Central Yukon
Rapid Ecoregional Assessment

Final Work Plan

Prepared for:

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Bureau of Land Management
Rapid Ecoregional Assessment

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Submitted by:

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Acronyms

ADF&G	Alaska Department of Fish & Game
AKNHP	Alaska Natural Heritage Program
ALFRESCO	Alaska Frame-based EcoSystem Code
AMT	Assessment Management Team
BLM	Bureau of Land Management
CA	Change Agent
CE	Conservation Element
CYR	Central Yukon REA
DMP	Data Management Plan
ESRI	Environmental Services Research Institute
GCM	Global Circulation Model
GIPL	Geophysical Institute Permafrost Lab
HUC	Hydrologic Unit Code
ISER	Institute of Social and Economic Research
LCM	Landscape Condition Model
MAGT	Mean Annual Ground Temperature
MQ	Management Question
NHD	National Hydrography Dataset
NOC	National Operations Center
REA	Rapid Ecoregional Assessment
SNAP	Scenarios Network for Alaska and Arctic Planning
Tech Team	Technical Team

Introduction

The fundamental goal of BLM's Rapid Ecological Assessments (REAs) is to provide an understanding of the current ecological status of the conservation elements (CEs) in the ecoregion, which change agents (CAs) are impacting them and where, the potential future status of CEs in relation to future projections of CAs, and the ecological integrity of the ecoregion as a whole. Informed by the management information needs [management questions (MQs)] identified for the Central Yukon Rapid Ecoregional Assessment (CYR), geospatial assessments of the ecological status of CEs, the landscape integrity of the ecoregion, and other assessments of the relationships between CAs and the CEs will be conducted to meet this goal.

The CYR is being conducted as an assistance agreement between BLM-Alaska and the Alaska Natural Heritage Program (AKNHP), University of Alaska Anchorage, in cooperation with the Scenarios Network for Alaska & Arctic Planning (SNAP), University of Alaska Fairbanks, and the Institute for Social and Economic Research (ISER), University of Alaska Anchorage. The three aforementioned University of Alaska entities will be referred to collectively as the UA Team for the remainder of the document.

As a large, cross-jurisdictional landscape assessment, the CYR is guided and focused by two inter-agency teams led by the BLM. The Assessment Management Team (AMT), comprised of land managers from federal, state, and local agencies that have direct responsibilities in the CYR Ecoregion, provides overall guidance and direction for the development of the REA and ensures that procedures and products are consistent with project objectives. The Technical Team, comprised of technical experts from participating federal, state, and local land management agencies, provides technical and ecological guidance, direction, review, and recommendations for the development of the REA. The purpose of these interactions is to facilitate interagency collaboration, cooperation, and resource sharing between the BLM and the UA Team and other agencies/entities.

Prior to the development and presentation of this Work Plan, the UA team had numerous opportunities to interact with both the AMT and Technical Team to present preliminary products and provide the opportunity for review and comment on draft products that fulfilled reporting requirements for the Pre-Assessment, Phase I of the project. All products and meeting notes are posted on the AKNHP product website for the Central Yukon REA and can be accessed on-line: http://aknhp.uaa.alaska.edu/landscape-ecology/central-yukon-rea/products/#content. To date, these briefings have included:

1. **Memorandum I: Management Questions, Conservation Elements, and Change Agents**
   - This memo provides a summary of the selection of MQs, CEs, and CAs. It also provides a synopsis of the ecological and socio-economic resources present in the CYR Ecoregion, outlines the reporting units for results, and describes the Conceptual Ecoregional Model.
   - Presented to AMT and Technical Team members in Fairbanks, September 5, 2014.
2. **Memorandum II: Data Discovery/Methods**
   - Within this memo we present the results of potential datasets to be used in the assessment (CE, CA, and MQ), evaluated the data for utility and quality, and identified potential data gaps. The memo also identified, described, and recommended models, methods, and tools for characterizing CEs, CAs, and

their interactions, including draft conceptual models, process models, and attributes and indicators tables.
- Presented to the AMT and Technical Team, January 29, 2015.

This document provides a general overview of the products, workflow and deliverables the University of Alaska team (UA team) proposes as part of the CYR REA, Phase II: Assessment.

Given the rapid nature of this assessment, this document will not review the methods proposed for this REA. Proposed methodologies were presented to the AMT during a full-day methods workshop (January 29, 2015), and are summarized in Memorandum II, which this document will refer to (http://aknhp.uaa.alaska.edu/landscape-ecology/central-yukon-rea/products/#content). The focus of this Work Plan is to provide an outline of how and when the UA team plans to complete key deliverables for the assessment, and what those deliverables will include.

