YKL Geospatial Model Overview

July 21, 2015

Background/Overview

The purpose of this document and accompanying "YKL Geospatial Model Overview" diagram is to provide a high-level document that outlines (not in full detail) the structure and composition of how the YKL REA was completed. This document serves as a 'cliff notes' version for a GIS person to re-trace steps taken by the REA contractor and reviewed by BLM. Further documentation will be released when it becomes available during a full and detailed models QC by the BLM National Operations Center (NOC) REA data team.

Change Agents

Climate

(Tech. supplement B, Section 1, pg. B-1,)

- All climate modeling done in R software. The geoprocessing done here was to manipulate the outputs from R. Mostly clipping to YKL study boundary and extracting to tables is done within the models.
- Everything within climate CA's assessing how climate will change over time. All climate models include estimates of uncertainty. MQ20, MQ21.

Temperature/Precipitation

- Historical weather station data
- Used Scenarios Network for Alaska and Artic Planning (SNAP) data
    - 5 different GCM models, incorporating latest IPCC 2014 report
        - Models were averaged, A2 emissions scenario used. A1B scenario used as comparison
        - Decadal averaged computed (2020's, 2050's, 2060's)
    - SNAP supports the CMIP3 models from IPCC's AR4 report
    - GCM outputs obtained by SNAP from Lawrence Livermore National Laboratory Program for Climate Model Diagnosis and Intercomparison (PCMDI) data portal
    - SNAP datasets downscaled to 771 m resolution using PRISM methods
    - Climate outputs derived from climate datasets include temperature and PPT data at monthly resolution
    - Derived datasets to estimate freezing dates for fall/spring (thaw/freezing date)
    - Temp. data used to create monthly estimated snow fraction data
    - Source datasets
        - SNAP Prism temp/ppt data 1971-2000, 771m resolution, monthly data CMIP3/AR4 A2 emissions scenario 5 model average, 771m resolution, decadal means (2010, 2020, 2050, 2060)

        - SNAP date of thaw (DOT)/day of freeze (DOF) projections from CMIP3/AR4 A2 emissions scenario 5 model average, 771m resolution, decadal means (2010, 2020, 2050, 2060)
        - SNAP length of growing season projections from CMIP3/AR4 A2 emissions scenario 5 model average, 771m resolution, decadal means (2010, 2020, 2050, 2060)
        - SNAP monthly snow day fraction projections from CMIP3/AR4 A2 emissions scenario 5 model average, 771m resolution, decadal means (2010, 2020, 2050, 2060)
    - Temperature/Precipitation sensitivity analysis done
    - Limitations: Between models variability (as shown in comparison between A1B and A2 emission scenarios) is a proxy for uncertainty. Resolution of climate data does not necessarily always match scale of phenomena that affect CE's, linkages are relatively clear but literature doesn't always provide precise threshold information.

Climate Toolbox A1B

- 7 models to address the following: Day of Freeze (DOF) & Day of Thaw (DOT) - these measures are used to estimate the length of the growing season. Also included are models to compute the average temps for Winter/Summer/January/July –Models extract these 7 parameters for Current/Near-Term/Long-Term predictions. Attributes averaged to 3rd and 5th level HUCs. It is assumed at this stage that these attributes are joined back to HUC boundaries and converted to raster.
  (Tech. supplement B, Section 1, pg. B-26)

Climate Toolbox A2

- 14 models to address the following:
- Snow Day Fraction (SDF) – SDF rasters for monthly averages extracted to the 3rd and 5th level HUCs for Current/Near-Term/Long-Term predictions.
- Day of Freeze (DOF) & Day of Thaw (DOT) - these measures are used to estimate the length of the growing season. Average Temps for Winter/Summer/January/July –Models extract these 6 parameters for Current/Near-Term/Long-Term predictions. Averaged to 3rd and 5th level HUCs.
  (Tech. supplement B, Section 1, pg. B-26)
- Cliomes – number of change events, difference between current/near/long-term cliomes
- Also included are models to compute the average temps for Winter/Summer/January/July – Models extract these parameters for Current/Near-Term/Long-Term predictions. Averaged to 3rd and 5th level HUCs.
- It is assumed at this stage that all these attributes are joined back to HUC boundaries and converted to raster.

