Central Yukon
Rapid Ecoregional Assessment

Memorandum I. Management Questions, Conservation Elements, and Change Agents

Prepared for:

Department of the Interior
Bureau of Land Management
Rapid Ecoregional Assessments

Submission Date:

3 October, 2014

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Acronyms used in this document:

ACEC	Area of Critical Environmental Concern
ADF&G	Alaska Department of Fish and Game
AKGAP	Alaska Gap Analysis Program
AKNHP	Alaska Natural Heritage Program
AMT	Assessment Management Team
BLM	Bureau of Land Management
CA	Change Agent
CE	Conservation Element
CYR	Central Yukon Rapid Ecoregional Assessment
ESRI	Environmental Services Research Institute
HUC	Hydrologic Unit Code
ISER	Institute of Social and Economic Research
MQ	Management Question
REA	Rapid Ecoregional Assessment
SNAP	Scenarios Network for Alaska and Arctic Planning
Tech Team	Technical Team
TEK	Traditional Ecological Knowledge
TNC	The Nature Conservancy
USGS	United States Geological Survey
UA	University of Alaska
USFWS	United States Fish and Wildlife Service
GIPL	Geophysical Institute Permafrost Lab

Introduction

Project Overview

The Bureau of Land Management (BLM) recently developed a landscape approach to enhance management of public lands. As part of this landscape approach, the BLM and collaborators are conducting Rapid Ecoregional Assessments (REAs) in the western United States, including Alaska. To address current problems and future projections at the landscape level, the REAs are designed to transcend management boundaries and synthesize existing data at the ecoregion (or in the case of Alaska, combinations of generally similar ecoregions) level. A synthesis and analysis of available data benefits the BLM, other federal and state agencies, and public stakeholders in the development of shared resources.

REAs evaluate questions of regional importance identified by land managers and statuses of regionally significant ecological resources and change agents. The resulting synthesis of regional information assists management and environmental planning efforts at multiple scales. REAs have two primary purposes:

1. To provide landscape-level information needed in developing habitat conservation strategies for regionally significant native plants, wildlife, and fish and other aquatic species; and

2. To inform subsequent land use planning, trade-off evaluation, environmental analysis, and decision-making for other interconnected public land uses and values, including development, recreation, and conservation.

Once completed, this information will provide land managers with an understanding of current resource status and the potential for future change in resource status in the near-term (15 year) and long-term (50 year).

The assessment area for the Central Yukon REA includes seven ecoregions: the Brooks Range (south of the ridge crest), Kobuk Ridges and Valleys, Ray Mountains, Davidson Mountains, North Ogilvie Mountains, Yukon – Old Crow Basin, and Yukon-Tanana Uplands.[1] This region has a boreal climate, with long cold winters and relatively brief but warm summers. Climate varies depending primarily upon elevation, proximity to the coast, and latitude. The Central Yukon Ecoregion includes 67 communities, with the majority of the population (88.4%) in the Fairbanks metropolitan area. The ecosystems within the ecoregions are considered to be intact and undisturbed relative to most ecosystems at lower latitudes. These ecoregions represent a dramatically different model than many of the REA efforts in the lower 48 states and provides a unique opportunity to assess how systems following relatively natural patterns are likely to change under various climate and land use change futures.

[1] Ecoregions based on Nowacki et al. 2001.

The Alaska Natural Heritage Program (AKNHP), Scenarios Network for Alaska and Arctic Planning (SNAP) and Institute of Social and Economic Research (ISER), collectively referred to in this document as the University of Alaska (UA) Team, will assess the current and potential future status of selected regionally significant ecological resources, referred to as Conservation Elements (CEs), at the ecoregional scale and their relationships to Change Agents (CAs), those features or phenomena that have the potential to affect the size, condition, and landscape context of the CEs. Additionally, the UA Team will address Management Questions (MQs) that were selected by state and federal land managers to inform current and ongoing management decisions.

Phase I Objectives

Phase I, the Pre-Assessment Phase of the REA, includes three tasks that are prerequisite to finalizing the components of the Work plan and continuing to Phase II, the Assessment Phase. These include:

Task 3. Selection of MQs, CEs, and CAs and the development of a Conceptual Ecoregional Model.

Task 4. Collection and evaluation of data layers necessary to conduct the assessment, and the identification of current data gaps.

Task 5. Development of an approach to analyses, including methods, models, and tools.

Memorandum I Objectives

Memorandum I provides a summary of the selection of MQs, CEs, and CAs and correlates to the results of Task 3, Phase I, as identified above. Additionally, Memorandum I provides a synopsis of the ecological and socio-economic resources present in the Central Yukon Ecoregion, outlines the reporting units for results, and describes the Conceptual Ecoregional Model.

The objectives of Task 3 of Phase I are:

1. Define the geographic boundaries of the assessment area.
2. Develop a Conceptual Ecoregional Model to represent to ecosystem resources, functions, and drivers present in the Central Yukon Ecoregion.
3. Produce a list of ecoregion-specific MQs based on questions important to land managers.
4. Identify representative biotic constituents and abiotic factors that are either regionally-significant to ecosystems, as indicated by reference in the Conceptual Ecoregional Model, or regionally-significant to land managers, as indicated by reference in the MQs, to be analyzed as a CE.
5. Identify regionally-significant disturbance factors to be analyzed as CAs.

Assessment Area

Geographic Boundary

The assessment area, referred to in this REA as the Central Yukon study area, consists of seven ecoregions defined by Nowacki et al. 2001: the Brooks Range (south of the ridge crest), Kobuk Ridges and Valleys, Ray Mountains, Davidson Mountains, North Ogilvie Mountains, Yukon – Old Crow Basin, and Yukon-Tanana Uplands (Figure 1). These ecoregions represent a unified mapping approach that blends traditional approaches (Bailey et al. 1994; Omernik 1987) with regionally-specific knowledge and ecological goals. The assessment boundary, following BLM guidelines, constitutes the seven component ecoregions and any 5th level hydrologic units that intersect the ecoregion boundaries. Additionally, at the request of the BLM, the assessment boundary include key lands surrounding the Dalton Highway.

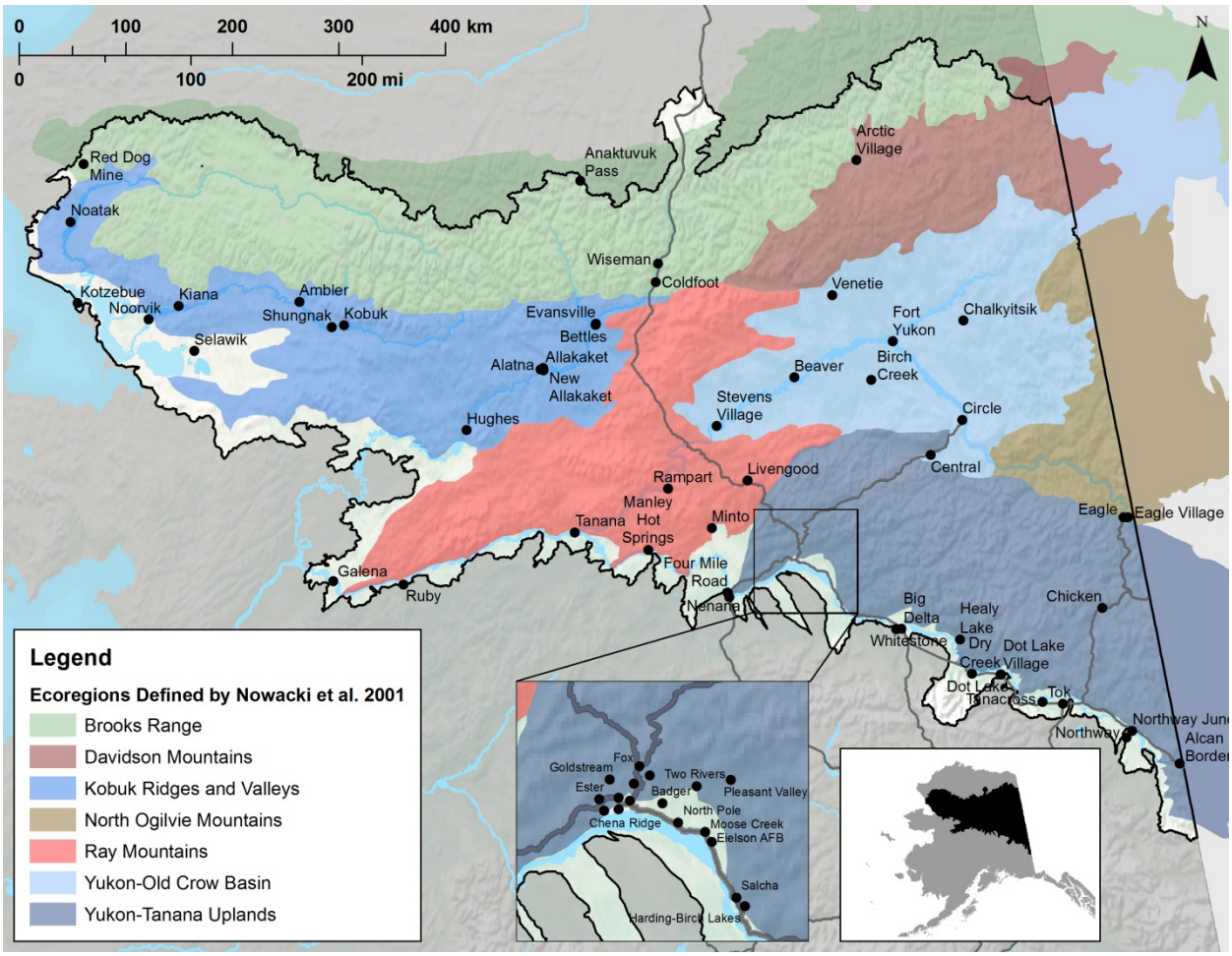

Figure 1. Ecoregions included in Central Yukon REA and study boundary.