This is a draft version of the CYR Work Plan document. The UA team is planning to meet with members of the BLM Alaska State Office and Fairbanks/Central Yukon Field Office on March 17, 2015, in Fairbanks, Alaska, to present this preliminary document. During that meeting we hope to finalize key decisions applicable to the development and finalization of the CYR Work Plan, which will be delivered no later than one month following the March meeting.

Data Management Plan

We will adhere to the BLM Data Management Plan (DMP) version 2 (Aug. 2012), that provides details required by BLM's National Operations Center (NOC), who will review and take ownership of the final data products. We will also follow advice provided by the NOC on data format, delivery and logistics. This means all products will be properly cataloged and have sufficient and informative metadata. Additionally, all spatial data will be contained in ArcMap documents, and will have a descriptive name and layer file, and will be compatible with ESRI software.

Workflow and Deliverables

The Workflow and Deliverables section is focused on documenting the steps and schedule to complete the **Assessment, Phase II : Tasks 5, 6, 7,** and **8** of the REA. **Task 5** involves the compilation and generation of "source" data sets (distribution models); **Task 6** represents the analysis of data to generate findings related to both MQs and the core REA analyses (where are CEs, CAs and their intersection); **Task 7** includes the development of the preliminary results report; and **Task 8** focuses on preparation of the REA final documents and products.

As defined by BLM, "source" data sets are those data layers needed to spatially represent CEs, CAs, and other features (e.g., permafrost) included in the assessment. In many cases, substantial spatial analysis is needed in order to develop the "source" data sets. Because the line between generating source data sets (Task 5) and conducting analyses to answer assessment questions (Task 6) is often fuzzy, we reference both "source" and "generated" datasets as products in the below tables.

The objectives of Task 7 and 8 are to consolidate the information and findings from the REA into several products. We will prepare a draft REA report that summarizes our findings and present this information to the Tech Team to receive feedback and direction prior to preparation of the final work product documents. We will incorporate comments on the draft report and prepare the

final REA report (described in detail below), which will be presented at an AMT workshop. At this juncture, the AMT will have the opportunity to comment on the final REA products prior to delivery. Simultaneously, we will be delivering all spatial data products following guidelines provided in the BLM Data Management Plan.

Workflow

This Work Plan marks the transition between the pre-assessment Phase I (Tasks 1 to 4) and assessment, Phase II (Tasks 5 to 8) of the REA. Table 1 shows the workflow and timelines for the REA beginning with Phase I ,Task 4 (Draft and Final Work Plans) and continues until the end of Phase II (Prepare REA documents). The numbers in the "REA Workflow" column correspond to the task numbers shown in the REA schedule of deliverables (Table 2), which lists both deliverable and proposed meeting dates for the remainder of Phase I and all of Phase II.

Draft Product Review

Review of preliminary products by Technical Team and AMT members is essential to the REA process, and serves as a "intuition-check" for our modeling efforts so that any glaring issues can be resolved before the formal presentation of the final results during the AMT 6 workshop (see Table 1). We propose a sequence of four update webinars/meetings to be held at the end of each task to provide the AMT and Technical Team members the opportunity to review and comment on draft products as they become progressively available. The purpose of each webinar/meeting and the associated goals are described below, and the proposed meeting schedule is included in Table 2.

1. **Distribution Models (Task 5):** the purpose of this meeting is to present preliminary results of the source datasets and distribution models for the individual CAs and CEs. Meetings will be structured as technical webinars that will be organized topically (e.g. abiotic CAs, coarse-filter CEs) and last approximately 1 - 2 hours in duration.
    - **Goal:** to obtain approval of source datasets and distribution models to allow the UA team to move forward with integrated analyses.
    - **Target Audience:** Technical Team and topical experts
2. **Integrated Products (Task 6):** we will present preliminary review of draft integrated products (the results of the spatial intersections to the CA x CE analysis and management questions) during a web-based rolling review, with a one-hour webinar by topical leads to answer questions about the mapped outputs.
    - **Purpose:** the intent of the rolling review is to provide a quick first look at data products to ensure the analysis is going in a direction supported by the Technical Team and AMT. Due to the rapid nature of the assessment, the rolling review is also quite rapid and will require quick turnaround from all reviewers
    - **Goal:** to obtain approval of integrated products to allow the UA Team to move forward with interpretation of results and begin to develop REA documents and materials.
    - **Target Audience:** Technical Team

3. **Preliminary Results (Task 7)**: we will prepare a draft final report and present preliminary results to the Technical Team and AMT during a two day meeting. This will occur approximately 2 months before the final AMT meeting and final report delivery to allow us to incorporate comments into the final REA products.
    - **Goal:** to obtain approval of preliminary results to allow the UA Team to produce the final REA report (s).
    - **Target Audience:** AMT and Technical Team
4. **Final Results (Task 8):** the purpose of this meeting will be to showcase the final NOS REA products to the members of the AMT and Technical Team, during a half-day meeting.
    - **Goal:** to provide an opportunity for final, collective input from the Tech Team and AMT prior to report delivery.
    - **Target Audience:** AMT and Technical Team

Table 1. REA Workflow.

