ENCANA'S SHALLOW GAS INFILL DEVELOPMENT PROJECT IN THE SUFFIELD NATIONAL WILDLIFE AREA

SUBMISSION REGARDING CUMULATIVE EFFECTS ASSESSMENT

Prepared by

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February 14, 2008

Report Structure

This submission is comprised of the following sections.

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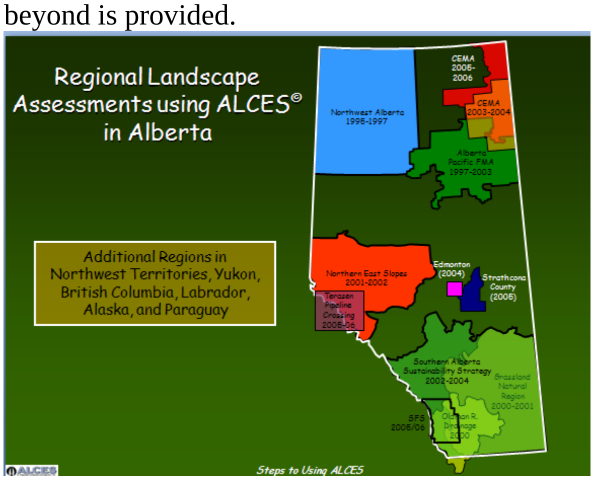
1. Defining a preferred approach for quantifying cumulative effects of landuse practices

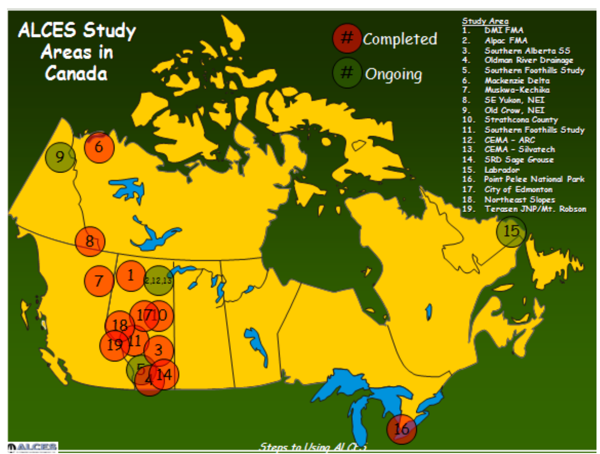
The guidelines that follow define an approach for assessing cumulative effects on the Suffield National Wildlife Area that can robustly answer the following five questions:

1. What was the "Range of Natural Variability" of selected valued ecosystem components (VEC) in the pre-industrial era?
2. To what extent has the current landscape changed from "natural" conditions that defined the pre-industrial era.
3. To what extent will proposed landuse projects affect, directly or indirectly, the future condition of selected valued ecosystem components (VEC)?
4. To what extent can best practices mitigate adverse cumulative effects?
5. What are the "key uncertainties" of the "cumulative effects system" that prevent accurate assessments of the proponent's project?

The methodology outlined in this synopsis will serve as a basis for evaluating the weaknesses of the Encana methodologies used for addressing the issue of cumulative effects. In contrast, the approach recommended below is intended to describe a preferred methodological approach, one that specifically deals with the limitations of conventional EIA as outlined by Duinker and Greig (2006) in their article:

Scenario analysis in environmental impact assessment: Improving explorations of the future. This approach has been widely deployed in Alberta during the past ten years by clients ranging from municipal governments, provincial governments, academia, grass-roots multi-stakeholder groups, and various industrial clients assessing project level cumulative effects. A map illustrating landscapes in Alberta and beyond is provided.





Step 1. Defining Range of Natural Variability

Without a solid empirical understanding of the dynamics of native grasslands ecosystems prior to the arrival of industrial landuse practices, it is impossible to construct a meaningful "reference" point against which one can compare any future landscape influenced by one or more landuse trajectories. The quantification of Range of Natural Variability (RNV) therefore becomes an essential requisite step in the assessment of cumulative effects of landuses. The recently completed Government of Alberta sponsored Southern Alberta Landscape (SAL) project recognized the comparative importance of RNV, and following the consultation with grassland ecologists, constructed a simulation model that allowed for the computation of RNV for several key grassland indicator processes and species. This approach recognized that herbivory, drought, and fire were the major natural perturbation agents responsible for maintaining variation in structure, species composition, soil organics, and nutrient reserves of native grassland ecosystems. For purpose of example, this variation can be expressed graphically as shown in Figure 1.

The CEA practitioner should use a Monte Carlo approach to capture the inter-annual variation that occurs because of random fire, drought, insects, etc.

It should be emphasized that the precise attribution of RNV models may not be possible, but that the goal is not to define an exact answer, but to compute “defendable” variation that approximates a natural pre-treatment landscapes. For the purposes of the NWA, the “range of natural variability” era could be considered to be those multiple decades (or centuries) prior to 1905. It is not necessary to know exact historic values for precipitation and fire to conduct these analyses, but rather to use existing estimates of variances for these variables.

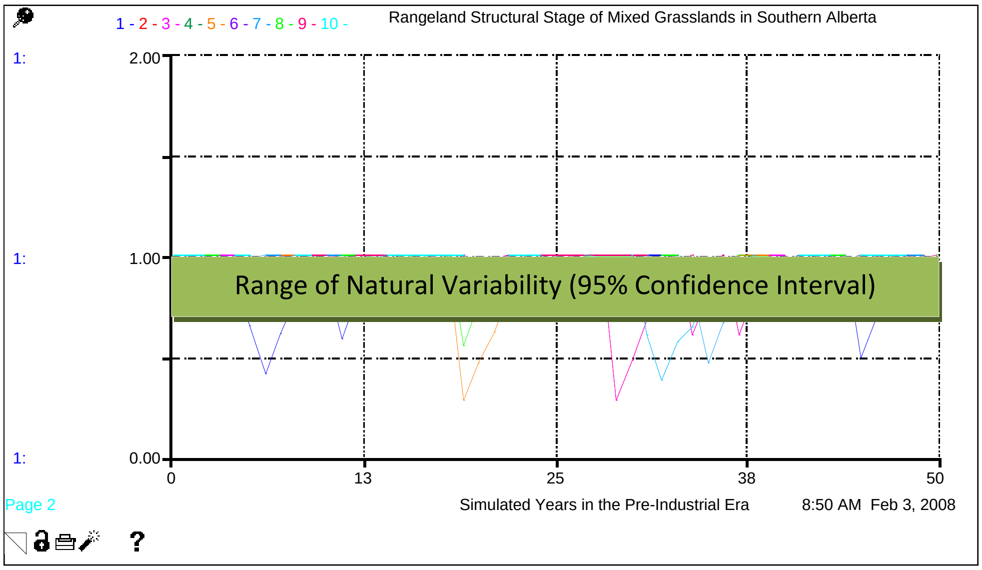


Figure 1. Simulated Range in Natural Variability of Mixed Grassland structural integrity. Variation caused by inter-annual variation in herbivory, climate and fire.

Step 2. Defining “Current” Cumulative Effects (or “Back-casting the Landscape”)

All too often, environmental impact statements (EIS) or cumulative effects assessments (CEA) focus on irrelevant scales of time and space. Constrained by narrow definitions of what defines a project, what bounds a geography worthy of exploration, what defines a proper interval of time, or the suite of landuses or natural disturbances that can be examined, the EIA practitioner is destined to limit his ability to reveal and discuss likely changes to defined VECs.

To illustrate this point, I have posted a series of landuse maps to a website that illustrate the temporal pattern in landuses for Alberta (and the SNWA) that pertain to:

- Cropland agriculture (http://www.abll.ca/maps/Crops/Area)
- Energy sector wellsites (http://www.abll.ca/maps/Energy_and_Mining_Sector/Well_Footprints)

What these map time series clearly indicate is how landuse trajectories that are growing at 2 to 3% per year can compound through time and result in profound landscape transformations.

Before proceeding with answering the question as to whether a proposed future project will have a significant adverse effect, it is critical to know whether the current landscape has already experienced a significant change because of cumulative effects of historic projects. This process can be referred to as “back-casting”.

To conduct this retrospective process, the EIA and CEA practitioner should reconstruct the temporal pattern of whatever historic landuse practices (energy, agriculture, transportation, forestry, residential) have occurred on this landscape. Much of this historic information for Alberta has been assembled and can be found at www.abll.ca.

The primary goal here is to contrast the changes that have occurred historically to the RNV values, and secondarily, to the values that immediately precede a specific proposed or historic landuse event. For example, in Figure 2, it is clear that structural integrity of mixed grasslands is beyond the range of natural variability and has experienced significant cumulative effects from one or more historic landuse events. Although project #4 may have only a marginal effect on a VEC relative to its condition immediately prior to the project, it is contributing to the net loss of performance of that VEC relative to its condition within RNV.

In terms of spatial scale, it is important to back-cast the landscape at a range of scales that include the local study area and the larger regional landscape. These two bracketed scales allow stakeholders to understand that landuse projects can have different effects at different scales, and to place the local effects into a broader regional context. For example, a specific project may have a modest (eg. 10%) local effect relative to conditions immediately prior to its arrival, but it may be occurring on a landscape type that has already lost over 90% of its area to previous landuses at the regional scale.

The key feature to emphasize here is that comparing any given year to the previous year is unlikely to ever lead to a conclusion that landuse has any effect on any VEC. Again, the goal is to compare "meaningful" time and "meaningful" space.

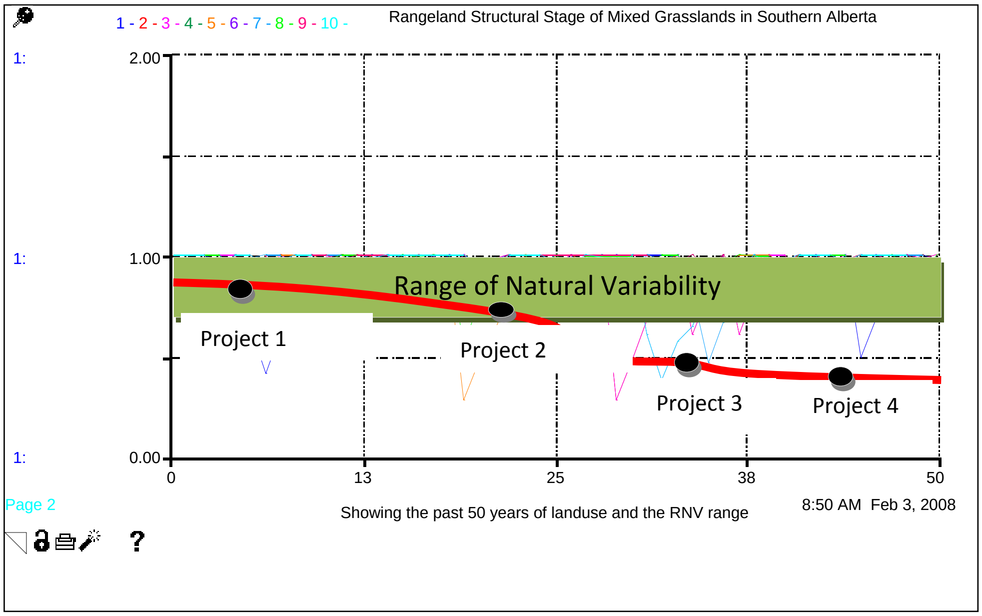


Figure 2. An example of simulated "back-casting" (shown in red) of Mixed Grassland structural integrity. The past 50 years of landuse are now contrasted against the "Range of Natural Variability". In this example, the Range Structural Stage of Mixed Grasslands is clearly outside of RNV and significant cumulative effects of historic landuses have already occurred.

