

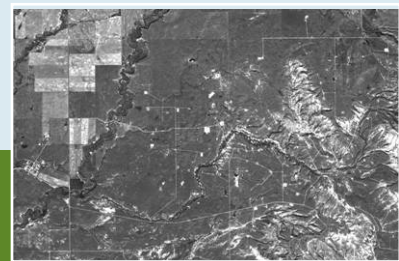
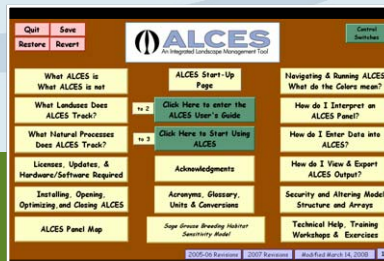
# ALCES®-based Habitat Simulation Modeling for Greater Sage-Grouse in Southeastern Alberta

March 2008

Prepared by Greg Chernoff, Brad Stelfox, and Guy Greenaway



MIISTAKIS  
INSTITUTE



Prepared for the Greater Sage-Grouse Recovery Action Group

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FINAL REPORT

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The on-going research behind this report was supported at different phases by:



Alberta  
Sustainable  
Resource  
Development  
(Fish and Wildlife)

Alberta  
Sustainable  
Resource  
Development  
(Lands)

Alberta  
Energy



A Suncor Energy  
Company

Petro-Canada  
Sustainable Grasslands  
Program

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## I. INTRODUCTION

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In support of the Sage Grouse Recovery Action Group's efforts to identify and quantify the potentially adverse effects of anthropogenic land use on sage grouse habitat, Alberta Sustainable Resource Development (Fish and Wildlife) retained the Miistakis Institute at the University of Calgary and Brad Stelfox of Forem Technologies Ltd. to develop, populate, and parameterize a cumulative effects simulation model for a 7X7 township region in southeastern Alberta. This model was subsequently used to conduct landscape-scale simulation modeling over a 50-year time period. The goal of the modeling is to generate plausible future scenarios based on current knowledge of landscape, ecology, and human use which explore potential trajectories for sage grouse viability, and to identify the drivers of change in a virtual environment.

The modeling presented in this report is based upon the ALCES® software (Forem Technologies Ltd.). ALCES® is a landscape simulator that enables resource managers, society, and the scientific community to explore and quantify dynamic landscapes subjected to single or multiple human land use practices and various natural disturbance regimes. The model was identified in the Alberta Greater Sage-grouse Recovery Plan (2005) as a decision support tool allowing the Recovery Action Group to determine priority areas for focusing recovery efforts.

Land use information (inputs) for the model were derived from existing data collected for the Southern Alberta Landscapes (SAL - formerly Southern Alberta Sustainability Strategy (SASS)) Project's ALCES®-based cumulative effects modeling, and modified into a format appropriate for sage grouse modeling. ASRD Fish and Wildlife convened a workshop to collect the data required for the wildlife module of the model (i.e., sage grouse data). The Alberta Conservation Association (ACA)-supported workshop brought together sage grouse experts from Canada and the United States.

Currently there is no comprehensive model to support decisions with respect to land use in the sage-grouse range of the province. Creation of such a model will greatly assist with integrating decisions for activities such as oil and gas development with sage-grouse conservation activities. This modeling approach may represent a prototypical method for recovery planning. By incorporating wildlife data, land use parameters, and management goals into a participatory process, alternate land use and management scenarios can be explicitly compared with reference to their impact on a target species.

Along with the generation of a realistic base-case scenario for current landscape composition and future planned land use, this research has examined the impacts of changing future land use trajectories related to the energy sector as an example of the type of sensitivity analysis that is possible in the ALCES® modeling environment, and of the capacity of this type of analysis to provide valuable information about the impact of different types of land use on sage grouse breeding occurrence and success.

## II. BACKGROUND

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### *Excerpted from the Alberta Greater Sage Grouse Recovery Action Plan, Executive Summary*

Greater sage-grouse (*Centrocercus urophasianus*), the largest grouse in North America, is a year-round resident of the sagebrush range of the semi-arid mixed-grass prairie regions of southeastern Alberta, southwestern Saskatchewan, and parts of eleven western states in the United States. Currently in Alberta, sage-grouse are located in the extreme southeastern corner of the province, centered south and east of the town of Manyberries. This 4000 km<sup>2</sup> area contains extensive native prairie and sagebrush flats which form unique habitat for sage-grouse. Canadian sage-grouse are entirely dependent on silver sage as a source of food and shelter. Sagegrouse have experienced decline in all parts of their range, and in Canada have been considered *Endangered* since 1998. The Minister of Sustainable Resource Development approved sagegrouse for listing as *Endangered* in Alberta in 2000. The Canadian Sage Grouse Recovery Team was formed in 1997 to address the population decline and recommend strategies for recovery in the *Canadian Sage Grouse Recovery Strategy*. In late 2002, the Minister of Sustainable Resource Development formally delegated the responsibility of drafting a provincial recovery plan to the Sage Grouse Recovery Action Group. This recovery plan serves as a follow up to the Canadian Strategy, with the purpose of recommending actions in the spirit of enabling sage-grouse recovery in a manner that respects livelihoods and current land uses within sage-grouse range.

The source of the species decline is poorly understood. However, many potential threats have been identified, including cropland conversion south of the Alberta border that effectively isolates the Alberta population. Water impediments may affect the health of the silver sagebrush communities required for sage-grouse survival. Increasing industrial activity is known to cause disturbance to the birds and contributes to fragmentation of habitat. Light to moderate grazing regimes currently in place favour sage-grouse, but recurring drought and climate change may have an impact. Predation and human disturbance from recreational activity also play a role.

The Sage Grouse Recovery Action Group believes sage-grouse can recover based on the following:

- There is remaining habitat to support sage-grouse.
- There is adequate technical information to define management actions that will benefit recovery.
- There is interest in the local community to participate in sage-grouse recovery efforts.

To facilitate a broader understanding of the natural and anthropogenic threats facing sage grouse and to assist in the definition of appropriate recovery management actions, the Recovery Action Group engaged Miistakis to assist in the development and application of an ALCES®-based model for a 7X7-township region in the southeastern corner Alberta, as indicated in figure 1.

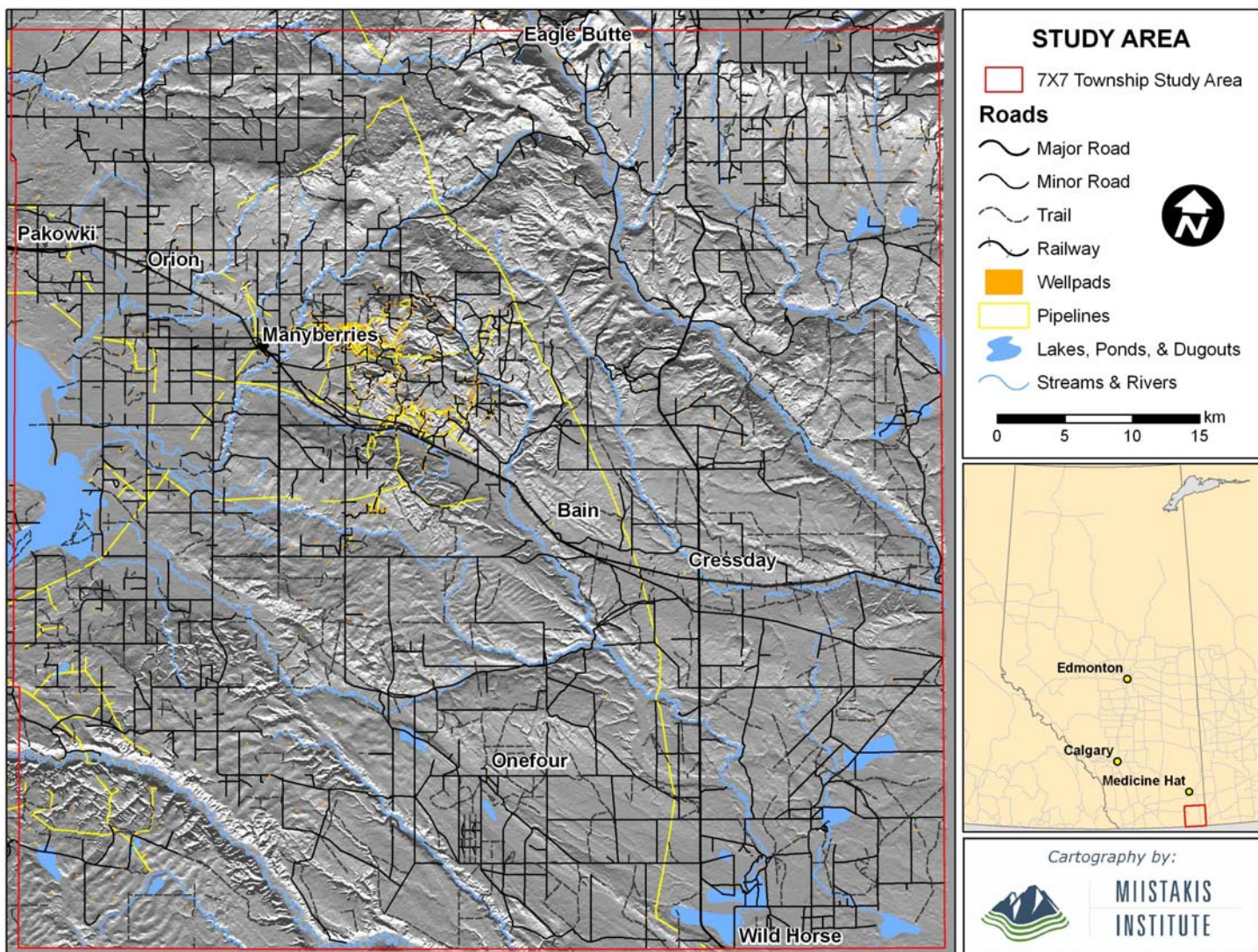


Figure 1 – Map of ALCES® sage grouse model study area.

### III. METHODS:

#### Describing Landscape and Land Use

The first step in the modeling process is to populate the model, with the four principle types of information that ALCES® requires in order to simulate cumulative effects of future land use:

1. A description of the “initial landscape” – that is, the ecological composition of the “naked” landscape, devoid of anthropogenic footprint. ALCES® requires the user to divide the landscape into 20 distinct landscape types, and fully account for the study area using these landscape types.
2. Anthropogenic “footprint types”. The user can define as many as 15 types of human use occurring, having occurred, or expected to occur on the landscape. Overall quantity (measured in area) of footprint

is required, as is the proportion of footprint that occurs within each of the 20 landscape types listed above.

3. Information is gathered from industry and other experts, past activity, or general industry trends, to inform ALCES® on the anticipated future trajectories for different types of development and land use, including associated footprint types, development life spans, and reclamation rates.
4. Finally, ALCES® requires information related to the ecological response of wildlife (in this case, sage grouse) to the different habitats and anthropogenic activity represented in the landscape.

## Land Cover Types

A 7X7 township rectangle in the southeastern corner of Alberta, comprising the entire Alberta range for greater sage grouse, was divided into 18 distinct land cover types (2 of the 20 available land cover types were not used). In most cases, the GIS data created for the application of ALCES® to the Southern Alberta Landscape (SAL – formerly SASS) Provincial Government initiative was queried to populate the model. In some instances, some modification of the SAL “canisters” was necessary.

The slender wheatgrass plant community needed to be divided into 5 distinct sub-communities, each with a corresponding specific habitat response for sage grouse. In this case, the SAL landcover type representing slender wheatgrass (JUNEGR) was numerically split according to the proportion of each type of sub-community to total area of slender wheatgrass recorded in the southeastern Alberta silver sagebrush inventory developed by Jones et al. in 2005. The ALCES field in the SAL dataset was used to differentiate between the three different types of water bodies.

The following table identifies the 18 land cover types, and provides a brief description of how the area for each was calculated.