REA Workflow	2015		2016		
	Mar.	May	Oct.	Mar.	May
AMT Workshops and Webinars	**Meeting**	**Webinar**	**AMT 4 Webinar**	**AMT 5**	**AMT 6**
Task 4: Prepare REA Work Plan	17				
Task 5: Compile and Generate Source Datasets (Distribution Models)		11, 12			
Task 6: Conduct Analyses and Generate Findings (Integrated Products)			19-23		
Task 7: Preliminary Results				16-17	
Task 8: Prepare Rapid Ecoregional Assessment Documents and Final Report					2

Numbers in red represent the anticipated date of deliverables, except in the case of AMT workshops where they represent the workshop number.

Table 2. Schedule of deliverables.

Phase I: Pre-Assessment	
Task/Deliverable	**Scheduled Completion/Delivery**
Task 4	**Prepare REA Work Plan**
Draft Work Plan to Central Yukon/Interior Field Office	Mar. 11, 2015
Work Plan Meeting	Mar. 17, 2015
BLM Comments to Contractor	Mar. 24, 2015
Final Work Plan	Mar. 31, 2015
Phase II: Assessment	
Task/Deliverable	**Scheduled Completion/Delivery**
Task 5	**Compile and Generate Source Datasets (Distribution Models)**
Draft Results Webinars of distribution maps (1 – 2 hr per topic)	May 11-12, 2015
Task 6	**Conduct Analyses and Generate Findings (Integrated Products)**
Summarize Integrated Products via AKNHP Website	Week of Oct. 5, 2015
AMT 4 Webinars on posted products (1-hr q/a with topical leads)	Week of Oct. 19, 2015
Technical Team Review and comments to contractor (at least 14 days following posting of materials on website)	Week of Oct. 26, 2015
Task 7	**Preliminary Results**
Draft Final Report to AMT	Mar. 9, 2016
AMT 5 Meeting (2 days)	Mar. 16-17, 2016
Workshop Summary	Mar. 24, 2016
AMT Comments to UA Team (14 days following AMT)	Mar. 31, 2016
Test source data delivery to NOC	Apr. 4, 2016
Task 8	**Prepare REA Documents and Final Results**
Updated Draft Final Report 2 to AMT	Week of Apr. 25, 2016
AMT 6 Presentation (1/2 days)	May 2, 2016
Workshop Summary	May 9, 2016
Final REA Documents, Materials, and Datasets	May 18, 2016

Community Meetings Schedule Completion Dates

Fairbanks North Star Borough (NSB)	**Regional Advisory Councils (RAC)**
Mar. 17, 2015	Spring 2015
Fall 2015	Fall 2015
Spring 2016	Spring 2016

Deliverables

Reporting Units and Scale

Reporting units for this analysis will be at the landscape level in scale and intent. The BLM has specified that results should be reported at the 5th level 10-digit hydrologic unit code (HUC), and that raw data should be provided at 30 m (or some derivative of 30 m) grid cell resolution or other native resolution as appropriate. Given the resolution of most available data in Alaska, raw data will be provided at 60 m grid cell resolution, when possible, and results will be reported at the 5th level HUCs, when appropriate. Exceptions include climate data, which are only available at a 771 m grid cell resolution. The 771 m grid cell resolution for climate data was proposed and accepted by the Technical Team during the CYR Data Discovery webinar.

We also plan to summarize climate data by terrestrial subregion, as defined by Nowacki et al. 2001 (Figure 1). This level of analysis was not presented during the Data Discovery Webinar, and we are seeking approval for it now. The main reason that we are interested in having the climate data products summarized by subregions is that vegetation and permafrost are inherently linked to landscape position, and we expect that changes to active layer and the resultant impact on vegetation will differ by subregions across the REA. Having climate and active layer data summarized by subregion will allow for a more direct translation of the results to the landscape. This is especially important for fire modeling as it is most pertinent at the sub-regional level, because at the pixel level internal model variability does not allow for sufficient temporal resolution for clear near-future and long-term projections.