Step 3. Forecasting a Proposed Project and Exploring Cumulative Effects

The primary objective of forecasting landscapes into the future is to evaluate the effects of proposed landuse activities on defined VECs. Every effort should be made to consider all certain and likely trajectories for all relevant landuse practices (both now and in the foreseeable future). In the case of

Encana's gas "infilling" project, was it not foreseeable in the 1980's that well spacing would need to increase to ensure that all marketable gas was extracted? Similarly, does the current Encana project reveal all anticipated future activity? For example, are we likely to see a 3rd pulse of gas well infilling in the 2030's to remove the last 20% of marketable reserves?

When simulating landuses into the future, it is advisable to explore a range of trajectories to address key uncertainties about the scenarios being explored. For example, simulations could explore:

- a range of alternative growth trajectories of landuses based on lower and upper expectations, and potential new technologies that may increase the percent of the hydrocarbon reserve that can be extracted
- a range of reclamation rates and destinations for various reclaiming footprints (seismic lines, wellsites, wellsite access roads, etc.)
- a range of establishment and growth rates for exotic plant species

When assessing the temporal response of VECs to a defined forecasting scenario, it is important that its performance be compared to the RNV and to its current pre-project status. For example, in Figure 3 below, Project 5 appears to induce a gradual deteriorating trend in a VEC relative to its current status in Year 0 (current), yet from the perspective of "meaningful" time, Project 5 represents an additive landuse project that contributes to moving a VEC significantly further away from its RNV.

The approach outlined above should apply to all VECS, whether they pertain to physical (e.g., bare soil), plant community structure (rangeland integrity index, index of exotic plants), wildlife community structure (pronghorn, burrowing owl, etc.), and ecological processes (landscape fragmentation).

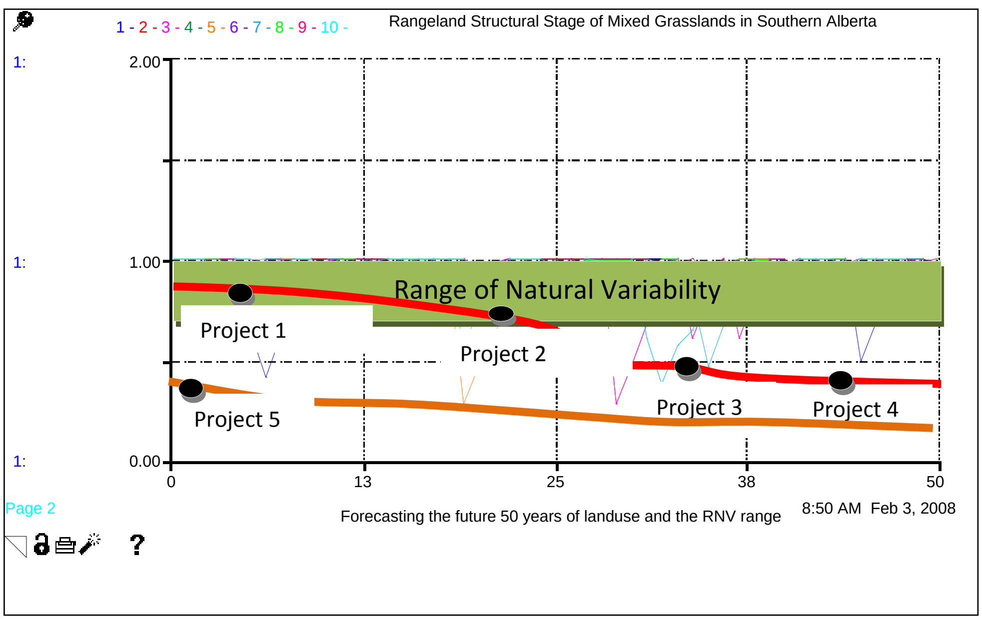


Figure 3. An example of simulated "fore-casting" (shown in brown) of Mixed Grassland structural integrity. The past 50 years of landuse are still contrasted against the "Range of Natural Variability", and the future forecasted effects on a VEC are displayed. In this example, the Grassland Integrity Index of Mixed Grasslands continue to decline because of the "additive" effects of both proximal (recent) and distal (less recent) landuse projects.

Step 4. Exploring the Cumulative Effects of Best Practice Technologies

A key objective of cumulative effects assessment is to offer empirical insight on how best to mitigate adverse environmental effects. Through the use of landuse simulation models, it is possible to quantify the relative effect of various landuse footprints (wellsite pads, wellsite access roads, processing plants, pipeline right-of-ways, seismic lines) on each of the defined VECs. Once the relative rankings of impacts are quantified, it is then possible for the CEA practitioner to assess the benefits of a defined range of "best practices" against the "business as usual" metrics that represent the base case. Numerous best practice options may reduce risk to VECs on the SNWA by either reducing total footprint loading on the landscape; these may include:

- Directional drilling
- Road harmonization
- Spatial overlap of linear features

To what extent have consultants evaluated the benefits of potential best practice options?

By demonstrating which landuse footprints is "driving" sensitivity of key VECS, and by consulting with the energy sector engineers, it is possible to assess the consequences of a suite of best practices on the full range of VECs. An example of this approach is illustrated in Figure 4.

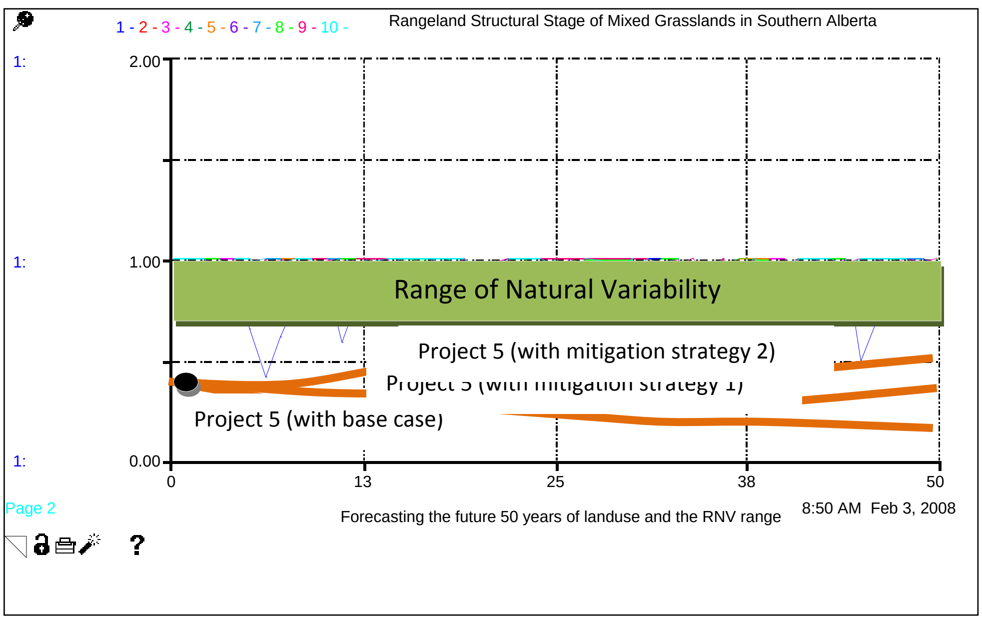


Figure 4. An example of simulated "fore-casting" (shown in brown) of Mixed Grassland structural integrity, while exploring two alternative "best practice" options. The future 50 years of landuse is contrasted against the "Range of Natural Variability". This graphic depicts the potential advantages of adopting best practice technologies on a defined VEC.

Step 5. Assessing Landuse and Ecological Uncertainty

Conducting CEA and simulating landuses is not a precise discipline defined by either accuracy or certainty. Rather than using this uncertainty as an excuse for not conducting proper CEA, the CEA practitioner should guide stakeholders in understanding which variables or relationships in the system possess uncertainty that has significantly influenced key VECs. This uncertainty can be addressed through "sensitivity" simulations and can provide profound guidance to regulators in terms of key relationships that require further research and monitoring.

2. Key Recommendations to address existing inadequacies of current CEA documents

1. Quantify "Range of Natural Variability" for all key VECs using landuse/landscape simulation models.

2. Conduct back-cast simulations of the SNWA for the period 1955 to 2005 to quantify existing changes to VECs relative to RNV values

3. Conduct fore-cast simulations of the SNWA for the period 2005 to 2055 to quantify predicted changes to VECs, given the defined trajectories of the infilling process. These results need to be compared to both current and RNV values.

4. Demonstrate quantitatively the extent to which adverse effects of Encana's activity on VECs can be mitigated through the adoption of best practices.

5. Quantify existing level of uncertainty for key relationships and explore consequences of this uncertainty using "sensitivity" simulations within landscape/landuse simulation models

3. Simulating the Shallow Gas Play on the NWA and reporting on key "Valued Ecosystem Components"

The simulation graphs which follow were generated using the Alberta Landscape Cumulative Effects Simulator (ALCES; www.alces.ca) and the analytical work completed by Dr. Brad Stelfox of Forem Technologies. Current landscape composition data and metrics were extracted directly from the Environmental Impact Assessment reports prepared by Encana's consultants and posted to the EIA website. Similarly, trajectory metrics that describe the shallow gas infilling project were extracted from the EIA website.

Key Assumptions

1. Existing descriptions of current anthropogenic footprint on the NWA contained within EIA documents are accurate and do not miss or exclude any linear or polygonal features.

2. The proposed amount (number, area, km) of infill gas wells, access roads, pipelines, are accurate.

3. For the purposes of the simulations conducted, I assumed that the existing footprint originating from the 1st pulse of shallow gas wells (1970s) will remain on the NWA landscape until 2055.

4. That there will be no subsequent (3rd, 4th) pulse of shallow gas infilling during the simulation period.

Back-cast and Forecast Simulations Results for Habitat Related Metrics

The energy sector footprint (both current and projected) is the result of shallow gas drilling episodes that occurred in the 1970s and proposed for the 2005-2010 period (Figures 5 and 6).

Area directly affected by current anthropogenic features is ~800 hectares, representing only ~2% of the NWA landscape area of ~45,000 ha (Figure 7, Figure 8). This area is expected to grow by about 25% following the infill drilling and comprise ~1050 ha, or about 2.3% of the NWA (Figure 7, Figure 8).

Although the direct footprint may be perceived as small, the indirect footprint is not. The point here is that numerous wildlife species, and ecological processes, can be significantly influenced by the area adjacent (referred to as a buffer) to linear (pipeline, roads) or polygonal (wellsite) features.

As shown in Figures 9 and 10, existing anthropogenic edge is about 1500 km (or 3.5 km/km^2) and this will increase to about 2200 km (5.2 km/km^2) following the proposed infill episode. If one "buffers" each of these edge features by differing buffer widths (50, 100, 200, 300, 400, and 500 m) on either side of the feature, it becomes apparent that a profound portion of the NWA can fall within the "zone of influence" of the energy sector footprints (Figure 11). For example, ~50% of the entire NWA falls within a 400 m buffer of the current landuse footprint, and this will grow to ~ 80% by the time the infill drilling is completed. The challenge for the ecologists of our team is to identify wildlife species, or ecological processes, that can be shown to be adversely affected within defined buffer widths.

One such ecological process that is very important to grassland integrity is the expansion of exotic invasive plant species that become established on disturbed native grasslands. Based on expansion rates of exotic invasives of 0.1 to 0.4 meters/year (arguably conservative values), the amount of native grassland area that will be "invaded" will be between 1500 and 5500 hectares (Figure 12). The landscape simulator suggests that as much as 1200 hectares may already be lost to invasive plants.