LT NUMBER	LT NAME	SOURCE
1	treed riparian	sum of all area values related either to “RIPW” or “TREE” land cover types in subset of SAL dataset
2	badlands	sum of all area values related to “BADLND” land cover types in subset of SAL dataset
3	slender wheatgrass saline lowlands	0.95% of all area values related to “JUNEGR” land cover types in subset of SAL dataset
4	slender wheatgrass overflow saline	1.08% of all area values related to “JUNEGR” land cover types in subset of SAL dataset
5	slender wheatgrass blowout	32.35% of all area values related to “JUNEGR” land cover types in subset of SAL dataset
6	slender wheatgrass loamy blowout	45.01% of all area values related to “JUNEGR” land cover types in subset of SAL dataset
7	slender wheatgrass overflow non-saline	20.60% of all area values related to “JUNEGR” land cover types in subset of SAL dataset

8	needle-and-thread, sandgrass	sum of all area values related to "SANDGR" land cover types in subset of SAL dataset
9	mixed grassland	sum of all area values related to "MIXEDGR" land cover types in subset of SAL dataset
10	grass shrubland	sum of all area values related to "SHRUB" land cover types in subset of SAL dataset
13	loticular features	29.04% of all area values related to "WATER" land cover types in subset of SAL dataset
14	lenticular features	50.70% of all area values related to "WATER" land cover types in subset of SAL dataset
15	cereal crops	sum of all area values related to "CERCR" land cover types in subset of SAL dataset
16	oilseed crops	sum of all area values related to "OILCR" land cover types in subset of SAL dataset
17	needle-and-thread, blue gramma grass	sum of all area values related to "BLUEGR" land cover types in subset of SAL dataset
18	forage crops	sum of all area values related to "FORCR" land cover types in subset of SAL dataset
19	reservoir	20.26% of all area values related to "WATER" land cover types in subset of SAL dataset
20	tame grass	sum of all area values related to "PASCR" land cover types in subset of SAL dataset

*Table 1 – Land cover types used in ALCES® model for sage grouse.*

## Footprint Types

The most recent version of the SAL dataset (described above) was used for the assessment and quantification of 9 different types of anthropogenic footprint. In every case, the area was derived by direct query of the FTPRINT\_ALC field in the SAL dataset.

FT NUMBER	FT NAME	SOURCE
1	major roads	area sum of all polygons for which FTPRINT_ALC = "Major Road" in subset of SAL dataset
2	minor roads	area sum of all polygons for which FTPRINT_ALC = "Minor Road" in subset of SAL dataset
3	rails	area sum of all polygons for which FTPRINT_ALC = "Rail" in subset of SAL dataset



5	two-track trails	area sum of all polygons for which FTPRNT_ALC = "Trail" in subset of SAL dataset
10	towns and cities	area sum of all polygons for which FTPRNT_ALC = "Urban" in subset of SAL dataset
12	gas plants	area sum of all polygons for which FTPRNT_ALC = "Gasplant" in subset of SAL dataset
13	well site	area sum of all polygons for which FTPRNT_ALC = "Wellpad" in subset of SAL dataset
14	pipeline	area sum of all polygons for which FTPRNT_ALC = "Pipeline" in subset of SAL dataset
15	irrigation canal	area sum of all polygons for which FTPRNT_ALC = "Canal" in subset of SAL dataset

*Table 2 – Anthropogenic footprint types used in ALCES® model for sage grouse*

The proportion of footprint type that occurs within each respective landcover type is an important metric in ALCES® algorithms for calculating the cumulative effects of both present and future land use. These proportions were measured by taking GIS polygon files representative of each type of footprint, superimposing them on a GIS layer representing a hypothetical landscape devoid of human influence, and using zonal statistics tools to determine on what landscapes footprints are occurring or are likely to occur.

## Land Use Trajectories

The ALCES® model developed for this research has borrowed heavily from the past work done by Alberta Environment and other provincial departments on the SAL project. One of the most complex and time-consuming endeavours in the initial parameterization of the model is that of identifying a "base case" in terms of potential future trajectories of different factors related to land use and development. The growth or decay curves for virtually all aspects of human use can be modified in successive model runs, but the base case provides a starting point from which to begin these modifications.

Normally, the process of building base case trajectories involves extensive consultation with local and industry experts, and analysis of historical data and industry-wide or local projections on future development outlook. This process can consume a significant amount of resources, and regardless of the diligence of the researcher and the honest and conscientious work of the experts whose knowledge is sought, is guaranteed by the nature of ecology and economics not to present a 100% predictive trajectory.

Due to the finite resources available for this project, the ability to capitalize on work already done in the region, and the applicability of most trajectory data to a subset of the original SAL study area, it was decided that the majority of the land use projections used in the SAL model could readily be applied to the sage grouse study area. For more information on the SAL project, please consult the Alberta Environment website. (<http://environment.gov.ab.ca/info/posting.asp?assetid=7771&categoryid=4>)

The only industry from which new future land use trajectory information was gathered is the oil and gas sector. The reason is mainly that this sector is more regionally sensitive than others. Therefore, it does not accommodate the "scaling down" of SAL projections to the 7X7 township sage grouse study area to the same extent as, for example, agriculture.

Alberta Energy was solicited to empirically derive 50-year forecasts specific to the region and related to the anticipated changes in conventional and non-conventional development. An overview of these projections is presented as the base case, in the following section. For more information on the development of an appropriate base case model for the oil and gas sector, please consult Bob Nichol or Brad Lloyd at Alberta Energy.

## Sage Grouse Ecology and Habitat

Sage grouse ecology is represented in the ALCES® model by two principle factors: Habitat Suitability Index and species-specific land use buffers. Information for both factors was collected through a consensus-based process at a sage grouse experts' workshop convened in March 2006 in Medicine Hat, Alberta. The workshop resulted in the derivation of habitat coefficients for both breeding occurrence and breeding survival; this research analyses only sage grouse breeding occurrence. A summary of the workshop results is included in the Appendix.

A Habitat Suitability Index (HSI) is a knowledge-based habitat model in which a unique suitability value between 0 (poorest quality habitat) and 1 (best quality habitat) is assigned to each land cover and footprint type in the model. Total HSI – that is, the cumulative habitat suitability value over the entire study area – is the principle metric employed in this research to assess the current and modeled future viability of Alberta's sage grouse population.

One critical discussion at that workshop focused on the relationship between habitat effectiveness and population density, as the proposed modeling approach would be looking at the impacts of various land use metrics on habitat quality. The expert group agreed that a certain habitat effectiveness would equate to a given density, and therefore modeling impacts on habitat provided an appropriate method of investigation.

It was also agreed that habitat suitability would vary depending on season (breeding, summer and winter), as well as the habitat needs for occurrence versus some measure of sage grouse fitness. For that reason, the expert group agreed that six different models would be parameterized separately, accounting for the different habitat needs for:

- Breeding Occurrence
- Breeding Survivorship
- Summer Occurrence
- Summer Survivorship
- Winter Occurrence
- Winter Survivorship

Though the expert group provided the above-described Habitat Suitability Index data for each sub-model, this report focuses only on the Breeding Occurrence sub-model, as this was considered to be representative (and perhaps conservatively so) of the sub-models, but provides a clear picture of the model output.

In order to provide a basis of comparison for sensitivity analyses, a range of natural variability in sage grouse habitat quality was calculated. This was achieved by removing all human population and resulting anthropogenic influence from the modeled landscape, thereby creating a hypothetical "human-less" environment. The model was run allowing only natural processes to govern the change in HSI values for sage grouse. The following graph shows the results of nine ALCES® runs that were used to establish an acceptable range in natural variability for sage grouse HSI values – this range is represented by the transparent green box, displayed in all HSI graphs presented in this report.

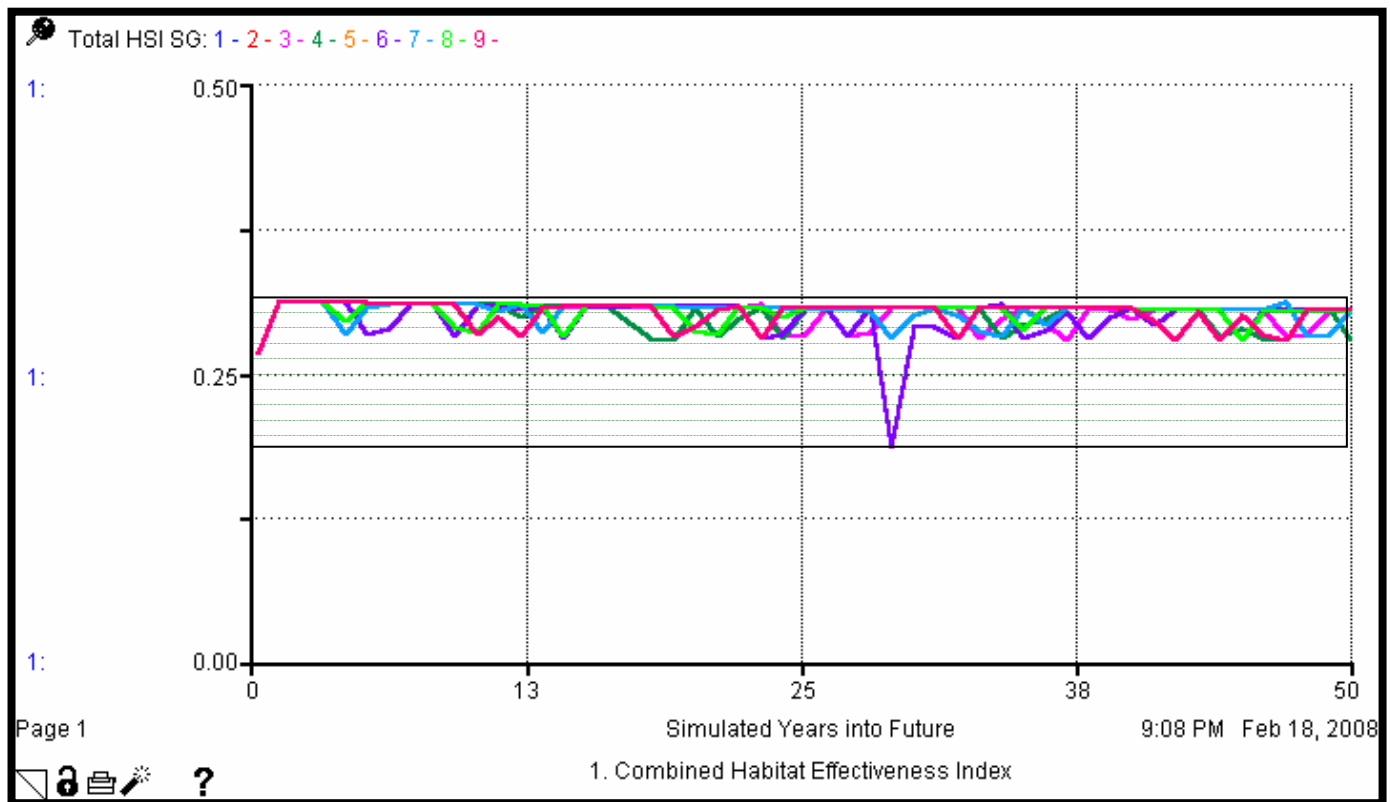


Figure 2 – Range of natural variability in sage grouse HSI Values, determined by 9 runs of ALCES® on a hypothetical human-less environment.

Buffers are areas around anthropogenic features (e.g. roads, pipelines, towns, etc.) over which those features exert a deterrent influence on sage grouse. At the Medicine Hat workshop, experts were asked to specify appropriate buffer distances for different anthropogenic footprints, and to specify use percentages (HSI modifiers) within these buffers.

## Running ALCES®

Once the initial landscape was described and the future land use and sage grouse ecology parameters were established, sensitivity analyses for sage grouse breeding occurrence were conducted in ALCES® to explore the relative effects of different levels of new well drillings, wellsite lifespan, and use of linear feature buffers by sage grouse.

The decision to focus on sensitivity to projected energy sector activity was based on several complementary factors:

- The energy sector is one of the main industries active in the southeastern corner of Alberta (the other main industry is agriculture), and its activities pose a significant threat to the continued survival of sage grouse. (Alberta Sage Grouse Recovery Action Group, 2005, p.7).
- The volatility of markets, the uncertainty around availability and marketability of petrochemical reserves, and the ever-changing nature of technology all lead to less certainty regarding oil and gas development than may perhaps be the case in other industry sectors.
- As mentioned above, the trajectories proposed by Alberta Energy are the only ones used in this model that were created specifically for this purpose. Other land use trajectories have been vetted through

the SAL process, and this sensitivity analysis presents an opportunity to examine the consequences to sage grouse associated with different hypothetical energy sector future development scenarios.