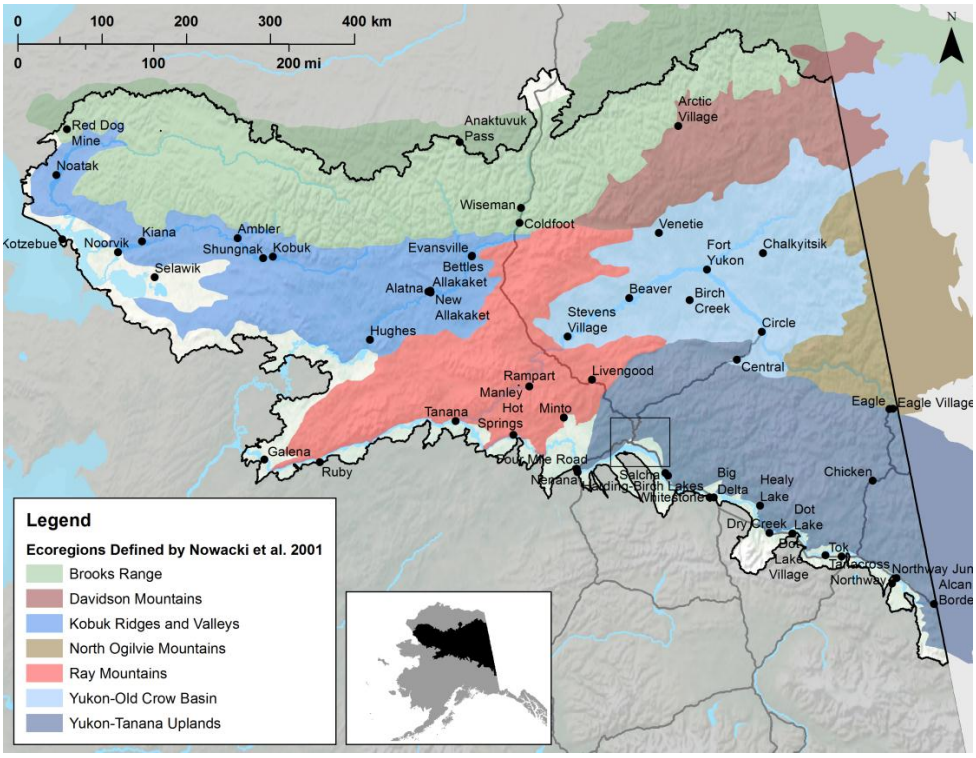

Figure 1: Terrestrial subregions used to summarize climate and fire data for the Central Yukon REA.

Final Proposed Products

To address regionally important questions, significant ecological resources and change agents, REAs focus on three primary elements:

- Change Agents (CAs), which are those features or phenomena that have the potential to affect the size, condition, and landscape context of ecological systems and components.
- Conservation Elements (CEs), which are biotic constituents or abiotic factors of regional importance in major ecosystems and habitats that can serve as surrogates for ecological condition across the ecoregion.
- Management questions (MQs), which are regionally specific questions developed by land managers that identify important management issues.

The CE and CA framework is synonymous with the core analysis of the REA. The "core analysis" refers to the status and distribution of CEs and CAs and the intersection of the two. The core REA analysis addresses the following five questions:

1. Where are conservation elements currently?
2. Where are conservation elements predicted to be in the future?
3. Where are change agents currently?
4. How might change agents change in the future?
5. What is the overlap between conservation elements and change agents now and in the future?

A total of 24 CEs and 6 CAs were selected for and approved by the AMT for the CYR REA. In addition to the core questions that are applied to all CEs and CAs, 20 specific MQs were also selected for this assessment (see Memorandum I).

Below we present a comprehensive list of prospective data products that will be generated for the CYR REA for the individual CEs and CAs, for the integrated CE x CA analysis, and for each of the MQs. We propose addressing each MQ using the CE and CA framework. We present our products list so that it reflects the relationship between the CEs/CAs and the MQs; therefore, you will find specific products related to each MQ nested within the specific CE or CA section that the MQ (s) is most closely aligned with.

Conservation Elements

Terrestrial Coarse-filter CEs

Terrestrial Coarse-filter CEs are defined as regionally important Biophysical Settings (BpS) that represent the characteristic vegetation assemblages, succession, and dominant ecological patterns of the Central Yukon Ecoregion. They adequately address the habitat requirements of most characteristic native species, ecological functions, and ecosystem services. A total of 7 Biophysical Settings within five different physiographic categories were selected as representative Terrestrial Coarse-filter CEs for this assessment (Table 3).

Table 3: List of Terrestrial Coarse-filter CEs (defined by Biophysical Settings) by physiographic regions for the Central Yukon Rapid Ecological Assessment.