“Core area” is a common landscape metric used to evaluate the performance of wildlife or plant species that are sensitive to anthropogenic edge created by landuse practices. Figure 13 illustrates the dramatic loss of core area (defined as the percent of the landscape available to the species and greater than 300 meters from the closest anthropogenic edge). The simulation results in ALCES indicate that ~90% of initial core area was removed from the 1st pulse of shallow gas drilling, and the remaining 5% will be lost to the proposed infill episode.

Using a different modeling approach, ALCES evaluates the amount of wildlife habitat available in the NWA given the historic shallow gas play and simulating the proposed infill development. The simulations were run with buffers of 100m, 200m, and 300m on all linear features, and illustrate that a 100 m buffer would result in habitat loss of 20%, that 200 m buffer would cause a loss of 65% of habitat, and a 300 m buffer would cause the loss of all habitat (Figure 14). These results assume that none of the buffer area is suitable as habitat. To deal with this assumption, one could consider the linear feature buffer to be 50% as useful as habitat outside the buffer, and therefore reduce the habitat loss values by 50%.

<u>Backcast and Forecast Simulations Results for Sensory Disturbance and Vehicular Mortality</u>

The current and proposed shallow gas play require a significant number of vehicular trips to the wellsite associated with pre-drilling assessments, well completions, and post-drilling monitoring activities. Based on visitation metrics provided by Encana and their consultants at the technical session held in Calgary on January 7-8th, 2008, ALCES was used to compute annual and cumulative number of trips, trip lengths (km), and person-hours at the wellsites on the NWA.

The number of trips per year in the NWA will peak at >30,000 with ~1.4 million trips occurring cumulatively by 2055. During this same time period, the number of annual km travelled on roads will peak at 45,000 km and cumulatively will amount to 2.2 million kilometers. The total number of person-hours will peak at 190,000 and cumulatively represents 5.8 million person-hours by 2055. Peak annual activities of trips, distance travelled, and person hours will occur during the infill drilling period.

It is important for the wildlife ecologists on the team to consider the cumulative effects of this magnitude of travel, visitation, and time spent at the wellsites on the wildlife communities. Questions worth asking include:

- What magnitude of vehicular mortality might occur to amphibians, reptiles, birds, and mammals?
- To what extent will wildlife species avoid grassland communities proximal to transportation networks because of noise?
- Given the magnitude of vehicular travel, what is the probability of vehicles introducing the seeds of exotic invasive plants?

4. Summary

The Environmental Impact Assessment prepared by Encana's consultants is incomplete in many respects. These include:

- Narrow definition of "valued ecosystem components". Focus is on vertebrates with no attention paid to either non-vertebrate biota or to ecological processes.
- Narrow definition of "time". The comparison of the shallow gas infill is that of the current landscape. No effort made to compute the "range of natural variability" of VECs in a pre-disturbance landscape.
- Complete omission of anthropogenic edge, or the concept of edge buffering.
- No effort made to quantitatively explore the consequences of "best practice" options, in comparison to business as usual activities.
- No attempt to quantify the "key uncertainties" of the shallow gas play in relation to defined VECs.

This concerns expressed above are confirmed by the absence of any simulation modeling work intended to track the arrival, persistence, and reclamation of all relevant footprints associated with the shallow gas play within the NWA, or the effects of these simulated anthropogenic features on a set of valued ecosystem components (VECs). The consultants state that there are no significant cumulative effects of anticipated landuses on several key VECs, yet present no simulation data to support these conclusions.

The argument for this key omission is the implementation of mitigation measures and avoidance of sensitive environments. Given the magnitude of both linear and polygonal features on the landscape today (~3 km/km^2) and the anticipated growth of linear feature density to 5 km/km^2 (once the proposed infill phase is completed) the possibility that the historic or proposed Encana landuses do not have a profound effect on key ecological variables is zero.

A key weakness of the EIA is its spatial focus on the direct footprint of anthropogenic features, and its relative inattention to indirect effects of landuse features. To robustly quantify the effects of this gas infill play on ecological processes, it is essential to consider the buffering effects on VECs. The direct footprint of landuse on this landscape is generally in the 2-2.5% range, but its spatial influence can extend to the 100% range for those ecological processes or wildlife species influenced by anthropogenic features within 500 m of linear or polygonal features. The EIA does adopt a constraint mapping technique, but generally uses an arbitrary buffer width of 100 m, though numerous VEC are adversely affected for distances of several hundred meters (for example, pronghorn can be spatially displaced within 500 m of some features of the oil and gas industry; see Tobin Seagal text within EIA). Further, the EIA indicates that where constraint mapping could not accommodate the desired gas extraction trajectories using exclusion and avoidance zones, then anthropogenic features were allowed to fall within these zones. This EIA needs to quantify the extent to which the ecological integrity of VEC are compromised by the "actual" proposed spatial and temporal trajectory of each landuse footprint associated with historic and proposed oil and gas activity.

To assist the impact assessment process, the EIA needs to provide indicator performance reference points. The EIA contains much detailed information that describes the current "static" landscape, but generally ignores the temporal variability that characterizes all ecological systems. Whether discussing pronghorn, sage grouse, exotic invasive plants, bare ground, and other VECs, a useful EIA needs to inform the reader about the "range of natural variability (RNV)" for each VEC, so that the RNV can serve as a reference point to allow the reader to determine the extent to which indicator performance is acceptable or unacceptable.

The construction and persistence of linear and polygonal features is a key element in the risk equation for all VECs. The EIA refers to the reclamation of these features, yet does not provide quantitative insight into the probability of achieving the intended reclamation trajectory, or the key uncertainties that might complicate the reclamation process.

Based on the above commentary, it is my opinion that the EIA could be significantly improved by incorporating the following additional elements:

- Tracking both the direct and indirect (buffered) footprint of each footprint type throughout the full lifespan of the gas play in NWA.
- Assessment of the uncertainty of performance of reclamation trajectories.
- Assessment of the uncertainty of invasion of exotic plants, and the anticipated expansion trajectories of invasive plants off all relevant anthropogenic features.
- Comparison of performance of key VECs to Range of Natural Variability for each of the first pulse (historic) and second pulse (proposed) of gas development. It makes no sense to compare the performance of VECS to the proposed infill relative to the current situation. A proper assessment of cumulative effects must consider the full set of actions and anthropogenic features of the full shallow gas play.

5.References

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EIR-05475; No of Pages 14

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Environmental Impact Assessment Review xx (2006) xxx–xxx

Environmental Impact Assessment Review

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Scenario analysis in environmental impact assessment: Improving explorations of the future

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Received 21 July 2006; accepted 11 November 2006

Scenario analysis in environmental impact assessment: Improving explorations of the future

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Received 21 July 2006; accepted 11 November 2006

Abstract

Scenarios and scenario analysis have become popular approaches in organizational planning and participatory exercises in pursuit of sustainable development. However, they are little used, at least in any formal way, in environmental impact assessment (EIA). This is puzzling because EIA is a process specifically dedicated to exploring options for more-sustainable (i.e., less environmentally damaging) futures. In this paper, we review the state of the art associated with scenarios and scenario analysis, and describe two areas where scenario analysis could be particularly helpful in EIA: (a) in defining future developments for cumulative effects assessment; and (b) in considering the influence of contextual change – e.g. climate change – on impact forecasts for specific projects. We conclude by encouraging EIA practitioners to learn about the promise of scenario-based analysis and implement scenario-based methods so that EIA can become more effective in fostering sustainable development.

6. **<u>Simulating the Shallow Gas Play on the NWA and reporting on key "Valued Ecosystem Components</u>**

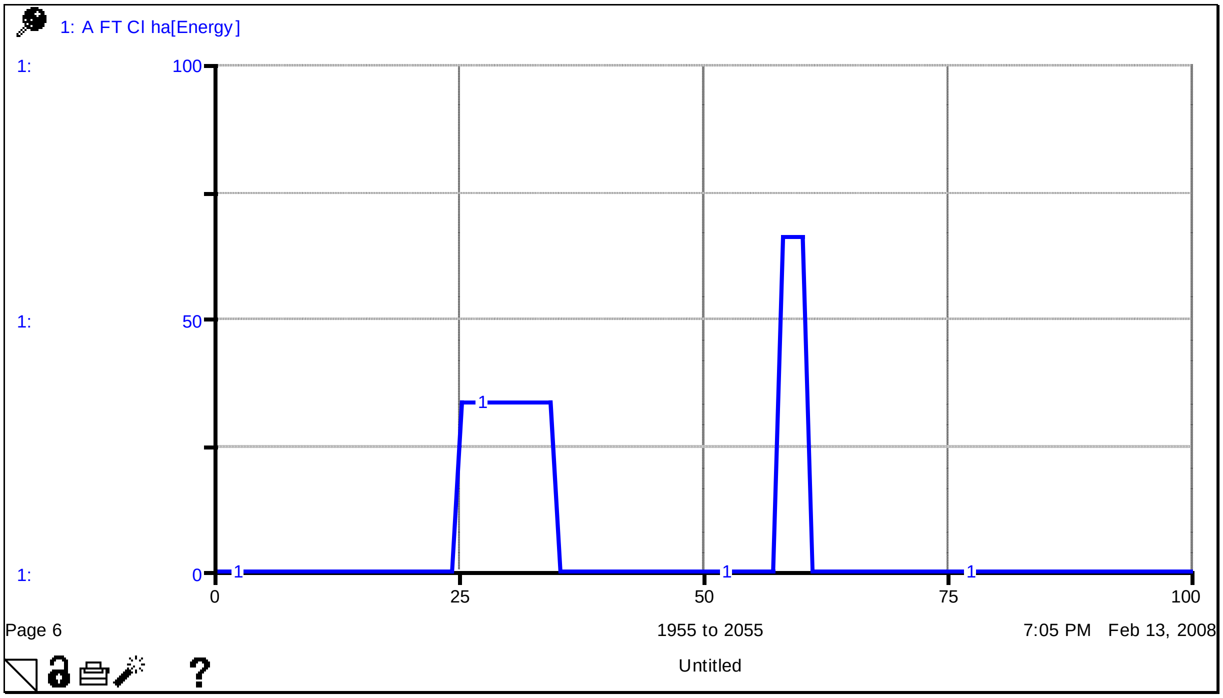

Figure 5. Simulated change in new annual anthropogenic area (in ha/yr) for the NWA. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055.