Cliomes

Cliomes are clusters of areas with similar climate patterns that change in a similar way or they describe how climate groupings change over time with respect to broad vegetation classes.

(Technical Supplement B, section 1.4, pg. B-37)

- A cliome is a group of existing land cover classifications, historical/projected climate data used to ID areas likely to undergo ecological pressure given climate changes. 18 cliomes identified through clustering algorithms with 24 input climate temp/ppt variables. Cliomes are proxies for how much climate may change and where.
- Cliomes were modeled for all time periods then tracked over time and results compared vs. other cliomes.
- MQ21 addressed where climate change will impact CEs. This was discussed in Tech. Supplement B, pg. B-45.
- Impacts related to climate change on different species in different regions were prepared and discussed. Predicted shifts from one cliome to another may not be reflected by immediate veg change but by increased stress on ecosystem components.

Invasive Species

(Also includes Forest Defoliators)

Tech. Supplement B, Section 4, pg. B-79, YKL_IV_CNL_ Invasives.tbx & YKL_IV_HC_InsectAndDisease.tbx

Density

Invasive & Non-Native Plant Density

Invasive plants and non-native use kernel density to determine density of infestations.

Vulnerability

Predicted states of current/near-term/long-term probability of invasives in YKL & likely vectors of invasives spread in YKL (*3 models, YKL_IV_CNL_Invasivs.tbx*)

- **Notes:** Modeling done at current (2010), near-term (2025), and long-term (2060) modeling
- **Inputs:** Input data derived from Ak. Exotic Plant Information Clearinghouse Database (AKEPIC 2013), anthropogenic data, current & future climate data, current/future development, CE distributions, environmental data.
- **Methods**: CART used to determine relationship between input variables (development, environmental data, and climate) and infestations. From this, areas within REA with projected high vulnerability were developed for current/future scenarios. Geoprocessing models mostly just clip and determine which HUC10 boundaries intersect infestations.
- **Results**: Map of current/future invasion vulnerability & known infestations with regional vulnerabilities

Development

(Tech. Supplement B: Anthropogenic, Section 5.2, pg. B-108)

- Results reported at 5th level HUC boundaries for REA
- Distribution of subsistence sp. distributions developed, Natural Resource Extraction, Transportation & Communication Infrastructure, Recreation, Human footprint
- Three toolboxes for quantifying the elements of Landscape Condition, Landscape Integrity and Cumulative Impacts were originally located within the Development change agent category but were moved to a new group by the REA data team called "Landscape Integrity". These three toolboxes should be run after the development toolbox.

Human Footprint (Developed Areas)

- **Notes:** Human footprint MQs were answered within the larger Landscape Condition model. TIGER city footprints were modified based on imagery to developed areas.
- **Inputs**
  (Tech. Supplement B: Anthropogenic, Section 5.2, Table B-20, pg. B-109)
  - Human footprint region comprised of: TIGER census files polygons (manually modified using imagery), general land status, roads & trails, Ak resource data file, mines & prospecting sites, renewable energy sites & contaminated sites.
- **Methods**: A detailed document exists for computing the LCM and landscape integrity. Detailed notes on processing the ARDF mining datasets for inclusion in the human footprint included within the technical supplement B, pg. B-110.
- **Models**: YKL_DV_C_Geo_LCM – portions of this model answer the MQ relating to human footprints.
- **Results**: Human footprints: Point locations of towns/names and polygon of total footprint with a quantified Sq. KM.
- **MQ 42:** Where is the current human footprint in the region?

Land Status

- **Notes**: Land status MQs were also answered within the larger LCM. Land ownership was primarily determined from Alaska Dept. of Natural Resources GIS data but vast portions of the REA still remain in flux (MQ44) based upon transfer from federal to state status. Mining claims and existing energy sites quantified and mapped.
- **MQ43:** What is the current land status in the region?
- **MQ44:** Where are unsettled land claims?

Future transportation and communications infrastructure

- **Notes**: Four hypothetical road construction projects exist for the region connecting remote towns with larger cities. MQs were also answered within the larger LCM model (Landscape Integrity > Landscape Condition)
- **MQ48**: Where are areas of energy and resource extraction currently and likely to occur in the future?