The 15 ALCES® model runs were designed to assess sensitivity of the model (and of sage grouse populations) to variability in three areas: rate of well drilling; lifespan of new and existing energy infrastructure; and percent use of energy sector buffers by sage grouse.

In the first two series of model runs, assessing sensitivity to well drilling rates and footprint lifespan, successive iterations examined the effects of taking 50%, 100% (base case), 200%, 300%, and 400%, respectively, of the values suggested by Alberta Energy. Sensitivity of sage grouse to energy sector buffer use was assessed by running the model with 80%, 72%, 64%, 56%, and 48% of energy sector buffers used by sage grouse.

Modeling and initial interpretation was performed by Brad Stelfox of Forem Technologies, developer of the ALCES® model.

## IV. RESULTS

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### General Comments

This section discusses the results of three separate sensitivity analyses designed to assess the response of sage grouse to alterations in different aspects related to energy sector activity within their range. The results of the sensitivity analyses are presented in detail below, but there are also some general comments that apply to all ALCES® outputs.

One key observation is that in all 15 ALCES® model runs, Potential habitat, defined as “the total direct area (in hectares) of habitat if a given species occupies all habitat types that have maximal value” (ALCES® 2007), changes very little over the 50 year time span of the model runs, regardless of the extent to which anthropogenic features occur on the landscape. The following two graphs (Figure 3 and 3a) illustrate this phenomenon. Figure 3 shows the change in potential sage grouse habitat over the 50 year time span relative to the entire study area. Figure 3a represents the same data in more detail, showing that there is in fact a change in total direct area between the five scenarios, but that it is very small relative to the total size of the study area.

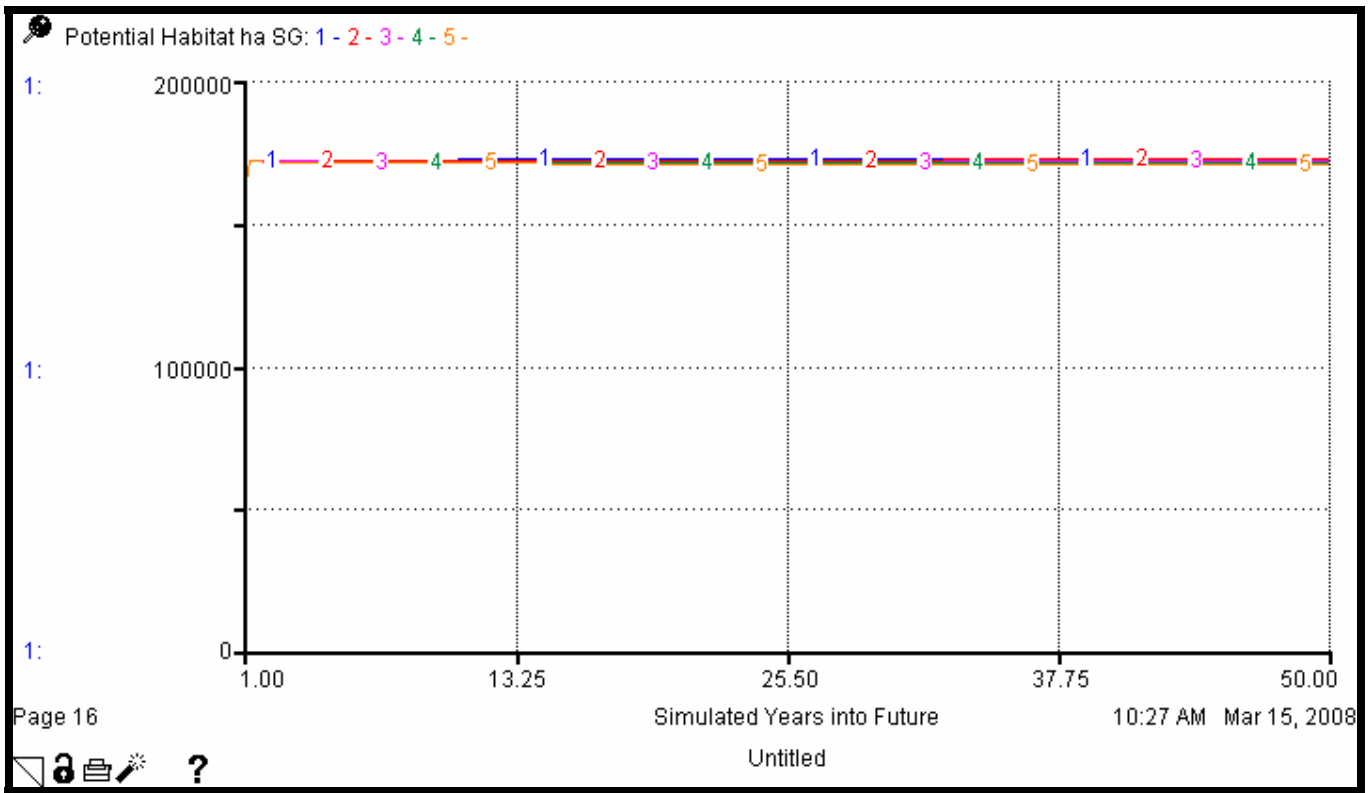


Figure 3 – Change in potential sage grouse habitat over 50-year time span.

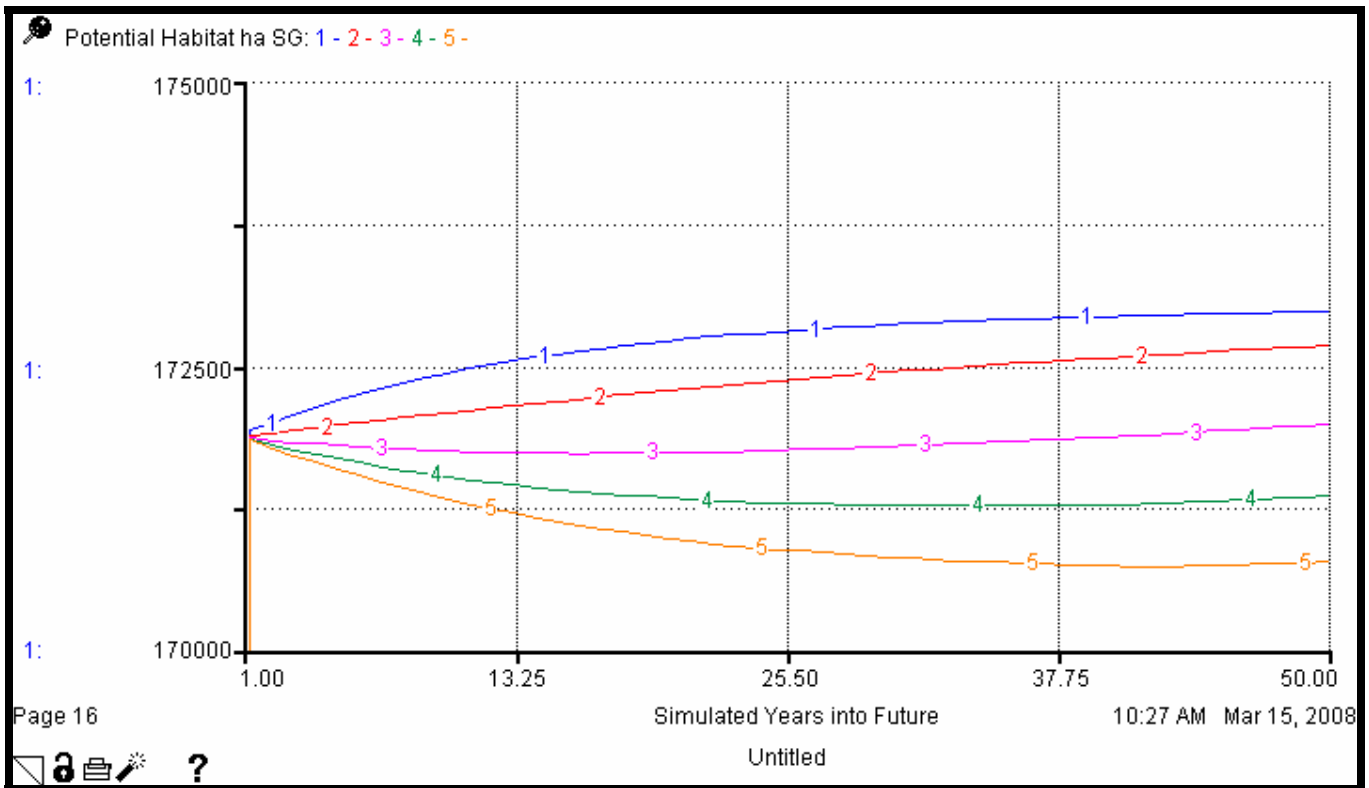


Figure 3a – Change in potential sage grouse habitat over 50-year time span (y-axis rescaled)

The lack of change in potential habitat is explained by the fact that most anthropogenic features are linear or otherwise very small in actual area (i.e., footprint). The ecological impact of development is only

appreciated in considering the buffered effects of its resulting anthropogenic footprint, which is not considered in the calculation of potential habitat (see discussions of effective habitat area sensitivity, below). So effectively, the amount of potential sage grouse habitat that is removed by even 4 times the projected level of oil and gas activity, for example, is negligible over a five-decade time span.

### Sensitivity to Changes in Drilling Rates

In order to assess the sensitivity of modeled sage grouse response to changes in the anticipated amount of new oil and gas activity in the region, five different scenarios were examined:

- **Scenario 1 (blue line on all graphs)** – 50% of new wells anticipated to be drilled, according to Alberta Energy.
- **Scenario 2 (red line on all graphs)** – “Base Case” – actual number of new wells anticipated to be drilled, according to Alberta Energy.
- **Scenario 3 (pink line on all graphs)** – 200% of new wells anticipated to be drilled, according to Alberta Energy.
- **Scenario 4 (green line on all graphs)** – 300% of new wells anticipated to be drilled, according to Alberta Energy.
- **Scenario 5 (orange line on all graphs)** – 400% of new wells anticipated to be drilled, according to Alberta Energy.

The following graph (Figure 4) shows the anticipated total annual number of new wells, based on the scenarios outlined above. The base case shows 14 new wells anticipated for year 1, reducing gradually to 4 new wells in year 50.

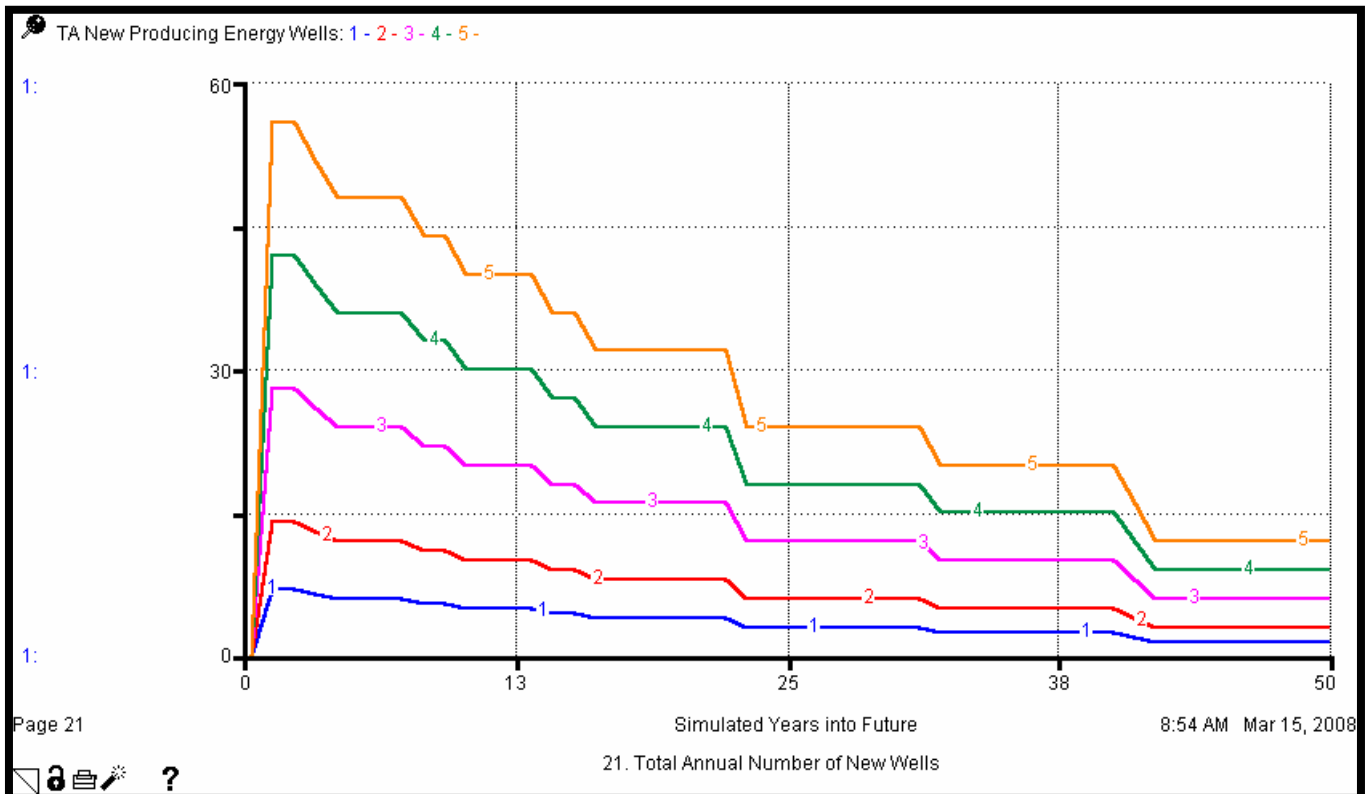


Figure 4 – Total annual new wells in southeastern Alberta, based on 50%, 100%, 200%, 300%, and 400% of anticipated future energy sector activity.