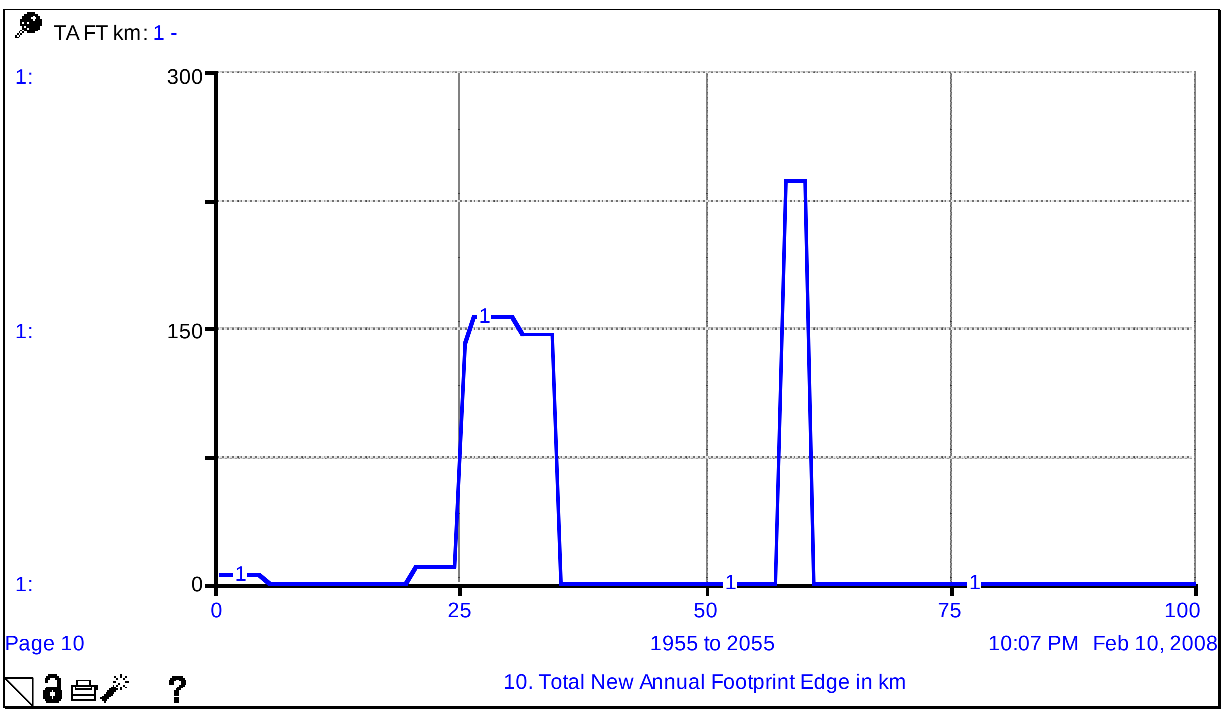

Figure 6. Simulated change in new annual anthropogenic edge (in km/yr) for the NWA. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055.

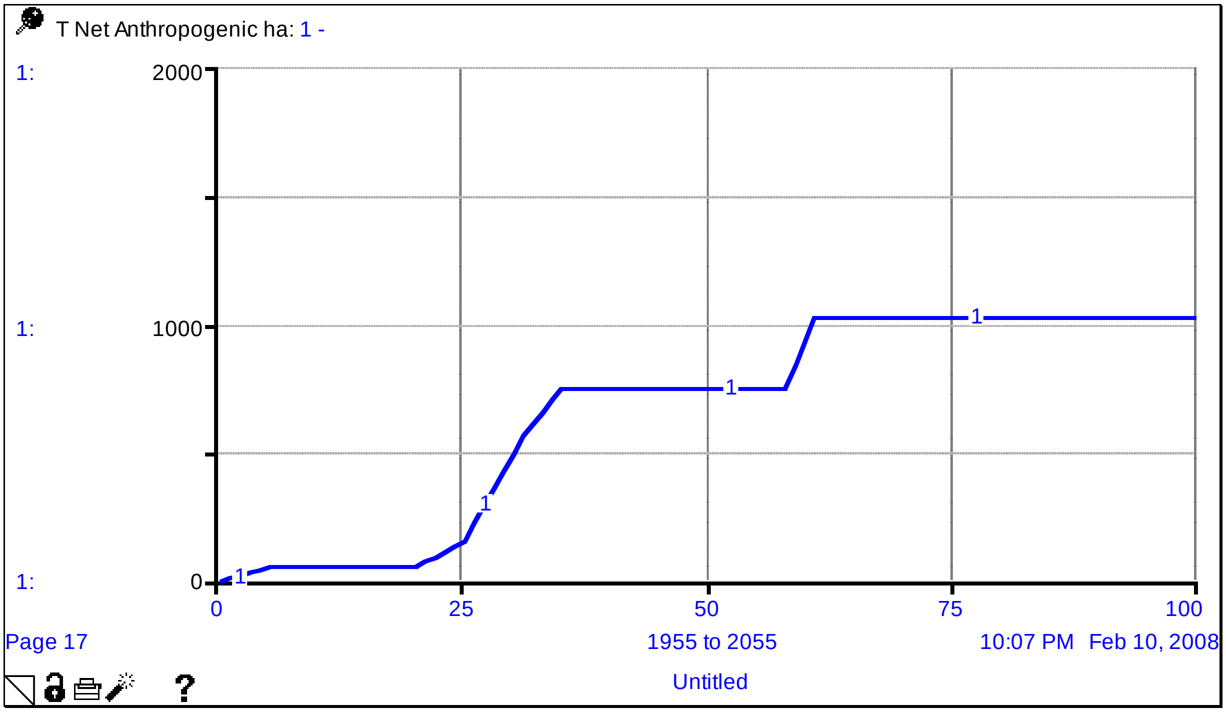

Figure 7. Total area (hectares) of the NWA present in direct footprint of the gas play. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055.

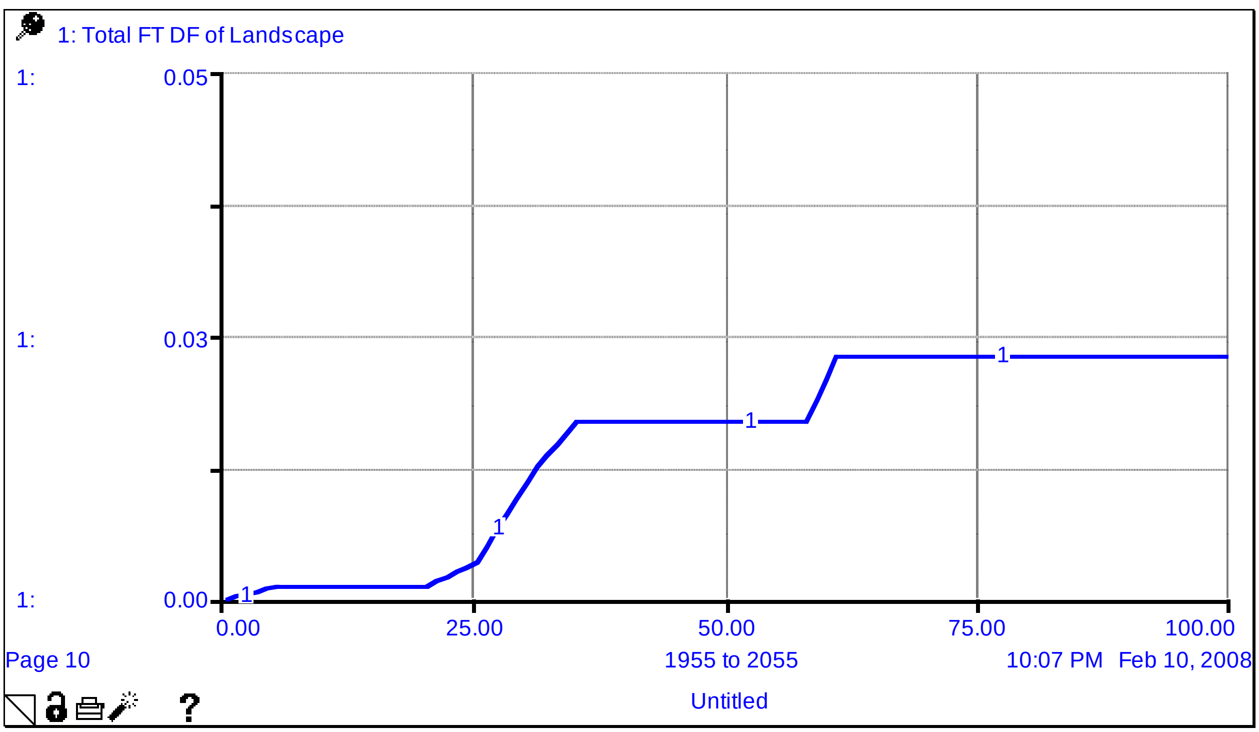

Figure 8. Total fraction of the NWA area present in direct footprint of the shallow gas play. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055.

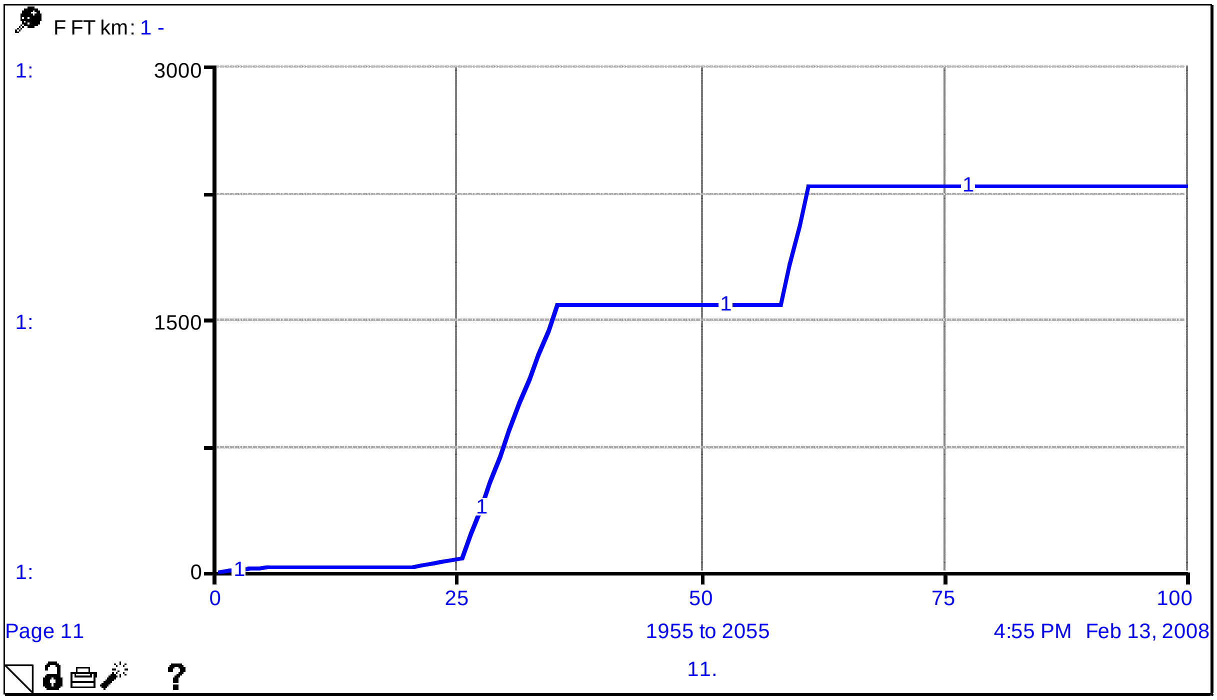

Figure 9. Simulated change in anthropogenic edge (in kilometers) for the NWA. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. This simulation is based on the assumption of no reclamation of existing or future footprint.