Future Mining Activity

- **Notes**: Donlin Creek (gold) and Pebble (copper) are to be the two largest mining operations in the world. Smaller areas also identified
- **MQ46**: Where are areas of energy and resource extraction currently and likely to occur in the future?

Future Alternative and Renewable energy sites

- **Notes**: ID of funded/unfunded renewable energy sites (based on AEA projects), potential wind/hydro/biomass energy sites (no discussion on data sources).
- **MQ47**: Where are planned sites for alternative/renewable energy?

- Others not described here – see Tech. supplement C. No modeling described in each.

Fire

(Technical Supplement B, pg. B-51, Insert Geospatial Modeling Toolbox name here)

- Historical fire data used to determine patterns, literature review to estimate landscape changes after fire, models used to project fire frequency by region/spatially and a percentage/risk basis
- Fire modeled using Ak Frame-based EcoSystem Code (ALFRESCO) to project future fire regime and effects on veg. classes.
    - **Inputs**: Historical climate data, Veg distribution and age structure data, BLM Historical fire perimeters (Fire Scar Map), literature on simulated fire linkages between fire/climate SNAP climate predictions
    - **Methods**
        - 1x1 KM pixels, simulated ecosystem types
        - Each pixel given a probability of ignition and flammability rating based upon vegetation type & age. ALFRESCO model calibrated using literature on burn rates and stand compositions
    - **Results**: Regional projected fire dynamics on vegetation
    - Tundra modeling not considered very robust, dropped. Boreal forests fully calibrated thru all REA.
    - **MQ22.** Fire history – Section 2.3, pg. B-57.
    - **MQ24**. Fire Frequency & Return Interval, Section 2.3, pg. B-59
    - **MQ23**. Climate impacts on fire: Section 2.1, pg. B-61
    - **Note**: No ESRI Modelbuilder files/tools/models were used to assess fire within the YKL. See report for further details.

Permafrost

(Tech Supplement B, Section 3, pg. B-67, YKL_Permafrost.tbx)

- **Data**
    - Historical permafrost samples, Soils data, snow cover, SNAP climate projections, vegetation
- **Methods**
    - Current/Near-Term/Long-Term estimates of the A2 climate scenario active layer thickness and Mean Annual Ground Temperature supplied as model inputs. The models clips the rasters to the YKL study boundary then performs zonal statistics to extract average input raster values for both the HUC5 and the HUC3 levels.
- **Analysis**
    - Used Geophysical Institute Permafrost Lab (GIPL) model to create output 1KM Mean Annual ground temperature (MAGT) and Active Layer Thickness (ALT) datasets.
- **Results**
    - Predictions of where permafrost thaw may occur and predictions of where thaw is less likely. Predictions of the effects of changing climate on permafrost.

- Measured by mean annual ground temperature (MAGT) at 1m depth and active layer thickness (ALT). Active layer thickness predicted for current (2010s), near term (2020), long-term (2050) and far (2060s).
- Addresses:
    - MQ16: What are current soil thermal regime dynamics: Tech. Supplement B, Section 3.4, pg. B-71
    - MQ17: How will soil thermal regimes change in future based on climate/soil tem models? : Tech. Supplement B, Section 3.4, pg. B-71
    - MQ18: Soil Thermal regimes & communities: Tech. Supplement B, Section 3.4, pg. B-76
- Notes: Permafrost is both a change agent and conservation element

Soil Thermal regimes and communities
(Tech. Supplement B. Section 3.4, pg. B-76)

- MQ18: Where are predicted changes in soil thermal regimes associated with communities and transportation routes?
    - Permafrost modeling outputs overlaid with routes and communities

Conservation Elements

Aquatic

Notes: TAUDEM required to re-run much of the Aquatic CE models.

Aquatic Coarse-Filter

- NHD data in Ak is extremely outdated, improvements are made within this toolbox using tools from TauDEM. A detailed writeup from AKNHP exists within this package.
- The coarse filter toolbox is broken into 4 parts (Predictors/ Distributions/ Status/ Interactions). The predictors group uses TauDEM tools to process the AK DEM to create several environmental/hydrological products which serve as predictor variables on the N. Pike and Dolly Varden observation points. The next step was to process the inputs within R for a distribution probability for both species. Next, within the distributions toolset – the output from the R modeling, salmon and sheefish distributions are generated. Also generated are the distributions of streams, connected & disconnected lakes. Within the Status toolset, the relative distributions are intersected with the landscape condition model.

