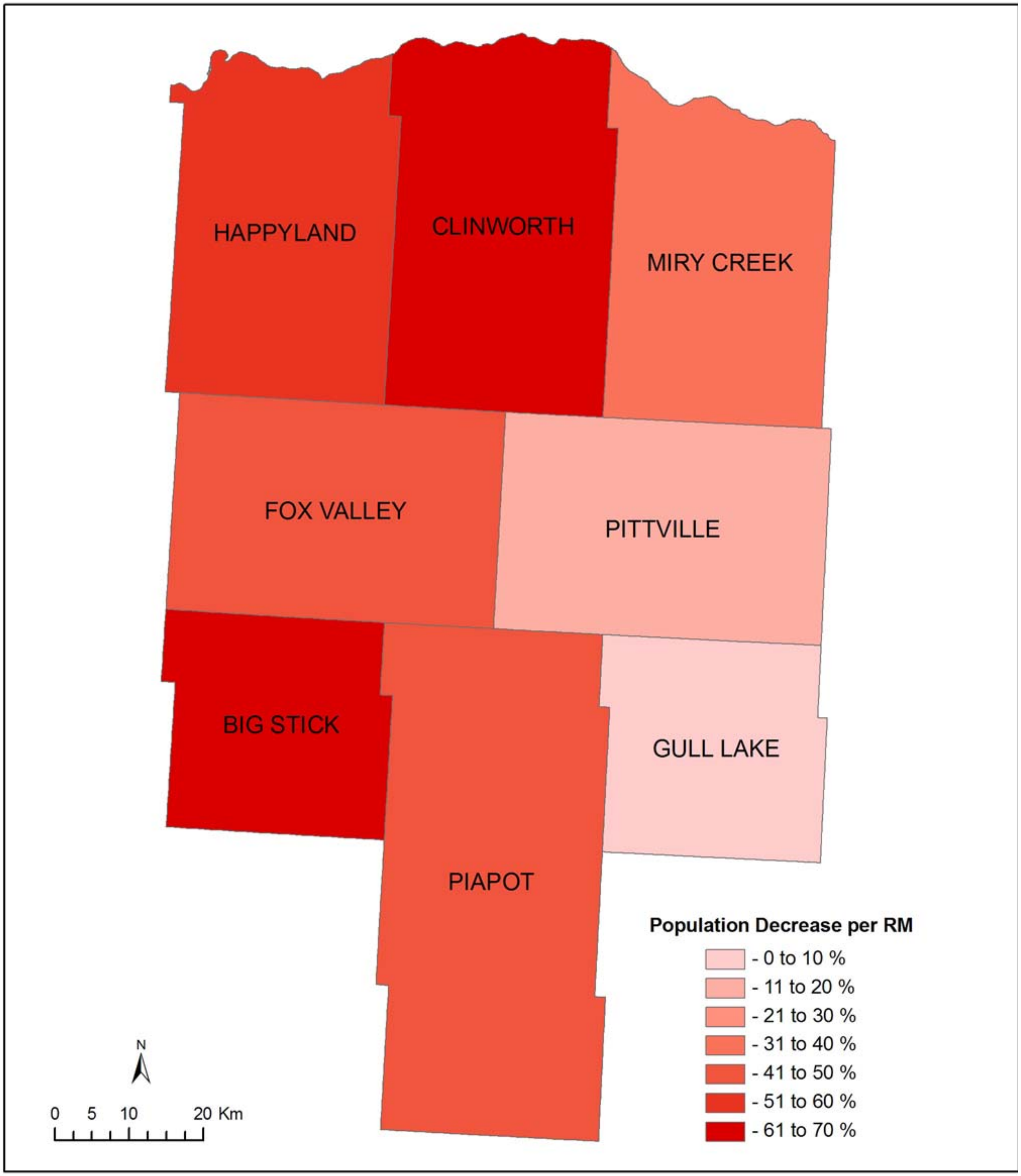



Figure 2-4-2. Population change by RM, 1951–2001.

| Table 2-4-2. Educational attainment of study area residents, 2001. | | |
|---|---|---|
| | Study Area | Saskatchewan |
| Population not attending school (count) | 4810 | 641350 |
| Less than high school graduation, certificate (%) | 41.52 | 36.36 |
| High school graduation certificate only (%) | 10.55 | 11.01 |
| Some postsecondary education (%) | 9.86 | 8.09 |
| Earned trades certificate or diploma (%) | 12.92 | 9.72 |
| Earned other certificate or diploma (%) | 13.71 | 14.93 |
| Earned university degree, Bachelor's or equivalent (%) | 10.46 | 18.19 |
| Earned university degree above Bachelor's (%) | 0.98 | 1.88 |

noted as "not in the labour force" dropped to zero, leaving all others engaged in employed activities. The labour force itself did not increase dramatically, but those individuals who previously declared themselves "outside of the labour force" were either not recorded by the census, or they moved from the region.

Most of the other RMs have relatively stable employment and participation profiles, with the exception of Miry Creek. Miry Creek saw a drop in employment and participation of over 30% between the 1996 and 2001 censuses. The number of people declaring themselves "not in the labour force" increased by over 900%—from 15 to 140. However, there was not an increase in the number of individuals listed as "unemployed."

Unemployment figures in the Study Area are well below provincial norms. According to Cecil (2006) these figures may be the manifestation of a dual set of factors: i) a reduction in the number of people entering the work force (young people)—a sign of either general population decline or rural depopulation as people leave the area seeking employment opportunities in other jurisdictions, and ii) those individuals who do remain in the area are typically self-employed in agriculture.

In all RMs male participation rates for 2001 exceeded the Saskatchewan average of 74.3%. The RMs of Clinworth and Miry Creek have the highest and lowest participation rates, respectively. Eight of the twelve reporting settlements also exceeded the provincial average. Females had higher participation rates if they resided in RMs (77.46%), than in settlements (57.3%). The majority (87.6%) of males and females who reside in RMs worked mostly full-time in 2001, an average of 49 weeks a year. The majority of females (43.5%) from settlements working mostly part-time hours recorded a similar number of weeks worked per year. In 2001 the highest unemployment rates were concentrated in the larger settlements of Burstall (4.4%) and Leader (3.8%). Considerable variation in unemployment rates existed between villages in the Study Area. For example, in the villages of Piapot and Tompkins unemployment rates exceeded 10% whereas Leader and Gull Lake reported unemployment rates of 3.8% and 2.8%, respectively.

### 4.2.6 Housing

The majority of housing within the Study Area in 2001 was owner-occupied, with limited rental dwellings. The average value of a house within the Study Area ranged from $8,800 in the village of Piapot to $73,900 in the RM of Fox Valley. The average value of a house in the RMs was $46,821 and the average value in the settlements was $32,342. The provincial average value of a dwelling in 2001 was $93,065. This is no different than that of other rural areas in Saskatchewan.

## 4.3 REGIONAL ETHNOGRAPHIC PROFILE

The ethnographic profile of the GSH RES Study Area was compiled by Black et al. (2006), based on interviews conducted with members of local governments and community members as well as secondary sources including census and community profiles. A total of 190 residents were interviewed face-to-face by field researchers who resided in the area June–August 2005. Interviews were transcribed and subjected to a thematic analysis. Responses were coded according to related content and analyzed for patterns.

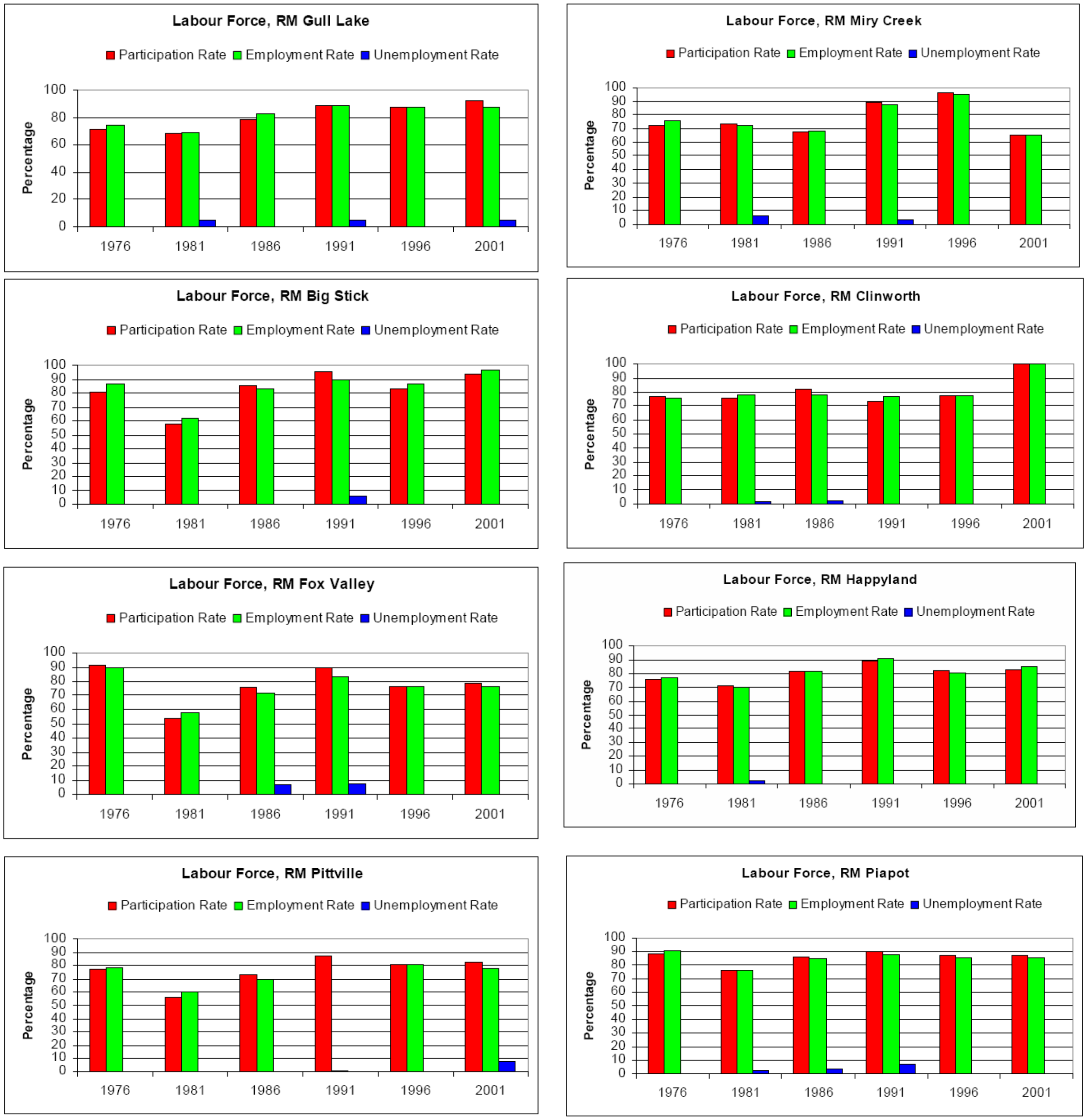



Figure 2-4-3. Labour force profiles by RM (Source: from Cecil 2006).

### 4.3.1 Study Components

The ethnographic profile identifies and describes baseline conditions of Human Capital in relation to: (a) public services and infrastructure: health, education, child care, volunteer and other services (numbers, distribution, perceived quality, and importance); (b) housing: conditions, programs, and amenities; (c) social conditions: crime rates, family structures, personal health, childhood development, income and employment characteristics, and social support networks; and (d) local perceptions: quality of life, quality of employment, employment security, working conditions, and environmental quality and change

### 4.3.2 Results

Like many other rural areas in the Prairies, the GSH region is characterized by a declining and ageing population base, by continuing changes to traditional economic activities (farming and ranching), and by changes in the quality of community life. Approximately half of the study respondents identified their primary occupation in the farming or ranching sectors. Other commonly reported occupations were service occupations (including gas/oil employment) and private business. Most of the respondents (85%) reported working full time. A majority of farmers and ranchers reported secondary employment or spouses working off the farm, a phenomenon related to the limitations of farm and ranch income to adequately support a family. A significant source of secondary employment is the gas industry, recognized by two-thirds of the respondents as one of the few opportunities for alternative employment in the region. Nevertheless, many respondents expressed concerns over the availability and quality of regional employment opportunities for female workers. Participant responses signal a variety of social issues similar to those found elsewhere in rural Saskatchewan.

#### *4.3.2.1 Negative perceptions of the regional economy*

Respondents expressed concerns over the long-term future of farming and ranching and a hope that gas revenues will continue to contribute much-needed tax dollars to the RMs. Regardless of the status of the gas industry, the majority of the respondents reported that the local economy has declined over the past 20 years.

#### *4.3.2.2 Out-migration*

A common sentiment among respondents was that smaller settlements are dying out because of the lack of young people staying in the area; the gas industry is not sufficient to retain youth, who leave in pursuit of better employment and financial opportunities.

#### *4.3.2.3 Gas industry and tourism*

Approximately 85% of interviewees welcomed gas development in the region, arguing that companies contribute to the tax revenue of the RMs and landowners, provide employment opportunities, and fund community activities. Without the presence of these companies, it was argued, the region would experience greater out-migration and land taxes would increase. Respondents did express concerns over migrating gas wells, water table contamination, the lack of use of appropriate technologies by gas companies, and the limitations of local governments to monitor the gas industry. Tourism, on the other hand, was perceived as an incipient economic activity limited to hunting and to visitations of the natural features found around the village of Sceptre, and to the Sceptre museum. Respondents indicated the existence of barriers to an expansion of regional tourism, such as poor highway conditions and lack of suitable accommodation. Participants living adjacent to the core area were concerned that an increase in tourists would lead to an increase in garbage and/or wildfires.

#### *4.3.2.4 Issues facing the local government*

Residents perceive that the area is governed at arm's length by the provincial government. Provincial funds are transferred to the RMs, which provide dollars to implement programs, conduct maintenance, and support various RM level activities; however, locally there is a perception that the RMs are left to implement such programs and to manage local affairs based solely on their own resources. Concerns were also expressed about the pressure that gas interests exert on local councils. However, the majority of interviewees indicated that both RMs and the GSHPDC are doing an excellent job managing the interests of local people and the GSH core area, supporting the inclusion of appropriate government agencies where necessary. Other key issues for local governments identified by respondents were the maintenance of the regional infrastructure and the regulation of the gas industry.

#### *4.3.2.5 Perceptions of quality of life*

A large number of respondents expressed concerns with deteriorating highway conditions and their impact upon access to local services and health care, school closures, availability of housing for seniors, the quality of water, and expenses associated with the upgrade and maintenance of water systems. Limited concerns were expressed about housing, crime, and potential health risks associated with regional economic activities.

#### *4.3.2.6 Perceptions of environmental qualities*

Respondents expressed limited concern about soil and air quality and environmental change. Most said there is no impact from the gas industry on their land, including soil and water sources. In relation to the GSH core area, most of the respondents had faith in ranchers and farmers as good stewards of the land and trusted them to manage the area properly. There was some concern about gas developments in the Review Area, but the majority of respondents felt that safer and more effective technologies could reduce the environmental impacts of the industry. ES1 land is a concern to 80% of the respondents, who argued that gas development should be restricted in that sensitive land.

#### *4.3.2.7 Treaty Land Entitlements*

Three-quarters of the respondents expressed concern over Treaty Land Entitlements (TLEs) in the Review Area in the sense that TLEs might be motivated by a desire to exploit natural resources for profit, possibly at the expense of conservation values.

### 4.3.3 Discussion

For the majority of respondents the sustainability of the region is problematic. Respondents were concerned about the future of farming and ranching in the region. Market conditions, bovine spongiform encephalopathy (BSE) and drought are all risk factors that affect the sustainability of these two economic activities. As a result, income provided by agricultural occupations is perceived as inadequate to support farm and ranch households and to sustain the economic viability of most of the regional communities. In this context the respondents perceive revenues from the gas industry as key to the socioeconomic vitality of the region. These revenues not only supplement the income of rural households but also contribute to the well-being of communities by increasing the tax base of local government and financially supporting local initiatives. Nonetheless, many respondents were doubtful about the capacity of the gas industry to adequately generate and sustain regional jobs and income. Its contribution as an employment alternative is recognized, but concerns exist about its limited capacity to expand female employment and reduce the process of out-migration of youth. Tourism is perceived as a potential new source of revenues, but with significant barriers to overcome, such as poor highway conditions and limited infrastructure.

Respondents also identified issues affecting community and quality of life. Particular concerns are the constant loss of young people who migrate to other regions, the closure of local schools, access to health services, costs associated with community water-system upgrades, unsafe highway conditions, and the increasing challenges these pose to local governments. However, environmental quality and crime were of little concern to the respondents. Pessimistic views of the economic and social sustainability of the region were accompanied by praise about community dynamics; the beauty, serenity, and safeness of the surroundings; and the way of life, which residents regard as unrivalled in terms of community, morals, and values.

## 4.4 GOVERNANCE IN THE GREAT SAND HILLS

To further explore many of the issues raised in the population and ethnographic profiles, we conducted a governance baseline study (Harriman et al. 2006). That study characterized governance instruments, policies, and decision-making structures related to land use and land management within the GSH Study Area, and identified aspects of governance that should be considered when recommending preferred land-use scenarios and creating a comprehensive land-use plan. Emphasis was placed on:

*Institutions:* decision-making authorities and arrangements at provincial, regional, and sub-regional levels;

*Mechanisms:* key policies, plans, and regulations that govern or affect decision-making;

*Management and decision-making effectiveness:* how institutions operate within the GSH Study Area;

*Relationships with ecological integrity and sustainability:* how mechanisms and institutions contribute to or detract from integrity and sustainability.

### 4.4.1 Study Approach

The study took place July–September 2005 and was based on review of secondary sources including archival documents and on-line source materials related to governance instruments and mechanisms, as well as documents obtained in the course of interviewing representatives of provincial government, gas companies, and non-government organizations. In addition, 29 face-to-face interviews were conducted with representatives of the provincial government, oil and gas companies, and non-government organizations involved in governance issues in the GSH region. A focus group meeting with several members of the GSH Planning District Commission was also conducted. Interviewees were asked a series of questions related to governance and to comment on various aspects of institutional arrangements. Interviews were transcribed and subjected to a thematic analysis. Responses were coded according to related content and then combined as relationships became apparent. Finally, between September–November 2006 a review specific to regulation of natural gas development and surface disturbance on Crown lands occurred (see MacFarlane 2006).

### 4.4.2 Results

#### *4.4.2.1 Governance issues of concern*

Governance issues of specific concern identified during the baseline study were those that relate in whole, or in part, to the following components:

*Climate change:* Specific emissions controls for venting methane and combustibles, as well as for flare efficiency, are currently in effect in the GSH. Climate change and carbon emissions are recognized as a concern across sectors; however, climate change policy is perceived as limited or weak in the province.

*Policies, zoning and land use:* Coordination and complexity of land-use regulations and policies are of concern. RM bylaws often reflect provincial policy, but they are not always consistent. Responsibilities over decision-making concerning land use and access is fragmented and sometimes contradictory. An overriding concern is the need for clear designation, zoning, and management of competing land uses.

*Gas development:* Environmental assessment of the gas industry is a concern, and would benefit from: (i) input and data contributed by interests other than the gas industry; and (ii) process streamlining, particularly with respect to consultation. Post-project approvals management of the industry is primarily based on "best management practices," with no regulatory environmental assessment follow-up system for verifying implementation and effectiveness of mitigation measures.

*Water resources:* Concern was expressed over the impacts of industry on water quality. Industry initiatives to manage impacts on water quality are largely self-regulated, and provincial and regional policies are perceived as either lacking or not sufficiently enforced at the local level.

*Biodiversity:* Coordination of efforts for data collection and monitoring for biodiversity protection is limited. Monitoring and conservation of features other than active dunes, e.g. flat land and native prairie, is identified as necessary for biodiversity protection.

*Economic land use:* No provincial program is currently in place to guide overall economic development of the region; rather, use patterns are the result of a combination of factors including the disposal of mineral rights, environmental policies, cooperation among government departments and agencies, and the ability of local industries to resource themselves. The result is tension between land users and uncertainty for developers; a perceived lack of fairness and simplicity in economic land use arrangements; and industry uncertainty with regard to TLE claims.

*Heritage resources:* Provisions exist for archaeological impact assessments in the Study Area; however, regulations and practices concerning the treatment and management of such resources are viewed as somewhat inconsistent with First Nations culture.

*Population and community:* No direct policies or programs address population decline in the GSH Study Area.

*Income and employment strategies:* No direct regional or local policies or programs support income and employment diversification.

#### *4.4.2.2 Government instruments of concern*

Two common issues were raised with respect to legislation affecting the GSH. First, the scope of legislation is seen as inadequate to address the current mix of land uses and interests in the region, attributable to either outdated legislation, or the legislation having been conceived too narrowly to cover the range of issues encountered. Second, many pieces of legislation were considered to lack enforcement provisions, making it difficult for responsible authorities to prevent undesirable activity. Certain policies and regulatory issues were emphasized in the governance interviews as problematic or conflicting and directly affecting the GSH region, namely:

*Provincial Lands Act:* This Act is criticized as outdated and insufficient to address current land-use activities in the GSH and new interests in Crown land, such as gas development and tourism operations. Concerns were raised over the lack of enforcement mechanisms.

*Conservation Easements Act:* Concern was stated over the lack of remedies to address violation of easements.

*Heritage Property Act:* This Act is perceived as not sufficiently accounting for aesthetic resources or other aspects of the natural landscape that may be considered heritage resources, and not adequately facilitating joint management of cultural resources with regard to First Nations.

*Crown Minerals Act, Crown Royalty Provision Statutes, Corporate Capital Tax:* Dissatisfaction was noted with the corporate capital tax among oil and gas producers, and with regard to restraints to maximizing gas development potential.

*Environmental Assessment Act:* Concern was expressed that "piecemeal" activity approvals circumvent the main objectives and function of the Act; cumulative impacts and "programs of activities" are not given due consideration within the scope of assessment, and there are no clear requirements for post-approval environmental assessment follow-up under the Act.

#### 4.4.2.3 *Surface disturbance regulations and natural gas development on Crown lands*

A separate governance review (MacFarlane 2006) was undertaken to identify current practices that are most likely to be potential causes of surface disturbance resulting from gas development, and to determine what provincial and municipal regulations and guidelines apply to the practices of concern.

Regulations, approvals, and management of gas development on Crown lands in the GSH are the responsibility of a number of government bodies (Table 2-4-3). Saskatchewan Industry and Resources (SIR) is the initial point of contact in the development process: receiving, reviewing, and approving the gas company's application for a license to drill, operate and produce under *The Saskatchewan Oil and Gas Conservation Act*. Surface lease and surface access on crown lands is granted by Saskatchewan Agriculture and Food (SAF) and reviewed under *The Provincial Land Regulations*. Development permits are granted by an RM under its respective zoning by-laws and per legislative authority granted under *The Rural Municipality Act* and *The Planning and Development Act*. Rural Municipalities typically require development permits for individual wells and compensation for road damages. Surface leases in the GSH Review Area are also subject to conditions specified by the GSH Planning District Commission. Clearance on heritage restrictions is considered through Culture, Youth and Recreation (CYR) under *The Heritage Property Act*, and a Heritage Resource Impact Statement may be required.

The approvals process for gas development in the GSH requires the gas company to work simultaneously with multiple provincial departments or agencies and RMs. The provincial departments or agencies playing a lead role in land management are SAF and SE, linked by their responsibility for review of a gas company's Environmental Protection Plan (EPP) or Environmental Impact Statement (EIS). Their relationship is less direct with SIR, Government Relations, and individual RM governments. No one single regulatory body leads the process of approval and communication with industry.

All gas proposals in the GSH usually require, as a minimum, an EPP identifying potential impacts, mitigation, and monitoring measures (Saskatchewan Environment and Resource Management 2000a, 2000b). Applications that are considered "development," as per section 2(d) of the Environmental Assessment Act, are required to undergo an environmental impact assessment (EIA) and preparation of an EIS. The latter would undergo a technical review, public consultation, a recommendation to the Minister of Environment, and a Ministerial decision on approval. In the absence of a determined need for an EIA, where approvals are made on the basis of an EPP, no formal opportunity for public consultation exists. There is limited formal control post-approval to ensure that EPPs are implemented and mit-

Table 2-4-3. Responsible authorities for gas development and operations.

| Gas development and operational activity | Responsible or regulatory government body | | | | |
|---|---|---|---|---|---|
| | SIR | SAF | SE | GR | RM |
| Gas leases and pads | • | • | • | • | • |
| Gas flow lines | • | • | • | • | |
| Roads and trails | | • | • | • | • |
| General operations | | | | | |
| - environmental monitors | • | | • | | |
| - well decommissioning | • | • | • | | |
| - spills | • | | • | | |
| - reclamation | • | • | • | | • |

igation measures are effective; moreover, the cumulative effects of developments are not particularly well documented or considered at the scale of the individual EPP.

Despite the high sensitivity of the GSH for species at risk and the potential for effects on a "unique, rare or endangered feature of the environment," a qualifier for an EIA under section 2(d)(i) of the Environmental Assessment Act, only 5 proposals have undergone full EIA—each having approved conditions for development and environmental protection (Figure 2-4-4). Over 1,500 gas wells have been drilled in the GSH Review Area.

The gas industry and government cooperate through the Saskatchewan Petroleum Industry and Government Environment Committee (SPIGEC), providing recommendations for various aspects of operations, such as site remediation guidelines and qualification guidelines for environmental monitors (Saskatchewan Petroleum Industry and Government Environment Committee 2000, 2002).

Specific concerns over gas development and operational activities and opportunities for improvements are as follows:

*Gas well pad surface leases:* Directional and slant drilling with multiple wells per well pad surface lease comprise now about 16% of the total wells present in the GSH region. This type of drilling first commenced in the late 1980s and today is implemented where a condition of an environment assessment-approved project area exists or where there are special site conditions, for example sand dunes. Results show a reduced surface disturbance, attributed to as little as 1 well pad per surface lease per section with 6 directional/slant wells and 1 vertical well per pad, an expected reduction in length of flow lines installed, and, most importantly, a reduced length of gravelled trails and roads. These attributes of multi-well pads add up to a significant gain for land conservation.

*Gas flow lines:* Plastic buried flow lines are not licensed, but are governed by CSA standards. Gas companies generally employ a lower-impact installation of spider ploughing in the GSH and, as per environmental guidelines, install lines in the fall prior to freeze-up. The opportunity exists to have a third party complete an overall mapping of flow lines in the GSH, to loop flow lines, and to share lines between different companies.

*Roads and trails:* The use and condition of roads and trails is variable, from commonly accessed gravelled roads and trails to simply earthen roads and infrequently driven trails. Both agricultural and gas industry road and trail access is common in some areas of the GSH, whereas in other areas trails are used only for access to specific gas well surface leases. There is an opportunity to establish an overall plan to verify use and condition of roads and trails in the GSH and, ultimately, to enable RMs, landowners, lessees, gas companies and SAF to better manage for maintenance as well as for future reclamation. For future gas well development, reducing the number of well pad surface leases per section and thereby reducing the overall length of roads and trails may represent the most critical change that could be made to reduce surface disturbance, coupled with remote operating technology and management practices for over-the-grass access.

*Environmental monitors:* The industry is relied on to implement and monitor best management practices. Environmental monitors working for individual gas companies provide the on-site monitoring to check compliance with conditions for drilling and other operations. At the local level, while there is good evidence that regulations and guidelines are in place to encourage environmental protection, the level of compliance is unclear. Monitoring and enforcing the regulations and guidelines are limited by government staffing levels to carry out these environmental functions. An example is SIR, which has 16 field officers responsible province-wide for 62,000 oil and gas wells expanding at the rate of 4,000 new wells per year. Only three SIR Field Officers service the southwestern area of Saskatchewan. The need exists to strengthen and expand the role of environmental monitors funded by the gas industry. Consideration could be given to changing the reporting relationship directly to the GSH Planning District Commission or the Government of Saskatchewan. Expanded roles could include all aspects of seismic exploration, drilling, maintenance, and reclamation.

*Well decommissioning:* The life of individual wells can range up to 50 years; decommissioning is not expected to be significant in the GSH within the near future. However, orphan wells are recognized as a growing liability to all parties. SIR, with industry associations, is moving forward to create an orphan well program that will create a

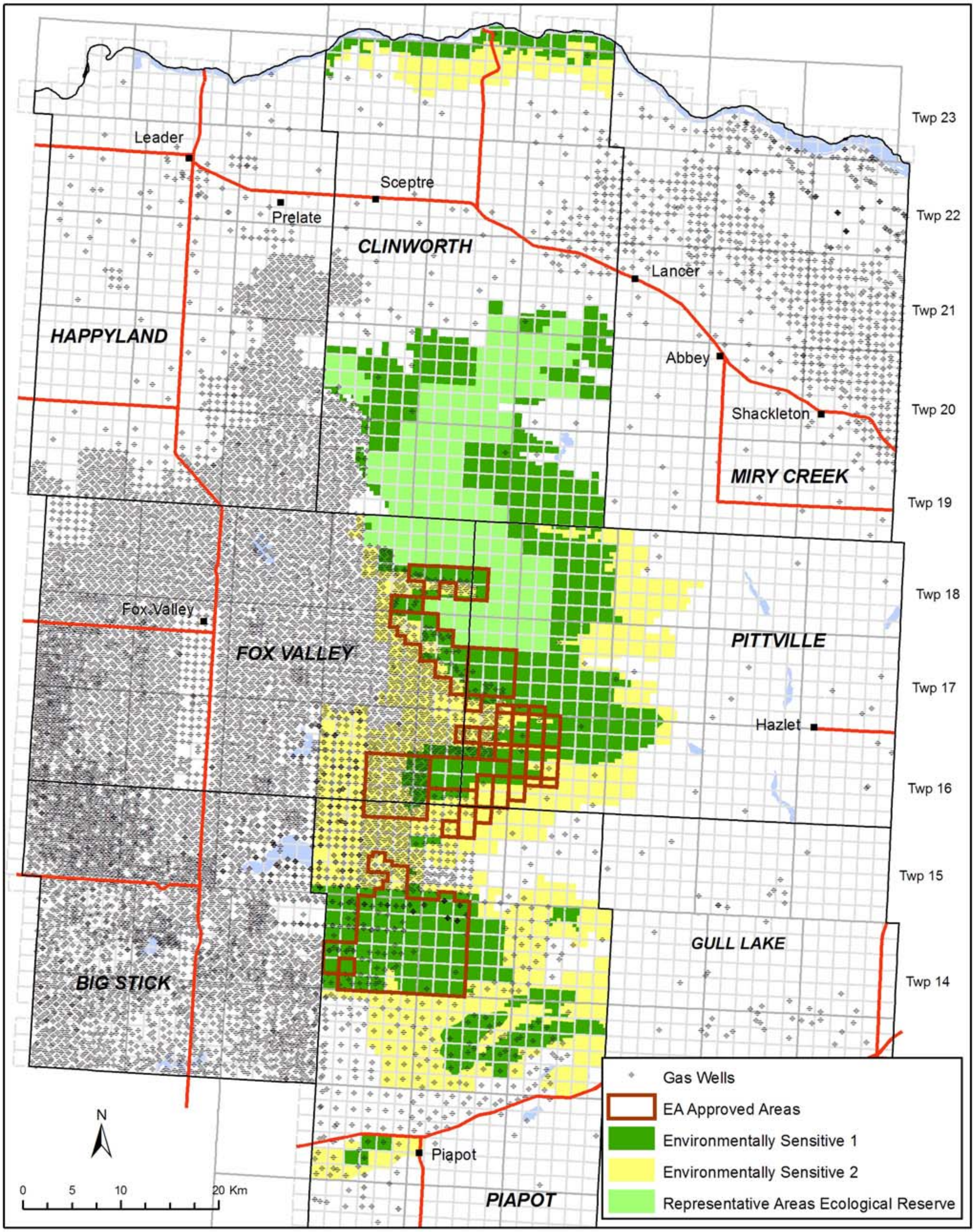



Figure 2-4-4. Environmental assessment approved gas project development areas.

financial source for funding decommissioning when a gas company does not have the necessary funds to complete the job. This new initiative is nearing completion and should contribute to reclamation objectives for the GSH.

*Spills reporting:* Spills associated with the gas industry are less prevalent and of smaller magnitude when compared to the oil industry. An upstream spill database indicating reported spill type, location, substance, recovery, spill area, and spill source is maintained by SIR, covering the period from 1991 to present. The numbers and distribution of reported upstream spill incidents included in this data base, up to December 2005, are depicted in Figures 2-4-5 to 2-4-7. The majority of reported spills are saltwater spills, accounting for approximately 8,465,300 l or 72% of total spill volume in the region since 1991. These have occurred outside the Review Area. The reported cumulative spill volume (all substances) since 1991 is 11,787,100 litres, of which 35% is reported to have been recovered. There is no centralized record of reported downstream spills and incidents; however numerous incidents are on record at the regional offices of SE Resource Stewardship and Integrated Land Use branches, each of which has been met with varying degrees of governmental response. According to the

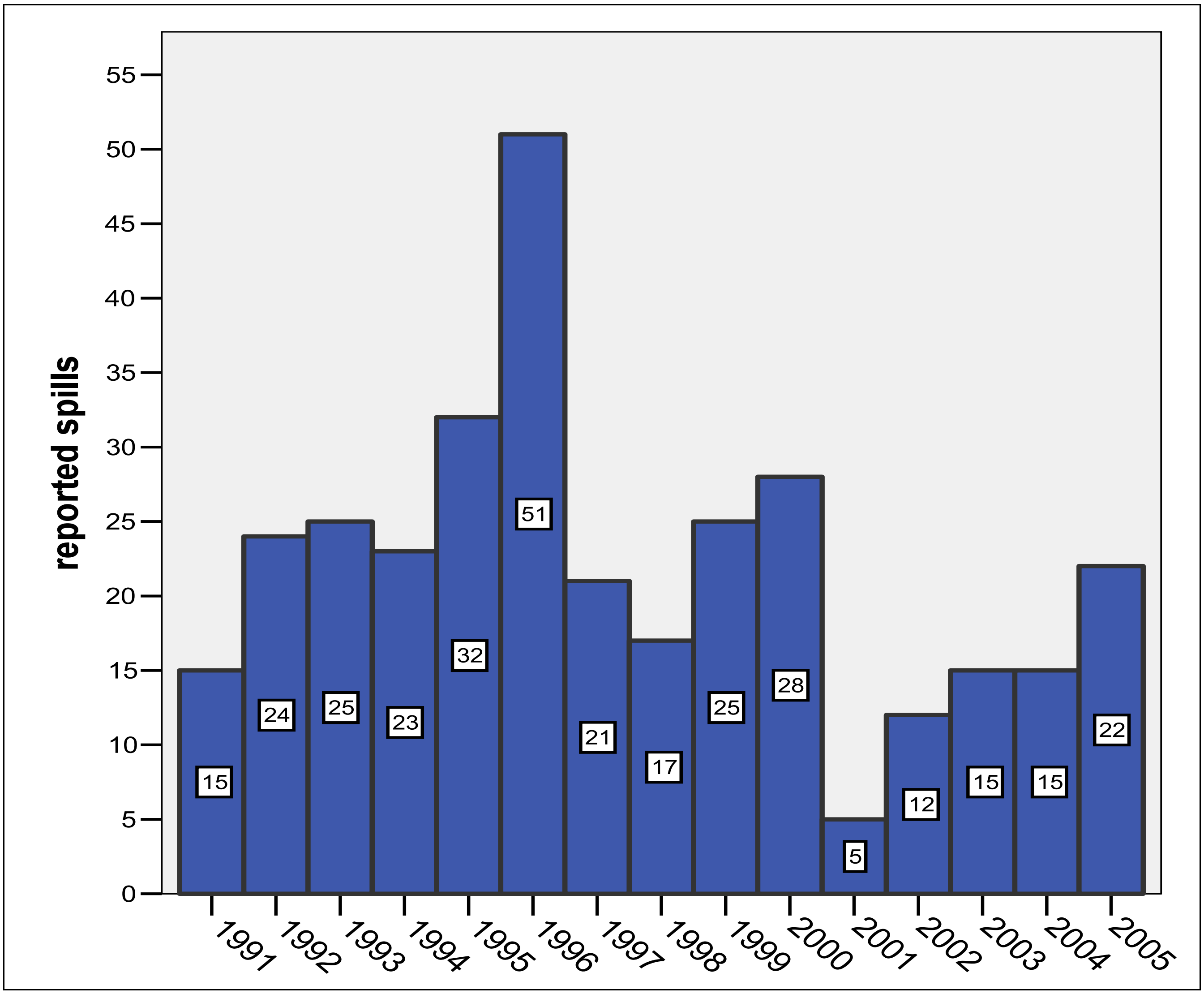



Figure 2-4-5. Reported spills in the GSH study and review areas.
Source: Compiled based on SIR upstream spills database.

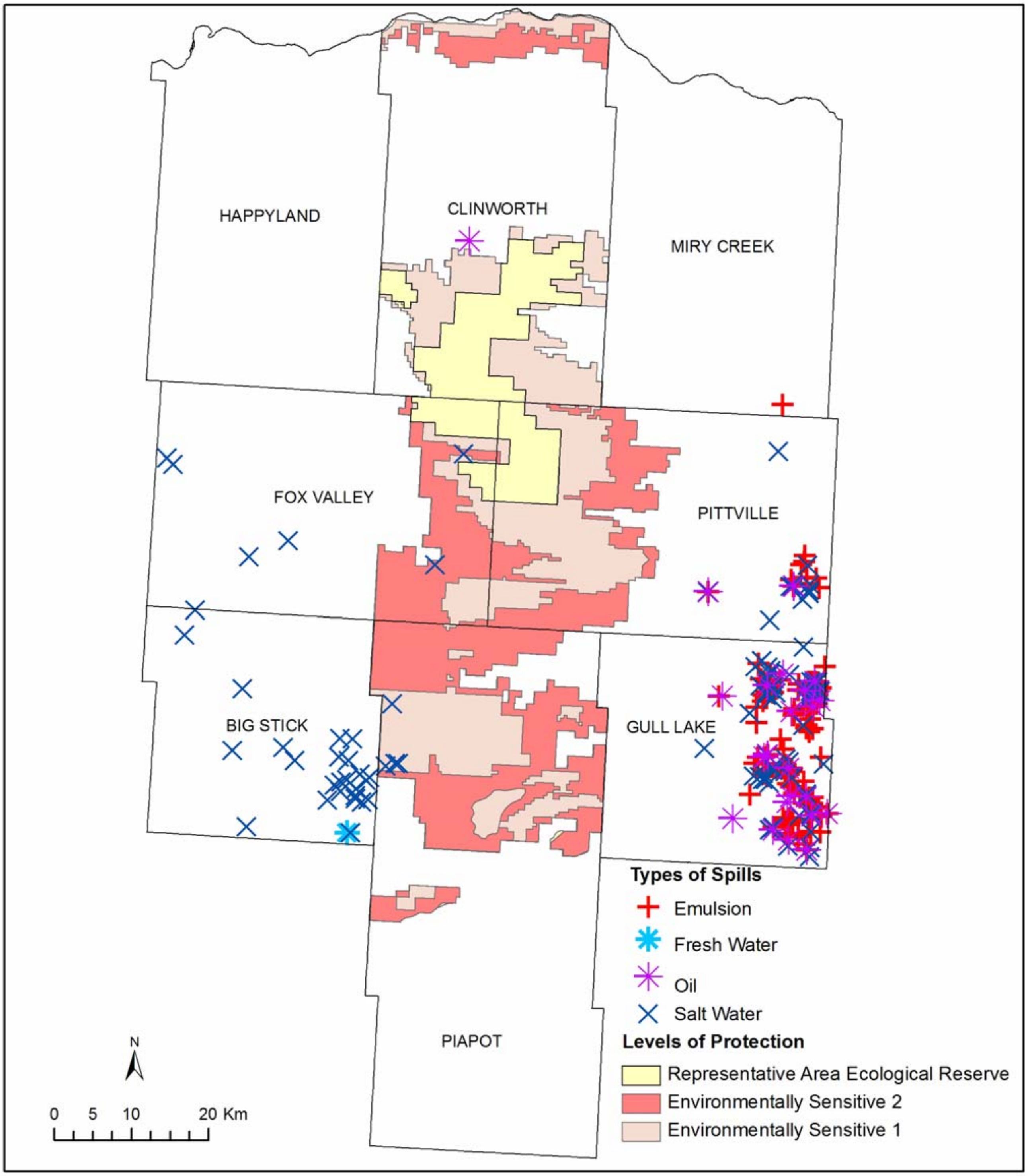



Figure 2-4-6. Distribution of reported upstream spills in the oil and gas sector, 1991–2005. Note: One mark may represent multiple spill incidents.

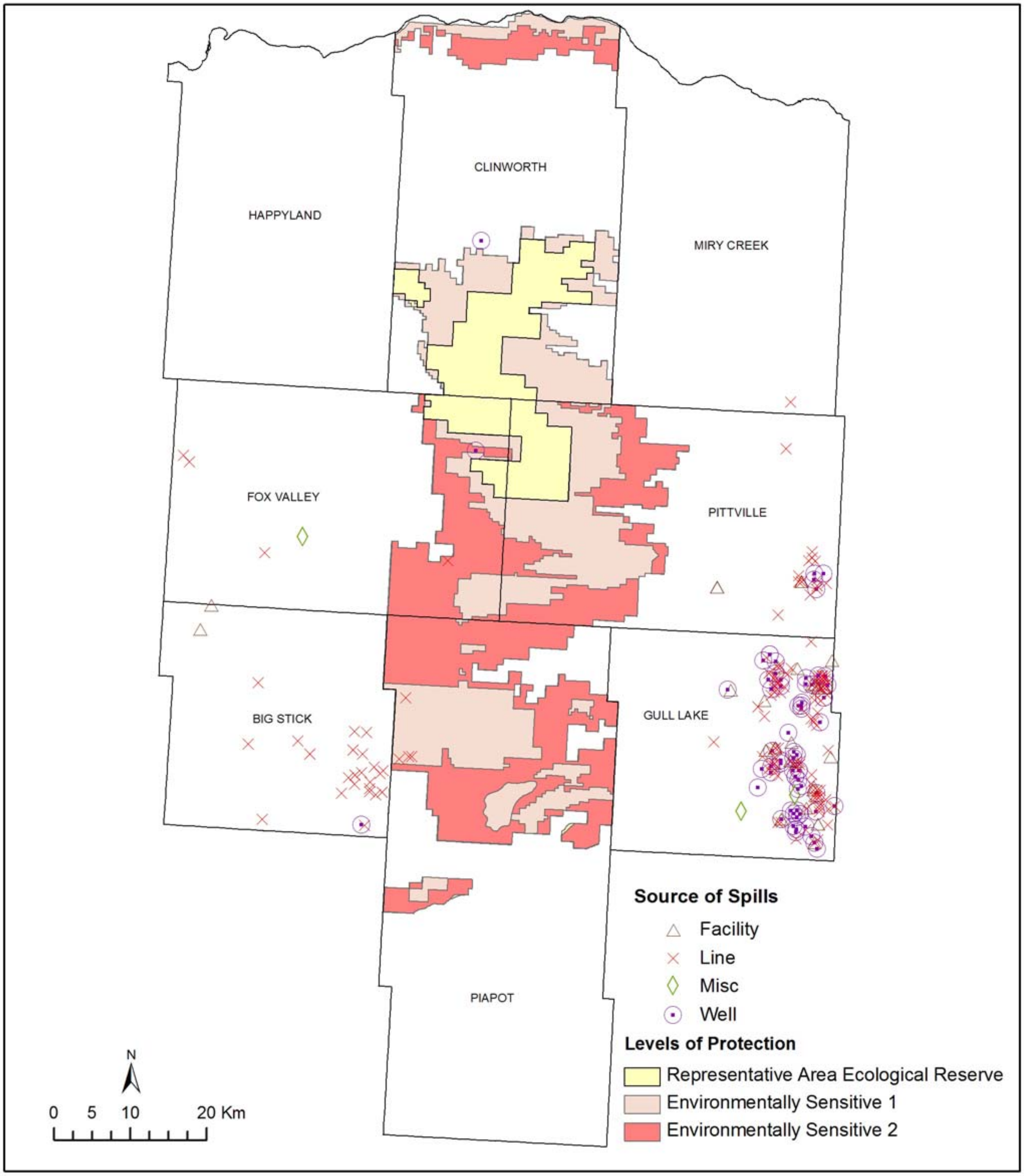



Figure 2-4-7. Distribution of reported upstream spills by spill source in the oil and gas sector, 1991–2005. Note: One mark may represent multiple spill incidents.

Saskatchewan Watershed Authority (SWA 2006), the stress potential in the South Saskatchewan Watershed due to spills is "moderate." However, SWA also indicates a strong correlation between the number of wells and spill potential ($r2 = 0.73$, $p < 0.001$). There is concern over the comprehensiveness of upstream spills report, and over mechanisms for monitoring and reporting of spills—which rest primarily with the operator. An effective environmental monitor is considered the most direct opportunity to report and manage spills.

*Reclamation of well sites and roads/trails:* SAF is particularly interested in a future monitoring and research program to evaluate best methods to reclaim lands, particularly roads and trails. There may be an opportunity to reduce the length of roads with over-the-grass access and use of remote technology for well operations.

### 4.4.3 Institutional Arrangements

A number of key themes concerning institutional arrangements emerged from the governance baseline study. In general, institutional arrangements in the GSH region are regarded as adequate but not as effective as they could be. In particular, it was found that governance issues in the GSH are related to the complexity and coordination of legislation first, and gaps or omissions in the legislation second. Issues of coordination and management in the GSH are largely in relation to the quality and strength of interrelations among the various parties. Certain groups (e.g., Aboriginal groups, NGOs, and tourism operators) are under-represented in decision-making, especially those that are either small in number, lack financial or human resources, or are only indirectly impacted by decision-making.

Information exchange among government departments needs improvement, especially regarding the sharing of ecological data. Although there is noted interest in community consultation and fair and inclusive decision-making, interagency cooperation and inter-municipal coordination need more attention to achieve effective management in the GSH. Government has generally been able to adapt to the demands of managing the GSH in the last 10 years, particularly in terms of promoting environmentally-sensitive development, but its efforts have been hampered by insufficient staff and other resource shortages. This is particularly the case in terms of staff for environmental monitoring and compliance. Capacity building, both in terms of human development and physical infrastructure, is needed in the GSH region. At present, the lack of financial, human, and infrastructure resources combined with a lack of baseline data limits the overall effectiveness of governance, and thus the scope of management options.

While the provincial government and gas companies feel that they are generally effective at consulting diverse interests, managing heritage resources, addressing sustainability, and working with land tenants to protect the environment, NGOs are divided in their opinions on these topics. Some of the outstanding environmental issues in the GSH region include a lack of attention to cumulative environmental effects, the need to create a "level playing field" in terms of responsibility for environmental management, and the need for landscape-level, coordinated management strategies. There is also concern that the effectiveness of gas companies' policies may be limited by centralized decision-making and a heavy reliance on sub-contractors. Industry self-monitoring and reporting does not contribute to alleviating concerns over compliance and transparency.

Legislation and land-use plans in effect in the GSH region (especially those that pertain to access and designation) need to be clarified and have enforceable elements. At present, the gas industry asserts that government is failing to provide a clear and timely development approvals process, a situation that is blamed partly on the controlling influence of RMs. There is also confusion around the purpose and powers of the GSH Planning District Commission. Related to this is the need to ensure consistency of RM bylaws, better coordinate the mandates of government departments, and to clarify the development and approvals process in the GSH. The most common suggestion to improve governance is to establish a central, higher-level governing body with real decision-making power, supported by an effective and balanced network of interests focused on long-range monitoring and planning.

## 4.5 HERITAGE RESOURCES

A study of heritage resources was undertaken to map and provide information about the natural and cultural heritage features in the Study Area. The results summarized here are from Gauthier and Galenzoski (2006) and include: i) heritage properties (archaeological sites and real properties, i.e., buildings and structural properties); ii) prime protection areas (e.g., representative areas, ecological reserves, regional parks); and iii) Crown land management systems (federal and provincial).

### 4.5.1 Study Approach

Based on consultation with Saskatchewan Environment, Saskatchewan Culture Youth and Recreation (CYR), and the Royal Saskatchewan Museum, information databases and supplementary information on archaeological, protected areas, and Crown Lands that related to Natural and Cultural Heritage Capital were obtained. Information was entered where necessary into a GIS compatible format. Screening data for heritage sensitive areas and supplementary data on Heritage screening criteria were acquired from Saskatchewan CYR. Other required information on protected areas and Crown lands was obtained through Saskatchewan Environment in GIS format.

### 4.5.2 Results

#### *4.5.2.1 Cultural heritage*

There are 224 sites of archaeological significance within the limits of the GSH Review Area. Sites, however, are most often discovered through the process of development as is shown in Figures 2-4-8 and 2-4-9. The archaeological significance of sites in relation to development is assessed on a case-by-case basis. Any proponent for development must first contact CYR to determine what, if any, mitigating factors must be taken into consideration. Any activity that is likely to result in alteration, damage, or destruction of heritage property is subject to specific regulations, such that an assessment may have to be carried out prior to the proposed activity to determine the effect of that activity on the property. A proponent may be required to prepare a report of the assessment to be submitted to the governing administration, and may have to undertake subsequent recommendations regarding salvage, preservation, or protective measures. Therefore, mandated recommendations may be put forward relative to three levels of assessment: prior, in situ, or post assessment.

#### *4.5.2.2 Natural heritage*

Varying levels of protection exist within the Review Area, which overlay provincial and federally managed lands as indicated in Figure 2-4-10. Saskatchewan Agriculture and Food (SAF) manage the majority of the land within the Review Area. The majority of this land is leased; however, there are two SAF managed community pastures. A relatively smaller portion of the land is managed under the PFRA at the federal level. The land within the Review Area is also subject to further protective designations as outlined in Table 2-4-4. Of particular importance is the Representative Area Ecological Reserve (RAER), which occupies approximately 18% of the Review Area.

### 4.5.3 Heritage Linkages

To demonstrate links among heritage datasets, various data layers were combined. Densities per km² were calculated for roads, gas wells, and archaeological features. The results were evaluated based on land protection coverage. The results, frequencies of occurrences of archaeological sites, gas wells, pipelines, and roads and trails relative to Representative Area Ecological Reserves (RAER) and the Environmentally Sensitive (ES) 1 Lands, are summarized in Table 2-4-5.

## 4.6 FIRST NATIONS USE AND CULTURE

The First Nations Use and Culture study by Peters et al. (2006) summarizes current and historic First Nations land uses and interests in the GSH area, and identifies those important issues and parameters of First Nations use and culture to be addressed in planning of future land uses in the GSH.

### 4.6.1. Study Approach

The baseline study was conducted with the assistance of various First Nations members, researchers, and governments of Treaty 4, Treaty 6, and Treaty 7. Secondary data were collected using historical records and documentation including treaty land entitlement interviews. Primary data were collected through cross-cultural interviews with Treaty 4 and Treaty 6 First Nations members, interviews with the Kainai (Blood) First Nation Elders of Alberta; in addition, a series of focus groups, organized by the File Hills-Qu'Appelle Tribal Council, were held with more than 30 individuals from across a number of Saskatchewan Treaty 4 First Nations (Table 2-4-6).