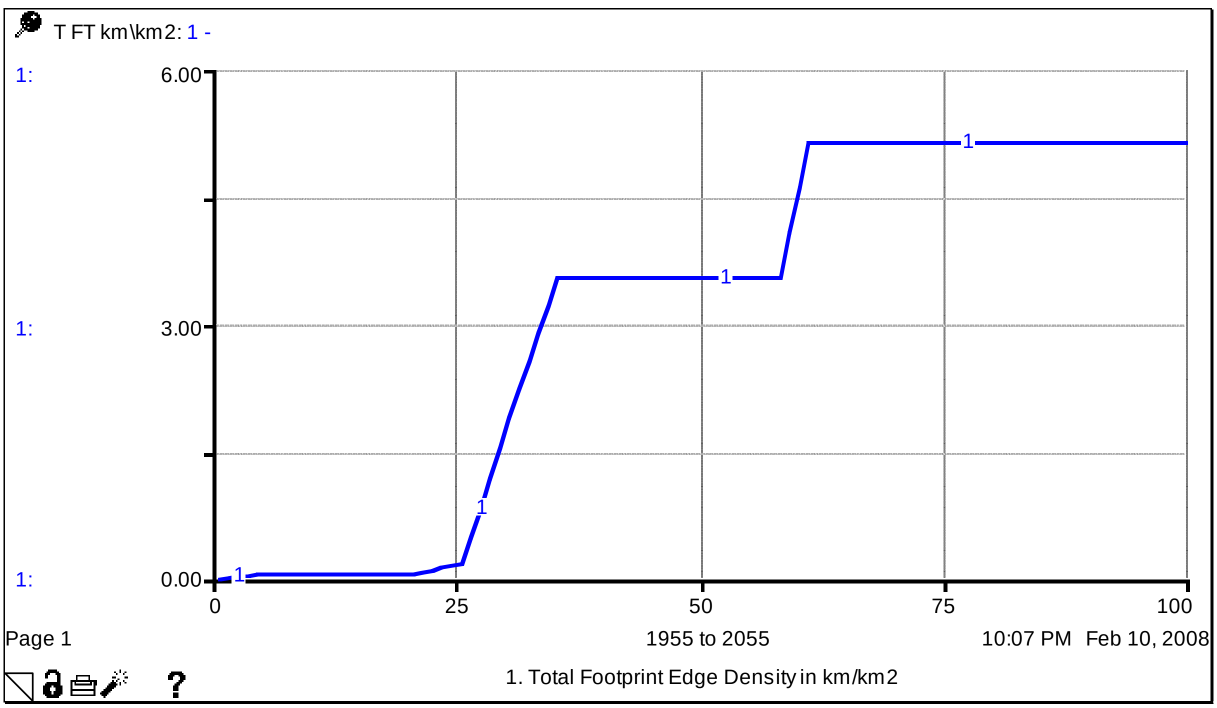

Figure 10. Simulated change in anthropogenic edge density (in kilometers/square kilometer) for the NWA. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. This simulation is based on the assumption of no reclamation of existing or future footprint.

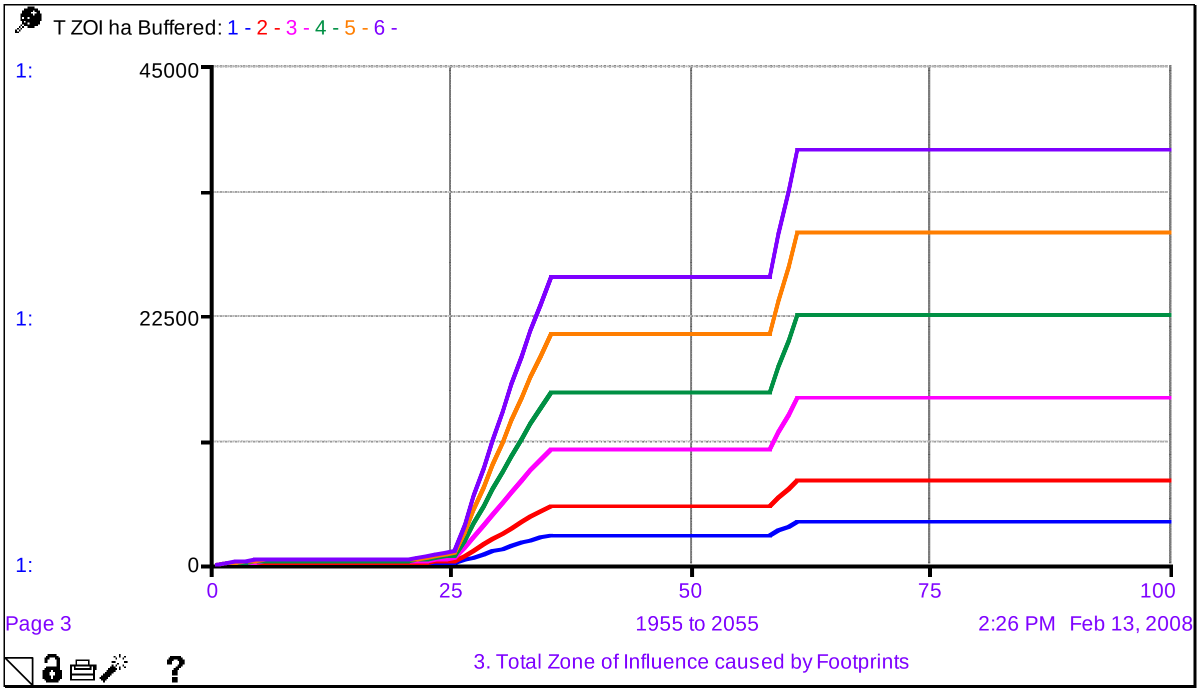

Figure 11. Total "zone of impact" of the gas play on the NWA (exclusive of actual footprint). Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. The buffer widths applied to the linear and polygonal footprints are 50 m (line 1), 100m (line 2), 200 m (line 3), 300 m (line 4), 400 m (line 5), and and 500 m (line 6). Note that Y axis scaled to the size of the NWA study area.

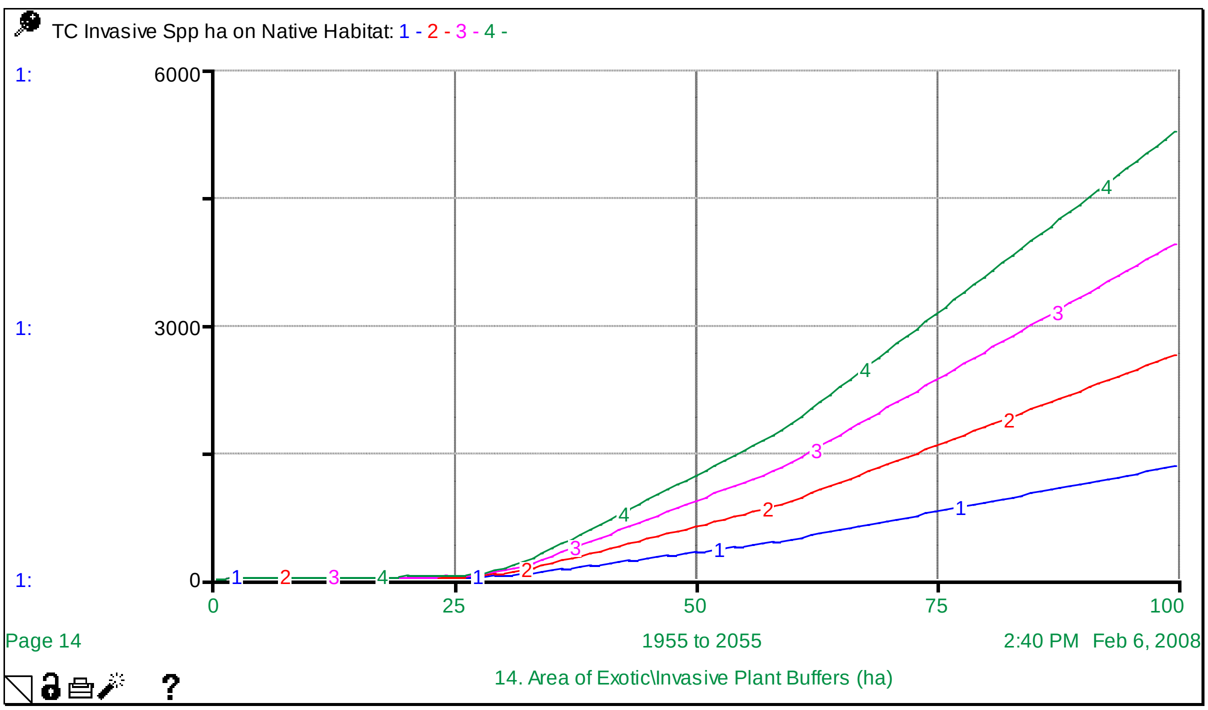

Figure 12. Area of exotic/invasive vegetation of the gas play on the NWA. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. The expansion rates of invasives applied to the linear and polygonal footprints are .1 m/yr (line 1), .2m/yr (line 2), .3m/yr (line 3), and .4m/yr (line 4).

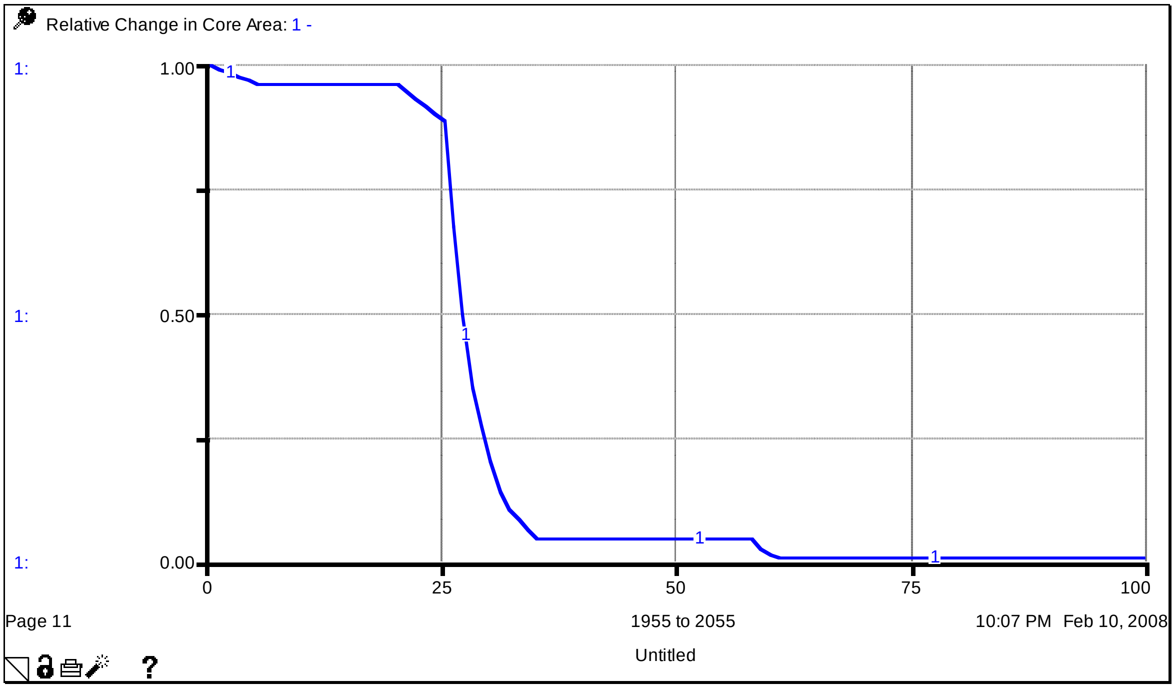

Figure 13. Simulated change in "core area" (minimum distance of 300 m from closest anthropogenic feature) of the gas play on the NWA. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. This simulation is based on the assumption of no reclamation of existing or future footprint.

