Grizzly Bear
Current Condition Assessment
GIS Analysis Technical Summary

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Contents

This document provides a summary of the Geographic Information System (GIS) steps used to prepare the Provincial Cumulative Effects (CE) Current Condition (2015) Assessment resultant for Grizzly Bears in British Columbia, Canada. The intended audience for this document is GIS or technical staff in the Natural Resource Sector.

1. Analysis Overview

The Provincial Cumulative Effects Grizzly Bear Current Condition Analysis prepares a series of metrics for spatial indicators relating to grizzly bear population status and habitat. These include core indicators for population status, mortality rate, hunter density, secure core areas, likelihood of human encounter (front country), and forage capability. A series of supplemental metrics are also calculated, which provide general information around bear population estimates, road density, quality food potential, and existing protection areas (see *GIS Analysis Chart* and *Value Protocol Appendix 2* ' Indicators' tab). The criteria for this analysis were developed in collaboration with the CE Grizzly Bear technical working group and advisory committee, under the provincial CE framework.

Metrics are calculated for each Assessment Unit (AU). The AUs are based on provincial Landscape Unit (LU) boundaries which cover the areas occupied by grizzly bears. The analysis is processed by Grizzly Bear Population Unit (GBPU)/LU groupings in order to break the processing into pieces manageable by the software (ArcGIS 10.2). The analysis is based on python geo-processing scripts and uses a combination of vector and raster analysis. Raster analysis uses either a 30x30m or 1 hectare (100mx100m) pixel size, and aligns to the Hectares BC standard origin.

The script relies on a combination of pre-prepared datasets, custom data inputs, and intermediate processed data to calculate indicator scores (metrics) for the AUs.

The results are prepared in geodatabase format, and are intended to be published to the BC Geographic Warehouse (BCGW) if endorsed. The analysis results are intended as a broad scale tool to help identify assessment units where further interpretation and investigation may be appropriate.

While effort has been made to use the 'best available' provincial data, the accuracy, completeness, and currency may vary depending on the data source. Improvements and revisions to both the input data and processing procedure are expected going forward.

2. Supporting Documentation

Please see the documentation listed here which describes the details of the assessment approach and rationale, the indicator criteria and classification thresholds, the data inputs, and a description of the resulting fields.

- *GIS Analysis Chart* (BCCE_Grizzly_2015_GIS_Analysis_Chart_v16_20160921.png)
- *Value Protocol* (Grizzly Bear Protocol_V2.3_13Oct2016.pdf)
- *Value Protocol Appendix 2* (Grizzly_Protocol_Appendix2_Indicators_Inputs_DataDict_2015_Phase2_20160921.xlsx)
- *Value Summary* (Grizzly Bear Value Summary_13Oct2016.pdf)

Note: The documents above refer to the versions available at the time this summary was prepared. Newer versions may become available. The documents above, along with this Technical Summary will be available with the data review package.

3. Script Analysis Steps

An outline of the major steps of the script is provided below. The script is provided as a separate python file as part of the documentation of the analysis.

The script was initially run in a stepwise fashion, with manual inclusion or exclusion of certain steps, as needed, in the development, testing and refinement stages. The script is not plug-and-play, i.e. it would require customization and knowledge of the data inputs in order to re-run. Referenced data sources and field names are specified in the script code, so if newer datasets are used, the data sources, fields and field values would have to be consistent with what was initially used, or updated in the script. Further automation, revision, and streamlining of the script may occur in potential future re-runs.

3.1.Data Dependencies

The analysis relies on several types of data as inputs:

1. Existing 'off-the-shelf' datasets, for example, from the BCGW. Specific selection criteria may have been applied.

2. Value added provincial datasets based on 'off-the-shelf' data, but merged, or with the addition of new custom attributes, for example. These include the consolidated roads, human disturbance, and seral information that was prepared for use as common data inputs for multiple CE values. The common, or core, datasets are stored here: \\spatialfiles.bcgov\work\srm\bcce\shared\data_library

   Additional data preparation scripts and documentation are also available in the data library in the applicable folders. Note that the library data represents a snap-shot in time and was prepared with certain assumptions and limitations.