Figure 5 shows the cumulative change in active wells, anticipated in the base case to drop from current levels of just below 600 to approximately 225 in five decades. The “400%” scenario shows active well numbers rising over the next two decades and gradually returning to just below current levels by the end of the ALCES® time horizon.

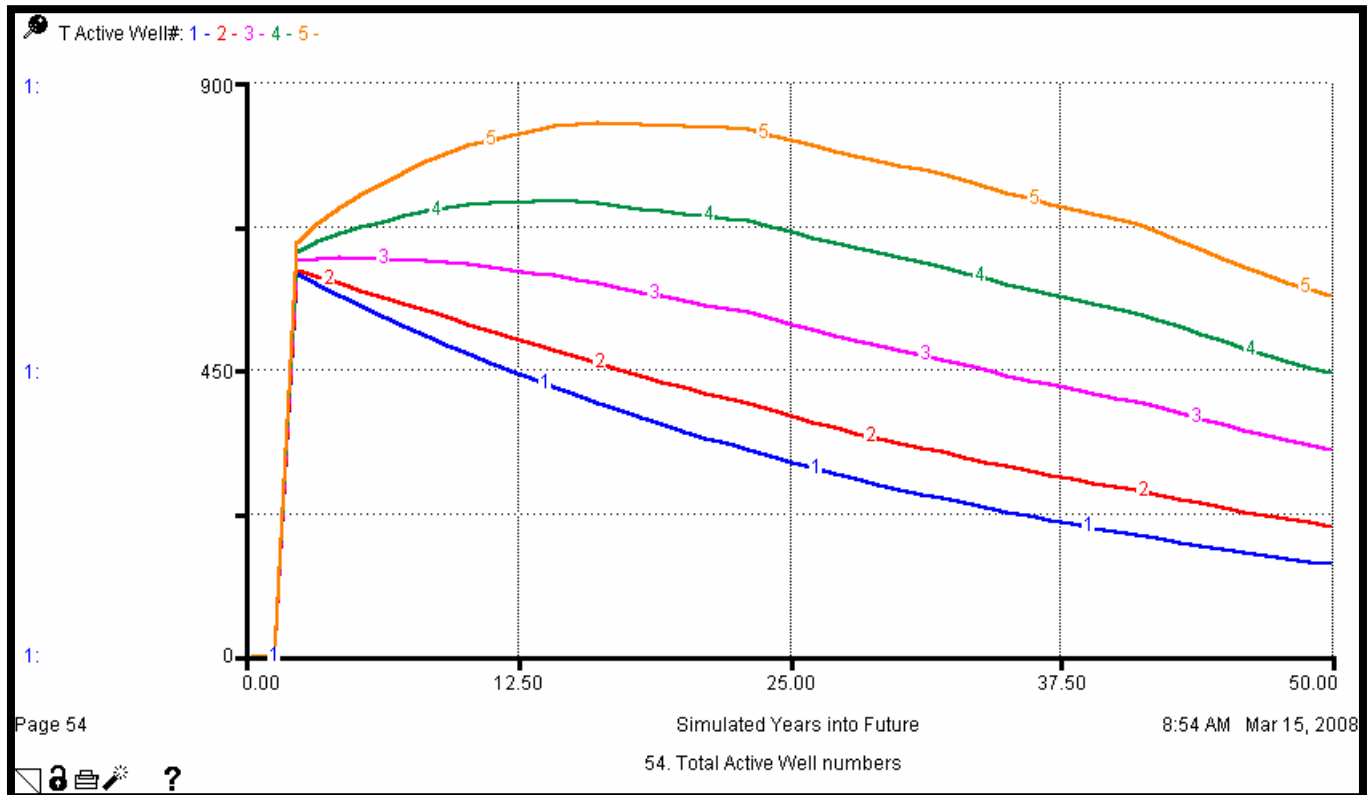


Figure 5 – Total active well numbers, based on 50%, 100%, 200%, 300%, and 400% of anticipated future energy sector activity.

As a result of progressively fewer new wells occurring on the landscape, predictably less area is anticipated to be covered by wellpad footprint. Figures 6 and 7 show the effects of varying well trajectories on annual and cumulative wellpad areas, respectively. Note that even the “400%” scenario indicates the gradual disappearance of the energy sector footprint from the southeastern Alberta landscape.

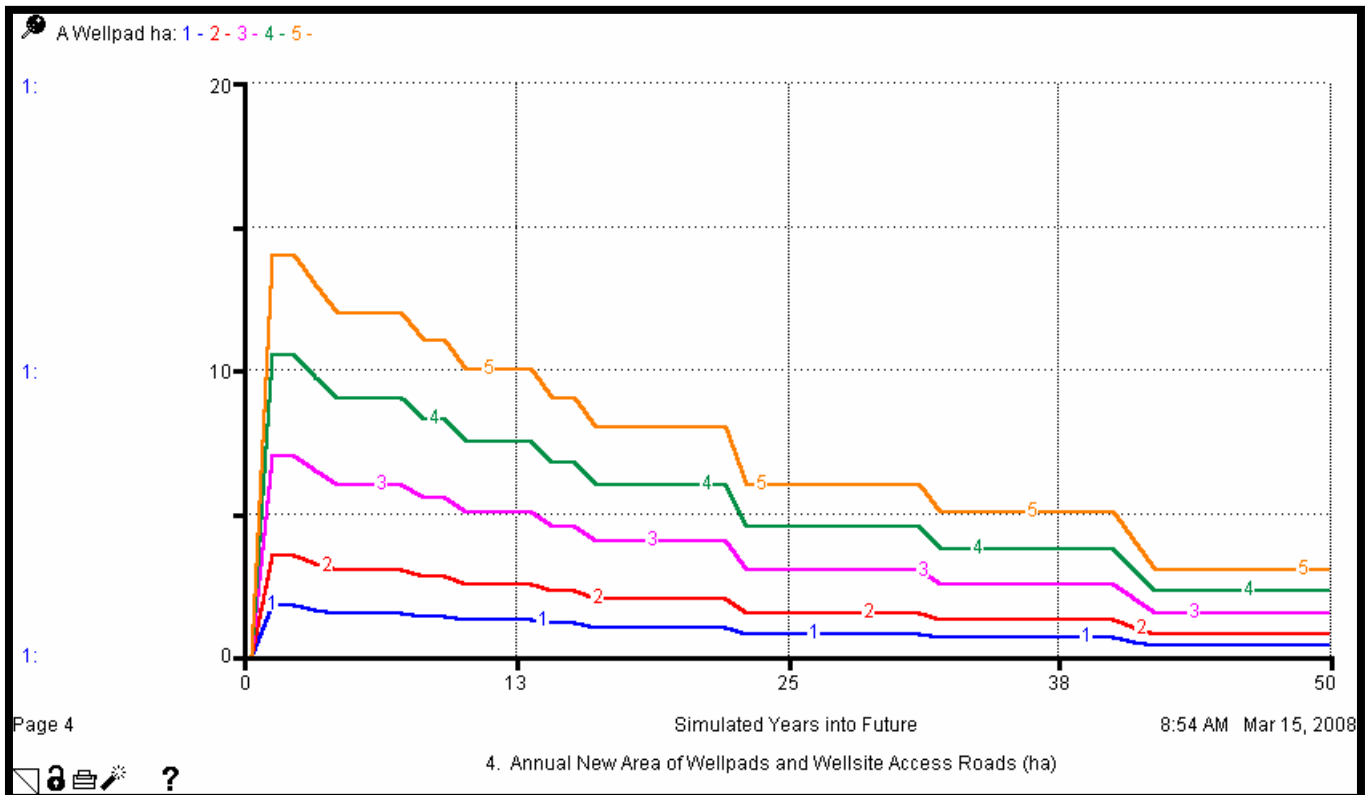


Figure 6 – Annual area (in hectares) of new wellpads over a 50-year time period, based on 50%, 100%, 200%, 300%, and 400% of anticipated future energy sector activity.

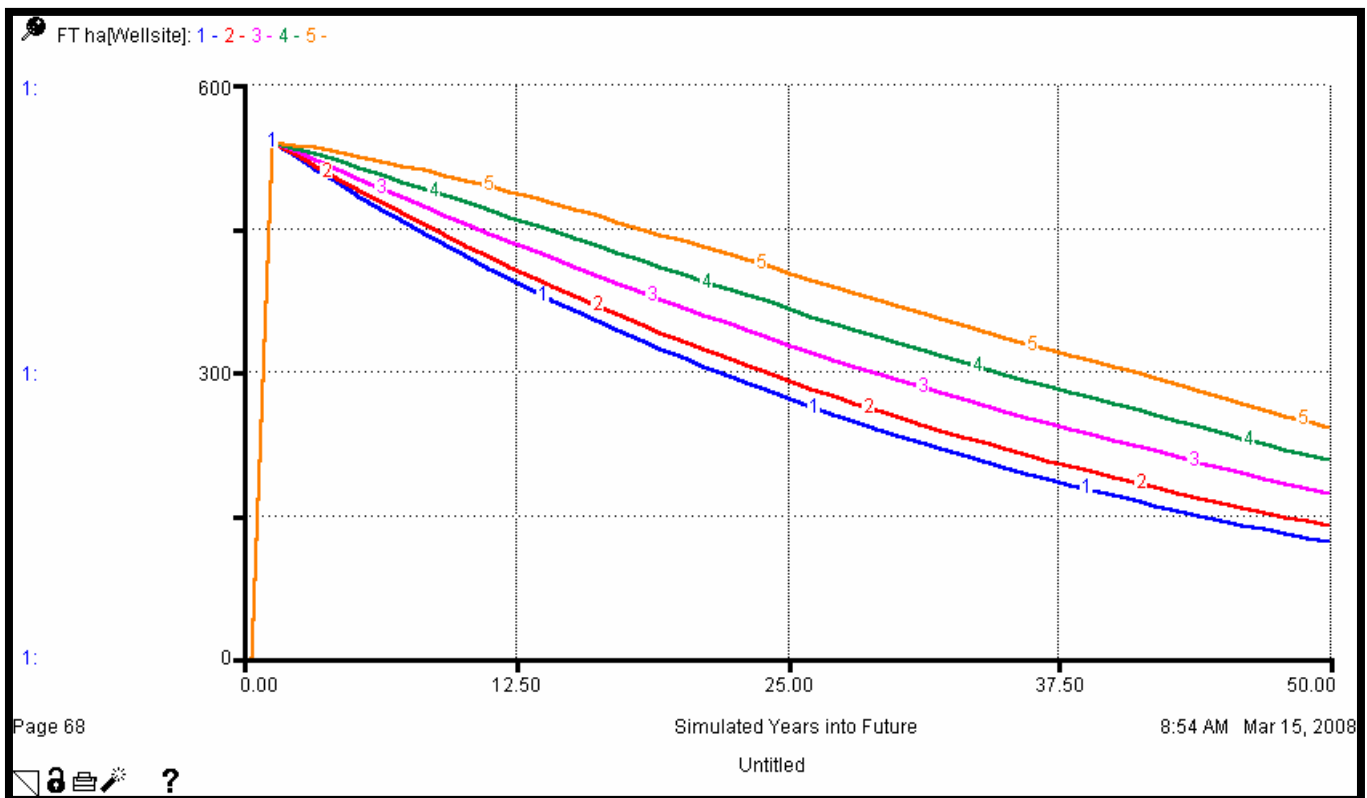


Figure 7 - Cumulative area (in hectares) of all wellpads over a 50-year time period, based on 50%, 100%, 200%, 300%, and 400% of anticipated future energy sector activity.



