Current and Future Biodiversity Intactness Assessment of the OSLI LEAP Project

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Background Information

The Alberta Biodiversity Monitoring Institute (ABMI) has developed a metric of biodiversity intactness that assesses the state of biodiversity across Alberta (Nielsen et al., 2007; ABMI 2012). Biodiversity intactness is calculated for each quarter-section of land as a percentage from 0% to 100%, and represents the difference in species abundances between current landscape conditions and reference conditions (*i.e.* if no anthropogenic footprint were present). Both decreases and increases in abundance relative to reference conditions contribute to reduced intactness (i.e. overabundant species are considered to reduce intactness). Intactness is calculated for individual species (including birds, vascular plants, mosses, soil mites, and mammals; see Appendix 1 for full species list) based on their statistically modelled responses to human footprint and other landscape elements, and then averaged across all species present to obtain an overall biodiversity intactness value.

ABMI's *Ecosystem Services Assessment* project is assessing how several ecological indicators, including biodiversity intactness, respond to land management activities such as restoration of human footprint features. The Oil Sands Leadership Initiative (OSLI) has conducted restoration work on seismic lines in the Algar region. As the ecological communities on these restored seismic lines recover, the biodiversity intactness of the Algar region will increase. Although the exact timeline and recovery trajectory are uncertain, ABMI can assess the expected future increase in biodiversity intactness of the Algar region attributable to seismic line removal, under the assumption of successful restoration on all treated lines.

Methods

We used current and future landcover GIS layers to assess biodiversity intactness before and following restoration work on selected seismic lines in the 6 townships of the Algar study region. Landcover data layers include information on dominant vegetation category, forest stand age and composition, upland or wetland type, and human footprint features. For the future analysis, selected seismic lines were removed from the landcover layer, and those areas were backfilled with the appropriate vegetation category (Figure 1). For each quarter-section, we summarized the area covered by each landcover type (vegetation or human footprint category) before and after seismic line restoration. Note that this assumes complete removal of seismic lines, although the likelihood of complete removal is unknown. If this assumption is met, this restoration work will reduce the human footprint area by 12.8%. However, due to the low levels of footprint currently observed in the study area, this only represents a decrease from 2.51% to 2.20% in the proportion of the region covered by human footprint.

Species intactness is calculated as the ratio of predicted species abundance under observed footprint conditions compared to reference footprint conditions, expressed as a percentage; values <1 represent

species that have declined under observed footprint conditions, and values >1 represent species that have increased. Ratios >1 are converted to a percentage between 0-100% for ease of comparison with species that decrease in abundance. Intactness analyses are run as a bootstrapped procedure with 100 iterations performed for each species abundance model (original data are resampled 100 times with replacement, and the entire analysis is replicated for each iteration; ABMI 2012). We report the median and 90% confidence intervals of intactness for each taxon (birds, plants, mosses, mites, and mammals), plus overall biodiversity intactness.