3. Custom or business area specific datasets, provided or developed for the specific value (grizzly bear) assessment. This includes bear population, hunter and mortality information, Broad Ecosystem Inventory (BEI) capability, and salmon abundance data), as well as a custom front/back country dataset that was prepared for the grizzly analysis by a contractor (Andrew Fall, using SELES).

For details on the data inputs, data preparation for consolidated disturbance; core habitat security; and human pressure index (front country/back country), see *Value Protocol Appendix 2* 'Data Inputs' and 'meta' data tabs, and Appendices III to IV of the *Value Protocol*.

3.2.Manual Data Preparation

Several datasets were manually revised or prepared specifically for the assessment. It was required to:

- Revise Grizzly Bear Population Unit (GBPU) polygons as per direction from Tony Hamilton. Some areas had expansions, others had boundary shifts.
- Revise GBPU/WMU/LEH/Park boundaries and associated bear density numbers. The initial dataset proved to have many slivers and a few attribute errors in the park areas. This was reviewed with Tony Hamilton and corrected as required.

- Combine Population Mortality data from three time periods into one dataset and link to the GBPU/WMU/LEH/Park boundaries.
- Identify 'coastally remote' LUs in consultation with Tony Hamilton, and create a dataset.
- Classify provincial consolidated roads based on assumed traffic use - High, Moderate, or Low Use. The assumed traffic use criteria are outlined in 'meta Roads' tab (*Value Protocol Appendix 2*). Note that the results created disconnected road use type segments - for example, high or moderate use road fragments were found where they only came from low use roads. This could be the result of inconsistent road type classification, the use of multiple road sources, each with different criteria, and/or from erroneous use assumptions. Further refinement is required.
- Receive Front/back country grid output from Andrew Fall, convert to poly, and classify.

3.3.Assessment Units

The grizzly bear assessment units are based on Landscape Unit (LU) polygons, clipped to occupied grizzly bear areas and with polygon slivers removed. There are 940 Landscape Unit based Assessment Units that are occupied by grizzly bears. Areas of the province that are extirpated (e.g. parts of the Thompson-Okanagan, Cariboo, and Peace); or were never occupied (e.g. Vancouver Island) are excluded from the analysis.

The analysis is processed by GBPU/LU groupings (55 provincially), or by provincial extent, depending on the analysis complexity and processing requirements. The grouped results are then rolled into a provincial table, and joined back to the provincial AUs. Note that the GBPU and LU boundaries do not match, but the groupings are based on which GBPU has the majority overlap with an LU. The net AU assessment area excludes major water, glacier and ice features from Baseline Thematic Mapping (BTM).

Note that the analysis uses a revised Draft of the GBPUs (Draft June 2015) for the GBPU boundaries. This draft requires further review in order to be updated to the BCGW. The GBPUs available in the BCGW as of spring 2015 were the 2012 version, which were not used for the analysis.

3.4.Referenced Scripts/Utilities

Several common functions (used for multiple analyses) reference other scripts (e.g. creating gdb, extracting data by an area-of-interest, re-ordering fields, zeroing null fields, exporting to xls, etc). The main reference is to the script_utils\CE_Function_Library.py. This script can be shared on request.

3.5.Major Steps

The steps below are listed in the general order of the script processing. The script function name is included in italics e.g. *FunctionName()*

1. Declare variables for data sources, queries, and field names. Set gdb version date(verDate variable).

2. Custom preparations for WMU and GBPU/WMU/LEH/Park boundaries.
   DataPrepDens()
   bndMashUp()
   Erase major water and ice features to calculate net polygon area (e.g. for Wildlife Management Units). If applicable, recalculate density based metrics for net LU area (this was originally used

for livestock density and human density). Prepare mash up of GBPU, WMU, LEH and park boundaries, which are the inventory polygons for the grizzly bear population and population density estimates, and which are further edited manually.