Landscape Reporting Unit

As per BLM guidance, reporting units for the Central Yukon REA will be at the landscape level in scale and intent. For most analyses, the BLM has specified that data be reported at the 5th level 10-digit

hydrologic unit code (HUC) with raw data being provided at 30 m grid cells for raster data or other native resolution as appropriate. Climate data will be provided at a resolution of 771 m grid cells and therefore any climate related questions will be answered at this scale as well. Many of the primary landscape level datasets for Alaska are also coarser than the 30 m pixel resolution recommended by the BLM (for example, the best available resolution for Digital Elevation Model is 60 m grid cells). Therefore the ultimate reporting unit of each analysis will be limited by the coarsest resolution of the data. In general, however, raw data will be provided at 60 m grid cell resolution, and results will be reported at the 5th level HUCs (Figure 2).

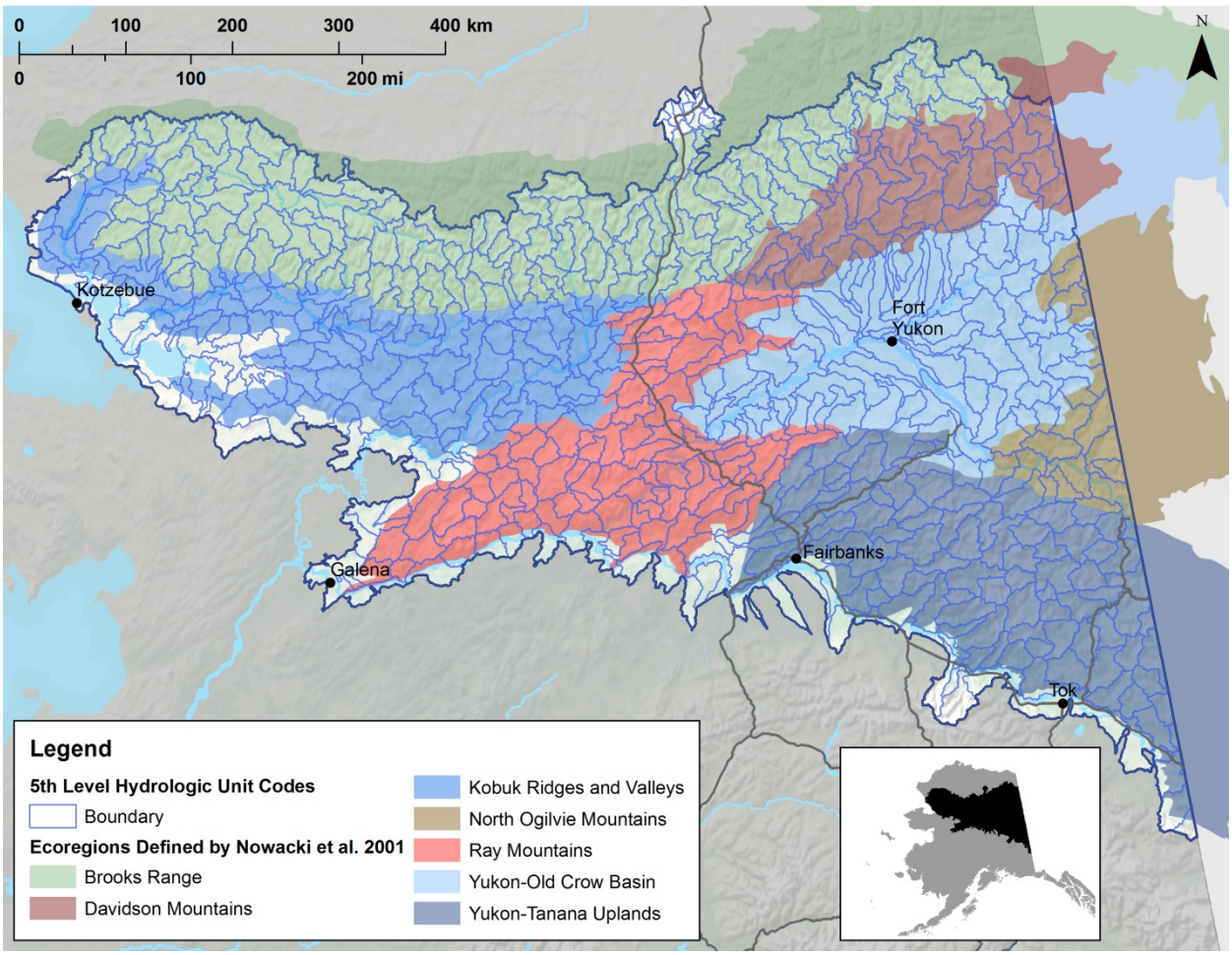

Figure 2. 5th Level HUCs within the Central Yukon study area.

Ecoregion Descriptions

The following narratives for each ecoregion are paraphrased from Nowacki et al.(2001). They provide general descriptions of ecosystem resources and drivers.

Brooks Range

This east-west range is the northernmost extension of the Rocky Mountains and includes the Brooks Range, British Mountains, and Richardson Mountains. Many of the mountains are comprised of steep, angular summits flanked by rubble and scree (Figure 3). On the western and eastern ends of the range, the topography becomes less rugged. Rivers and streams cut narrow ravines into the terrain. During the Pleistocene, glaciers covered the higher portions of the range. Only a few small cirque glaciers remain. A dry, polar climate dominates the land. Winters are long and cold, and summers are short and cool. Air temperatures decrease rapidly with increased elevation. Permafrost is mostly continuous south of the ridge crest. Dominant vegetation classes on the south side of the range are sedge tussocks and shrubs in valleys and lower slopes, sparse conifer-birch forests in large valleys, and alpine tundra and barrens at higher elevations. The ecoregion provides habitat for dall sheep, caribou, marmots, gray wolves, and brown bears. Groundwater fed springs and streams provide habitat for arctic grayling.

Figure 3. Rugged terrain of the Brooks Range.

Kobuk Ridges and Valleys

The Kobuk ridges and valleys ecoregion is comprised of a series of paralleling ridges and valleys that radiate south from the Brooks Range, created partially by high-angle reverse faults and interceding troughs. In the past, ice sheets descending from the north covered the area. Broad valleys are covered with alluvial and glacial sediments while intervening ridges are covered with rubble (Figure 4). Climate is dry continental with long, cold winters and short, cool summers. During winter, cold air drains from the Brooks Range into the valleys. Permafrost is thin to moderately thick throughout much of the area.

Forests and woodlands dominate much of the area. Trees become increasingly sparse in the west. Tall and short shrub communities of birch, willow, and alder occupy ridges.

Figure 4. Kobuk River.

Ray Mountains

The Ray Mountains are comprised of compact, east-west oriented ranges. Metamorphic bedrock is covered with rubble, and soils are shallow and rocky (Figure 5). During the Pleistocene, the Ray Mountains remained largely unglaciated. Climate is continental with dry, cold winters and somewhat moist, warm summers. Permafrost is discontinuous and ranges from thin to moderately thick. Dominant vegetation classes are black spruce woodlands; white spruce, birch, and aspen on south-facing slopes; white spruce, balsam poplar, alder, and willows on floodplains; and shrub birch and *Dryas*-lichen tundra at higher elevations. Clear headwater streams are important habitat for arctic grayling. Moose, brown bears, gray wolves, red fox, lynx, and marten are common.

Figure 5. Low ridge with rock outcrops in Ray Mountains.

Davidson Mountains

Mountains with coarse rubble slopes are interspersed with broad floodplains underlain by unconsolidated glacial and alluvial sediments (Figure 6). Thin to thick permafrost underlies the majority of the ecoregion. Climate is continental with cold winters and short, cool summers. Dominant vegetation classes are black spruce woodlands; white spruce and balsam poplar along rivers; and white spruce, resin birch, and quaking aspen in uplands. Shrub communities of willow, alder, and birch are also common. Forest fires are frequent. Moose, bears, and wintering caribou are common.