Aquatic Fine-Filter

- Chinook Salmon, Chum Salmon, Sheefish, Northern Pike, Dolly Varden
- New distribution maps developed for Chinook salmon, chum salmon, and sheefish
- Predicted distribution models for Northern pike and Dolly Varden (developed in consult with FWS, ADF&G, USGS & BLM)

Terrestrial

Terrestrial Coarse-Filter

- Deciduous Forest, White Spruce or Black Spruce Forest, Tall Shrub, Low Shrub, Dwarf Shrub, Herbaceous Wetlands, Large Floodplains
- **Vegetation**: This model simply clips the mosaic all the different veg maps into a single regional veg map. The mosaic of the input datasets is from a different study.
- **Data Sources**: The data sources toolset computes the intersection of the various vegetation distributions outlines which are combined to form a single regional veg map. There is a lack of seamless/recent veg map in Alaska.
- **Boundaries**:
    - Clip Ak dept. of Game & fish data
- **Distribution**: Distribution of deciduous forest, dwarf shrub, herbaceous wetlands, low shrub, spruce forest, and tall shrub are reclassed from the regional veg map and clipped to the YKL study area.
- **Status**: Same categories as with distribution, these individual distributions are intersected (Raster Mask) with the Landscape condition model.

Terrestrial Fine-Filter

- Fine filter species consist of Muskox, Tumpeter Swan, American Beaver, Northern Red Backed Vole, Nearctic Brown Lemming, Snowshoe Hare, Olive Sided Flycatcher, Caribou, Gray Wolf, and Moose.
- **Distribution**: Distributions of Moose, Caribou, Muskox, American beaver, Gray Wolf, Peregrine Falcon, Trumpeter Swan, Olive-sided flycatcher are clipped from a statewide dataset (primarily data source from GAP). Grey wolf prey base and peregrine falcon distribution have some additional steps.
- **Forage and Habitat**: Habitat assessed for Muskox, Lichen, and Willow. Muskox habitat quality inputs included specific vegetation classes and floodplains mosaic. Lichen inputs included fire history, Lichen source years, and specific vegetation classes, mosaicked together. Willow habitat quality inputs include a buffer on major lakes and streams, floodplains, Tall & Low Shrubs mosaicked to a new willow habitat raster, also included was a elevation mask.
- **Boundaries**: Clip of the Alaska Depart of Fish and Game (ADFG) game management units to the YKL study boundary.
- **Sensitive Species Overlap**: Sensitive Species Distribution – combination of Peregrine Falcon Riparian habitat with Trumpeter Swan and Olive-Sided Flycatcher habitats. Sensitive Species Vegetation – Intersection (Raster Mask) of AK mosaic of vegetation with Sensitive Species Distribution.
- **CE/CA Interactions**:
    - Peregrine Falcon annual PPT difference (A2): Raster subtraction of current annual PPT from long-term annual PPT, then extract by mask within modeled peregrine falcon habitat within YKL.

- Peregrine Falcon Growing Season Change (A2): Raster subtraction of current growing season length from long-term growing season projection, then extract by mask within modeled peregrine falcon habitat within YKL.
- Olive Sided Flycatcher Growing Season Change (A2): Raster subtraction of current growing season length from long-term growing season length, then extract by mask within modeled Olive-Sided Flycatcher habitat within YKL.
- Willow Habitat Growing Season Change (A2): Raster subtraction of current growing season length from long-term growing season length, then extract by mask within modeled willow habitat distribution within YKL.

- **Status**: Distributions are intersected with Terrestrial Landscape Condition for status assessments

Landscape Integrity Assessments

Landscape Condition

- **Notes**:
- **Inputs**: Urban, Invasives, Current & Historic Mines, Non-Native Plants, Industrial Power Lines, Transportation, Alaska Resource Data File (ARDF)
- **Models**:
- **Results**:

Landscape Integrity

- **Inputs**: Inputs from Landscape Condition Model (Current/Near/Long-Term)
- **Models**: Select LCM > 5, convert to polygon and calculate area
- **Results**: "Landscape Integrity" results of top selection and area class from Landscape Condition Model.