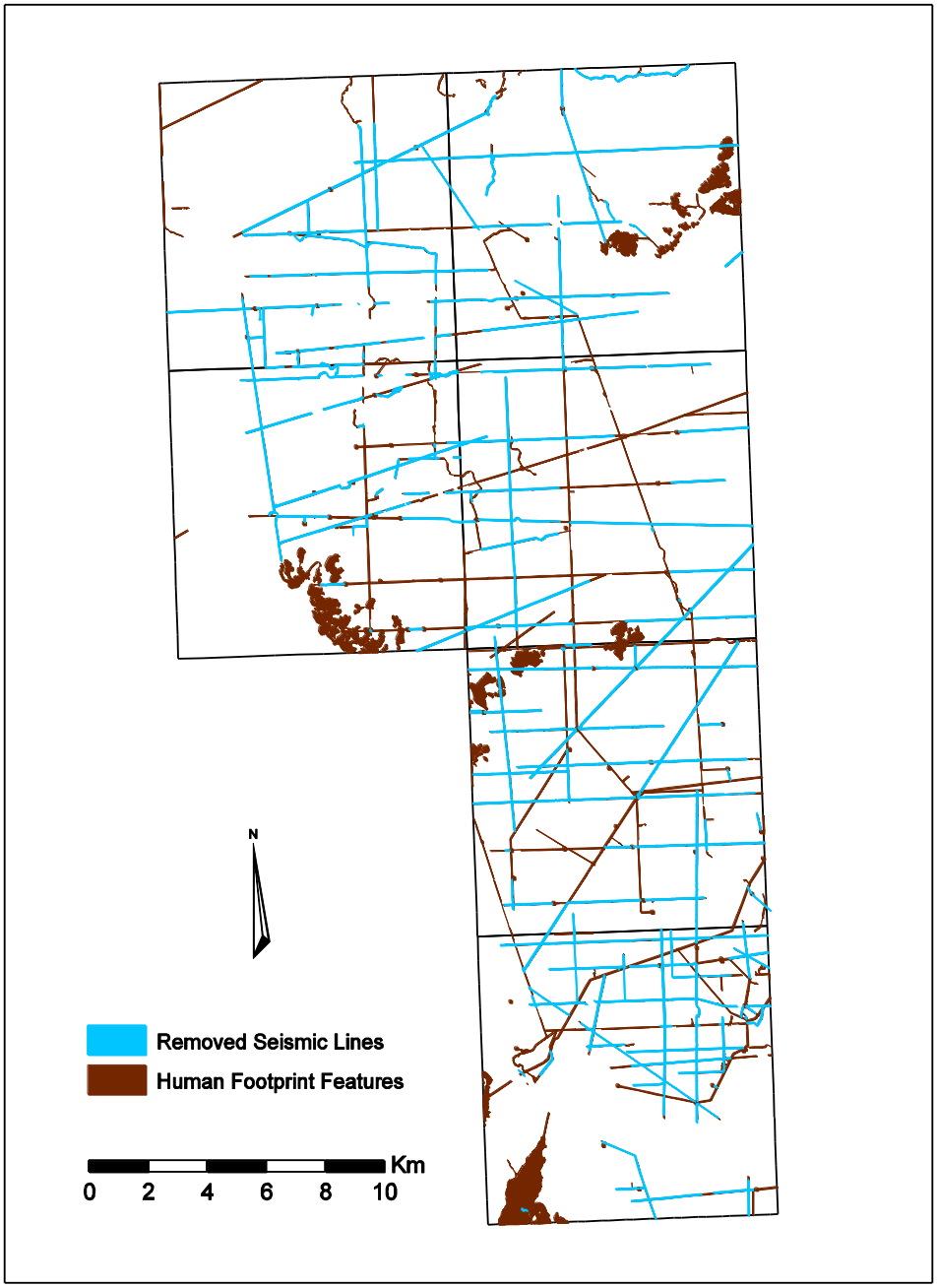

Figure 1. Human footprint features in the Algar study region, highlighting seismic lines being restored via the OSLI LEAP project.

Results and Discussion

Current biodiversity intactness in the Algar region is relatively high for all taxa analyzed, ranging from 92.56% for vascular plants to 97.64% for mammals, with an overall intactness across all taxa at 95.96% (Table 1). However, intactness is calculated as a ratio where values >1 are also considered to represent a loss of intactness, and upper confidence limits often exceeded this threshold; that is, species were predicted to be overabundant relative to reference conditions, leading to lower intactness values. For example, the median intactness value for mammals was 97.64%, with a lower CI of 97.12% and upper CI of 96.64%; the upper CI represents a ratio greater than 1 (*i.e.* overabundance), which is why the reported upper CI for intactness is actually *lower* than the median or lower CI values (Table 1).

Seismic line removal was predicted to increased biodiversity intactness by 0.77% for all taxa combined, with some taxa responding more strongly than others; vascular plant intactness increased by 1.01%, while mammal intactness only increased by 0.37% (Table 2). This variability is expected, as each species responds differently to seismic lines. It should also be noted that many rare (or otherwise difficult to monitor) species are not included in this analysis, such as woodland caribou. A full list of species included in the biodiversity intactness analysis is provided in Appendix 1.

Table 1. Predicted current intactness values for five taxa in the Algar study region. Included are the median value of 100 bootstrapped iterations and the 90% confidence intervals. Intactness values where species were overabundant relative to reference conditions are indicated with the symbol OA.

Taxon	Predicted Intactness: Current	Lower 90% Confidence Interval	Upper 90% Confidence Interval
Birds	96.47% (OA)	95.22%	87.44% (OA)
Plants	92.56% (OA)	91.27%	81.55% (OA)
Mites	96.81%	88.30%	93.61%
Mosses	96.32%	90.24%	95.25% (OA)
Mammals	97.64%	97.12%	96.64% (OA)
ALL	**95.96% (OA)**	**92.43%**	**90.90% (OA)**

Table 2. Predicted change in intactness for 5 taxa in the Algar study region. Included are the median value of 100 bootstrapped iterations and the 90% confidence intervals.