### 4.6.2 Results

#### *4.6.2.1 First Nations treaties*

The GSH area is of historic, contemporary, and future cultural, spiritual, and economic significance to many First Nations. The area itself is considered to be the traditional territory of the Blackfoot Confederacy of

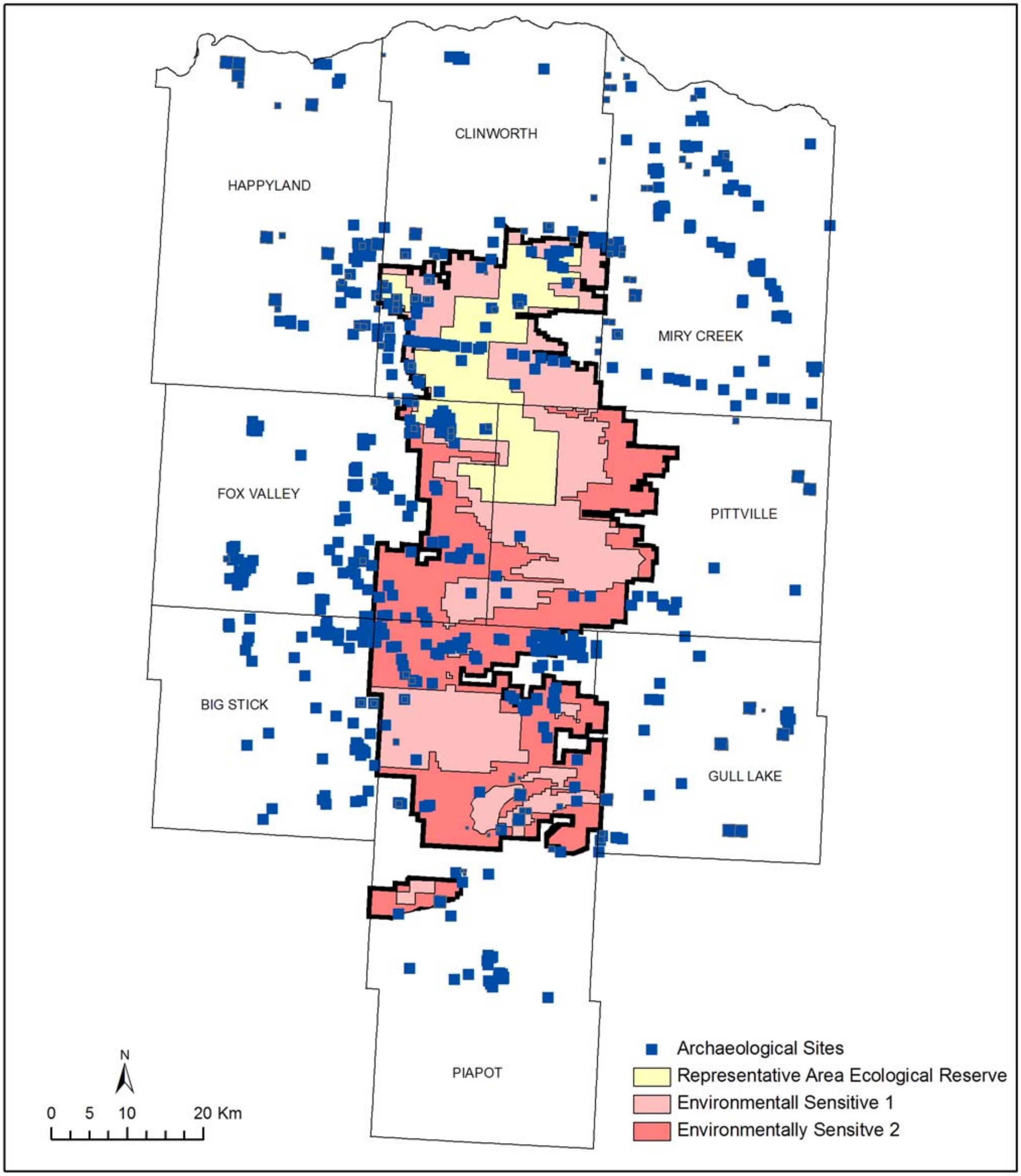



Figure 2-4-8. Archaeological sites in the GSH.

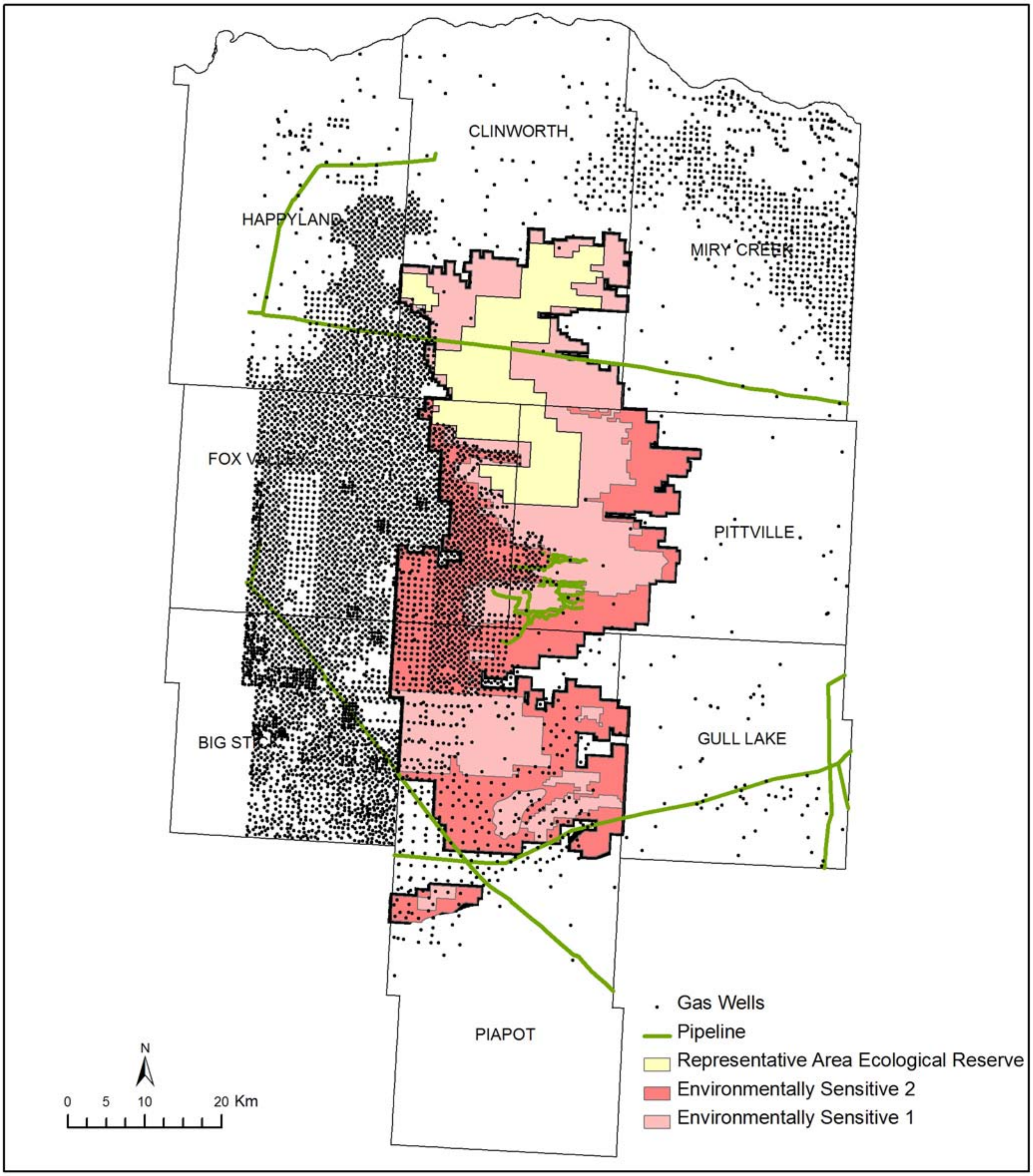



Figure 2-4-9. Gas wells and major pipelines in the GSH.

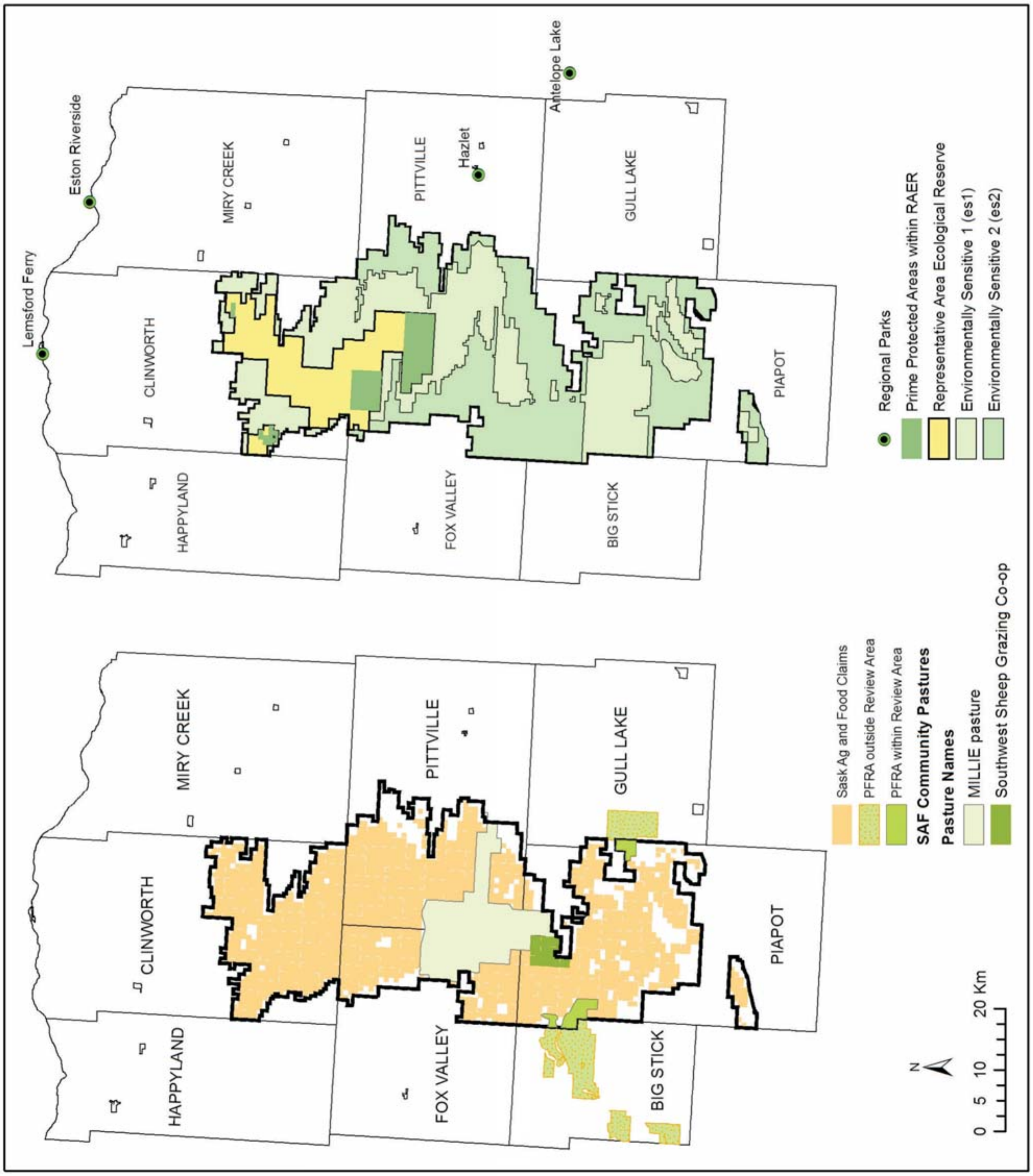



Figure 2-4-10. Levels of protection with land management within the Review Area.

Table 2-4-4. Summary of managed conservation areas within the Great Sand Hills.

| Natural Heritage with Review Area (203070.39 Ha) | | | | Activities | | |
|---|---|---|---|---|---|---|
| ZONING | ~AREA Ha | ~% of Review Area | Legislation and Administrator | Gas | Tourism/Recreation | Ranching |
| Representative Area Ecological Reserve (includes Prime Protection Areas) | 37343.51 | 18.39 | Protected under the Representative Area Ecological Reserves Regulation as unique ecological reserves that are designed to protect representative areas of natural landscapes and to conserve biological diversity; Administered by SE. | No Development | Activities for which a permit is not required: generally any recreation activity which does not jeopardize the sustainability of the area (such as no introduction into the representative area of any plant or animal species; or leave in the representative area any articles or materials taken into the representative area by that individual), including but not limited to: trapping, hunting, angling, mushroom picking, berry picking, walking, hiking, backpacking, and nature observation and appreciation. | As an existing activity at the time of designation, ranching is allowed. |
| ES 1 | 82885.62 | 40.82 | Minister of Municipal Government RM zoning bylaw; administered by Review committee, SE, and SAFRR. | No Development; Environmentally Sensitive 1 (ES1) which included 455 sections (117,845 ha) of lands protected from oil and gas development, At Council's Discretion -Existing oil and gas and mineral development which received necessary regulatory approvals prior to the passage of this bylaw. Oil and natural gas pipelining where it is necessary to connect existing oil or natural gas wells to existing oil or natural gas transmission networks, for the purpose of ensuring production to the existing oil and natural gas wells. | Natural Trails, look-out sites; Open space passive recreation activities. | Existing and compatible agricultural uses, e.g., cattle grazing. |
| ES 2 | 82687.11 | 40.72 | Minister of Municipal Government RM zoning bylaw; administered by Review committee, SE, and SAFRR. | Development with provisions: Environmental Protection Plan (EPP) – significant environmental concerns have been identified and subjected to an interagency review; Environmentally Sensitive 2 (ES2), that included 306 sections (79,254 ha) of land surrounding the ES1, and that could be developed for oil and gas with special environmental provisions. | Natural Trails, look-out sites; Open space passive recreation activities. | Existing and compatible agricultural uses, e.g., cattle grazing. |
| WHPA | 168138.19 | 82.79 | The Wildlife Habitat Protection Act (WHPA) protects listed provincial Crown lands from sale or destruction of habitat. Lands under WHPA or associated regulations are held by one of: Saskatchewan Environment; Saskatchewan Agriculture and Food (SAF); or Saskatchewan Watershed Authority. | Typically require an EPP. The only recent example of a project requiring an EIA involved exploration in the Great Sand Hills—limited to 4 wells/quarter section. | Low-impact/non-consumptive recreation activities. | Existing and compatible agricultural uses, e.g., cattle grazing. |
| PFRA | 2304.93 | 1.14 | Marginal agricultural lands managed by the Prairie Farm Rehabilitation Administration. | Mineral extraction with EPP and/or EIA if required. | Wildlife habitat, sustainable recreation, and preservation of archaeological sites. | Sustainable grazing practices. |

| Table 2-4-5. Summary of various human features in the Great Sand Hills study area relative to designations of conservation lands. | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Review Area | RAER | RAER | ES1 | ES1 | ES2 | ES2 |
| FEATURE | Sites or km | Sites or km | Density/Km$^2$ | Sites or km | Density/Km$^2$ | Sites or km | Density/Km$^2$ |
| Archaeological | 224 sites | 58 | 0 to 9 | 52 | 0 to 9 | 114 | 0 to 9 |
| Gas wells | 1407 sites | *1 | 0 | 367 | 0 to 1 | 1039 | |
| Pipeline | 30 km | 7 | | 15 | | 8 | |
| Roads and Trails | | | 0 to 2 | | 0 to 2 | | 2 to 5 |
| * Shown 27 m within RAER and likely a digitising error or shapefile snap error. | | | | | | | |

| Table 2-4-6. Treaty 4 focus group First Nation participants. | | |
|---|---|---|
| Cowessess First Nation | Cote First Nation | Carry the Kettle First Nation |
| Kahkewistahaw First Nation | Daystar First Nation | Standing Buffalo First Nation |
| Kawacatoose First Nation | Fishing Lake First Nation | Whitebear First Nation |
| Little Black Bear First Nation | Fishing Lake First Nation | |
| Nekaneet First Nation | Gordon First Nation | |
| Ochapowace First Nation | Kinistin First Nation | |
| Okanese First Nation | Muscowpetung First Nation | |
| Peepeekisis First Nation | Pasqua First Nation | |
| Piapot First Nation | | |
| Starblanket First Nation | | |
| Sakimay First Nation | | |

Alberta and the Saskatchewan Treaty 4 First Nations, and is of significant importance to Treaty 6 and numerous other First Nations groups in Saskatchewan and North Dakota:

*Treaty 4 First Nations:* At least part of the GSH Review Area itself lies within the area covered by the Qu'Appelle Treaty (Treaty 4), signed in 1874, with several adhesions. Only the Nekaneet First Nation has a reserve near the GSH, located 121 km southwest of Swift Current and occupying 5,602 ha of land. Preservation of the GSH and access for traditional use are of primary importance to Treaty 4 Elders.

*Treaty 6 First Nations:* Signed in 1876 by bands of the Plains Cree, Woodland Cree, and Assiniboine, Treaty 6 contains 30 First Nations plus two additional First Nations (Shoal Lake and Red Earth) that are located within the Treaty 6 area but adhere to Treaty 5. Several Treaty 6 First Nations form Battleford Tribal Council and Saskatoon Tribal Council have an interest in the GSH area, with particular interest in TLE selections. A number of Treaty 6 First Nations members either hunt or continue to hunt in the GSH area; others have historical connections to the region.

*Alberta Treaty 7 First Nations:* Treaty 7, a peace treaty, was negotiated with the Blackfoot Confederacy in 1877. Signatories included tribes of the Blackfoot Confederacy, (Siksika, Piikani, and Kainaiwa [Blood]), Tsuu T'ina (Sarcee), and the Stoney (Bearspaw, Chiniki, and Wesley/ Goodstoney). Although the Blackfoot live primarily in Montana and in the Treaty 7 area of southern Alberta, the GSH formed part of the Blackfoot's traditional territory and currently holds a significant place in their belief system. This belief system is also reported to be held by the Tsuu T'ina (Sarcee). Primary interests are access and preservation.

#### 4.6.2.2 *First Nations use and significance of the Great Sand Hills*

There is a long history of First Nations use of the GSH, and the area is considered by First Nations to be highly significant in terms of medicines, culture, and spiritual practices. Historically, a number of First Nations used the GSH for hunting and gathering activities, spiritual, and ceremonial purposes. The GSH is identified as a transitional area, occupied by different First Nations over time as they migrated and camped through the area, hunted, or as they forced other groups out of the area in warfare. Considerable archeological evidence suggests use of the GSH by historic peoples.

First Nations that had frequented the GSH area historically usually continued to use it following the signing of treaties; however, Elders from all of the Treaties note that they had been kept away from the GSH in recent years due to the nature of land ownership. Currently, most First Nations do not use the area for traditional hunting activities. Spiritual and cultural uses remain, as well as newly developing economic interests. The area remains a source of medicines gathered by First Nations and continues to be important in their cultural and spiritual worldview.

### 4.6.3 Discussion

There is general consensus amongst First Nations participants on the need for First Nations' perspectives on, and involvement in, land-use planning and decision-making in the GSH. The GSH continues to be important in the cultural worldview of First Nations and holds significant spiritual significance with respect to the surrounding landscape. For many, the GSH is identified as sacred. Preservation of the site is called for across First Nations groups, but there is also recognition that gas development will likely continue in the region. As such, land-based impacts and revenue sharing are also issues of concern.

There are a number of issues that differ between First Nations groups concerning the current baseline and future management of the GSH; however, several key issues and impact areas (expressed here in no particular order of importance) emerge across groups:

*Impacts on First Nations culture:* The point-specific nature of archaeological resources is not a good indicator of the spiritual and cultural significance of the GSH for First Nations. Protecting archaeological sites alone does not equate with protecting First Nations spiritual or cultural values in the GSH.

*Land access by First Nations peoples:* The contemporary property regime of the GSH area is seen as a restriction on First Nations access to "their own land." Thus, few First Nations people have traveled extensively in the area in recent years. A common request across First Nations' participants was that (at a minimum) an area be set aside in the GSH, which they could access for spiritual and ceremonial purposes.

*Impacts on heritage resources:* A significant number of artifacts and remains have been discovered in the GSH, due in large part to surface disturbance associated with gas development activities. Given that the GSH area is recognized as a transitional area, occupied by different First Nations at different points in time, confirmation of the origins of these archeological resources is often difficult. There is an expressed need for proper ceremonial practices and elders guidance (or a council of elders) when archaeological sites are found, and that remains be re-buried within the GSH.

*Plants collected for medicinal and ceremonial purposes:* The GSH is reported as providing important sources of medicines for First Nations. No primary data were available from First Nations participants as to the specific plants that are currently used or their location (secondary sources do indicate First Nations medicinal uses of certain plants known to be found in the GSH), but several reports suggest that these plants are: i) being affected by the gas industry, and ii) not easily accessible to First Nations. Many of the known medicinal and ceremonial plants gathered from the GSH (e.g. Chokecherry, Sweet grass), are found at locations outside of the GSH region and throughout much of southern Saskatchewan. However, the medicinal and cultural significance of plants found within the GSH are perceived to be greater than those same plants found in other locations. Plants in the GSH are seen as providing "stronger medicines."

*Economic benefits from the gas industry:* Widespread concern exists that gas development in the GSH has occurred without due consideration for First Nations rights and interests. Overall there is a desire to see the GSH protected. Only Treaty 6 members spoke directly of economic interests in gas development; however, this is in large part a reflection of those individuals interviewed (e.g. Band leaders and development officers). That being said, there is a general sense that gas development will continue in the GSH and that under such conditions First Nations should, at minimum, be involved in revenue sharing.

*Governance and decision making:* First Nations participants expressed concern that they have not been involved in decision-making concerning land use and development in the GSH. A recommendation emerged to establish a "council of elders and traditionalists" for government to consult and work with so as to ensure that proper protocols are followed concerning development, land use, land access, and heritage resource management, and to ensure that the sacred nature of the GSH is properly respected.

# Chapter 5: Perceptions of Development and Associated Impacts

## 5.1 INTRODUCTION

A broad social survey of local residents of the GSH Study Area was designed and implemented between April and May 2006 to gather information about the present and future potential impacts of three main economic activities in the region—the gas industry, ranching, and tourism—upon regional households, communities, and the GSH Review Area. In addition, recognizing the importance of various stakeholder interests in the region, particularly the ranching community, towns and RMs, environmental non-government organizations, the gas industry, various levels of government, and the First Nations, the Scientific Advisory Committee also engaged in separate workshops (survey sessions) with each interest group between July and November 2006. Summarized here are the study approaches and key findings.

## 5.2 SOCIAL SURVEY

This section summarizes the results of a social survey conducted by Nelson et al. (2006) for the Great Sand Hills RES, designed to gather information about the present and future potential impacts of three economic activities—the gas industry, ranching, and tourism—upon regional households, communities, and the GSH Review Area. The information contained within this report is derived from phone interviews conducted with a sample of residents from the Study Area.

### 5.2.1 Methods

The survey instrument consisted of a 19-page interview integrated into a computer-aided telephone interviewing system. A stratified sampling procedure was developed and oriented toward obtaining a sample that would be representative of the spatial distribution of the population in the Study Area. Each RM was assigned a stratum, with the exception of Happyland and Gull Lake, which were divided into two strata to avoid an over-representation of the residents of the two larger towns, Leader and Gull Lake. Of approximately 2,700 households in the Study Area, a final sample size of 432 adults was obtained with 45% "rural" and 55% "town," reflecting the actual population distribution of the Study Area.

The survey instrument was organized into two main sections: (i) one oriented to obtain basic demographic information from the respondents; and (b) a second section consisting of a series of questions aimed at gauging interviewees' attitudes to the impacts of ranching, tourism, and the gas industry on their households, their communities, and the GSH. Respondents were asked to consider the current impacts of each regional industry, as well as the potential impacts of an increased activity level for each industry in the region, a decreased activity level, and a continuation of the status quo in each case.

### 5.2.2 Social Survey Results

An examination of the demographic characteristics of the sample, and a comparison of those characteristics with data from the 2001 census, suggests that the sample is a fair representation of the population of the GSH Study Area. Less than one-third of the respondents (28%) are not in the paid workforce, the majority of which are retired. Agriculture still predominates in the region, being the largest occupational status category with over 50% of the respondents in the sample engaged in *paid* agricultural employment; only 10% reported that their main occupation was in a business that they own themselves. Of the respondents who list employment in the agriculture industry as either their primary or secondary occupation, 52% are farmers, 27% are ranchers, and 21% report working on a mixed operation. Of all the respondents, 57% report that they either own or lease agricultural land (28% report having deeded or leased land in the GSH). Of those respondents who own agricultural property, only 58% are engaged in agriculture as their primary occupation; another 7% are involved in agriculture as a secondary job.

A large proportion of the respondents, approximately one-third, reported having a second or third job in addition to their main occupation, a phenomenon clearly related to the upheavals of the agricultural economy. In this context the gas industry provides jobs and/or revenues that allow many regional households to cope with the uncertainties of the agricultural economy: 40% of the respondents indicated that they are dependent on income from the gas industry, either in the form of wages from gas industry employment or from revenue generated from gas wells on their property. Altogether, 10% report having some employment with the gas industry, but no wells; 26% report having an income from wells with no gas industry employment; and 4% report income from both sources. Income from the gas industry is derived from wells existing on land owned or leased by farmers and ranchers.

Whereas the regional population is declining overall, there is some degree of stability in the composition of those communities: most of the people who live in the area have been there for a long time, and say they are likely to remain. Over 80% of respondents tended to rate themselves as having a moderate to very high level of knowledge about the GSH, although the number of respondents reporting periodical visits to the area is significantly lower. Levels of familiarity vary across the 8 RMs, with higher levels found in places where people's day-to-day work and travel (e.g., ranchers) bring them closer to the Review Area or to where access to the Review Area is relatively easy.

#### *5.2.2.1 Impacts*

Several issues intersect and influence each other in the GSH Study Area. The main industries of natural gas, ranching/farming, and a modest tourism industry are all affected by variations in the other industries. Likewise, each of these industries affects the communities and residents of the GSH area. Respondents were asked about their preferred options in relation to each of the three economic activities: if they favoured more, the same, or a reduced development (Tables 2-5-1, 2-5-2, and 2-5-3). Overall, two-thirds and three-quarters of respondents support an increase in the development of the gas industry and tourism, respectively. Preferences in relation to ranching, on the other side, were more inclined to maintaining the existing level of development (although one-third of the respondents chose more development). This choice is not a rejection of ranching but rather recognition of the fact that ranching has natural limits for its expansion in the region. "Less development" was desired by some respondents only in the case of the gas industry, where 10% expressed that inclination.

#### *5.2.2.2 Impacts of the gas industry*

Most respondents stated that the gas industry has positive impacts and benefits regional communities (86%) and households (56%) in terms of more jobs, increasing revenues, and larger tax-base revenue to RMs. This enthusiasm, however, is less strong regarding the positive impacts of the industry upon the GSH Review Area. Only 44% of the respondents recognized positive impacts of the industry upon the area, while the rest expressed concerns about damage resulting from road development, chemical spills, and damage to wildlife habitat, plants, and grasses in the area. Benefits of gas activity are reported among both rural and town residents, but people who live and/or work closer to the land (i.e. farmers/ranchers, people who live outside the settlements, people who visit the GSH often) are more likely to see themselves benefiting from the activity of the gas industry.

Most people tend to support further gas development in terms of the benefits for households and communities. Approximately two-thirds of the respondents would anticipate a positive or very positive impact on their household income should gas activity increase, but when it comes to the potential positive impacts of increased gas activity on their communities, the number of optimistic respondents jumps substantially. Over 90% of the respondents expected positive impacts from the expansion of gas industry on employment opportunities and local businesses and services. However, between half and two-thirds of the respondents predicted negative consequences for the GSH Review Area as a result of more gas development. Specific concerns identified with regard to gas activity in the GSH are identified in Table 2-5-4.

Support for gas development is strong among those who own or lease land—they benefit from the existence of gas wells—and yet, they are the same people who express concerns about the negative impacts of gas activity, in terms of quality of life and environmental issues. Two-thirds of those who reported positive impacts to their household stemming from the gas industry are people who own/lease land. Still, landowners were more likely than non-land owners/lessees to report negative impacts.

#### *5.2.2.3 Impacts of ranching*

The impacts of ranching activity on the community are viewed positively by the majority of the respondents (89%). Ranching is thought to hold communities

| Table 2-5-1. Preferred level of the gas industry by RM. | | | |
|---|---|---|---|
| Rural Municipality | More gas industry development | Same amount | Less gas industry development |
| Big Stick | 72% | 14% | 14% |
| Clinworth | 69% | 21% | 10% |
| Happyland | 69% | 21% | 10% |
| Fox Valley | 66% | 28% | 6% |
| Gull Lake | 65% | 26% | 9% |
| Pittville | 64% | 28% | 8% |
| Piapot | 60% | 26% | 14% |
| Miry Creek | 55% | 29% | 17% |

| Table 2-5-2. Preferred level of Ranching by RM. | | | |
|---|---|---|---|
| Rural Municipality | More ranching development | Same amount | Less ranching development |
| Big Stick | 38% | 62% | 0% |
| Clinworth | 47% | 53% | 0% |
| Fox Valley | 40% | 60% | 0% |
| Gull Lake | 41% | 56% | 3% |
| Happyland | 35% | 64% | 1% |
| Miry Creek | 14% | 86% | 0% |
| Piapot | 29% | 71% | 0% |
| Pittville | 33% | 67% | 0% |

| Table 2-5-3. Preferred level of tourism by RM. | | | |
|---|---|---|---|
| Rural Municipality | More tourism development | Same amount | Less tourism development |
| Big Stick | 68% | 32% | 0% |
| Clinworth | 64% | 28% | 8% |
| Fox Valley | 72% | 22% | 6% |
| Gull Lake | 74% | 23% | 3% |
| Happyland | 80% | 18% | 2% |
| Miry Creek | 60% | 40% | 0% |
| Piapot | 51% | 37% | 11% |
| Pittville | 64% | 33% | 3% |

together economically through support of local businesses, and socially through aiding in the retention of population and supporting community events. In terms of the impacts of the ranching industry on the regional household, close to half of the respondents (49%) reported a positive impact and a minority (8%) report negative impacts. Negative impacts of ranching upon households and communities were not directly associated with the activity but rather with the strains of dealing with external problems, such as the BSE crisis. In terms of the GSH Review Area, almost three-quarters believe that ranching had positive impacts, arguing at the well-managed ranching is the best use of the land. At the same time, however, concerns were raised in relation to "damage from overgrazing," or "cattle wearing down grass in high-traffic areas." (Table 2-5-5).

| Table 2-5-4. Impacts of the gas industry on GSH, specified. | |
|---|---|
| Positive impact of the gas industry on GSH, specified | Yes, mentioned |
| Develops roads and trails that can be useful, i.e., for fighting fires | 45% |
| Through such things as EPPs, identify and protect rare species | 31% |
| Develops water sources | 20% |
| Revenue benefits agriculture | 11% |
| Gas industry has good environmental standards | 7% |
| Negative impact of the gas industry on GSH, specified | Yes, mentioned |
| Damage from construction of roads and trails | 46% |
| Ecological damage to wildlife habitat | 44% |
| Ecological damage from drilling | 39% |
| Ecological damage to rare plants | 35% |
| Ecological damage from spills | 32% |
| Ecological damage from introduction of foreign species or noxious weeds | 32% |
| Damage to water supply (including underground sources) | 13% |
| Conflicts with ranching industry (i.e., cattle getting loose, broken fences, etc.) | 10% |
| General environmental damage | 10% |
| Damage from gas crews, i.e., garbage | 6% |

| Table 2-5-5. Impacts of Ranching on GSH, specified. | |
|---|---|
| Positive impact of Ranching on GSH, specified | Yes, mentioned |
| Belief that well-managed ranching is the best use of the land | 57% |
| Positive impacts to the ecosystem | 44% |
| Water development has been positive for plants and animals in the area | 22% |
| Environmental benefits, based on ranchers' attitudes/activities | 11% |
| Environmental benefits, physical benefits of ranching | 7% |
| Negative impact of Ranching on GSH, specified | Yes, mentioned |
| Damage from overgrazing | 54% |
| Damage from cattle trails or high-traffic areas around water | 38% |
| Environmental concerns, generally | 27% |
| Ranchers control of land and access | 7% |

When asked to consider an increase or decrease in ranching and the effect of this change, the majority of our respondents (63%) indicated a preference for ranching to remain at its present level and only 1% called for less ranching activity. The remainder (36%) called for more ranching activity in the area. In the case of a hypothetical expansion of ranching, over two-thirds of the respondents predicted no impact on their households. When asked to consider the potential impacts of increased ranching on the community, respondents showed much more optimism about the positive spin-offs of such an increase than was the case for their individual households. In reflecting on the potential impacts of increased ranching on the GSH Review Area, over one-third of the respondents expressed concerns about negative impacts on active sand dunes, effects of roads and trails, soil and sand erosion, and impacts on grasslands. People living outside of the towns and people involved in agriculture are more likely to fear negative consequences emerging from more ranching than is the case for townspeople and those not involved in farming and ranching.

#### *5.2.2.4 Impacts of the tourism industry*

Most respondents see advantages for their community from the tourism industry, but not necessarily for their own households. Those who do see direct benefits for their families tend to live in a town or village. Three quarters of the respondents suggest that tourism promotes education and awareness about the GSH Review Area; yet many believe that tourism disrupts the ecological conditions of the GSH (Table 2-5-6). Although most respondents tend to downplay the potential negative impacts of tourism to the GSH, most call for a careful and controlled approach to tourism development.

Because tourism is not currently a significant factor in most people's lives, few people predicted any impact from an increase or decrease in tourism on their households. In the case of communities, more tourism is seen as potentially being highly beneficial for local employment and businesses. Thus, concern is expressed by more respondents when it comes to the potential negative consequences for employment and businesses in local communities from such a decrease. Finally, with regard to the GSH Review Area, the respondents in the sample are divided on whether increased tourism would have negative effects or no effects.

#### *5.2.2.5 Cross impacts*

Participants were also asked whether the three main industries in the area impact each other. Approximately two-thirds indicate that the gas industry has the potential to affect the ranching industry (Table 2-5-7). The impact mentioned most often, by 32% of participants, was positive contribution to ranching income. The negative impact identified most frequently, by 15% of participants, concerned the potential impact of gas activity on grazing pastures.

### 5.2.3 Key Observations

The existence of a vigorous gas industry in the area, and the financial infusion that this industry provides to people, businesses, and communities, sets this region apart from other areas of the southern region of the province. The people of the GSH Study Area, as with many other rural areas, are vulnerable to the upheavals of agricultural markets and climatic events. In this context, the

Table 2-5-6. Impacts of Tourism on GSH, specified.

| Positive impact of Tourism on GSH, specified | Yes, mentioned |
|---|---|
| Promotes education and awareness about the GSH | 74% |
| Brings attention to conservation of native prairie areas | 57% |
| Exploration and travel in the area are somewhat controlled | 26% |
| Hunters control animal populations | 2% |
| Keeps environmental hazards down, must be sensitive to environment | 1% |
| **Negative impact of Tourism on GSH, specified** | **Yes, mentioned** |
| Increased garbage left from tourists | 48% |
| Disruption from increased traffic in the area | 40% |
| Damage from tourists and hunters leaving designated paths and trails | 36% |
| Increased fire risk from cigarettes, exhaust pipes, etc. | 32% |
| Ecological damage from tourists picking rare/endangered species of plants or flowers | 28% |
| Damage to grass/plants from foot traffic | 10% |
| Damage from vehicles, ATVs, and Crazy Carpets | 6% |
| Loss of food sources for wildlife when tourists pick berries | 4% |
| Vandalism | 3% |

| Table 2-5-7. Percentage identifying potential for industry A to affect industry B. | | | | |
|---|---|---|---|---|
| | | Industry B | | |
| | | Gas industry | Ranching industry | Tourism industry |
| Industry A | Gas industry | | 63% | 30% |
| | Ranching industry | 28% | | 26% |
| | Tourism industry | 11% | 20% | |

presence of a gas industry contributes to a reduction of that vulnerability by providing additional revenue and employment to a large number of households. For a large proportion of the respondents, the community benefits most from the presence of the gas industry. These benefits involve more revenues for established local business and employment for local people; however, concerns are expressed about road damage and issues related to a transient workforce. Enthusiasm is less strong regarding the positive impacts of the industry upon the GSH Review Area. Over half of the respondents expressed concerns about ecological damage resulting from the development of the gas industry in this area.

Although a majority of respondents hold a positive view of the gas industry and are in favour of its continuation and expansion, those same people express concerns over the impacts of the industry at every level. It would be unfair, however, to characterize the juxtaposition of these seemingly contradictory attitudes as ambivalence. The co-existence of opposing attitudes can be taken as evidence of a well-rounded knowledge among community members of the competing interests involved in the gas industry in the GSH region, the high relative importance of each, and the awareness of the necessity to find a balance.

Ranching, a traditional and long-established industry in the GSH region, was assessed positively by most of the respondents, and ranchers were perceived as responsible users of the land. Close to half of the respondents positively assess the impacts of ranching on the households, and nine out of ten note the positive impacts of ranching on the local communities. In terms of the GSH Review Area, most believe that ranching had positive impacts, arguing that well-managed ranching is the best use of the land, although concerns were raised in relation to overuse of the resources. Relatively few people believe that either an increase or decrease in ranching will have an effect on their own households. There is, however, a rather higher level of concern when it comes to the impact of a change in the level of ranching on the community. Most people feel that more ranching will benefit the businesses and services in their community, with few negative repercussions. Finally, most respondents do not feel that there would be any impact on the GSH environment if ranching were to either decrease or increase. Those who express concerns tend to be mostly farmers and ranchers.

Of the three industries, tourism is the least developed and the one that exists mostly in the form of a potential to be developed. The assessment of the current impacts of tourism on communities and the GSH Review Area were highly positive. Conversely, relatively few respondents—one in five—recognized positive impacts upon the household. Most of the enthusiasm for tourism is expressed by people who live in the towns and villages and among those employed in their own businesses, as opposed to farmers and ranchers, employees, or people outside the workforce.

## 5.3 PARTICIPATORY GIS WORKSHOPS

Sessions were held with select interest groups between July and October 2006. The approach was to engage each interest group separately. The Scientific Advisory Committee consulted with the GSH Planning District Commission for suggestions on participants for the rancher and community sessions, with Saskatchewan Environment regarding government and environmental non-government organizations (ENGOs), and with the Canadian Association of Petroleum Producers regarding gas industry representatives. The first survey session was held with the GSH Planning District Commission, followed by sessions with representatives of the ranching community, the towns and RMs, government, ENGOs, the gas industry, and Treaty 4 (File Hills Qu'Appelle) and Treaty 7 (Blood Tribe) First Nations (Table 2-5-8).

### 5.3.1 Methods

Survey sessions were structured in two parts. The first part of the survey session was intended to: i) provide the participants with a description of the objectives

| Table 2-5-8. Survey session participants and session schedule. | | | |
|---|---|---|---|
| Group | Date | Location | Participants |
| GSH Planning District Commission | 18 July 2006 | Hazlet, SK | 11 |
| Ranchers | 8 August 2006 | Fox Valley, SK | 19 |
| Communities | 9 August 2006 | Leader, SK | 11 |
| Government | 16 August 2006 | Regina, SK | 10 |
| ENGOs | 17 August 2006 | Regina, SK | 12[1] |
| First Nations, T4 File Hills Qu'Appelle | 27 September 2006 | Fort Qu'Appelle, SK | 4[2] |
| Gas Industry | 28 September 2006 | Calgary, AB | 10[3] |
| First Nations, T7 Blood Tribe | 10 November 2006 | Standoff, AB | 10[4] |

1. Note additional survey session was held with one individual who was unable to attend the planned session with other ENGO representatives.
2. FHQ interests were represented by an Elder's Advisory Committee formed for this study.
3. Gas industry participants represented 8 different gas industry companies.
4. Blood Tribe participants were identified and assembled by the Blood Tribe's own research coordinator.

associated with the survey and identify any issues about the process and modify accordingly; and ii) identify goals that participants have for the GSH, including a discussion of issues and opportunities associated with achieving goals and objectives. The focus was on the social, economic, and natural capital of the GSH. During the session, participants worked in small groups (with the assistance of technical staff) and, when feasible, entered information into a computer file system that allowed them to see the range of goals, objectives, issues, and opportunities that they identified.

The second part of the survey focused on a discussion and identification of preferred land use for the GSH. Depending on the session, participants either: (i) worked together in small groups (with the assistance of technical staff) to view on the computers a variety of mapped information for the area, and discussed possibilities regarding the occurrence and distribution of preferred uses of the GSH; or (ii) stayed as a group and viewed mapped information on a central screen around which they engaged in joint discussion.

The approach varied as a result of time constraints and was modified for First Nations sessions based on consultation with the File Hills Qu'Appelle and Blood Tribe research coordinators.

### 5.3.2 Survey Session Summary Results

Amongst several participant groups, common natural, social, and economic capital goals or targets for the GSH could be identified. Identification of these goals depended, in part, on the group's views and understandings of the area and how the survey sessions unfolded in terms of time and topics of interest to the participants. Summarized in Table 2-5-9 are a number of goals or targets that emerged from the survey sessions. The First Nations (Treaty 4, File Hills Qu'Appelle, and Treaty 7, Blood Tribe) and gas industry session participants chose to discuss more broadly their values or concerns for the GSH, rather than identify specific natural, social, and economic goals and targets.

The level of discussion and detail differed between the File Hills Qu'Appelle and Blood Tribe First Nation participants. However, a common goal expressed by both was the need to preserve the GSH and to discontinue gas development across the region. Preservation of land, particularly in and around the current RAER, was seen as a priority for both spiritual reasons and for access to the land to perform ceremonies and other traditional activities such as hunting and collecting of medicinal plants. Enhanced protection of disturbed cultural sites also was identified as a common goal, as was a more open and consistent communication process between First Nations, government, and locals, in particular communities and ranchers. Some elders identified distrust towards First Nations from the locals within the GSH as being a barrier to access in the area and felt that the distrust was unwarranted. The need for a more detailed traditional use study of the GSH Review Area before further development and planning decisions are made was recognized by both participant groups.

Table 2-5-9. Survey session summary: goals and targets for the GSH.

| | Natural capital goals or targets | Social capital goals or targets | Economic capital goals or targets |
|---|---|---|---|
| GSH Planning District Commission | i) maintaining or improving the ecological sustainability of the area in relation to gas and ranching; ii) increasing protection of the area both in a spatial context and at the regulatory level; iii) managing access to the area, as well as monitoring and implications for infractions such as fines and reclamation; iv) acquiring First Nations knowledge of the area may be beneficial to the purpose of ecological sustainability. | i) increasing the population base, keeping people in the community, and decreasing stress within the family and enhancing quality social outlets; ii) enhancing localized stable services, particularly in regards to health care and secondly, increasing economic opportunities either within present activities or with additional prospects. | i) viable and sustainable present day economic practices, including land and water management, and diversification towards hunting and tourism focuses; ii) education in ranch and water management in order to reduce expenditures and increase profit in an efficient, adaptable, and environmentally sustainable way. |
| Ranchers | i) maintaining the ecological integrity and better management of gas and tourism, industries with the potential to adversely affect the region particularly in terms of land degradation, invasive species, and water quantity and quality; ii) ensuring responsible development through better monitoring and education, with a larger contiguous conservation area maintained on land that is deemed most sensitive to disturbance; iii) sustaining development by minimizing its imprint through, among other actions, reducing the number of trails. | i) loss of young and senior population due to economic opportunities in Alberta for the former, and by the lower taxes for the latter; ii) lack of educational opportunities and proper health care facilities. | i) payment of ranchers for good management practices; ii) equity in payments from gas development for compensation to lessees as opposed to payments for those with deeded land; iii) justly compensating ranchers for their monitoring activities. |
| Communities | i) adequate and strong regulations, independent monitoring-enforcement to ensure best management practices, and a sustainable environmental gas development practice; ii) expansion and development of stronger preservation, protection, conservation or restoration areas, particularly regarding relatively intact areas and the need for balancing the conservation effort in the south portion of the GSH. | i) education efforts to raise public awareness and understanding of the GSH environment, combined with better acknowledgement of the ranching lifestyle; ii) direction of royalties from the gas industry to better support local infrastructure and social services. | i) ranching activity is seen as an integral part of the GSH area and, while ranchers are stewards of the land, restoration and stronger agricultural land-use practices were suggested; ii) stronger environmental regulation and monitoring of the gas industry, combined with increased local government control of land use; iii) increased monitoring and management of hunting activity; iv) possibility that TLE lands could be available for purchase by non-First Nation populations. |
| Government | i) maintenance/improvement of existing *biodiversity and ecological integrity* of the GSH through conservation efforts including the expansion of protected areas and reduction of fragmentation (roads) and access, remediation of disturbed sites, restoration of ecotones and native grassland, development of corridors, control of invasive species, and monitoring of endangered species; ii) maintenance of the *sustainability of the water resources*, with best management practices for water systems and the maintenance of the water table status. | i) maintain/ facilitate a strong/cohesive/ viable *sense of community or community spirit*; ii) maintain/ increase the community *infrastructure or social network* (i.e., services and infrastructure such as healthcare, education, roads and highways, social programs, and facilities); iii) maintain/ increase the population in the area, keeping the young population and attracting the retired population; iv) stronger inter-municipal cooperation; v) maintain the *family ranching lifestyle*, and better definition of viable economic ranching units by government policy. | i) increased economic diversification of the area; ii) keeping revenues from the gas industry in Saskatchewan; iii) higher value of local agricultural products; iv) economic/ business plan. for the region and better coordination and integration of government levels and sector departments. |
| ENGOs | i) preservation, conservation, maintenance of the natural environment, and a reduction in gas development impacts on native prairie through best management practices; ii) maintenance of the *sustainability of the water resources*, along with an assessment of present water conditions and a consistent system of water quality and quantity monitoring. | i) maintain or sustain quality of life through, among other things, access to adequate social services, health, and education. | i) ensure ecological objectives are considered for any economic development and/or diversification; ii) promotion of eco-tourism in an ecologically friendly way as a viable option to increase economic health within the area. |

Gas industry representatives identified a number of issues and concerns that need to be considered for the current RES and for future planning and management of the GSH, including:

- Acknowledgement of the link between impacts associated with recoveries to the time frame of recovery. Longer recovery times allowed for lower impact development. If an objective is to minimize surface disturbance, longer recovery time periods are required.
- More restrictive exploration and development constraints will result in less future exploration and development.
- The rights of the various industries in the GSH need to be balanced so that no one industry bears greater penalties than another.
- The gas industry is in favour of fewer roads and minimizing surface disturbance because that will lead to economic savings.
- Best management practices to reduce impacts should be developed in consultation with the industry and in cooperation with other stakeholders.
- Although the GSH has not experienced substantial reclamation activities, the gas industry feels that such activities will form a larger part of management practices.
- An "orphan" fund is being set up within the industry to address concerns about wells that require servicing or reclamation but for whom no responsible owner can be identified or held accountable. Industry representatives noted, however, that drilling is not allowed without the clear capacity of the drilling company to cover costs associated with accidents.
- Clear regulations and rules are needed, as opposed to guidelines, in order to ensure that all are following the same requirements to the same standards.
- Too few competent people are available to serve as environmental monitors.
- There are probably areas within the GSH in which no development should occur.

#### *5.3.2.1 Perceived threats to goals and targets for the Great Sand Hills*

Alongside the goals and targets for the GSH, session participants identified a number of threats or triggers of concern to the region and to meeting those goals and targets. These are summarized here across participant groups, and according to each of natural, social, and economic capital. For detailed results by survey session and by participant group, see Gauthier et al. (2006):

*Natural capital:* An issue consistent across most participant groups was industry development and industry practices within the area, and subsequent perceived repercussions on the landscape. The gas industry was identified to be of most immediate concern in relation to sustaining the natural environment and ecological integrity of the GSH, particularly in terms of road and trail development and the implications for biodiversity, habitat fragmentation, and introduction of invasive species. Whereas ranchers were identified by many as stewards of the land, there is recognition of the environmental disturbance (e.g., dugouts and damaged pastures due to overgrazing) produced by ranching practices and malpractices. The current economic farming-ranching pressures (i.e., farming-ranching market) were identified as an important driver of landscape disturbance and unsustainable use of water resources. Threats to ecological integrity also extended to the tourism industry, in particular uncontrolled tourism activity and unrestricted access to the GSH through the large number of roads and trails that exist.

Limited baseline knowledge and incomplete understanding of impacts were identified as concerns, coupled with inconsistencies in and non-compliance with best management practices across industries operating in the region—in particular the gas industry. Limited environmentally sustainable targets and the lack of incentives and monitoring/enforcement were identified as threats to the region; one group identified the lack of an agency in charge of overseeing environmental management and monitoring as particularly problematic. The lack of understanding of water systems, an uncontrolled and uncoordinated use of water resources, water contamination, and climate change (drought), combined with competing and increasing water demands, were identified as threats to the integrity of the region.

*Social capital:* Many of the threats to social sustainability goals and targets in the GSH region are no different from those for any other rural area of Saskatchewan. For example, the lack of education, health, and other social and infrastructural services, such as road conditions, were seen as contributing to an already declining rural economy and population base. Local populations are forced to travel to nearby larger centers for access to goods and services, and the lack of incentives to bring such services to the rural community and poor road infrastructure accentuate the problem. It is difficult to retain youth in the region due, in part, to limited economic opportunity, and much of the older population is forced to relocate to areas where the necessary health and other social support services are available. An additional concern was the uncertainty over TLE settlements and changes in land tenure.

*Economic capital:* Many of the threats to economic sustainability are closely linked to social conditions, such as the lack of adequate services (e.g., doctors, dentists) and infrastructure (e.g., roads) geared to support the economic goals and/or attract a young and skilled workforce to the area. Related to this is the lack of capacity in terms of local skilled or educated personnel, and limited incentives (e.g., taxation) as a threat to attracting and maintaining people. Other key threats to the region included limited economic opportunity outside of the oil and gas sector, coupled with poor economic conditions and instability in farming and ranching. Low income to agricultural producers based on subsidies combined with higher leases and taxes and lower returns in the ranching sector were of key concern. Additional concerns circulated around adaptability to threats such as climate change, animal disease, and unknown or as yet unidentified threats stemming from increased access to the area. Uncertainty over ranchers' rights to the land in relation to TLEs and ranchers' ability to make a living off the land was also raised.

#### *5.3.2.2 Land use*

Desired land-use patterns and zoning for the GSH varied considerably across participant groups. While all recognized competing interests and the need for some increased level of conservation, not all agreed on the nature and extent of zoning or priority land use designations. Summarized below are selected results from the survey sessions. Maps produced by session participants are depicted in Figures 2-5-1 to 2-5-5.

*Great Sand Hills Planning District Commission:* Discussion regarding land-use zoning focused on six major topics. First, the need to establish conservation areas with enhanced protection, including representation of habitat and landform diversity, coupled with an expansion of the current RAER (Figure 2-5-1). Second, recognition of the importance of ranching in the GSH and subsequent zoning of the entire region as ranching land, along with a stated need for further promotion and understanding of best management practices for water and rangeland management. Third, the need for a road and trail management plan with emphasis on the gas industry. Fourth, designation of two small areas for tourism and recreation, specifically eco-tourism, in the detached small southern portion of the Review Area and in a small plot located in the northwest of the Review Area (which is already used as a spot for tourism). Tourism, both eco-tourism and tourism with a First Nations focus, were seen by some to be an unexplored potential. Hunting was viewed as acceptable for the entire Study Area with limited trail access. Fifth, gas development, although viewed as having an economic benefit for the area, was recognized as having the potential for cumulative impacts. Preference was expressed for downsizing gas well spacing on the perimeter of the Review Area to access gas only from the very edge. Finally, current land occupants are cautiously accepting of First Nation ceremonial use of the GSH but fear an ulterior motive to access for spiritual ceremonies.

*Ranchers:* Four major land-use issues were identified and discussed by the ranching participant group. First, an area should be set aside for tourists, which would grant only limited access to the GSH Review Area. Second, ranchers were generally accepting of First Nation involvement within the area in relation to spiritual and religious ceremonies; however, there were some concerns as to whether access for such purposes would lead to securing secure minerals or additional access for hunting. Third, ranchers did not see any great economic benefit in gas development using present technology as practiced in the area, to themselves or to the community. Fourth, in terms of ranching, water availability was raised as the main issue, but obtaining provincial governmental approval for water involves a considerable number of bureaucracies.