Figure 6. Winter in Davidson Mountains.

North Ogilvie Mountains

Flat-topped hills and a plain are primarily underlain by calcareous sedimentary rock. The ecoregion was not glaciated and is therefore heavily eroded. Ridges and upper slopes are barren and jagged rock outcrops are common (Figure 7). Shallow soils cover the rocky colluvial deposits of slopes that are subject to frequent landslides and debris flows. Lower and more stable slopes have developed deeper soils that are extensively underlain by permafrost. Low shrub tundra with willow, alder, and birch and spruce woodlands occur at lower elevations. The streams originating in the North Ogilvie Mountains feed the Porcupine, Yukon, and Peel rivers. Few lakes exist. Climate is continental with cold winters and short, cool summers. Brown bears, wolverine, dall sheep, caribou, lemmings, and pikas are common.

Figure 7. Calcareous rock outcrops and ridges in the North Ogilvie Mountains.

Yukon – Old Crow Basin

Mountain toeslopes around the Porcupine River form a basin comprised of depositional fans, terraces, and pediments (Figure 8). The region was largely unglaciated and is heavily eroded. Surrounding the flats, surficial deposits of colluvial, alluvial, and aeolian origins are deep and underlain by continuous permafrost. The poorly drained flats contain extensive wetlands with many thaw lakes and ponds. Deltaic fans, river terraces, and floodplains are common on the landscape. Climate is dry continental with large seasonal temperature fluctuations. Winters are cold and dry because of dominant arctic high pressure systems. Common vegetation ranges from wet herbaceous marshes to open black spruce forests to closed spruce-deciduous forests on well-drained uplands. The wetland complexes formed by the Yukon River support large numbers of waterfowl and other migratory birds. Moose, bears, northern pike, and salmon are common.

Figure 8. Floodplain and extensive flats along the Porcupine River.

Yukon-Tanana Uplands

Broad, rounded mountains of moderate height are underlain by metasedimentary volcanic crust blocks and continental shelf deposits. Surficial deposits are bedrock and rubble on ridges and upper slopes, colluvium on lower slopes, and alluvium in the narrow valleys. The region is underlain by discontinuous permafrost thick on north-facing slopes and thin in valleys. Climate is continental with cold winters and warm summers. White spruce, resin birch, and quaking aspen dominate south-facing slopes (Figure 9). North-facing slopes are primarily black spruce woodland or forest while valleys are dominated by black spruce woodlands and tussock bogs. Low birch-ericaceous shrub and *Dryas*-lichen tundra are common at the uppermost elevations. Forest fires are very common in this region resulting in a patchwork of forest ages. Caribou, moose, snowshoe hare, marten, lynx, black bears, and brown bears are common. Abundant cliffs provide habitat for peregrine falcons. Chinook, chum, and coho salmon spawn in the clear headwater streams.

Figure 9. Low, broad ridges of the Yukon-Tanana Uplands.

Climate

This region has a boreal climate, with long cold winters and relatively brief but warm summers. Climate varies depending primarily upon elevation, proximity to the coast, and latitude. Although in general the most extreme cold occurs at high elevations, some areas experience localized temperature inversions. With mean annual temperatures below freezing in most areas, but above freezing in others, permafrost is discontinuous. This discontinuity occurs at both fine scales and broader scales.

Selected historical weather station data for the REA study area are shown in Table 1. Historical climate station data for several variables, including maximum, minimum, and mean monthly temperatures and monthly precipitation, are available from the Alaska Climate Research Center, ACRC (http://climate.gi.alaska.edu/), with "Climate Normals" representing mean values for 1981–2010 (Figure 10). Note that data are not available for all communities in the REA, including some that might be expected to fall outside the range show in this table – particularly Arctic Village and Anaktuvuk Pass. Although winter temperatures are coldest to the north, summer temperatures are coolest to west, on the coast.

Table 1: Examples of historical mean monthly temperatures (°F) from the Alaska Climate Research Center, ACRC (http://climate.gi.alaska.edu/).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Eagle	-9.5	-3.7	7.2	28.9	46.1	57.9	60.4	53.6	41.8	23.0	3.0	-4.0	25.5
Fairbanks International Airport	-7.9	-1.3	11.4	32.5	49.4	60.4	62.5	56.1	44.9	24.2	2.6	-4.1	27.7
Galena	-9.2	-1.1	8.4	26.1	45.4	58.6	60.6	54.4	44.1	23.6	4.4	-3.8	26.1
Kotozebue 25N	-8.5	-4.3	-0.2	14.8	36.4	51.3	55.4	49.6	39.7	19.6	4.1	-3.5	21.3
Nenana Municipal Airport	-6.1	0.4	10.7	30.7	47.7	58.5	60.9	55.0	43.8	23.2	3.2	-2.6	27.2
Northway Airport	-14.8	-5.9	7.9	29.5	45.8	55.9	59.0	53.9	41.6	21.2	-2.3	-11.4	23.5
Wiseman	-10.0	-5.6	4.1	22.9	42.0	55.8	56.9	50.0	38.0	16.6	-2.6	-5.7	22.0

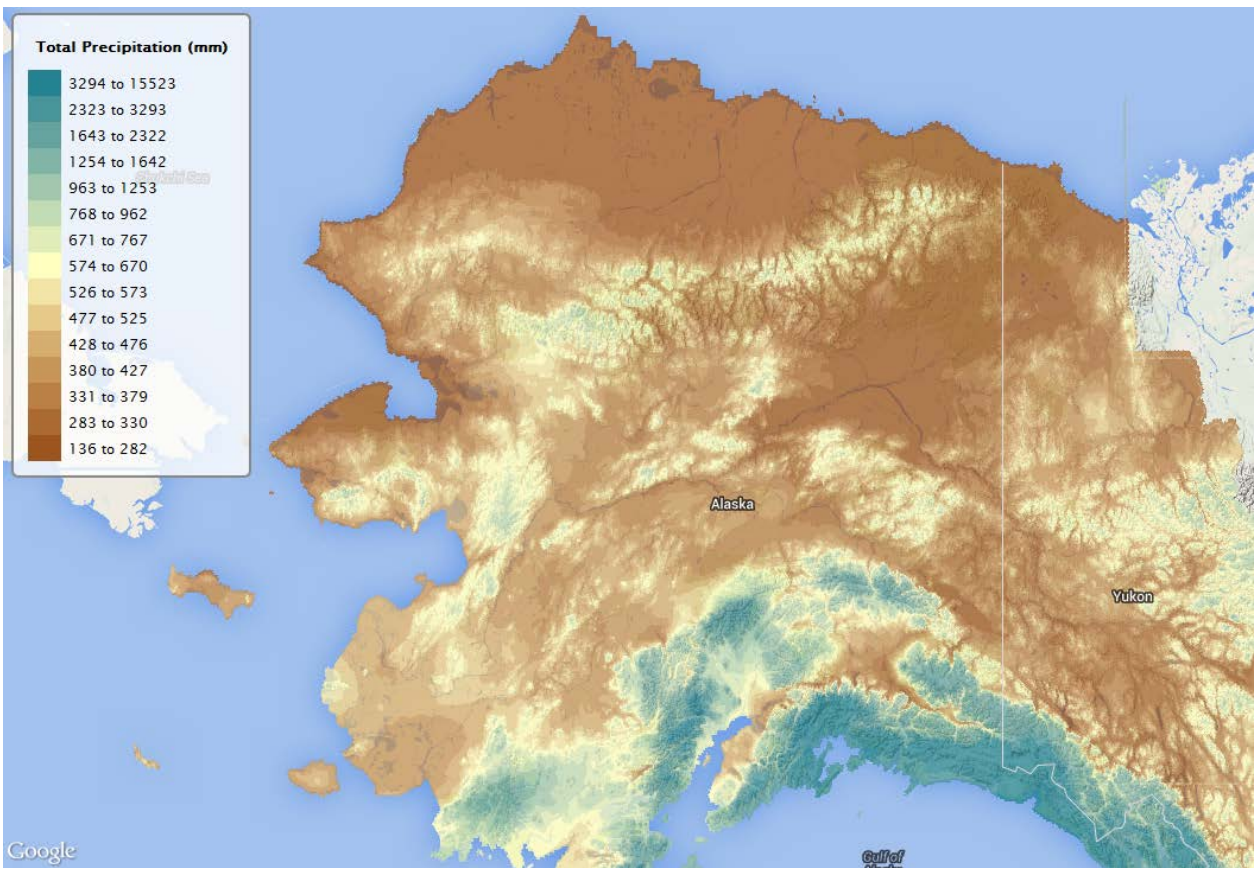

Figure 10: Historical total mean annual precipitation (rainwater equivalent) 1961–1990. These data are based on gridded interpolated climate data, via SNAP (www.snap.uaf.edu).