Physiography	Biophysical Setting
Upland:	1. Alpine Dwarf Shrub Tundra BpS
	2. Alpine and Arctic Tussock Tundra BpS
	3. Upland Low Shrub Tundra BpS
Lowland:	4. Upland Mesic Spruce-Hardwood Forest BpS
	5. Upland Mesic Spruce Forest BpS
	6. Lowland Woody Wetland BpS
Riparian:	7. Floodplain Forest and Shrub BpS

For each of these coarse-filter CEs, we propose the following list of data products which will be developed and delivered as part of the core analysis :

- Conceptual Model
- Current Distribution Map
    - Developed and delivered at 30 m resolution
- Current Status
    - Intersection of current distribution and landscape condition
- Future Status
    - Intersection of current distribution and future landscape condition (2020s & 2060s).
- CA x CE analysis
    - For each coarse-filter CE, an analysis of those relevant CA that cause change will be reviewed and described.

In addition, we will be addressing the following Management Questions related to these CEs: AH1, G1, and G2 (Table 4).

Table 4. Management questions for the Terrestrial Coarse-Filter CEs, the anticipated format of the final data product (s), and additional comments.

MQ #	Management Question	Data Format	Comments
AH1	What rare, but important habitat types that are too fine to map at the REA scale and are associated with coarse- (or fine-) filter CEs that could help identify areas where more detailed mapping or surveys are warranted before making land use allocations (such as steppe bluff association with dry aspect forest)?	Spatial map	We will develop a map of known rare ecosystems associated with Coarse-Filter CEs.
G1	Where are refugia for unique vegetation communities (eg. hotsprings, bluffs, sand dunes) and what are the wildlife species associated with them?	Literature review and Spatial map	We will produce two products: A map known locations of rare ecosystems and a list of wildlife species associated with them from literature review.
G2	Which unique vegetation communities (and specifically, which rare plant species) are most vulnerable to significant alteration due to climate change?	Table and Spatial model	We will produce 2 tables: a list of rare ecosystems and rare plants in the CYR. Current and future distribution models of rare plant habitat will be created based on rare plant/ecosystem and climate change datasets.

Aquatic Coarse-filter CEs

Four habitat types were selected as Aquatic Coarse-Filter CEs the Central Yukon Ecological Assessment:

1. large streams and rivers
2. small streams (including headwater streams)
3. large connected lakes
4. small connected lakes

The CYR lacks an aquatic habitat classification map necessary to define Aquatic Coarse-Filter CEs by habitat and to develop distribution models. Thus, the Aquatic Coarse-Filter CEs were identified as a **data gap**. The limitations of this mapping effort were summarized in Memorandum III: Methods.

For each of the Aquatic Coarse-Filter CEs, we propose the following list data products which will be developed and delivered as part of the core analysis:

- Conceptual Model
    - We plan to develop conceptual models at a level of detail such that they include drivers and effects that are specific to a stream or lake type, although that will limit their generality to the mapped spatial distributions. Examples include temperature effects on shallow lakes or expected changes in hydrology to small streams.

- Current Distribution Map
    - We plan to develop distribution maps for both large and small connected lakes using the National Hydrography Dataset (NHD). The NHD lacks stream order, thus we will develop distribution maps for streams and rivers using TauDEM software and 60 meter National Elevation Dataset (NED).
- Current Status
    - Intersection of current distribution and landscape condition –summarized for each 5th level HUC .
- Future Status
    - Intersection of current distribution and future landscape condition (2020s & 2060s)

There are no Management Questions related to the Aquatic Coarse-Filter CE.

Terrestrial Fine-filter CEs

Seven vertebrate species were selected as Terrestrial Fine-filter CEs for the Central Yukon REA. These include:

1. Caribou (*Rangifer tarandus*)
2. Dall's sheep (*Ovis dalli*)
3. American beaver (*Castor canadensis*)
4. Snowshoe hare (*Lepus americanus*)
5. Golden eagle (*Aquilia chrysaetos*)
6. Gray-cheeked thrush (*Catharus minimus*)
7. Trumpeter swan (*Cygnus buccinator*)

For each of the terrestrial fine-filter CEs, we propose the following list of data products which will be developed and delivered as part of the core analysis :

- Conceptual Model
- Current Distribution Map
    - Developed and delivered at 60 m resolution
- Intersection of Current Distribution Map with relevant CAs (current, near-term and long-term when appropriate)
    - Specific maps will be developed and delivered only for those CE x CA relationships that are biologically meaningful (identified through the conceptual model and assessment of attributes and indicators) at 60 m resolution.
    - Each relevant CA will also be summarized and delivered in tabular format.

In addition, we will be addressing the following Management Questions related to these CEs: AE1, L1, N3, T1, X1, and X2 (Table 5).

Table 5. Management questions for the Terrestrial Fine-Filter CEs, the anticipated format of the final data product (s), and additional comments.