*Community:* The need for some protection of lands in the southern portion of the GSH area was raised, as well as the need to restrict tourism activity to well defined and selected areas. The

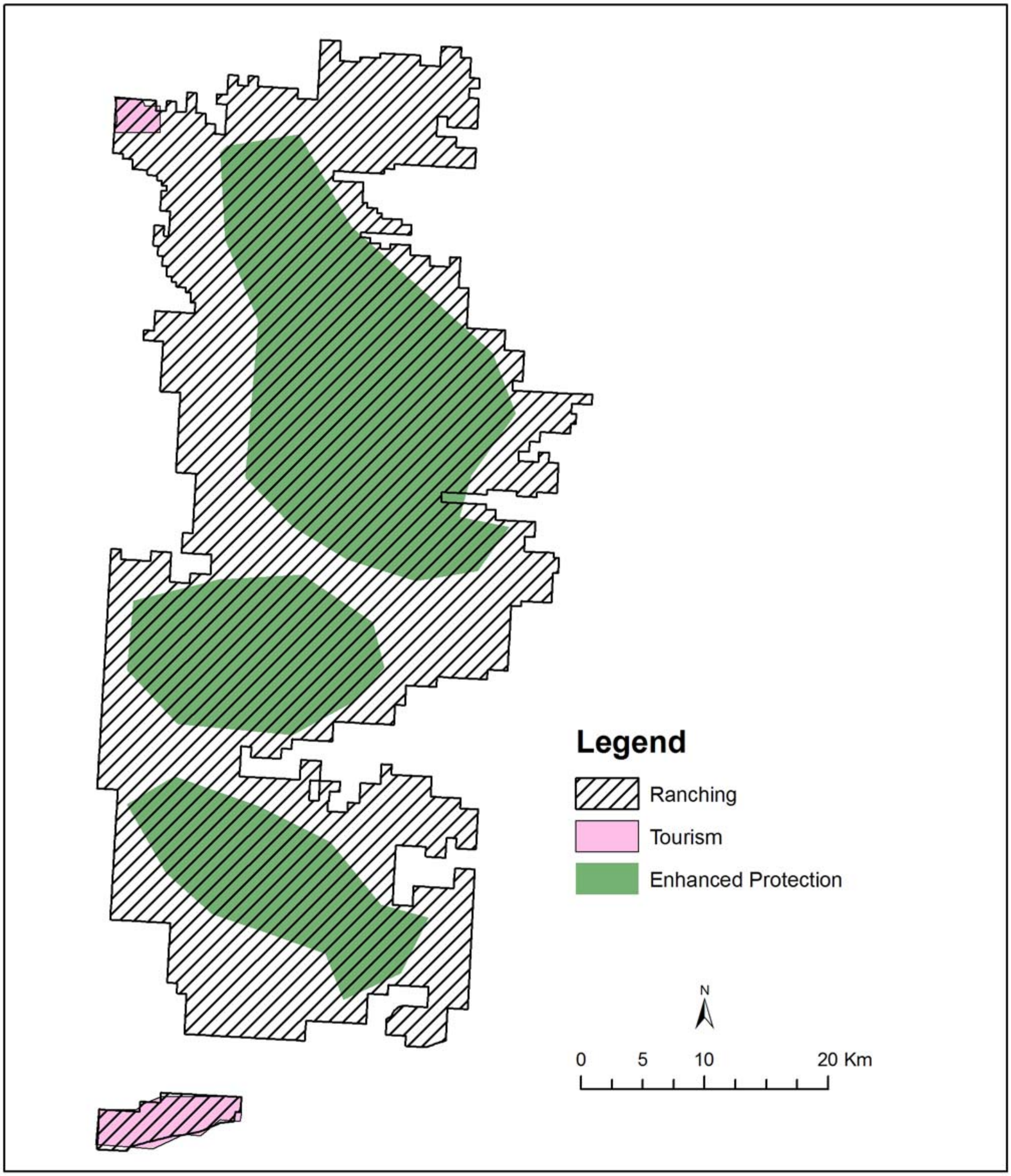



Figure 2-5-1. Land-use map generated by Great Sand Hills Planning Commission participatory GIS workshop participants.

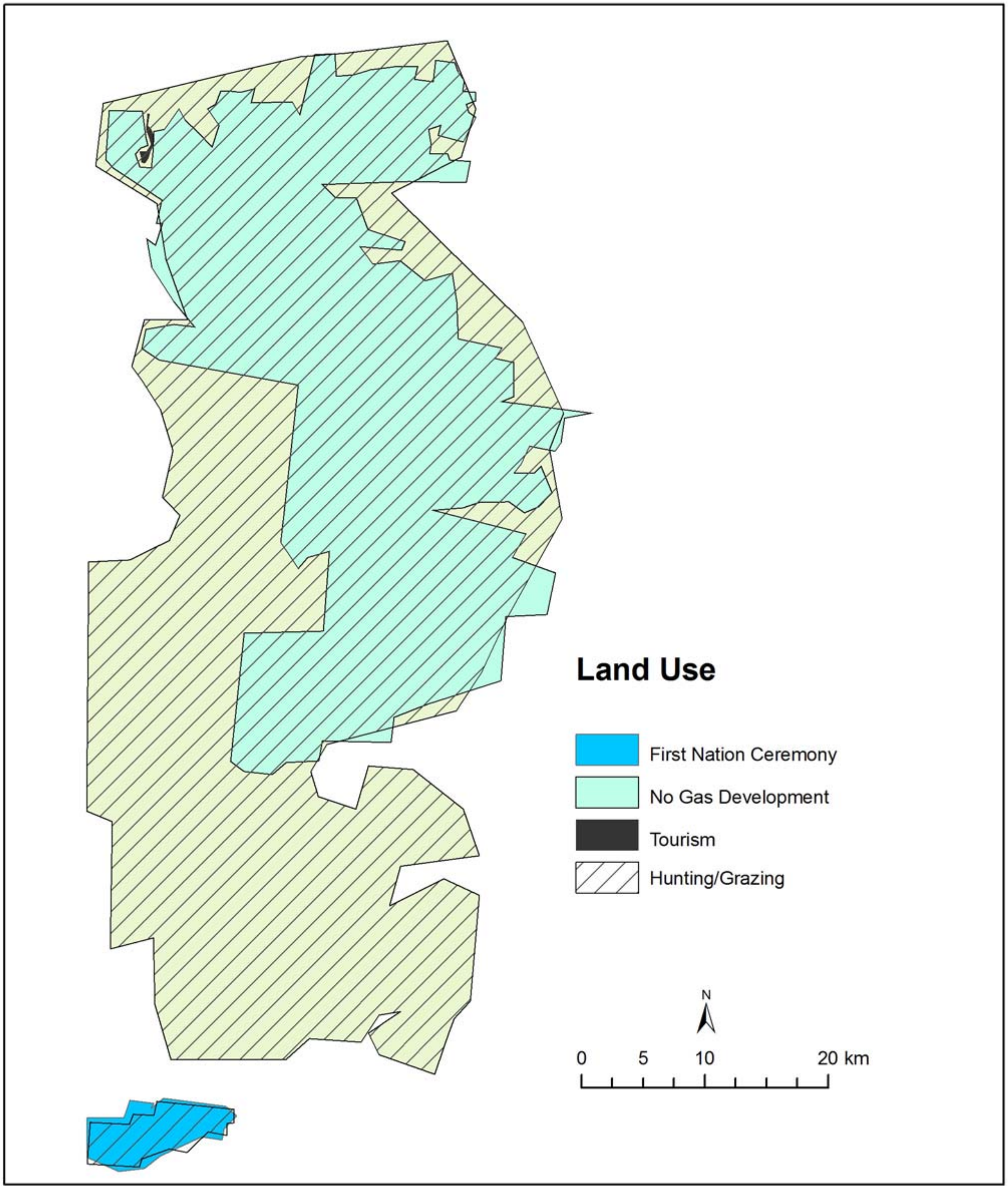



Figure 2-5-2. Land-use map generated by Government participatory GIS workshop participants.

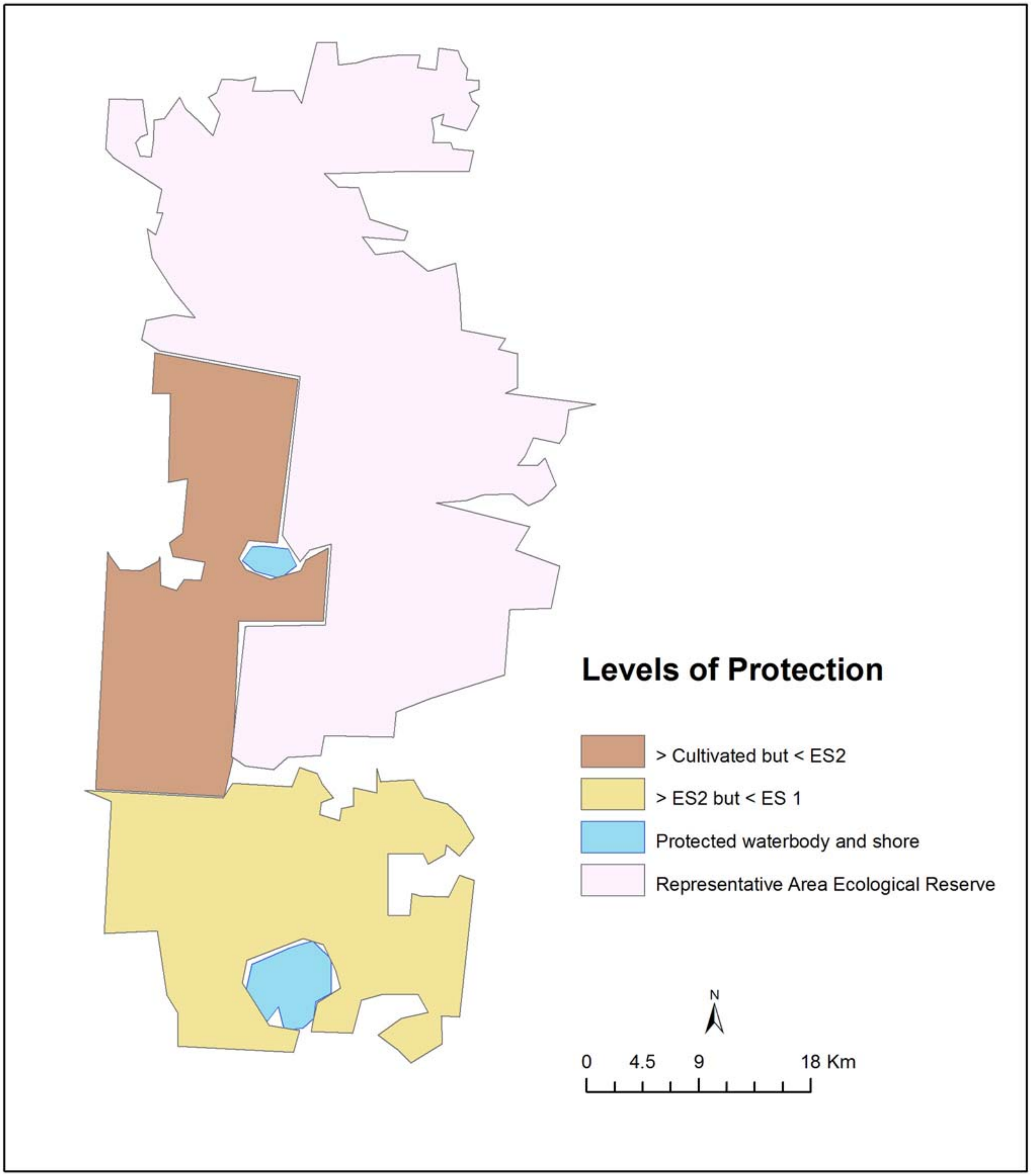



Figure 2-5-3. Land-use levels of protection map generated by Government participatory GIS workshop participants.

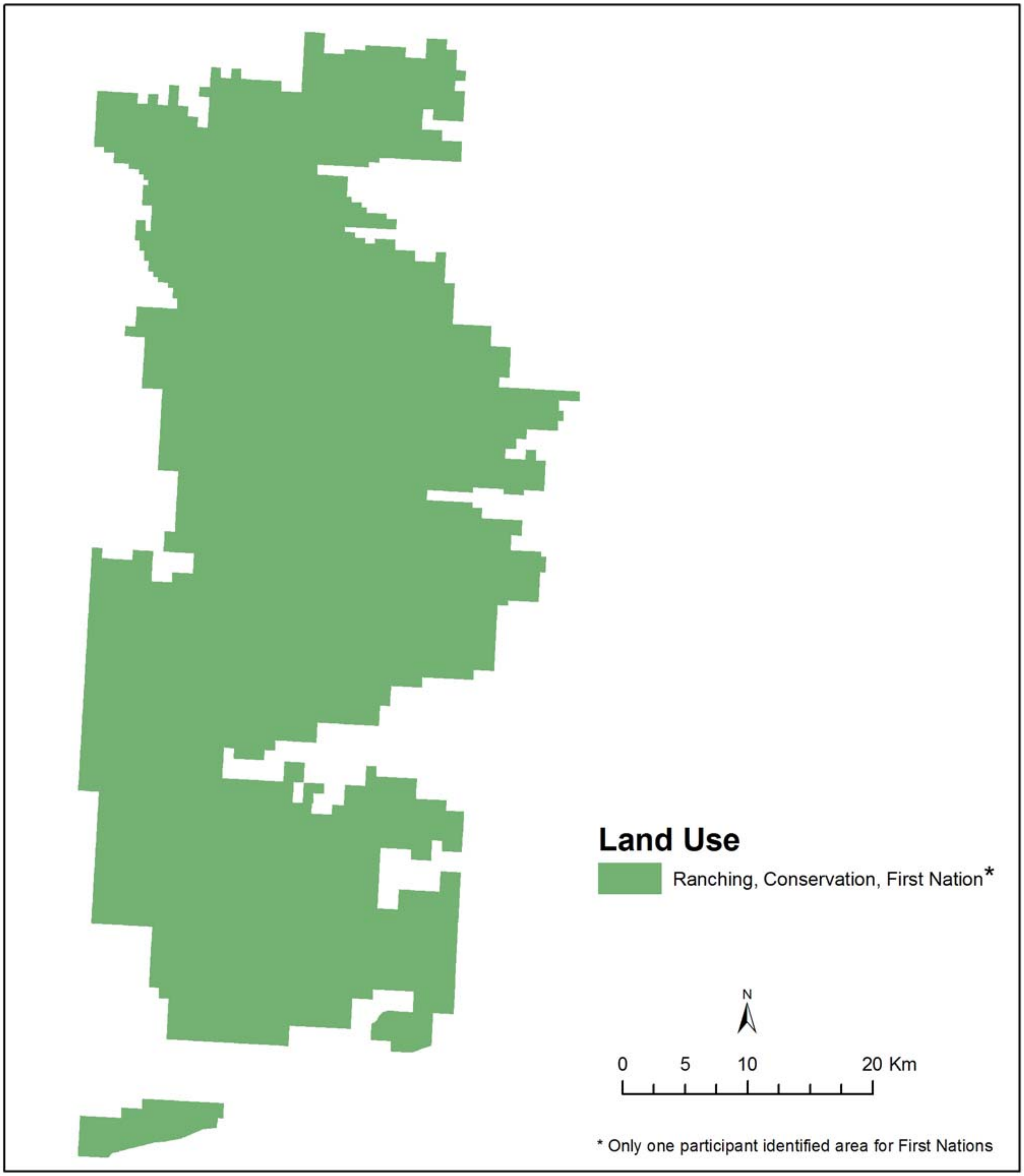



Figure 2-5-4. Land-use map generated by ENGO participatory GIS workshop participants.

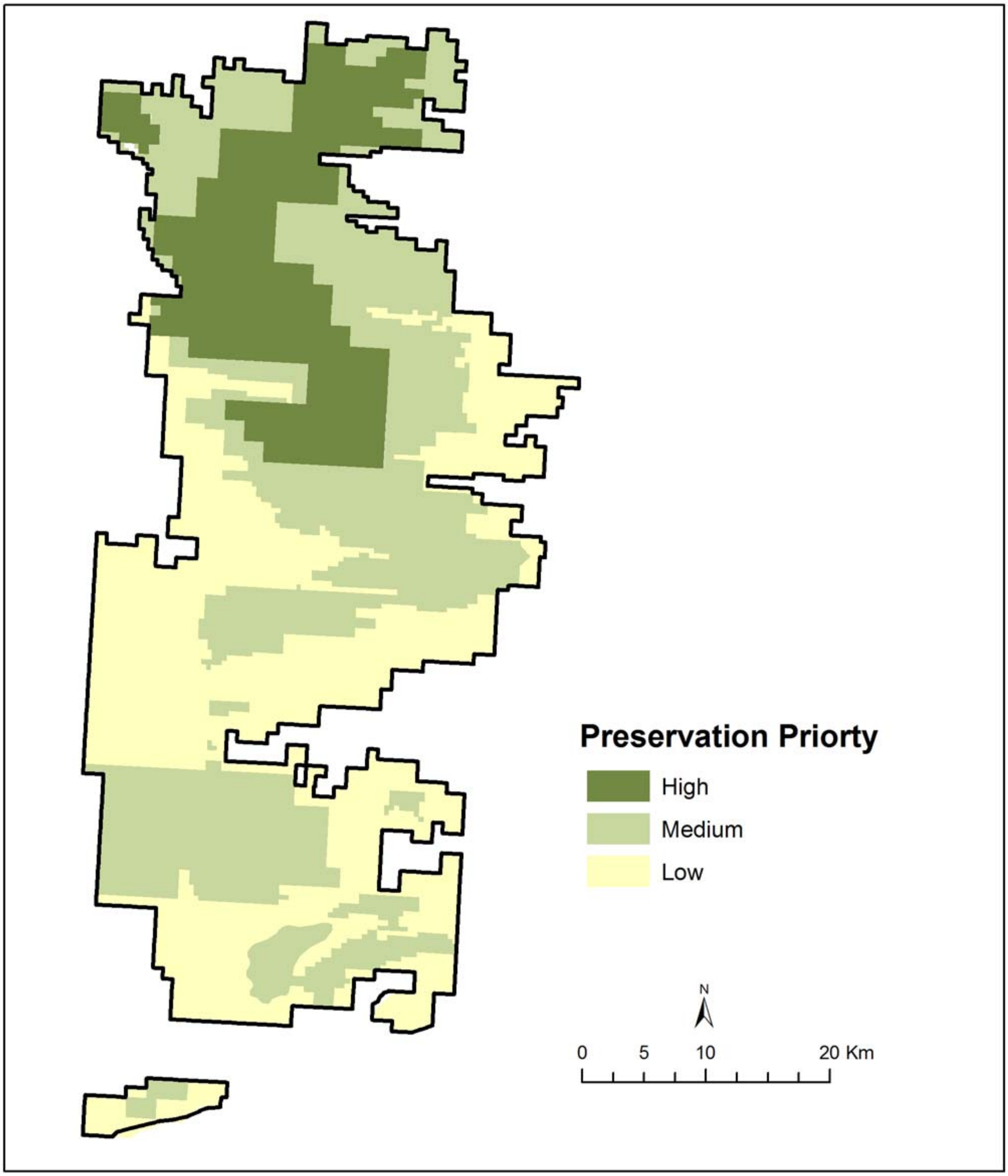



Figure 2-5-5. Land-use map generated by Treaty 4 FHQ elders.

distribution of ranching activity was said to be constrained primarily by existing grassland; water is already being piped. Strong suggestions were made for allowing gas development only if best management practices are followed, and if development occurs on frozen land. Moreover, drilling should be done from outside the boundary of the GSH area. Finally, First Nations access for spiritual and ceremonial purposes was not seen as a problem; however, there were concerns raised in terms of TLEs and mineral rights.

*Government:* Participants in the government sub-groups identified the following points regarding land use. First, the GSH Review Area should allow all land uses under a land-use plan, best management practices, and strict regulations. Second, family ranching was identified as the main land use in the GSH, and it should be maintained in family units. This will serve to sustain native habitats, but will also require people to turn to secondary employment such as gas and oil for jobs. Third, where there are active dunes, no traffic should be allowed for oil and gas activity, rather only guided access to minimize disturbance (see Figure 2-5-2 and 2-5-3). No more roads or pipelines should be put into the sensitive areas, and the industry should wait until adequate technology has been developed. If development occurs, it should happen outside the sensitive areas, not within them, and those areas that have not yet been touched by gas development should be left alone. Fourth, First Nations access is not an issue as long as they are willing to follow conservation rules. There should be no TLE lands in the sensitive areas unless it is a traditional spot, and any First Nations used land should be for surface use only. Fifth, tourism should be guided in ES1 areas. Finally, a minimum 5-km buffer should be established around the area, particularly towards the west side, and the area should be connected by corridors to the South Saskatchewan River to the north. A second corridor could link the Piapot isolated area all the way to the Cypress Hills, linking to the sand hills in Alberta.

*ENGOs:* The sub-groups participated in a wide-ranging discussion of land-use issues that tended to be at a comprehensive rather than a detailed geographic scale. In terms of conservation, for example, it was suggested that the area be zoned for regulatory hunting and tourism (but tourism restricted to one point per RM), but exclude any gas development. Ranching was identified as a sustainable and viable land use in the region, as was First Nations access for medicinal, spiritual, and religious ceremonial purposes. It was noted that there should be sensitivity and consideration for Blackfoot First Nation issues and concerns in this regard. It was suggested that the entire area be set aside as an ecological reserve, and the gas resource viewed as a heritage for future generations with no further development until adequate best management practices are developed (Figure 2-5-4).

*First Nations:* Common themes emerged across the File Hills Qu'Appelle and Blood Tribe sub-groups in terms of the cultural and ecological significance of the GSH, and the need for broader areas of protection. It was noted that gas development destroys medicinal plants and disturbs ancestral sites, and it was suggested that no new gas activity be permitted. The File Hills Qu'Appelle sub-group suggested that ranching was not a major concern; however, enhanced communication to ensure land use and access was needed. Tourism was not seen as an issue for the File Hills Qu'Appelle sub-group or even as a concern. Both the File Hills Qu'Appelle and Blood Tribe sub-groups noted the importance of maintaining intact habitat, such as the current RAER. In terms of access, the File Hills Qu'Appelle sub-group noted that access to all land in the GSH Review Area should be granted for hunting, ceremonies, and to obtain medicinal plants.

A map was derived with input from File Hills Qu'Appelle elders on preferred land uses, which accurately reflected their views on the preservation of First Nations culture and use within the GSH area (Figure 2-5-5). Areas with highest development (disturbance) have the least value in relation to medicinal plants, whereas those with little or no development are considered to have higher preservation priority. Within this context, it was noted by the Elders that the present Representative Area Ecological Reserve (RAER), ES1, and ES2 zoning best reflected their own priorities within the Study Area. That is, the areas with highest present protection had the most medicinal value and thus warranted the highest priority for continuing protection. Areas with decreasing levels of protection had more development and subsequently were of a lesser priority for preservation. The group expressed an interest in unrestricted access to areas with the highest priority (RAER) for the purpose of ceremonies and plant gathering. The Blood Tribe participants chose not to map priority areas without a more detailed land-use study.

### 5.3.3 Discussion

Primary concerns for the GSH region were the impacts of gas exploration and development, insufficient monitoring and controls in relation to surface disturbance, lack of clarity regarding land-use regulations, and the need for programs that foster population growth and stimulate economic opportunities. There was a general consensus on maintaining the ecological integrity of the Review Area and concerns over any practices that would result in significant surface disturbance to the GSH. Environmental policy enforcement and monitoring were regarded by many stakeholders as inadequate and requiring strengthening, and access to and sustainability of water was an important concern.

Ranching was generally regarded as an acceptable land use within the area subject to application of best management practices that reduce surface disturbances. Many respondents agreed that compensation for practicing BMPs should be considered. Overall, there was agreement that access to the area should be carefully monitored and controlled by the gas industry, tourists, or others. The lack of adequately trained and available environmental monitors for gas developments is a concern.

Restrictions on land use are acceptable if fairly balanced across land uses, but a trail and road management plan was considered important for the sustainability of the area, as was the need for increased protection in the southern portion of the Review Area. Access to the area by First Nations for ceremonial or spiritual purposes was a key concern for First Nations participants. Such access was generally acceptable to other participants, but there were concerns regarding the intentions of First Nations with respect to possible TLEs.

Policies that would stimulate population increases within the region and economic diversity were considered essential to sustainability of the area. Views varied on the extent to which expansions of gas development and tourism would result in tangible benefits to local residents and communities. The need for clear rules and regulations across governments was identified as an important issue, and there was a general sense that consultation opportunities with government were inadequate, fragmented, and too complex.

# Chapter 6: Economic Capital Baseline Assessment

## 6.1 INTRODUCTION

The purpose of the economic capital baseline assessment was to characterize the current economic conditions of the Great Sand Hills region and to establish future potential economic values for scenario assessments. The scenario assessments are projections of the possible trade-off between forms of economic activity such that any proposed land-use change or surface disturbance minimization strategy is understood within the context of the economic potential associated with the proposal. The baseline report is presented here in two parts based on Cecil (2006). The first part summarizes the findings of the economic baseline study, presenting an economic valuation of activities in the Study Area according to dominant economic sector activities. The economic baseline study consisted of five objectives, to:

- identify the dominant sectors of economic production in the Study Area and characterize their production and economic contribution;
- describe the amount of economic capital invested;
- distinguish investment capital according to private and public sector sources;
- characterize economic sectors according to their economic contribution;
- characterize the economic costs and benefits associated with mitigation, restoration, enhancement, and monitoring activities.

The second part addresses government revenue and projected and potential economic activity in the region. This section of the economic assessment was intended to provide economic context and perspective to final scenario development. The objective of the government revenue baseline was to characterize provincial and municipal revenues, expenditures, and investments in the Study Area. The government revenue baseline study consisted of two objectives, to:

- identify sources of provincial and municipal government revenues, expenditures, and investment associated with gas exploration and development, agriculture, recreation, and tourism;
- characterize provincial and municipal government investment associated with mitigation, restoration, enhancement, and monitoring activities associated with various forms of economic activity.

## 6.2 METHODS

The economic baseline study was compiled based on statistical review of available economic data; a literature review to gain insight to the nature of human responses to changes in the economic landscape; and interviews with representatives from the RMs, the Great Sand Hills Planning District Commission, and oil and gas companies operating in the GSH region. Data sources included Statistics Canada, the Saskatchewan Bureau of Statistics, office of the RMs of the GSH, and offices of the communities in the GSH. Archival information was collected from documents and other materials from the office of the RM of Clinworth, which houses historical documents related to the Great Sand Hills Planning District Commission; documents and other materials from the Great Sand Hills Planning District Commission office in Sceptre; newspaper clippings, local newsletters, and relevant publicly documented correspondence to the Planning District Commission; government records; on-line materials related to economic activities in the region; and non-confidential documents collected from local communities and businesses.

The government revenue baseline and economic model for the region were developed based on data collected from the above same sources and cross-referenced for validity where possible. The data were subject to modeling in linear, quadratic, cubic, and multivariate formats to establish best fit, processed with SPSS (the Statistical Package for the Social Sciences), and fit to an overall model (Grand Model) to assess Total Economic Activity under Current Productivity (TEACUP). The model approach is conceptualized in Figure 2-6-1 and detailed in (Cecil 2006).

Data quality and availability posed a number of limitations to the economic baseline and model. Economic data are often presented as spatially aggregated

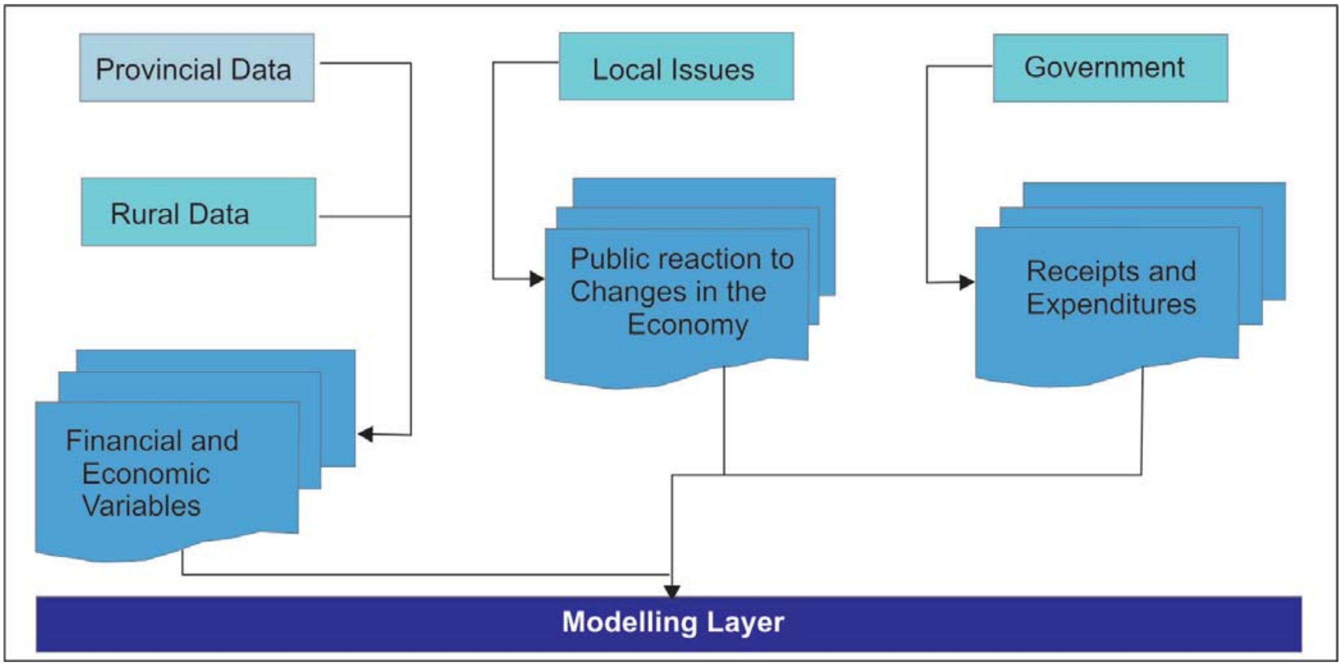



Figure 2-6-1. Total economic activity under current productivity conceptual model.

groupings so as to ensure confidentially. This results in lower resolution of data reporting. In addition, local statistical information, where available, was often limited thus making local reporting difficult, and archival sources, such as RM office records and local newspapers, in and of themselves are often a source of potential bias. For the purposes of the economic baseline, interviews with the population of the GSH provided the socio-economic context to overcome the biases of the above points, but the unstructured interviews were anecdotally based and intended as a validation/invalidation instrument only.

## 6.3 RESULTS

### 6.3.1 Economic Capital Baseline

The information presented here outlines the dominant sectors of the regional economy, namely gas and ranching, and summarizes their potential economic contribution to the provincial economy. These two sectors are dominant in the Study Area and their indices of specialization are extremely high, creating a lens of economic concentration so focused that even minor fluctuations in these sectors are amplified at the local level. Other sectors of importance to the GSH are recreation and tourism, but neither is discussed in detail because their contributions to the regional and provincial economies cannot be sufficiently disaggregated from the data.

#### *6.3.1.1 Employment*

Employment figures in virtually every sector of the economy have increased considerably since the 1970s, and even more so in the last decade. Of particular note, however, is the dramatic decline in agricultural employment in Saskatchewan. Across all of the RMs in the Study Area agriculture and primary industries dominate the employment profile (Table 2-6-1)—accounting for between 60% and 81% of all RM employment, some of the highest agricultural employment concentration figures in the entire province (Cecil 2006a). Employment in sectors other than agriculture and primary industry is unstable and limited. Moreover, the number of individuals employed by the largest sectors is, at best stable, and often declining. The exception to this norm is the RM of Big Stick where employment is supported by the growth of the gas extraction sector. Overall, employment within the region is down over the last 25 years.

#### *6.3.1.2 Earnings by industrial sector—excluding agriculture*

The RMs have a limited employment profile beyond agriculture and the primary sector. Earnings in the RMs are highly variable, with a low in Piapot of $19,606 and a high of $36,422 in Gull Lake (based on 2001 data). Although one might infer a higher income in the RMs

| Table 2-6-1. Employment profile by RM. | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gull Lake | | Bigstick | | Fox Valley | | Pittville | | Miry Creek | | Clinworth | | Happyland | | Piapot | |
| Industry Divisions | 1981 | 2001 | 1981 | 2001 | 1981 | 2001 | 1981 | 2001 | 1981 | 2001 | 1981 | 2001 | 1981 | 2001 | 1981 | 2001 |
| Both sexes- total labour force | 175 | 195 | 115 | 145 | 195 | 200 | 185 | 185 | 270 | 260 | 285 | 220 | 295 | 255 | 285 | 265 |
| Industry Not applicable | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| All Industries | 170 | 195 | 115 | 145 | 200 | 200 | 185 | 190 | 270 | 260 | 285 | 215 | 295 | 250 | 285 | 270 |
| Primary industries | 125 | 125 | 95 | 105 | 180 | 160 | 165 | 135 | 195 | 195 | 230 | 130 | 225 | 165 | 235 | 220 |
| Manufacturing industries | 5 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Construction industries | 10 | 15 | 0 | 10 | 0 | 0 | 5 | 15 | 10 | 0 | 10 | 10 | 15 | 0 | 0 | 0 |
| Transport, storage, comm., other utility industries | 5 | 0 | 0 | 0 | 0 | 15 | 5 | 0 | 5 | 20 | 5 | 35 | 15 | 15 | 0 | 10 |
| Trade | 10 | 10 | 15 | 0 | 10 | 0 | 5 | 10 | 15 | 20 | 25 | 20 | 10 | 10 | 5 | 25 |
| Finance, insurance, and real estate | 5 | 20 | 0 | 0 | 5 | 10 | 5 | 0 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| Community, business and personal service | 15 | 30 | 0 | 5 | 5 | 10 | 5 | 50 | 30 | 20 | 5 | 20 | 25 | 60 | 35 | 0 |
| Public administration and defense | 0 | 0 | 0 | 10 | 0 | 10 | 5 | 0 | 0 | 0 | 10 | 0 | 10 | 0 | 5 | 0 |
| Other industries | | | | | | | | | | | | | | | | |
| Source: Compiled based on Cecil (2006) | | | | | | | | | | | | | | | | |

with gas extraction, given the weekly wage rates for the province in the oil and gas sector are almost 27% higher than the next highest paid goods-producing industry, such a conclusion cannot be determined for the RMs directly from the data. The RMs most closely associated with gas extraction, namely Fox Valley and Big Stick, provide little conclusive evidence of higher incomes from a broader economic base. Overall, annual incomes within the Study Area vary considerably and do not follow the traditional trajectory of steady increases, but have a fluctuating pattern typical of "boom-bust" economic cycles. The highest incomes can be found among the male population of the RM of Gull Lake.

#### *6.3.1.3 Value of building permits*

A large number of building permits typically indicates active construction and growth. Permit data for the Study Area indicate that most of the construction has occurred in the communities of Leader, Gull Lake, Cabri, and Burstall. Of the 353 permits issued in these four communities since 1971, their total value is $19,297,275, with all other communities combined contributing $826,523 in additional value. The small value of permits indicates limited new construction and reflects modest renovations and farmstead improvements.

#### *6.3.1.4 Economic concentration*

All RMs in the Study Area depict a level of economic concentration significantly greater than the province. In the RM of Clinworth, for example, economic activity is 2.87 times the provincial level of economic concentration. In the RM of Piapot, this level is 4.37. The extent of economic concentration in the RMs implies that even a minor fluctuation in industrial activity, commodity prices, resources markets, or the general business climate, can act as a lens to focus and heighten the economic impact felt in the region. Industrial or agricultural policy created within the province, for example, may have greater implications for the Study Area because so much economic activity is tied directly to so few economic actors.

#### 6.3.1.5 *Invested capital outflow*

Equipment costs in the agricultural sector have increased as the scale of farms has grown and as the local grain-handling tradition of the prairies is replaced with more distant and centralized in-land terminal systems. Costs associated with crop production have also seen increases due to higher fuel costs, labour costs, fertilizer costs, and seed-marketing costs. In addition, increasingly expensive equipment is now required to support the growing scale of operations. With the low cost of borrowing since 1997, low interest rates may permit investment into agriculture that would not otherwise occur, such as farm amalgamation, distributed irrigation systems, and capital investments. Given that there are virtually no manufacturers of machinery and equipment in the RMs to support capital investments into these operations, the flow of invested capital monies is outbound from the GSH region.

#### 6.3.1.6 *Public and private investment by industry*

The national trend in housing starts is reflected in an increase in housing investment provincially, but the number and value of building permits within the Study Area is lagging behind that of other market areas in both volume and value. Of particular note, however, is investment in the primary sector. Gas industry firms (e.g., EOG Resources, Apache, Action Energy, Burlington Resources, Anadarko Canada, and EnCana Corporation) have invested in excess of $171 million in the Great Sand Hills region in land acquisition, bonuses, and infrastructure development (SIR 2006).

#### 6.3.1.7 *Manufacturing*

Saskatchewan lags behind the national manufacturing and construction employment rate by 8.37% and, at more than 5.5 times below the provincial average, regional employment in manufacturing in the Study Area RMs is highly under-represented. Only 55 persons living in the RMs in 2001 were listed as employed in the manufacturing sector—less than one-tenth of 1% of the provincial work force, and only 2% of the Study Area work force. Without a manufacturing base economic diversification is restricted, and sectoral concentration results.

#### 6.3.1.8 *Value of material sales by kind*

The oil industry contributes over 50% of the provincial GDP, followed by potash and natural gas sales, with both playing significant roles. With over 2.7 trillion cubic feet of gas reserves identified by Saskatchewan Industry and Resources (of which over 220 billion cubic feet exist within the study region), and a market value from that area alone of over $630 million (exclusive of government revenues, at fall 2006 prices) gas development may have a significant potential to contribute to the economic prosperity of the region.

#### 6.3.1.9 *Number and average size of farms*

The number of farms in Saskatchewan is decreasing, but the farms that remain are larger in acreage. Within the GSH region the patterns are more pronounced. Farm sizes have been, on average, larger than farms in the rest of Saskatchewan; within most of the RMs the number of small land holdings is very limited, with larger farms favoured. Of the 9,903 farms in the Study Area, only 49 farms are of 70 ac or less, while almost 2,100 farms are over 1,600 ac. The largest of the farms/ranches in the region is in excess of 59,500 ac with 11 other farms/ranches over 10,000 ac (SAF 2006). Within the GSH Study Area proper, there are only 110 farms/ranches other than crown lands.

#### 6.3.1.10 *Production of field crops, crop prices, and farm debt*

The economic contribution of crop agriculture is significant within the Study Area. Crop-based agriculture contributed over $67 million to the local economy in 2004. Spring wheat, barley, and rye represent a large share of the economic value of crop production at over $31 million, and represent the largest areas under specific cereal crop cultivation. Specialty crops, such as peas ($12.9 million) and lentils ($4.8 million), also make a significant contribution to the local economy.

#### 6.3.1.11 *Livestock market*

Potential economic value of ranching is a reflection of rents paid to lease the land from Saskatchewan Agriculture and Food; the costs of operating the farm based on the land practice groups and soil characteristics of the area (AAFC 2005); the maximum potential compensation back to the lessee from gas wells situated on their leased lands (Figure 2-6-2); and the potential gross income to be earned based on average livestock weights and prices during the last calendar quarter of the year. The economic value of ranching also assumes

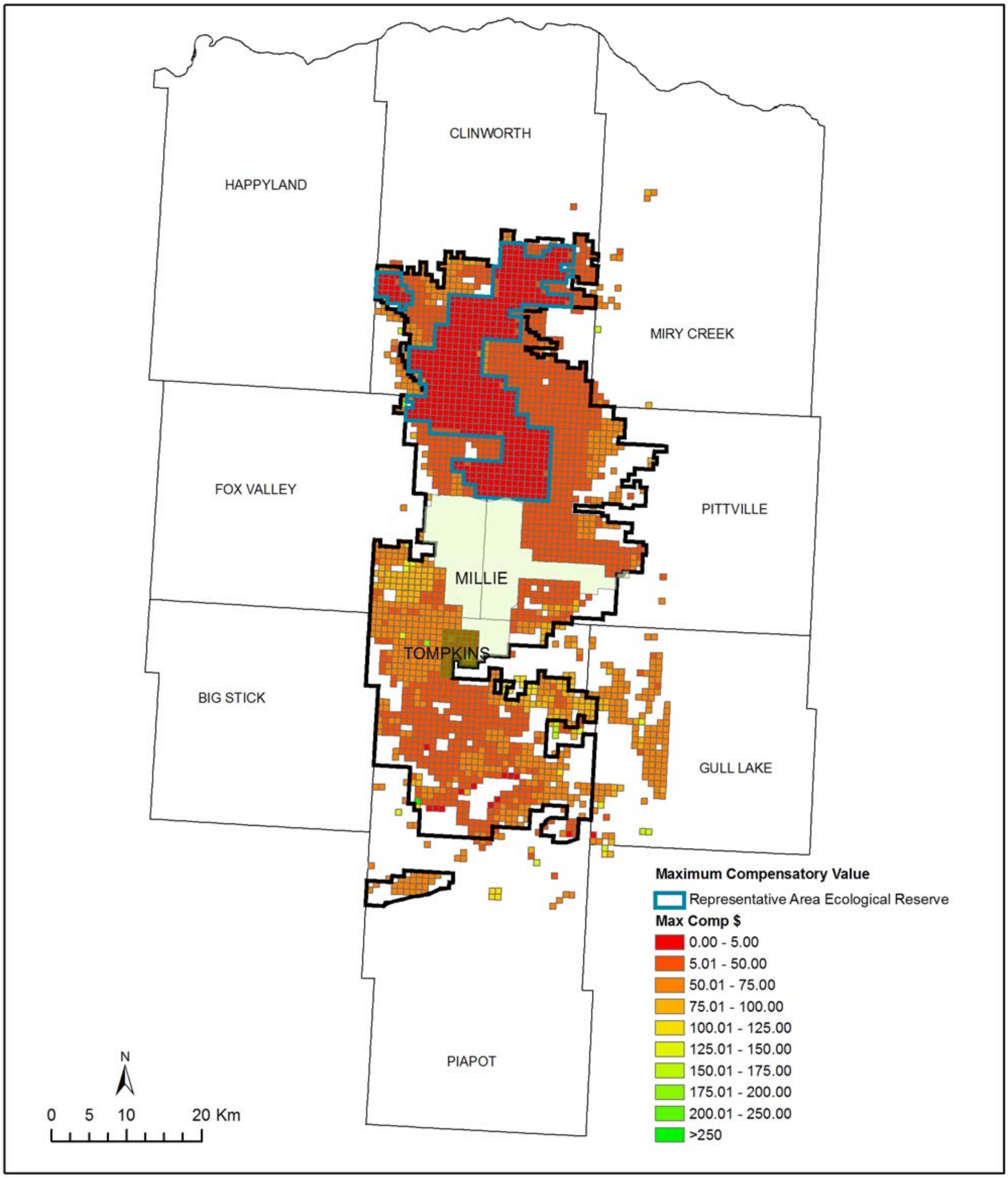



Figure 2-6-2. Maximum compensatory value to Lessees from gas wells on ranching land. Source: Cecil (2006).

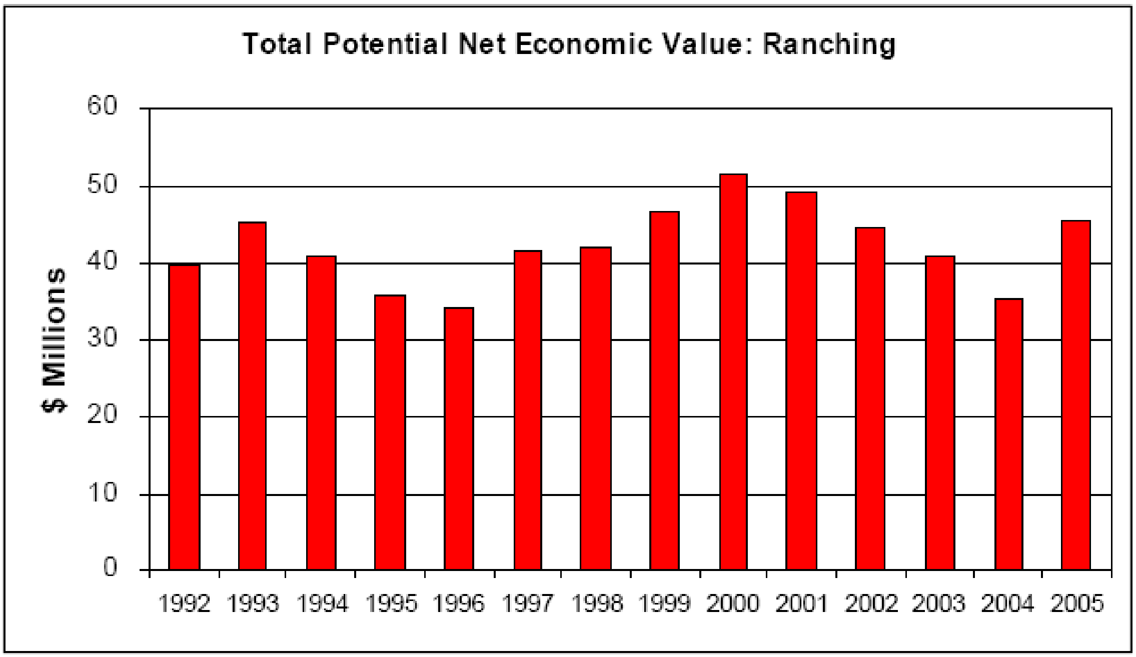



Figure 2-6-3. Total potential net economic value of ranching. Source: Compiled by Cecil (2006)

the land is being utilized at 80% of its carrying capacity. Ranching value for the Study Area has fluctuated over the period of study (Figure 2-6-3). The potential net ranching value from the Study Area farms peaked in 2000 after a five-year rise in incomes. With the BSE crisis values have been dropping, but since the reopening of the border, potential net value is once again on the rise. The potential net value of ranching is based on the total economic flow from the activity within the region. The sector produces rents to government, operations expenses are paid by ranchers to local (and non-local) businesses, and the revenues are paid to the ranchers from the sale of cattle. Income is the difference between costs and revenues. From the limited number of ranches covering 191,375 ha, the potential economic value of the Study Area from ranching was in excess of $45.4 million in 2005.

### *6.3.1.12 Established natural gas reserves*

According to CAPP, Saskatchewan is the country's third largest natural gas producer at 273 billion cubic feet (bcf) [or 7.736 billion $m^3$]/yr for 2004, up 4.5% from 2003 (CAPP 2005). Gas well sales and production data indicate the total economic value of gas sales to the province. At its height, gas sales were in excess of $1.28 billion/yr. The economic contribution to the provincial economy of the gas wells of the GSH region is in excess of $600 million/yr. From those sales, the government of Saskatchewan has realized on average $35.7 million/yr since 1990 in revenues from the wells of the GSH region.

Specific to the GSH Review Area, Saskatchewan Industry and Resources (2007) reported for fiscal year 2005-2006 a total gas production of 208.7 million $m^3$ with provincial revenues of $3.64 million comprising $1.40 million Crown royalty, $1.80 million corporation capital tax surcharge, and $0.44 million on mineral lease rentals. Additionally surface lease rentals are paid to Saskatchewan Agriculture and Food. For 2006 an estimated $1.3 million revenue was gained from the rental of 1327 surface leases, averaging 2 ac per site and with a payment of $506/ac. Overall provincial revenues for FY 2005–2006 were estimated at $4.94 million for the GSH Review Area.

## 6.3.2 Economic Model of Baseline Activity

The economic model of baseline activity allows the GSH RES research teams to establish the current state of the economy of the GSH region beyond descriptive and anecdotal understandings and provides the basis for forecasting into the future one possible trajectory of economic activity based on past experience. The Grand Model for the GSH is an aggregation of various submodels (described in detail in Cecil 2006), each of which were used to forecast potential economic impacts based on historical trends. The Grand Model attempts to capture all potential sources of economic exchange in the Study Area at the local and the provincial level. The model is a mathematical and relational expression of the economic data and is not to be interpreted as a true reflection of the economic conditions within the region. The model output is to be used as a comparative tool to express changes and trends, relative to baseline. The model of Total Economic Activity under Current Productivity is a function of a constant (a correction for statistical externalities and scalar forces) plus or minus Rural Municipality Income, Rural Municipality Revenues, Bonuses Paid in the Rural Municipality, Rural Municipality Land Area for Sale or Lease, Rural Municipality Infrastructure, and Provincial oil and gas Revenues (gas in the case of the Great Sand Hills). The Rural Municipality Revenues are a function of a subset of variables comprised of Rural Municipality Taxes, Grants to in lieu of Taxes, Total Grants paid in the Rural Municipality, Rural Municipality Own Source Revenues, and the Rural Municipality Sales of Services.

#### 6.3.2.1 *Total economic activity: current productivity*

Total economic activity is a reflection of all forms of income, revenues generated from the region, and government activity. Figure 2-6-4 depicts the current trajectories for each of the RMs. The RMs of Fox Valley, Big Stick, and Piapot are growing in economic productivity, while the Rural Municipalities of Pittville, Miry Creek, and Clinworth show only moderate growth over time. Fox Valley leads the group of Rural Municipalities and has done so since the early 1980s. As time progressed, the differences between the RMs became greater—those in the western portion of the Study Area, more closely associated with gas development, grew at a faster rate than those areas with more traditional agricultural economic bases. Ranching and total oil and gas revenue are the most significant contributors to total economic activity in the region according to the model.

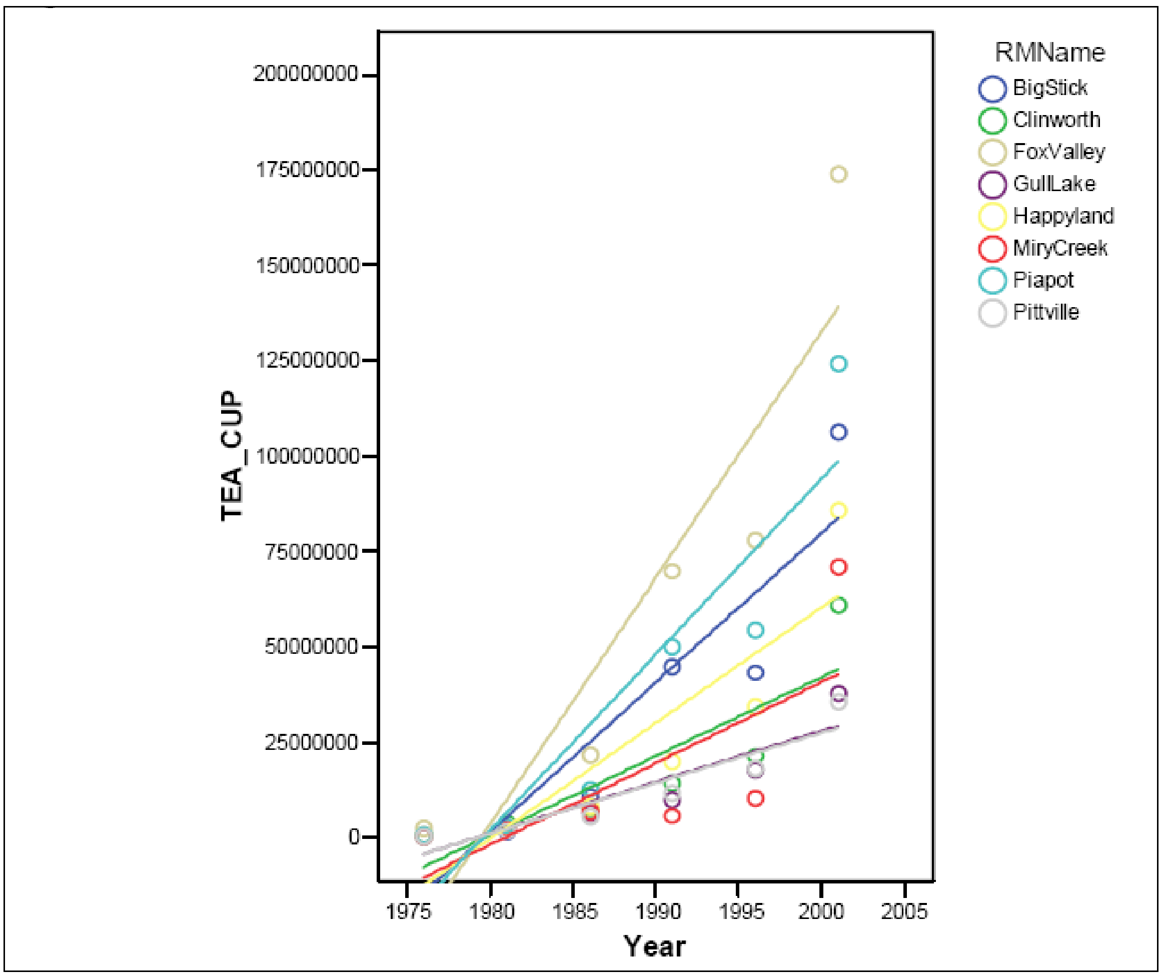



Figure 2-6-4. Current economic trajectories for study area RMs.