Socioeconomic Description

Central Yukon region is 393,311.18 sq. km, almost as large as California, with a total population of 112,357 in 2012 (Alaska Department of Labor 2013). Majority of this population (99,280, or 88.4%) lives in the Fairbanks metropolitan area (19,280 Sq. Km or 4.9% of the total area), comprised of 17 distinct

communities. The remaining population is distributed among 50 communities with population ranging from 5 people in Evansville to 3,237 people in Kotzebue. Table 2 shows the 2010 total population and Alaska Native population for each community, organized by census area or borough.

Table 2: Total population and total Alaska Native (AIAN) population by community, 2010

Community	Total Population 2010	Total AIAN Population 2010	Percentage of AIAN population
Fairbanks North Star Borough			
Badger CDP	19482	950	5%
Chena Ridge CDP	5791	358	6%
College CDP	12964	1227	9%
Eielson AFB CDP	2647	24	1%
Ester CDP	2422	163	7%
Fairbanks city	31535	3148	10%
Farmers Loop CDP	4853	308	6%
Fox CDP	417	31	7%
Goldstream CDP	3557	121	3%
Harding-Birch Lakes CDP	299	10	3%
Moose Creek CDP	747	38	5%
North Pole city	2117	71	3%
Pleasant Valley CDP	725	27	4%
Salcha CDP	1095	47	4%
South Van Horn CDP	558	37	7%
Steele Creek CDP	6662	250	4%
Two Rivers CDP	719	26	4%
Total	**96590**	**6836**	**7%**
North Slope Borough			
Anaktuvuk Pass city	324	270	83%
Total	**324**	**270**	**83%**
Northwest Arctic Borough			
Ambler city	258	218	84%
Kiana city	361	326	90%
Kobuk city	151	136	90%
Kotzebue city	3201	2355	74%
Noatak CDP	514	487	95%
Noorvik city	668	590	88%
Red Dog Mine CDP	309	157	51%
Selawik city	829	708	85%
Shungnak city	262	247	94%
Total	**6553**	**5224**	**80%**
Southeast Fairbanks Census Area			

Alcan Border CDP	33	0	0%
Big Delta CDP	591	14	2%
Chicken CDP	7	0	0%
Dot Lake CDP	13	3	23%
Dot Lake Village CDP	62	51	82%
Dry Creek CDP	94	0	0%
Eagle city	86	7	8%
Eagle Village CDP	67	26	39%
Healy Lake CDP	13	11	85%
Northway CDP	71	56	79%
Northway Junction CDP	54	36	67%
Tanacross CDP	136	109	80%
Tok CDP	1258	153	12%
Whitestone CDP	97	0	0%
Total	**2582**	**466**	**18%**
Yukon-Koyukuk Census Area			
Alatna CDP	37	36	97%
Allakaket city	105	100	95%
Arctic Village CDP	152	135	89%
Beaver CDP	84	82	98%
Bettles city	12	0	0%
Birch Creek CDP	33	33	100%
Central CDP	96	4	4%
Chalkyitsik CDP	69	59	86%
Circle CDP	104	88	85%
Coldfoot CDP	10	1	10%
Evansville CDP	15	8	53%
Fort Yukon city	583	520	89%
Four Mile Road CDP	43	13	30%
Galena city	470	299	64%
Hughes city	77	74	96%
Livengood CDP	13	3	23%
Manley Hot Springs CDP	89	12	13%
Minto CDP	210	190	90%
Nenana city	378	142	38%
New Allakaket CDP	66	65	98%
Rampart CDP	24	23	96%
Ruby city	166	147	89%
Stevens Village CDP	78	66	85%
Tanana city	246	213	87%
Venetie CDP	166	152	92%

Wiseman CDP	14	0	0%
Total	**3340**	**2465**	**74%**

In order to better comprehend the region and its population, and in order to facilitate reporting results of analyses at an ecoregional level, communities need to be combined into groups. Communities can be grouped in several ways – by census area/boroughs, by watershed, by road vs. non-road communities, by incorporated vs. unincorporated communities, etc. Table 3 shows the four such groupings.

Table 3: Population totals by groups of communities

	Total Population 2010	Total AIAN Population 2010	Percentage of AIAN population	Number of communities
By Census Areas/Boroughs				
Fairbanks North Star Borough	96,590	6,836	0.07	17
North Slope Borough	324	270	0.83	1
Northwest Arctic Borough	6,553	5,224	0.80	9
Southeast Fairbanks Census Area	2,582	466	0.18	14
Yukon-Koyukuk Census Area	3,340	2,465	0.74	26
Total	**109,389**	**15,261**	**0.14**	**67**
By Incorporation Status				
1st Class City	716	512	0.72	2
2nd Class City	7,083	5,698	0.80	14
Home Rule City	34,030	3,361	0.10	3
Unincorporated	67,560	5,690	0.08	48
Total	**109,389**	**15,261**	**0.14**	**67**
By connectivity status				
Not connected by Road	9,260	7,506	0.81	27
Connected by Road	100,129	7,755	0.08	40
Total	**109,389**	**15,261**	**0.14**	**67**
By Watershed				
Colville River	324	270	0.83	1
Kobuk River	2,529	2,225	0.88	6
Koyukuk River	336	284	0.85	8
Noatak River	4,024	2,999	0.75	3
Tanana River	99,732	7,626	0.08	32
Yukon River	2,444	1,857	0.76	17
Total	**109,389**	**15,261**	**0.14**	**67**

Fairbanks is the largest city in the region, with regional other regional and sub-regional hub communities serving as transportation and service hubs for several communities around them. Fairbanks North Star Borough is the most populated borough with 88.3% of the region's population. Forty communities are

connected by road, and comprise 91.53% of the region's population. Approximately 14% of the region's population is Alaska Native and a majority of them are in the Fairbanks North Star Borough, while they comprise just over 7% of the of the total borough's population. In contrast, almost 80% of the Northwest Arctic Borough's population and 74% of the Yukon-Koyukuk Census Area's population is Alaska Native. Similarly, while almost 50% of the Alaska Native population in the CYR region live in the Tanana River watershed, they comprise only 7.65% of the total population in the watershed. Alaska Natives are the majority in other watersheds (75% or more).

The economic structure of the region can be better understood by considering the entire region in three distinct parts – Fairbanks North Star Borough, communities along the road system in the eastern part of the region, and the rest of the region. Fairbanks North Star Borough (pop. 96,590 in 2010), is comprised of 17 communities, second largest concentration of people in the state, and is considerably larger than any other community in the region. It is well connected, with an international airport, road and rail links to the rest of the state. With a large retail and service sector, Fairbanks serves several functions of the oil and gas industry on the North Slope of Alaska. The borough is also home to University of Alaska's research campus with a large student population, and also has two major defense installations – Fort Wainwright and Eielson Air Force Base – contributing significantly to the local economy.

Twenty three communities outside the Fairbanks North Star Borough are on the road system. Local economics of these communities are a distinct mix of resource extraction, subsistence, and tourism. Communities located along the Dalton highway running from Fairbanks to Prudhoe Bay – Livingood, Coldfoot, and Wiseman – primarily serve the freight traffic to and from the North Slope oil and gas fields. Remaining 27 communities in the region are remote and are connected by air year round. With the exception of Kotzebue, which serves as a hub community and the seat of the Northwest Arctic Borough, all other communities are primarily dependent on a mix of few full-time local jobs and subsistence.

Community Meetings

Community meetings are scheduled to inform the general public in the region of the activities of the REA. The purpose of these meetings is to inform the general public about the REA process, its expected outcomes, and gather stakeholder input on CEs, CAs, and MQs. From past experience, we learned the following lessons:

1. Conducting one-time meetings in selected communities is less useful for continued communication and feedback, and more expensive, as the project proceeds.

2. Identifying one (ideally) representative body of individuals for the entire region ensures that the information is disseminated as widely as possible in an efficient way.

3. Repeated (at least twice during the project duration) meetings with the same representative body over the course of the project will ensure adequate time for the audience to grasp and reflect on the scope and content of the information presented, and identify potential uses of that information for their own purposes.

Given these considerations, following are potential representative groups/organizations in the region that can serve as the audience for CYR REA's community meetings:

ADF&G Advisory Committees: ADF&G divides the state into 6 regulatory regions. Each region has several Advisory Committees (a total of 82 for the entire state), each committee covering approximately 4–10 villages. These committees' meet once or twice a year and provide recommendations to the Boards of Fish and Game on important fishing and wildlife issues in their respective areas. The CYR boundary includes parts of the Arctic (9 committees) and Central (15 committees) ADF&G regions. CYR boundary includes a region that concerns at least 16 of these committees. While the Committees are representative of the communities within each Committee's area of concern, there are numerous committees and they do not seem to have a central representative body.