Cumulative Impacts

- **Inputs**:
  - **Long-Term Abiotic**: Output is Long-Term future abiotic cumulative impacts. Inputs of current and long term future Alaska mean Jan. Temp, Long-Term Alaska annual and total PPT, current and long-term Alaska mean annual ground temperature, and current/long-term Alaska mean July Temp.
  - **Long-Term AthroBiotics**: Output is long-term anthropogenic/biotic cumulative impacts. Inputs of Current & Long-term HUC10 LCM, Current & Future Infestation vulnerability estimates. Combined using majority filter on LCM and raster combine.
  - **Long-Term Cumulative Impacts**: Output is long-term future cumulative impacts estimate. Inputs include current and future HUC 10 landscape condition models, current and long-term mean Jan temperature, current and long-term Ak annual total PPT, Current and long-term infestation vulnerability, current and long-term AK mean temperature, current and long-term Ak annual ground temperature.

- **Near-Term Abiotic**: Output is Near-Term future abiotic cumulative impacts. Inputs of current and near-term future Alaska mean Jan. Temp, Near-Term Alaska annual and total PPT, current and near-term Alaska mean annual ground temperature, and current/ near-term Alaska mean July Temp.
- **Near-Term AthroBiotics**: Output is near-term anthropogenic/biotic cumulative impacts. Inputs of Current & near-term HUC10 LCM, Current & near-term Infestation vulnerability estimates. Combined using majority filter on LCM and raster combine.
- **Near-Term Cumulative Impacts**: Output is near-term future cumulative impacts estimate. Inputs include current and future HUC 10 landscape condition models, current and near-term mean Jan temperature, current and near-term Ak annual total PPT, Current and near-term infestation vulnerability, current and near-term AK mean temperature, current and near-term Ak annual ground temperature.

- **Notes**: Run LCM prior to Cumulative Impacts assessment

Management Questions

(Modified Table A-2 with corresponding modeling toolbox noted, Technical Supplement A - Introduction: MQs selected by the AMT for analysis as part of the YKL REA and section of the Technical Supplement in which they are addressed. MQs that are redundant with the core REA analysis are marked by an asterisk (*).

Vegetation Communities			
1	*What are the possible impacts on vegetation communities from climate change?*	Section D-1.3*	A2 Climate& Terr. Fine F.
2	*What is the current distribution of vegetation communities?*	Section D-1.11	Terr. Coarse F.
3	*How and where will changes in permafrost impact vegetation?*	Section D-1.3*	A2 Climate& Terr. Coarse F.
Wildlife			
4	*What is the current distribution of primary winter forage (lichen) for caribou in the region, and how is that expected to change?*	Section D-2.5*	Terr. Fine F.
5	*Where are caribou calving grounds in the region, and how are they expected to change?*	Section D-2.5*	Terr. Fine F.
6	*What is the current seasonal distribution of moose in the region?*	Section D-2.4*	Terr. Fine F.
7	*What is the current distribution of primary winter forage (willow) for moose in the region, and how is that expected to change?*	Section D-2.4*	Terr. Fine F.
8	*Is there musk ox habitat in the region, and if so, how might it change in the future?*	Section D-2.7*	Terr. Fine F.
9	*What is the current distribution of migration corridors for caribou, and how are they likely to change in the future?*	Section D-2.5*	Terr. Fine F.
10	*Where are key prey species located in the region?*	Section D-2.14	Terr. Fine F.
11	*What is the current distribution of the American Peregrine Falcon in the region, and how is that expected to change?*	Section D-2.11*	Terr. Fine F.
12	*Where is habitat for sensitive species that are also conservation elements?*	Section D-2.13	Terr. Fine F.
13	*What are the current types and potential impacts of diseases in ungulate populations (caribou, moose), and how are these impacts expected to change in the future?*	Section D-2.6	N/A
14	*How, where, and when could Essential Fish Habitat (EFH) be affected by predicted changes in climate?*	Section D-4.3* Section D-4.4*	N/A
15	*Where and how might mineral resource development affect fishery habitat?*	Section D-4.8	N/A