Taxon	Change in Predicted Intactness	Lower 90% Confidence Interval	Upper 90% Confidence Interval
Birds	0.87%	0.59%	1.22%
Plants	1.01%	0.79%	1.27%
Mites	0.79%	0.35%	1.34%
Mosses	0.80%	0.50%	1.25%
Mammals	0.37%	0.26%	0.52%
ALL	**0.77%**	**0.50%**	**1.12%**

References

Alberta Biodiversity Monitoring Institute. 2012. Manual for Estimating Species and Habitat Intactness at the Regional Scale. Version 2012-12-04. Alberta Biodiversity Monitoring Institute, Edmonton, AB. Available from abmi.ca (accessed November 2013)

Nielsen, S.E., E.M. Bayne, J. Schieck, J. Herbers, and S. Boutin. 2007. A new method to estimate species and biodiversity intactness using empirically derived reference conditions. *Biological Conservation* 37:403-414.

Appendix 1: Species Analyzed

Birds			
Alder Flycatcher	Canada Warbler	Least Flycatcher	Ruby-crowned Kinglet
American Crow	Cape May Warbler	Le Conte's Sparrow	Ruffed Grouse
American Goldfinch	Cedar Waxwing	Lesser Yellowlegs	Rusty Blackbird
American Redstart	Chipping Sparrow	Lincoln's Sparrow	Savannah Sparrow
American Robin	Clay-colored Sparrow	Magnolia Warbler	Solitary Sandpiper
Bank Swallow	Common Raven	Mourning Warbler	Song Sparrow
Barn Swallow	Common Yellowthroat	Northern Flicker	Sora
Bay-breasted Warbler	Connecticut Warbler	Northern Waterthrush	Spotted Sandpiper
Black and White Warbler	Dark-eyed Junco	Olive-sided Flycatcher	Swainson's Thrush
Black-billed Magpie	Evening Grosbeak	Orange-crowned Warbler	Swamp Sparrow
Black-capped Chickadee	Fox Sparrow	Ovenbird	Tennessee Warbler
Blackpoll Warbler	Golden-crowned Kinglet	Palm Warbler	Tree Swallow
Black-throated Green Warbler	Gray Jay	Pileated Woodpecker	Vesper Sparrow
Blue-headed Vireo	Greater Yellowlegs	Pine Siskin	Warbling Vireo
Blue Jay	Hairy Woodpecker	Red-breasted Nuthatch	Western Tanager
Boreal Chickadee	Hermit Thrush	Red-eyed Vireo	Western Wood-pewee
Brewer's Blackbird	House Wren	Red-winged Blackbird	White-throated Sparrow
Brown Creeper	Killdeer	Rose-breasted Grosbeak	White-winged Crossbill
Brown-headed Cowbird			

Vascular Plants			
Abies balsamea	*Corylus cornuta*	*Lycopodium complanatum*	*Rosa woodsii*
Achillea alpina	*Crepis tectorum*	*Lycopodium dendroideum*	*Rubus arcticus*
Achillea millefolium	*Delphinium glaucum*	*Maianthemum canadense*	*Rubus chamaemorus*
Actaea rubra	*Deschampsia cespitosa*	*Maianthemum stellatum*	*Rubus idaeus*
Adoxa moschatellina	*Drosera rotundifolia*	*Maianthemum trifolium*	*Rubus pubescens*
Agrostis scabra	*Dryopteris expansa*	*Matricaria discoidea*	*Rumex occidentalis*
Alnus incana	*Elymus repens*	*Medicago sativa*	*Salix arbusculoides*
Alnus viridis	*Elymus trachycaulus*	*Melilotus alba*	*Salix bebbiana*
Alopecurus aequalis	*Empetrum nigrum*	*Melilotus officinalis*	*Salix discolor*
Amelanchier alnifolia	*Epilobium ciliatum*	*Mertensia paniculata*	*Salix glauca*