USFS Regional Advisory Councils (RAC): For purposes of subsistence management, USFS divides Alaska into 10 regions, with an RAC for each region. RAC's are constituted to provide recommendations and information to the Federal Subsistence Board, to review policies and management plans, and to provide a public forum for subsistence issues. The RACs meet at least twice a year – early spring and early fall. The CYR boundary includes parts of four of these regions, with a majority of CYR within Western Interior and Eastern Interior RAC regions. RACs are fewer in number and their calendars are available. While they are fewer in number, and their calendars are available, members are appointed by the Secretary of the Interior, and may not be representative of each community within each region.

Boroughs: There are two organized boroughs in the CYR region - Fairbanks North Star Borough, Northwest Arctic Borough (Minor areas of North Slope Borough and Denali Borough are also within the CYR boundary but are not considered for this purpose). The rest of the CYR region is unorganized. While the Fairbanks North Star Borough is home to the majority of the population within CYR region, the Borough covers a minor part of the CYR region. Both organized boroughs have planning commissions that have jurisdictional authority over land use issues, and are representative bodies. While a large portion of the CYR region is not covered, a majority of the population is represented.

Native For-Profit Organizations: CYR Boundary includes just two native for-profit corporations - Doyon and NANA. Since they are private corporations, they may not have representative bodies on public matters. Additionally, their for-profit status may bias their feedback

Native Non-Profit Organizations: Majority of the CYR Boundary is covered by just two organizations - Tanana Chiefs Conference and Maniilaq. Both organizations have multiple public representative bodies. One or a combination of these bodies may be a viable alternative. However, these organizations do not have a major land use function, and thus may not be directly concerned with the primary purpose of an REA.

In view of all the above options, a combination of Planning Commissions of both Boroughs and the USFS RACs may be most appropriate for a meaningful community meetings strategy. Reaching out to four different groups will be challenging both in terms of logistics and budget. The project team proposes to work with the BLM and the AMT to identify a combination of liaisons from both the project team and

BLM to engage these groups over the course of the project. We hope to present project material at least twice, at strategically meaningful times, to each group.

Ecoregional Conceptual Model

The Ecoregional Conceptual Model portrays an understanding of critical ecosystem components, processes, and interactions necessary for the maintenance of sustainable ecosystems. By summarizing existing information and hypotheses on the structure and function of ecosystems, the Ecoregional Conceptual Model provides the framework to assess ecological conditions and trends. The complex interactions of ecosystem resources, ecological drivers, and CAs is simplified in the Ecoregional Conceptual Model to clearly show ways in which ecosystem resources interact with one another and the relationships between ecosystem resources, CAs, and ecosystem drivers. The model provides the scientific justification for the selection of CAs and informs the selection of CEs by capturing representative ecosystem resources and their processes.

The Ecoregional Conceptual Model for the Central Yukon study area (Figure 11) provides a coarse-scale interpretation of key ecological resources, drivers, and CAs of the seven constituent ecoregions. The model is divided into the following components:

- **Principal ecosystem resources**, including vegetation, animals, soil resources, freshwater resources, and ocean (coastal zone).
- **Ecosystem drivers**, including climate and atmospheric conditions (i.e. precipitation, temperature, cloud cover etc.) and landscape setting (i.e. geology, elevation, and proximity to ocean)
- **Anthropogenic** (land use, commercial / sport harvests, recreation) and **non-anthropogenic CAs** (climate change, fire, and invasive species).
- **Relationships between ecosystem resources** with interactions between them identifying key ecosystem processes and functions (for example, soils resources provide habitat for animals).
- **Relationships of ecosystem drivers and CAs** as external forces for ecosystem resources (for example, climate change alters composition, structure, and productivity of ecosystem resources and climatic conditions provide carbon and nitrogen setting providing essential components to the ecosystem resources).

The Conceptual Ecoregional Model will serve as a framework for measuring the cumulative impacts of all the CAs on all the CEs, providing a measure of overall current and future landscape and ecological integrity. Specific information on how this relationship will be established will be addressed in our subsequent methods memo.

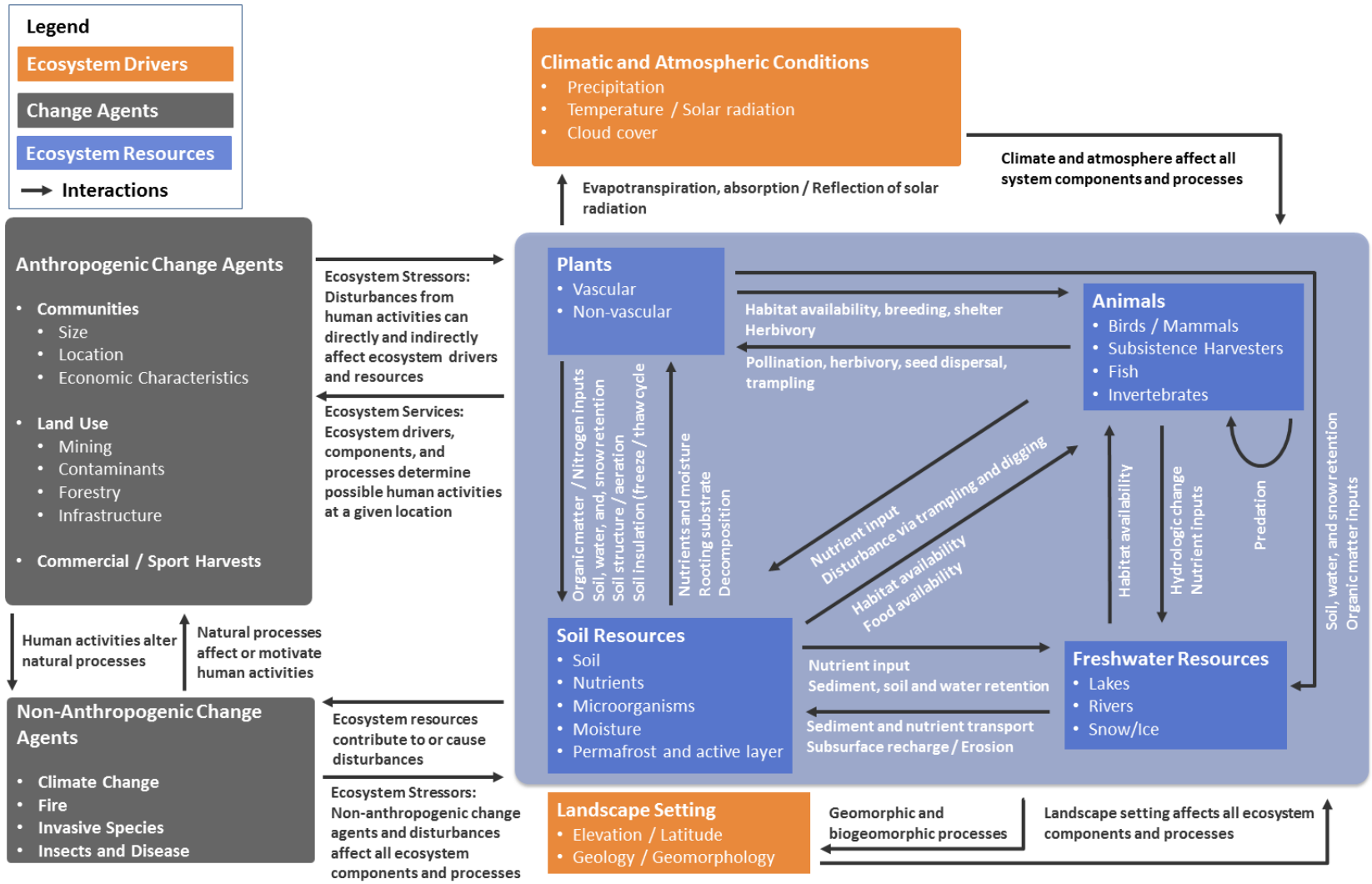

Figure 11. Ecoregional Conceptual Model for the Central Yukon study area.

Proposed REA Elements (CEs, CAs, and MQs)

REAs have two primary purposes:

1. To provide landscape-level information needed in developing habitat conservation strategies for regionally significant native plants, wildlife, and fish and other aquatic species; and
2. To inform subsequent land use planning, trade-off evaluation, environmental analysis, and decision-making for other interconnected public land uses and values, including development, recreation, and conservation.

To do this, REAs have three primary elements:

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

MQs focus REAs on pertinent management and planning concerns for the region (See MQ section below). MQs are also used to create CE and CA lists by identifying critical resources and management concerns for the region. In addition to the MQs, CEs are also identified via the Ecoregional Conceptual Model (Figure 11). Although a basic list of CAs are provided by the BLM (see CA section below), MQs can identify additional CAs to be considered in the analysis. One of the strengths of this approach is the integration of management concerns (via the MQs) and current scientific understanding (conceptual ecoregional model) into a comprehensive assessment (Figure 12).