The functions above were run for preliminary boundary preparations and custom edits, but can be ignored if not needed.

3. Prepare Mid Seral information - *SeralPrep ()*
   The pre-run provincial seral dataset (based on VRI and harvesting data) is further classified to identify mid-seral dense conifer areas. This is a sub-set of the general mid-seral stands, which are dark, closed, and conifer dominant and therefore have poor potential for forage.

4. Prepare Road and Utility information - *RoadsPrep()*
   The provincial consolidated roads layer is selected for open roads. Open roads exclude gated, overgrown, restricted, trail, or skid roads. Note that information for identifying these types of non-open roads was inconsistent and scarce, but is all that is available at this point. Extract transmission and pipelines utility lines from TRIM. Open roads are combined with utility corridors and railway linework for road density analysis (see below).

5. Set variables for the final compiled gdb, the summary table, AU field names, and final AU feature class summary date (sumDate variable).

6. Prepare resultant overlay for LUs, BEI, Bear Density, and BEC Capability - *createResultant_LU_BEI()*

7. Prepare the LU Assessment Units Attributes - *__getLargestPerc()*
   A series of attributes are a calculated for each AU to describe:

   - the net AU area - excluding major ice and water features. The net AU area is used as the 'denominator' when calculating proportional metrics. For example, the proportion of protected area in an AU.
   - the Reporting Unit (RU) with the greatest overlap (max)with the AU, and list of overlapping RUs. Reporting Units are similar to district or Timber Supply Areas (TSAs) and were prepared for the BC CE project.
   - the max and list of Grizzly Bear Population Units (GBPUs) overlapping with the AU
   - the max and list of Wildlife Management Units (WMUs) overlapping with the AU.

The following steps are run by GBPU/LU group, as they require more intensive processing. They generally relate to road density, habitat capability, and secure core (raster) processing:

8. Set Up for each GBPU/LU grouping
   - create summary table to collect all metrics - *createStatsTable()*
   - prepare processing area boundaries (buffer, erase water ice) - *BndPrep()*
   - clip input data for BEI Capability, Bear Population , Mid-Seral, as required - *LU_Clips()*

9. Clip and merge open roads, utilities, and rail lines - *Roads_Clip()*

Use the GBPU/LU buffered boundary as the clipping area, so that road density calculations will consider access routes adjacent to the area of interest (AOI). The results are later clipped back to the AOI boundary and merged provincially.

10. Calculate road length by road use classification - *RoadUseLength()*
    For open roads, calculate the length by use class (H, M, L).

11. Calculate linear road density (km/km2) for 'open' roads and utilities - *RoadDensityLinear()*
    Linear road density per LU is calculated for 'open' roads and utility corridors.

12. Calculate raster road density (km2/km2) for open roads and utilities, and for High and Moderate use roads only - *RoadDensityRaster()*

13. Calculate Capable Secure Core Areas - *SecureCore()*
    Secure Core Areas are road-less areas in patches of capable habitat >= 10km2. 'Roadless' is derived using raster line-density using 30m pixel and 500m neighborhood/search radius, and is has zero road density. Capable area is weighted based on the proportion of Broad Ecosystem Unit 1 & 2.

    500m buffers on select human disturbance are also excluded from Secure Core: mining, oil & gas, utility ROWs, agricultural, urban, urban mixed . Disturbance does not include harvest cut blocks or seismic lines.

    See *Values Protocol*, Appendix IV for details on preparing the capable secure core areas.

14. Prepare the PseudoBTM (Land Use/Cover/Disturbance) - *getPseudoBTM()*
    The Pseudo BTM is a pre-processed input that uses 'current' disturbance information (forest harvesting, rights- of-way, seismic lines, mining and urban areas) to update the Baseline Thematic Mapping (BTM) land use/land cover polygons (see *Value Protocol Appendix 2* 'meta Development' tab). This part of the script merges the PseudoBTM by GBPU area, extracts selected disturbance (excluding harvesting and seismic lines, which are recoverable areas), and buffers the selected areas. This is then used to erase areas from the secure core polygons.