Andromeda polifolia	*Epilobium palustre*	*Mitella nuda*	*Salix maccalliana*
Apocynum androsaemifolium	*Equisetum arvense*	*Moehringia lateriflora*	*Salix myrtillifolia*
Aralia nudicaulis	*Equisetum fluviatile*	*Moneses uniflora*	*Salix pedicellaris*
Arctostaphylos uva ursi	*Equisetum hyemale*	*Orthilia secunda*	*Salix petiolaris*
Arnica cordifolia	*Equisetum pratense*	*Osmorhiza depauperata*	*Salix planifolia*
Astragalus americanus	*Equisetum scirpoides*	*Packera paupercula*	*Salix pseudomyrsinites*
Beckmannia syzigachne	*Equisetum sylvaticum*	*Parnassia palustris*	*Salix pyrifolia*
Betula glandulosa	*Eriophorum vaginatum*	*Pedicularis labradorica*	*Salix scouleriana*
Betula neoalaskana	*Eurybia conspicua*	*Petasites frigidus*	*Schizachne purpurascens*
Betula papyrifera	*Festuca rubra*	*Phleum pratense*	*Scirpus microcarpus*
Betula pumila	*Fragaria vesca*	*Picea glauca*	*Scutellaria galericulata*
Bromus ciliatus	*Fragaria virginiana*	*Picea mariana*	*Shepherdia canadensis*
Bromus inermis	*Galeopsis tetrahit*	*Pinus banksiana*	*Sibbaldiopsis tridentata*
Calamagrostis canadensis	*Galium boreale*	*Pinus contorta*	*Solidago canadensis*
Calamagrostis stricta	*Galium trifidum*	*Piptatherum pungens*	*Solidago multiradiata*
Caltha palustris	*Galium triflorum*	*Plantago major*	*Sonchus arvensis*
Campanula rotundifolia	*Geocaulon lividum*	*Platanthera hyperborea*	*Spiranthes romanzoffiana*
Carex aquatilis	*Geranium bicknellii*	*Platanthera obtusata*	*Stellaria longifolia*
Carex aurea	*Geum aleppicum*	*Platanthera orbiculata*	*Stellaria longipes*
Carex bebbii	*Geum macrophyllum*	*Poa palustris*	*Symphoricarpos albus*
Carex brunnescens	*Geum rivale*	*Poa pratensis*	*Symphoricarpos occidentalis*
Carex canescens	*Goodyera repens*	*Polemonium acutiflorum*	*Symphyotrichum ciliolatum*
Carex diandra	*Gymnocarpium dryopteris*	*Populus balsamifera*	*Symphyotrichum puniceum*
Carex disperma	*Halenia deflexa*	*Populus tremuloides*	*Taraxacum officinale*
Carex foenea	*Heracleum maximum*	*Potentilla norvegica*	*Thalictrum venulosum*
Carex gynocrates	*Hieracium umbellatum*	*Prosartes trachycarpa*	*Thlaspi arvense*
Carex magellanica	*Hordeum jubatum*	*Prunus pensylvanica*	*Trientalis borealis*
Carex siccata	*Juncus arcticus*	*Prunus virginiana*	*Trifolium hybridum*
Carex utriculata	*Kalmia polifolia*	*Pyrola asarifolia*	*Trifolium pratense*
Carex vaginata	*Larix laricina*	*Pyrola chlorantha*	*Trifolium repens*
Castilleja miniata	*Lathyrus ochroleucus*	*Ranunculus lapponicus*	*Typha latifolia*
Chamaedaphne calyculata	*Lathyrus venosus*	*Ranunculus macounii*	*Urtica dioica*
Chamerion angustifolium	*Leymus innovatus*	*Rhinanthus minor*	*Vaccinium caespitosum*
Chenopodium album	*Lilium philadelphicum*	*Rhododendron*	*Vaccinium myrtilloides*

		groenlandicum	
Cicuta maculata	*Linnaea borealis*	*Ribes glandulosum*	*Vaccinium oxycoccos*
Circaea alpina	*Listera cordata*	*Ribes hudsonianum*	*Vaccinium vitis idaea*
Cirsium arvense	*Lonicera caerulea*	*Ribes lacustre*	*Viburnum edule*
Comarum palustre	*Lonicera dioica*	*Ribes oxyacanthoides*	*Vicia americana*
Corallorrhiza trifida	*Lonicera involucrata*	*Ribes triste*	*Viola canadensis*
Cornus canadensis	*Luzula parviflora*	*Rosa acicularis*	*Viola renifolia*
Cornus sericea	*Lycopodium annotinum*		