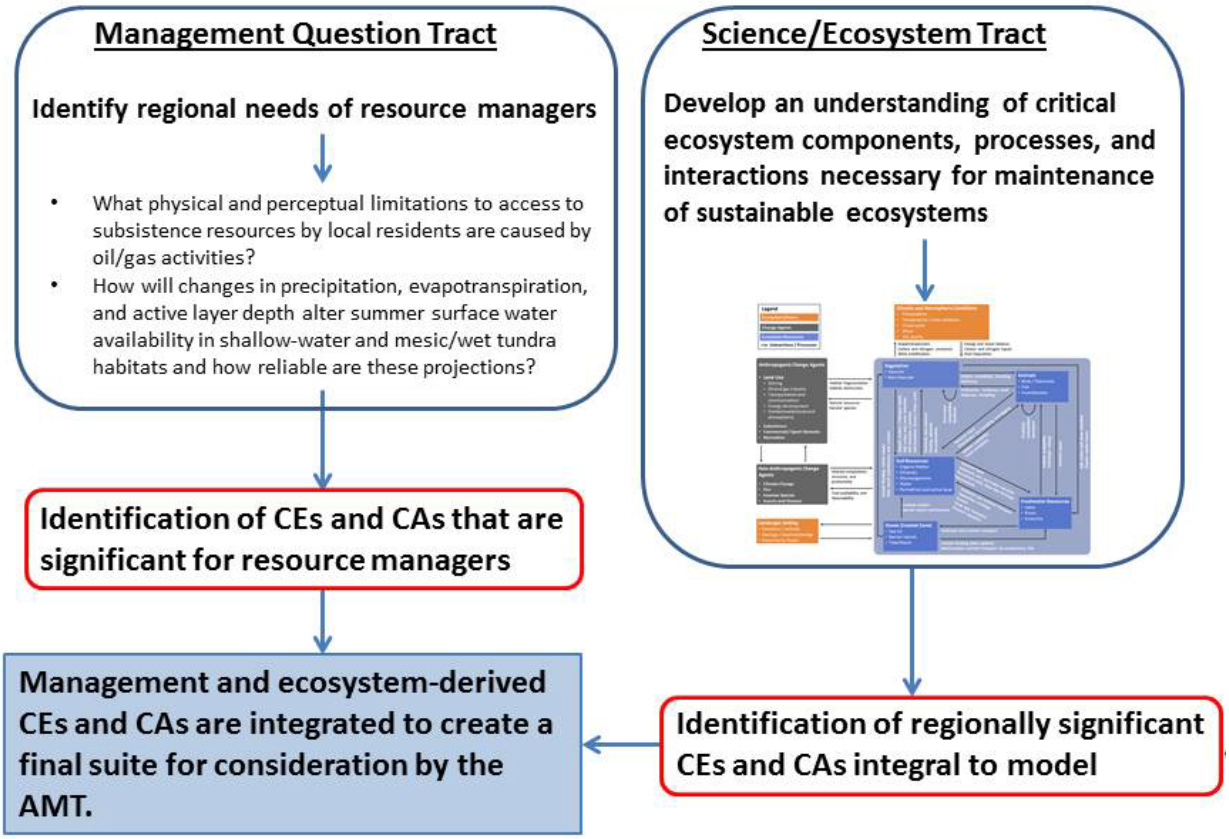

Figure 12. Diagram showing the relationship between MQs tract and the science/ecosystem tract. Red outlined boxes show the key outcomes of both the MQ and CE tract, with the blue box illustrating the combined effects of integrating the two tracts.

Following the two primary tracks, products from the REA can be conceptualized as two distinct deliverables:

1. Analysis and products in response to each MQ.
2. A series of "core" REA products that identify how the landscape is likely to change, as well as metrics of landscape and ecological integrity.

MQ findings will vary from literature reviews to spatial models, and will be related to the overall assessment, when appropriate. However, the products developed to identify and address the issues concerning CEs and CAs are considered the core REA analyses. Separate from the MQs, the core REA questions are:

1. Where are conservation elements currently? (list to be finalized at our first AMT meeting)
2. Where might conservation elements be in the future?
3. Where are change agents currently?
4. How might change agents change in the future?
5. Where will change agents impact conservation elements in the future?

Thus, there is substantial opportunity for overlap between the two tracks, which we have addressed in our selection of MQs, CEs and CAs.

Management Questions

Identifying Management Questions is an extremely important first step in framing a Rapid Ecoregional Assessment (REA). MQs are meant to compliment the core REA analysis (described above) and provide regional managers the opportunity to highlight specific management concerns relevant to the larger ecoregion, and provide a tangible way in which REA efforts can be applied towards management planning.

The University of Alaska (UA) team received an initial list of Management Questions from the BLM Central Yukon Field Office (Appendix A), who spent substantial time and effort identifying regionally important resource questions. The UA Team has subsequently been in close communication with the BLM to ensure our understanding of the nature and intent of the question is as clear as possible. Through our conversations with the BLM, we decided to parse out original multi-part questions into distinct questions and have indicated which questions were originally clustered by creating a unique "alphanumeric code" for each cluster of questions. This produced a list of 78 potential MQs.

Additionally, as a general rule all the original management questions from BLM had overarching questions of "How reliable are these predictions? Are there other data/models which provide information that is different than the output presented?". These questions will be addressed as a standard component to all analyses throughout the REA and for the purposes of the ranking were removed; however, we do intend to fully address these concerns as part of each management question.

After several consultations regarding many of the proposed questions, the UA Team reviewed the MQs and provided three forms of feedback to assist in the selection process:

1. Effort Required by UA Team
    - This is a <u>relative</u> measure of the anticipated effort needed to address the MQ. Questions that were ranked as "low" effort, generally fit into the core analyses of the REA, and therefore would require minimal *additional* effort. Conversely, questions ranked as "substantial" effort, would require extensive *additional* work, which could reprioritize our resources.
2. In Scope?
    - This is listed as either yes or no and is an indication of whether the UA Team feels the question is within scope of the REA (see the national BLM guidance on MQs for REAs below). In some cases, additional comments in this field explain the rational.
3. Possible Approach
    - This indicates the type of analysis (spatial or literature review or both) we anticipate producing if the MQ is included in the assessment.

These fields (effort, in scope, and approach) were not meant to be interpreted as a ranking by the UA team; that is not our role in this assessment. These fields helped inform the AMT on the anticipated

work required to address the MQ and helped in the ranking process to understand the level of effort required to complete the assessment.

Given the rapid nature of the REA, the BLM locally suggested we limit the number of MQs to around 20 (with a maximum of 30). Based on the success of the North Slope MQ selection process using the Delphi survey method (Hess and King 2002; Scolozzi et al. 2012; O'Neill et al. 2008) to prioritize and focus our MQs, the UA team employed the same approach for the Central Yukon REA. The UA team sent out the list of MQs to the AMT and asked members to simply rank which 20 questions where their top questions, which 20 additional questions where next priority (mid), and which questions were of lowest priority to them (remove):

- **Top** - This is a critical question that needs to be addressed, irrespective of data availability or any other limitations.
- **Mid** - I/we think this is an important question, but need some preliminary data to assess its relevancy to the REA.
- **Remove** - This is an important question, but given REA timeframe/budget/scope, it can be removed from this assessment.

Each AMT member was asked to consider the following guidance from the BLM National Operations Center (NOC) on how to craft a good Management Question:

- Is the MQ about large-scale, region-wide issues?
- Can the MQ be answered by available geospatial information, remote sensing, or acceptable surrogates at the landscape scale?
- If the MQ cannot be addressed spatially, would a literature review be an appropriate use of the REA?
- If it is an inventory question, can it be addressed within the timeframe of the REA?
- Does the MQ inform a specific practical management decision or resource allocation to be made (i.e., Which areas due to resource vulnerability require protection as ACEC's? Which areas should be avoided for authorization of new roads or utility corridors?)
- Does the MQ identify the potential subsequent decision process and or action associated with the answer to the question?
- Has the MQ been answered in another recently competed ecoregional assessment and is there additional information that warrants reexamining this issue?

After receiving 10 responses from our first ranking by the AMT, 18 MQs surfaced as being the top or mid priority MQs by the majority of the voting members of the AMT (Appendix A). The UA team met with the AMT and Technical Team members during our first AMT meeting on September 5, 2014 and discussed the MQ ranking process, survey method, and asked for additional MQs to be considered. Based on this process we added one additional MQ to the list to be included in a second round of voting. To ensure consistency and confidence in our MQ selection, we sent out another round of MQ surveys to ensure the first ranking was agreed upon by the majority of the AMT.