### 6.3.2.2 *Ranching total economic activity: current and potential*

The model forecasted ranching income removes the variances experienced in the sector over the last 15 years and bases future potential income on a stabilized industry with modest growth. The model also factors in a stable operations input, with operations costs, land improvements, and general operations fixed at the maximum rate set by Agriculture and Agri-food Canada. As shown in Figure 2-6-5, potential ranching economic value is projected to rise to just over $50 million in the next 15 years. Data up to the projected values vary, but the model attempts to minimize that variance. The result is a stable sector with predictable inputs, outputs, contributions to the local economy in the form of operations values, rent collected from Saskatchewan Crown lands, revenues from sales, incomes to the ranchers, and taxes derived from those incomes. The total economic value of ranching in the Study Area represents, at present, approximately $45 million in revenues, rents, income and sales to the local and regional economy with an annual growth rate of approximately 0.75 %/yr, or a total potential economic contribution of over $716.4 million over the next 15 years.

### 6.3.2.3 *Gas total economic activity: current and potential*

The assessment of the economic contribution of gas extraction in the GSH Study Area is based on a number of assumptions, including set averaged well development costs at $191,000 per well head; infrastructure development costs for pipelines and compressor stations; one-time payments for well site development, and ongoing payments for access to the well site based on the standard rates as defined in the Crown Oil and Gas Royalty Regulations; GLJ's 2P and 3P reserve projections; and consideration on in-fill wells and step-out wells.

The 3P model results show a potentially significant revenue stream to government throughout the 15-year projection window. A number of factors enter into consideration when addressing the government revenue stream from gas development. Royalties from the Milk River pool are expected to generate $6.733 million over the next 15 years; corporate taxes collected represent $32.729 million; mineral leases provide an additional $0.927 million; and $3.861 million is expected in surface lease payments to Saskatchewan Agriculture and Food, for a total future potential to be realized by the

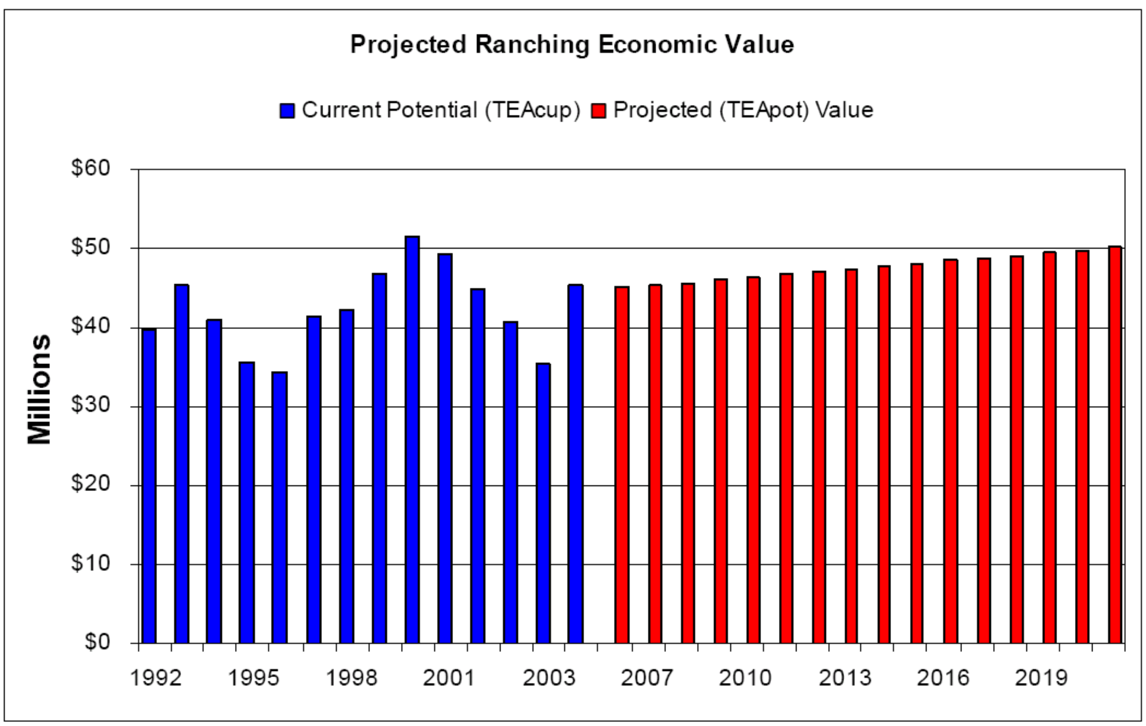



Figure 2-6-5. Projected ranching potential economic value.

provincial government from the Milk River pool of $44.251 million over the next 15 years.

The one-time siting and ongoing lessee payments are a bit more modest. The one-time payments represent slightly more than $500,000 and the ongoing payments to lessees approximately $1.5 million over the 15 years. It is not these figures that play the most significant role in local economic development derived from gas development (although these figures are the ones that are most readily realized by individuals, as payments are made directly to them). It is the well development costs and ongoing operational expenses by the industry that provide the most local economic gain from gas development—a total economic contribution of over $116 million to the local economy over 15 years.

The 2P model is more conservative in its estimations. Royalties represent $4.440 million over the next 15 years; corporate taxes collected represent $7.518 million; mineral leases provide an additional $0.797 million; and $3.321 million is expected in surface lease payments to Saskatchewan Agriculture and Food, for a total future potential to be realized by the provincial government from the Milk River pool of $16.076 million over the next 15 years.

As there are fewer new wells required for the 2P scenario, the one-time payments and ongoing lessee payments are considerably less than the previous model—$349,000 and $1.118 million, respectively. The local economic impact of that investment potentially can represent slightly more than $79 million over 15 years.

For brevity and conciseness, the following tables aggregate the Milk River and Second White Specks data into existing, and existing and future, 3P and 2P projections (Tables 2-6-2 through 2-6-5).

The Second White Specks (SWS) pool is a more modest producer in the southern reaches of the Study Area. Because the pool is more limited, all in-fill and step-out developments are proposed to be completed by 2015. With the addition of only 79 and 123 new wells for the 2P and 3P scenarios, respectively, the economic contribution of this new development is limited.

The 3P scenario represents the following payments to government: Royalties represent $2.841 million over the next 15 years; corporate taxes collected represent $829,000; mineral leases provide an additional $400,000; and $1.670 million is expected in surface lease payments to Saskatchewan Agriculture and Food, for a total future potential to be realized by the provincial government from the SWS pool of $5.741 million over the next

Table 2-6-2. Milk River & Second White Specks pools proven plus probable and possible (3P) projections (Existing Wells).

Existing Well Forecasts
Milk River & Second White Specks (SWS); Proved plus Probable plus Possible (3P)

| Year | Existing Producing Wells | Total Mcf/d | Industry Investment (Operating) | On-going Payments (Lessees) | Total Gas Royalties to Gov't* | Corporate Tax to Gov't | Mineral Lease Rental to Gov't | Max. Surface Lease to SAF | Provincial Forecast Economic Value | Local Forecast Economic Value |
|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | 1432 | 23,183 | 15,850,000 | 143,200 | 1,026,737 | 1,820,000 | 429,600 | 1,790,000 | 5,066,337 | 2,520,700 |
| 2008 | 1432 | 20,741 | 15,830,000 | 143,200 | 807,116 | 1,722,000 | 429,600 | 1,790,000 | 4,748,716 | 2,517,700 |
| 2009 | 1430 | 18,808 | 15,794,000 | 143,000 | 668,409 | 1,643,000 | 429,000 | 1,787,500 | 4,527,909 | 2,512,100 |
| 2010 | 1413 | 17,241 | 15,833,000 | 141,300 | 553,825 | 1,527,000 | 423,900 | 1,766,250 | 4,270,975 | 2,516,250 |
| 2011 | 1413 | 15,947 | 15,970,000 | 141,300 | 471,404 | 1,430,000 | 423,900 | 1,766,250 | 4,091,554 | 2,536,800 |
| 2012 | 1413 | 14,699 | 15,742,000 | 141,300 | 421,148 | 1,375,000 | 423,900 | 1,766,250 | 3,986,298 | 2,502,600 |
| 2013 | 1319 | 13,537 | 15,316,000 | 131,900 | 370,892 | 1,294,000 | 395,700 | 1,648,750 | 3,709,342 | 2,429,300 |
| 2014 | 1319 | 12,710 | 15,501,000 | 131,900 | 370,692 | 1,249,000 | 395,700 | 1,648,750 | 3,664,142 | 2,457,050 |
| 2015 | 1319 | 11,792 | 15,127,000 | 131,900 | 297,517 | 1,196,000 | 395,700 | 1,648,750 | 3,537,967 | 2,400,950 |
| 2016 | 1218 | 10,922 | 14,617,000 | 121,800 | 265,353 | 1,136,000 | 365,400 | 1,522,500 | 3,289,253 | 2,314,350 |
| 2017 | 1179 | 10,253 | 14,487,000 | 117,900 | 238,215 | 1,093,000 | 353,700 | 1,473,750 | 3,158,665 | 2,290,950 |
| 2018 | 1171 | 9,721 | 14,609,000 | 117,100 | 215,097 | 1,063,000 | 351,300 | 1,463,750 | 3,093,147 | 2,308,450 |
| 2019 | 1166 | 9,256 | 14,809,000 | 116,600 | 193,989 | 1,037,000 | 349,800 | 1,457,500 | 3,038,289 | 2,337,950 |
| 2020 | 1166 | 8,835 | 15,035,000 | 116,600 | 174,892 | 1,012,000 | 349,800 | 1,457,500 | 2,994,192 | 2,371,850 |
| 2021 | 1166 | 8,040 | 13,895,000 | 116,600 | 157,805 | 939,000 | 349,800 | 1,457,500 | 2,904,105 | 2,200,850 |
| Totals | | | 228,415,000 | 1,955,600 | 6,233,091 | 19,536,000 | 5,866,800 | 24,445,000 | 56,080,891 | 36,217,850 |

*Royalty projections based on production degradation curve. Extrapolations are estimates ONLY.

Table 2-6-3. Milk River & Second White Specks pools proven plus probable (2P) projections (Existing Wells).

Existing Well Forecasts
Milk River & Second White Specks (SWS); Proved plus Probable (2P)

| Year | Existing Producing Wells | Total Mcf/d | Industry Investment (Operating) | On-going Payments (Lessees) | Total Gas Royalties to Gov't* | Corporate Tax to Gov't | Mineral Lease Rental to Gov't | Max. Surface Lease to SAF | Provincial Forecast Economic Value | Local Forecast Economic Value |
|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | 1,432 | 23,054 | 15,833,000 | 143,200 | 1,012,808 | 1,812,000 | 429,600 | 1,790,000 | 5,044,408 | 2,518,150 |
| 2008 | 1,430 | 20,419 | 15,778,000 | 143,000 | 783,998 | 1,700,000 | 429,000 | 1,787,500 | 4,700,498 | 2,509,700 |
| 2009 | 1,416 | 18,349 | 15,681,000 | 141,600 | 640,265 | 1,609,000 | 424,800 | 1,770,000 | 4,444,065 | 2,493,750 |
| 2010 | 1,413 | 16,711 | 15,761,000 | 141,300 | 527,691 | 1,486,000 | 423,900 | 1,766,250 | 4,203,841 | 2,505,450 |
| 2011 | 1,413 | 15,304 | 15,761,000 | 141,300 | 446,276 | 1,378,000 | 423,900 | 1,766,250 | 4,014,426 | 2,505,450 |
| 2012 | 1,319 | 13,852 | 15,060,000 | 131,900 | 394,009 | 1,301,000 | 395,700 | 1,648,750 | 3,739,459 | 2,390,900 |
| 2013 | 1,319 | 12,873 | 15,216,000 | 131,900 | 344,758 | 1,237,000 | 395,700 | 1,648,750 | 3,626,208 | 2,414,300 |
| 2014 | 1,259 | 11,684 | 14,364,000 | 125,900 | 304,553 | 1,166,000 | 377,700 | 1,573,750 | 3,422,003 | 2,280,500 |
| 2015 | 1,218 | 10,854 | 14,218,000 | 121,800 | 270,379 | 1,113,000 | 365,400 | 1,522,500 | 3,271,279 | 2,254,500 |
| 2016 | 1,171 | 10,117 | 14,100,000 | 117,100 | 237,210 | 1,059,000 | 351,300 | 1,463,750 | 3,111,260 | 2,232,100 |
| 2017 | 1,166 | 9,545 | 14,279,000 | 116,600 | 211,076 | 1,025,000 | 349,800 | 1,457,500 | 3,043,376 | 2,258,450 |
| 2018 | 1,166 | 9,030 | 14,482,000 | 116,600 | 186,953 | 990,000 | 349,800 | 1,457,500 | 2,984,253 | 2,288,900 |
| 2019 | 1,166 | 8,212 | 13,558,000 | 116,600 | 166,851 | 922,000 | 349,800 | 1,457,500 | 2,896,151 | 2,150,300 |
| 2020 | 805 | 6,763 | 10,278,000 | 80,500 | 149,754 | 772,000 | 241,500 | 1,006,250 | 2,169,504 | 1,622,200 |
| 2021 | 773 | 6,355 | 10,121,000 | 77,300 | 124,687 | 746,000 | 231,900 | 966,250 | 2,068,837 | 1,595,450 |
| Totals | | | 214,490,000 | 1,846,600 | 5,801,268 | 18,316,000 | 5,539,800 | 23,082,500 | 52,739,568 | 34,020,100 |

*Royalty projections based on production degradation curve. Extrapolations are estimates ONLY.

Table 2-6-4. Milk River & Second White Specks pools proven plus probable and possible (3P) projections (Existing and Future Wells).

Existing and Future Well Forecasts for GSH Study Area
Milk River & Second White Specks (SWS); Proved plus Probable plus Possible (3P)

| Year | TOTAL Producing Wells | TOTAL Industry Infrastructure Investment | Industry Investment (Operating) | On-going Payments (Lessees) | TOTAL Gas Royalties to Gov't* | TOTAL Corporate Tax to Gov't | TOTAL Mineral Lease Rental to Gov't | TOTAL Max. Surface Lease to SAF | Provincial Forecast Economic Value | Local Forecast Economic Value |
|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | 1480 | 10,629,600 | 15,850,000 | 148,000 | 1,075,140 | 1,987,370 | 444,000 | 1,850,000 | 5,356,510 | 4,119,940 |
| 2008 | 1523 | 20,612,850 | 15,830,000 | 152,300 | 1,479,233 | 2,291,872 | 471,300 | 1,903,750 | 6,146,155 | 5,618,728 |
| 2009 | 1545 | 25,466,750 | 15,794,000 | 154,500 | 1,076,595 | 2,615,615 | 505,200 | 1,931,250 | 6,128,660 | 6,343,613 |
| 2010 | 1538 | 28,142,150 | 15,833,000 | 153,800 | 1,486,750 | 2,810,914 | 505,500 | 1,922,500 | 6,725,664 | 6,750,073 |
| 2011 | 1577 | 36,778,700 | 15,970,000 | 157,700 | 1,100,177 | 2,863,877 | 511,500 | 1,971,250 | 6,446,804 | 8,070,005 |
| 2012 | 1617 | 45,636,700 | 15,742,000 | 161,700 | 1,325,007 | 3,288,478 | 517,500 | 2,021,250 | 7,152,235 | 9,368,505 |
| 2013 | 1547 | 50,951,500 | 15,316,000 | 154,700 | 1,606,468 | 3,612,780 | 494,700 | 1,933,750 | 7,647,698 | 10,094,825 |
| 2014 | 1545 | 50,047,700 | 15,501,000 | 154,500 | 2,152,777 | 3,959,093 | 498,300 | 1,931,250 | 8,541,420 | 9,986,805 |
| 2015 | 1541 | 49,622,800 | 15,127,000 | 154,100 | 713,127 | 4,054,106 | 500,100 | 1,926,250 | 7,193,583 | 9,866,570 |
| 2016 | 1436 | 48,276,100 | 14,617,000 | 143,600 | 837,815 | 4,174,170 | 469,800 | 1,795,000 | 7,276,785 | 9,577,565 |
| 2017 | 1409 | 50,933,500 | 14,487,000 | 140,900 | 499,932 | 4,227,447 | 458,100 | 1,761,250 | 6,946,729 | 9,953,975 |
| 2018 | 1394 | 49,383,350 | 14,609,000 | 139,400 | 850,329 | 4,301,676 | 455,700 | 1,742,500 | 7,350,205 | 9,738,253 |
| 2019 | 1382 | 47,833,200 | 14,809,000 | 138,200 | 928,806 | 4,399,072 | 454,200 | 1,727,500 | 7,509,578 | 9,534,530 |
| 2020 | 1375 | 46,283,050 | 15,035,000 | 137,500 | 482,702 | 4,368,026 | 454,200 | 1,718,750 | 7,023,678 | 9,335,208 |
| 2021 | 1338 | 38,089,400 | 13,895,000 | 133,800 | 192,835 | 4,139,992 | 454,200 | 1,672,500 | 6,459,527 | 7,931,460 |
| Totals | | 598,687,350 | 228,415,000 | 2,224,700 | 15,807,693 | 53,094,488 | 7,194,300 | 27,808,750 | 103,905,231 | 126,290,053 |

*Royalty projections based on production degradation curve. Extrapolations are estimates ONLY.

| Table 2-6-5 Milk River & Second White Specks pools proven plus probable (2P) projections (Existing and Future Wells). | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Existing and Future Well Forecasts for GSH Study Area<br>Milk River & Second White Specks (SWS); Proved plus Probable (2P) | | | | | | | | | | |
| Year | Existing Producing Wells | TOTAL Industry Infrastructure Investment | Industry Investment (Operating) | On-going Payments (Lessees) | TOTAL Gas Royalties to Gov't* | TOTAL Corporate Tax to Gov't | TOTAL Mineral Lease Rental to Gov't | TOTAL Max. Surface Lease to SAF | Provincial Forecast Economic Value | Local Forecast Economic Value |
| 2007 | 1478 | 10,186,700 | 15,833,000 | 147,800 | 1,148,851 | 1,812,000 | 443,400 | 1,847,500 | 5,251,751 | 4,050,755 |
| 2008 | 1501 | 15,722,950 | 15,778,000 | 150,100 | 1,518,506 | 1,700,000 | 464,100 | 1,876,250 | 5,558,856 | 4,875,243 |
| 2009 | 1511 | 21,498,650 | 15,681,000 | 151,100 | 1,763,650 | 1,609,000 | 488,400 | 1,888,750 | 5,749,800 | 5,728,048 |
| 2010 | 1532 | 26,352,550 | 15,761,000 | 153,200 | 1,548,729 | 1,486,000 | 491,100 | 1,915,000 | 5,440,829 | 6,470,233 |
| 2011 | 1537 | 27,920,700 | 15,761,000 | 153,700 | 940,823 | 1,378,000 | 494,700 | 1,921,250 | 4,734,773 | 6,705,955 |
| 2012 | 1467 | 33,235,500 | 15,060,000 | 146,700 | 1,020,108 | 1,301,000 | 470,100 | 1,833,750 | 4,624,958 | 7,391,025 |
| 2013 | 1459 | 31,003,000 | 15,216,000 | 145,900 | 765,741 | 1,237,000 | 473,100 | 1,823,750 | 4,299,591 | 7,078,750 |
| 2014 | 1417 | 35,450,000 | 14,364,000 | 141,700 | 910,600 | 1,166,000 | 457,500 | 1,771,250 | 4,305,350 | 7,613,800 |
| 2015 | 1376 | 34,989,100 | 14,218,000 | 137,600 | 673,112 | 1,113,000 | 447,000 | 1,720,000 | 3,953,112 | 7,518,665 |
| 2016 | 1320 | 32,996,050 | 14,100,000 | 132,000 | 471,086 | 1,059,000 | 432,900 | 1,650,000 | 3,612,986 | 7,196,408 |
| 2017 | 1322 | 34,546,200 | 14,279,000 | 132,200 | 320,469 | 1,025,000 | 431,400 | 1,652,500 | 3,429,369 | 7,455,980 |
| 2018 | 1317 | 33,438,950 | 14,482,000 | 131,700 | 297,814 | 990,000 | 431,400 | 1,646,250 | 3,365,464 | 7,319,843 |
| 2019 | 1298 | 29,231,400 | 13,558,000 | 129,800 | 277,052 | 922,000 | 431,400 | 1,622,500 | 3,252,952 | 6,548,210 |
| 2020 | 919 | 25,245,300 | 10,278,000 | 91,900 | 207,203 | 772,000 | 323,100 | 1,148,750 | 2,451,053 | 5,420,395 |
| 2021 | 836 | 13,951,350 | 10,121,000 | 83,600 | 177,004 | 746,000 | 313,500 | 1,045,000 | 2,281,504 | 3,694,453 |
| Totals | | 405,768,400 | 214,490,000 | 2,029,000 | 12,040,748 | 18,316,000 | 6,593,100 | 25,362,500 | 62,312,348 | 95,067,760 |
| *Royalty projections based on production degradation curve. Extrapolations are estimates ONLY. | | | | | | | | | | |

15 years. Using the same multiplier for the contribution to the local economy, the SWS 3P scenario provides a local economic infusion of $5.594 million over 15 years.

The 2P projections are more conservative, with total contributions to government of $3.683 million and $3.592 million to the local economy over the next 15 years.

In summary, the revenue streams to both government and to the individuals in the Study Area from the Second White Specks reserve are limited when compared to the Milk River pool. The Milk River gas reserves are potentially larger and of greater production volumes, resulting in higher revenue streams to government and lessees. That increased revenue stream, however, comes with greater surface disturbance. The overall economic value of these lessee payments and royalty taxes are minute when compared to the investment made in the gas pool area by the gas industry itself. Using the assumptions outlined in Cecil (2006), and confirmed by the summary report on best practices and by the Canadian Association of Petroleum Producers, the industry will make large capital investments in the pool areas to extract the gas reserves. The Second White Specks pool has the potential to contribute over $27.2 million in well site development under the 3P scenario and almost $17.5 million under the 2P model. The 2P model stops well investment after 2015, as there are no viable sites at the 50% probability level after that date. The Milk River pool, being more extensive, has the potential to contribute over $338 million in infrastructure development under the 2P model and over $571 million under the 3P scenario (both values being realized over the 15-year window).

Industrial infrastructure development is a potential economic contributor to the Study Area. However, the firms that are the infrastructure investors are extra-regional, many of them extra-provincial, with much of the capital, profits, labour, and materials coming from outside the Study Area. The result is a large investment in the area, but little long-term benefits in the form of profits and materials supply stay in the region. There are, however, reported efforts on behalf of the gas companies (Burlington, Anadarko, Arc, and EnCana) to hire local people, buy local products, and support local businesses. The reported target, albeit informal, is to have 20% of the development and ongoing site support come from the local communities and population. Local businesses report the number to be somewhere between 10 and 20%. Taking a mid-value of these anecdotal reports, a more conservative 15% value is used as a local

| Table 2-6-6. Summary of existing and future well forecasts for the GSH Study Area. | | |
|---|---|---|
| Existing and Future Well Forecasts for GSH Study Area | | |
| Summary | 2P | 3P |
| Potential Provincial Economic Value | $62,312,348 | $103,905,231 |
| Potential Local Economic Value | $95,067,760 | $126,290,053 |
| TOTAL Potential Economic Value | $157,380,108 | $230,195,284 |
| TOTAL Industry Infrastructure Investment | $620,258,400 | $827,102,350 |

economic multiplier. Based on this premise, then, from the Milk River and the Second White Specks reserves, in combination with the existing wells in the area, the summary of economic potential from gas development in the Study Area is described in Table 2-6-6.

## 6.4 CONCLUSION

The regional economy of the GSH Study Area is dominated by two economic sectors—ranching and gas development. With such a high level of specialization the region is extremely sensitive to even minor fluctuations in economic conditions affecting ranching and gas activities. The total potential economic value of ranching in the Study Area represents, at present, approximately $45 million in annual revenues, rents, income, and sales to the local and regional economy with an annual growth rate of approximately 0.75%/yr, or a total potential economic contribution to the economy of over $716.4 million in the next 15 years.

The contribution of the other dominant sector in the economy as identified by the model is gas extraction. In 2007 the total economic value of gas extraction from the current 1,432 wells in the Study Area represents $5.044 million to the provincial government, and to local land holders and lessees, $2.518 million in local economic spin-offs and site payments. Over the next 15 years, the existing wells of the Study Area are forecast to produce economic returns of $52.740 million to the government in royalties, taxes, and payments, and a total economic contribution of $34.020 million in goods and services purchases from the local economy. Over the next 15 years, given current development trajectories within the region, the economic contributions to both government and the local economies could potentially represent over $157 million and $230 million for the 2P and 3P development scenarios respectively.

# Chapter 7: Baseline Summary

## 7.1 INTRODUCTION

The Great Sand Hills Regional Environmental Study baseline assessment set out to identify and characterize current environmental conditions, trends, and cumulative change for selected natural, social, and economic variables in the GSH Review Area and Study Area. Temporally, the baseline considered the cumulative effects of human activities from the 1950s to present, based on decadal changes, in order to assess the future sustainability of various surface disturbance scenarios. The underlying objectives of the baseline assessment were, first, to identify those key human activities in the region that have the greatest potential for surface disturbance and, therefore, for affecting the ecological integrity and sustainability of the GSH, and, second, to identify the key issues and concerns associated with selected Valued Ecosystem Components (VECs) that are of primary importance to human development; regional ecological, social, and economic sustainability; and planning and decision-making (Table 2-7-1). This Chapter summarizes the key human driving forces of surface disturbance in the region and identifies the key impact issues, VEC linkages, and concerns that emerged from the baseline assessment. This information will be carried forward to trends projection and scenario analysis and used in identifying priority management recommendations for maintaining the ecological integrity of the GSH.

## 7.2 SURFACE DISTURBANCE IN THE GREAT SAND HILLS

The combination of unique landscape elements and many occurrences of endangered, threatened, and sensitive species makes the GSH a biologically important landscape and natural refuge. Nevertheless, despite relatively pristine conditions in comparison to the surrounding region, the GSH has been influenced by both large-scale and long-term anthropogenic surface disturbance. Of particular concern are the patterns and impacts associated with livestock grazing and natural gas exploration and development, and the potential of these activities to cause significant habitat alteration and fragmentation across the GSH landscape. Of the 77 total biodiversity features identified for MARXAN baseline analysis, including 26 rare species, 23 biophysical habitats and enduring features, and 28 focal species, many were found to have little or none of their distribution within the current RAER protected area, leaving them vulnerable to disturbances associated with livestock grazing and natural gas exploration and development elsewhere in the GSH.

Table 2-7-1. Great Sand Hills regional environmental study VECs

| Natural capital | Social capital | Economic capital |
|---|---|---|
| regional climate | population and community | economic land use |
| economic geology | community change/quality of life | commercial activity and productivity |
| gas reserves | local governance | income and employment |
| water resources | Great Sand Hills use and perceptions | government revenue |
| land cover and biodiversity | heritage resources | |
| terrain sensitivity | First Nations use and culture | |
| soils | government instruments and institutional arrangements | |

### 7.2.1 Principal Anthropogenic Disturbances

Natural gas development has been ongoing in the GSH since the early 1950s, with the most intense development occurring since 1980. Current gas production in the area is estimated at over 180 billion cubic feet (BCF), and proved, probable, and possible reserves are estimated at nearly 670 BCF. There are currently 132,370 ha of gas leases in the region and an additional 7,996 ha of leases for gas exploration, together representing approximately 70% of the GSH land base. On over 1,400 surface leases with single and multiple well heads per pad there are more than 1,500 gas wells. Most well pad surface leases are developed in the west and southwest portion of the Review Area. Vertically drilled wells, typically with one well head per pad on a surface lease, represent 84% of the total well inventory. This development occurs in densities of up to 8 wells and 8 well pad surface leases per section in the Review Area. Lower-impact directional and slant drilling have occurred in a minority of cases, constrained, in part, by topography, reserve depth, cost, and the willingness of industry. In those areas of the GSH where directional and slant drilling has occurred, there are cases where 8 wells per section have been sustained across only 1–4 well pads.

Activities associated with gas development have resulted in disturbance of native habitat at drilling sites, disturbance of habitat during pipeline construction, and an overall increase in human activity in the region. Although the RES baseline assessment did find many of the individual disturbances associated with gas development to be minimal in extent, and even positive for some disturbance-obligate species, gas development and maintenance activities cannot be considered independently of the impacts of roads and trails used for drilling and maintenance. As the majority of natural gas wells have spur roads, it is not possible to differentiate the impact of natural gas wells from that of associated roads. In much of the gas-developed areas of the western GSH, for example, as well as in isolated patches on the eastern boundary, there are 2–3 km of road/km$^2$ and in many places more than 3 km of road/km$^2$. At the current scale of development, the cumulative impacts of well pads and associated roads and trails to service the infrastructure are over-arching concerns in relation to sustaining the ecological integrity of the GSH, particularly in terms of the implications for biodiversity, habitat fragmentation, and the spread of non-native species.

Over 40% of participants in the RES baseline community social survey indicated some form of dependency on income from the gas industry, either in the form of wages from gas industry employment or from revenue generated from gas wells on their property. Approximately 85% welcomed gas development in the region and over two-thirds supported an increase in development of the gas industry, noting the positive impacts and benefits to regional communities and households.

Livestock grazing has exerted a much longer-term and widespread influence on the landscape and integrity of the GSH. Ranching is considered by most respondents to be an ecologically acceptable activity in the GSH and a cohesive influence for rural communities economically through support of local businesses and socially through helping retain population. The total current economic value of ranching in the study represents approximately $45 million in revenues, rents, income, and sales to the local and regional economy. The total potential economic contribution of ranching is projected to be over $716 million in the next 15 years. However, many RES baseline survey session participants did recognize the potential environmental disturbance (e.g., dugouts and damaged pastures due to overgrazing) produced by ranching practices and malpractices in the Review Area. The focal species modeling and habitat suitability indices further indicate that although grazing is ubiquitous across the GSH, the most notable footprint is the over-concentration of animals around cattle watering holes. This concentration of impact has resulted in a network of permanent trails and extensive vegetative trampling and erosion surrounding watering sites.

Together, ranching and natural gas dominate the land use and regional economy of the GSH Study Area, and are of primary concern in terms of anthropogenic surface disturbance and threats to ecological integrity. Other potentially damaging activities in the GSH, namely tourism, are concentrated both in terms of geographic extent and magnitude and generate a relatively insignificant contribution to the regional economy in comparison to gas development and ranching.

### 7.2.2 Key Disturbance Conditions

Baseline predictions of range health for the GSH suggested that 5% of the landscape was in an "unhealthy" condition, 42% in a "healthy, but with problems" condition, and 53% in a "healthy" condition. All three anthropogenic disturbances (gas well activity, roads and trails, and livestock watering holes) were found to result in reductions of rangeland health, but unhealthy conditions were most associated with areas around livestock watering holes, where overgrazing and trampling have noticeably eroded range health. Reductions in range health around livestock watering holes are most significant within 250 m of the disturbed site, but are observed out to 750 m. Reductions in range health due to gas wells and roads, on the other hand, while significant, are not as broad or as large in effect, with only slight decreases in range health within a 100-m zone. Moderate reductions in range health in the vicinity of well sites appear to be caused by congregation of livestock. However, when considering the additive impacts of gas wells and roads, the cumulative reduction in range health is significant.

In terms of focal species, gas development itself does not appear to reduce occurrence; however, associated road development does have negative impacts. Gas development activities at the well site produced no significant adverse impacts on the 8 rare and traditional-use plants considered in the baseline. However, rare and traditional-use plants are not common in areas that coincide with current gas development, so it cannot be concluded that spatial expansion of gas activity would not result in significant impacts. Gas development is also associated with a marginal increase in the non-native crested wheatgrass, which can lead to erosion of ecological integrity through reductions in native plant cover.

The presence of roads has a significant, adverse impact on some rare plants, for example smooth arid goosefoot occurrence over a 100-m distance and beaked annual skeleton-weed occurrence over a 300-m distance. However, the greatest threats to smooth arid goosefoot may be competition from non-native plants and trampling from livestock. Non-native and invasive plants, crested wheatgrass and smooth brome, increase substantially in occurrence along roads. The impacts of roads are also significant for a number of bird species. Baird's Sparrow, Chestnut-collared Longspur, and Savanna Sparrow are negatively associated with roads, whereas Clay-colored Sparrow and Common Nighthawk are positively associated with roads. Only Sprague's Pipit, Brown-headed Cowbird, and Spotted Towhee lacked a significant response to human disturbance in the baseline studies, and were explained instead by habitat distributions.

Several bird species are positively associated with gas well sites. Only Clay-colored Sparrow was found to respond negatively to gas well presence, while most others respond with marginal increases within a 1-km radius of a well. Chestnut-collared Longspur and Upland Sandpiper were found to respond positively and significantly to gas wells, which may be a reflection of selection for structure (e.g., perch sites) or that disturbances associated with well sites have created enhanced habitat conditions for these disturbance-evolved species.

In terms of livestock watering holes, the probability of occurrence of focal species varies significantly based on distance to the disturbance center; exceptions were windflower and prairie dunewort. Only six-weeks fescue was found to be positively, but marginally, associated with livestock watering holes. All other species were found to be adversely affected, decreasing in occurrence near livestock water holes. Areas directly surrounding livestock watering holes were also found to have increased occurrence of non-native plants, and a reduction in the occurrence of several sensitive bird and plant species. Beaked annual skeleton-weed is amongst the species most sensitive to surface disturbance surrounding livestock watering holes.

Five of the focal bird species considered in the baseline assessment respond significantly to livestock watering holes, with Horned Lark occurrence dramatically decreasing in occurrence within 100 m of a watering hole. Only Chestnut-collared Longspur was positively associated with livestock watering holes. Some other rare native species, such as Ord's kangaroo rat, apparently benefit from the disturbed soils and vegetative structures associated with livestock watering holes. Watering holes have the potential to enhance biodiversity by favouring such disturbance-obligate species, but at the risk of harming other native species and favouring non-native species, most of which are strongly disturbance-adapted. Hypothetically, there may be a threshold of watering hole density on the landscape, below which native biodiversity, in general, is enriched and above which it becomes increasingly threatened.

## 7.3 PRIORITY VEC ISSUES AND IMPACTS

In addition to the overarching concern of surface disturbance, a number of direct and indirect VEC interactions and driving forces of change are of concern in the GSH, and affect the ecological, social, and economic sustainability of the region. A total of 25 priority VEC linkages were identified from the baseline assessment as significant to address in scenario assessment and/or to consider in management recommendations for the GSH (Figure 2-7-1). Fourteen of these linkages and impacts relate in some way, either positively or negatively, to activities associated with gas development and various aspects of the natural, social, and economic environment. The key VEC linkages and impacts identified in the interaction matrix (Figure 2-7-1) are summarized below:

1. The main geological resources of economic interest in the GSH are aggregates, sodium sulphate minerals, and oil and gas reserves. Gas is by far the dominant product. The *terrain sensitivity* of the landscape, especially in ES1 land, is a concern to members of the ranching, First Nations, and local RM communities, who argue that *gas exploration and development* should be restricted in these areas.
2. *Sensitivity of the terrain* and the coordination and complexity of *governance* and land-use regulations and policies are of concern. RM bylaws often reflect provincial policy, but they are not always consistent. Responsibilities over decision-making concerning land use and access are fragmented and sometimes contradictory. An overriding concern is the need for clear designation, zoning, and management of competing land uses.
3. *Terrain sensitivity* models indicate that the topography and landscape within the core of the GSH is highly sensitive to current anthropogenic *land-use patterns* of disturbance. An increased degree of disturbance is occurring adjacent to livestock watering holes located in low, moderate, and high sensitivity areas. On the other hand, recent research indicates no soils highly sensitive to acid deposition in the GSH.
4. *Gas exploration and development*, specifically drilling gas wells, has a short-term requirement for surface *water resources*. The water is typically taken from a landowner's dugout or slough. While isolated incidents of gas contamination of water sources have been reported due to pipeline leaks, there is no evidence of significant, adverse effects on the supply or quality of water for drilling. However, industry initiatives to manage impacts on water quality are largely self-regulated, and provincial and regional policies are perceived as either lacking or not sufficiently enforced at the local level.
5. *Gas exploration and development*, when considered cumulatively with associated roads and trails, negatively affects *land cover and biodiversity*, measured in part by focal species occurrence. The exceptions are disturbance-obligate focal species or focal species whose natural habitat distribution is found primarily within gas-disturbed areas. Range health decreases within a 100-m zone of gas disturbance sites. However, the impact on land cover is less than that of cattle watering holes.
6. *Gas exploration and development* has not contributed significantly to human *population* stability in the Study Area RMs. Notwithstanding expansion in gas activity since 1980, the regional population has continued to decline. No significant long-term correlation exists between levels or distribution of gas development and population change. Gas development, and its current pattern of hiring and investment, is apparently not a sufficient activity to maintain population or recover declining population.
7. *Gas exploration and development* is seen as contributing positively to *social conditions* in the Study Area through generating tax revenues to RMs and land owners, providing employment opportunities, and funding community activities. Gas development is also seen as negatively affecting social conditions through negative impacts on quality of life and deterioration of highway/road infrastructure by use of heavy equipment.
8. Although expansion of *gas exploration and development* is largely supported by baseline social survey participants, there is widespread, *local public perception* that the GSH area is being affected adversely from road development, chemical spills, and damage to species habitat due to gas activity.
9. *Local governance* and responsibilities over decision-making concerning *gas exploration and development*, permitting, access, and enforcement are fragmented and sometimes contradictory across the RMs. The RM of Piapot is currently not a member of the GSH Planning District Commission, but lands within this area are of considerable interest for future gas development.
10. Environmental assessment of *gas exploration and development* activities is a concern, with post-project approvals management of the industry primarily based on best management practices. The industry is relied on to implement and monitor best management practices. There is a noted dissatisfaction with *governance*, particularly the corporate capital tax, among oil and gas producers, and concern with regard to constraints to maximizing gas development.
11. Provisions exist for archaeological impact assessments in the Study Area; however, *gas*

| | Natural Capital | | | | | Human Capital | | | | | | Economic Capital | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VECs | Terrain sensitivity and soils | Economic geology/gas exploration and development | Water resources | Land cover and biodiversity | Population and community | Quality of life and social conditions | Local use and perceptions of the GSH | Local governance | Governance | Heritage resources | First Nations | Economic land patterns | Commercial | Income and employment | Government revenues |
| Regional climate | I | | I | I | I | I | I | | I | | | I | I | I | |
| Terrain sensitivity and soils | | 1 | I | I | | I | I | I | 2 | I | I | 3 | I | | I |
| Economic geology/gas exploration and development | | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Water Resources | | | | | | I | | I | I | | | I | I | I | I |
| Land cover and biodiversity | | | | | 17 | | 18 | | 19 | | 20 | 21 | | I | |
| Population and community | | | | | | I | I | I | I | | | I | I | 22 | I |
| Quality of life and social conditions | | | | | | | | I | I | I | | I | 1 | 1 | I |
| Local use and perceptions of GSH | | | | | | | | I | I | | I | I | I | | |
| Local governance | | | | | | | | | I | | I | I | I | I | I |
| Governance | | | | | | | | | | I | 23 | I | I | I | 24 |
| Heritage resources | | | | | | | | | | | 25 | I | I | | I |
| First Nations use and culture | | | | | | | | | | | | I | I | | |
| Economic land use patterns | | | | | | | | | | | | | I | I | I |
| Commercial activity and productivity | | | | | | | | | | | | | | I | I |
| Income and employment | | | | | | | | | | | | | | | I |

# = Indicates priority linkage between baseline component, addressed in scenario assessment and/or RES recommendations

I = Indicates important linkage between baseline study components and issues addressed indirectly through other, priority baseline linkages

Indicates no discernible, immediate linkage between baseline components

Figure 2-7-1. Key baseline Valued Ecosystem Components issues and impact linkages.

*exploration and development* activities, including well pads and pipelines, have significant adverse impacts on *heritage resources* in terms of archaeological site disturbance.

12. *Gas exploration and development* is perceived as negatively affecting *First Nations* cultural and spiritual values of the GSH. An indefinite moratorium on gas development is called for by elders of both Treaty 4 (File Hills Qu'Appelle) and Treaty 7 (Blood Tribe).

13. *Gas exploration and development* is a major *economic land use* within the GSH. The market value of over $500 million (exclusive of government revenues, at fall 2006 prices) suggests that gas development may have a significant potential to contribute to the economic prosperity of the region.

14. Some *gas exploration and development* industry firms have invested in excess of $171 million in the GSH region in land acquisition, bonuses, and infrastructure development. However, the firms that are the infrastructure investors are extra-regional, many of them extra-provincial, with much of the capital, profits, labour, and materials coming from outside the Study Area. The result is a large investment, but little long-term *financial* benefits to the people of the GSH.

15. *Employment* in the primary sector dominates the region, more so than many other rural areas of Saskatchewan. Activities associated with *gas exploration and development* are a significant source of secondary employment in the region, either in the form of wages from gas industry employment or from revenue generated from gas wells on ranchers' properties. Approximately 40% of baseline social survey participants report having some form of secondary income or direct employment from the gas industry.

16. The economic contribution to the provincial economy of the gas wells of the GSH region is in excess of $500 million/yr. From those sales, Saskatchewan has realized on average $35.7 million/yr since 1990 in *government revenues* from the wells of the GSH region. *Gas exploration and development* also contribute significantly to the tax base of the Province in terms of corporation taxes.

17. Changes to *land cover and biodiversity*, anthropogenic or natural, define conditions for use activities, such as ranching and tourism opportunity, and indirectly affect the income and revenues of local *population*, communities, and local government.

18. Land cover and water resources have a limited carrying capacity, and *local perception* and understanding suggest that ranching activity is not likely to increase significantly beyond current conditions. Gas activities are perceived as a threat to *land cover and biodiversity*, sustainability of water resources, and wildlife habitat.

19. *Governance* issues in the GSH are related to the complexity and coordination of legislation first, and gaps or omissions in the legislation second. Information exchange among government departments needs improvement, especially regarding the sharing of ecological data. However, the Provincial Lands Act is outdated and insufficient to address current *land-use* activities in the GSH. There is also an overall lack of enforcement mechanisms for environmental and regulatory violations and limited government coordination of efforts for data collection and monitoring for *biodiversity* protection. Monitoring and increased conservation of features other than active dunes, e.g., flat land and native prairie, is identified as necessary for biodiversity protection.

20. Current *land cover* in the GSH is considered an important source of medicines by *First Nations*. First Nations elders perceive development in the GSH to negatively affect medicine sources and the *biodiversity* of the region, and call for enhanced levels and scope of protection, particularly in current ES1 zoned areas.

21. The *economic land-use patterns* in the GSH with the greatest potential for surface disturbance and significant impacts to *land cover and biodiversity* are ranching, in particular livestock watering holes, gas well development, and associated roads and trails. Reducing watering hole development in sensitive areas, and reducing the number of well pads per section—thereby directly reducing the overall length and impact of roads and trails—represent the most critical changes that could be made to reduce surface disturbance.

22. The region suffers from human *population* decline, attributed primarily to the loss of youth in search of education, *income, and employment* opportunities not currently available in the GSH. Overall, employment within the region is down over the last 25 years. There are no direct policies or programs in the Study Area to address population decline, nor are there regional or local

policies or programs to support income and employment diversification.

23. The current *governance* framework and land tenure for the GSH is perceived by *First Nations* as unduly restricting their access to traditional lands. First Nations currently do not see themselves as adequately represented in decision-making concerning GSH land use and future management.

24. Royalties and current *governance* structure of land tenure and surface leases are significant contributors to *government revenue*. The current total economic value of ranching in the study represents approximately $45 million in revenues, rents, income, and sales to the local and regional economy and a total potential economic contribution of over $716 million in the next 15 years. The current (2007) total economic value of gas in the Study Area represents approximately $5 million in government revenues, of which $1.012 million are from royalties, and a total potential economic contribution of over $86 million in the next 15 years from these existing wells.

25. There are more than 200 *heritage resource* sites of archaeological significance inside the GSH Review Area. These sites are most often discovered through the process of gas development. The First Nation origin of these artifacts is not documented; however, the GSH are of significant cultural and spiritual significance to both the Treaty 4 and Treaty 7 *First Nations*, and they are concerned over the disturbance and removal of artifacts.

## 7.4 CONCLUSION

Issues facing the rural population and economy of the GSH are not substantively different from those of any other rural area of Saskatchewan. However, indices of resource dependency and specialization in the GSH are higher than for many rural areas of the province, suggesting that the region is extremely vulnerable to external market changes and government policies and initiatives both locally and beyond. Moreover, the GSH is the traditional territory of many Treaty 4 and Treaty 7 First Nations; current land-use activities in the region, namely gas development, are in direct conflict with their traditional use practices, culture, and belief system.

Ranching and gas development are the key economic contributors to the region, providing direct and indirect income support to local residents and revenues to local, regional, and provincial governments. However, the activities associated with ranching and gas development, in particular livestock watering holes, gas well development, and roads and trails, pose considerable threat to the ecological integrity and sustainability of the GSH landscape.

The current RAER contains the greatest concentration of habitat for only 37% of the focal species assessed in the RES baseline. This suggests that most of the species of concern in the GSH, including rare, endangered, and threatened species, are represented mostly elsewhere in the Review Area and, in many cases, are sensitive to the cumulative effects of continued anthropogenic surface disturbance. Management actions that limit disturbing activities, through establishment of new conservation areas and expansion of the existing one, and that ensure best management practices across all lands in the GSH, are necessary to conserve the biological resources and maintain the ecological integrity of the region.

# PART 3

## GREAT SAND HILLS REGIONAL ENVIRONMENTAL STUDY – PROJECTED TRENDS AND ALTERNATIVE FUTURE SCENARIOS –

# Chapter 1: Identification, Selection, and Delineation of Core Biodiversity Areas

## 1.1 INTRODUCTION AND OBJECTIVE

Paramount to any conservation planning effort is the identification of areas in the landscape that, because of their high conservation value, require more stringent protection than the remainder of the landscape. Biodiversity is not distributed randomly or uniformly in any landscape; rather, it tends to be concentrated in certain places (Noss et al. 1997), often called "hotspots" (Myers et al. 2000). Identification and protection of hotspots and other areas of conservation significance is the first step in developing a defensible system of conservation areas in any region. These areas have the most to lose if not managed sensitively.

In Section 2, Chapter 3, we illustrated how the site-selection algorithm, MARXAN, can be used to highlight hotspots and other areas of conservation importance in a landscape, given a set of "goals" concerning features (species, vegetation types, landforms, etc.) that are desired to be represented in the landscape of interest. As described in that chapter, MARXAN minimizes the total "cost" of a potential reserve design by identifying the smallest overall area needed to meet planning goals and by selecting planning units that are clustered rather than dispersed. Hence, MARXAN and similar algorithms give planners the "most bang for the buck." This approach conforms to the tenets of modern systematic conservation planning, which is distinguished by several characteristics (Noss et al. 1997, Margules and Pressey 2000, Groves 2003):

- Explicit, quantitative goals
- Assessment of how well goals are met in existing reserves
- Efficiency – most bang for the buck
- Complementarity – sites are chosen to complement existing protected areas and other selected sites in terms of features represented
- Flexibility – analyzes and compares alternative ways to achieve goals
- Consideration of irreplaceability – extent to which a site is needed to achieve planning goals (or how much each site contributes to achievement of goals)
- Attention to persistence – viability of species and other features over the long term

## 1.2 METHODS AND RESULTS

We considered a variety of MARXAN runs with different assumptions and goal sets to select suites of candidate conservation areas in the Great Sand Hills. Based on discussions from six meetings and conference calls during November and December of 2006, we finalized identification and selection assumptions, goals, and spatial patterns of potential core biodiversity areas within the GSH. Those core biodiversity areas then became an integral component of the preferred scenario, as discussed in the following two chapters. Our discussions centered on the relative suitability of less disturbed versus more highly disturbed areas of the GSH for new conservation areas, qualities and limitations of the biodiversity data used to identify biologically rich areas, the appropriate range of goals used for individual species of varying conservation concern and prevalence within the Study Area, and approaches to quantify the vulnerability of core biodiversity areas to ongoing degradation.

Roads and trails are a reasonable surrogate for anthropogenic surface disturbance in the Study Area because they are used for most human activities. As we were interested in identifying areas for protection that haven't witnessed substantial anthropogenic disturbance, but are at risk to future degradation, we stratified the GSH into a "highly-developed" area that contains substantial road and trail footprints and a "less-developed" area with fewer roads and trails (see Part 2, Chapter 3). On average the GSH has approximately 1.5 km/km$^2$ of roads/trails. As noted in Part 2, based on mean and standard deviation values of road/trail density, we defined highly-developed areas as those having at least 1.9 km/km$^2$ (average density plus 0.5 standard deviation in density) and less-developed areas as having less than 1.9 km/km$^2$. Using this stratification, we restricted MARXAN analyses for selection of core biodiversity to the less developed zone. The primary rationale for this decision is that the less-developed zone is relatively more pristine and will be more practical to maintain in a condition of high ecological integrity.

As discussed in Part 2, Chapter 3, non-systematic species observations (i.e., Conservation Data Centre files and our own opportunistic sightings during the two field seasons) are an inadequate basis for modeling and mapping region-wide biodiversity patterns. We therefore excluded these data from direct use in MARXAN site-selection analyses and instead report the overlap of MARXAN-identified sites with opportunistic data in a post-hoc manner. The one exception was observations of Sharp-tailed Grouse leks, which were included in MARXAN analyses, because leks are relatively permanent features on the landscape and broadly integrate landscape conditions in the surrounding area on local populations.

We also excluded biophysical habitat types (vegetation classes, enduring features, surface watercourses, and topographic depressions) from MARXAN analyses because of the notable similarity or overlap between patterns of biophysical elements and focal species hot spots. This redundancy can be explained by the fact that vegetation types (landcover classes) were the primary explanatory variables in focal species models.

Final biodiversity features targeted in MARXAN site-selection analyses included: 1) seven focal species from the grassland guild; 2) four focal species that were independent of other species; 3) absence of two non-native species; and 4) Sharp-tailed Grouse leks (Table 3-1-1). Rather than set a MARXAN goal of 50% for all features, we varied goals according to global and provincial species status and species rarity within the GSH. We summed global and provincial status numbers for a status sum, ranked the sums (with 1 being the highest rank), and moved SARA or COSEWIC-listed species up one rank. We gave absence of non-native species (which have no status) the lowest rank. Species rarity was judged by the percent of the total Study Area estimated to be species habitat.