Mites			
Achipteria coleoptrata	*Diapterobates humeralis*	*Nanhermannia sp 1*	*Platynothrus peltifer*
Achipteria sp 1	*Eniochthonius crosbyi*	*Neogymnobates luteus*	*Platynothrus yamasakii*
Allosuctobelba sp 2	*Epidamaeus arcticola*	*Neonothrus humicola*	*Propelops alaskensis*
Anachipteria howardi	*Epidamaeus coxalis*	*Neoribates aurantiacus*	*Protoribates haughlandae*
Anachipteria sp 1	*Epidamaeus floccosus*	*Nothrus borussicus*	*Quatrobelba montana*
Atropacarus striculus	*Epidamaeus sp 2*	*Nothrus pratensis*	*Rhysotritia ardua*
Camisia biurus	*Eremaeus translamellatus*	*Nothrus sp B*	*Roynortonella sp 1*
Carabodes granulatus	*Eueremaeus marshalli*	*Oribatodes mirabilis*	*Scheloribates pallidulus*
Carabodes labyrinthicus	*Eueremaeus quadrilamellatus*	*Oribatula sp 1*	*Scutozetes lanceolatus*
Cepheus sp 1	*Euphthiracarus flavus*	*Peloribates canadensis*	*Sphaerozetes arcticus*
Ceratoppia quadridentata arctica	*Gymnodamaeus ornatus*	*Peloribates pilosus*	*Tectocepheus sarekensis*
Ceratozetes cuspidatus	*Heminothrus longisetosus*	*Pergalumna sp 1*	*Tectocepheus velatus*
Ceratozetes gracilis	*Hermanniella robusta*	*Phthiracarus borealis*	*Tegoribates americanus*
Ceratozetes thienemanni	*Hydrozetes sp E*	*Phthiracarus boresetosus*	*Trhypochthonius tectorum*
Chamobates cuspidatus	*Hypochthonius rufulus*	*Pilogalumna sp 1*	*Unduloribates dianae*
Dentizetes ledensis	*Mycobates incurvatus*		

Mosses			
Amblystegium serpens	*Dicranum scoparium*	*Mylia anomala*	*Sanionia uncinata*
Anastrophyllum hellerianum	*Dicranum undulatum*	*Oncophorus wahlenbergii*	*Sarmentypnum exannulatum*
Aulacomnium palustre	*Drepanocladus aduncus*	*Plagiomnium cuspidatum*	*Scapania glaucocephala*
Blepharostoma	*Eurhynchiastrum*	*Plagiomnium*	*Sphagnum*

trichophyllum	*pulchellum*	*drummondii*	*angustifolium*
Calliergon cordifolium	*Funaria hygrometrica*	*Plagiomnium ellipticum*	*Sphagnum capillifolium*
Calliergon giganteum	*Geocalyx graveolens*	*Plagiomnium medium*	*Sphagnum fuscum*
Calypogeia sphagnicola	*Hamatocaulis vernicosus*	*Plagiothecium denticulatum*	*Sphagnum girgensohnii*
Campyliadelphus chrysophyllus	*Haplocladium microphyllum*	*Plagiothecium laetum*	*Sphagnum magellanicum*
Campylium stellatum	*Helodium blandowii*	*Platydictya jungermannioides*	*Sphagnum russowii*
Campylophyllum hispidulum	*Herzogiella turfacea*	*Platygyrium repens*	*Sphagnum squarrosum*
Cephalozia connivens	*Hylocomium splendens*	*Pleurozium schreberi*	*Sphagnum warnstorfii*
Cephalozia lunulifolia	*Hypnum lindbergii*	*Pohlia nutans*	*Straminergon stramineum*
Cephalozia pleniceps	*Hypnum pratense*	*Polytrichum commune*	*Tetraphis pellucida*
Ceratodon purpureus	*Jamesoniella autumnalis*	*Polytrichum juniperinum*	*Tetraplodon angustatus*
Chiloscyphus pallescens	*Lepidozia reptans*	*Polytrichum piliferum*	*Thuidium recognitum*
Chiloscyphus polyanthos	*Leptobryum pyriforme*	*Polytrichum strictum*	*Tomentypnum nitens*
Climacium dendroides	*Lophocolea heterophylla*	*Ptilidium ciliare*	*Tritomaria exsectiformis*
Dicranum acutifolium	*Lophocolea minor*	*Ptilidium pulcherrimum*	*Brachythecium*
Dicranum elongatum	*Lophozia excisa*	*Ptilium crista castrensis*	*Bryum*
Dicranum flagellare	*Lophozia heterocolpos*	*Pylaisia polyantha*	*Cephaloziella*
Dicranum fragilifolium	*Lophozia ventricosa*	*Rhizomnium gracile*	*Plagiochila*
Dicranum fuscescens	*Marchantia polymorpha*	*Riccardia latifrons*	*Orthotrichum*
Dicranum polysetum	*Mnium spinulosum*		

Mammals			
Snowshoe Hare	Marten	Canada Lynx	Deer
Red Squirrel	Fisher	Gray Wolf	Moose
Voles, Mice, and Allies	Marten and Fisher	Coyote	Grouse, Ptarmigan, and allies
Weasels and Ermine			