The second round of MQ surveys resulted in seven responses. The results were tallied based on ranks for each question then reordered based on those tallies. Questions that were consistently ranked as either Top 20 or Mid 20 by over half of the voting AMT members were selected as our final list of MQs (Table 4). In addition to the to 20 MQs we also identified 12 alternative MQs with almost half of the AMT agreeing on these questions being either top 20 or mid 20 MQs (Table 5). These questions will considered as replacement MQs if any of the final MQs cannot be adequetly addressed by the UA team, pending AMT approval.

Table 4. The final working list of Management Questions (MQs) for the CYR REA based on Delphi survey results. Shown is the MQ, MQ number, and the conservation elment and change agent associated with the MQ.

Conservation Element	Change Agent	MQ #	Management Question
Terrestrial (Vegetation)	Fire	A1	How is climate change likely to alter the fire regime in the dominant vegetation classes and riparian zones?
Terrestrial (waterfowl)	Climate/ Land Use and Development	AE1	Where is primary waterfowl (black scoter or trumpeter swan) habitat located?
Terrestrial		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)?
Terrestrial (Vegetation)	Soil Thermodynamics	B1	How is climate change likely to alter permafrost distribution, active layer depth, precipitation regime, and evapotranspiration in this region?
Terrestrial (Vegetation)	Soil Thermodynamics	B2	What are the expected associated changes to dominant vegetation communities and CE habitat ?
Terrestrial (Vegetation)	Climate	C1	How will changes in precipitation, evapotranspiration, and active layer depth alter surface water availability and therefore ecosystem function (dominant vegetation classes)?
Terrestrial (Vegetation)	Climate	E1	How is climate change affecting the timing of snow melt and snow onset, spring breakup and green-up, and growing season length?
Terrestrial (Vegetation)	Climate	F3	How are these pathways likely to change in response to climate change, with special emphasis on increased shrub cover and treeline changes?
Terrestrial (Vegetation)	Climate	G1	Where are refugia for unique vegetation communities (eg. hotsprings, bluffs, sand dunes) and what are the wildlife species associated with them?

Terrestrial (Vegetation)	Climate	G2	Which unique vegetation communities (and specifically, which rare plant species) are most vulnerable to significant alteration due to climate change?
Terrestrial (Caribou)	Climate/ Land Use and Development	L1	What are caribou seasonal distribution and movement patterns?
Terrestrial (Sheep)	Climate/ Land Use and Development	N3	How might sheep distribution shift in relation to climate change?
Terrestrial and Aquatic	Land Use and Development	Q1	Which subsistence species (aquatic and terrestrial) are being harvested by whom and where is harvest taking place?
Terrestrial (Reindeer/Caribou/Vegetation)		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?
	Land Use and Development	U1	Compare the footprint of all types of landscape and landscape disturbances (anthropogenic and natural changed) over the last 20 and 50 years.
	Land Use and Development	U3	How and where is the anthropogenic footprint most likely to expand 20 and 50 years into the future?
Aquatic (Fish)	Land Use and Development	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)?
Aquatic (Fish)	Land Use and Development	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)?
Terrestrial (Mammals)	Land Use and Development	X1	What have the past cumulative impacts of road construction and mineral extraction been on terrestrial CE habitat and population dynamics?
Terrestrial (Mammals)	Land Use and Development	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)?

Table 5. Alternative Management Questions (MQs) for the CYR REA based Delphi Survey results. Shown is the MQ, MQ number, and the conservation elment and change agent associated with the MQ. MQs from this list will be selected if a top 20 MQ is not able to be addressed by the UA team.

Conservation Element	Change Agent	MQ #	Recommended Management Question
	Climate	AD1	How will climate-related changes in snow cover, active layer depth, and breakup affect regulation (specifically the allowed timing of) of winter travel on BLM managed lands?
Terrestrial (waterfowl)	Climate/ Land Use and Development	AE2	How might waterfowl (black scoter or trumpeter swan) distribution shift in relation to climate change?
	Land Use and Development	IN5	Where should potential roads to Ambler, Nome, Umiat, and Stevens village (100 foot wide road or utility corridors from the Dalton Highway) be placed in order to protect conservation system units (as far away as possible from the CSUs)?
Aquatic (Fish)	Land Use and Development	J1	What are baseline characteristics and trends (historic based on data and TEK as well as future based on anticipated development) in quality and quantify of fish habitat (lakes and streams) as well as fish distribution and movement?
Terrestrial (Caribou)	Climate	K1	How will caribou winter and summer habitat be affected by climate change?
Terrestrial (Caribou)	Climate/ Land Use and Development	L3	How might caribou seasonal distribution and movement patterns shift in relation to climate change ?
Terrestrial and Aquatic	Land Use and Development	O1	What additional baseline data (i.e. drivers) are needed for fish, birds, and other terrestrial species for enhancing food security (health and safety of subsistence food)?
Terrestrial and Aquatic	Land Use and Development	Q2	What are historic and projected trends in subsistence harvest of these species? How reliable are these predictions?
Aquatic (Fish)	Land Use and Development	V3	What percentage of headwater streams in the region are currently in an intact/pristine state?
Aquatic (Fish)	Land Use and Development	W1	What have the past cumulative impacts of road construction and mineral extraction been on aquatic CE habitat and population dynamics?
Terrestrial (Vegetation)	Land Use and Development	Y1	What and where are the impacts of mineral and gravel extraction development (i.e. gravel pad and road construction) on vegetation communities and hydrology (known impacts include burial, dust, saline runoff and altered soil moisture)?
	Land Use and Development	Z1	Which BLM lands create important linkages between conservation system units (via roads and waterways)?

Conservation Elements

Conservation Elements (CEs) are defined as biotic constituents (i.e. wildlife and plant species or assemblages), abiotic factors (i.e. soils) of regional importance in major ecosystems and habitats across the ecoregion, or high biodiversity priority sites (i.e. Important Bird Areas). CEs are meant to represent key resources in the ecoregion that can serve as surrogates for ecological condition across the ecoregion.

The final selection of priority conservation elements will be a limited suite of specific CEs, the conservation of which is intended to serve as a coarse-filter/fine-filter representation of the ecoregions natural resources. Most CEs are defined through the "coarse-filter / fine-filter" approach required by BLM guidelines, and used extensively for regional and local landscape assessments (Jenkins 1976; Noss 1987). This approach focuses on ecosystem representation as "coarse-filters" with a limited subset of focal species and species assemblages as "fine-filters". The coarse-filter / fine-filter approach is closely integrated with ecoregional and CE-specific modeling exercises (Bryce et al. 2012.).

Coarse-Filter Conservation Elements

Coarse-filter CEs were identified first and include regionally significant terrestrial vegetation types and aquatic habitats representing dominant ecological patterns across the REA area. Coarse-filter CEs collectively should represent the habitat requirements of most characteristic native species, ecological functions, and ecosystem services described in the Conceptual Ecoregional Model. Ecological models (both conceptual and spatial) for each coarse-filter CEs will be fully developed later in the assessment in order to quantify the individual and cumulative impacts of CAs on the CEs.

Terrestrial Coarse-Filter Conservation Elements

Terrestrial coarse-filter CEs are regionally important vegetation classes that represent the characteristic vegetation assemblages and the dominant ecological patterns of the CYR REA study area. They adequately address the habitat requirements of most characteristic native species, ecological functions, and ecosystem services.

To describe terrestrial coarse-filter CEs within the CYR REA, we will identify the major vegetation types of the region in the context of their dominant successional pathways and disturbance regimes. This approach is similar to the Biophysical Setting concept developed as part of the LANDFIRE effort (LANDFIRE 2010) in which vegetation classes were described based on the biophysical environment, dominant vegetation cover, and natural disturbance regime.

While reviewing the list of proposed CEs for inclusion in the final selection, we considered the following questions:

- Is the CE directly identified through a management question or the conceptual model?
- Does the CE represent a widely distributed class whose distribution can be mapped given existing information?
- Is the CE is represented indirectly through the assessment of a fine-filter CE?

The coarse-filter CEs listed in Table 6 were selected because they capture the dominant vegetation communities and ecosystem functions within the study area, and, additionally, they are linked to specific management questions. While we have several MQs that address rare ecosystems, we ultimately decided not to include these as CEs. Two main factors guided into this decision: 1) we have a limited number of CEs that we can describe within the context of the REA and those CEs should capture the majority of the landscape, and 2) we lack adequate information to accurately map the distribution of the rare ecosystems. We will describe these unique ecosystems in the context of the MQs, including descriptions of their know distributions and identification of data gaps.

For each CE we will develop a distribution map and a conceptual model specific to the CE. Distribution maps will be developed by selecting vegetation classes from the landcover mosaic developed by AKNHP (Boggs et al. 2012) and the National Land Cover Database for Alaska (Homer et al. 2004). To develop distribution maps for Floodplain Forest & Scrub we will intersect the floodplain boundary delineated within the Circumboreal Vegetation Map (CAFF 2011) with the AKNHP landcover mosaic and extract forest and shrub classes from within the delineated floodplain boundary.