Anthropogenic edge has a significant bearing on the ecological viability of sage grouse (Aldridge 2005, p.190). As the model indicates a diminishing energy sector footprint on the landscape and a consequent reduction in the amount of anthropogenic edge, this would suggest an improvement over time in the quality of habitat available to sage grouse.

Figures 8 and 9 demonstrate the effects of removal of energy sector footprint from the landscape on some key metrics for sage grouse. Figure 8 shows the “Zone of Influence” for sage grouse under the 5 well-drilling trajectories; Zone of influence is the area under the anthropogenic footprint, buffered by the species-specific distances (in this case, determined by Delphi process at the March 2006 workshop in Medicine Hat) over which those land uses affect species behaviour. The base case suggests a gradual and decelerating decrease in total zone of influence over the next 50 years; if 4 times the anticipated rate of new well-drilling were to occur, the zone of influence would be expected to increase over the next decade and a half, followed by a gradual decrease over the remaining 35 years.

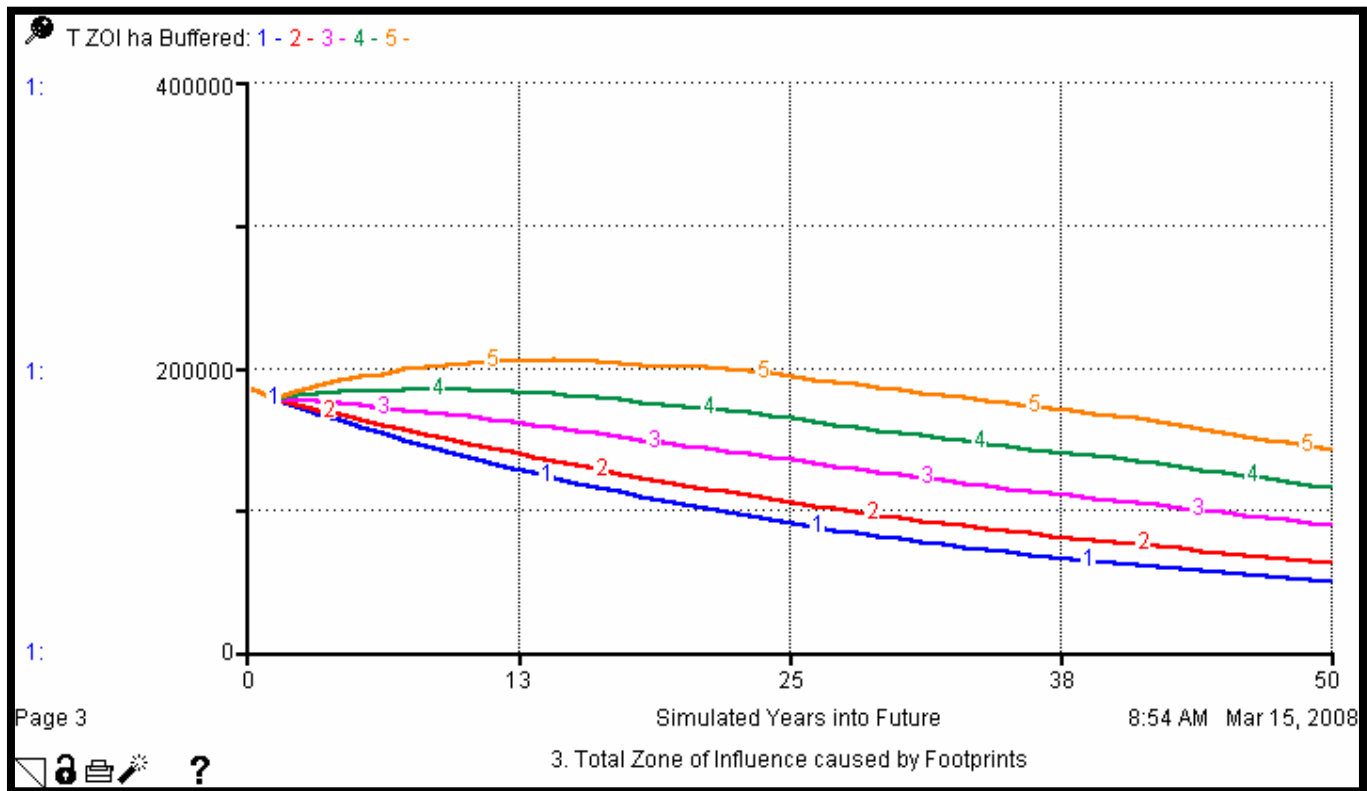


Figure 8 – Zone of influence for sage grouse, based on 50%, 100%, 200%, 300%, and 400% of anticipated future energy sector (well drilling) activity.

Figure 9 shows the “Effective Habitat Area” for sage grouse under the 5 well-drilling scenarios. Effective habitat area is inversely related to zone of influence, and is a measure of the discounted (HSI-weighted) area of habitat available to sage grouse, considering not only habitat quality, but discounted habitat use within anthropogenic footprint buffers. Higher effective habitat values indicate greater chance of survival for sage grouse. In scenarios 1-3 (50-200% of Alberta Energy projections), effective habitat area begins increasing immediately. In scenarios 4 and 5, Effective Area initially decreases, then increases after approximately a decade and 15 years, respectively.

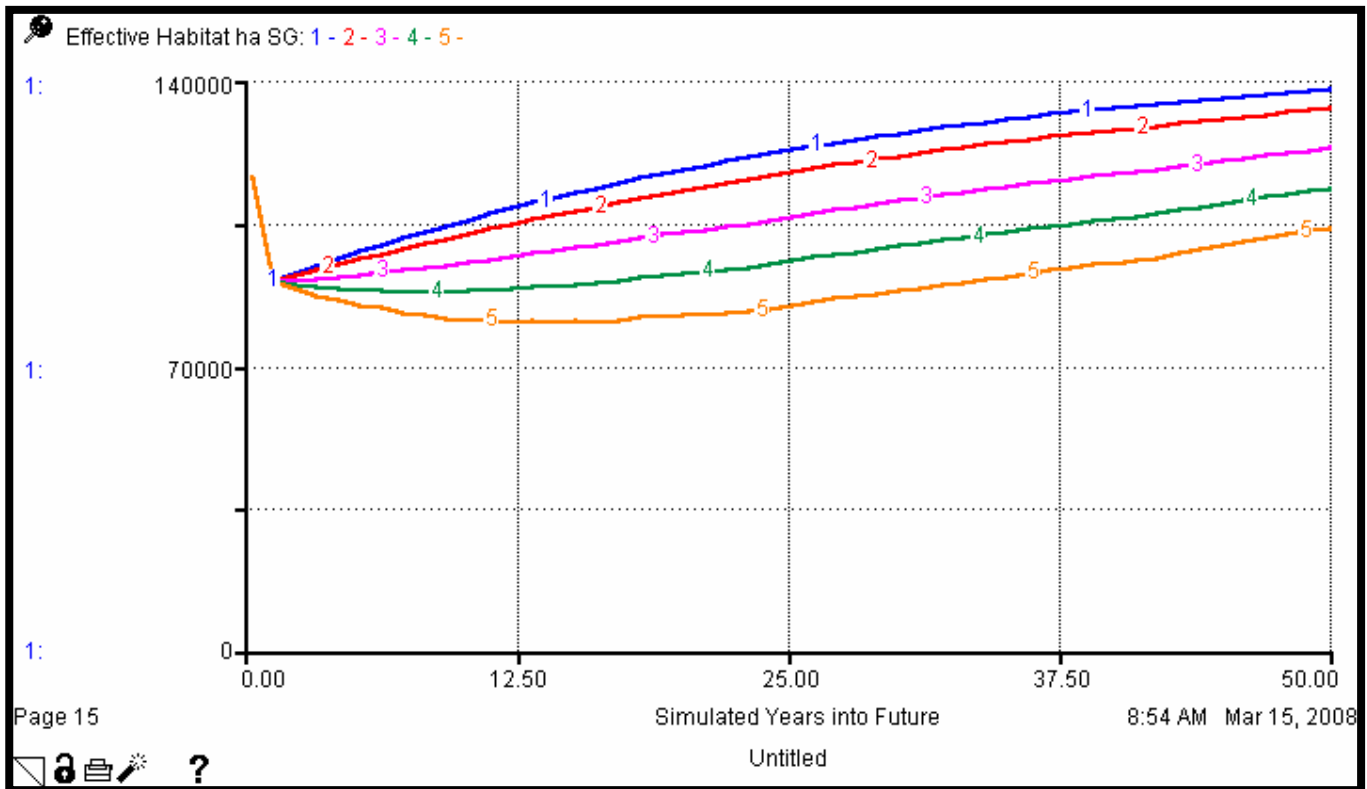


Figure 9 – Effective habitat area for sage grouse resulting from changes of 50%, 100%, 200%, 300%, and 400% in anticipated future energy sector (well drilling) activity.

The sensitivity of sage grouse breeding occurrence to changes in well drilling activity is best summarized by examining the total HSI values that result from the 5 different sensitivity scenarios, presented in figure 10.

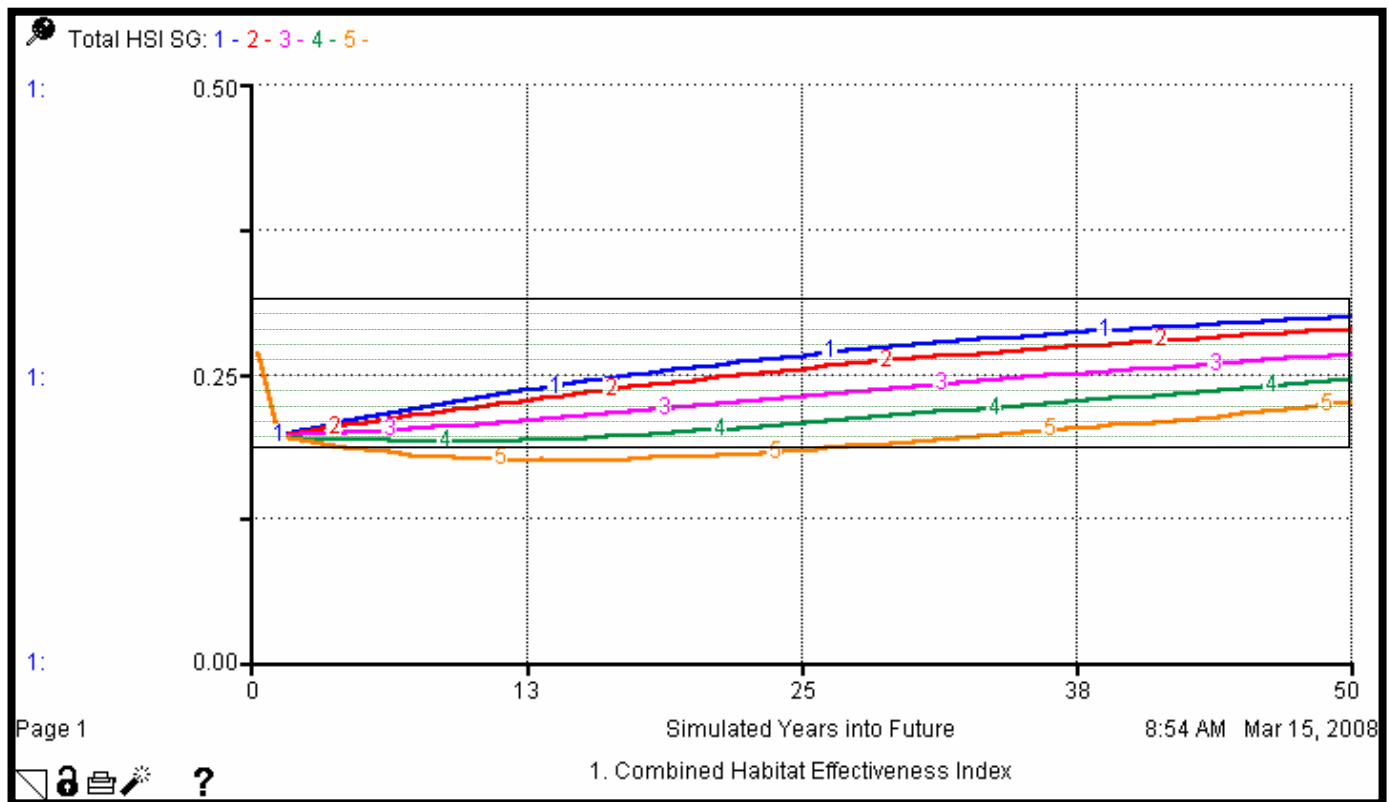


Figure 10 – HSI graph for sage grouse, based on 50%, 100%, 200%, 300%, and 400% of anticipated future energy sector (well-drilling) activity.