Abiotic Factors			
16	*What are the current soil thermal regime dynamics?*	Section B-3.3*	N/A
17	*Based on the predictions of the best available climate models and soil temperature models, how will soil thermal regimes change in the future?*	Section B-3.3*	A2 Climate
18	*Where are predicted changes in soil thermal regimes associated with communities and transportation routes?*	Section B-3.4	N/A
19	*How might changes in temperature, precipitation, evapotranspiration, and soil thermal dynamics affect general hydrology and hydrology-dependent CEs such as waterfowl in the region?*	Section D (All)	N/A
20	*What are the projected monthly, seasonal, and annual temperature, precipitation, and length of warm and cold seasons for the REA, and how do these projections vary across time, across the region, and across varying global greenhouse gas emissions scenarios?*	Section B-1.3*	A1B/A2 Climate
21	*Where will climate change impact CEs, including subsistence species?*	Section B-1.4*	N/A
22	*What is the fire history of the ecoregion?*	Section B-2.3*	N/A
23	*What climatic conditions are likely to result in significant changes to fire activity?*	Section B-2.3*	N/A
24	*What is the current frequency (return interval) and the likely future frequency for fire in the ecoregion and broad sub-regions?*	Section B-2.3*	N/A
Biotic Factors			
25	*What is the current distribution and area (percent of land with infestations) of introduced and invasive species in the YKL?*	Section B-4.3*	Invasives
26	*Which areas are most likely to be susceptible to infestation by invasive plant species currently?*	Section B-4.3*	Invasives
27	*Which areas are most likely to be susceptible to infestation by invasive plant species in the future, specifically in relationship to climate change and proposed development?*	Section B-4.3*	Invasives
28	*What are the likely vectors for new infestations or spread of existing infestations?*	Section B-4.4	Invasives
29	*What is the current distribution of forest pest outbreaks in the ecoregion?*	Section B-4.5	Insect & Disease

Anthropogenic Factors			
30	*What are current socioeconomic conditions in YKL communities?*	Section B-5.4	See Report
31	*What are the projected socioeconomic conditions in the future?*	Section B-5.5	See Report
32	*How could community economic profiles vary with respect to development scenarios (including mines) in the near future (including access to subsistence, energy sources, and other resources)?*	Section B-5.5	Dev.
33	*What are the potential impacts of renewable energy projects on local economies the region?*	Section B-5.5	Dev.
34	*How might change in transportation corridors impact communities?*	Section B-5.5	Dev.
35	*Where are current subsistence harvest areas?*	Section B-5.6	Dev.
36	*What do ADFG harvest data and TEK/LTK show about how harvest amounts, types of fish/animals/plants, and harvest seasons changed in the recent past (including beavers)?*	Section B-5.6	Dev.
37	*How could larger community populations affect subsistence resources?*	Section B-5.7	Dev.
38	*What are general (sport) harvest levels of salmon, moose, and caribou in the recent past?*	Section B-5.10	Dev.
39	*Where are current sport hunt areas?*	Section B-5.10	Dev.
40	*What have been the commercial harvest levels of salmon over the past 10 years?*	Section B-5.8	Dev.
41	*Where are current commercial fish harvest areas?*	Section B-5.8	Dev.
42	*Where is the current human footprint in the region?*	Section B-5.3*	Dev.
43	*What is current land status in the region?*	Section B-5.3*	Dev.
44	*Where are unsettled land claims?*	Section B-5.3*	Dev.
45	*Where is recreation activity highest?*	Section B-5.9	Dev.
46	*Where are areas of energy and resource extraction currently and likely to occur in the future?*	Section B-5.3*	Dev.
47	*Where are planned sites for alternative/renewable energy?*	Section B-5.3*	Dev.
48	*Where is planned transportation/communication infrastructure to be located?*	Section B-5.3*	Dev.
49	*How might recreational use in the region change over time?*	Section B-5.9	Dev.
50	*Are there areas in the REA that are impacted by mercury contamination?*	Section B-5.11	Dev.