MARXAN goals were assigned using status scores with rarer species with higher ranks having higher goals than more common species with lower ranks (Table 3-1-2). Average goals for the 14 species was

Table 3-1-1. The focal species, non-native plant absences, and Sharp-tailed Grouse leks targeted in the MARXAN analyses, their global and provincial status, status sum, and rank as explained in the text, and the percent of the GSH study area occupied by each species.

| Species | Global Status | Provincial Status | Status Sum | Rank | Study Area % |
|---|---|---|---|---|---|
| *Grassland Guild* | | | | | |
| Baird's Sparrow | G4 | S4B | 8 | 4 | 35.7 |
| Chestut-collared Longspur | G5 | S5B | 10 | 6 | 24.2 |
| Grasshopper Sparrow | G5 | S4B | 9 | 5 | 42.0 |
| Savanna Sparrow | G5 | S5B | 10 | 6 | 33.7 |
| Sprague's Pipit | G4 | S4B | 8 | 3 | 50.8 |
| Marbled Godwit | G5 | S5B, S5M | 10 | 5 | 29.6 |
| Prairie dunewort | G3/G4 | S1 | 4 | 1 | 22.3 |
| *Independent spp* | | | | | |
| Ord's kangaroo rat | G5 | S2 | 7 | 2 | 0.28 |
| Low milk-vetch | G5 | S3 | 8 | 4 | 48.5 |
| Smooth arid goosefoot | G3/G4 | S2 | 5 | 1 | 19.7 |
| Beaked annual skeleton-weed | G5? | S2 | 7 | 3 | 7.0 |
| *Invasive plant absence* | | | | | |
| Crested wheatgrass | | NA | | "6" | 43.1 |
| Smooth brome | | NA | | "6" | 27.4 |
| *Other* | | | | | |
| Sharp-tailed Grouse leks | G4 | S5G, S5N | 9 | 5 | <1% |

Table 3-1-2. An example matrix showing MARXAN goals according to species status sum rank and species rarity (percent of study area available as potential habitat).

| Percent habitat available | Status sum "rank" | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 0–1% | 60% | 55% | 50% | 45% | 40% | 35% |
| 1–5% | 55% | 50% | 45% | 40% | 35% | 30% |
| 5–10% | 50% | 45% | 40% | 35% | 30% | 25% |
| 10–25% | 45% | 40% | 35% | 30% | 25% | 20% |
| 25–50% | 40% | 35% | 30% | 25% | 20% | 15% |
| 50–75% | 35% | 30% | 25% | 20% | 15% | 10% |
| 75–90% | 30% | 25% | 20% | 15% | 10% | 5% |
| 90–100% | 25% | 20% | 15% | 10% | 5% | 0% |

approximately 30%, and ranged from 55% for Ord's kangaroo rat to 15% for Savanna Sparrow, crested wheatgrass absence, and smooth brome absence. Although our site-selection exercises were restricted to the less-developed portions of the Study Area, we set goals based on habitat availability across the entire GSH, forcing MARXAN to meet those goals in the less-developed zone. We further explored goal sets that averaged 20% to 65% (Figure 3-1-1) with subsequent discussions determining that the 30% goal set should be used, since it provided the clearest delineation of discrete core biodiversity areas (Figure 3-1-2a). We used a sum runs score ≥75 to define 30%-goal core areas (Figure 3-1-2b), then "squared off" irregularly-shaped patches according to quarter-section boundaries, subdivided them according to township boundaries, and added additional quarter sections containing at least 40 ac of wetland or lakes (Figure 3-1-3a). Table 3-1-3 lists the percentage of biodiversity features contained in planning units with sum runs scores ≥75 for the 30% goals, and also the percentage in core areas defined above.

We calculated the biological irreplaceability of core biodiversity areas as the average sum run scores for planning units with their centres in the core area (Figure 3-1-3a). Irreplaceability scores ranged from 68 to 92 and averaged 85 (Figure 3-1-3b). The process of squaring off the core biodiversity areas resulted in inclusion of some planning units with sum runs scores lower than 75, thus lowering irreplaceability values. We did not calculate irreplaceability for wetlands-based core areas because many were not in the less-developed area used for the MARXAN analyses, and because focal species models were developed for only upland habitats. However, the contribution to regional biodiversity made by the wetlands-based core areas is considerable.

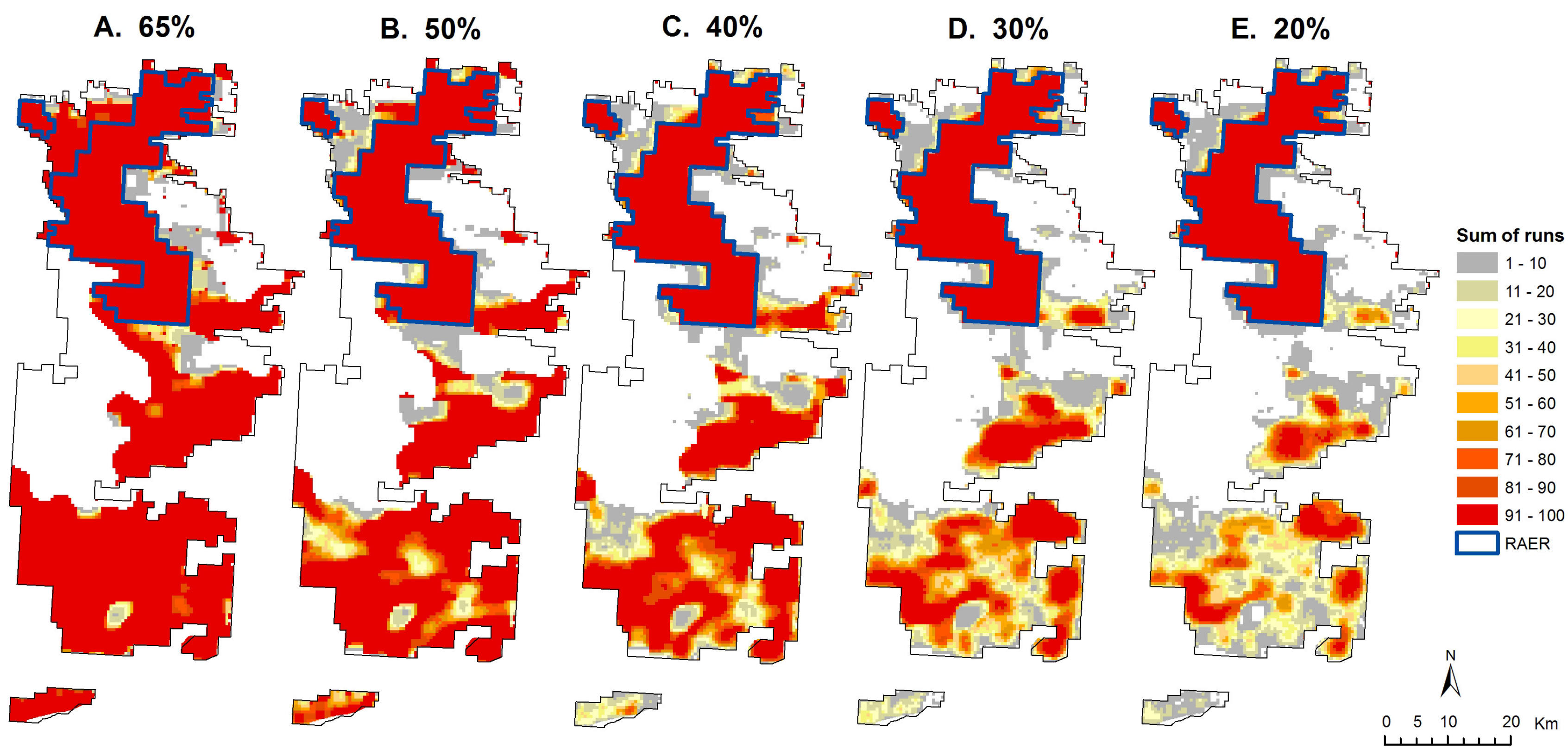



Figure 3-1-1. MARXAN sum runs results for 13 focal species plus Sharp-tailed Grouse leks, using species goals that varied according to species status and rarity, and averaging 20–65% across the five results shown.

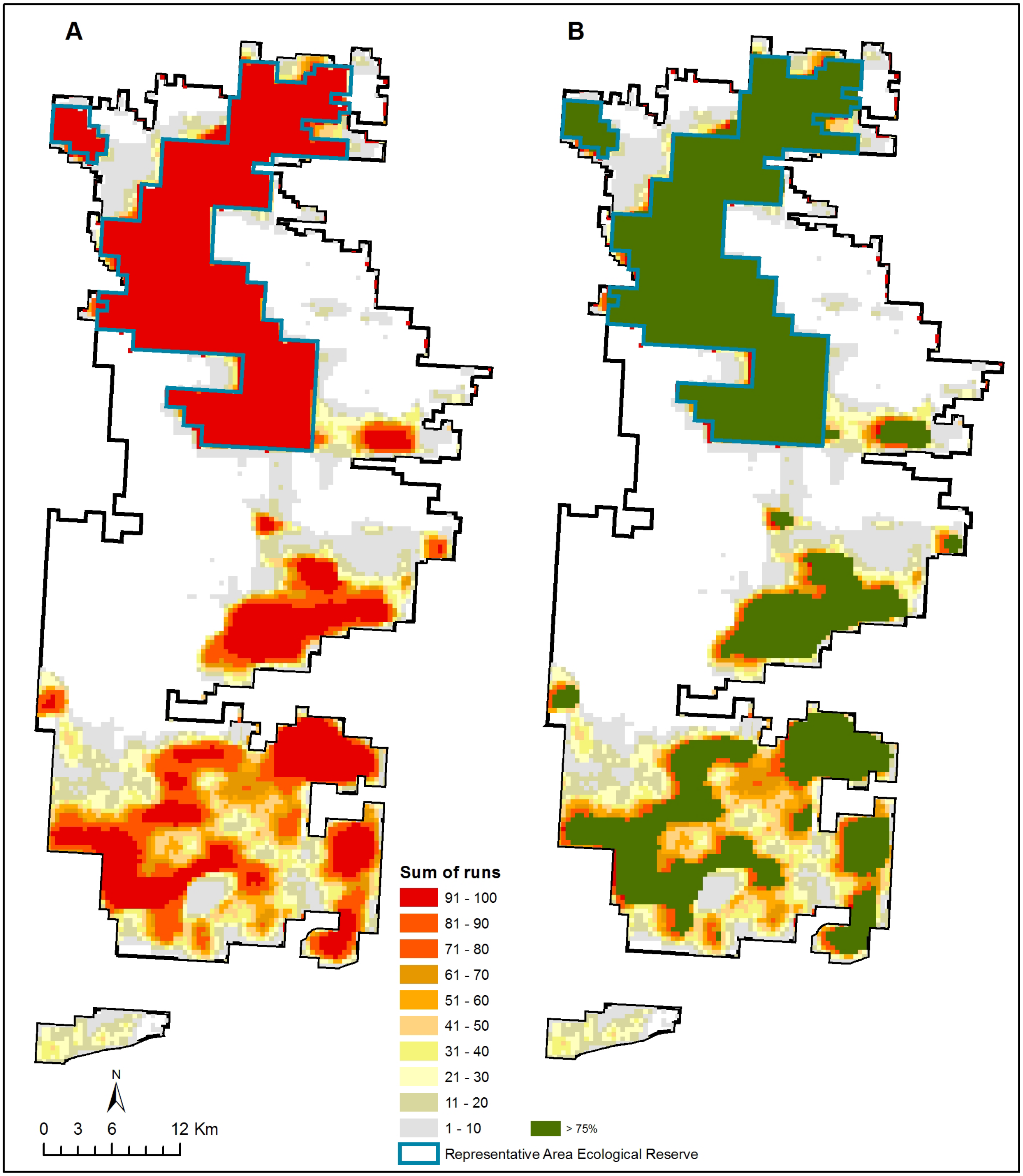



Figure 3-1-2. MARXAN sum runs results for 13 focal species plus Sharp-tailed Grouse leks goals averaging 30% (A), and core biodiversity areas having planning unit sum runs scores ≥75 (B).

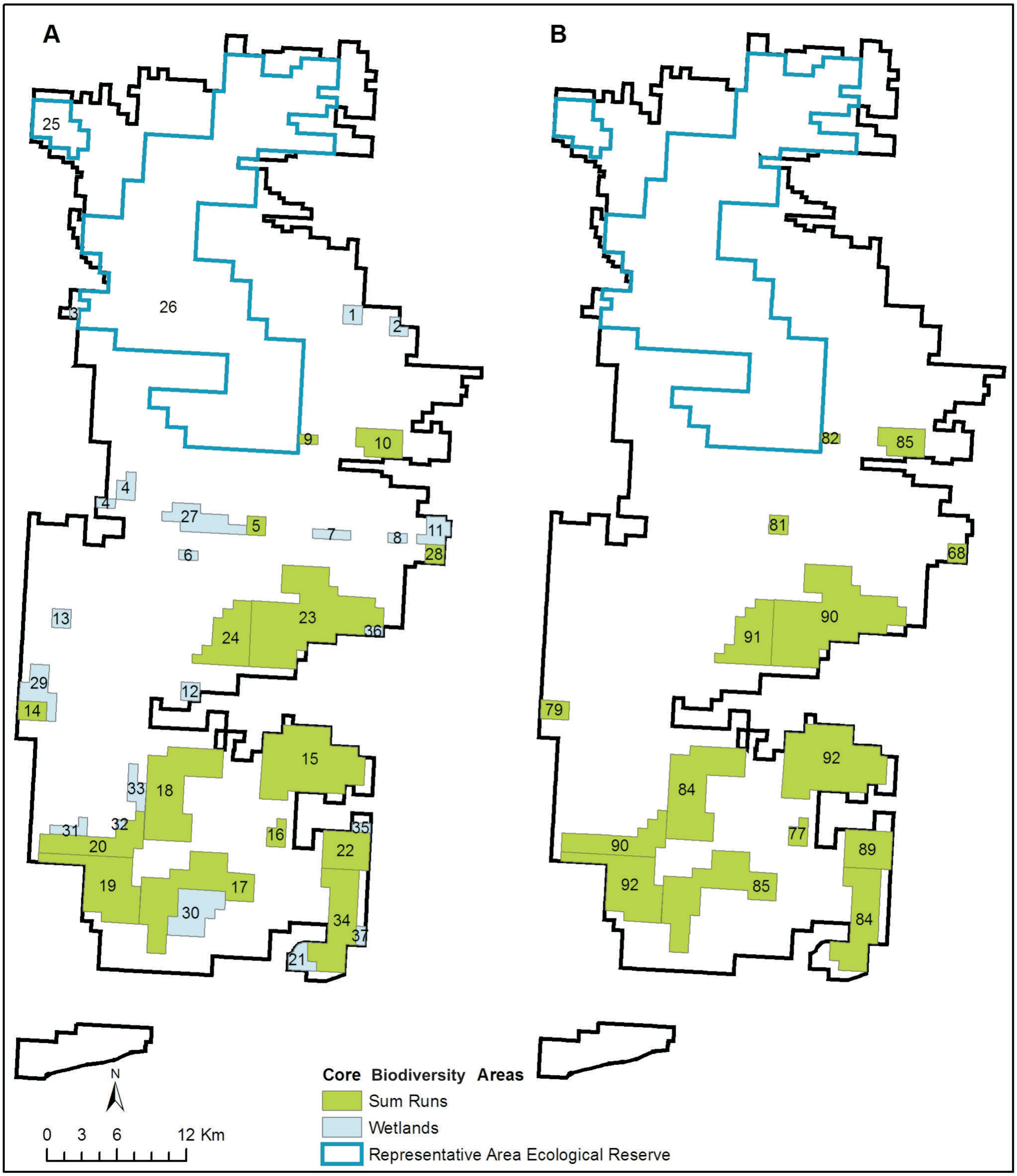



Figure 3-1-3. Sum runs-based (green) and wetlands-based (blue) core biodiversity areas with I.D. numbers (A), and sum runs-based core biodiversity areas labelled with irreplaceability value (B).

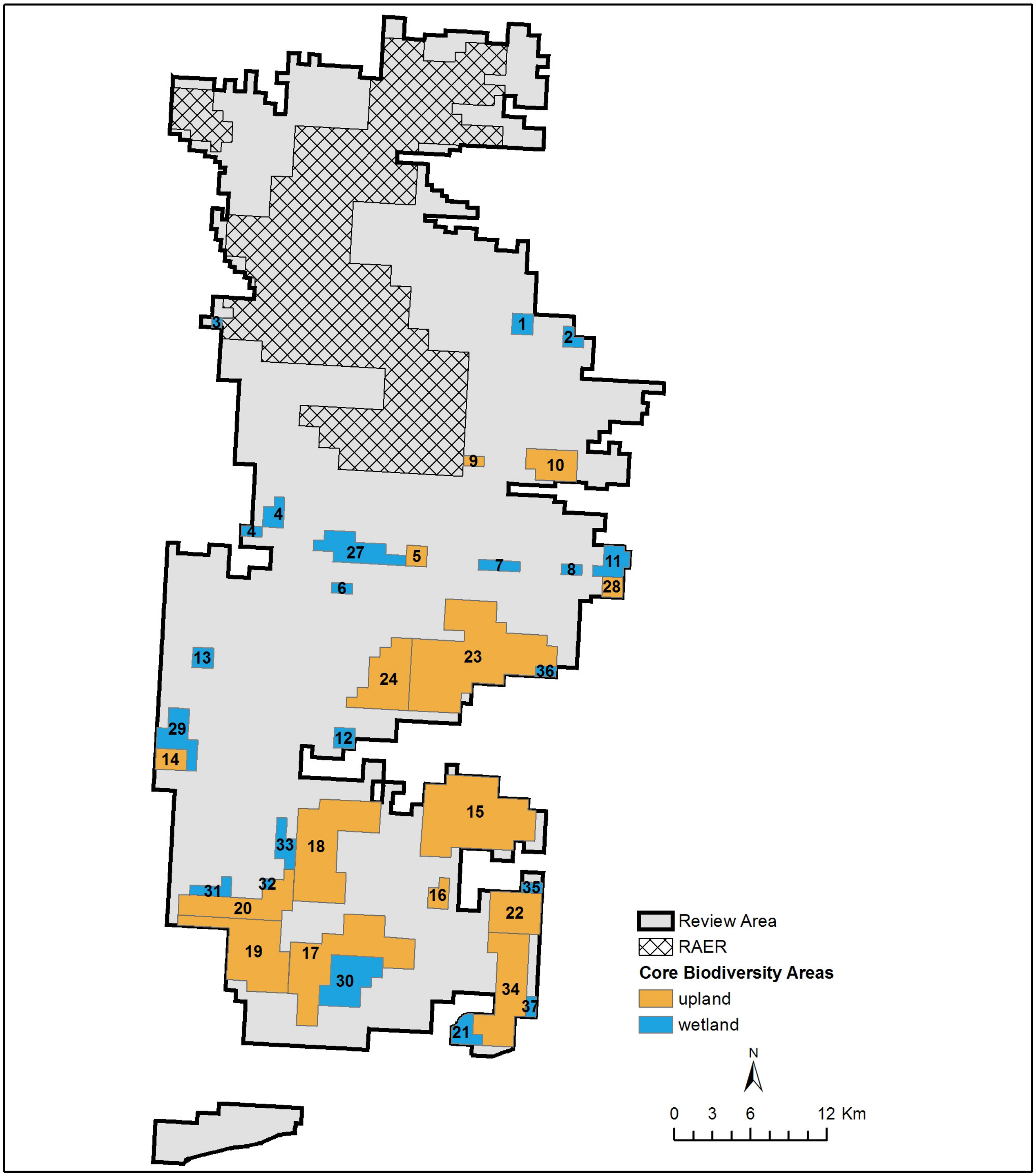



Figure 3-1-3a. Core Biodiversity Areas, Great Sand Hills, Saskatchewan.

Table 3-1-3. Biodiversity features used in MARXAN analyses (MARXAN Target = Y), with total amount in the Review Area, amount in the RAER, and percent protected within the RAER, in the 30% goals MARXAN sum runs ≥75, and in core areas (including the RAER).

| FEATURE | MARXAN Target | Review Area (ha) | RAER (ha) | % of feature | | |
|---|---|---|---|---|---|---|
| | | | | RAER | 30≥75 | CORES |
| Rare Species | | | | | | |
| *CDC element occurrence* | | | | | | |
| American White Pelican | N | 7529 | 0 | 0 | 31.7 | 55.2 |
| Burrowing Owl | N | 9 | 0 | 0 | 66.7 | 33.3 |
| Common Poorwill | N | 7817 | 5552 | 71.0 | 72.7 | 72.5 |
| Ferruginous Hawk | N | 73 | 0 | 0 | 37.0 | 35.6 |
| Long-billed Curlew | N | 1102 | 151 | 13.7 | 40.4 | 44.7 |
| Migratory bird concentration | N | 1644 | 0 | 0 | 11.0 | 96.7 |
| Piping Plover | N | 6 | 0 | 0 | 0 | 100 |
| Olive-backed pocket mouse | N | 4012 | 0 | 0 | 3.4 | 12.0 |
| Ord's kangaroo rat | N | 808 | 281 | 34.8 | 44.1 | 45.3 |
| Beaked annual skeleton-weed | N | 1497 | 875 | 58.5 | 58.7 | 58.5 |
| Bur ragweed | N | 1615 | 668 | 41.4 | 41.4 | 43.8 |
| Lemmon's alkalai-grass | N | 7117 | 0 | 0 | 28.5 | 53.2 |
| Low milk-vetch | N | 537 | 0 | 0 | 0 | 0 |
| Narrow-leaved water-plantain | N | 50 | 0 | 0 | 0 | 0 |
| Nodding umbrella-plant | N | 50 | 50 | 100 | 100 | 100 |
| Prairie dunewort | N | 315 | 0 | 0 | 0 | 0 |
| Sand dune wheatgrass | N | 5 | 0 | 0 | 0 | 0 |
| Six-weeks fescue | N | 202 | 152 | 75.2 | 75.3 | 75.25 |
| Sleepy catchfly | N | 50 | 0 | 0 | 0 | 0 |
| Small lupine | N | 922 | 273 | 29.6 | 29.9 | 29.9 |
| Smooth arid goosefoot | N | 2791 | 1875 | 67.2 | 68.4 | 67.1 |
| Spiny milk-vetch | N | 1395 | 803 | 57.6 | 57.6 | 57.6 |
| Upright narrow-leaved pondweed | N | 2886 | 0 | 0 | 5.2 | 16.6 |
| Wedge-scale saltbush | N | 96 | 0 | 0 | 0 | 0 |
| *2006 Field season observations* | N | Count | Count | | | |
| Sharp-tailed Grouse leks | Y | 18 | 5 | 27.8 | 33.3 | 33.3 |
| American White Pelican | N | 1 | 0 | 0 | 0 | 0 |
| Ferruginous Hawk | N | 23 | 4 | 17.4 | 26.1 | 26.1 |
| Golden Eagle | N | 1 | 0 | 0 | 0 | 0 |
| Loggerhead Shrike | N | 26 | 1 | 3.9 | 7.7 | 7.7 |
| Long-billed Curlew | N | 33 | 2 | 6.1 | 27.3 | 33.3 |
| Northern Harrier | N | 25 | 0 | 0 | 20.0 | 24.0 |
| Piping Plover | N | 1 | 0 | 0 | 0 | 100 |
| Sage Thrasher | N | 1 | 0 | 0 | 0 | 0 |
| Sprague's Pipit | N | 95 | 9 | 9.5 | 32.6 | 37.9 |
| Bur ragweed | N | 3 | 1 | 33.3 | 33.3 | 33.3 |
| Carolina whitlow-grass | N | 4 | 0 | 0 | 0 | 0 |
| Cinquefoil | N | 2 | 0 | 0 | 100 | 100 |
| Common moonwort | N | 5 | 1 | 20.0 | 20.0 | 20.0 |
| Golden currant | N | 3 | 0 | 0 | 0 | 0 |
| Low pussytoes | N | 2 | 0 | 0 | 0 | 0 |
| Narrowleaf cottonwood | N | 1 | 0 | 0 | 0 | 0 |
| Narrow-leaved water-plantain | N | 1 | 0 | 0 | 0 | 0 |
| Nodding umbrella-plant | N | 1 | 1 | 100 | 100 | 100 |
| Pursh's milk-vetch | N | 2 | 0 | 0 | 0 | 0 |
| Rough pennyroyal | N | 4 | 1 | 25.0 | 75.0 | 75.0 |
| Slender mouse-ear cress | N | 6 | 0 | 0 | 0 | 0 |
| Smooth spike-primrose | N | 1 | 0 | 0 | 0 | 0 |
| Spiny milk-vetch | N | 5 | 0 | 0 | 20.0 | 20.0 |

| Table 3-1-3. Continued | | | | | | |
|---|---|---|---|---|---|---|
| FEATURE | MARXAN Target | Review Area (ha) | RAER (ha) | % of feature | | |
| | | | | RAER | 30≥75 | CORES |
| Biophysical habitat types | | | | | | |
| *Enduring features* | | ha | ha | | | |
| AFHB | N | 8572 | 0 | 0 | 28.1 | 38.7 |
| AFUA | N | 6443 | 0 | 0 | 26.6 | 27.9 |
| ALKB | N | 8835 | 382 | 4.3 | 14.1 | 29.8 |
| ALUA | N | 19591 | 2599 | 13.3 | 15.2 | 21.9 |
| AMHB | N | 699 | 0 | 0 | 0 | 0 |
| AMHD | N | 5205 | 0 | 0 | 80.2 | 79.9 |
| AMKD | N | 9542 | 0 | 0 | 30.4 | 33.8 |
| REHB | N | 59489 | 0 | 0 | 21.9 | 25.8 |
| REHD | N | 78280 | 34294 | 43.8 | 46.1 | 45.5 |
| *SPOT vegetation types* | N | | | | | |
| Alkalai flat | N | 1171 | 25 | 2.1 | 30.7 | 84.6 |
| Bare sand GSH | N | 309 | 209 | 67.6 | 71.2 | 70.55 |
| Grassland | N | 63909 | 3834 | 6.0 | 34.8 | 39.5 |
| Juniper | N | 30680 | 11721 | 38.2 | 39.6 | 39.8 |
| Mixed shrub | N | 31254 | 7381 | 23.6 | 29.6 | 32.7 |
| Revegetated 25% | N | 2563 | 111 | 4.3 | 34.2 | 47.2 |
| Revegetated 50% | N | 8337 | 891 | 10.7 | 24.5 | 28.9 |
| Sagebrush | N | 37540 | 9699 | 25.8 | 33.1 | 35.2 |
| Silvery grassland | N | 13966 | 798 | 5.7 | 23.7 | 25.1 |
| Trees | N | 7448 | 2413 | 32.4 | 34.3 | 37.2 |
| Vegetated wetland | N | 713 | 2 | 0.3 | 1.5 | 83.9 |
| Wet meadow | N | 448 | 1 | 0.2 | 8.9 | 14.7 |
| *Other* | N | | | | | |
| Toe slopes and swales | N | 45652 | 12197 | 26.7 | 36.9 | 39.0 |
| Surface watercourses (metres) | N | 55836 | 0 | 0 | 28.0 | 37.5 |
| Focal species models | | | | | | |
| *Grassland guild* | | | | | | |
| Baird's Sparrow | Y | 66996 | 2349 | 3.5 | 34.6 | 40.0 |
| Chestnut-collared Longspur | Y | 45407 | 878 | 1.9 | 21.9 | 26.3 |
| Grasshopper Sparrow | Y | 78826 | 2176 | 2.8 | 30.7 | 35.3 |
| Marbled Godwit | Y | 55496 | 1184 | 2.1 | 37.1 | 43.4 |
| Savannah Sparrow | Y | 63152 | 1233 | 2.0 | 33.4 | 39.0 |
| Sprague's Pipit | Y | 95393 | 6503 | 6.8 | 32.3 | 37.3 |
| Prairie dunewort | Y | 41869 | 824 | 2.0 | 40.3 | 46.2 |
| *Shrub guild* | | | | | | |
| Clay-colored Sparrow | N | 108740 | 32504 | 29.9 | 34.9 | 36.5 |
| Spotted Towhee | N | 37659 | 9070 | 24.1 | 31.0 | 33.7 |
| Chokecherry | N | 106309 | 30945 | 29.1 | 33.5 | 35.0 |
| Six-weeks fescue | N | 76790 | 22942 | 29.9 | 33.0 | 33.8 |
| *Independent species* | | | | | | |
| Ord's kangaroo rat | Y | 521 | 257 | 49.3 | 53.2 | 52.3 |
| Beaked annual skeleton-weed | Y | 13113 | 207 | 1.6 | 48.0 | 53.6 |
| Low milk-vetch | Y | 90984 | 15841 | 17.4 | 37.2 | 40.3 |
| Smooth arid goosefoot | Y | 37027 | 5534 | 14.9 | 28.9 | 31.7 |

| Table 3-1-3. Continued | | | | | | |
|---|---|---|---|---|---|---|
| FEATURE | MARXAN Target | Review Area (ha) | RAER (ha) | % of feature | | |
| | | | | RAER | 30≥75 | CORES |
| *Invasives absence* | | | | | | |
| Crested wheatgrass | Y | 106875 | 30701 | 28.7 | 37.0 | 38.6 |
| Smooth brome | Y | 136199 | 25478 | 18.7 | 36.4 | 39.4 |
| *Range health* | | | | | | |
| Moderate range health | N | 86169 | 6947 | 8.1 | 29.7 | 35.7 |
| High range health | N | 106007 | 29770 | 28.1 | 36.2 | 38.5 |
| *Other* | | | | | | |
| Brown-headed Cowbird | N | 79900 | 22265 | 27.9 | 32.6 | 34.7 |
| Common Nighthawk | N | 32469 | 10488 | 32.3 | 34.3 | 34.4 |
| Horned Lark | N | 75916 | 2476 | 3.3 | 33.6 | 39.2 |
| Long-billed Curlew | N | 81597 | 2669 | 32.7 | 28.3 | 33.1 |
| Upland Sandpiper | N | 89459 | 14426 | 14.7 | 35.4 | 38.9 |
| Small lupine | N | 81424 | 24103 | 29.6 | 33.5 | 34.4 |
| Windflower | N | 103916 | 26923 | 25.9 | 34.0 | 35.4 |
| Canadian thistle absence | N | 159415 | 28366 | 17.8 | 34.2 | 37.2 |
| Kentucky bluegrass absence | N | 127088 | 24326 | 19.1 | 34.9 | 38.1 |

# Chapter 2: Past Trends and Possible Futures in Surface Disturbances and Biodiversity Condition for the Great Sand Hills of Saskatchewan

## 2.1 INTRODUCTION AND OBJECTIVE

As part of our assessment of the status and vulnerability of the natural capital of the Great Sand Hills Review Area, we assessed trends in surface disturbances from 1979 to 2005 for three anthropogenic disturbances: 1) roads/trails; 2) gas well surface leases; and 3) livestock watering holes. Annual rates of change were determined from past trends and used to guide spatial modeling of future scenario landscapes in the year 2020. Here we report on activities associated with surface disturbance using a retrospective analysis of aerial photography and database records, as well as projected future landscape conditions in the GSH, considering three scenarios that vary in intensity and location of gas development and livestock watering holes. One of the three scenarios is a preferred scenario that minimizes human impacts on areas of high biodiversity value. We discuss the implications of potential future development (i.e., the three scenarios) on overall biodiversity condition, selected focal species, and range health to demonstrate the environmental benefit of imposing conservation actions in identified core biodiversity areas.

## 2.2 METHODS

### 2.2.1 Retrospective Assessment of Surface Disturbances

We determined past occurrences of road/trails, livestock watering holes, and gas well surface leases within the GSH Review Area through comparisons of historic (1979 and 1991) and current (2005) aerial photography images (roads/trails and livestock watering holes) and queries of existing geo-spatial databases that have identified year of establishment (gas well surface leases). We verified current conditions for each disturbance type using 2005 aerial photographs, updating locations of features where necessary. Based on 1979 baseline conditions (1979 aerial photographs), annual rates of change were determined for two historic time periods to quantify status quo trends in future scenarios and for comparisons with projected future growth rates. The first historic period was 1980–1991 (12 years), while the second historic period was 1992–2005 (14 years).

#### *2.2.1.1 Photo-interpretation*

Photo-interpretation and GIS analysis were used to evaluate amounts of road/trail and livestock watering hole features (dugouts, troughs, tanks, etc.) for the years 2005 (current), 1991, and 1979. In rare cases, some road/trail segments were present historically, but were not observed in subsequent time periods. Adjusting for the loss of these features, we estimate the total kilometres of roads/trails or number of livestock watering holes for the following three time periods:

1) 1979 (feature was evident in photos from 1979, 1991, and 2005);
2) 1980 to 1991 (feature was evident in photos from 1991 and 2005); and
3) 1992 to April 2005 (feature was evident only in photos from 2005).

#### *2.2.1.2 Gas well surface leases*

Using available GIS files (i.e., the gsh_wells.shp ESRI shapefile), we estimated the year that drilling was completed from the "FINISH DATE" attribute field. Each gas well surface lease was classified into one of the three time periods identified (see above). Although a few (4%) surface leases were listed as oil, disposal, or undefined converted wells, we refer to all wells as gas, since they represent the vast majority (96%) of well surface leases and current activities in the GSH region. Furthermore, as some areas of the GSH also contain directional or slant wells that were not represented in the gsh_wells shapefile, we refer to wells more generally as surface leases or pads, which is consistent with our goal of measuring trends in surface disturbances, and not necessarily well numbers. Using the 3 defined time periods we estimated the total number and annual rate of change in gas well surface leases within the GSH Review Area for two intervals (1980–1991 and

| Table 3-2-1. Scenario assumptions used for modeling future development of gas reserves and changes associated with livestock grazing. Landscapes were projected for the year 2020 (15-year horizon). | | | |
|---|---|---|---|
| Variable | Scenario 1 (baseline 1) | Scenario 2 (baseline 2) | Scenario 3 (preferred scenario) |
| A. Gas development | | | |
| 1. Extent of gas development (GLJ Petroleum Consultants Ltd 2006) | Proven + Probable (2P) | Proven + Probable + Possible (3P) | Proven + Probable (2P) |
| 2. Maximum well pad density per section | 8 | 8 | 2 |
| 3. Road development | Roads to each well pad (least cost path from section lines) | Roads to each well pad (least cost path from section lines) | Roads to each well pad (least cost path from section lines) |
| 4. Restrictions in location | No new development in RAER | No new development in RAER | No new development in RAER and restricted development in core biodiversity areas |
| B. Livestock grazing | | | |
| 1. Rate of development | 5 new water holes per year | 5 new water holes per year | 5 new water holes per year |
| 2. Minimum distance from existing watering site | 1,200 metres (0.75 miles) | 1,200 metres (0.75 miles) | 1,200 metres (0.75 miles) |
| 3. Restrictions in location | None | None | No new watering sites in RAER and core biodiversity areas |
| C. Core biodiversity areas | | | |
| 1. Upland sites | No protection outside of RAER | No protection outside of RAER | RAER & 40 acre planning parcels chosen from MARXAN |
| 2. Wetlands, ponds, or lakes | No further protection | No further protection | RAER & quarter sections with >40 acres in wetland or lake |

1992–2005). As the Review Area excludes a large number of gas well surface leases just to the west of the core study boundary, rates of change reported here should be considered modest.

### 2.2.1.3 *Relationship between historic gas (well pads) and road/trail development*

To determine the relationship between road/trail extent and gas development, we compared and analyzed spatial databases of historic (1979–2005) gas well pads with road/trail development over the same period. Because the association of roads/trails with individual gas well pads would typically occur at a local scale of no more than 1 mi distant from a well pad, we assessed relationships of roads/trails and well pads at this spatial scale. First, total length of new roads/trails (1979 to 2005 segments) was estimated in a GIS for two zones of the Review Area: 1) within a 1-mi radius of each new well pad established between 1979 and 2005; and 2) areas further than 1 mi from these same new well pads. Second, we estimated densities (km/mi$^2$) of new roads/trails and new well pads (number/mi$^2$) within a 1-mi (1600-m) radius of each 10-m Study Area pixel in a GIS.

Using GIS results, we report on the percent of new roads/trails associated with new wells pads and the overall strength of relationship between new gas well-pad development and new road/trail development using three complementary statistical analyses. In the first analysis we estimated a Pearson correlation between the two density grids (new well-pad densities and new road/trail densities) using random Review Area locations (sample size reflecting the number gas well pads identified between 1979 and 2005). Using these results, we graphed the relationship between new roads/trails and new well pads by estimating the mean

(±SE) new road/trail density for each 1-unit increase in new gas well-pad density (i.e., 0, 1, 2, etc. well pads/mi$^2$). In the second statistical analysis, we compared density of new roads/trails at new well-pad locations and a sample of random sites (at the same sample size as new well pads) that were no closer than 1 mile from new well-pad locations using a Mann-Whitney two-sample statistic and a null hypothesis that road/trail density at new well-pad locations is equal to road/trail density at random sites away from new well pads. Finally, in our third analysis we used logistic regression to estimate the odds ratio of any new road/trail segment occurring within a 1-mi radius of a new well pad compared to random locations occurring away from new gas development.

## 2.3 FUTURE SCENARIO ASSESSMENT OF SURFACE DISTURBANCES

We projected gas and watering hole developments for the year 2020 (15 years into the future from 2005) under three separate scenarios that vary in extent of gas reserves, density of gas well pads per section, road development associated with well pads, and number of new livestock watering holes (Table 3-2-1). The first two "baseline" scenarios were based on past trends in development for the GSH (retrospective analysis of livestock watering holes) and a gas reserve analysis from GLJ Petroleum Consultants Ltd (2006). In contrast, our third scenario represented a "preferred" or conservation-based approach that strived to maintain biodiversity through protection of critical biodiversity hotspots identified in MARXAN (i.e., core biodiversity areas; see Chapter 1) and a reduction in surface disturbance for areas outside of identified biodiversity hotspots (i.e., the matrix). In all three scenarios we assumed that the Representative Areas Ecological Reserve (RAER) would be maintained with its current moratorium on gas development extended. We compare amounts and rates of development for each of the three scenarios and two historic periods, as well as characterize their potential impact on biodiversity.

### 2.3.1 Location of Future Gas Well Pads

Based on recommendations from GLJ Petroleum Consultants Ltd (2006), we assumed a maximum density of 8 wells or well pads per legal land section (1 mi$^2$) for all future gas developments in the Milk River formation and a maximum density of 2 wells or well pads per section in the more marginal Second White Specks formation. Using a GIS, we simulated gas well-pad locations for each section in the GSH using a staggered pattern that was typical and representative of extensive gas development adjacent to the Review Area (Figures 3-2-1 and 3-2-2). Development of gas well pads was modeled for each section based on whether they occurred within economically viable areas of gas development for the specific scenario and whether it was an in-fill or step-out development. In-fill developments were projected for sections with at least one existing gas well by filling-in additional wells to achieve the maximum well-pad density prescribed in each scenario. Simulated locations of wells were used for in-filling by locating those sites (7 or less) at maximum distances from existing wells. Step-out developments, on the other hand, were defined as sections without existing gas wells and thus were prescribed at the maximum density of 8 (Milk River formation) or 2 (Second White Specks formation) well pads per section, again using the simulated gas well-pad locations. Spatial extent, and thus the total number of sections developed, varied depending on the scenario. For scenarios 1 and 3, proven plus probable (i.e., 2P) gas reserves were used to

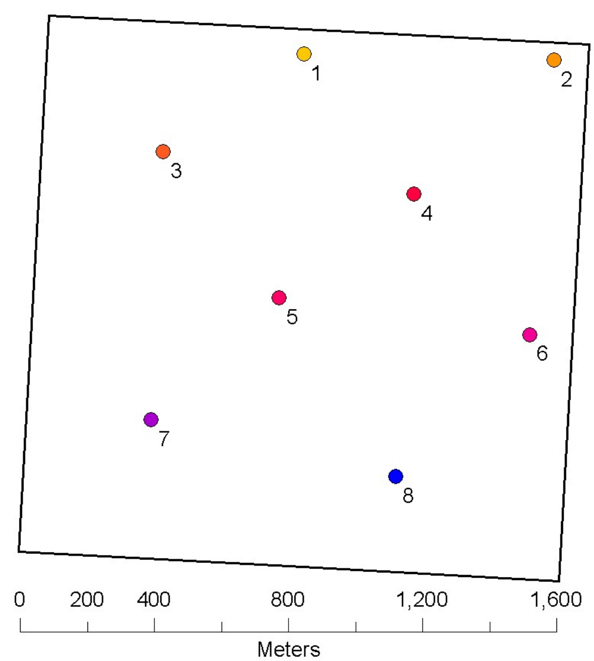



Figure 3-2-1. Simulated pattern of gas well pads for future scenario modeling of gas development. For densities of 8 wells per section all sites are chosen; for 1 well pad per section number 5 is chosen; for 2 well pads per section numbers 1 and 5 are used; finally for 4 well pads per section 3, 4, 7, and 8 are chosen. Minimum distance in horizontal (east-west) or vertical (north-south) wells is approximately 735 m, while diagonal wells are a minimum distance of 530 m.

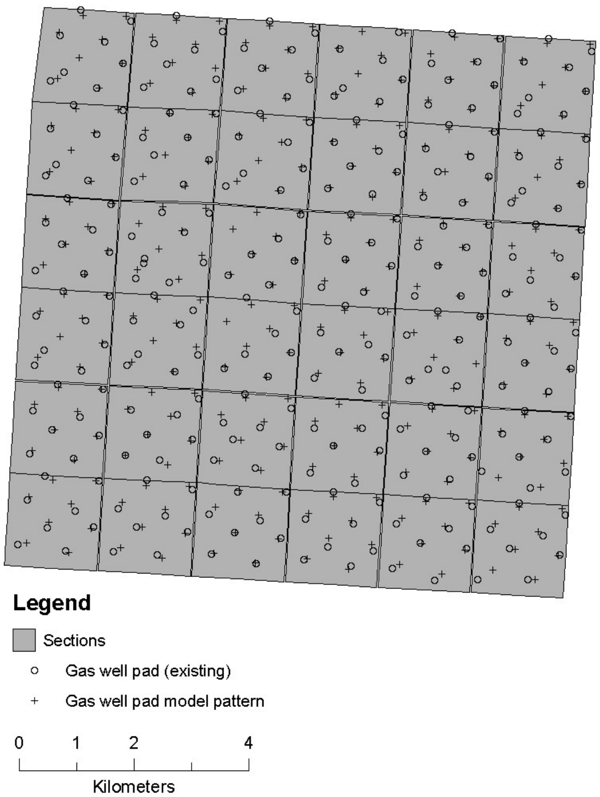



Figure 3-2-2. Patterns of existing well pads (circle symbol) and simulated well pads (plus symbol) for Township 18, Range 25 west of the 3rd Meridian. This township lies just to the west of the review area and approximates a density of 8 well pads per section, which is assumed to be the maximum for future development in the Great Sand Hills. Patterns between observed and simulated well locations are similar.

define the spatial extent of step-out locations, whereas for scenario 2 proven, probable, and possible (i.e., 3P) gas reserves were used. As the Milk River formation dominates the Review Area, the majority of expanded gas development used a well density of 8 per section in baseline scenarios. Despite the potential for economically viable gas production in the Representative Area Ecological Reserve (RAER), no gas development was assumed within RAER boundaries. All simulations were for a future landscape in 2020, based on a 15-yr horizon of gas development recommended from GLJ Petroleum Consultants Ltd (2006). We assumed that all historic (pre-2006) surface disturbances (roads and well sites) were still present on the landscape in the year 2020 (i.e., we did not consider abandonment and possible restoration). Finally, we did not consider in any of the scenarios future gas pipelines or additional infrastructure associated with the distribution and processing of natural gas.

### 2.3.2 Location of Future Roads/Trails

We assumed a road/trail would be associated with each new well pad. New roads/trails were simulated in a GIS using a shortest path analysis from existing roads/trails with a preference for first developing roads along section boundary allowances before entering into the section to access new well sites. This analysis was not optimized for all well pads simultaneously and thus may potentially overestimate the length of roads. This bias, however, is consistent among scenarios, thereby allowing a direct comparison or ranking. As we did not consider new roads/trails for other land-use/land management activities, projected road/trail levels may in fact be conservative. As we lacked explicit spatial information on road/trail activity and type, we assumed all linear features to be similar in class, despite field observations that suggest a wide diversity in human activity and footprint. For modeling purposes, this assumption means that even small trails represented an accessible linear feature for drilling rigs, maintenance, etc. Since this isn't likely the case, estimates of total kilometres of new roads may again be quite conservative. Additional development of small trails would likely be required, increasing total kilometres of new roads. For focal species assessments, the generalization regarding roads means that significant responses are an average response. In most cases, larger hard-surface/graveled roads would substantially increase the impact on sensitive species, whereas small vegetated trails would be unlikely to have significant effects on behavior and viability. Until road/trail use and type can be quantified for all road/trail segments, the average road/trail condition must be assumed.

Besides projecting roads/trails for the three specific future scenarios, we also sought to quantify how road/trail levels may vary as a function of gas well-pad density. To assess such differences we simulated road development using our GIS simulation model at four different well-pad densities: 1, 2, 4, and 8 well pads/section. We selected a 120-mi$^2$ (10 x 12 sections) region of the GSH that lacked active gas well activity, but still contained a normal background level of roads/trails at 3.4 km/mi$^2$. For each well-pad density treatment, we simulated new well pads and roads from the shortest path analysis of existing roads. Total kilometres of new roads were estimated as well as densities on a per section (km/mi$^2$) basis. We examined plots of well pad density and road/trail density for evidence of an inflection point where well pad densities below the inflection would represent a preferred, minimal footprint.

### 2.3.3 Location of Future Livestock Watering Holes

We assumed that the most direct surface disturbance associated with ranching activities was that associated with livestock watering holes, where concentration of animals results in destruction of vegetation and soil erosion. Based on a retrospective analysis of annual rate of change in livestock watering holes from 1979 to 2005, future watering holes were projected at similar annual rates for the future. Locations of new watering holes were assigned (randomly) to regions of the Review Area > 1,200 m (0.75 mi) from existing livestock watering holes. This threshold distance was based on suggestions from experts and largely supported by analyses of minimum distance between existing water holes for selected areas of the Review Area.

## 2.4 CHARACTERIZING THE VULNERABILITY OF CORE BIODIVERSITY AREAS TO DEVELOPMENT

Using core biodiversity areas identified through wetland/water queries and MARXAN site-selection analyses (see Chapter 1), we summarized current and future levels of gas well pads, roads/trails, and livestock watering holes, as well as changes to range health and two focal species (beaked annual skeleton-weed and the non-native crested wheatgrass), for each of the 37 core biodiversity areas. Vulnerability of each core biodiversity area was ranked based on potential increases in future surface disturbance from each scenario. More specifically, vulnerability ranks were based on potential changes in density of well pads, roads, and livestock watering holes, as well as percent change in focal species habitat. For ranking developments, those core areas with the highest change in density of surface disturbance were ranked as highly vulnerable (i.e., 1), while those core areas with low or even no change in density of surface disturbances were ranked low (i.e., 37). In contrast, focal species vulnerability ranks were based on changes in habitat distribution, with those core areas seeing the greatest loss of natives (e.g., beaked annual skeleton-weed) or gain of non-natives (e.g., crested wheatgrass) as the most vulnerable. Vulnerability ranks were used to summarize threats for core areas and prioritize conservation needs for areas with the highest biodiversity representation.

## 2.5 RESULTS AND DISCUSSION

### 2.5.1 Retrospective Assessment of Trends in Surface Disturbances

#### *2.5.1.1 Gas well pads*

There were 76 gas well surface leases present in the GSH Review Area in 1979 (Table 3-2-2). By 1991, 653 new wells (54 wells per year) were established, and by 2005 an additional 738 wells (53 wells per year) were added (Table 3-2-2). Most gas well development occurred on the western side of the Review Area and south of the RAER (Figure 3-2-3).

Table 3-2-2. Total length of roads/trails and total number of gas well surface leases and livestock watering holes (including SAF troughs) and annual rate of change for each surface disturbance per time interval.

| | Road/Trail length | | Gas well pads | | Livestock watering holes | |
|---|---|---|---|---|---|---|
| Year or period of time | Total km | Annual rate of change | Total number | Annual rate of change | Total number | Annual rate of change |
| 1979 | 2,497[a] | – | 76 | – | 378 | – |
| 1980–1991 | | | | | | |
| (12 years) | 2,932[b] | 36.3 | 728 | 54.3 | 428[c] | 4.5 |
| 1992–2005 | | | | | | |
| (14 years) | 3,175[b] | 17.4 | 1,463 | 52.5 | 507[c] | 5.6 |
| Year unknown | 0 | | 1 | | 0 | |

a. Total length of roads in 1979 includes 51 km and 112 km that were not present in 1991 and 2005 images, respectively.
b. Total length of roads in the 1980-1991 period includes 28 km that were only present in 1991 images; the latter periods include 3 km that were present in 1991 and 2005 images but were outside the coverage of the 1979 imagery.
c. Number does not include 4 watering holes that were visible in 1979, but not in 1991 or 2005 images.

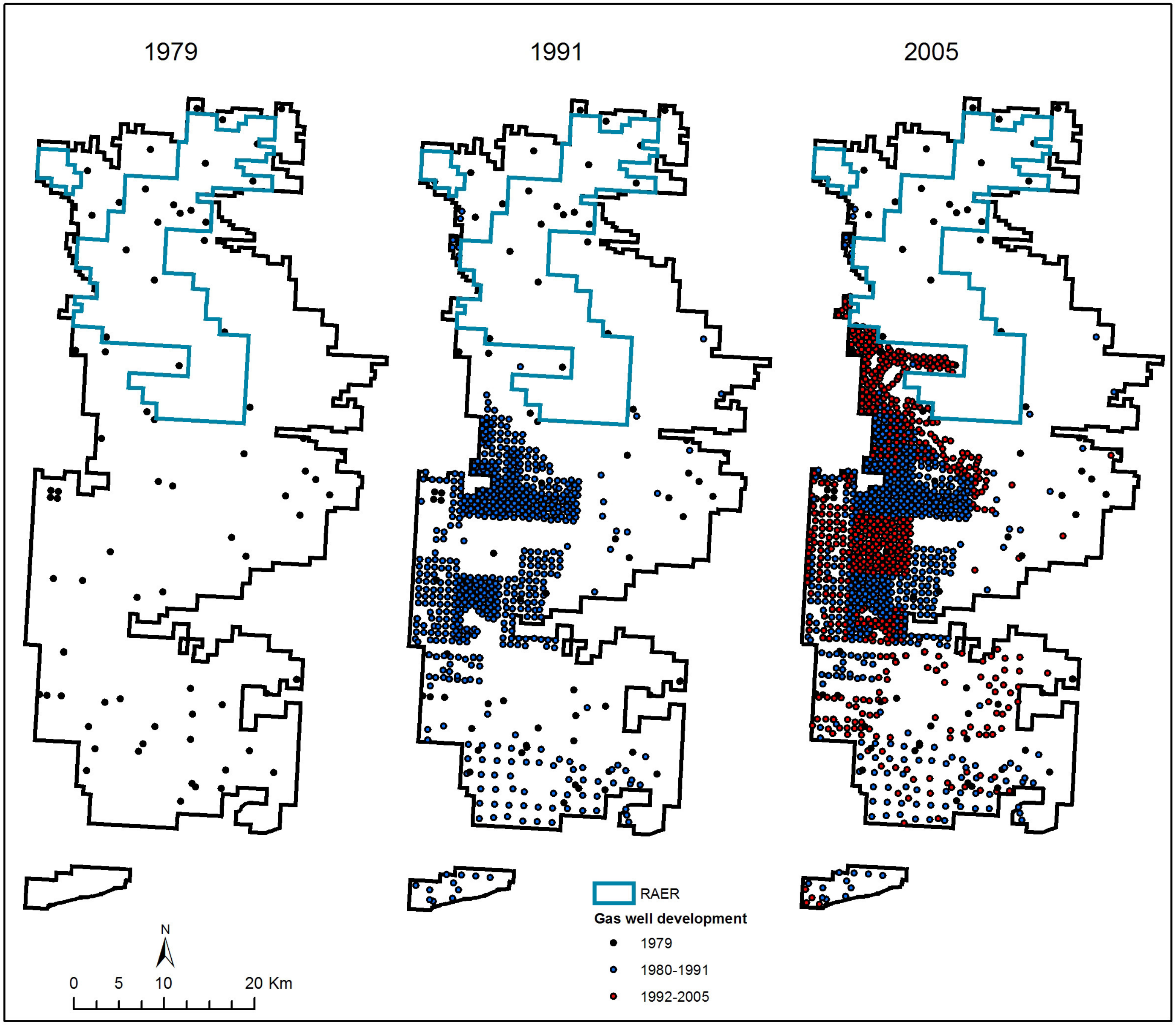



Figure 3-2-3. Time sequence of gas well surface leases in the Great Sand Hills Review Area for 1979 (map on left), 1991 (map in middle), and current (2005) conditions (map on right).

#### 2.5.1.2 *Roads/trails*

We estimate that 2,497 km of roads/trails were present in 1979 (Table 3-2-2). By 1991, there was an increase of an additional 435 km to a total of 2,932 km (486 km added and 51 km no longer visible). By 2005 another 383 km of roads/trails were added and 140 km disappeared, resulting in an overall increase since 1991 of 243 km or a total of 3,175 km. Road/trail development occurred at a rate of approximately 40 km/yr during the first period (1980–1991), but because of road disappearance, we estimate the overall rate of change at 36 km/yr (Table 3-2-2). In comparison to the first period, rate of road/trail development decreased in the second period (1992-2005) to 27 km/yr, or an average rate of change considering road loss of 17 km/yr (Table 3-2-2). Overall, road/trail development was spatially associated with areas of gas development (Figures 3-2-3 and 3-2-4).