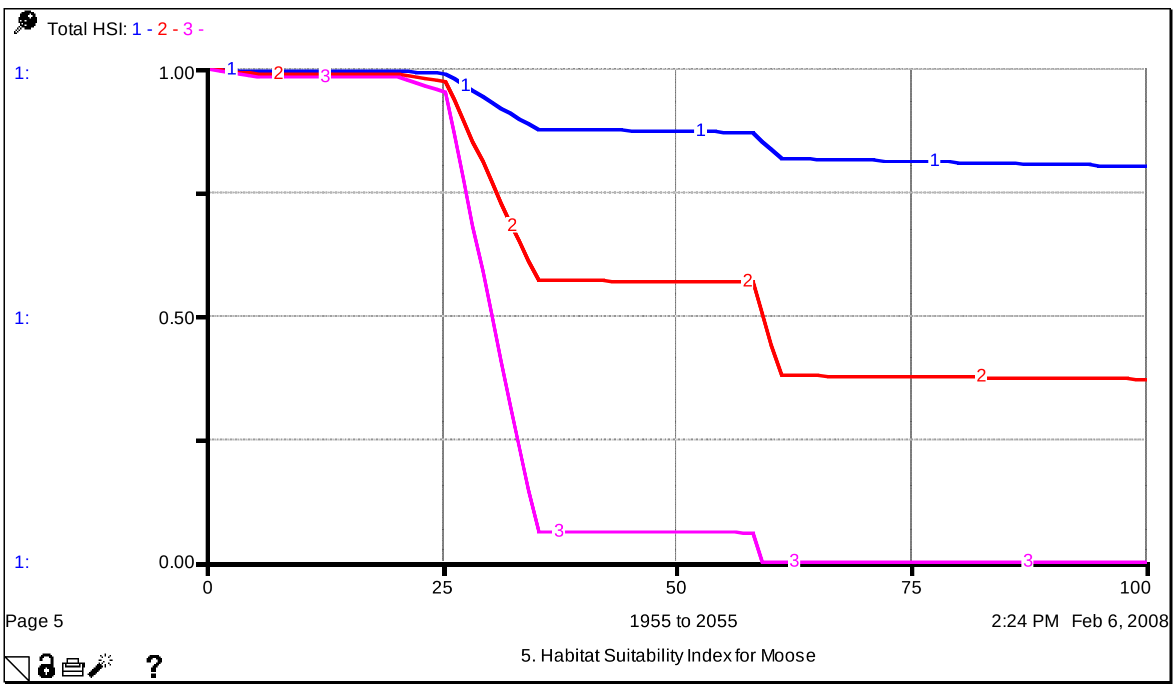

Figure 14. Changes in availability of native grassland habitat (indexed to 1) for a hypothetical edge sensitive grassland species, as depleted by buffers on anthropogenic features of 100m, 200m, and 300 m. Full non-use of buffers applied. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055.

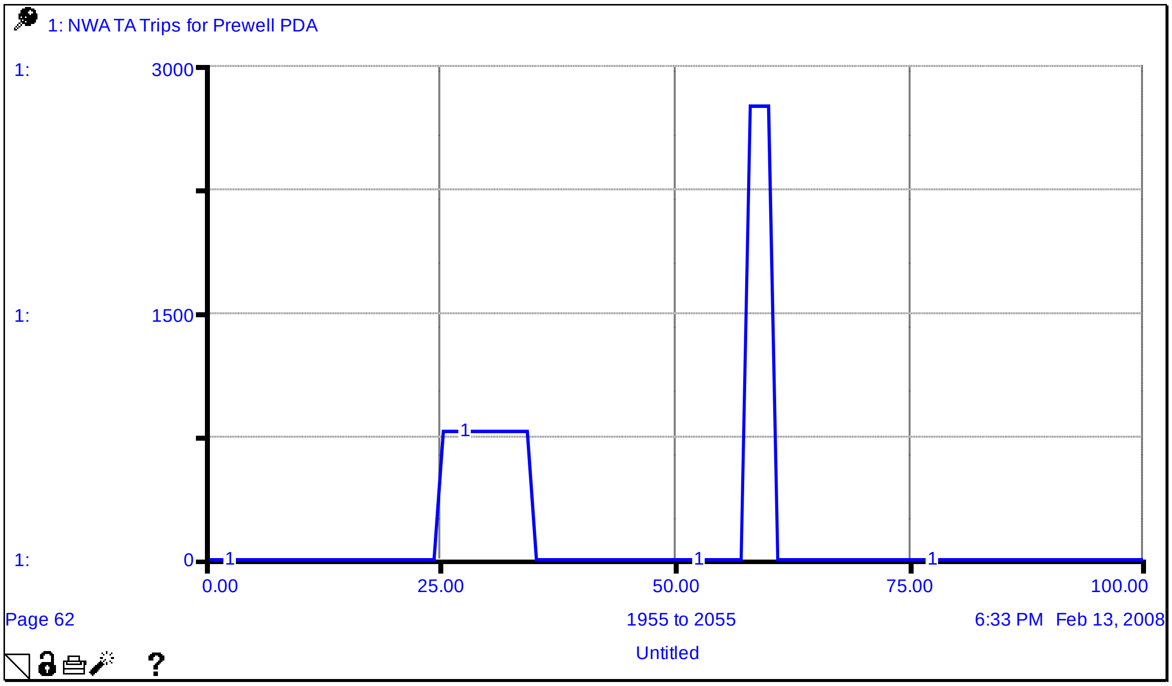

Figure 15. Simulated annual number of pre-drilling assessment trips (#/yr) to well locations for the NWA. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. This simulation is based on the assumption that level of pre-well assessment proposed for the infill also applied to the first phase of drilling.

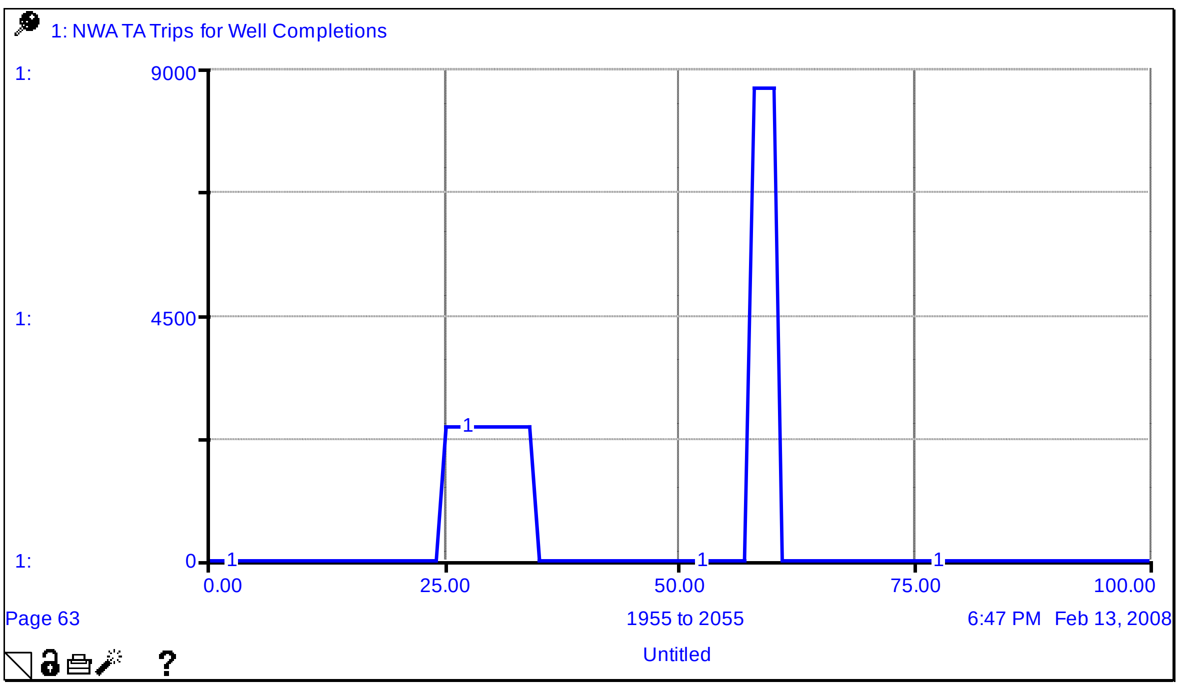

Figure 16. Simulated annual number of well completion trips (#/yr) to well locations for the NWA. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. This simulation is based on the assumption that level of pre-well assessment proposed for the infill also applied to the first phase of drilling.

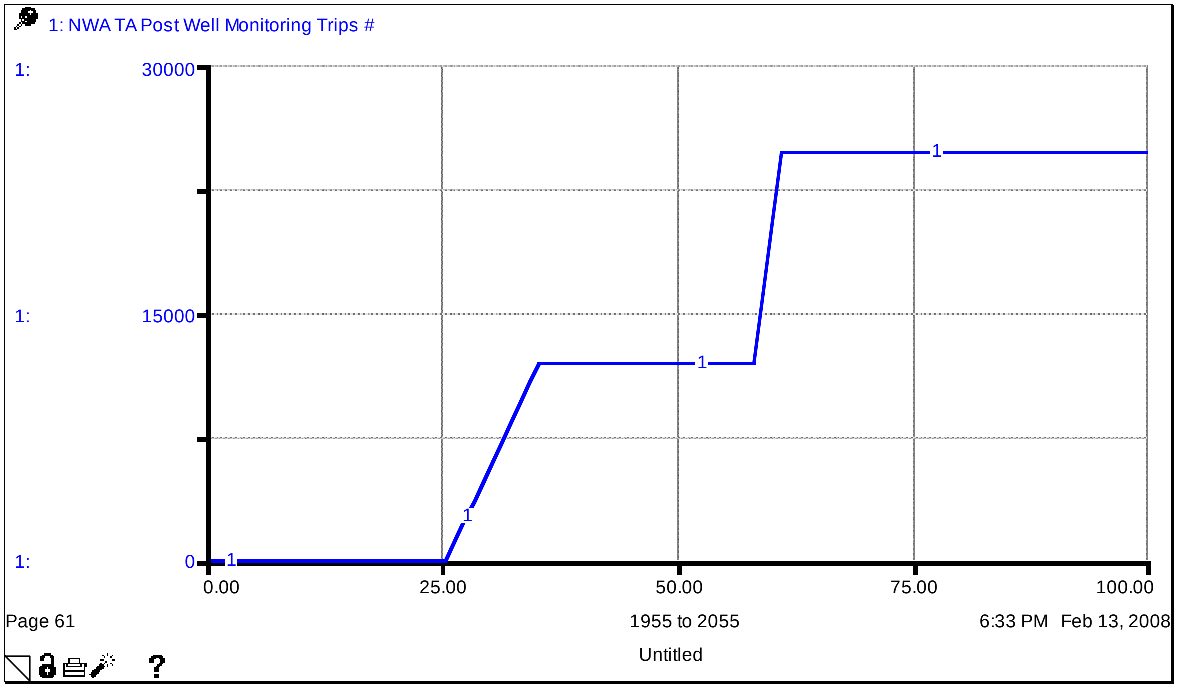

Figure 17. Simulated annual number of post-drilling monitoring trips (#/yr) to well locations for the NWA. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. This simulation is based on the assumption that level of pre-well assessment proposed for the infill also applied to the first phase of drilling.