Changes in HSI values demonstrate that there is considerable sensitivity of sage grouse breeding occurrence to deviations from forecasted energy sector activity in southeastern Alberta. In all but the “400%” scenario, however, HSI values remain within the range of natural variability described in the previous section.

### Sensitivity to Changes in Lifespan of Energy Sector Footprint

The length of time over which anthropogenic footprints of different types persist on the landscape dictates to a significant extent the amount of footprint present at any given time, and hence the effect of that footprint on wildlife. Base case values for energy sector footprint lifespans were adopted from the SAL ALCES® model, and were used directly in the sage grouse modeling exercise. The initial model metrics tend to err on the side of aggressive reclamation rather than conservative. In order to assess the sensitivity of sage grouse to changes in footprint lifespan, however, five scenarios were examined and represented by independent ALCES® model runs:

- **Scenario 1 (blue line on all graphs)** – 50% of SAL ALCES® footprint lifespan.
- **Scenario 2 (red line on all graphs)** – “Base Case” – 100% of SAL ALCES® footprint lifespan.
- **Scenario 3 (pink line on all graphs)** – 200% of SAL ALCES® footprint lifespan.
- **Scenario 4 (green line on all graphs)** – 300% of SAL ALCES® footprint lifespan.
- **Scenario 5 (orange line on all graphs)** – 400% of SAL ALCES® footprint lifespan.

Regarding the sensitivity to the above changes of annual and total (cumulative) new wells and annual wellpad area, the model results are not appreciably different from those presented in figures 4-6, above. The

metric of cumulative (total) wellpad area, however, demonstrates high sensitivity to changes in expected lifespan of energy infrastructure, as illustrated in figure 11. If footprint lifespan were reduced by half (and if all other model assumptions are valid), then the energy sector footprint would be completely deleted from the landscape within the next 5 decades. If footprints persist 3 times longer than their anticipated lifespan, however, the next five decades of oil & gas activity would be expected to produce no net change in the amount of energy sector footprint in southeastern Alberta.

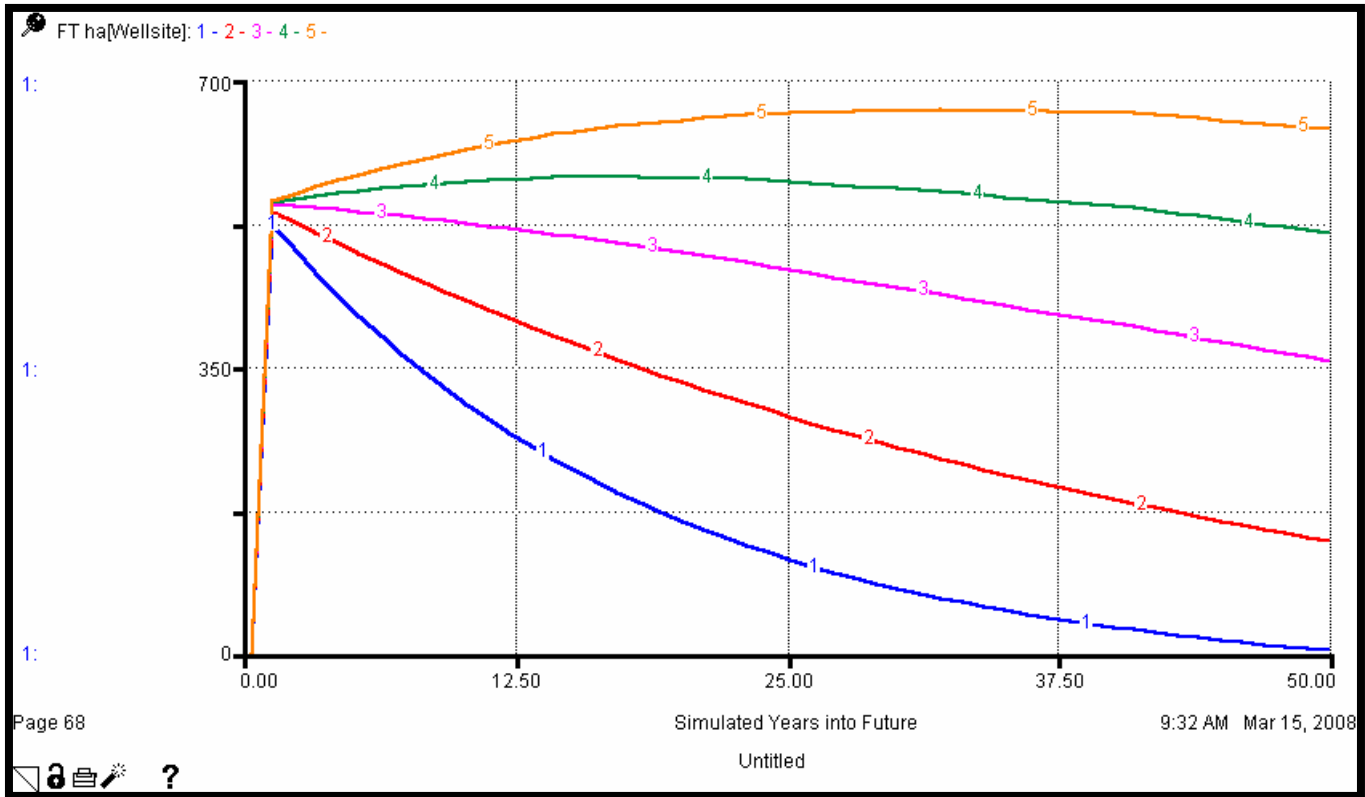


Figure 11 - Cumulative area (in hectares) of all wellpads over a 50-year time period, based on 50%, 100%, 200%, 300%, and 400% of anticipated lifespan of energy sector infrastructure.

Zone of influence appears to be much more sensitive to changes in footprint lifespan than it was to changes in well-drilling trajectory, as deduced by comparison of figures 8 (above) and 12 (below). In the base case, zone of influence experiences a steady, almost linear decline over the modeling horizon. In scenarios 3 through 5, zone of influence begins by increasing, and in the “400%” scenario, it doesn’t start to decrease until the 5<sup>th</sup> decade.

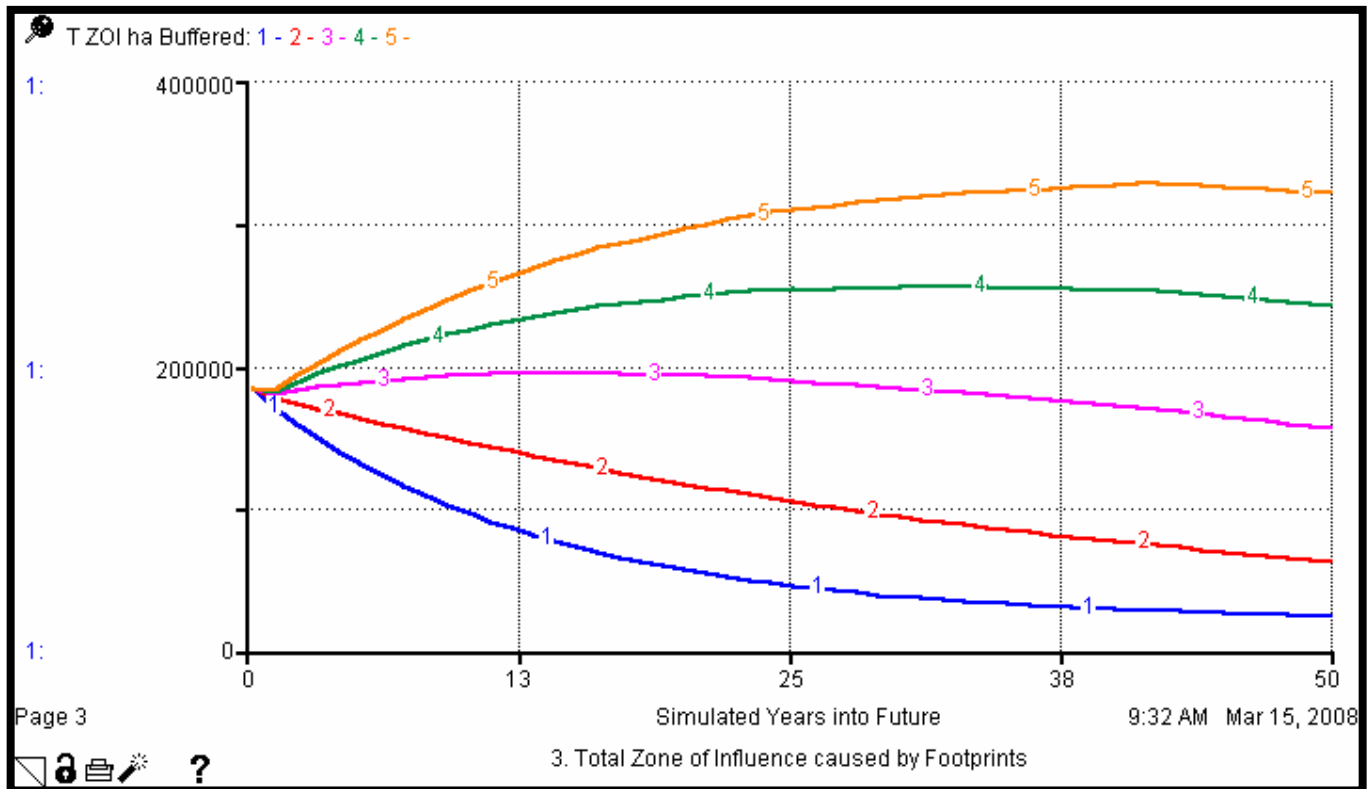


Figure 12 – Zone of influence for sage grouse over a 50-year time period, based on 50%, 100%, 200%, 300%, and 400% of anticipated lifespan of energy sector infrastructure.

Effective habitat area also exhibits strong sensitivity to changes in energy sector footprint lifespan, as demonstrated in figure 13.