#### 2.5.1.3 *Livestock watering holes*

There were 378 livestock watering holes present in 1979 (Table 3-2-2). By 1991, 54 new watering holes were present, an increase of 4.5 sites/yr. By 2005 an additional 79 livestock watering structures, or about 5.5 holes/yr, were present. Overall, we assume a rate of increase of 5 livestock watering holes/yr over the entire retrospective analysis, although we acknowledge that 86% of structures were recently (since 2004) added in the central region of the Review Area due to infilling activities associated with Saskatchewan Agriculture and Food (SAF)-distributed watering system troughs (Figure 3-2-5). Beyond the SAF-distributed water systems in the central part of the Review Area, other new watering holes were scattered throughout the Review Area without any obvious spatial pattern (Figure 3-2-5).

#### 2.5.1.4 *Relationship between historic gas (well pads) and road/trail development*

Maps depicting density of new roads/trails and well pads from 1979 to 2005 show a strong spatial overlap between road/trail development and gas well-pad development (Figure 3-2-6). This association was supported statistically by a Pearson correlation, *r*, of 0.868 ($p<0.001$) and a Mann-Whitney *U* value of -44.092 ($p<0.001$). Mean density of new roads/trails surrounding new well pads was 1.68 km/mi$^2$ (±0.022 SE), whereas mean density of new roads/trails at random locations away from areas of gas development was 0.09 km/mi$^2$ (±0.005 SE), suggesting that the vast majority of new roads/trails detected between 1979 and 2005 were directly associated with gas development. In fact, 93% (802.0 km of 860.7 km) of all new road/trail segments established between 1979 and 2005 were within a 1-mi radius of new gas well pads established during that same period. This left only 58.7 km of the 860.7 km of total road/trail development that was presumably associated with other land-use activities beyond gas development. Based on logistic regression analyses, new roads/trails were 153 times (±55 SE, $p<0.001$) more likely to be built in association with a new well pad than random locations elsewhere in the Review Area. Graphically, the relationship between new road/trail density and new well-pad density was consistent with an expected positive association, although the rate of change in road/trail density after 8 well pads/mi$^2$ appears to asymptote (Figure 3-2-7). This result may reflect the fact that some sites in the Review Area had multiple surface leases.

## 2.6 FUTURE SCENARIO ASSESSMENT OF SURFACE DISTURBANCES

### 2.6.1 Gas Well Pads

#### 2.6.1.1 *Baseline scenarios*

From a 2005 baseline of 1,463 surface leases (1,559 gas wells), we projected an additional 1,446 well pads by 2020 (96/yr) for 2P gas reserves (scenario 1) and 1,887 well pads by 2020 (126/yr) for 3P gas reserves (scenario 2) (Table 3-2-3; Figure 3-2-8). Location of future gas well pads occurred throughout the west, central, south, and northwest areas of the GSH, with greater expansions in the east for the 3P gas reserve extent in scenario 2 (Figure 3-2-9). Since spatial simulations restricted future gas development from occurring inside the RAER, these estimates were conservative when compared to those of GLJ Petroleum Consultants Ltd (2006). Given the known extent of gas reserves and overlap with the RAER, an additional 378 (scenario 1-2P gas) or 804 (scenario 2-3P gas) well pads would have been projected by 2020 without RAER designation. Regardless of restriction due to RAER status, rates of gas development were approximately twice (96–126 well pads/yr) that of historic trends (53–54 well pads/yr). It is possible that the 15-year horizon suggested by GLJ Petroleum Consultants Ltd (2006) is liberal, particularly given the somewhat marginal nature of gas reserves in much of the GSH and the current and projected low prices of natural gas.

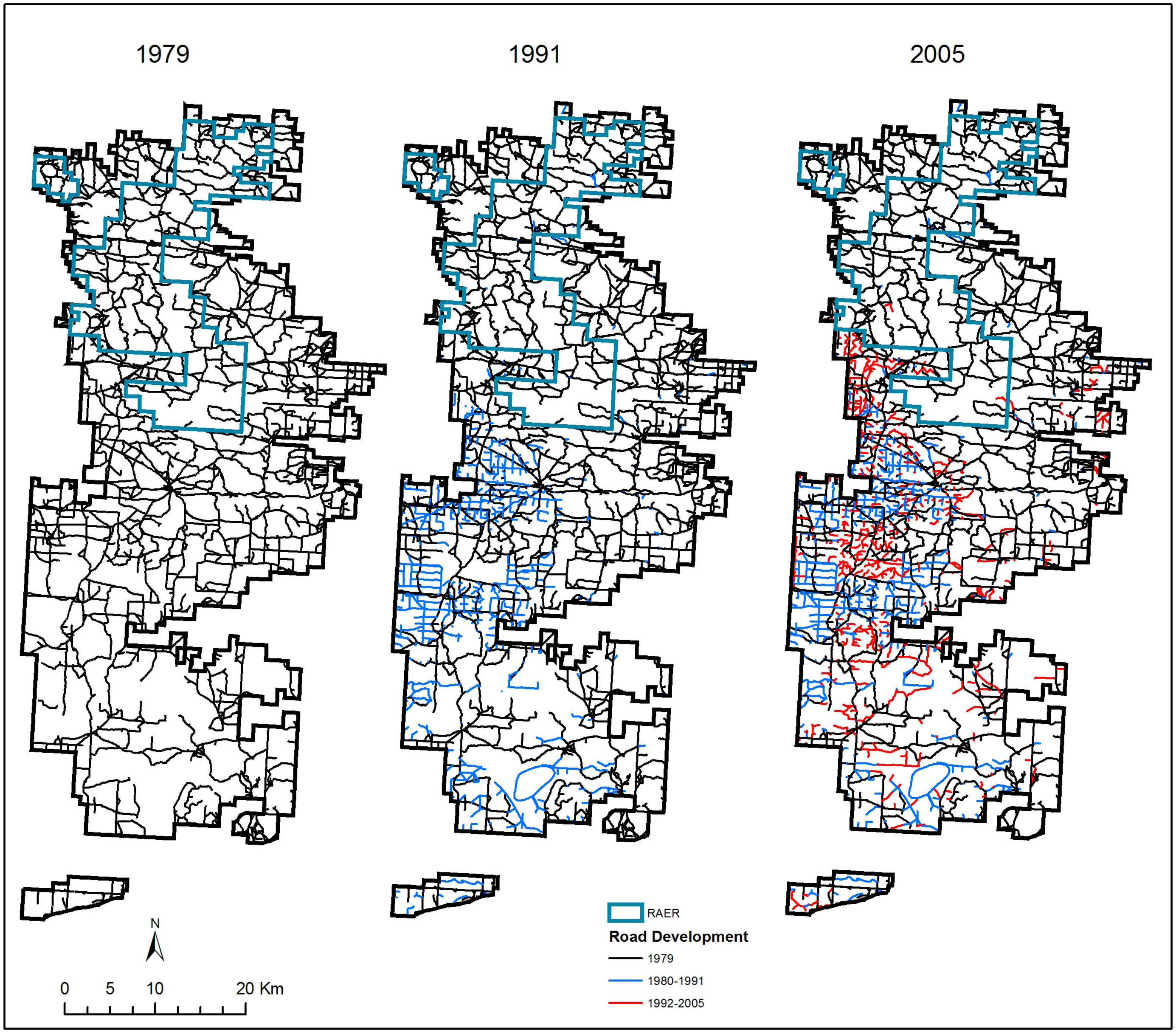



Figure 3-2-4. Time sequence of road and trail development in the Great Sand Hills Review Area for 1979 (map on left), 1991 (map in middle), and current (2005) conditions (map on right).

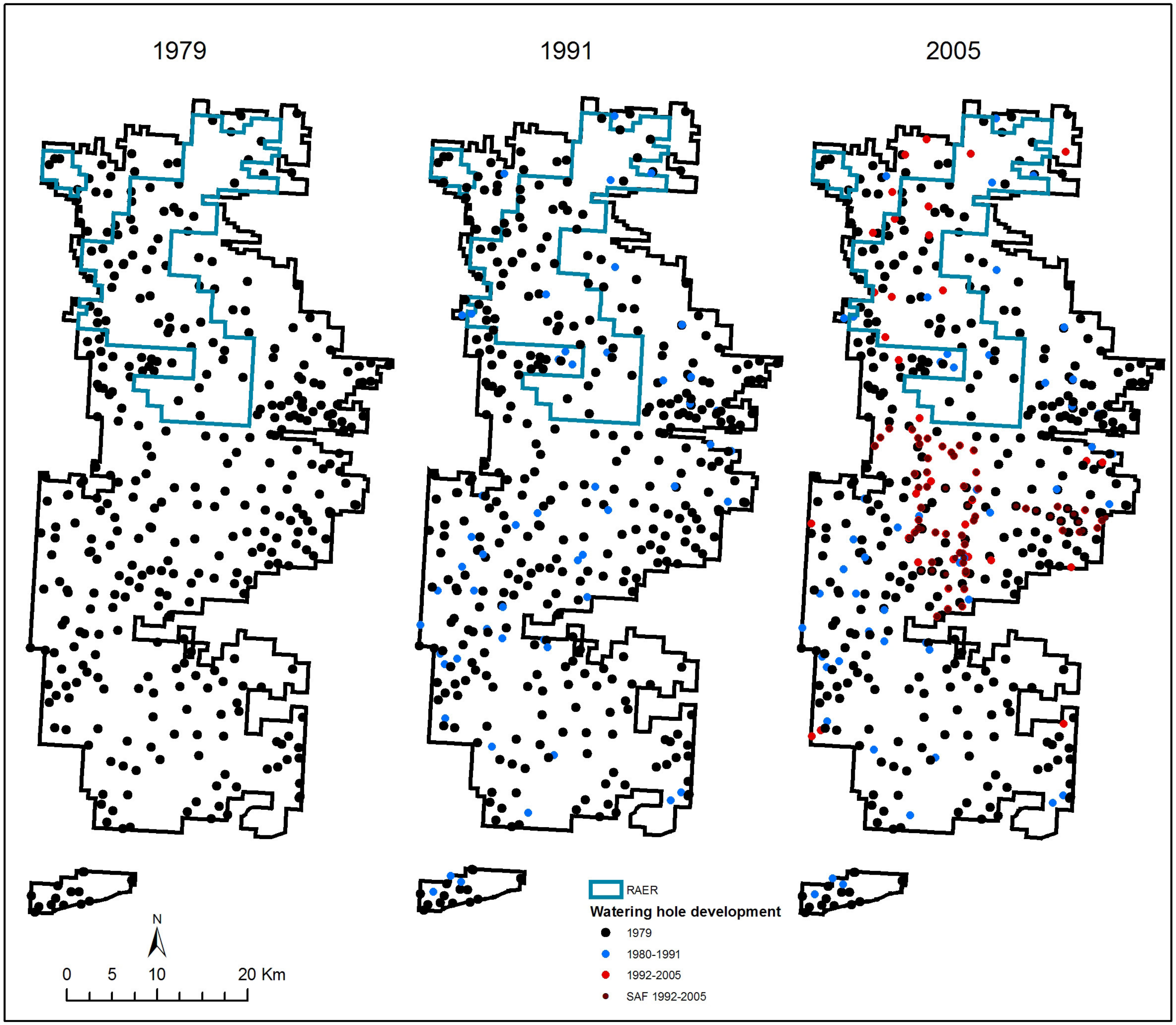



Figure 3-2-5. Time sequence of livestock watering hole and SAF trough development in the Great Sand Hills Review Area for 1979 (map on left), 1991 (map in middle), and current (2005) conditions (map on right).

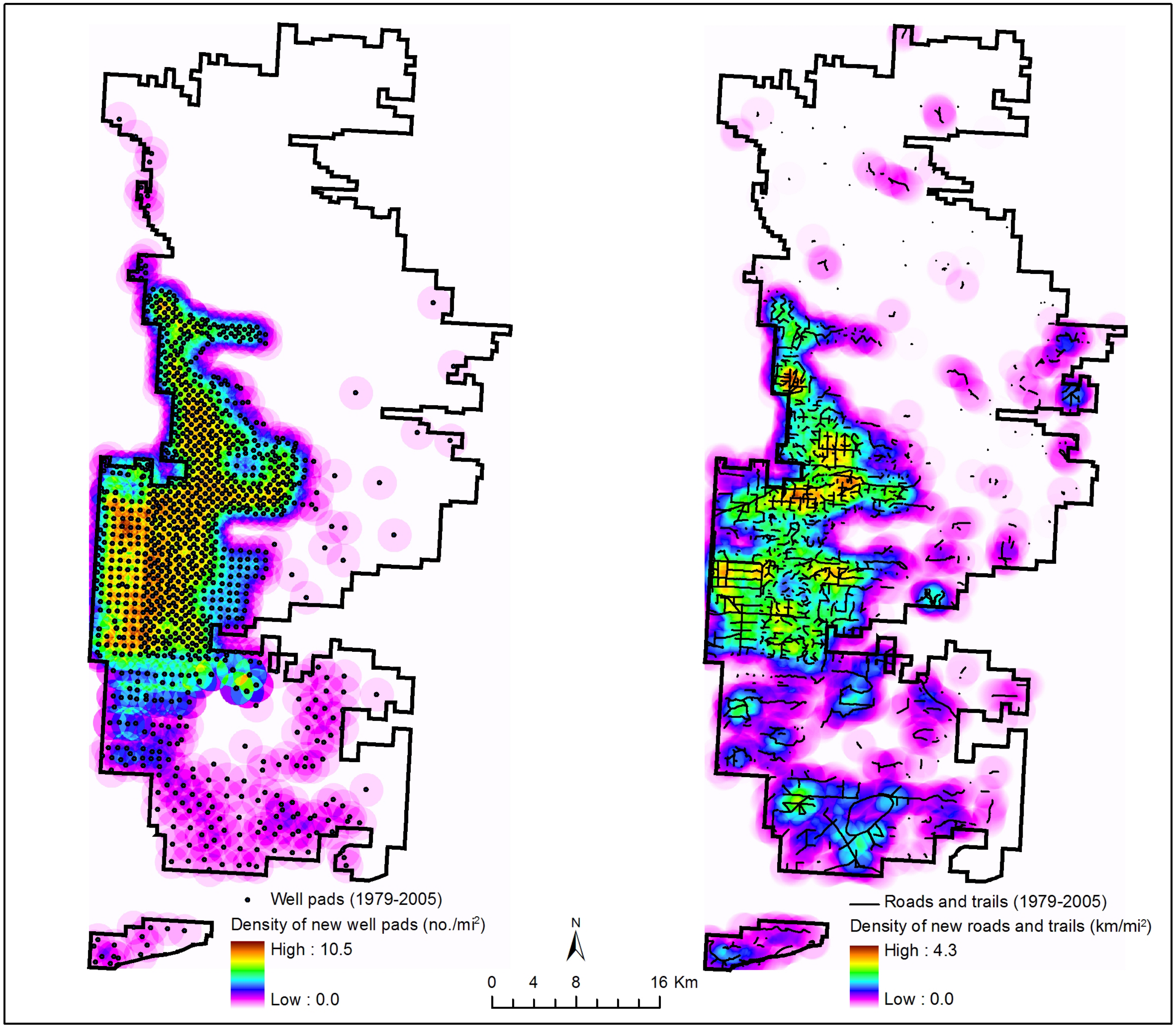



Figure 3-2-6. Location of gas well pads (a) and roads (b) established between 1979 and 2005. Density of well pads (a) and roads/trails (b) within a 1-mi radius are depicted in ramped colors from white (0/mi²) to dark red (10.5 well pads/mi² or 4.3 km/mi² of roads/trails) and are based on a units per mi² basis.

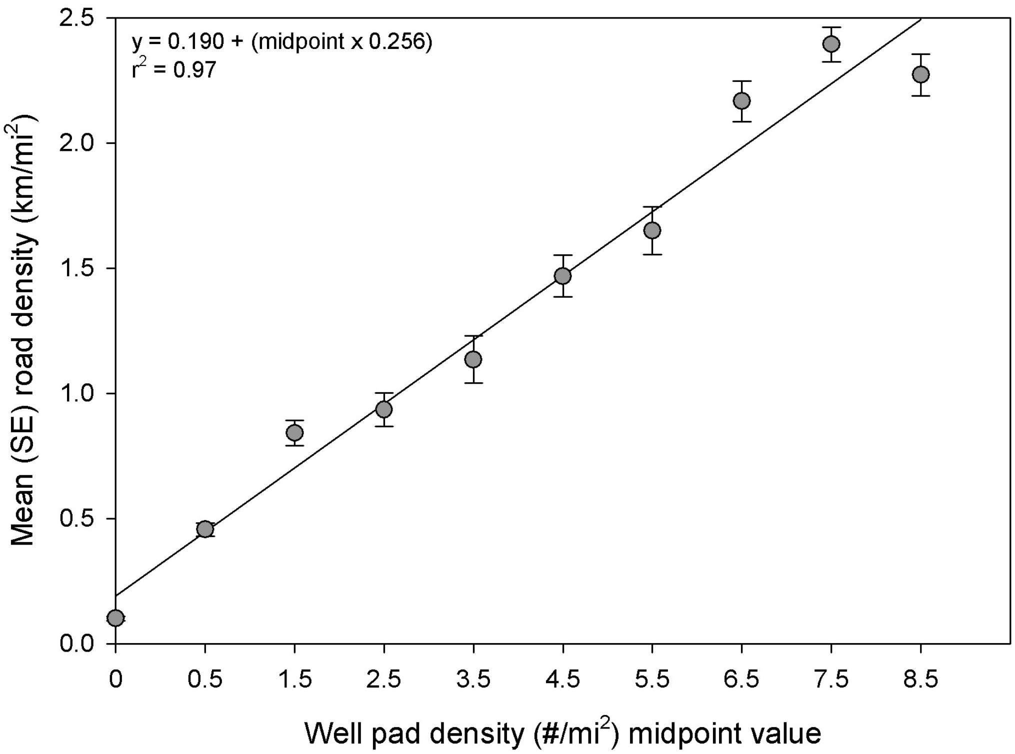



Figure 3-2-7. Relationship between development of roads/trails (as per road/trail density) and gas wells (as per well pad density class) in the Great Sand Hills. Regression line reflects mean values of road/trail density for each well pad density class (e.g., 0, 0 to 1, 1 to 2, 2 to 3, etc.). The strength of relationship in the regression is therefore biased high.

### *2.6.1.2 Preferred scenario*

By limiting gas development in core biodiversity areas (see Chapter 1) and holding maximum well-pad density at two per section outside of core biodiversity areas, the preferred scenario resulted in a total of 309 new well pads (Table 3-2-3; Figure 3-2-8). Although this represents a substantial reduction (21 well pads/yr) from baseline conditions (96–126 well pads/yr), directional or slant drilling from multi-well sites could be used to offset losses by maintaining a well density of 8 per section (i.e., 3 directional or slant wells per vertical well) outside of proposed core biodiversity areas. To further mitigate potential losses associated with core biodiversity areas, directional/slant drilling could also be used from existing well pads or along core biodiversity area boundaries. We are aware of the technological and economic challenges posed by directional/slant drilling and strongly encourage industry to work creatively with SIR and SE to address the challenge of assessing how directional and slant drilling can be employed to gain the most access from within existing gas well surface lease pads of core biodiversity areas and from perimeter locations to core biodiversity areas and/or RAER. As one example of possible accessibility afforded by directional/slant drilling we conducted an analysis based on a surface horizontal reach of 400-m and 1000-m. These results should be treated only as an example and are not

Table 3-2-3. Projected future additions under 3 scenarios (described in Table 3-2-1) for gas well pads, livestock watering holes, and roads in the Great Sand Hills.

| | | | | Gas well pads | | Road length | | Livestock watering holes | |
|---|---|---|---|---|---|---|---|---|---|
| Scenario Number | Gas | RAER | Core areas | Number of new sites | Annual rate of change | km of new roads/trails | Annual rate of change | Number of new sites | Annual rate of change |
| 1-baseline | 2P | Yes | No | 1,623 | 108.2 | 624 | 41.6 | 75 | 5.0 |
| 2-baseline | 3P | Yes | No | 2,068 | 137.9 | 814 | 54.3 | 75 | 5.0 |
| 3-preferred | 2P | Yes | Yes | 309 | 20.6 | 110 | 7.3 | 51 | 3.4 |

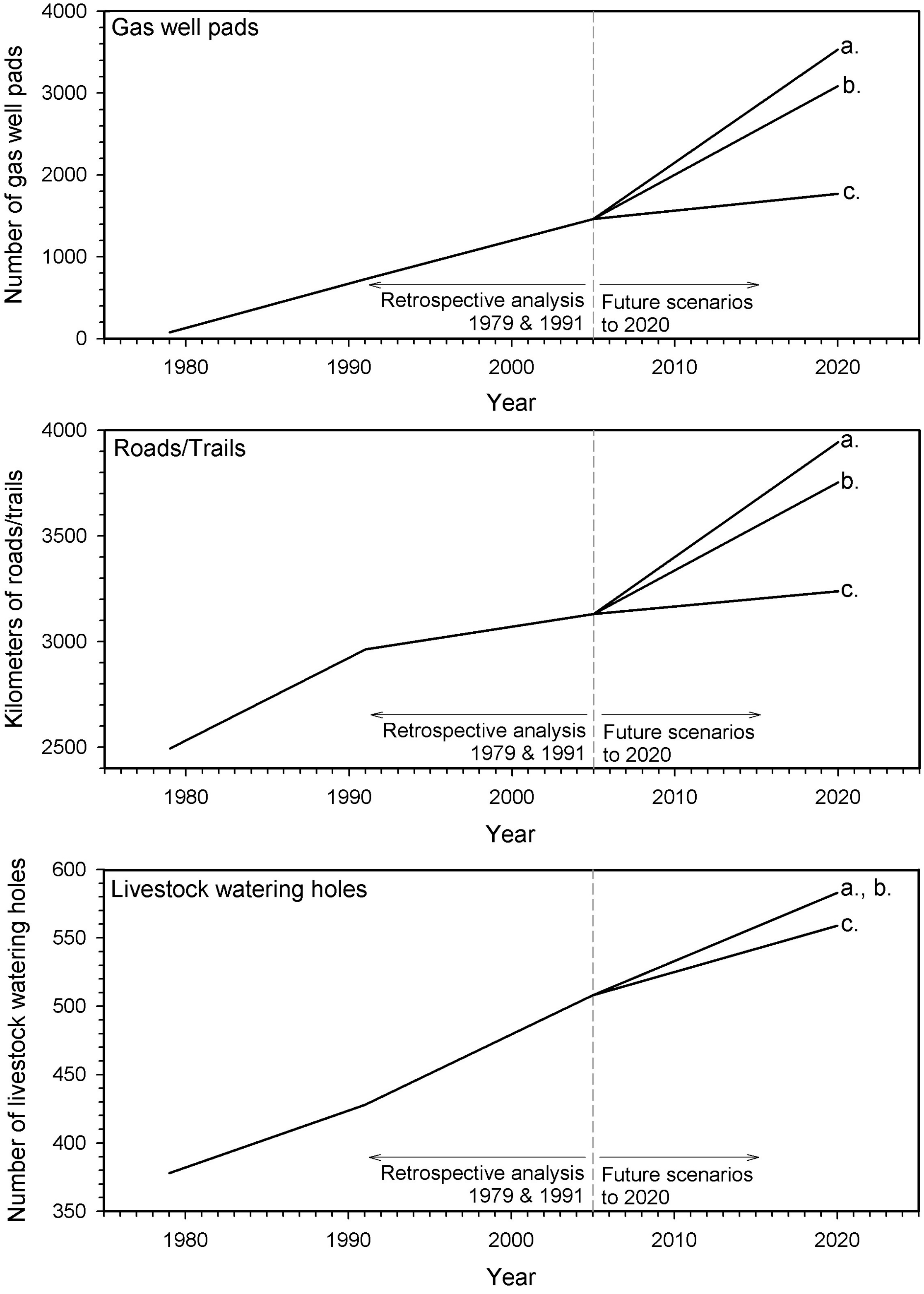



Figure 3-2-8. Past trends in total number and kilometres of surface disturbances within the Great Sand Hills Review Area and possible future projection under 3 scenarios: a: 3P gas reserves at a maximum of 8 well pads/section & 75 new livestock watering holes; b: 2P gas reserves at a maximum of 8 well pads/section & 75 new livestock watering holes; and c: preferred scenario of 2P gas reserves at a maximum of 2 well pads/section & 51 new livestock watering holes both excluded from 37 core area biodiversity hotspots.

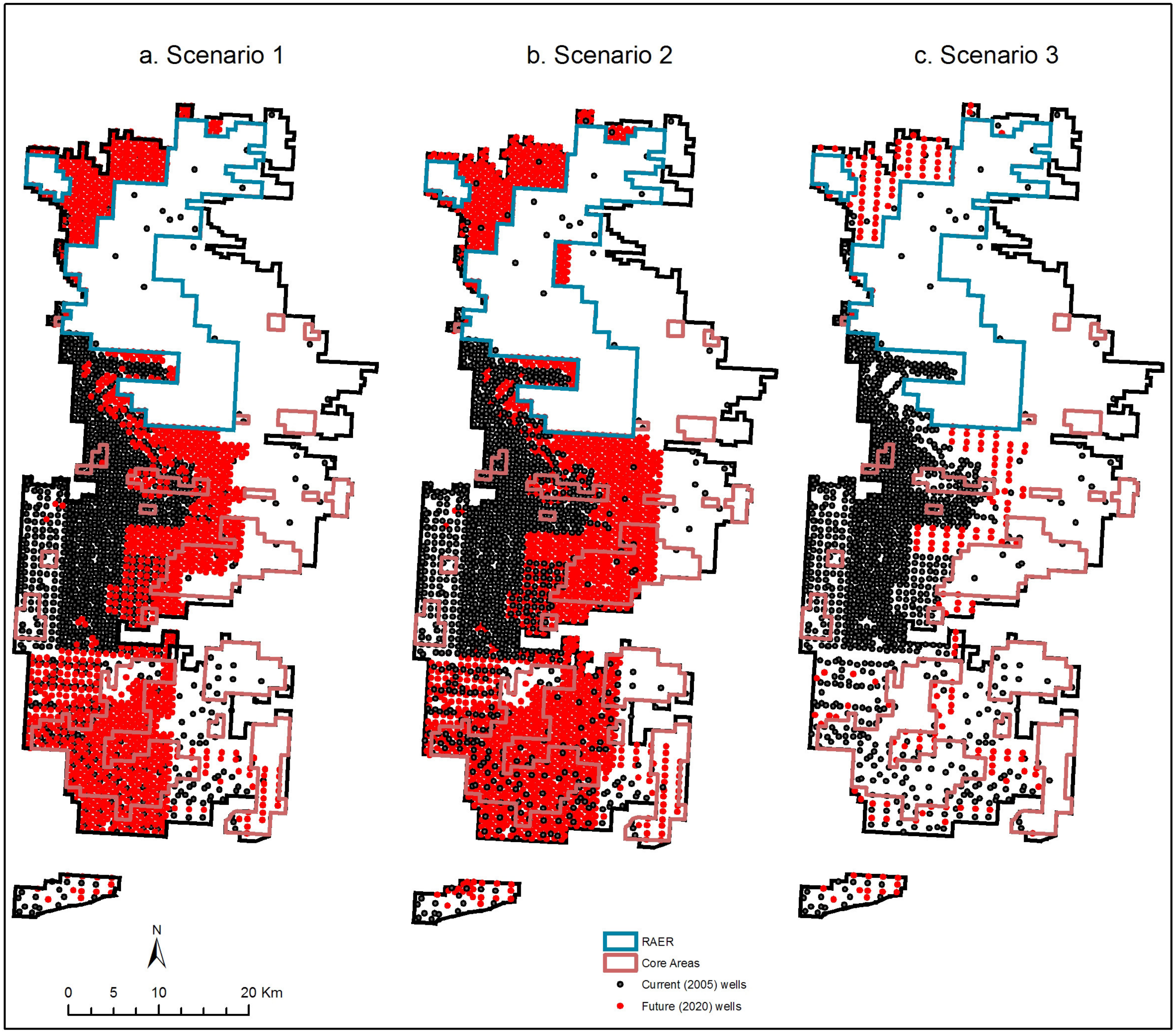



Figure 3-2-9. Projected locations of future gas well pads in 2020 for 3 scenarios: a) Scenario 1-2P gas reserve extent and a maximum of 8 well pads per section; b) Scenario 2-3P gas reserve extent and a maximum of 8 well pads per section; and c) Scenario 3-2P gas reserve extent and a maximum of 2 well pads per section.

meant to be prescriptive. In this example, using existing wells inside non-RAER core biodiversity area boundaries, we estimate that 19% of the area of core biodiversity areas could be accessed with directional/slant drilling for a maximum horizontal reach of 400-m and additional 34% accessible under a maximum horizontal reach of 1000-m (Figure 3-2-10). For simplicity, this analysis assumes that the gas company undertaking the directional/slant drilling owns the mineral leases on all immediately adjoining lands. In practice, this may not exist and would limit access. This example further suggests that 47% of the area of core biodiversity areas would be inaccessible to directional/ slant drilling using existing gas well pad surface leases under current technologies. Considering similar reaches, directional or slant drilled wells into core biodiversity along their peripheries would result in 36% of the area of core biodiversity areas being accessible to gas wells with a 400-m horizontal reach and an additional 35% accessible with a 1000-m horizontal reach (Figure 3-2-10). Under this example, 29% of the area of core biodiversity areas would be inaccessible to drilling from their peripheries considering gas pools beyond a 1000-m horizontal reach. When considering both peripheries and existing well pads with directional or slant drilling, 45% of the area of core biodiversity areas would be accessible from a 400-m horizontal reach and an additional 40% from a 1000-m reach, leaving 15% of the area inaccessible beyond the 1000-m reach (Figure 3-2-10). This example analysis suggests that although our proposed new core biodiversity areas (not including the RAER) represent an area of 373 km$^2$, or 18% of the total GSH Review Area, approximately 56 km$^2$ or about 3% of the Review Area (not including the RAER) would be inaccessible to directional or slant drilling under current technologies. It also suggests that because the RAER is much larger, much less of this ecological reserve would be accessible from directional or slant drilling along its periphery. Based on the potential for accessibility and limiting surface disturbance, we strongly encourage the gas industry to work further with partners to explore the potential of directional/slant drilling in the Review Area.

### 2.6.2 Roads/Trails

Based on simulations exploring road and trail development at four densities (Figure 3-2-11), we estimated that, on average, 420 m (3.8 km/mi$^2$ of total roads/trails) of additional road would be needed to establish each well pad, 1020 m (4.4 km/mi$^2$) for 2 well pads/section, 1,710 m (5.1 km/mi$^2$) for 4 well pads/section, and 2,980 m (6.3 km/mi$^2$) for 8 well pads/section (Figure 3-2-12). Rates of increase in roads per well-pad density were relatively constant with a weak inflection point at 1 well pad/section. Locating well pads along existing roads with only short spur roads off of them could reduce total road development substantially.

#### *2.6.2.1 Baseline scenarios*

From a 2005 baseline of 3,175 km of roads and trails, we projected an additional 624 km of new roads to access well pads in the 2P gas reserve scenario (scenario 1) and 814 km of new roads to access well pads in the 3P gas reserve scenario (scenario 2) (Table 3-2-3; Figure 3-2-8). Annual rate of increase in kilometres of road (Scenario 1: 42 km/yr; and Scenario 2: 54 km/yr) was approximately twice that of historic (1979–2005) baseline rates (26 km/yr), which would be necessary to match forecasted rates of increase in gas well pads. Because new roads were modeled as a function of the modeled locations of new gas wells, the regions of the Review Area that saw the greatest increase in roads were the west, central, south, and northwest areas (Figure 3-2-13).

#### *2.6.2.2 Preferred scenario*

By restricting gas development within core biodiversity areas and holding maximum well-pad density at 2 per section outside of core biodiversity areas, the preferred scenario (scenario 3) resulted in a total of only 110 km of new roads (Table 3-2-3; Figure 3-2-13). This represented an increase of 7 km/yr, a substantially lower rate of increase than baseline scenarios at 42 and 54 km/yr.

### 2.6.3 Livestock Watering Holes and Range Health

#### *2.6.3.1 Baseline scenarios*

From a 2005 baseline of 507 livestock watering holes, we projected an additional 75 water holes (5/yr) by the year 2020 for scenarios 1 and 2 (Table 3-2-3; Figure 3-2-8). Locations of watering holes were throughout the Review Area where zones further than 1,200 m from existing watering holes were available (Figure 3-2-14).

In 2005 we estimated range health conditions for the Review Area at 52.7% "healthy," 42.6% "healthy, but with problems," and the remaining 4.7% of the landscape as "unhealthy" (Figure 3-2-15). Baseline scenarios for 2020 suggested that the "healthy" class would decline by 6.2% and 7.3% for scenarios 1 and 2,

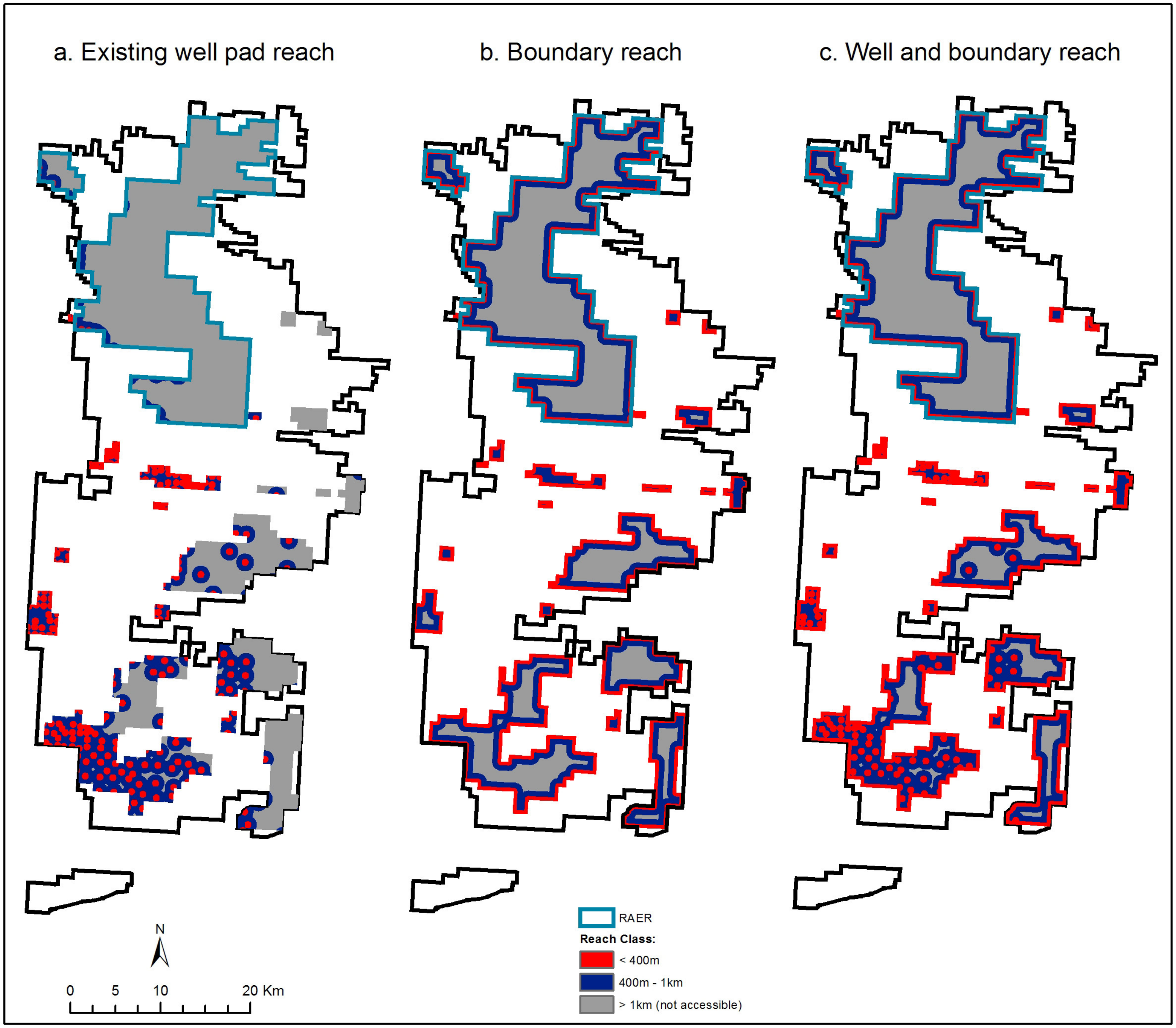



Figure 3-2-10. Accessibility of core areas to directional or slant drilling based on a 400-m reach (red), a 400-m to 1-km reach (blue), or areas greater than the maximum assumed reach for gas pools in grey. Areas from existing well pads depicted in a, core area periphery in b, and combined well pads and periphery in c.

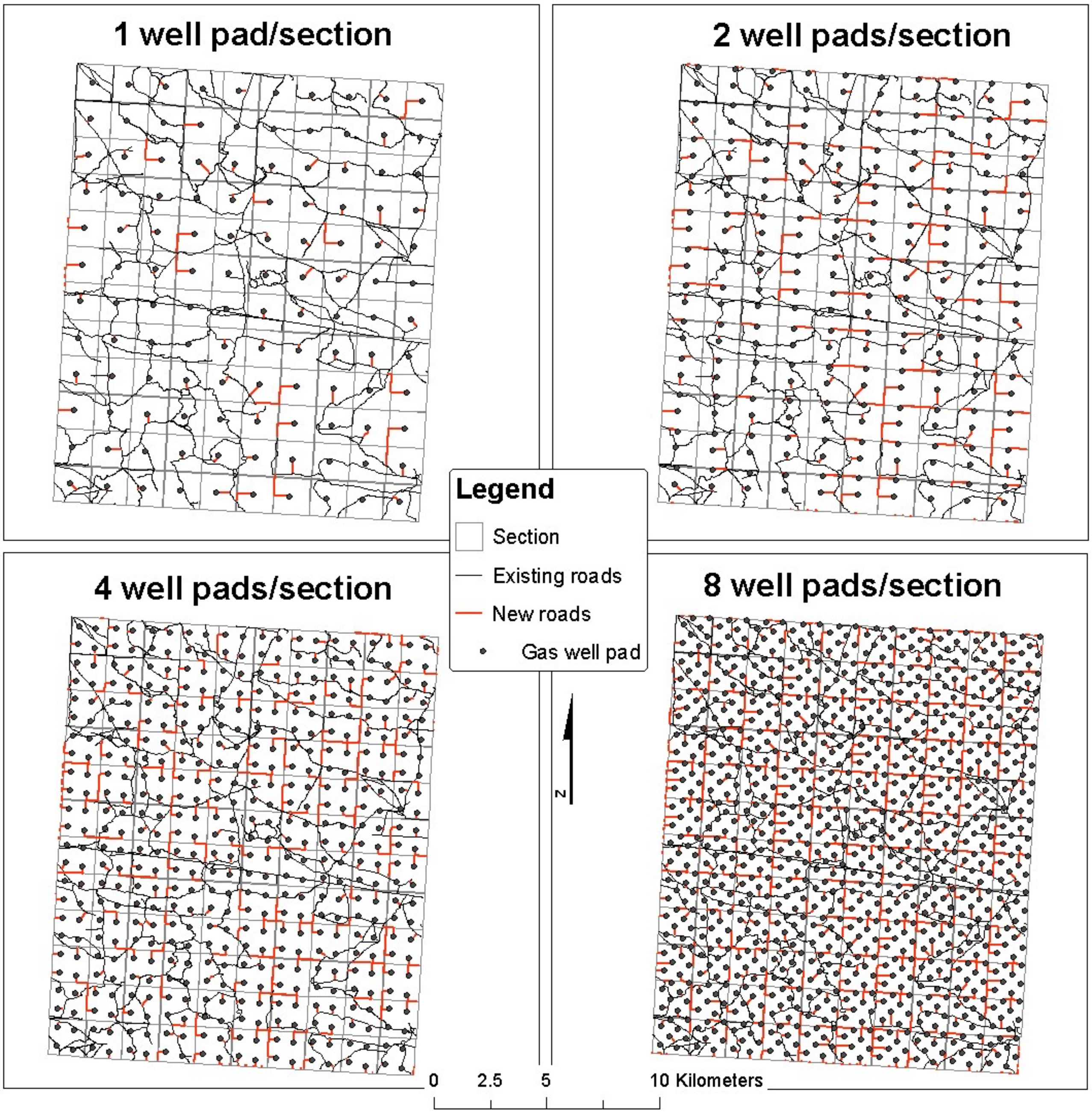



Figure 3-2-11. Example of projected gas development of roads and well pads for a 10 X 12 mile undeveloped region of the Great Sand Hills. Well pad density was modeled at 1, 2, 4, and 8 pads per section. For each well pad density total kilometres of roads and road densities were estimated to determine relationships between well pad density and road development.

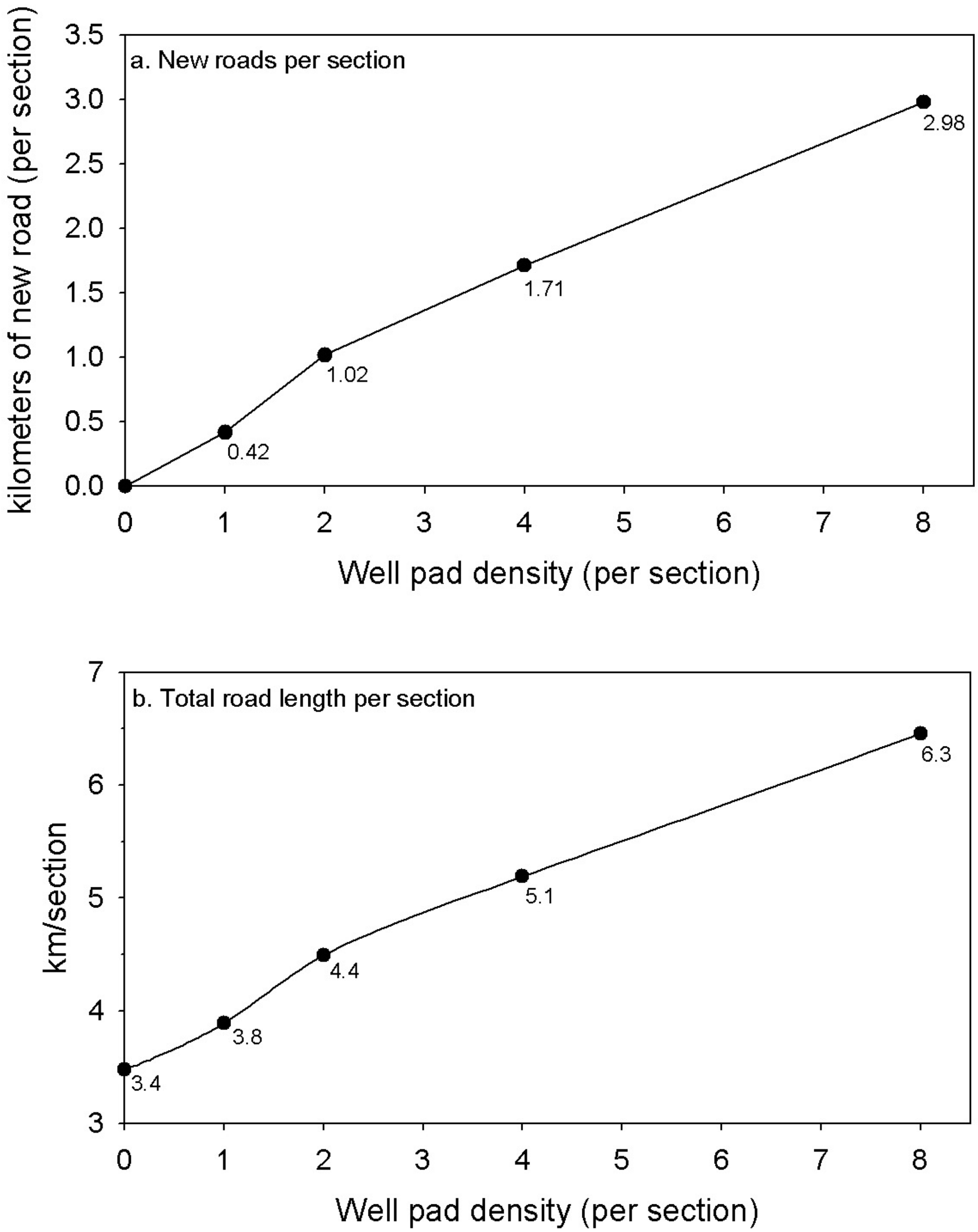



Figure 3-2-12. Average kilometers of new roads per section by well pad density simulation in the top (a.) and total road density (km/mi$^2$) by well pad density simulation in the lower graph (b.). Simulations were for a 120-mi$^2$ region of the Great Sand Hills with a baseline road density of 3.4 km/mi$^2$.

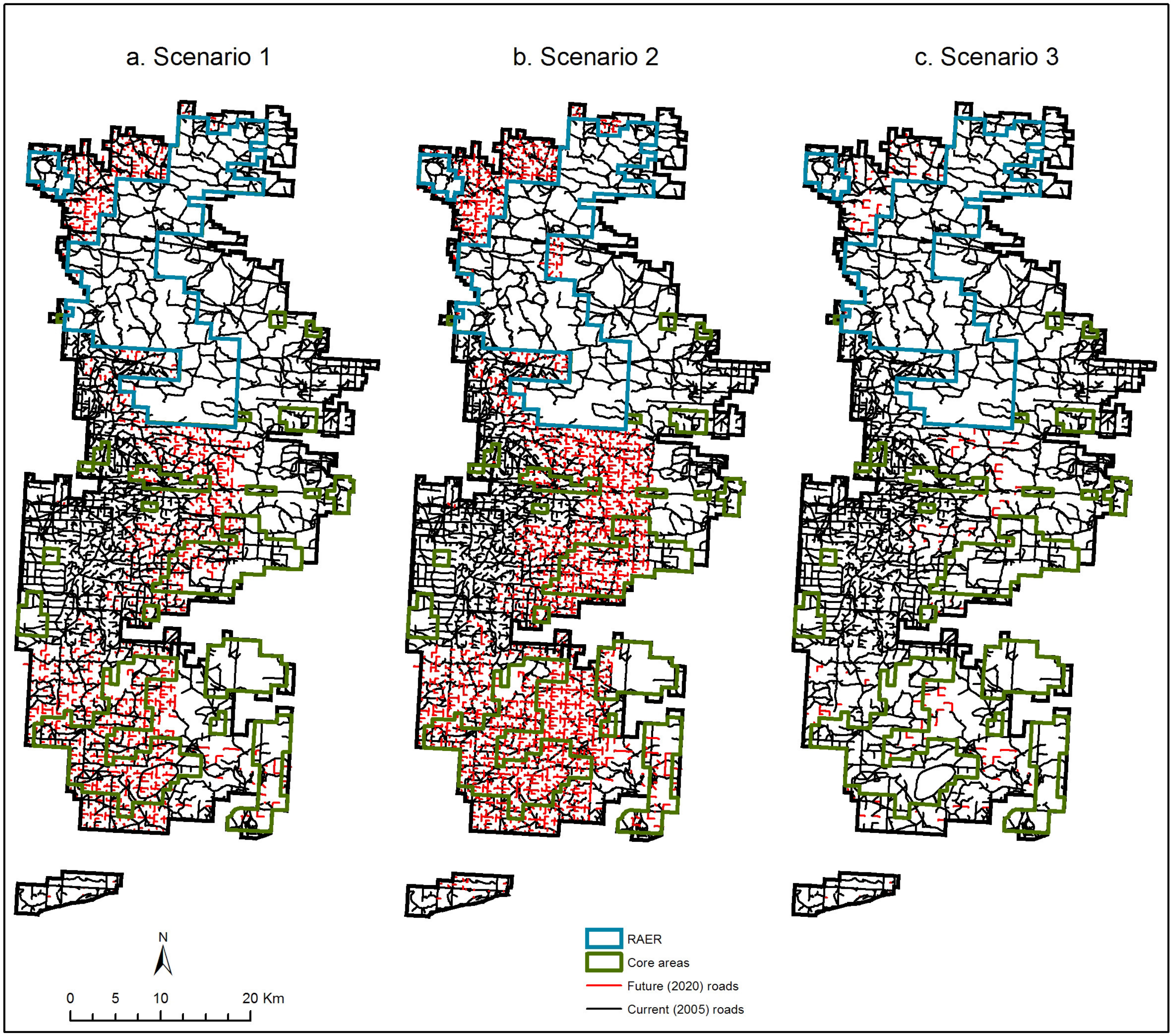



Figure 3-2-13. Projected locations of future roads associated with gas well pads in 2020 for 3 scenarios: a) Scenario 1-2P gas reserve extent and a maximum of 8 well pads per section; b) Scenario 2-3P gas reserve extent and a maximum of 8 well pads per section; and c) Scenario 3-2P gas reserve extent and a maximum of 2 well pads per section.

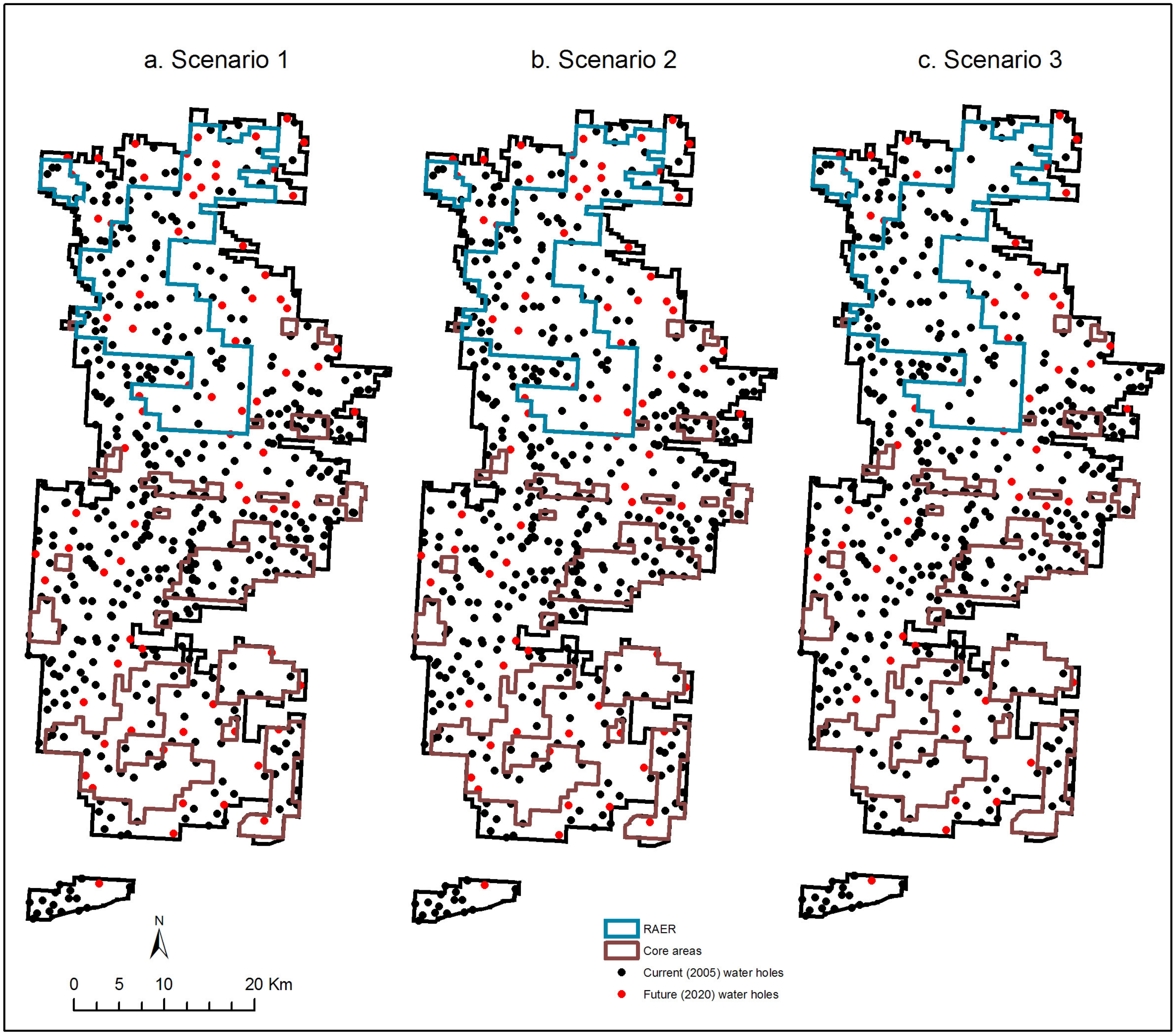



Figure 3-2-14. Projected locations of future livestock watering holes in 2020 for three scenarios: a) Scenario 1; b) Scenario 2; and c) Scenario 3. Both a and b gain the same 75 new watering holes by 2020, while c restricted 24 of the 75 watering holes due the presence of core biodiversity areas.