    See *Values Protocol*, Appendix III for details on the consolidation of disturbance information.

15. Clip road density and secure core back to the GBPU/LU boundary - *clipRdensCore()*
    The clipped outputs will then be merged into a provincial layer.

The following steps are run at the provincial extent:

16. Create Provincial merged datasets
    mergeRdensCoreBC()
    eraseSecCoreDisturb()

Clip buffered GBPU output for road density, secure core, and disturbance to the GBPU/LU boundaries, and merge provincially. Further erase select disturbance from the secure core areas.

17. Create Provincial Summary table- *mergeTables()*

    Merge the summary results for each GBPU/LU processing unit into a provincial table, to link back to the provincial AU polygons. Any null numeric fields are replaced with zero. This table is used as the basis to further calculate indicator metrics/classifications from the raw input scores, and to add additional provincial based metrics to.

18. Summarize Bear Population Mortality by LU - *PopMortality()*

    Grizzly Bear mortality from various means (hunting, natural causes, vehicle, etc) and over many years is tracked by the Ministry of Environment. For the purposes of this analysis, we are interested in areas where allowable hunting allocation may be exceeded. Mortality is examined for all bears and just female bears. Where hunting allocation is exceeded for either all bears, or females, in any of 3 time periods (covering 2000 to 2014) in allowable hunting areas, the mortality unit (composed of a combination of GBPU, Wildlife Management Unit (WMU), Limited Entry Hunting (LEH), and park boundaries) is flagged. If an LU overlaps with a flagged mortality unit by more than 10%, the LU is also flagged.

19. Summarize Hunter Day Density by LU - *hunterDensity()*

    Hunter density information supplied by Tony Hamilton was further extrapolated to LU. Density is calculated as number per net area.

20. Summarize the proportion of Front Country by LU - *FrontBackCountry_Class()*

    The proportion of front country in an AU is an indicator for the likelihood of human-bear encounter. The input for this dataset was provided by Andrew Fall as a SELES based grid analysis. Front country is identified based on travel time from major population centers and high use roads. The proportion of front/back country is further related to Likelihood of Encounter Class (see *Value Protocol* Appendix V).

21. Summarize Salmon biomass and Quality Food Flag for each LU

    sumSalmon()
    FlagQualityFood()

    Salmon escapement data by stream reach was provided by DFO and further interpreted by Tony Hamilton. This was then used to summarize to the LU level. Summarize the Total kilograms of Salmon by LU, and the proportion of High or Very High capable areas to identify LUs with high potential for quality food.

22. Summarize the proportion of mid-seral dense Conifer (poor forage) by BEC Zone

    midSeralSumm()
    BEC_LU_Summ()
    BEC_midSeral_LU_Summ()

The mid-seral dense conifer (poor forage potential) is summarized by Biogeoclimatic Ecosystem Classification (BEC) Zone. BEC Zones with High or Moderate ecological sensitivity are evaluated for the proportion of potential poor forage. Areas with insufficient seral data (e.g. within TFLs) are also flagged.

23. Summarize the proportion of Protected/Restricted areas that are also Capable to support Grizzly Bears

    ParksProtected()
    BEI_Hab_Protected()

    For each LU, summarize the %of Parks, Protected Areas, or Restrictions, etc 'High' restricted areas are considered 100% protected. For 'Medium' areas, consider as 50% of area protected. Exclude 'Low' restricted areas. Further, calculate the proportion of the LU which has high or very high Broad Ecosystem Inventory (BEI) capability, and which is also protected or restricted.

    The input dataset is a consolidated layer for protected or restricted areas, prepared by the Forest Analysis and Inventory Branch (FAIB) circa 2012. Note that this dataset is under revision. See *Value Protocol Appendix 2* 'meta Protected' for classification details.