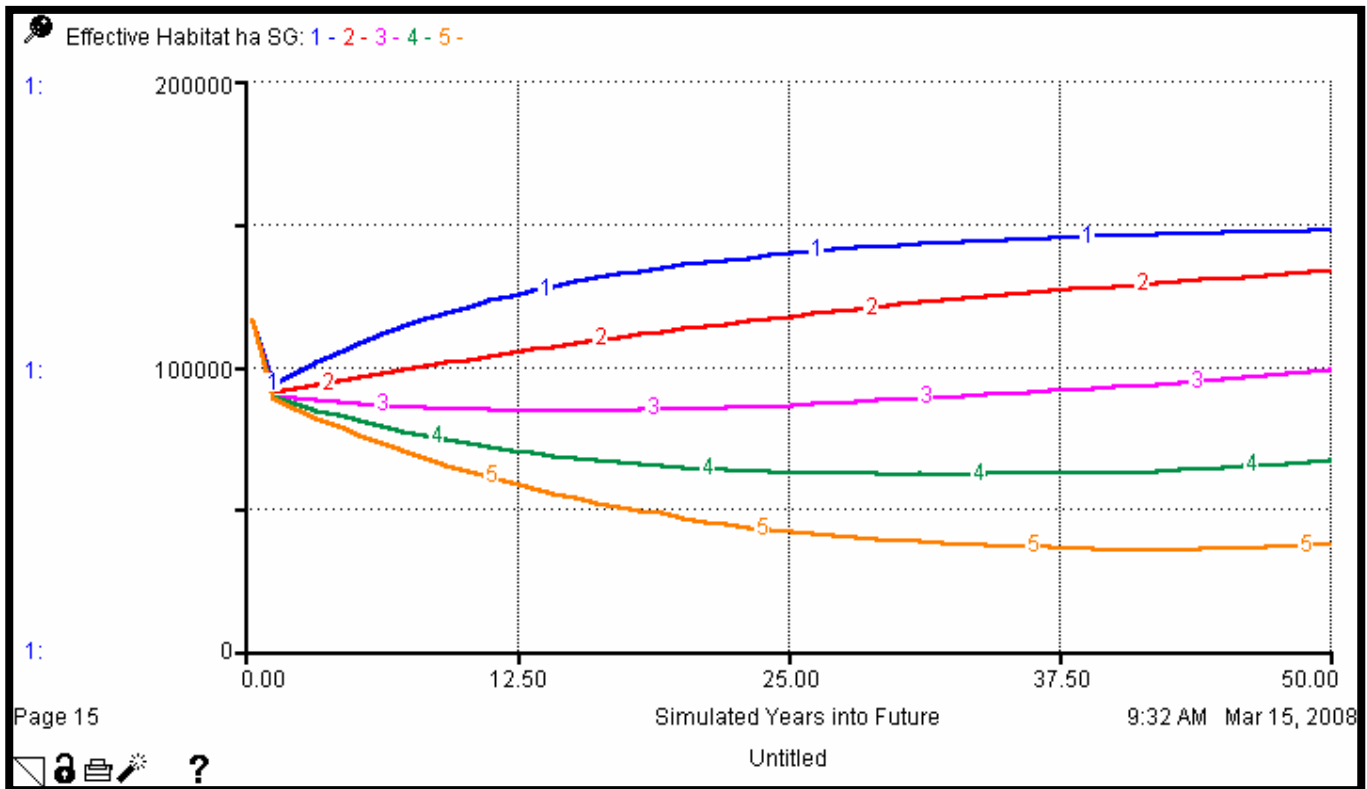


Figure 13 – Effective habitat area for sage grouse over a 50-year time period, based on 50%, 100%, 200%, 300%, and 400% of anticipated lifespan of energy sector infrastructure.

Scenarios 1 and 2 would result in immediate and persistent increases in effective habitat over the 50-year modeling horizon; scenario 3 would result in a net gain in effective habitat; and scenarios 4 and 5 would result in both short and long-term net losses in effective habitat.

Figure 14 shows the results of the footprint lifespan sensitivity analysis as it directly affects breeding occurrence for sage grouse. Scenarios 1 through 3 are within (or above) the range of natural variability for HSI values, as determined through ALCES® runs (see figure 2). Scenarios 4 and 5 lead to HSI values dropping below the range of natural variability within the first few years, and never recovering to levels within the acceptable range.

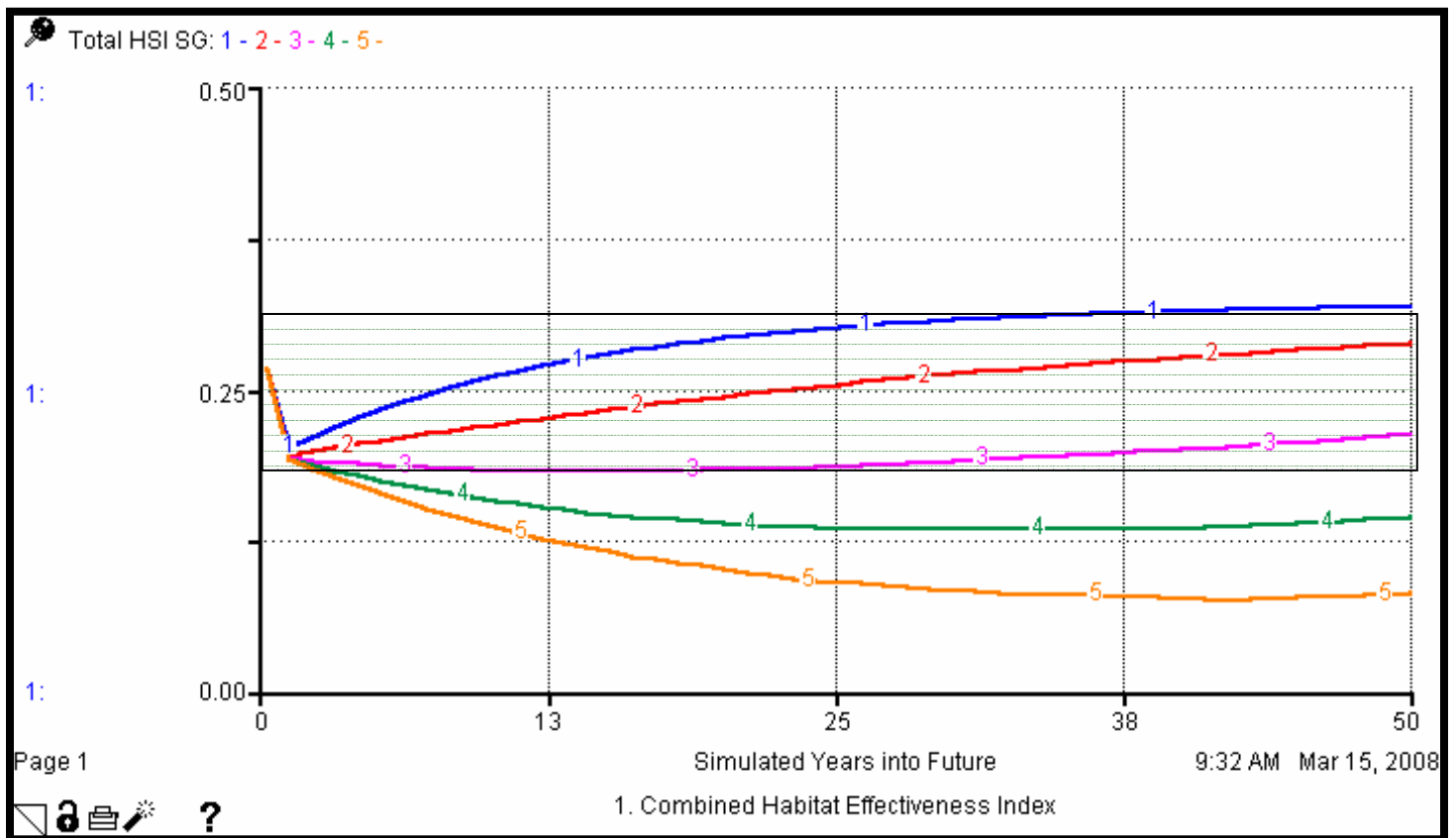


Figure 14 – HSI graph for sage grouse over a 50-year time period, based on 50%, 100%, 200%, 300%, and 400% of anticipated lifespan of energy sector infrastructure.

## Sensitivity to Changes in Percentage of Buffer Use

In conjunction with changes in footprint lifespan and projected rates of well-drilling, the percentage of energy sector footprint buffers that are used by sage grouse was also assessed for impact on breeding occurrence metrics using a similar sensitivity analysis methodology to the previous two analyses. This percentage works as a “multiplier” in the ALCES® model, effectively reducing the habitat quality within specified buffer distances of energy sector footprints by predetermined factors (or percentages). Five scenarios were considered:

- **Scenario 1 (blue line on all graphs)** – “Base Case” – 80% of energy sector footprint used by sage grouse.
- **Scenario 2 (red line on all graphs)** – 72% of energy sector footprint used by sage grouse.
- **Scenario 3 (pink line on all graphs)** – 64% of energy sector footprint used by sage grouse.
- **Scenario 4 (green line on all graphs)** – 56% of energy sector footprint used by sage grouse.
- **Scenario 5 (orange line on all graphs)** – 48% of energy sector footprint used by sage grouse.

This sensitivity analysis produced two remarkable results, illustrated in figures 15 and 16. Figure 15 shows the sensitivity of effective habitat area to changes in buffer use percentage, and shows effective habitat quickly dropping to zero in both the fourth (56% buffer use) and fifth (48% buffer use) scenarios.

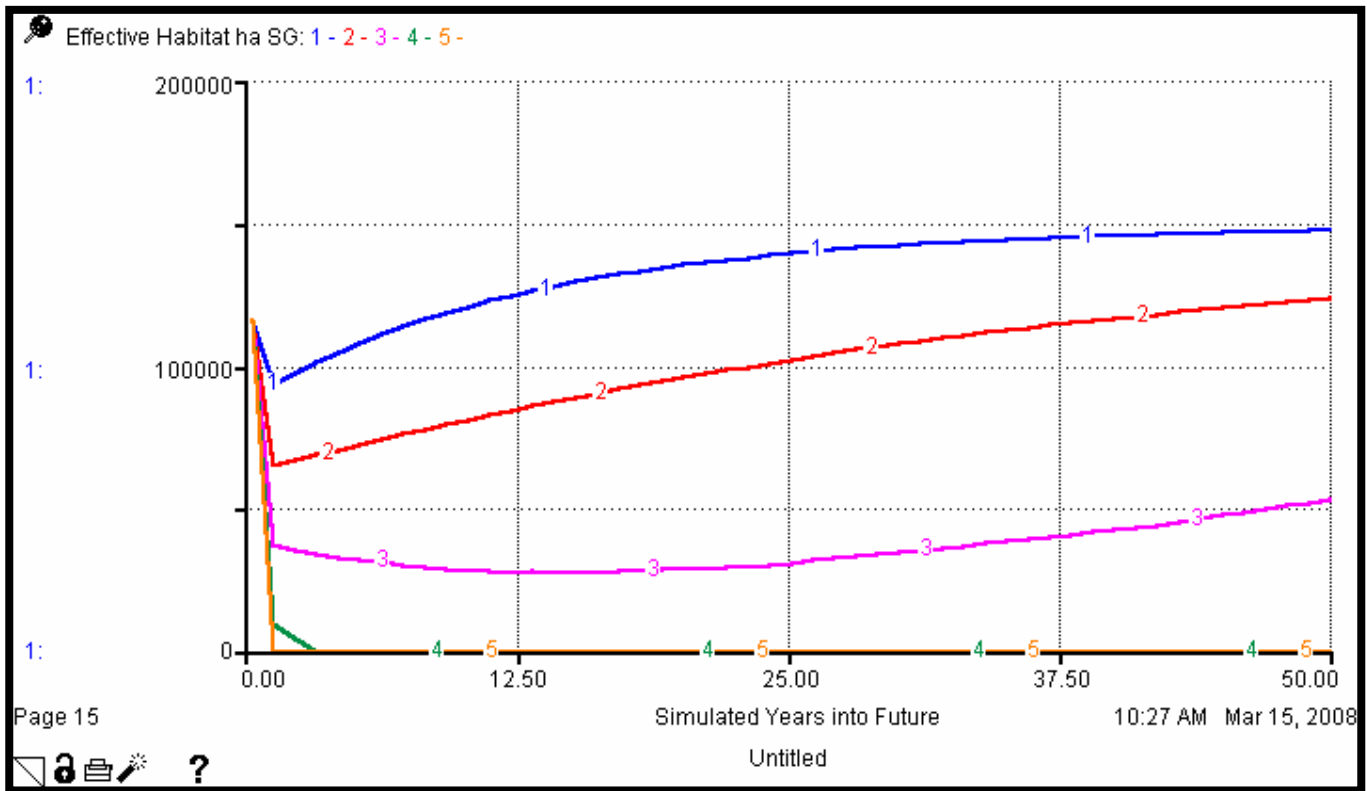


Figure 15 – Effective habitat area for sage grouse over a 50-year period, based on 80%, 72%, 64%, 56%, and 48% energy sector buffer use.