MQ #	Management Question	Data Format	Comments
AE1	Where is primary waterfowl habitat located?	Spatial map and list of species	A map of suitable wetland habitat will be created. A list of waterfowl species associated with wetland habitat types.
L1	What are caribou seasonal distribution and movement patterns?	Spatial maps	We will produce 2 products: a seasonal distribution map of ranges and seasonal movement patterns map.
N3	How might sheep distribution shift in relation to climate change?	Spatial maps	We will produce 2 products: a map current and future potential habitat. Snow depth data would further define winter ranges is a data gap.
T1	The introduction of free-ranging reindeer herds to this region has been proposed. What areas would be most likely to biologically support a reindeer herd?	Spatial maps	We will produce 2 products: potential reindeer summer and winter ranges.
X1	What have the past cumulative impacts of road construction and mineral extraction been on terrestrial CE habitat and population dynamics?	Literature review and spatial maps	We will produce 2 products: A literature review on past studies of impact. A spatial map of current footprint on CE habitat for caribou, sheep, and moose.
X2	How might future road construction and mineral extraction infrastructure (e.g. both temporary and permanent roads [Umiat, Ambler, Stevens Village], pads, pipeline, both permanent and temporary) affect species habitat, distribution, movements and population dynamics (especially caribou, moose, sheep)?	Spatial maps	A spatial map of future footprint on CE habitat for caribou, sheep, and moose. An additional potential product if data are available, is a map comparing road density to hunting pressure by GMU.

Aquatic Fine-filter CEs

Five species were selected as Aquatic Fine-Filter CEs and approved by the AMT during the AMT I Workshop. These include:

1. Chinook salmon (*Oncorhynchus tshawytscha*)
2. Chum salmon (*Oncorhynchus keta*)
3. Northern pike (*Esox lucius*)
4. Sheefish / inconnu (*Stenodus leucichthys*)
5. Humpback whitefish (*Coregonus pidschian*)
6. Dolly Varden (*Salvelinus malma*)

Existing spatial data that would enable us to map the distribution of the six selected Aquatic Fine-Filter CEs is extremely limited. The most comprehensive datasets for anadromous fish is the ADF&G Anadromous Waters Catalog, and for resident fishes is the ADF&G Freshwater Fish Inventory. No complete spatial distribution data for fish species currently exists and no absence data exists (that we are aware of, or that is available in digital format), limiting habitat distribution

modeling efforts. We have identified humpback whitefish and northern pike as **data gaps** and will not be producing distribution models or spatial products for these two species. We will produce:

- Conceptual Models for each CE
- Distribution maps for three fish species (Chinnok salmon, Chum salmon, Sheefish).
- Distribution model will be produced for Dolly Varden based on presence and absence data.
- Change Agent layers (both climate and development) that can be used in future analyses of fish distribution, and will be delivered as spatial data layers. These were identified in the attributes and indicators table and can be found in Memorandum II: Data Discovery/Methods.

In addition, we will be addressing the following Management Questions related to these CEs: W2 and V1 (Table 6).

Table 6. Management questions for the Aquatic Fine-Filter CEs, the anticipated format of the final data product (s), and additional comments.

MQ #	Management Question	Data Format	Comments
W2	How might future road construction and mineral extraction infrastructure (e.g. both temporary and permanent roads, pads, pipeline) affect fish habitat, fish distribution, and fish movements (especially chinook, chum, sheefish)?	Spatial model and literature review	We will identify these current or potential future human footprint activities in relation to fish habitat. We will also quantify the amount of fish habitat and riparian habitat that could potentially be affected in the future. A literature review focused on CE fish species (Chinook, chum, and sheefish) will entail the impacts of road construction and mining on fish habitat, fish distribution, and fish movements.
V1	How does human activity (e.g. mineral extraction, gravel extraction) alter stream ecology and watershed health (i.e. water quantity, water quality, outflow/stream connectivity, fish habitat, and riparian habitat)?	Spatial model and literature review	We will produce a map that spatially represents gravel extraction and fish distribution and quantify the amount of fish habitat that could potentially be affected in the future. A literature review focused on CE fish species (Chinook, chum, and sheefish) will entail the impacts of gravel extraction and mining on water quantity, water quality, outflow/stream connectivity, fish habitat, and riparian habitat.

Change Agents

Change agents (CAs) are those features or phenomena that have the potential to affect the size, condition, and landscape context of Conservation Elements (CEs). Change Agents in the region are broadly organized as:

- Climate Change (Abiotic)
- Wildfire (Abiotic)
- Invasive Species (Biotic)
- Insects and Disease (Biotic)
- Anthropogenic Uses (Anthropogenic)

Abiotic CAs

Abiotic change agents were retained as described in the methods document. We intend to provide modeled outputs for 10 climatic variables (Table 7). These will be delivered as standalone products and for use in further analyses to describe their relationship with the various CEs. As described in the methods document, this project will focus on the A2 emissions scenario. Decadal averages will be used, as opposed to data for single years, in order to reduce error due to the stochastic nature of GCM outputs, which mimic the true inter-annual variability of climate. Thus, the project will use climate data for the 2020s rather than just 2025, and the 2060s rather than the single year 2060.