24. Flag LUs that have the presence of WHA or EBM grizzly Areas - *Flag_WHA_EBM()*

    This is a supplementary indicator which flags if an LU has any Wildlife Habitat Areas (WHAs) or Coastal Ecosystem Based Management (EBM) areas specified for grizzly bears. Sliver polygon overlaps less than 0.05% of the total LU are ignored.

25. Prepare Final Indicator Summary and Classification

    classifyIndicatorFields ()
    createSummaryPoly()
    version_and_export()

    Classify indicator metrics/scores and rollup calculations based on assessment procedure thresholds (see *Values Protocol*). There are six core indicators which are counted in the rollup, and seven supplemental indicators which provide contextual information (see *GIS Analysis Chart*, *Value Protocol*, and *Value Protocol Appendix 2* 'Indicators' and 'Rollup Criteria' tabs).

    Link the summary table to the spatial provincial LU assessment units, re-order fields, and prepare final attribute values. Export summary table to excel and prepare shape files, as needed.

4. Analysis Outputs

The results of the analysis include:

- a file geodatabase of the Assessment Unit (LU) polygons with applicable metrics and indicator classifications. The AU polygons and (select) attributes are also intended to be published to the BCGW once endorsed by executive.
- the file geodatabase also includes the provincial data inputs pertinent to grizzly bears, e.g. open roads, habitat capability (BEI), bear density, etc.

- Common inputs used for multiple CE values can be found in the CE data library: W:\srm\bcce\shared\data_library. Note that there is now also a 1:50k tile library for common CE data inputs, which is stored here: W:\srm\bcce\shared\data_library\tile_whse. A script has been created to help append desired data from the tile library, for an AOI.
- A data dictionary describing the data inputs, indicators, thresholds, and summary attributes. See *Value Protocol Appendix 2*.
- ArcMap lyr files to provide symbology for indicators and rollup.
    1. Summarized view of the 6 core indicators and supplemental indicators, by LU summary polygon.

    2. Detailed symbology for all indicators, main data inputs, and LU Summary polygons.

- Provincial Overview maps for the indicator and rollup results. The rollup result map - or number of core indicators flagged as exceeding a benchmark, can also be found in the *Value Summary*.

Several iterations of the analysis were run, using the same 2015 data inputs, but with different benchmark and rollup criteria. The final dataset version is v.1.2. April 21, 2016.

5. Conclusions and Recommendations

5.1. Processing Challenges

- Data processing for the full provincial extent proved to be slow or impossible for large datasets. Therefore, processing was split by GBPU/LU processing areas as needed. Note that, for the future, we may switch to 1:50k tile processing.
- The script may be run on several servers at once for different GBPU/LU groupings.
- The 'Background Geoprocessing' desktop terminal server (DTS) may be used for intensive multi-day processing.
- Originally run using ArcGIS 10.1 or 10.2, python may be configured (in Eclipse) to use the 64 bit vs 32 bit version. This helped alleviate script crashes due to memory issues, etc. Note, however, that some commands were not available in the 64 bit version, or need to be updated to use the 64 bit processor, e.g. switching from VB to python expressions in CalculateField.
- a processing mask (including a 5km buffer) or extent may be used to restrict the raster processing environment. This is turned off/cleared before doing any full extent/provincial processing.

5.2. Future Steps/Considerations

- Revise the FAIB protected/restricted layer with newest available dataset - once complete (spring 2017?)
- Further refinement by Forest Management Landbase (FMLB), Crown Forested Landbase (CFLB), or Timber Harvesting Landbase (THLB), for example for the Mid-Seral Conifer indicator.
- Incorporate newest numbers for Hunter Density and Bear Mortality
- Confirm GBPU edits and incorporate any new changes
- Confirm bear density layer and incorporate any new data

- Include Population Connectivity Index or Isolation Index
- Review road traffic use criteria and results
- Inclusion of camps, dumps, orchards, resorts etc as bear attractants/potential conflict
- Ideally we would have more detailed habitat information in a provincial format, i.e. based on Predictive Ecosystem Mapping (PEM) or Terrestrial Ecosystem (TEM) detailed site series.
- consider more raster processing, vs vector.