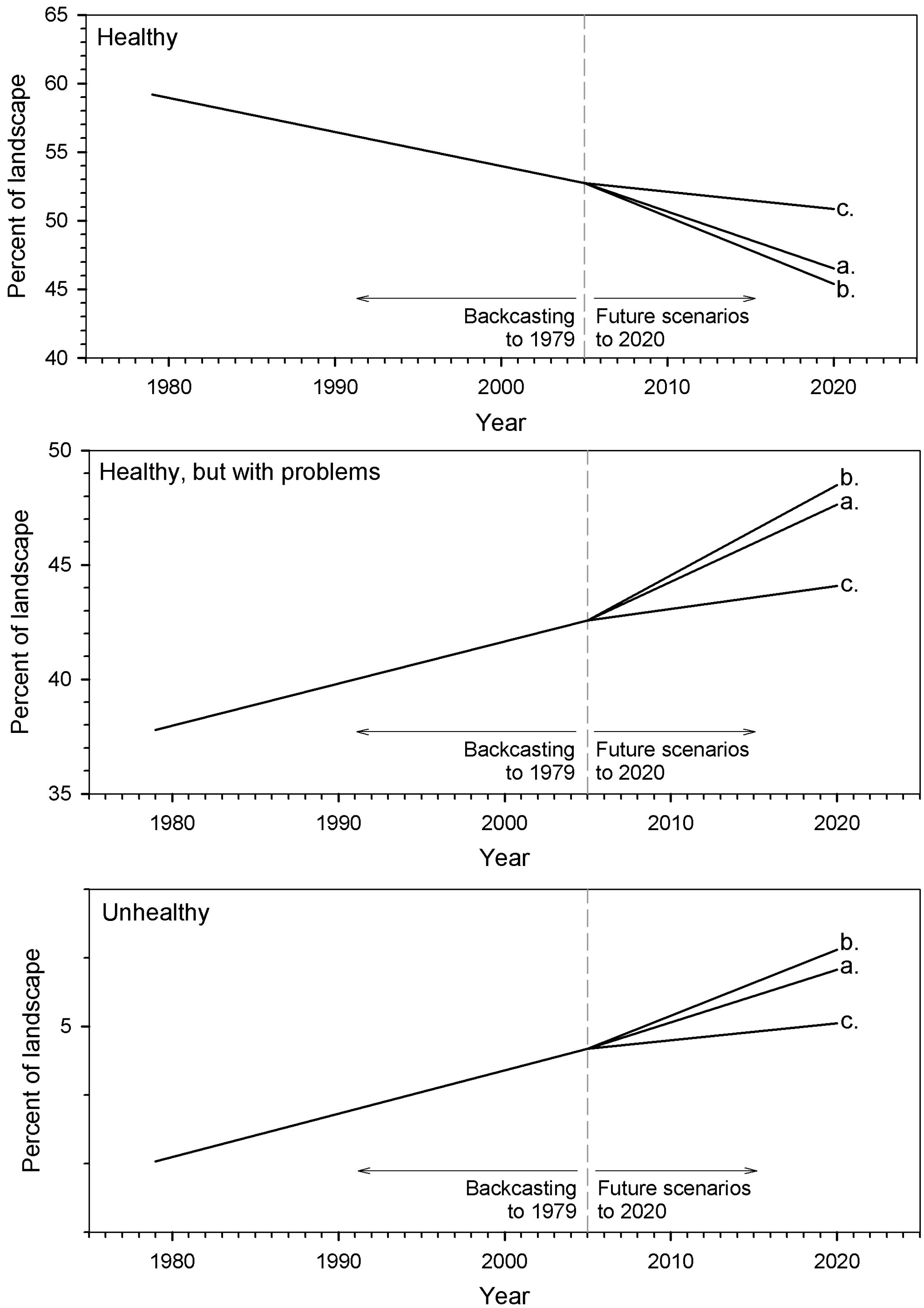



Figure 3-2-15. Trends in the three range health classes of "healthy" (>74), "healthy, but with problems" (50-74), and "unhealthy" (<50) conditions projected from 1979 to 2020. In 2020, three scenarios were compared: a) Scenario 1; b) Scenario 2; and c) Scenario 3 (preferred scenario). Note that scale (% of landscape) varies among range health categories.

respectively, while the “healthy, but with problems” category would increase by an additional 5.1% for scenario 1 and 5.9% for scenario 2 (Figure 3-2-15). Finally, we predicted that “unhealthy” conditions would increase in baseline scenarios 1 and 2 by an additional 1.2% and 1.4%, respectively (Figure 3-2-15). As the number and location of new livestock watering holes were constant between scenarios 1 and 2, differences in range health categories between these scenarios were due to extent of gas development.

#### *2.6.3.2 Preferred scenario*

In contrast to the more ubiquitous distribution of new watering sites in the two baseline scenarios, the preferred scenario excluded watering holes from core biodiversity areas (Figure 3-2-14) resulting in a reduction of 24 watering holes or a total of 51 new sites (Table 3-2-3; Figure 3-2-8). This represented an average increase of 3.4 new watering holes/yr from a baseline rate of 5/yr without considering core biodiversity areas.

We predicted range health conditions in the Review Area under the preferred 2020 scenario as 50.9% “healthy,” 44.1% “healthy, but with problems,” and the remaining 5% of the landscape as ”unhealthy” (Figure 3-2-15). Differences in range health patterns from 2005 were much less extreme than in the two baseline scenarios, with a 1.9% loss of healthy conditions in the preferred scenario compared to 6.2% and 7.3% losses in baseline scenarios 1 and 2, respectively. Compared to range health conditions estimated for the 1979 landscape and those predicted for 2005, the preferred scenario reduced trends in degradation of range health, while both of the baseline scenarios were projected to increase degradation of range health conditions (Figure 3-2-15). Although livestock watering holes were the primary driver influencing range health conditions, the overall score and subsequent classes were influenced by cumulative effects of both livestock grazing (watering holes) and gas development (roads and gas well pads), which is reflected in the increase in the trend of range health categories for scenarios 1 and 2.

## 2.7 THE VULNERABILITY OF CORE BIODIVERSITY AREAS TO DEVELOPMENT

### 2.7.1 Vulnerability of Core Biodiversity Areas to Future Gas Developments

The southwestern part of the Review Area had the highest vulnerability ranks for future gas development based on increased densities of gas well pads and roads in baseline scenarios (Figure 3-2-16). Small core biodiversity areas in the west-central part of the Review Area were considered to have low vulnerability, since little if any additional gas wells were expected in this already heavily developed region. Similarly, small core biodiversity areas in the northeast also had low vulnerability, not because this region already had wells, but instead because it lacked economically viable gas reserves at this time. The RAER ranked low in vulnerability in the baseline scenarios, since gas development was excluded from the RAER, although in some instances small segments of roads were simulated along the RAER boundary to access future wells along the reserve periphery. This resulted in small increases in development and a vulnerability ranking slightly higher than some core biodiversity areas that had no gas development.

### 2.7.2 Vulnerability of Core Biodiversity Areas to Livestock Grazing

When considering livestock grazing and more specifically livestock watering holes, the highest concentration of watering holes for core biodiversity areas approached 4 sites per section (Figure 3-2-17). No clear patterns were observed, except for high concentrations of watering holes in the smallest core biodiversity areas (Figure 3-2-17). This result was likely an artifact of the small size of these areas, rather than regional concentrations. Because we had less confidence in the resolution of locations for future livestock watering holes, with their locations potentially occurring anywhere in the Review Area, vulnerability was ranked on current water hole density instead of projected future patterns.

### 2.7.3 Vulnerability of Focal Species to Future Development

For the two focal species we selected as primary indicators—crested wheatgrass and beaked annual skeleton-weed—future landscapes showed losses of the rare beaked annual skeleton-weed and an expansion in the distribution of the exotic plant, crested wheatgrass (Figure 3-2-18). Differences among scenarios suggested substantial benefits of the preferred scenario, whereas differences between baseline scenarios 1 and 2 were marginal, with scenario 1’s lower rate of anthropogenic disturbance resulting in slightly greater extent in beaked annual skeleton-weed and a smaller extent in crested wheatgrass. Baseline scenario 1 and the preferred scenario (scenario 3) resulted in a reduction in the

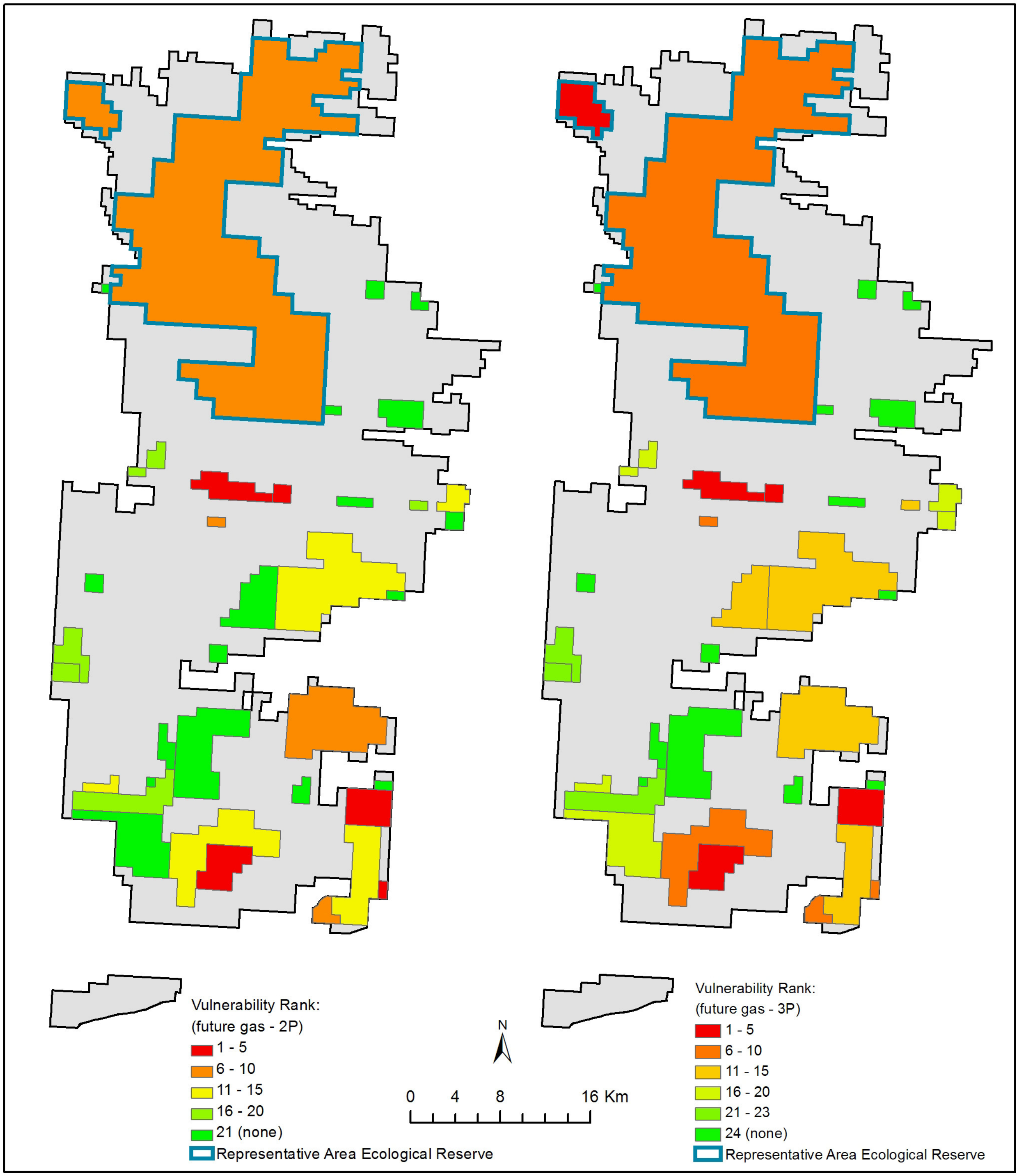



Figure 3-2-16. Vulnerability ranks (1 [in red] being the most vulnerable and 37 [in green] the least vulnerable) of core biodiversity areas to future gas development based on projected increases in gas well pads and roads for scenario 1 (map on left) and 2 (map on right).

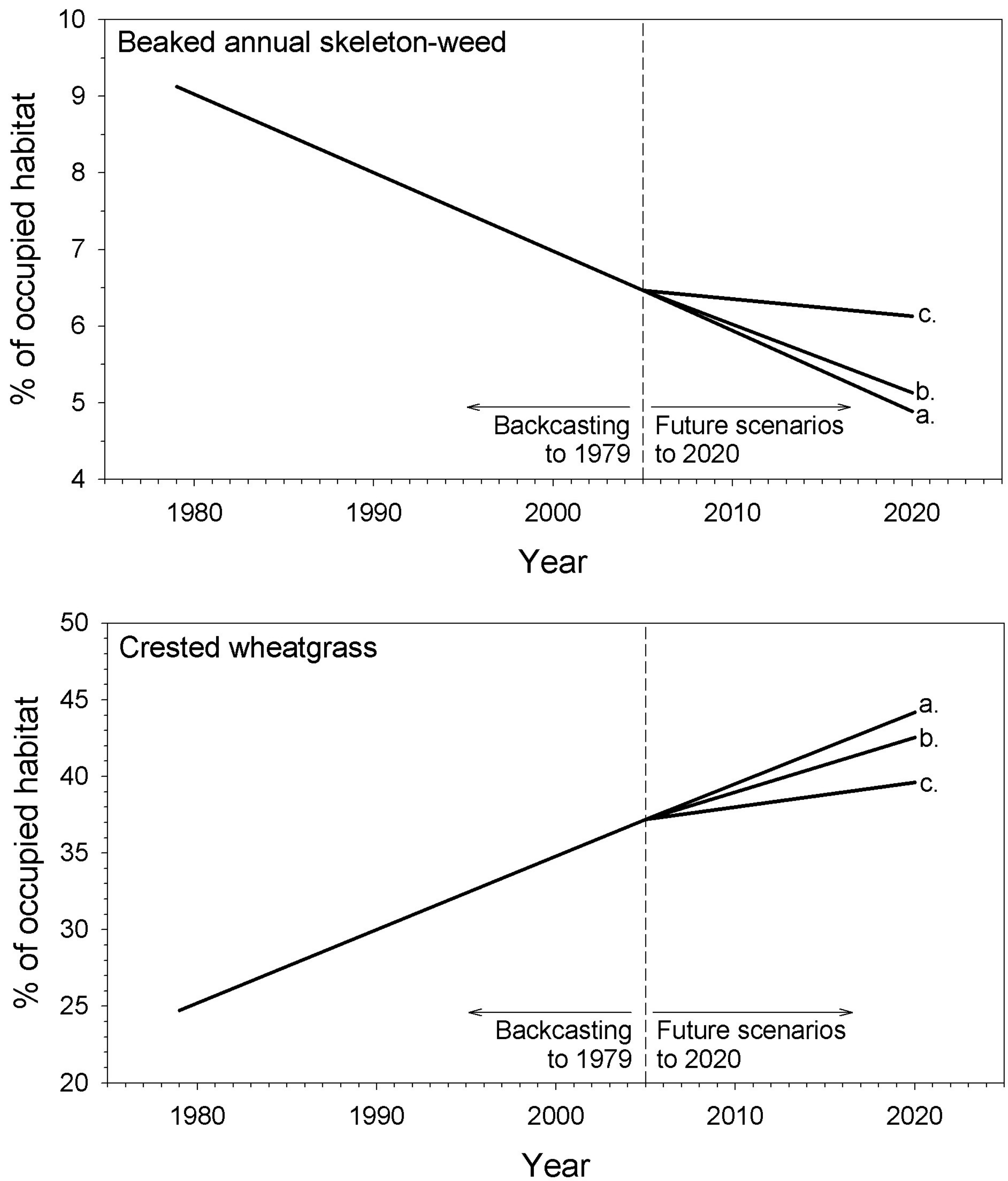



Figure 3-2-18. Predicted amount of occupied habitat (% of GSH review area) for beaked annual skeleton-weed and crested wheatgrass in 1979, 2005, and 2020. In 2020, three scenarios were compared: a) 3P gas reserves at 8 well pads/section & 75 new livestock watering holes; b) 2P gas reserves at 8 well pads/section & 75 new livestock watering holes; and c) preferred scenario of 2P gas reserves at 2 well pads/section & 51 new livestock watering holes both excluded from 37 core biodiversity areas.

rate of loss for beaked annual skeleton-weed and a gain in crested wheatgrass when compared to past trends. Further conservation action along with restoration and management activities, which were not considered in any of our scenarios, could lead to gains in habitat for beaked annual skeleton-weed and a reduction in the extent of crested wheatgrass.

### 2.7.4 Core Biodiversity Area Rankings

When considering all the species used in MARXAN site selection, the core biodiversity area with the highest biodiversity rank was an area in the southeast in an arm of the Review Area that contains a glacial tunnel valley complex (Figure 3-2-19). The presence of this geologically unique feature and associated high levels of biodiversity suggest that protection of this area is critical for preservation of the natural capital of the GSH. The RAER had a low overall biodiversity ranking, although this was partly a reflection of our selection of focal species that were not already well represented in the RAER. As we did not conduct field work in wetlands due to time constraints, or model wetland species and habitats, ranks for some small wetland-based core biodiversity areas may be artificially low for their conservation value.

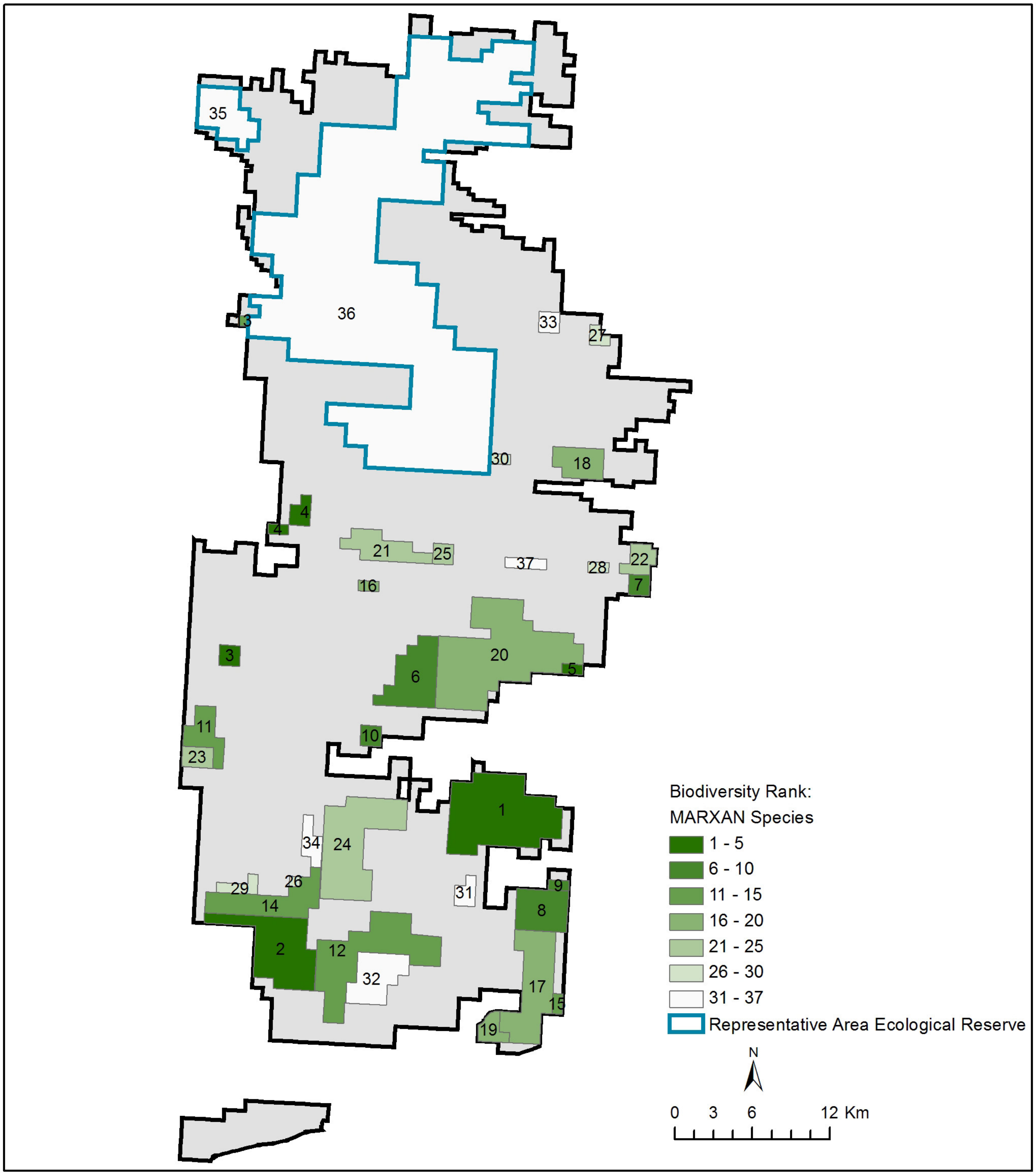



Figure 3-2-19. Estimated overall biodiversity rank based on the sum of percent occupied habitat for species used in MARXAN site selection. Numbers represent the rank with the highest biodiversity condition with a 1 (in green) and lowest biodiversity contribution as a 37 and in white. Note that species selected for MARXAN site selection did not include wetland species or estimates of focal species in wetland habitats.

# Chapter 3: Economic Assessment: Associated Opportunity Costs of Proposed New Core Biodiversity Areas and the Preferred Scenario

## 3.1 Introduction

To determine the opportunity cost of designating core biodiversity areas as "restricted/no development" (i.e., similar to the current RAER), the proposed new areas and the RAER were assessed for their economic potential. This assessment dealt specifically with gas development in those areas and does not include an assessment of ranching.

Based on the economic assessment from the baseline economic report and from data presented by GLJ Petroleum Consultants Ltd. (2007), a current estimate has been calculated of the royalties, taxes, and leases to government, as well as the potential contribution to the local economy for existing wells in the core biodiversity areas plus the RAER. For these core biodiversity areas and RAER, forecasts are also provided from 2007 through 2021—the 15-year window of the baseline reports—to assess future, or opportunity costs, associated with the designation of the 35 new areas.

## 3.2 Existing Gas Wells—Core Biodiversity Areas and RAER

The existing gas developments within the GSH draw reserves from two separate pools—Milk River and Second White Specks. The 444 existing wells within the 35 core biodiversity areas and RAER will produce for the 2007 calendar year a total of $1.722 million for the provincial government divided among 4 revenue streams: royalties ($446,710), corporate taxes ($587,000), mineral leases ($133,200) and surface leases to Saskatchewan Agriculture and Food (SAF) ($550,000). These are the known values for the industry's contribution to the provincial government this year as forecasted by the economic modelling and verified against independent assessments from GLJ Petroleum Consultants Ltd.

The existing wells of the 35 core biodiversity areas and RAER operate under the 2P (proven and possible) development regime (scenario 1). The existing wells within these areas are forecasted to produce the following revenue stream over the next 15 years: $2.097 million in royalties from the existing wells; $5.652 million in corporate taxes collected; $1.583 million from mineral leases; and $6.599 million from surface lease payments to SAF, for a total future potential to be realized by the provincial government from the existing 444 wells of $15.932 million over the next 15 years. Given that the ongoing maintenance and operating costs for the existing wells represents in excess of $63 million over 15 years, plus the on-going payments to lessees, the impact of the existing gas industry in these areas potentially represents over $9.9 million to the local economy over 15 years (using existing local multipliers from the economic baseline).

The more extractive 3P (proven, probably, possible) scenario 2 presents even larger sums. This scenario increases government revenues to $2.254 million in royalties, $5.942 million in corporate taxes, $1.630 million in mineral leases, and $6.790 million in surfaces leases to SAF, for a total government revenue stream of over $16.6 million over 15 years. As the development costs (specifically on-going operating costs) are slightly higher than the 2P scenario, it has the potential to contribute $10.3 million to the local economy over the next 15 years.

## 3.3 Future Wells

The 35 core biodiversity areas already have gas development within them, but there is the potential for even further development based on the reserves within the Milk River and Second White Specks reserve pools. There are already surface and mineral leases in these areas; therefore, the economic value of those existing leases in the core biodiversity areas is calculated.

The future development scenarios are based on the 3P and 2P designations as projected by GLJ Petroleum Consultants Ltd. and spatially delineated by the Natural Capital team (both cross-referenced for accuracy of projections). Future wells in the core biodiversity areas under the 2P regime produce the following results: Royalties from the new wells are expected to generate $8.822 million over the next 15 years; corporate taxes collected represent $12.273 million; mineral leases provide a modest $466,000; and surface lease payments to SAF provide $10.264 million, for a total future potential to be realized by the provincial government from the proposed 2P wells of $31.826 million over the next 15 years. The local economic benefit from well siting, ongoing payments, and economic multipliers as defined in the baseline report total $34.334 million over the same time period.

The 3P scenario represents over 50% more development in the same areas, and therefore increases substantially the values to all parties. Government revenues increase to $9.660 million in royalties, $15.671 million in corporate taxes, $466,800 in mineral leases, and $12.849 million in surfaces leases to SAF, for a total government revenue stream of more than $38.647 million over 15 years. The local economic contribution has the potential to add $55.126 million to the local economy over the next 15 years.

For the existing and future gas developments within the newly proposed core biodiversity areas, the economic activity can be summarized as follows:

| Existing and Future Well Forecasts for the 35 Core Areas | | |
|---|---|---|
| Summary | 2P | 3P |
| Potential Provincial Economic Value | $38,685,868 | $44,365,195 |
| Potential Local Economic Value | $59,974,385 | $85,415,093 |
| TOTAL Potential Economic Value | $98,660,253 | $129,780,288 |
| TOTAL Industry Infrastructure Investment | $395,673,900 | $564,771,950 |

## 3.4 Opportunity Costs—RAER

As the RAER is already a no-development area, it has to be considered separately from proposed core biodiversity areas in economic analysis. Following the same format as above and addressing the existing 2P and more extractive 3P scenarios in turn, the RAER represents the following economic potential:

- Under the 2P scenario, the RAER shows government revenues of $1.656 million in royalties, $4.492 million in corporate taxes, $1.181 million in mineral leases, and $4.964 million in surfaces leases to SAF, for a total government revenue stream of over $12.296 million between 2007 and 2021. The local economic contribution has the potential to add $21.782 million to the local economy during that same time period.
- Under the 3P scenario, the RAER shows government revenues of $2.106 million in royalties, $6.694 million in corporate taxes, $1.181 million in mineral leases, and $4.964 million in surfaces leases to SAF, for a total government revenue stream of over $14.855 million over 15 years. The local economic contribution had the potential to add $39.301 million to the local economy during that same time period.

Simply stated, these figures presented above represent the current opportunity costs (2P and 3P) for the existing Ecological Reserve. In its decision to delineate the RAER, the government has defined that area as ecologically important and was willing to forego the potential revenue associated with that area in the following amounts:

| Opportunity Costs for Current RAER | | |
|---|---|---|
| Summary | 2P | 3P |
| Potential Provincial Economic Value | $12,293,006 | $14,855,006 |
| Potential Local Economic Value | $21,782,430 | $39,301,090 |
| TOTAL Potential Economic Value | $34,075,436 | $54,156,096 |
| TOTAL Industry Infrastructure Investment | $142,800,200 | $258,732,600 |

## 3.5 Core Biodiversity Area Wells

With the RAER wells identified and removed from the analysis so there is no double-counting of revenues or potential economic activity, the 15-year (2007–2021) summary of economic activity as a result of designating the remaining 35 core biodiversity areas is as follows:

| Existing and Future Well Forecasts for the Remaining 35 Core Biodiversity Areas | | |
|---|---|---|
| Summary | 2P | 3P |
| Royalties | $9,263,118 | $9,898,545 |
| Corporate Taxes | $13,433,000 | $14,919,000 |
| Mineral Leases | $ 869,796 | $915,696 |
| Surface Leases | $2,826,948 | $3,776,948 |
| Potential Provincial Economic Value | $26,392,862 | $29,510,189 |
| Potential Local Economic Value | $38,191,955 | $46,114,003 |
| TOTAL Potential Economic Value | $64,584,817 | $75,624,192 |
| TOTAL Industry Infrastructure Investment | $252,873,700 | $306,039,350 |

### 3.6 The Preferred Scenario

Under the preferred sustainability scenario, industrial infrastructure development in the core biodiversity areas is limited to a cap in the number of well pads in the area, and well development is capped based on current industry norms. With the limited introduction of new wells, and the decommissioning of non-viable wells in future years, the result is a progressive decline of wells from 2007 to 2021. That decline has impacts on revenues to the government and the local economy.

A caveat must be noted: The projection that follows is based on current industrial trajectories in well development. It is unknown at this time how industry will respond to the recommended limits on development, e.g., a wait-and-see approach, or a more aggressive approach to develop as fast as possible to extract and reap profit sooner rather than later. The following projection assumes current business practices prevail.

As the 3P scenario is not being entertained for the remaining Review Area, and only the 2P development model (with associated limitations as defined by the preferred scenario) is being considered, the following economic forecast represents the remaining lands of the Review Area, excluding the 35 proposed core biodiversity areas:

- Under the Preferred Scenario, the Review Area shows government revenues of $3.947 million in royalties, $12.438 million in corporate taxes, $5.723 million in mineral leases, and $22.536 million in surfaces leases, for a total government revenue stream of over $44.644 million between 2007 and 2021. The local economic contribution has the potential to add $58.624 million to the local economy during that same time period.

### 3.7 Conclusion

The designation of the newly identified core biodiversity areas doubles the size of the ecologically reserved lands within the Review Area from 372.32 km$^2$ (RAER) to 745.56 km$^2$. The lost revenues from the newly designated core biodiversity areas have economic multipliers of 0.9745 (2P) and 0.6845 (3P), meaning that they less than double the opportunity cost in doubling the land area protected.

From an economic perspective, with the preferred scenario implemented across the Review Area, the province and the local economies continue to benefit from ongoing gas development with revenues to government projected at over $44 million and local economic contributions of over $58 million. Meanwhile, ranching would continue as an economic activity while preserving areas of high conservation value.

The following table summarizes the suite of costs over the period 2007–2021 associated with the designation of the new 35 core biodiversity areas, continuing designation of the RAER, and a reduction in development associated with the preferred scenario recommended by the SAC:

| | Government (millions) | Local Economy (millions) |
|---|---|---|
| GSH Potential Revenues | $62.312 | $95.068 |
| Loss from RAER | $(12.293) | $(21.782) |
| Forecast Revenues | $50.019 | $73.286 |
| Less Preferred Scenario | $(44.644) | $(58.624) |
| Opportunity Cost on Non-Core Lands | $5.375 | $14.662 |
| Plus Loss from 35 Core Lands | $26.393 | $38.192 |
| TOTAL Opportunity Cost | $31.768 | $52.854 |

### 3.8 A Note on Interpreting Economic Impacts

The economic analysis was conducted at the resolution of the section, while core area boundaries recommended by the SAC were determined at the resolution of the quarter section (an irresolvable scalar artifact of data sources and resolutions). Due to the large number of small core areas with high amounts of perimeter per unit area, the difference in footprint of core areas between these two resolutions is 189 km$^2$, or a 373 km$^2$ area for the recommended core areas at quarter sections and a 562 km$^2$ area for the economic assessment at the detail of the section. The economic assessment of opportunity costs to both government and the local economy therefore represents a fiscally conservative over-estimate, by a factor of 1.5, of potential economic value for recommended core biodiversity areas.

# PART 4

## GREAT SAND HILLS REGIONAL ENVIRONMENTAL STUDY – RECOMMENDATIONS FROM THE SCIENTIFIC ADVISORY COMMITTEE –

## PREAMBLE

The recommendations presented in this chapter are based on the weight of evidence from the natural and social sciences research data available to us, which consistently confirm that the sustainability of human activity in the Great Sand Hills is reliant on the sustainability of ecosystem elements and processes that are not significantly perturbed by human activities. Landscape ecology provided the conceptual framework for assessing the consequences of human activities and for evaluating and visualizing the impacts of alternative development scenarios. Our methods focused on integrating biodiversity information in a strategic environmental assessment at a landscape and regional scale.

Our recommendations focus on sustaining the ecological integrity of the Great Sand Hills and are grounded in the realities of natural, social, and economic capital for the region. This regional perspective is critical to the long-term success of these recommendations, should they be adopted. Therefore, prior to presenting the recommendations, we provide below a brief overview based on our results of the regional context of the GSH, highlighting the broader initiatives that will support the overall sustainability of the local communities and people of the GSH and also serve as the foci for our recommendations. We focus principally on aspects of biodiversity and conservation, governance and institutional arrangements, and environmental assessment. The Regional Environmental Study revealed those aspects of the GSH to contain issues of critical and formative importance that, if not dealt with effectively, would make it impossible for other issues to be adequately addressed. Those other issues requiring active attention relate to reducing impacts, environmental monitoring, reclamation and sustaining regional communities, including issues related to First Nations.

In this final part of the GSH RES report, we refer to geographic areas as we have throughout the report, e.g., the GSH Study Area refers to the 8 RMs; the GSH Review Area refers to the principal area of our field studies, which includes portions of 4 RMs, as earlier defined. In addition, we refer to Reserve and Non-Reserve Areas within the GSH Review Area. The Reserve Areas refer to the Representative Area Ecological Reserve (RAER) and the additional core biodiversity areas identified in this study. Non-Reserve Areas refers to all other areas outside of the Reserve Areas within the GSH Review Area.

### Status of Biodiversity and Conservation

The GSH are nationally and internationally significant as one of the largest remnants of native grassland in Canada—an island of mixed-grass prairie and shrubland in a sea of intensive agriculture (Gauthier and Wiken 2003). The GSH have remained essentially intact with high ecological integrity because their sandy soils and rugged terrain are not conducive to cultivation. The SAC recognizes that temperate grasslands, savannas, and shrublands are the most highly endangered ecosystems in North America and worldwide (Noss et al. 1995, Samson and Knopf 1996). Globally, the ratio of habitat converted to habitat protected is higher for temperate grasslands, savannas, and shrublands (10:1) than for any other biome (Hoekstra et al. 2005), making the protection, restoration, and proper management of these ecosystems among the highest global conservation priorities. Therefore, protection of the biodiversity and ecological integrity of the GSH is critical not only for Saskatchewan, but for Canada, North America, and the world.

The GSH are best known for their active sand dunes. Although active dunes represent a relatively small portion of the area, the sand dune formations collectively provide habitat for many species that are rare or declining in Saskatchewan and Canada, including Ord's kangaroo rat, slender mouse-ear cress, and smooth arid goosefoot. The first two species are largely dependent on sand dunes, which have become rarer since the early 20th century due to changes in climate. Beyond sand dunes, the GSH are a mosaic of extensive open grasslands, a patchy network of shrubs and trees, as well as wetlands and lakes. This rich vegetation mosaic, largely patterned from the hummocky terrain derived from Pleistocene and Holocene deposits, provides more than 2,000 $km^2$ of contiguous native habitat. Given the extent and diversity of native habitats, the GSH are an important refuge for game species, including Sharp-tailed Grouse, white-tailed and mule deer, and pronghorn antelope. Native non-game species are also well represented, including several grassland birds known to be declining across their ranges. The SAC emphasizes, however, that the current Representative Area Ecological Reserve (RAER) in the GSH protects a biased sample of habitats—i.e., there are serious "gaps" in protection, most notably native grassland.

With this combination of unique landscape elements (i.e., sand dunes), known occurrences of Endangered, Threatened, and sensitive species, important game species, and more generally a refuge of natural heritage, the GSH are of inestimable value to present and future generations of Saskatchewan and Canada. The SAC recognizes that sustaining the biodiversity of the GSH is critical to securing its ecological integrity, and that this goal, in turn, is paramount to any consideration of sustainable development. Therefore, our recommendations with respect to biodiversity and conservation in the GSH are appropriately strong and include a proposal for additional Reserve Area (i.e., core biodiversity areas).

## Governance and Institutional Arrangements

Existing institutional arrangements in the GSH region are regarded as adequate by many stakeholders and First Nations, but not as effective as they should be. Issues of coordination and management in the GSH are related mainly to the quality and strength of interrelations among the various parties rather than to inadequate legislation. Information exchange among government departments, for example, needs improvement, especially regarding the sharing of ecological data. Although we noted interest in community consultation and fair and inclusive decision-making, in general, the provincial government is regarded by many stakeholders and First Nations as relatively ineffective at balancing interests in the region. Interagency cooperation and inter-municipal coordination need more attention to achieve effective management. There currently exist amongst provincial government departments and agencies different, and often competing, views and perspectives concerning the most appropriate use and development of the GSH. There is a need to establish a greater consensus and clearer vision amongst government departments and agencies about the nature of and need for activities and land uses that are consistent with the principles of sustainability in the GSH, and to communicate this vision to GSH stakeholders and First Nations.

Both the provincial government and the GSH Planning District Commission have generally been able to adapt to the demands of managing the GSH in the last 10 years, particularly in terms of promoting environmentally-sensitive development, but efforts are hampered by shortages of staff and other resources. Capacity building, both in terms of human development and physical infrastructure, is needed in the GSH region. At present, the lack of financial, human, and infrastructure resources combined with a lack of baseline data limits the overall effectiveness of governance and the scope of viable management options.

Two common issues were raised by stakeholders and First Nations with respect to legislation affecting governance in the GSH. First, the scope of the legislation is inadequate to address the current mix of land uses and interests in the region. This is sometimes due to outdated legislation or legislation that has been conceived too narrowly to cover the range of relevant issues encountered in current management, as is the case with the *Provincial Lands Act*. Second, many pieces of legislation and management mechanisms lack sufficient enforcement, which makes it difficult for responsible authorities to prevent or curb undesirable activity.

At present, government is criticized by the gas industry for failing to provide a clear and timely development approvals process, a situation that can be attributed partly to the controlling influence of the RMs. There is also confusion around the purpose and powers of the GSH Planning District Commission, and a recognized need to better coordinate the bylaws of RMs and the mandates of government departments, and to simplify the development review process in the GSH. The most common suggestion to improve governance is to establish a central, higher-level governing body with decision-making power, supported by an effective and balanced network of interests focused on long-range planning.

Related to institutional arrangements and governance is the issue of conflict resolution processes and mechanisms. From our discussions with a variety of stakeholders and First Nations, there is considerable recognition of potential land-use conflicts and the need to resolve differences before they escalate to nonproductive or destructive levels. Local community residents and First Nations people, by way of example, have both spoken of a need for dialogue on land usage, ownership, and access as a way of alleviating the concern and distrust that currently surrounds these issues. Gas industry representatives spoke of a need for increased dialogue aimed at clarifying the rules and regulations that would shape their activities in the GSH area and at focusing and refining the goals of the local communities with regard to gas resources. The SAC strongly endorses the need for Government, in consultation with stakeholders and First Nations, to find effective mechanisms for the early resolution of land-use conflicts (see http://www.environmentalsociety.ca/issues/energy/oil-patch.pdf). Government should promote the joint participation of different stakeholders and First Nations in the decision-making processes in regard to the GSH as a way to identify different interests and promote consensus.

## Environmental Assessment

The environmental assessment (EA) program in Saskatchewan has been in existence since the mid 1970s. Legislation formalizing what had been learned in practice was put in place in 1980 with the creation of *The Environmental Assessment Act*. *The Act* applies to projects (i.e., plans and programs), operations, and expansions, as well as specific activities. Since its inception, the program has reviewed a number of geographically extensive and strategic level studies in anticipation of large-scale developments such as the Churchill River Basin Study, the Cluff Lake Inquiry, and the Poplar River/Island Falls studies. Like those, this Regional Environmental Study (RES) of the Great Sand Hills (GSH) has focused on understanding the environmental limitations and opportunities for development in this ecologically sensitive area. The Scientific Advisory Committee (SAC) believes that such regional landscape-based approaches will help Saskatchewan realize its vision for sustainability, by providing insight into the complex nature of development decisions and integrating ecological and socio-cultural interests with the desire for economic development before irreversible decisions and actions are taken.

Nonetheless, the SAC's review of the assessment process and its historical application in the GSH has revealed some serious concerns. Our concerns lie not within *The Act* itself, but in the changing way that *The Act* has been applied over the last 20 years, especially with respect to cumulative environmental effects. For example, in the GSH as each gas development project came on stream, the proponents were not required, as part of their EA, to consider their impacts as additive to those of other projects already approved. This weakness was highlighted as part of the GSH Land Use Strategy Review (2004) and SAC agrees that it is imperative that this trend be reversed.

More specific to the GSH and this study, the *EA Act* lays out six tests against which activities are measured to determine whether or not they constitute a "development" requiring an environmental impact assessment. Two of these tests are particularly germane: 1) "have an effect on any unique, rare or endangered feature of the environment," and 2) "cause widespread public concern because of potential environmental changes." The latter test is a primary reason for the GSH RES being undertaken. The former test accurately reflects the position of the SAC that the GSH is *a unique and rare* environment, being the largest remaining remnant of a once vast native grassland. Further, continuance of the ecologically distinct structure and function of this region is endangered to the extent that cumulative effects upon the landscape are not being addressed and sustainable development actions are not being employed. There is no doubt in our minds that appropriate application of the *EA Act* can address threats to the ecological integrity of the region.

## Reducing Impacts

Many stakeholders noted the positive impacts of ranching, especially in terms of retaining population, support for local business, and contributing to the social cohesion of communities. In addition to their contributions to the social and economic fabric of their communities, ranchers are also seen as responsible custodians of the natural environment making an important contribution to environmental sustainability. Concerns were raised, however, about the surface impacts of grazing related in particular to trails and water dug-outs. There was also some criticism that the ranching industry is not subject to the same level of regulatory control or scrutiny in regard to surface disturbances as other industries, particularly the gas industry.

In order to maintain the environmentally sound nature of the ranching industry, it is important to insure that best management practices for range management (including water management) are consistently implemented by ranchers. Stakeholders felt that the provincial government has an important role to play in working with ranchers to develop, communicate, and assist in implementing best management practices. For example, a system of rewards might be put in place to encourage ranchers to participate in and adopt best management practices.

There is a clear recognition and acceptance by many local people of the economic importance of the gas industry to the region and the province. There is also an equally clear desire that exploration and development activities of the gas industry do not impair the ecological integrity of the GSH. Therefore, it is imperative that measures capable of decreasing the surface impacts of gas industry activity on the sensitive environment of the GSH and surrounding areas be examined and put into practice. All relevant technologies toward that end should be employed where appropriate, and new practices and methods with a high potential to contribute to the reduction of surface disturbances should be investigated. Future gas industry activity in the GSH should be based upon a principle of maximizing the quality of life experienced by area residents and minimizing impacts upon the ecological integrity of the region. Threats to quality of life that emerge from gas industry activity, as cited by local stakeholders, include contamination of drinking water and water for livestock, fumes and air quality issues, and damage to local roads and highways, as well as more general nuisances and disruptions to peoples' day-to-day home and work life. Although significant regulatory processes are already in place for gas exploration and development, the identification, implementation, and monitoring of best management practices for the gas industry were considered an important requirement by stakeholders and First Nations. Significant concerns also were raised about the lack of adequate compensation afforded to landowners from gas activity on their lands.

### Environmental Monitoring

During the Great Sand Hills Land Use Strategy Review (2004), the public expressed the importance of assessing how existing land uses affect the ecology of the area. Accordingly, the final report of the review made the following recommendations with respect to ecological monitoring in the area:

- establish a comprehensive program that monitors ecological integrity by establishing appropriate indicators and benchmark areas for future comparisons;
- undertake an invasive plant study every five years;
- employ qualified environmental monitors who report to the landowner/manager to oversee developments and enforce provincial and municipal environmental protection plan obligations.

In reference to these recommendations concerning monitoring, we did not detect in our study any significant improvement in this critical area of concern. The SAC considers this to be one of the most serious gaps in the long-term management of the area. Increasing disturbance of the thin soils of the GSH is the single most important ecological factor that challenges the sustainable development of the area for three reasons. First, areas with the standing vegetation removed are more likely to start increasing in extent due to wind erosion. Second, areas with little or no native vegetation are more likely to become colonized by non-native invasive plant species that will eventually invade their surroundings. Third, and most importantly, surface disturbance is the common theme that links all human and non-human activities in the area and thus serves as an excellent focus on which to build a monitoring program. For example, grazing cattle herds create elaborate trail systems as a result of their need for water; gas companies create roads linked to their need to access the gas resource; large wildlife species such as deer and antelope create trails, and smaller wildlife species, such as badgers and ground squirrels expose the soil through their digging activities. In turn, newly-exposed areas support different native species than more established areas. While there are numerous natural sources of surface disturbance not attributable to human activities, there is a special onus to manage the degree and extent of human-caused surface disturbances, especially with the omnipresent threat of non-native plant species invasion, a problem that will be exacerbated with global warming.

### Reclamation

Given the sensitive nature of soils in the GSH Review Area, and the serious threat of non-native plant species invasion, it is critical that areas subject to human-caused surface disturbance or exotic plant species invasion undergo reclamation back to a near-native state in a timely fashion. This was highlighted in the GSH Land Use Strategy Review (2004) and has been a central theme of discussions in the area over the last few years. Reclamation guidelines do exist (Saskatchewan Petroleum Industry/Government Environment Committee, 2000) although they likely need updating. Given the anticipated lifespan of gas wells, water dugouts, roads, trails, and other infrastructure, significant reclamation activities are unlikely to be undertaken within the near future. However, all relevant stakeholders must begin planning now for significant future reclamation. Part of this planning should be the use of permanent environmental monitors to identify areas for surface reclamation or for special management of non-native plant invasion. Another part must involve the creation of a reclamation fund to ensure that proper reclamation activities do eventually take place, even if original stakeholders no longer operate in the area. This fund should also support reclamation research projects, should they be required. Reclamation activities should be overseen by a joint partnership between industry, agriculture, a revitalized Great Sand Hills Planning District Commission, the RMs, the lessees, and the provincial government. The SAC believes that, along with enhanced environmental monitoring, proper reclamation of surface disturbance is critical to the long-term maintenance of ecological integrity in the area.

## Sustaining Regional Communities

Reflecting an all-too-characteristic trend in many rural Saskatchewan areas, human numbers in the GSH Study Area are generally declining. While environmental considerations are important to local area residents, our economic and social analyses of communities showed that their primary preoccupations related to economic and social concerns around declining populations and ways to halt, and eventually reverse, that trend. Specific reference was made to the quality of infrastructure, access to health and education services, provisions for commercial activities, and other economic and social factors influencing the quality of their lives.

Stakeholders were of the view that government at all levels should pursue all potential efforts to retain population and increase economic activities. Government should promote and support local initiatives oriented to increase the social and economic sustainability of communities. Such support should contribute to the social cohesion of communities and to their capacity to address their needs. Such efforts might involve promoting higher values for locally produced agricultural products and/or a system of tax incentives targeted at local residents and businesses. Stakeholders also felt that serious efforts should be made to stabilize the provision of localized services, with an emphasis on health care and educational services, since those services contribute to improvement in the quality of life of local residents and help to retain young people.

Any economic or social activity in the GSH area is dependent on the state of the local infrastructure. At this point the poor condition of roads and highways acts as a limiting factor on the development/sustainability of both the social and economic health of local communities. Tourism development, for example, depends on the state of the highways that give access to areas with tourism potential. Furthermore, the state of the road system limits the response time of emergency vehicles. To address this, SAC supports the view that adequate resources be devoted to road improvements.

As expressed by those who participated in the different studies of the local communities, gas, ranching, and tourism contribute to the economic sustainability of the region. Our economic baseline assessment showed that the regional economy of the GSH Study Area is dominated by ranching and gas development. With such a high level of specialization the region is extremely sensitive to even minor fluctuations in economic conditions affecting ranching and gas activities. Stakeholders were of the view that no single industry was sufficient to insure sustainability objectives and that measures should be taken to avoid domination and/or extinction of one industry by another. While each industry was regarded as important to the GSH area, domination by any one of them would not be sufficient to maintain population or income levels over the long term.

Therefore, any future approaches or programs oriented toward economic development or sustainability in the GSH area should avoid prioritizing the needs of one industry to the detriment of others. Stakeholders felt that the main industries in the area should always be regarded as components of a larger, intricately integrated whole and should be dealt with as such. The existence of both a vigorous ranching and gas industry in the area, and the considerable financial infusion that those industries provide to people, businesses, and communities, combined with the potential for tourism, sets the GSH apart from other areas of the province. The vulnerability of households in the region to upheavals in either agricultural or natural gas markets is mediated by the presence of both industries, which reduce vulnerability by providing additional revenue and employment to a large number of households. As well, the health of both industries benefits communities by bringing more revenues for established local business, employment for local people, and larger tax base revenue to RMs. In these terms, SAC recognizes the importance of the gas and ranching industries for the economic sustainability of the region.

Tourism is perceived by many residents and First Nations participants as an economic activity that does not have a significant damaging impact on the GSH environment. On the contrary, many stakeholders argued that the main benefit of tourism on the GSH stems from the greater levels of environmental awareness and attention that come as a result of tourism development. However, that perception is grounded in a current reality of relatively little tourism activity within the region. Some respondents were therefore concerned about the potential damage to that GSH environment that a movement of large numbers of people into the Review Area could create.

In that context, the SAC is of the view that Government should increase its efforts to promote the development of the nascent tourism industry in the GSH area. An increase in tourist activity in the area would have the dual benefits of injecting economic vitality into local communities and, at the same time, promoting environmental awareness. Nonetheless, given concerns over the impact of the tourism industry on the quality of life experienced by local residents, it is necessary that the development of a responsible and sensitive tourist industry in the GSH area should at all times be characterized by practices that include consideration for the comfort and safety of the people who make their lives in the area. Many stakeholders felt that tourism should be restricted geographically to less sensitive areas and should be characterized by practices with minimal environmental impacts. Therefore, establishing tourist accessible zones as well as zones where tourism access is completely restricted would likely receive local support. Furthermore, tourist activities should be oriented towards imparting information on the sensitive nature of the local environment, and should be implemented in ways such that the impact of the human presence is minimized.

The establishment of regulatory support and supporting infrastructure for the regional tourism industry, and the facilitation of coordination among tourism services providers in the region, are necessary if tourism is to be promoted as a viable economic opportunity. The SAC strongly encourages the Government of Saskatchewan to lead in coordinating efforts that would explore opportunities for First Nations involvement in development of the regional tourism industry.

The Great Sand Hills are of significant cultural value to the First Nations peoples of southern Saskatchewan and Alberta. Of immediate concern to those First Nations, in particular to the File Hills Qu'Appelle representatives of Treaty Four and to the Blood Tribe Elders of Treaty Seven, are issues concerning: 1) the impacts of development on First Nations values and culture; 2) restrictions on First Nations use and access to the GSH due to current land use zoning; and 3) the lack of First Nations involvement in GSH planning and decision making processes. In addition to spiritual and cultural interests in the GSH, a number of First Nations see potential economic opportunity in terms of natural gas development. While economic interests were not expressed by the elders who participated in this study, such issues were raised by a number of Band Council members and in particular by participants of Treaty Six. The current RES is directed toward managing the ecological integrity and future sustainability of the GSH. However, there is a need for First Nations economic interests and Treaty Land Entitlements (TLEs) in the GSH to be addressed through the appropriate consultation processes.

Issues concerning the uncertainty of TLEs were raised in the 1991 *Land Use Strategy*, the 2004 *Land Use Strategy Review*, and continue to be of concern to local land lessees in the GSH region today. However, issues of TLE selection, negotiation, and mineral rights are beyond the scope of the RES and should be addressed under a separate review process.

The SAC acknowledges the sensitivity of First Nations' issues and concerns in the GSH, and recognizes a disconnect between First Nations' interests in the GSH and perceptions of First Nations' interests (see Peters et al. 2006, and Gauthier et al. 2006). This disconnect is, in part, due to differences in "World Views" between First Nation and non-First Nation peoples, and differences in understandings of the nature and significance of the GSH landscape.