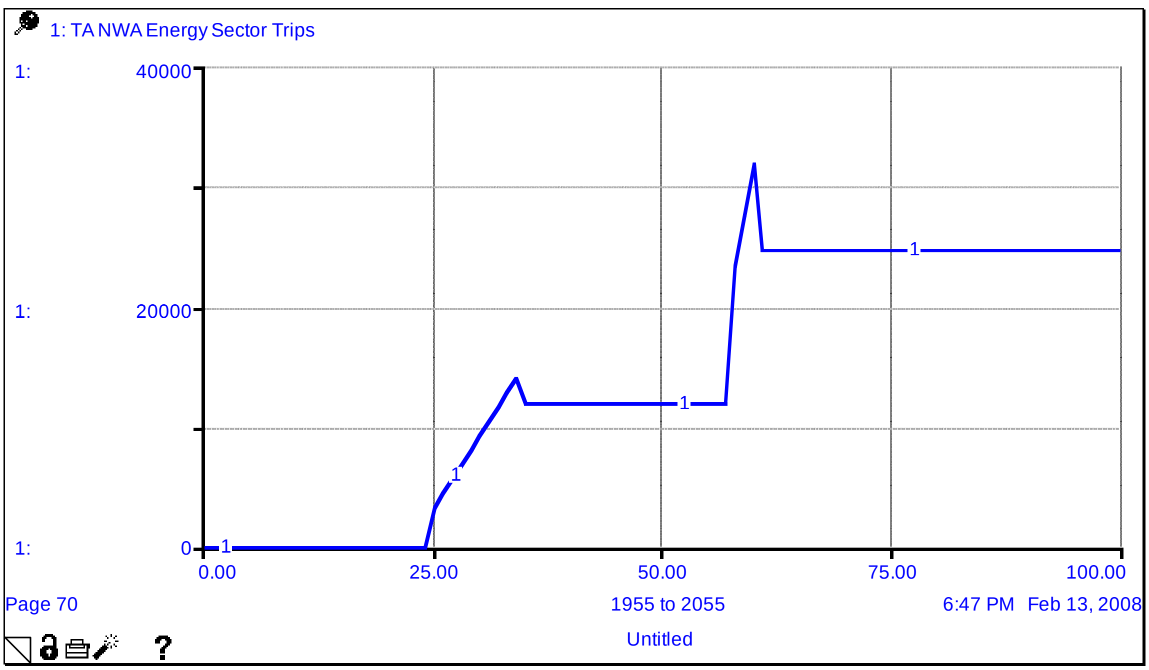

Figure 18. Simulated total annual number trips (#/yr) to well locations for the NWA. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. This simulation is based on the assumption that level of pre-well assessment proposed for the infill also applied to the first phase of drilling.

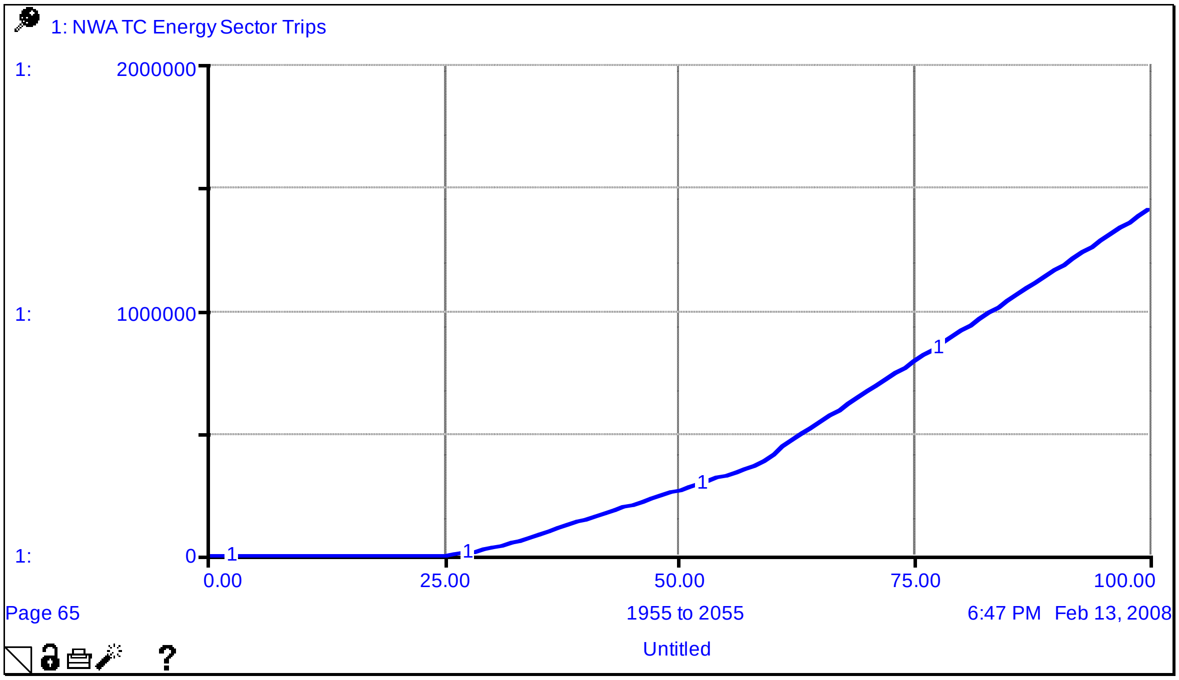

Figure 19. Simulated total cumulative number of trips (#/yr) to well locations for the NWA. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. This simulation is based on the assumption that level of pre-well assessment proposed for the infill also applied to the first phase of drilling.

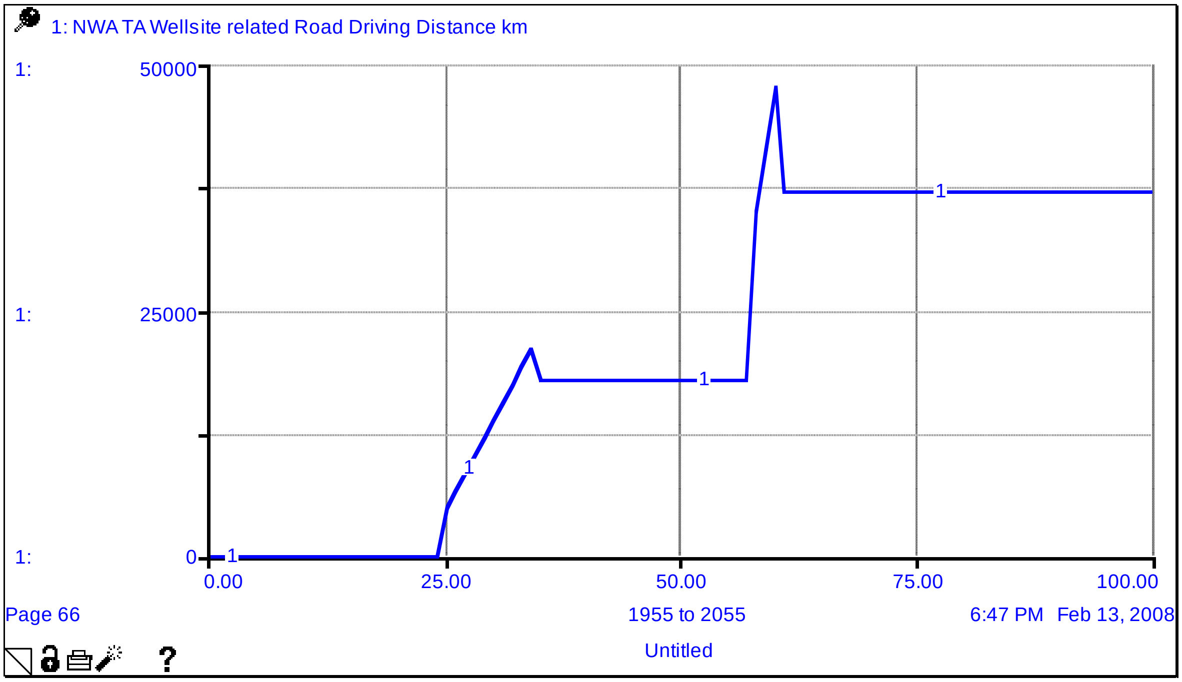

Figure 20. Simulated annual distance travelled (km/yr) along roads and truck trail in the NWA for activities related to shallow gas play. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. This simulation is based on the assumption that level of pre-well assessment proposed for the infill also applied to the first phase of drilling.

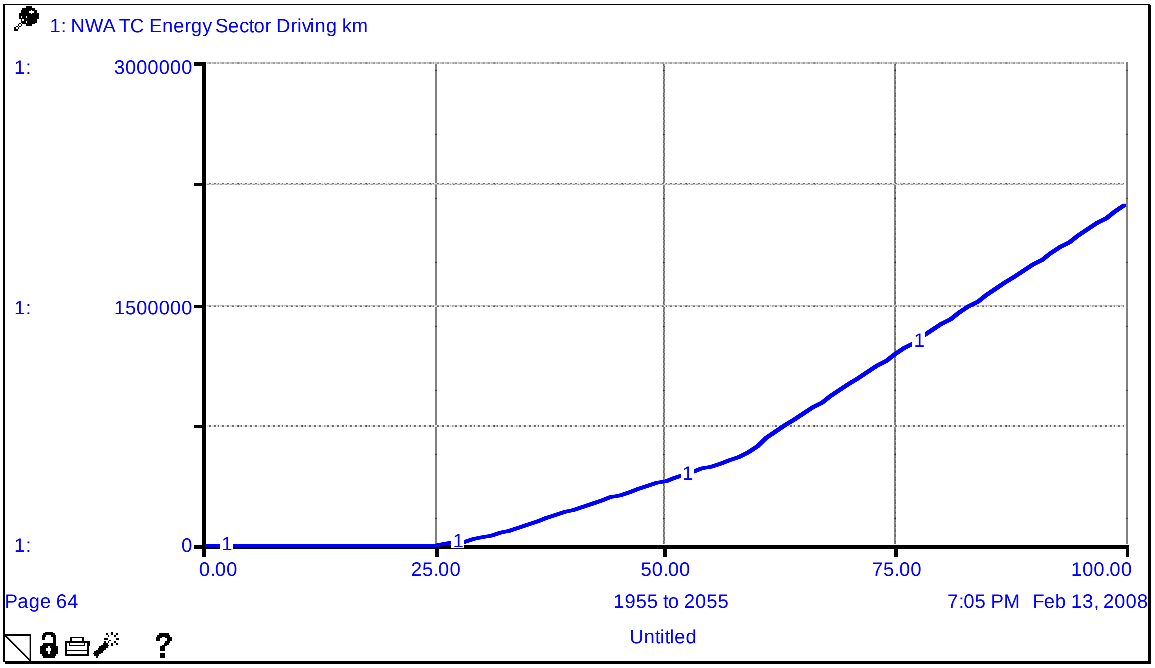

Figure 21. Simulated cumulative distance travelled (km) along roads and truck trail in the NWA for activities related to shallow gas play. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. This simulation is based on the assumption that level of pre-well assessment proposed for the infill also applied to the first phase of drilling.