Table 7. List of Abiotic CAs by metric.

Climate Change – Precipitation (summer, autumn winter, and spring seasonally, plus annual totals)	**Climate Change** – Monthly Snow Day Fraction
Climate Change – Temperature (hottest and coldest months)	**Fire** - Return Interval
Climate Change - Thaw Date	**Fire** - Vegetation Response
Climate Change - Freeze Date	**Permafrost** - Ground Temperature at one meter depth
Climate Change – Cliomes (climate clusters)	**Permafrost** - Active Layer Thickness

For each of these change agents, we propose the following list of data products which will be developed and delivered as part of the core analysis :

- Current distribution
- Near-term distribution (2020s)
- Long-term distribution (2060s)

In addition, we will be addressing the following Management Questions related to abiotic CAs: A1, B1, B2, C1, E1, and F3 (Table 8).

Table 8. Management questions for the Abiotic CAs, the anticipated format of the final data product (s), and additional comments.

MQ #	Management Question	Data Product Type	Comments
A1	How is climate change likely to alter the fire regime in the dominant vegetation classes and riparian zones?	Spatial model and table, both summarized by vegetation classes and riparian zones.	We will model projected fire frequency, overlaid with vegetation classes and spatially analyze the results.
B1	How is climate change likely to alter permafrost distribution, active layer depth, precipitation regime, and evapotranspiration in this region?	Spatial models	We will produce 3 spatial layers, one for likely changes in permafrost (based on projected threshold changes in MAGT); one for projected changes in ALT, and one for projected changes in precipitation regime (based on changes in seasonal precipitation and in snow day fraction). Evapotranspiration will be considered via regional modeling and literature review, but not spatially at the pixel level.
B2	What are the expected associated changes to dominant vegetation communities and CE habitat in relation to altered permafrost distribution, active layer depth, precipitation regime, and evapotranspiration?	Spatial map, table, and graphs.	SNAP climate and GIPL results from MQ B1 will be linked to CE habitat through a series of spatial intersections exploring current and future changes to vegetation communities. Results will be displayed in tabular, graphical, or spatial formats, and the ecological significance will be interpreted through a literature review.
C1	How will changes in precipitation, evapotranspiration, and active layer depth alter surface water availability and therefore ecosystem function (dominant vegetation classes)?	Spatial model	We will overlay outputs from SNAP precipitation and evapotranspiration models and SNAP/GIPL permafrost models with maps of vegetation from the core analysis (Coarse-Filter CEs) and maps of current surface water.
E1	How is climate change affecting the timing of snow melt and snow onset, spring breakup and green-up, and growing season length?	Spatial model	We will use SNAP climate data and derived seasonality datasets to model changes in seasonal timing
F3	How are major vegetation successional pathways likely to change in response to climate change, with special emphasis on increased shrub cover and treeline changes?	Spatial models and table.	Vegetation changes modeled and mapped at the level of ecological sub-regions. Data also presented in tabular form. Treeline mapped spatially via ALFRESCO “best reps.”

Biotic CAs

Invasive species
While much of Alaska, including the Central Yukon, has not witnessed dramatic impacts of invasive species in natural systems, they are increasing in abundance, distribution, and economic harm. For this CA, we propose the following list of deliverables:

- Current distribution
- Predicted potential distribution (2060s)
    - Invasion vulnerability maps will be estimated using the 2060s predicted growing season length, mean annual temperature, mean July temperature, and identifying which species are currently associated with those values (described in Methods document).
    - Levels of invasion vulnerability will be delineated as: those in which no known invasive species are expected to occur; areas in which the climate is suitable for a small cohort (<10 species) of weakly to modestly invasive non-native species may occur; areas in which climate is suitable for a larger cohort (>10 species); and areas in which the climate is suitable for one or more species considered moderately to highly invasive.

There are no Management Questions related to invasive species.

Insects and Disease
Insect and disease agents will be analyzed as a CA for the Central Yukon REA, but only in the current time scenario. Future areas of vulnerability will not be modeled because the nature of insect and disease outbreaks is too stochastic and the relationship of outbreaks with other CAs is not understood well. For this CA, we propose the following list of deliverables:

- Historic (past 25 years) distributions of insect and disease damage areas.
- Current (past 5 years) distributions of insect and disease damage areas.