Overall, the SAC believes that a greater level of knowledge transfer, communication, and First Nations' participation in GSH land use planning and decision making are needed. This can be accomplished, in part, by the industry and various levels of government adopting *The Government of Saskatchewan Guidelines for Consultation with First Nations and Métis People: A Guide for Decision Makers* as a minimum standard for First Nations consultation and communications concerning the GSH. The document sets out an approach to be used by all Government of Saskatchewan departments respecting consultations with First Nations and Métis in circumstances where action contemplated by Government may adversely affect Treaty or Aboriginal rights (Government of Saskatchewan 2006). While the approach to consultation presented in this document is flexible, five important characteristics of the First Nations and Métis consultation process are described:

- notification of the community to be consulted of the intended action or undertaking in an appropriate manner and in a sufficient level of detail;
- provision of an appropriate period of time to allow the community being consulted to prepare its views and to report back;
- presentation to the proponent by the community being consulted and an opportunity for open discussion;
- full and fair consideration by the proponent of the views presented;
- reporting back to the community on the direction or specific actions chosen by the proponent.

Our discussions with and surveys of residents of the GSH indicate that while environmental considerations are highly important to them, they have significant social and, especially, economic concerns. Those concerns are diverse and include numerous issues such as health care and education, infrastructure and commercial activity. It is to this last point that this final portion of our regional context pays particular attention. Stakeholders noted in numerous forums that the quality of life associated with traditional economic activities (particularly ranching) is becoming more closely associated with new economic activity (gas development) in the region. The SAC acknowledges that ranching and gas extraction have the potential to contribute significant economic returns to the government and the local economy. In that context, our focus has been to consider how such benefits may be sustained while insuring the ecological integrity of the GSH.

Our studies show that the gas reserves in the Review Area have the potential to double the revenues to government from the region in the next 15 years (going from current 2P production revenues to 3P production with in-fills and step-outs). The local economic spin-offs (using the same 2P to 3P trajectory) quadruples over the same time period. Therefore, from a purely economic perspective, the continued expansion of gas extraction within the Review Area may be perceived as highly desirable. However, this economic activity is not a sustainable activity in the long-term—a fact accepted by the gas companies themselves—as the resource is non-renewable and limited in quantity. On the other hand, ranching is perceived to be more sustainable in the long-term, using renewable resources and preserving a way of life present in the region for generations. The critical question is whether a means exists to insure the ecological integrity of the GSH Review Area while meeting the socio-economic needs of the people who derive their livelihood from the area, and recognizing both traditional and new forms of economic activity that have different short and long-term demands on the land.

To add to the complexity and breadth this question poses, the gas reserves within the Review Area are not fully understood, especially within the northeast portion of the GSH. Projections to date and contained within the economic baseline report and the reports from GLJ Petroleum Consultants Ltd. are based on information available at the time of publication. There could be more (or little) gas in the northeast region. The lack of assessment is a factor of information availability—test wells have not been established in that area, and as such there are no data. To further add to the complexity of the issue, gas pricing is highly variable, and the industry operates on very small margins. In theory, in order to address the "margins" issue, delaying development of the Milk River and Second White Specks pools should allow the value of the resource to increase in price due to inflationary pressures and the costs of development should decline as technology becomes more widespread, resulting in a larger potential margin for the industry and tax revenues for government. Again, further complexities enter into consideration: the retail price of gas is increasing at 2% on average, while the Consumer Price Index is increasing at a rate closer to 3%. Therefore, under those conditions, the actual economic value of the resource declines over time, meaning that it could be seen as more financially valuable as a resource today. The developmental implication is that the reserves within the study area have greater value in constant dollars if they are developed sooner rather than later. We have, therefore, in our recommendations considered the timelines of development relative to our core biodiversity areas and the economic implications of insuring land-use practices that minimize surface disturbance impacts on ecological integrity.

## STUDY AREA/REVIEW AREA RECOMMENDATIONS

The recommendations of the Great Sand Hills Regional Environmental Study are predicated on the principle of minimizing surface disturbance as a means of contributing to the sustainability of the ecological integrity of the area. Following the outline of the regional context description in the preceding Preamble, our recommendations are presented according to the following sections: Biodiversity and Conservation Lands Designations and Management; Governance; Acts and Regulations; Reducing Impacts; Environmental Monitoring; Reclamation; and Sustaining Regional Communities.

### Biodiversity and Conservation Lands Designations and Management

*Core Biodiversity Areas*

1. We recommend that 35 new sites identified as core biodiversity areas in this study be provided a level of protection equal to that of the current RAER.

Our assessment of the distribution of biodiversity across the GSH compared to present management showed that the current level and distribution of protection is inadequate. The Representative Area Ecological Reserve (RAER) contained the greatest concentration of habitat for only 37 % (10 of 27) of assessed species, suggesting that the majority of species were better represented elsewhere in the Review Area and highlighting the need for additional conservation areas. Therefore, we recommend new conservation areas within the GSH. In particular, to represent viable examples of grassland vegetation and associated focal species habitat requires the addition of extensive areas in the south and west of the Review Area to the conservation reserve system. Our identified core biodiversity areas are mostly concentrated in the less developed southern part of the GSH.

2. Until such time as an Ecological Reserve designation is achieved, those 35 core biodiversity areas should receive elevated statutory conservation protection so as to be protected from further surface disturbance and should be immediately subject to the following conditions:

   a. no new mineral or surface leases;
   b. existing well pad surface leases are grandfathered;
   c. where surface leases are already approved but no wells drilled, a maximum of one well pad surface lease per section is permitted;
   d. where a gas well(s) has already been drilled, any new additional drilling must occur on existing well pad surface leases;
   e. all land-use activities are conducted only within the confines of existing pads, roads, and trails;
   f. reclamation and monitoring are applied to the highest practical standard possible;
   g. ranching operations are allowed only to the extent that they support and do not compromise the maintenance of the natural ecological system and its components.

   The existence of land-use activity and mineral dispositions within core biodiversity areas is recognized. As soon as practical, Government should pursue avenues to achieve Ecological Reserve designation for all core biodiversity areas using appropriate means, including but not limited to mineral rights buy-backs and land trades.

*Non-Reserve Areas*

3. We recommend limiting new well pads, watering holes, and associated roads/trails in the non-reserve areas of the GSH Review Area.

All three anthropogenic disturbances assessed (gas well pads, roads/trails, livestock watering holes) resulted in reductions in range health, although the spatial scale and magnitude of these responses varied by impact type. This finding supports our preferred scenario.

*Land-Use Zoning*

4. We recommend that the boundaries of ES1 and ES2 zoning designations be altered to correspond with the boundaries identified in our study for Reserve and Non-Reserve Areas, respectively.

The 2004 Review recommendations noted that in the absence of scientific understanding, the utilization of ES1 and ES2 zoning should be continued. The GSH RES has provided increased information for the Review Area that has improved our collective understanding of some aspects of the status of biodiversity. That information and our modeling has refined our understanding of areas within the Review Area that require increased attention relative to land-use activities. We identified and mapped 35 core biodiversity areas, and those areas as well as the RAER should be reflected in the zoning designations for the Review Area.

*Land Management Plans*

5. Saskatchewan Environment (SE) in consultation with other provincial government departments, RMs, and local lessees should, as quickly as practical, develop and implement a land management plan for the RAER and the 35 new core biodiversity areas in the Review Area. Furthermore, the SAC recommends that activities leading to human-induced disturbance on all Non-Reserve lands within the GSH Review Area (i.e., all lands not captured in the core biodiversity areas and RAER) should be the subject of, at a minimum, an Environmental Protection Plan (EPP). To ensure that the recommendations of this report, and any subsequent plans issuing forth, are adhered to, these recommendations should be appended to any government lease sales, offerings, or renewals made within the GSH Review Area.

Those Non-Reserve lands constitute a critical landscape matrix that serves to buffer the core biodiversity areas from indirect impacts and also significantly contributes to the overall ecological integrity of the region. EPPs in the Review Area must include consideration for environmental monitoring, reclamation, and the application of best management practices. These EPPs should be reviewed by SE and approved only if they are in compliance with the recommendations and environmental protection objectives established in this document. In various places throughout these recommendations, we refer to the importance of developing, implementing and monitoring best management practices associated with land use activities including ranching, gas exploration and development and tourism. To be most effective, best management practices should be collaboratively defined and made a part of land management plans and should be a standard of measure for any follow-up requirements and regulatory processes associated with those plans. Updating of best management practices, and their adoption and implementation, should be formally undertaken on an annual basis.

*Fire Ecology*

6. We recommend continued experimentation with prescribed fire as a means of restoring and maintaining range health in the GSH.

7. We also recommend that a program be established to compensate local ranchers to conduct prescribed burning to reduce encroachment of shrubby vegetation in grasslands. This program could be funded by government, ENGOs, and other private donors. One potential source of funding may exist through the federal government under their Species At Risk Act, as these range management efforts will maintain and enhance critical habitats for federal species of concern.

The Government, through the leadership of Saskatchewan Environment, should take the lead role in introducing fire to the landscape with the introduction of a pilot fire education program to show fire as a natural process and to show producers how the introduction of controlled fire can increase the grass in the area and reduce the shrub encroachment on the native grasslands. Fire is a controversial topic among land owners and lessees in the GSH. Although some ranchers are interested in using prescribed burning to help maintain or restore range health, the general attitude of ranchers toward fire is one of fear, sparked by past destructive fires that destroyed homesteads, coupled with a belief that grazing by livestock essentially substitutes for fire as a natural disturbance. Nevertheless, ecological research supports the hypothesis that virtually all grassland ecosystems in North America evolved with fire—whether lightning-set or human set—and that fire can be helpful in maintaining and restoring healthy prairie ecosystems. In the northern Great Plains, including Saskatchewan, research suggests that the reintroduction of fire would help restore the natural structure, composition, and function of grasslands (Romo 2003). Climate-change models suggest that a drier and hotter climate is likely for the GSH, which will increase the potential for prairie fires. It is clear that, over the long term, fire may be beneficial both to range health and to livestock producers; however, in the short term, uncontrolled fires could have catastrophic effects on the livelihoods of the landowners and producers affected.

*Wide-Ranging Species*

8. We recommend that research be undertaken to better understand the requirements of wide-ranging species, such as pronghorn antelope, that use the GSH on a seasonal basis.

Key species not considered in this Regional Environmental Study, because data were inadequate to consider them rigorously, include wide-ranging mammals that require areas vaster than the GSH to maintain viable populations. Among these species is the pronghorn. We were not able to develop a model for pronghorn because the available population information was generalized over a very large area (many times the size of the GSH). Inferring quality of habitat for small patches within the GSH was therefore impossible. Furthermore, there were no available pronghorn telemetry datasets available in the local area. Pronghorn in the GSH apparently tend to prefer the agricultural zone over that of the GSH Review Area, at least during certain times of the year. However, it is not unlikely that the GSH provides an important refuge for kidding in the spring or meets other critical life-history needs. Modeling a wide-ranging species such as the pronghorn requires consideration of multiple scales of habitat, from local to inter-regional. In this case, further research is needed to determine the importance of a presumed migratory corridor for pronghorn from the GSH through the Cypress Hills to wintering areas in Montana. Other wide-ranging species reported with increasing regularity in the GSH are gray wolf and puma (mountain lion, cougar). Virtually nothing is known about the status of these potential keystone (highly interactive) species in the GSH. Again, research is sorely needed. For all such species, conservation and management must consider a broad regional scale beyond the GSH.

*Rare Species Database*

9. We recommend increased funding of Saskatchewan Conservation Data Centre (CDC) to support sufficient

staff for keeping data current, including entry of data collected during our 2005 and 2006 field seasons.

10. We also recommend that all future surveys for rare species in the GSH (and elsewhere) include presence-absence data, not just presence data, and implement a rigorous and systematic sampling design (i.e., sampling habitats in proportion to abundance in a stratified-random fashion, rather than concentrated along roads) whenever possible.

Rare species data for this study came from two sources: the Saskatchewan Conservation Data Centre and new surveys of plants and birds during the 2006 summer field season. Our assessment is that the rare species database for the GSH is currently inadequate and biased towards sightings in accessible locations (e.g., along roads).

*Ord's Kangaroo Rat*

11. We recommend validating and protecting sites predicted from our study throughout the GSH Review Area that support Ord's kangaroo rats.

One of the rare species of particular concern in the GSH is Ord's kangaroo rat. Like many other rare taxa within the GSH, this species has not been systematically surveyed. Our focal species model predicts 520 ha (or about 0.26 % of the Review Area) of potential Ord's kangaroo habitat in the Great Sand Hills Review Area. Much of the predicted distribution was in the northwest portion of the Review Area, although a number of smaller and more isolated sites were predicted throughout the GSH. Further validation of these small and isolated sites is necessary.

*Wetlands*

12. The SAC recommends an organized inventory and ongoing monitoring of wetlands in the GSH.

Because of time constraints, the SAC did not conduct field work in wetlands, nor did we model wetland species and habitats. Therefore, biodiversity value rankings (i.e., hotspots identified by MARXAN) for some small wetland-based core biodiversity areas may be artificially low.

*Communications Plan – Best Management Practices*

13. We recommend a communication plan for landowners and lessees through a partnership of government (local and provincial), industry, First Nations and academia that highlights best management practices for biophysical surveys and a permitting plan for research activity on leased land.

## Governance

14. The SAC recommends strengthening the representation and mandate of the Great Sand Hills Planning District Commission to play a more direct and centralized role in land-use planning, regulation, and decision-making in the Great Sand Hills.

15. The SAC recommends that the mandate of the Commission be one of maintaining the ecological integrity and long-term sustainability of the GSH region and its associated communities.

The various roles of government departments and agencies in planning and decision-making in the GSH, as well as current legislation and land-use plans, need to be clarified to all stakeholders. Clarification is necessary in order to reduce current confusion and concerns over roles and responsibilities for land-use management, regulation, approvals, permitting, and decision-making, and is especially relevant to address existing concerns that power and influence in the GSH currently favor government and economic interests. The Great Sand Hills Planning District Commission (the Commission) was established in 1994 under the *Planning and Development Act* as a result of recommendations emerging from the 1991 Great Sand Hills Land Use Strategy. Prior to the 1991 Planning Strategy, each RM in the GSH region had its own set of bylaws, which may or may not have coincided with neighbouring RMs, and land use was determined by a mix of provincial policy and local edict (Harriman et al. 2006). The Commission was created to provide for greater consistency in land use policy and bylaw administration amongst member RMs, and to provide advice on the management and sustainability of the Great Sand Hills and RM communities. Since its inception, the Commission has played a significant role in managing the day-to-day activities of the GSH. However, the SAC believes that the Commission currently lacks the proper mandate, resources, and institutional structure to ensure the longer term ecological integrity of the GSH and the sustainability of GSH communities. Of particular concern to the SAC is that many of the issues raised in the 2004 *Land Use Strategy Review* resurfaced during the current RES, including:

- concerns over the clarity of roles, powers, and responsibilities;
- institutional fragmentation;
- a central body with limited centralized control;
- inadequate representation of parties and interests;
- lack of sufficient mandate and resources;
- separation of the Commission from environmental monitoring and accountability.

Given that these problems and challenges continue to persist, there is an immediate need to strengthen the capacity of the Commission so as to ensure its direct, and effective, involvement in decision-making and in the longer term planning and management of the GSH.

16. Consistent with principles of capacity building as identified by the Delft Declaration (see Biswas 1996), the SAC recommends that the Commission adopt a new structure—that of a "corporate board."

One of the medium-term recommendations emerging from the 2004 *Land Use Strategy Review* was to create and formalize a partnership between provincial agencies and municipal councils for management of the GSH. Corporate boards, in contrast to advisory boards (e.g., the current Commission), have governance and management responsibilities and decision-making authority. The objective of a corporate management structure is to strengthen local governance in the GSH, but at the same time eliminate the redundancy associated with the current advisory board system. As one example, the recommended board structure may reflect many of the characteristics of the Qu'Appelle Planning District, which consisted of a corporate board of provincial and municipal interests, but, similar to the current Commission structure, and consistent with the principles of local governance, the balance of decision-making power rests with the municipal members. Provisions to establish corporate district planning authorities do exist within Bill 12, *The Planning and Development Act*, 2007 (section 108), which at the time of this report had received third reading in the legislature. The traditional practice under the existing *Planning and Development Act* has been to respect the local autonomy granted to the municipalities. The Commission would thus represent shared power and have the capacity and authority to centralize the decision-making process so as to ensure that RM bylaws related to the GSH are consistent and facilitate the most effective and efficient land-use management, regulation, development approval, and permitting processes.

17. In order to secure representative membership , the SAC recommends that the membership of the board be expanded to include:

- Broader RM membership, including members from each of the eight RMs of Fox Valley (171), Clinworth (230), Pittville (169), Piapot (110), Happyland (231), Miry Creek (229), Gull Lake (139), and Big Stick (141).
- Representative membership of the "urban" settlements/villages that are contained within the above RM geographic boundaries.
- Representation from Saskatchewan Environment, Saskatchewan Agriculture and Food, Saskatchewan Industry and Resources, Government Relations, and First Nations Metis Relations.
- Representation from First Nations. The GSH lie within the area covered by the Qu'Appelle Treaty; thus, the member should be identified by the File Hills Qu'Appelle Tribal Council. Representation from First Nations would serve as a liaison between the Commission and the File Hills Qu'Appelle Tribal Council and would advise on appropriate First Nations protocols and other issues concerning land use and decision making in the GSH.
- Representation from each of the gas, ranching, and tourism communities.
- Representation from the environmental organization non-government sector.

The objective of a broadened membership is to ensure that the decisions of the Commission are supported by an effective network of interests and are, at the same time, locally driven. Government needs to make a decisive effort to integrate under-represented groups in the overall governance of the GSH, especially those that are small in numbers, lacking in financial and human resources, or are either indirectly impacted by or physically distant from decision-making (e.g., NGOs, First Nations, tourism operators, ranchers, oil and gas operators, people living in the immediate vicinity of the GSH, and local communities). This can, in part, be achieved by expanding the Commission's membership. In addition to such expansion, there is a need for broader and more substantive consultation and review processes in relation to environmental assessment, EPP reviews, and land-use decision making.

18. In order to enhance capacity and coordination for environmental follow-up, the SAC recommends that a follow-up mechanism be established for the GSH

through the GSH Planning District Commission consisting of:

a. Environmental monitors established for the GSH and responsible to the local municipalities through the Commission.
b. A full-time Environmental Manager employed by the Commission to oversee environmental monitoring activities and auditing of best management practices in the GSH and to coordinate environmental management activities in the region (e.g., trail reclamation).
c. Consistent with efforts to build local capacity, that the Commission employ a District Planner to manage other land uses and broader socioeconomic activities in the region.

Best management practices for gas activity in the GSH are non-binding, proposed impact mitigation measures upon which projects are approved in "good faith." Under the current approvals process for gas activities there is no formal requirement for follow-up of best management practices to ensure that they have been implemented and that they are effective. The positions recommended above will serve to address these serious gaps in a coordinated fashion.

19. The SAC recommends that the Commission's Environmental Manager have the mandate to review industry and government environmental monitoring data and programs in the GSH, and to release to the public an annual follow-up report that documents the "state of best management practices compliance and performance" in the GSH.

The Environmental Manager would, in principle, serve the role of a "watch dog" over GSH development and land-use activities. While non-binding, information provided by the Environmental Manager could be used by the Commission and by Saskatchewan Environment, Environmental Assessment Branch, for subsequent decision making and industry permitting purposes.

20. The SAC recommends that a centralized information/resource system be established to house annual monitoring reports, industry EPPs, RM bylaws, regulations, and community economic profiles and investment/infrastructure profiles concerning the GSH region.

This information would be housed and managed by the GSH Planning District Commission, under the direction of the Executive Secretary and Commission's Environmental Manager, and made available to its members and to outside parties as determined appropriate by the Commission. The objective would be to provide centralized, easy, and shared access to industry, monitoring, and regulatory information for land-use management, EPP development, cumulative effects assessment, decision making, and economic investment purposes.

21. The SAC recommends that the Commission receive a sustained funding commitment, the balance of which is sourced by the provincial government and Commission membership. Such funding would be directed toward:

- a paid Executive Secretary position for the Commission;
- a paid Environmental Manager position for the Commission;
- a paid District Planner position for the Commission
- funding long-term ecological monitoring and data sharing;
- meeting regular Commission operating costs.

The 2004 *Land Use Strategy Review* identified concerns over inadequate funding and resourcing of the Commission which, among other things, results in unnecessary procedural delays in permitting and restricts the ability of the Commission to make the most informed decisions. The SAC acknowledges that these concerns have not been addressed and that the Commission remains under-funded and under-resourced. Funding could be secured from a portion of the provincial revenues from gas royalties, ancillary gas revenues, and/or ranching income taxes and lease rents for the area.

22. The SAC also recommends that special funding arrangements be established on a cost-shared basis among members to support Commission special research initiatives, monitoring, and development projects.

## Acts and Regulations

*Review of GSH RES Report under EA Act*

23. We recommend that the final report and recommendations of the Great Sand Hills Regional Environmental Study should be subjected to a full review pursuant to *The Environmental Assessment Act*.

It is the view of the SAC that the body and recommendations of the Regional Environmental Study report contribute to the scientific foundation of an operational Regional Sustainability Plan focused on the maintenance of ecological integrity within the GSH and therefore should be subject to a review under the *EA Act*.

*Review of EA Process*

24. We recommend that the EA process be modified to include consideration of the cumulative effects of all land-use projects in order that a more realistic assessment of the impacts of human activities on the ecological capacity of GSH can be determined.

The SAC suggests that a process and system be developed to assist proponents in meeting this requirement so that the burden is borne in a collective fashion and not by a single entity.

*Review of the EA Act*

25. The SAC recommends that as a criterion-based screening mechanism, further guidance and decision support criteria be developed for determining "development" under section 2(d) of *The Environmental Assessment Act*.

The need for an Environmental Impact Assessment (EIA) of activities in the GSH is determined, in part, under the screening criteria of section 2(d) of *The Environmental Assessment Act*. Under section 2(d), applications that are considered "development" are required to undergo an EIA. However, despite the high sensitivity of the GSH for species at risk and the potential for effects on a "unique, rare or endangered feature of the environment," a criterion for an EIA under section 2(d)(i), only 5 proposals have undergone full assessment. The screening checklist under European Directives 85/337/EEC and 97/11/EC may serve as a model for development.

*Amendment to EA Act*

26. The SAC recommends that *The Environmental Assessment Act* be amended to include a formal requirement for environmental impact assessment follow-up.

The SAC has identified a number of concerns and recommendations in relation to monitoring gas activities and associated best management practices in the GSH. The majority of these concerns and recommendations apply to gas development approved under EPPs. However, for those gas development activities that do trigger the full environmental impact assessment process under section 2(d) of *The Environmental Assessment Act*, a formal post-approval follow-up mechanism is necessary. The objectives for a follow-up program under *The Act* should be to: 1) verify that proposed environmental and socioeconomic mitigation measures have been implemented; 2) verify that implemented impact mitigation measures are working as intended; 3) verify the accuracy of project impact predictions; and 4) identify and manage unanticipated environmental and socioeconomic impacts.

*Review of the Provincial Lands Act*

27. The SAC recommends that the government review the purpose and effectiveness of the current *Provincial Lands Act* and revise, replace, or update *The Act* to address current land activities in the GSH and new interests on Crown land.

The *Provincial Lands Act* was enacted in 1978, and is administered by both Saskatchewan Agriculture and Food and Saskatchewan Environment. Although *The Act* does address particular land uses concerning agriculture, surface leases, and grazing, there is both government and non-government concern that *The Act* does not adequately address the current mix of land uses (e.g., oil and gas developments and tourism) and interests (e.g., First Nations, TLEs, and third-party interests such as tourism operators) in the GSH.

*Amendment to the Heritage Property Act*

28. The SAC recommends that the *Heritage Property Act* be amended to clearly provide for the protection of heritage sites based on aesthetic and cultural grounds and that joint management of such resources occurs, where applicable, with the affected First Nations.

On 15 January 2002 the Government of Saskatchewan's Heritage Assessment Unit of Community and Heritage Services proposed 24 amendments to the *Heritage Property Act*. Included amongst these amendments was clarification of sections 65(1) and 66.1(1) concerning Crown ownership of skeletal remains, the Crown's stewardship role, and *The Act*'s relationship to *The Ceremonies Act*. To the best of the SAC's knowledge, clarification and amendment of sections 65(1) and 66.1(1) have not occurred. There is concern amongst both government agencies and First Nations that while

*The Act* is successful in the protection of "built heritage," there is inadequate attention to the designation and protection of heritage properties based on aesthetic or First Nations' spiritual or cultural values.

## Reducing Impacts

*New Well Pad Surface Leases and Roads/Trails*

29. We recommend that gas lease holders be required to use directional/slant drilled wells. Specifically, multi-well pads with directional/slant drilled wells or a combination of directional/slant drilled wells with a vertical well on the same pad is permitted.

Based on logistic regression analyses, new roads/trails were more likely to be built in areas associated with a new well pad surface lease than random locations elsewhere in the Review Area. This supports our earlier recommendation to limit new well pad surface leases to 2 per section in the Non-Reserve Area and allow no new well pad surface leases in core biodiversity areas, subject to the conditions identified in Recommendation # 2. To mitigate potential impacts of gas development on core biodiversity areas, directional/slant drilling could be used from existing well pad surface leases along core biodiversity area boundaries, thus limiting intrusion of roads and trails. By restricting gas development within core biodiversity areas and holding maximum well pad surface lease density at 2 per section outside of core biodiversity areas, our preferred scenario resulted in a total of only 110 km of new roads. Locating well pad surface leases along existing roads with only short spur roads off of them could reduce total road and pipeline development across the GSH substantially.

*"Incident" Management*

30. The SAC recommends an improved and more transparent process for management of incidents that impact negatively upon the environment during construction, operation, and decommissioning of any development on the land (e.g., distributed water systems, gas wells).

Improvements should include computer-based tracking to ensure that proper follow-up of logged complaints occurs. Similar to the existing SIR spills database, such logging could be web-based, thus ensuring increased transparency to the general public. Affected RMs and landowner/lessees should be involved with full regard to the constraints of due process.

*Distributed Watering Systems*

31. We recommend that before the approval and construction of any new distributed watering systems in the Review Area, the proponent must make a request to Saskatchewan Agriculture and Food (SAF) and SE, and that the provincial agencies provide assistance with location preference, and gathering of information on rare and endangered species.

32. We recommend requiring an environmental assessment process prior to installing distributed watering systems, and that overall grazing pressure be controlled in areas receiving distributed water, such as by use of management-intensive grazing, rotational grazing, or rest-rotation grazing, in order to maintain range health.

33. We also recommend intensive monitoring of the overall and cumulative effects of distributed water systems on the GSH ecosystem.

Our study indicated unhealthy range conditions associated with areas around livestock watering holes, where overgrazing and trampling have noticeably eroded range health conditions and have resulted in increased occurrence of non-native plants and a reduction in the occurrence of several sensitive bird and plant species. Distributed (shallow buried) water systems are being used to increase the carrying capacity of livestock in some areas in the GSH, and are subsidized by the National Water Supply Expansion Program (NWSEP) from Agriculture and Agri-Food Canada. The advantages of such systems for the producer are becoming well accepted, and include enhancing water quality and quantity (especially in a drought), ability to cross-fence, greater animal weight gain, and increased distribution of cattle to previously inaccessible areas. It is less clear, however, whether such systems will benefit native flora and fauna by reducing surface disturbance; in terms of cumulative impacts, they could do more harm than good. Research and monitoring of distributed watering systems is necessary to make valid predictions about long-term impacts on range health, invasive plants, and sensitive focal species.

*Fragmentation by Linear Features*

34. We recommend that fragmentation of natural habitats in the GSH by roads, trails, pipelines, and other

linear disturbances be controlled and ultimately reduced, accompanied by intensive monitoring of ecological impacts. Specifically, we recommend a combined approach in which no new roads or other surface disturbance are allowed in the Reserve Area (i.e., existing RAER and 35 new core biodiversity areas), and best management practices are applied and monitored in the Non-Reserve Area across the GSH Review Area. We also recommend quantification of the use of roads as part of the ongoing monitoring of and adaptive management within the GSH.

The ecological consequences of habitat fragmentation on large grassland ecosystems, such as the GSH, have been poorly studied. However, research in many regions has shown that an increase in the density of roads, trails, pipelines, and other linear disturbances—an important category of habitat fragmentation in the GSH—can have multiple impacts on the native biota. One of the more serious consequences of such fragmentation is the spread of invasive non-native species. Management actions that limit road development, both in the form of new conservation areas and best management practices, are likely to have the greatest impact on conserving the biological resources of the GSH.

### Environmental Monitoring

35. The SAC recommends that within one year of the date of this report, an ongoing environmental monitoring program for the GSH should be designed and implemented.

Monitoring efforts to date within the Review Area have been fragmentary, inadequate, and primarily focused on the specific activities of gas projects, such as well drilling. However, all human activities in the area create surface disturbance to some degree and, therefore, all users need to be held jointly responsible for the funding and delivery of such a program, including government, industry, agriculture, First Nations, and NGOs. To build and maintain the GSH environmental monitoring program, partnerships should be established, firstly between the primary users (government, industry, agriculture, NGOs) of the area and then with external sources of monitoring expertise, such as the Alberta Biodiversity Monitoring Program. The program should, as a minimum, include the following features:

a. *Coarse and fine filter monitoring approaches.* The spatial extent of existing and new roads and trails should be periodically tracked with the aid of remote sensing technologies, such as satellite imagery. Such imagery could also be used to classify vegetation communities and track their changes over time, whether caused by direct human activities, climate change, or other factors. These coarse filter approaches should be supplemented with elements of fine filter periodic monitoring, which should include soil acidification monitoring, range health assessments, breeding bird surveys, species at risk surveys, non-native plant surveys, game species surveys, and project monitoring, such as for new roads, wells, or watering sources. Where of value, for example in understanding species-habitat relationships, fine filter elements could be integrated with coarse filter elements, such as vegetation communities.

b. *Standardized protocols and rigorous design.* The Regional Environmental Study has contributed to a baseline for many of the coarse and fine filter monitoring elements. Future monitoring should, as much as possible, retain the protocols associated with the RES surveys. However, attention should be paid to the design of the monitoring program to ensure that it meets the requirements of statistical testing and the recording and retention of metadata.

c. *Centralized monitoring metadata and data storage and access.* The RES study revealed that the existing environmental data and associated metadata for the GSH were not all recorded, digitized, stored, managed, and easily accessible. Current access to ecological information and information exchange requires improvement to facilitate an even flow of information among the parties as a way to better the governance of the GSH region. We earlier recommended in relation to a restructured Great Sand Hills Planning District Commission that a centralized information/resource system be established under the auspices of the Commission. To serve even wider needs, the SAC is also of the view that the Government of Saskatchewan, through Saskatchewan Environment, should establish a clearing house for ecological data sharing for the GSH, possibly through the Saskatchewan Conservation Data Centre. The clearing house should include data held by industry (for example, in the form of past EPPs and EAs) related to the GSH. To be most effective, that data storehouse needs to be linked to others across North America. Ecological data stemming from the GSH RES could serve as a foundation, with future data received from and made available to, other government departments and agencies, industry, the GSH Planning District Commission, and researchers. Various national and regional clearing houses for ecological information currently exist, ranging from national biodiversity research and information sharing and networking (e.g., clearing house mechanisms under the Convention on Biological Diversity) to regional ecological spatial data and metadata sharing (e.g., Wyoming Geographic Information Science Center, Natural Resources Data Clearinghouse; ECOSHARE: Interagency Clearinghouse of Ecological Information for the Pacific Northwest), and may be looked to as potential models for adaptation.

d. *Dedicated environmental monitors.* So that all users are held accountable to environmental policies and operational guidelines, sustaining the ecological integrity of the GSH requires the services of full-time environmental monitors. We earlier recommended that environmental monitors be employed through a restructured Great Sand Hills Planning District Commission. Consideration should also be given to reimbursing the expenses of lessees when they carry out the functions of environmental monitoring. In doing so, provincial government departments would enter into joint partnership ventures that foster long-term trusting relationships that contribute to the ecological integrity of the area. Currently, ranchers often serve in the role of unpaid monitors. Given the insufficient numbers of environmental monitors and the uneven quality of current monitoring, it is necessary to formalize and standardize monitoring activity with both training and compensation. In this way larger numbers of trained rancher-monitors can be fielded effectively. In addition, greater emphasis should be placed on the use of remote well and pipeline monitoring technology (e.g., cellular telemetry and SCADA), which have the benefit of decreasing trail use and chronic intrusion into remote or sensitive habitats.

e. *Cradle to grave project monitoring.* Post-industry or agriculture project reclamation and re-vegetation monitoring programs should be made mandatory. Reclamation and re-vegetation programs are largely still considered as an additional cost or inconvenience. Once a project (e.g. gas well, pipeline, watering source) is constructed, follow-up reclamation monitoring is often non-existent. In addition, clearer and concise expectations and requirements need to be made. For example, the regulatory request that there be no rutting or no excessive rutting on access trails does not define "excessive." To facilitate the development of cradle-to-grave monitoring, we recommend a pilot research program on trail reclamation to assess methods and costs that is conducted as a partnership among SE, SIR, SAF, the University of Regina, University of Saskatchewan, and SIAST.

f. *Research Needed on Response of Species to Gas Development.* In 2006 a rigorous sampling strategy —both in methodology and distribution of sampling—was instituted to quantify the effects of gas development, associated roads and trails, and other soil-disturbing activities on biodiversity in the GSH Review Area. Selected birds, rare plants, and range quality were quantified within a framework for establishing baseline conditions and assessing effects of current human activities and future development scenarios. We were not able to detect a significant response to gas well sites for any of the eight rare and traditional use plants assessed. This does not mean that there are no impacts. Rather, because the distributions of most species (except prairie moonwort) did not overlap the area of current gas development, conclusive judgment on the impact of gas development on these species is not possible at this time. Further research, for example applying a before-after-control-impact (BACI) experimental design, is needed to address the question of the impacts of gas development on rare plants and other species. We recommend repeating bird and plant surveys and range health assessments at the same locations as the 2006 field surveys at five-year intervals in order to monitor the effects of future development.

## Reclamation

### *Reclamation Guidelines*

36. Within one year of the date of this report and in order to reflect the latest techniques available, the SAC recommends that the Saskatchewan Government establish an inclusive review process of existing reclamation guidelines that involves appropriate government agencies, industry representatives, stakeholders, First Nations, and industry.

*Reclamation Fund*

37. To ensure the restoration of land subject to surface disturbances irrespective of their cause, the SAC recommends that a reclamation fund be established in the same manner as that proposed for environmental monitoring in the Review Area.

The Orphan Wells Program already exists for the restoration of lands disturbed by the gas industry. However, this needs to be supplemented to cover the broader reclamation of surface disturbances not associated with gas development, including the need to eliminate pockets of invasive, non-native plant species before they become widely established. As with monitoring, the responsibility for such funding should come from all parties creating surface disturbance; however, the government must take the lead role and allocate for this purpose some of the revenues (e.g. gas royalties, taxes, surface lease payments) generated from the Review Area.

*Reclamation Monitoring*

38. Environmental monitors (as identified in earlier recommendations) should be used to survey the GSH area for areas requiring surface reclamation or management of non-native plant species invasion; these monitors should also track the progress of reclamation projects.

*Reclamation and Restoration*

39. We recommend extensive conservation, restoration, and management activities in the GSH, including reclamation of gas line routes and abandoned roads and well pads, as well as eradication of non-native plants wherever feasible. Serious infestations of invasive non-native plant species should be identified and subject to eradication programs.

Many areas of disturbed soil within the GSH require restoration. Because of limitations of time and data within our study, restoration and management activities were not considered in any of our scenarios, but our models suggest that appropriate management and restoration could lead to gains in habitat, for example, for beaked annual skeleton-weed and a reduction in the extent of crested wheatgrass, among other benefits. Unfortunately, some plant species used in prior reclamation of disturbed soils—especially smooth brome and crested wheatgrass—are non-native and are proving to be problematic invasive species in the GSH.

*Native Seed Sources*

40. The SAC recommends that only locally adapted native seed sources be used for reclamation; all seed sources must be carefully scrutinized for contamination by unwanted plant species.

## Sustaining Regional Communities

The recommendations that follow are grounded in the observations of the natural, social and economic capital of the region and contextualized through the economic lens developed specifically in the economic baseline report. The recommendations follow from a focus on a balance between ecological integrity and the overall sustainability of the local populations, their economic well-being, ongoing economic development, and recognition of a region in economic transition between two disparate economic actors.

*Compensating Agricultural Leaseholders*

41. We recommend that Saskatchewan Agriculture and Food re-evaluate the amount of compensation to agriculture leaseholders for gas surface leases in the Review Area.

The 2004 Review recommended that Saskatchewan Agriculture and Food review the compensation payment to ranchers for gas developments on leased land with a view to perhaps increasing sharing of revenue directed at stewardship initiatives of benefit to the area. We fully support that earlier recommendation and suggest that Government should look to other jurisdictions for potential examples of more equitable crown lessee compensation policies for gas well pad surface leases.

*First Nations Consultation*

42. The SAC recommends Government consultation with First Nations as part of the GSH RES implementation strategy, and that the consultation processes adopt the principles outlined in *The Government of Saskatchewan Guidelines for Consultation with First Nations and Métis People: A Guide for Decision Makers*.

Based on the notion that "consultation would be required with those First Nations whose traditional territories coincided with the geographic area where the impact would be felt," the SAC strongly urges that consultation for RES implementation include both

Saskatchewan First Nations interests and the interests of the Blackfoot Confederacy of Alberta, who claim the GSH as their traditional territory and as an area of contemporary cultural and spiritual significance.

*First Nations Council of Elders and Traditionalists*

43. To facilitate ongoing consultation and knowledge sharing post-RES implementation, the SAC recommends the establishment of a "Council of Elders and Traditionalists," with whom governments and industry would be able to consult and work in order to insure that proper protocols are followed with regard to issues of development, land use, land access, and heritage resource management, and to ensure that the sacred nature of the GSH is properly addressed.

Decisions about land use in the GSH do not always concern Treaty Rights. In many cases, consultation with First Nations is necessary to ensure that First Nations' interests and cultural values in the GSH are known and respected. This advisory group should consist of an appropriate number of elders and traditionalists familiar with the GSH. The Council should be formed, organized, and coordinated by each of the Treaty area representative Councils. One primary role of the Council of Elders and Traditionalists would be knowledge sharing.

44. The SAC recommends that ceremonial sites of particular interest to First Nations be identified as part of the RES implementation process, based on consultation with Treaty Four and Treaty Seven members or the Council of Elders and Traditionalists.

The RES baseline study results indicate that the immediate purpose of First Nations access to the GSH is to engage in spiritual and cultural activities, such as ceremonies and the collection of medicinal plants. While there is now access to Community Pastures in the GSH through Saskatchewan Agriculture and Food, other areas of the GSH, including the RAER, are also of significant cultural and spiritual value to Treaty Four and Treaty Seven First Nations people. While the SAC cannot recommend access to particular areas, as many areas of interest are potentially subject to a Crown lessee agreeing to such access, every consideration should be extended to permit First Nations access to land within the GSH for spiritual ceremonies and medicinal plant collection. In keeping with an earlier recommendation, First Nations membership on the GSH Planning District Commission could facilitate such negotiations.

*Heritage Resources*

45. The SAC recommends that an appropriate protocol be established between industry, government, and First Nations concerning the treatment of disturbed heritage sites.

The GSH area is rich in archaeological resources, many of which are uncovered during gas exploration and development processes and many of which are of historical, cultural and spiritual value to First Nations.

*Labour and Employment*

46. The SAC recommends that the Government of Saskatchewan, through Regional Economic and Cooperative Development (RECD) in partnership with the local REDAs and Western Economic Diversification (WED), develop a series of information sessions, mailings to businesses, and workshops detailing the specific application procedures and success strategies for Provincial, REDA, and WED programs and initiatives that can be offered to the employers of the region.

47. We recommend that a partnership of government agencies (RECD, REDA, and WED) develop a close working relationship with the Great Sand Hills Planning District Commission to improve program uptake and increase local adoption of the various labour and employment programs.

Economic diversification has been a cornerstone of economic discussion since the 2001 Saskatchewan Action Plan. The Regional Economic Development Authority (REDA) has a mandate to develop locally-based employment and economic opportunities for the benefit of the local population through grassroots initiatives. Western Economic Diversification (a federal program) serves a similar purpose, although over a larger jurisdiction. The programs these agencies offer can be better marketed to the businesses and people of the region to improve awareness of programs and monies for economic diversification. Quarterly information sessions (hosted throughout the communities of the region) and mailings are warranted to increase program awareness.

48. As the business taxes collected in the region are relatively small, the SAC recommends to the Government of Saskatchewan, through Saskatchewan Finance, that business tax relief be granted for 3 years to those businesses that are provided provincial or federal support

through labour and employment programs and provide new employment opportunities.

We anticipate the revenue impact to be minimal while population retention may be improved, and diversification of the local economy enhanced.

49. In order to spur economic diversification and the retention of young people, the SAC recommends that the Government of Saskatchewan, through Saskatchewan Finance, create a progressive income tax structure for new employment.

For those Rural Municipalities that have indices of economic specialization above 50, for every new job created outside the sector of concentration, an income tax credit of 10% of gross earnings should be provided to each new employee for the first 5 years of employment.

*Earnings and New Construction*

50. The SAC recommends that the Government of Saskatchewan, through Saskatchewan Finance, establish a property tax break for 3 years for individuals who are new "non-traditional" sector employees, if during their 5 years of income tax credits for employment in the region (based on the above recommendation), they purchase a new home or a home 20% more expensive than their previous (owned) dwelling.

We anticipate that the tax revenue loss would be marginal through implementation of this recommendation, and the region will be perceived to be forward-thinking and tax-friendly, especially to new (young) employees.

*Economic Concentration and Capital Investment*

51. The SAC recommends that the Government of Saskatchewan, through RECD, Saskatchewan Finance, and in partnership with the GSH region banks and credit unions, establish business loans for those businesses outside the dominant economic sectors (agriculture and gas extraction) with below-prime interest rates for new operations/divisions/ventures that support value added services to the dominant sectors.

Because economic diversification comes at an investment price, it is incumbent upon initiatives and programs such as those noted by the agencies above to provide to grassroots efforts the funding needed to get such ventures launched. Funding will come from two sources—first from the agencies themselves and their internal funding mechanisms for directly related project/initiative ventures, and second from financial institutions such as local banks and credit unions for projects of a larger scope or scale than that of the agencies.

52. The SAC recommends that the Government of Saskatchewan, through Saskatchewan Finance, establish for new businesses in the GSH region the elimination of corporate taxes for the first 10 years of operations, followed by a reduced corporate tax rate (for example, from 35% to 30%).

The reduction of tax rates should provide incentives to locate businesses not in the major population centres, but in smaller communities. With lower loan interest rates, location incentives, income tax breaks for new employees, and property tax abatements (the suite of economic recommendations above) all attracting (or retaining) a local rural population, the viability of new rurally based businesses may be enhanced.

*Manufacturing*

53. The SAC recommends to the Government of Saskatchewan, through RECD and in conjunction with information sessions from economic development agencies such as WED and the REDA, that educational workshops be provided to help small manufacturers develop business plans and marketing strategies.

To further support manufacturing in the region, small locally based manufacturing should be encouraged. Small businesses, however, are limited in their potential due to economies of scale. The educational workshops, business plans, and marketing strategies should be specifically oriented to increasing capacity to tackle larger contracts in the gas sector of the broader region, in order to stabilize their current operations and create longer-term growth and diversification for the region.

54. To further facilitate the creation of economies of scale, the SAC recommends to the Government of Saskatchewan, in partnership with the GSH Planning District Commission, the creation of a Great Sand Hills Manufacturers Alliance (GSHMA).

The GSHMA would serve as an intermediary between local firms and the gas sector, or other large potential contract providers. This alliance of business interests in the region would have the mandate to seek larger contracts for not one, but a host of smaller locally based firms. Collectively, the smaller firms may share resources, skills transfer, and bring a larger body of personnel to projects that normally would be beyond the capabilities of any one firm. Start-up funding for the GSHMA may be sourced from either REDA or the Canadian Manufacturers Association.

*Ranching*

55. The SAC recommends that Saskatchewan Environment in consultation with other provincial government departments, RMs, and local lessees, implement improved education in best management practices for the ranching industry.

To ensure the maintenance of the ecological integrity of the GSH that supports the dominant economic sector of the region, this recommendation is in concordance with the recommendations of the SAC on the eventual development of a Regional Sustainability Plan for the Review Area. In conversations and interviews, ranchers indicated they would welcome more education, and specifically implementation strategy sessions, on how best to manage their lands. Regularly scheduled workshops held throughout the region on best management practices—and their functional implementation—are welcomed by the ranching community.

56. Building on the rationale(s) provided in the suite of recommendations under the heading of Environmental Monitoring, the SAC recommends (from an economic perspective) that dedicated environmental monitoring officers be hired for the region with a special focus on members of the ranching communities.

Working in consultation with Saskatchewan Environment, Saskatchewan Agriculture and Food, the Saskatchewan Watershed Authority, and other associated governmental departments, and reporting to the GSH Planning District Commission, these monitoring officers would conduct various environmental surveys (water quality, invasive plants, soils, etc.), monitor the application and use of best practices in the region, and conduct educational workshops. Funding for these positions should be ear-marked out of current collections from the region, for example 1% of all ranching income taxes collected from the Study Area and 5% of all provincial revenues (royalties, taxes, and lease payments) for Crown Lands in the Study Area would provide base funding for monitoring positions.

57. The SAC recommends to the Government of Saskatchewan, through the Saskatchewan Watershed Authority: (a) that a one-time baseline assessment of water *quantity* be established as soon as possible (before the end of 2008 is recommended given other pressures on water resources such as gas extraction and possible climate variability); (b) that a one-time baseline assessment of water *quality* be established as soon as possible (preferably before the end of 2007); and (c) that ongoing water quality and quantity comparisons throughout the region be conducted by the environmental monitors as part of the Environmental Monitoring and Land Management suite of recommendations.

A recurring theme from various stakeholders within the GSH region is water resources. Ranchers, business owners, ENGOs, and local residents alike made reference to water resources in various forums. The ability of the local population to access clean and consistently high quality water in order to maintain their current lifestyle and quality of life was noted. This three-part recommendation is based on the need for not only a clean water supply to support business and economic development, but also on the need for an assessment of water supply (quantity) in order to develop a sustainable regional resource-use strategy in support of economic development and specific uses of the common resource. The shorter timeline for the second part of the recommendation is based on the fact that water can be more readily sampled and tested than can subsurface water quantities be determined.

58. The SAC recommends to the Government of Saskatchewan, through the Saskatchewan Watershed Authority, that for any gas exploration and development within the Study Area, a water quantity and quality assessment and statement be created prior to any on-site activity.

This recommendation is offered in conjunction with the previous recommendation in order to sustain the dominant local economic activity without compromising both its future economic potential and the quality of life for local residents based on the introduction of new industrial activity. All water resources (surface and groundwater) are to undergo quality analysis to ensure that gas development in the region does not negatively impact other economic sectors or the community's water supply. The analyses are to be conducted prior to development and at regular intervals during drilling to ensure the well does not seep gas into the surrounding strata and water.

*Tourism and Eco-tourism*

59. The SAC recommends to the Government of Saskatchewan, through Saskatchewan Tourism, Saskatchewan Transportation, the Southwest Saskatchewan Tourism Association, the local communities, and the GSHPDC, the creation of a coordinated and integrated regional tourism plan built upon the foundations of ecologically sensitive tourism and recognition of the economic, social, and historical forces that shape the region, past and present.

The history of the Great Sand Hills region, its communities, the settlement patterns, and the geographic and biologic significance of the region are an attraction to tourists. The creation of a historical route, complete with cairns, roadside pullouts, and stops at the various museums, all along the current highway routes (#21 and #32) with a stop at the dunes (akin to the Saskatchewan Geo-Log Route around the Finger Lakes and Fort Qu'Appelle) is appropriate for the region. The route and its stops can detail the history of the First Nations People, agriculture, ranching, the changing landscape, and birds and plants, to name a few. The tour, as it winds through the communities, may serve to accrue retail economic benefits due to increased local tourism. Whereas increased local tourism may be beneficial to the local economies of the GSH region, controlled access to the dunes and the region in general is required given the rare and unique nature of this ecological area. In that context, we strongly encourage attention to the appropriate use of boardwalks as an available tool. Furthermore, any literature promoting the region as a tourist destination should have explicit statements about where people can and cannot tread. An information board or shelter at the dune turn-about on the Straw Road would serve this purpose for minimal cost. In order to attract tourists to the region, well-marked signs leading them to the attractions of the region are required not only along the regional highways (#21 and #32), but also along the TransCanada highway in order to draw potential tourists. In support of increased tourism, some infrastructure exists in current museums, but staffed kiosks should be added to the entry points of the tour route to provide information about the tour, specifically at the eastern and western entry points near the provincial highway intersections with the Trans Canada highway.

*Gas Development*

60. The SAC recommends that the Government of Saskatchewan, through RECD: (a) develop and implement a "hire local, buy local" policy for gas firms operating in Saskatchewan; and (b) develop a local industry capability assessment framework (similar to the assessment from HRSDC for skilled foreign workers).

A recurrent theme among local businesses and the residents of the GHS region is the importance of a diversified economic base that includes gas development among the mix of activities that will support their futures. In order for that future to have a sustainable economic horizon for the people and communities of the GSH region, the economic activity also must be retained within the local economy. The proposed local industry capability assessment is intended as an assessment of local business capacity and capabilities and would be applied whenever an out-of-province firm wishes to source goods and services from out-of-province or beyond the local region. The intention is to identify local firms that may bid on contracts prior to those contracts being sourced extra-regionally. The GHSPDC and the newly proposed GSHMA would serve as intermediaries facilitating dialogue between the gas industry and local manufacturers.

61. The SAC recommends that the Government of Saskatchewan, through Saskatchewan Environment and under the auspices and direct assessment of the environmental monitors proposed herein, require that "environmental performance bonds" be posted by all gas companies operating in the GSH Study Area.

In the event of a leak, seep, blow-out, water contamination, or other form of environmental disturbance beyond established provincial and industry guidelines and regulations (as determined by the environmental monitors), the bond is cashed to pay for immediate remediation efforts. The bond should be set at a significantly high value such that it is an incentive to meet industry and government environmental expectations. If there are environmental problems such as, but not limited to, the incidents listed above, the value of the bond is intended to cover the costs of remediation. The bonds may also serve to provide income loss payments to lessees when remediation takes productive land/water out of operational use.

62. The SAC recommends to the Government of Saskatchewan that, through Saskatchewan Industry and Resources, a comprehensive assessment of current and projected gas reserves and their economic valuations be conducted every 3–4 years.

As noted in the introductory remarks for this section, the gas reserves and their economic value can be better understood given the dynamic conditions of that economic sector. This recommendation is offered to more fully appreciate the long-term economic implications for the GSH Study Area, the local population, and the provincial government, given a continually shifting economic and technologic landscape. This reassessment of the economic impacts is required in light of ongoing changes to the gas industry and to the Government's economic relationship to that industry. We note that in July 2008, as proposed in the recent 2007 provincial budget, the Corporate Capital Tax and Corporate Capital Tax Resource Surcharge have been proposed for elimination. As these parameters change, so too will the impact of the industry on government revenues, the industry's perception of the business climate in the region, and its ongoing operating costs and associated profits. As these latter points have the potential to manifest in increased/accelerated activity in the Review Area, there are numerous potential impacts on the local economy. Ongoing economic reassessment and valuation is therefore an important component in our understanding of the sustainability of the GSH.

## Concluding Comments

The Great Sand Hills Scientific Advisory Committee has given careful consideration to issues of ecological integrity of the Great Sand Hills and to the situation faced by local communities. The recommendations of the SAC are designed to contribute towards a sustainable future for the GSH and its communities using a balanced approach founded on principles of sustainable development. Our recommendations are based upon our scientific studies of the past two years and our assessment of past studies and plans for the GSH, and are a direct outcome of our preferred sustainability scenario. The SAC is strongly of the view that our recommendations should be considered in their entirety as an integrated package serving the needs of regional communities and the people of Saskatchewan.

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