Figure 16 shows the HSI response to changes in buffer use percentage. The results suggest that the range of natural variability in sage grouse HSI values can only be maintained if energy sector buffers are used at a level of approximately 80% or higher; 72% buffer use results in HSI values dropping below the range of natural variability and remaining low for the first decade, and any lower use remains persistently below the range minimum.



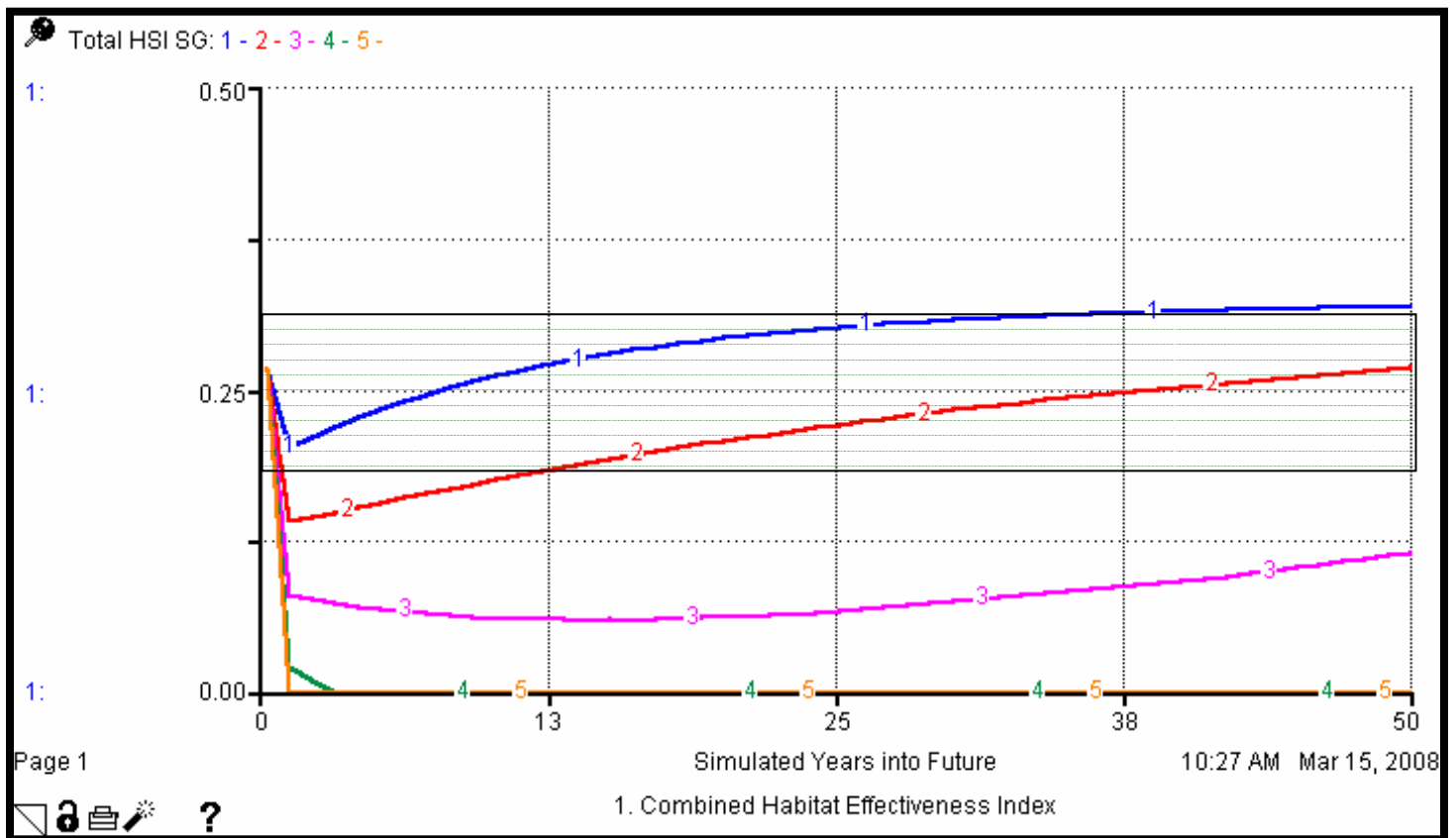


Figure 16 – Total habitat suitability index for sage grouse over a 50-year period, based on 80%, 72%, 64%, 56%, and 48% energy sector buffer use.

## V. DISCUSSION

It is clear from the research presented above that sage grouse breeding occurrence in southeastern Alberta is highly sensitive to three key aspects of the energy sector:

1. Projected number of new wells to be drilled in the area, and the development of associated infrastructure (roads, pipelines, etc.);
2. Anticipated lifespan of existing and new energy sector infrastructure; and
3. Percentage of habitat within energy sector footprint buffer areas that is used by sage grouse.

The first two of these factors are well within the sphere of human control, and the third has more to do with the behavioural ecology of sage grouse. In theory, the rate and location of new oil and gas activity can be controlled by appropriate planning and policy. The lifespan of energy infrastructure can likewise be minimized by ensuring that aggressive reclamation practices are encouraged. But the extent to which sage grouse are willing to use areas within specified distances of energy sector activity can only be controlled to the extent to which the ecological impacts of this activity can be minimized.

If the other information related to land use in southeastern Alberta (human settlement and population, agriculture, recreation, etc.) represents an accurate record of current use and reasonable trajectories of future development, and if the range of natural variability described above is a valid and ecologically defensible benchmark by which to evaluate the likelihood of sage grouse population viability, then this research suggests some measures that, if followed, might improve sage grouse' chances of recovery and continued survival.

Regarding energy sector activity, sage grouse are more likely to respond favourably to a landscape in which:

1. New drilling and exploration proceeds at a rate that does not exceed three times that forecasted by Alberta Energy (see above);
2. The lifespan of energy infrastructure does not exceed 200% of projected lifespans as identified in the SAL ALCES® model; and
3. Sage grouse use habitat within energy sector buffers at a rate of 80% or higher.

It is important to note that this research has evaluated the sensitivity of sage grouse breeding occurrence (one aspect of its ecology) to changes in projected hydrocarbon activity (one aspect of human influence on sage grouse). The outcomes presented here should be viewed as a starting point and a basis for further research and discussion.

A base-case ALCES® model has now been developed for the 7X7 township southeastern corner of Alberta, comprising the entire provincial sage grouse range. This model has been populated with the best and most accurate data currently available regarding description of the initial landscape, projected changes in human land use and activity, and predicted responses of sage grouse to both natural and anthropogenic changes. The ALCES® model is robust and complex, and allows for the consideration of many possible future trajectories through the manipulation of a multitude of different variables.

The Recovery Action Group would therefore be wise to consider the outcomes of the sensitivity analysis presented in this document, endeavour to understand these results, and understand the power of cumulative effects assessment to inform decisions regarding land use. Further, the Group should evaluate and prioritize other unanswered questions regarding the future of sage grouse in Alberta, and consider looking to future ALCES® runs for insight into these questions.

## VI. CONCLUSION

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An ALCES®-based landscape simulation model has been developed for a 7X7-township region in the southeastern corner of Alberta. This model allows members of the Recovery Action Group to assess the potential ecological impacts on sage grouse of various different plausible future land use scenarios.

A sensitivity analysis was conducted, which determined that sage grouse breeding occurrence likelihood is highly sensitive to changes in various facets of energy industry activity, including rate of exploration, lifespan of energy infrastructure, and the extent to which sage grouse are able to use habitat within specified distances of energy sector footprint.

It is expected that the ALCES® sage grouse model will be a valuable tool in the formulation of strategies and policies directed at the continued viability of Alberta's sage grouse population.

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## APPENDIX A – RESULTS OF EXPERT WORKSHOP, MARCH 2006, MEDICINE HAT

The following represents the results of a workshop of Canadian and American sage-grouse experts. The expert team was tasked with identifying, in a consensus-based process, a suite of HSI metrics for sage-grouse which could then be used to populate the wildlife module in the ALCES® model. The full meeting record is also available.

### Sage Grouse Expert Opinion Model

Landscape Cover Type	Prev Rank	Breeding Occ	Breeding Surv	Summer Occ	Summer Surv	Winter Occ	Winter Surv	Rangeland Successional Stage		
		(0 - 1)	(0 - 1)	(0 - 1)	(0 - 1)	(0 - 1)	(0 - 1)	Early	Mid	Late
Prairie Treed & Riparian		0	0	0	0	0	0			
Reservoir		0	0	0	0	0	0			
Badlands		0.1	0.1	0.1	0.1	0.05	0.05			
Needle and Thread / Blue Grama		0.25	0.1	0.1	0.1	0.05	0.05			
Silver Sagebrush / Wheat Grass										
Saline Lowlands	4	0.05	0.1	0.1	0.1	0.2	0.2	LLL	MHM	HMH
Overflow saline (lowlands)	3	0.5	0.25	1	0.55	1	1	LLL	MHM	HMH
Blowout	1	0.5	0.4	0.8	0.85	0.8	0.8	LLL	MHM	HMH
Loamy Blowout	2	1	1	0.5	0.5	0.3	0.3	LLL	MHM	HMH
Overflow Non-Saline	5	0.9	0.7	1	1	0.3	0.3	LLL	MHM	HMH
Needle and Thread / Sand Grass		0.25	0.1	0.1	0.1	0.05	0.05			
Mixed Grass		0.25	0.1	0.1	0.1	0.05	0.05			
Fescue Grassland		0.25	0.1	0.1	0.1	0.05	0.05			
Fescue Parkland		0	0	0	0	0	0			
Grassland - Shrubland		0	0	0	0	0	0			
Foothills Shrubland		0	0	0	0	0	0			
Cereal		0	0	0	0	0	0			
Oilseeds & Pulses		0	0	0	0	0	0			
Specialty		0	0	0	0	0	0			
Forage		0	0	0	0	0	0			
Tame Gr		0	0	0	0	0	0			
Stream / Rivers		0	0	0	0	0	0			
Ponds / Lakes		0	0	0	0	0	0			
Rock/ice		0	0	0	0	0	0			
Major Road		0	0	0	0	0	0			

Minor Road & Trail	0	0	0	0	0	0
Rail	0	0	0	0	0	0
Transmission Lines	0	0	0	0	0	0
Gravel Pits	0	0	0	0	0	0
Canal	0	0	0	0	0	0
Agricultural Residences	0	0	0	0	0	0
Rural Residences	0	0	0	0	0	0
Recreational Facilities	0	0	0	0	0	0
Industrial Plants	0	0	0	0	0	0
Seismic Line	0	0	0	0	0	0
Wellsite	0	0	0	0	0	0
Pipeline	0	0	0	0	0	0
Feedlot	0	0	0	0	0	0

<b>Anthropogenic Features</b>	<b>Buffer Width (m)</b>	<b>Buffer Width (m)</b>	<b>Buffer Width (m)</b>	<b>Buffer Width (m)</b>	<b>Buffer Width (m)</b>	<b>Buffer Width (m)</b>
Major Road	1000					
Minor Road	1000					
Two track trail	100					
Rail	1000					
Transmission Lines	1000					
Power line	100					
Gravel Pits	100					
Canal	0					
Impoundment	100					
Agricultural Residences	500					
Rural Residences	1000					
Town City	1000					
Recreational Facilities	500					
Industrial Plants	1000					
Seismic Line	0					
Wellsite	500					
Pipeline	100					
Feedlot	1000					

<b>Anthropogenic Features</b>	<b>Use %</b>	<b>Use %</b>	<b>Use %</b>	<b>Use %</b>	<b>Use %</b>	<b>Use %</b>
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Major Road	1000	0.6	0.75				
Minor Road	1000	0.6	0.75				
Two track trail	100	1	1				
Rail	1000	1	1				
Transmission Lines	1000	1	0.9				
Power line	100	1	1				
Gravel Pits	100	0.75	1				
Canal	0	1	1				
Impoundment	100	1	1				
Agricultural Residences	500	0.75	0.95				
Rural Residences	1000	0.75	0.95				
Town City	1000	0.75	0.95				
Recreational Facilities	500	0.75	1				
Industrial Plants	1000	0.75	0.95				
Seismic Line	0	1	1				
Wellsite	500	0.8	0.75		0.75		
Pipeline	100	1	1				
Feedlot	1000	0.75	1				