Short-term future trends can be inferred by comparing the two. There are no Management Questions related to insects and disease.

Anthropogenic CAs

Anthropogenic CAs were retained from the data discovery/methods memo (Table 9). A map of the current human footprint will be the primary data product for the anthropogenic CAs.

For the human foot print CAs we separated them into two classes to separate linear and point\polygon features: Anthropogenic – Permanent Block Features (Buildings, mines, etc.) and Anthropogenic – Permanent Linear Features (Roads. Rivers, etc.).

Several MQs require a review of primary source documents such as meeting minutes. In some cases, review of gray literature may be the only available method. Where accessible and available, primary source documents will be obtained and analyzed to answer questions. Gray literature may include reports from various sources such as Alaska Department of Fish and Game.

Table 9. List of Anthropogenic CAs.

Transportation and Communication Infrastructure
Energy Development
Subsistence
Natural Resource Extraction (mining and oil and gas)
Recreation

For each of these Change Agents, we propose the following list of data products which will be developed and delivered as part of the core analysis:

- Current distribution
- Future distributions (2020s and 2060s): We intend to produce future distributions for two points in time – Near Term Distribution (2020s) and Long-Term Distribution (2060s). However, given the lack of clear direction in future policy and adequate past data, it may not be feasible to produce meaningful products for these time horizons.

In addition, we will be addressing the following Management Questions related to anthropogenic CAs: Q1, U1, and U3 (Table 10).

Table 10. Management questions for the Anthropogenic CAs, the anticipated format of the final data product (s), and additional comments.

MQ #	Management Question	Data Product Type	Comments
Q1	Which subsistence species (aquatic and terrestrial) are being harvested by whom and where is harvest taking place?	Spatial map	Hunting and fishing is reported by aggregate units, exact location data of either hunting or fishing for any species is limited or unavailable. Given the large data gaps, data are only as reliable as its coverage over time and across the geography.
U1	Compare the footprint of all types of landscape and landscape disturbances (anthropogenic and natural changed) over the last 20 and 50 years.	Spatial map	We will be limited by the availability of historical information, and the amount of time available within the scope of this project to identify the historic development of the human foot print in the region.
U3	How and where is the anthropogenic footprint most likely to expand 20 and 50 years into the future?	Spatial map	This question will be answered through a review of policy and plan documents available through various permitting agencies and divisions of the state and federal government.

Integrated Products

Landscape Integrity

Landscape integrity provides a quantifiable and readily assessable measure of naturalness, which can be used then to assess the current and potential future status of ecological resources.

We propose the following list of **integrated products,** which will be developed as part of the core analysis:

1. Landscape Condition Model (LCM)
    a. Combined impact of human development and invasive species on overall condition
    b. Used to assess CE status
    c. Developed for current, near, and long-term time periods
    d. Developed and delivered at 60m resolution, summarized at 5th level HUC
2. Landscape Intactness
    a. Assessment of large intact blocks
    b. Developed for current, near, and long-term time periods
3. Cumulative Impacts
    a. Measure of the magnitude of climate change
    b. Sum of all human-derived impacts in the future (2020s & 2060s)
    c. Developed for near and long-term time periods
    d. Summarized at 5th level HUC

Final Report

After all the REA products have been reviewed and accepted by the Tech Team and AMT, we will summarize all the results into a final report, which will be partitioned into two distinct documents. The first document will be a **Summary Report** that outlines the key findings of the Central Yukon REA. The second document will be a **Technical Supplement**, which is intended for readers with interest and expertise in the various components of the REA and who want to understand more specific details regarding methods, results, applications, limitations, and data gaps than are provided in the Summery Report.

At a minimum, the following information will be included in the final summary documents:

- Summary
- Introduction, including description of the ecoregional assessment process
- Ecoregional resource concerns and MQs
- Brief summary of the methodologies used in the investigation
- Summary of ecoregion conditions regarding CEs and CAs
- Results and findings of output products regarding status and potential for change
- Specific answers to MQs
- An appendix listing all the data gaps encountered throughout the course of the data discovery and analysis.

The final report will be accompanied by an AMT meeting to review and discuss all the findings of this REA. The draft final report will be made available by early-March 2016, followed by an AMT meeting a week later. The final report will be delivered to the BLM by May 18, 2016.

References

Nowacki, G., P. Spencer, M. Fleming, T. Brock, and T. Jorgenson. 2001. Ecoregions of Alaska: 2001. U.S. Geological Survey Open-File Report 02-297 (map).

BLM REA DMP. 2012. Bureau of Land Management Rapid Ecoregional Assessment Data Management Plan. Version 2. Division of Resource Services, National Operations Center, Bureau of Land Management, U.S. Department of the Interior. Denver, CO. 44 pp.