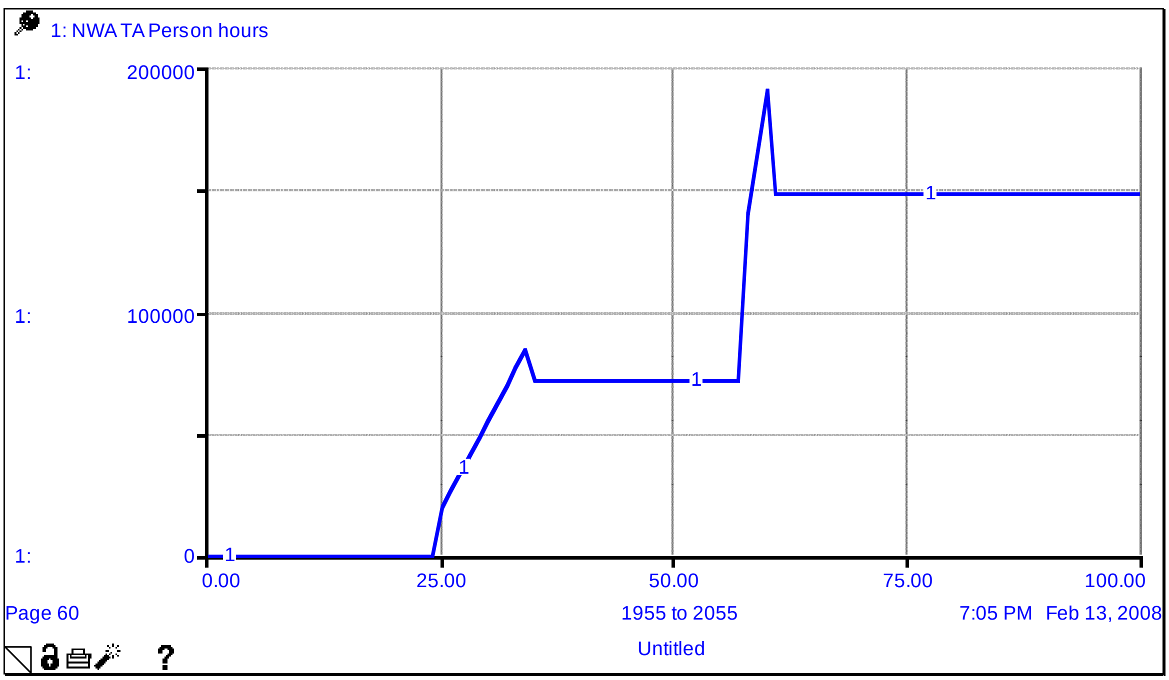

Figure 22. Simulated annual number of person-hours (#/yr) for the NWA associated with pre-drilling assessments, drilling completions, and post drilling monitoring. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. This simulation is based on the assumption that level of pre-well assessment proposed for the infill also applied to the first phase of drilling.

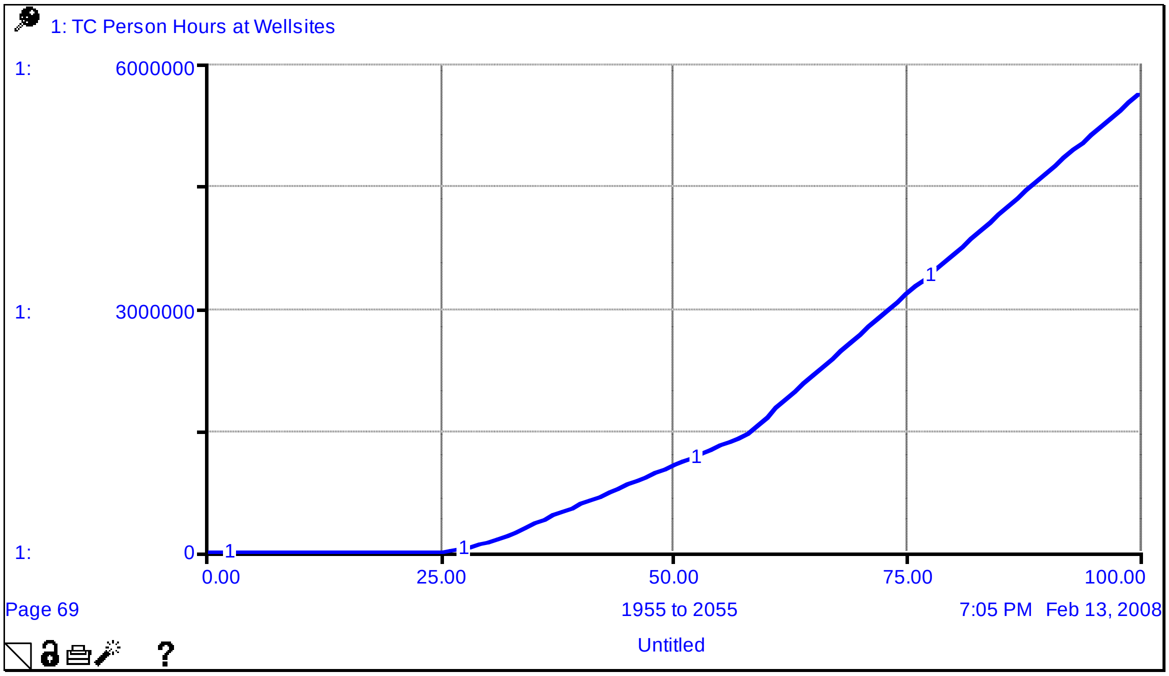

Figure 23. Simulated cumulative number of person-hours (#) at and near wellsite centres for the NWA. Years 0 to 50 refer to 1955 to 2005 and Years 50 to 100 refer to Years 2005 to 2055. This simulation is based on the assumption that level of pre-well assessment proposed for the infill also applied to the first phase of drilling.

7.Stelfox Resume

J. Brad Stelfox, Ph.D.

Landscape Ecologist
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(403) 949-3008 (office), 949-2663 (fax), (403) 689-3008 (mobile)
bstelfox@www.foremtech.com

Professional Interests

Sustainable Resource Management, Cumulative Effects Analyses, Carbon Pool Dynamics, Disturbance Regimes, Water Dynamics, Forest Ecosystem Management, University Instruction

Personal

Birth	March 14, 1958, Edmonton, Alberta, Canada
Status	Married; three children
Nationality	Canadian
Physical	Health, excellent; height, 180 cm; weight, 75 kg

Education

Ph.D. Wildlife Productivity and Management 1985	University of Alberta, Department of Animal Science, Edmonton, Canada. Title: Mixed-species game ranching in Kenya, East Africa.
B.Sc. Zoology 1980	University of Alberta, Department of Zoology, Edmonton, Canada

Research and Teaching Foci

Forest Ecosystem Management, Landscape Carbon Pool Dynamics, Cumulative Land Use Simulation Modelling, Climate Change Scenarios, Wildlife Management, Water Dynamics, Fire Ecology, Plant Ecology

Appointments & Experience (Since 1995)

2005- Current **Landscape / Landuse Systems Dynamics and Modeling (ALCES); Southern Upper Bow Basin Cumulative Effects Assessment Project**
Lead, cumulative effects assessment, Upper Bow Basin Cumulative Effects Assessment. Responsibilities include development of a landuse/landscape modeling approach for the client, and the modification of the ALCES model to incorporate relevant indicators, scenarios and response surfaces. Providing disciplinary leadership in water dynamics, plant community structure, forestry, energy, agriculture, and residential sectors.

2005- Current **Landscape / Landuse Systems Dynamics and Modeling (ALCES); Southern Foothills Study**
Lead, cumulative effects assessment, Southern Foothills Study. Responsibilities include development of a landuse/landscape modeling approach for the client, and the modification of the ALCES model to incorporate relevant indicators, scenarios and response surfaces. Providing disciplinary leadership in water dynamics, plant community structure, forestry, energy, agriculture, and residential sectors.

2004- Current **Landscape / Landuse Systems Dynamics and Modeling (ALCES); CEMA, Alberta**
Lead, Cumulative effects assessment. Responsibilities include development of a landuse/landscape modeling approach for the client, and the modification of the ALCES model to incorporate relevant indicators, scenarios and response surfaces.

2004- 2006 **Landscape / Landuse Systems Dynamics and Modeling (ALCES); NEI North Yukon**
Responsibilities include development of a landuse/landscape modeling approach for the client, and the modification of the ALCES model to incorporate relevant indicators, scenarios and response surfaces.

2004- 2006 **Landscape / Landuse Systems Dynamics and Modeling (ALCES); Kenai, Alaska**
Responsibilities include development of a landuse/landscape modeling approach for the client, and the modification of the ALCES model to incorporate relevant indicators, scenarios and response surfaces.

2004- Current **Adjunct Professor, Department of Biological Sciences, University of Alberta**
Responsibilities include membership on graduate student committees and invited lecturer on issues of landuse management and wildlife biology.

2003 - 2006 **Advisor, Integrated Resource, Integrated Land Management Program, Alberta Research Council**
Responsibilities include training ARC personnel in the use of the ALCES landscape model, and in guiding the development and implementation of ARC ILM Program.

2003 - Current **Adjunct Associate Professor, Faculty of Environmental Design, Univ. of Calgary**
Responsibilities include membership on graduate student committees and invited lecturer on issues of landuse management and wildlife biology.

2002 – 2005 **Southern Alberta Sustainability Strategy Cumulative Effects Initiative**
Lead, Cumulative Effects Assessment. Responsible for the implementation of the ALCES model as a landscape simulator to assess the risks and opportunities associated with different landuse scenarios for the southern Alberta regional landscape.

2001 – 2003 **North-East Slopes Regional Cumulative Effects Initiative**
Lead, Cumulative Effects Assessment. Responsible for the implementation of the ALCES model as a landscape simulator to assess the risks and opportunities associated with different landuse scenarios for the north-east slopes regional landscape.

2000 – Current **Member, Adaptive Management Experiment (AME) Research Unit**
Responsibilities include development of a long-term active adaptive management framework for an industry-sponsored (Alberta-Pacific Forest Industries Inc.) research initiative in the boreal forest landscape of Alberta. Primary objectives are to discover, articulate and implement best management approaches to landuses in the boreal forest.

1999 – 2000 **Member, Alberta Endangered Species Scientific Advisory Committee**
Responsible for reviewing status of selected biota in Alberta and providing advice to the Government of Alberta concerning population status.

1998 - Current **Developer of ALCES (A Landscape Cumulative Effects Simulator)**
Funded by WEPA (Western Economic Partnership Agreement), the Government of Alberta, and Alberta-Pacific Forest Industries, Stelfox has continued development of the ALCES model. This model is becoming widely adopted by government, industry and the environmental community as an effective tool for exploring issues of landscape and resource use sustainability.

1997 - 1999 **Director of the Board, Alberta Conservation Association**
Served as a board member representing the scientific community and the public at large.

1995 - Current **Forest Landscape Ecologist, Forem Technologies Ltd.**
Senior ecologist working on boreal, parkland, and prairie ecosystem management and cumulative effects projects. Past projects involve development of forest ecosystem management plans for Daishowa-Marubeni International, Peace River, Alberta-Pacific Forest Industries Inc, Athabasca, Sunpine Forest Products, Northern East Slopes, Southern Alberta Sustainability Strategy. Developed the spatially stratified simulation model "Alberta Landscape Cumulative Effects Simulator" to track past, present and future changes to forest landscapes caused by human landuse practices.

Awards and Recognitions

2007	Finalist, Alberta Emerald Award in the "Community Involvement" Category
2004	Recipient, Alberta Emerald Award in the "Research and Innovation" Category
2002	Recipient, Al-Pac/ASTech Innovation in Integrated Landscape Management Prize
2002	Finalist, Alberta Emerald Award in the "Research and Innovation" Category
2001	Finalist, Al-Pac/ASTech Innovation in Integrated Landscape Management Prize
1997	Distinguished Service Award, The Wildlife Society, Alberta Chapter
1987	Stelfox Scholarship Fund, School for Field Studies, Beverly, Massachusetts
1985	Province of Alberta Graduate Scholarship.
1981-1983	National Sciences and Engineering Research Council Graduate Scholarship.

Publications

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Stelfox, J.B. 2004. Alberta's Boreal Forest – A landscape in transition: Implications for sustainable landscapes and landuse. Pp. 35-50. In The Human Ecological Footprint. The Kenneth Hammond Lectures on Environment, Energy and Resources 2002 Series. Faculty of Environmental Sciences, University of Guelph.

Stelfox, J.B., R.M. Levy, and H. Gariepy. A comparison of urban footprint associated with alternative growth strategies for the City of Edmonton (2000-2030). Prepared for the City of Edmonton Planning Department. April, 2004.

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