Table 6. Terrestrial coarse-filter conservation elements for the Central Yukon REA.

Coarse-Filter Conservation Element	Selection Criteria	Source Map
Alpine Dwarf Shrub Tundra	matrix alpine shrub type	AKNHP mosaic
Alpine & Arctic Tussock Tundra	matrix class above treeline in the Brooks Foothills	AKNHP mosaic
Upland Mesic Spruce-Hardwood Forest	matrix upland forest type	NLCD
Upland Mesic Spruce Forest	matrix upland forest type	NLCD
Upland Low Shrub Tundra	matrix low shrub type above treeline	AKNHP mosaic
Lowland Woody Wetland	matrix forested wetland; includes black spruce wetlands and sedge-shrub wetlands	NLCD
Floodplain Forest and Shrub	Important ecosystem function and wildlife habitat	CBVM & AKNHP mosaic

Aquatic Coarse-Filter Conservation Elements

Four aquatic habitats have been selected that represent the dominant ecological patterns across the CYR REA area (Table 7).

Table 7. Aquatic coarse filter conservation elements for the North Slope REA.

Conservation Element	Selection Criteria Linkages to MQs or Conceptual Model
Rivers and large streams	MQs; Conceptual model = fish and invertebrate habitat, export of nutrients and organic matter downstream, important spawning, rearing, and overwintering fish habitat.
Small streams (including headwater streams)	MQs; Conceptual model = fish and invertebrate habitat; export of nutrients downstream; headwater streams are important salmonid rearing habitat.
Large, freshwater connected lakes	MQs; Conceptual model = fish and invertebrate habitat; Important breeding habitat for aquatic insects, fish, waterbirds and shorebirds and provide subsistence and recreational use
Small, freshwater connected lakes	MQs; Conceptual model = fish and invertebrate habitat; Important breeding habitat for aquatic insects, fish, waterbirds and shorebirds and provide subsistence and recreational use

Fine-Filter Conservation Elements

Fine-filter CEs consist of regionally significant species and species assemblages that are not adequately represented by the coarse-filter CEs. Fine-filter CEs are therefore also critical to the assessment of ecological integrity. CEs are derived from either the ecoregional conceptual model or from management concern identified from management questions.

For each selected fine-filter CE we intend to:

- Map their current distribution.
- Develop a species specific conceptual model.
- Identify key ecological attributes and indicators for each attribute.
- Map their current status (the overlap of current distribution with change agents and intactness).
- Assess potential for change in the near-term (2025) and long-term (2060).

Terrestrial Fine-Filter Conservation Elements

For the terrestrial fine-filter CE selection process, BLM provided a working list of 11 mammals and 9 birds of management concern that are known to occur in the CYR region. This list was presented to AMT members at the CYR Kick-off meeting on June 10th, 2014. From these discussions, we reduced the list to 8 species (4 mammals and 4 birds), which are included with selection criteria and descriptions of their ecological and social importance to the REA study area (Table 8). During the review process, we considered the following factors for each species on the working list:

- Whether the CE is directly identified through a management question.
- Whether the CE is directly identified through the conceptual model. The birds and mammals selected under this category are representative of the major functional groups in arctic terrestrial ecosystems.
- Whether the species or assemblage is not adequately represented indirectly through the assessment of major “coarse-filter” ecosystem types for the ecoregion. For example, species strongly affiliated with freshwater marshes or inland dunes may be adequately treated in the REA through assessment of these surrogate coarse-filter features, and will likely not be treated as fine-filters.

We anticipate that this revised list will continue to evolve as we move forward with data discovery, community meeting input, and future memo and Work plan revisions.

Table 8. Proposed terrestrial fine-filter conservation elements for the Central Yukon REA. Also included is information regarding functional group, ecosystem function, general habitats used by the CE, seasonality of CEs, and additional selection comments.

Taxonomic Group	Functional Group	Conservation Element	Habitat	Seasonality	Selection Criteria Linkages to MQs or Conceptual Model
Mammalia	Large herbivore	Caribou	Tundra, open woodlands	Yearround, non-migratory	Caribou were identified directly through management questions and are an important subsistence resource to the region. Ecosystem function = food availability (prey), herbivory, trampling.
Mammalia	Medium herbivore	Sheep	Open alpine ridges, meadows, and steep slopes with extremely rugged ground (for predator avoidance)	Yearround, non-migratory	Sheep were identified directly through management questions and are an important subsistence resource to the region. Ecosystem function = food availability (prey), herbivory.
Mammalia	Medium herbivore	Beaver	2nd to 4th order streams. Deciduous forest, tall shrub, lakes, rivers	Yearround, non-migratory	Ecosystem function = mechanical disturbance, major driver of hydrologic change on aquatic and riparian ecosystems.
Mammalia	Small herbivore	Snowshoe hare	Coniferous and mixed forests with abundant understory.	Yearround, non-migratory	Key prey for a variety of avian and mammalian predators. Population dynamics are characterized by large inter-annual fluctuations which is a driver for predator populations. Ecosystem function = food availability (prey) and herbivory.

Taxonomic Group	Functional Group	Conservation Element	Habitat	Seasonality	Selection Criteria Linkages to MQs or Conceptual Model
Aves	Carnivore	Golden eagle	Cliffs, riparian areas	Summer: Alaska; Winter: South	Representative of cliffs and riparian habitats.
Aves	Small insectivore	Gray-cheeked thrush	Closed canopy of medium height shrubs and dense woody undergrowth.	Summer: Alaska; Winter: South (e.g. Equator)	Representative for small insectivores and shrubland habitat.
Aves	Large waterbird	Trumpeter swan	Summer/breeding: Close to waterbodies	Summer: Alaska Winter: South	Representative of waterfowl species and wetlands.

The original BLM proposed list also included: Gray Wolf, American black bear, Grizzly or brown bear, Moose, North American river otter, American marten, Alaskan tiny shrew, Rusty blackbird, American Kestral, Blackpoll warbler, Gray-cheeked thrush, Short-eared owl, Longtailed duck and Black scoter.

Aquatic Fine-Filter Conservation Elements

Six fishes have been selected as Conservation Elements (Table 9). Selection criteria and descriptions of their ecological and social importance to the REA study area below.

Table 9. Proposed aquatic fine-filter conservation elements for the Central Yukon REA.

Conservation Element	Habitat	Home range/ Dispersal	Seasonality	Selection Criteria Linkages to MQs or Conceptual Model
Chinook salmon	Freshwater streams-spawning and overwintering habitat	Migratory	Juveniles resident in streams for 1-2 years; adults migrate out of study area to sea	Conceptual model = nutrient inputs to both aquatic and terrestrial ecosystems, food resource for large predators; important subsistence species. Proposed by BLM.
Chum salmon	Freshwater streams-spawning habitat	Migratory	Short juvenile residency period (2-3 weeks)	Conceptual model = nutrient inputs to both aquatic and terrestrial ecosystems, food resource for large predators. Proposed by BLM.
Northern Pike	Deep, slow waters of large rivers; spawning habitat along lake shores or streams	Spring migration from overwintering areas to spawning grounds and then to summer feeding areas are generally short distances. Movement during the summer is localized between warm, shallow feeding areas	Resident	Conceptual model = predation in aquatic food webs. Northern pike are long-lived resident species that are mostly found in deep lakes. They eat other fish, making them susceptible to bioaccumulation of contaminants. Northern pike also represent an important subsistence species, especially during the winter months. Proposed by BLM.

Conservation Element	Habitat	Home range/Dispersal	Seasonality	Selection Criteria Linkages to MQs or Conceptual Model
Sheefish (inconnu)	Overwinter in brackish waters and lakes and sloughs; spawn in clear, swift streams	Summer movement's upstream from spawning habitats; anadromous populations move in and out of study area seasonally	Anadromous and resident populations	Conceptual model = predation in aquatic food webs. Sheefish feed mostly on other fish and have both anadromous and resident populations, both of which tend to migrate over long distances. Proposed by BLM.
Humpback whitefish	Spawn in rivers and streams with flowing water	Extensive upstream spawning migrations	Anadromous	Conceptual model = important to subsistence users. Humpback whitefish are harvested in high numbers in Interior Alaska.
Dolly Varden	Spawn and overwinter in streams and lakes	Summer movement's upstream from spawning habitats; anadromous populations move in and out of study area seasonally	Anadromous and resident populations	MQs; Conceptual model = headwater streams. Dolly Varden are an important subsistence species and are well distributed throughout the stream network, although they are typically found in the smallest reaches of the river network. In addition, they exhibit both anadromous and resident forms. Proposed by BLM.

Change Agents

CAs are those features or phenomena that have the potential to affect the size, condition, and landscape context of CEs. CAs include broad factors that have region-wide impacts such as wildfire, invasive species, climate change, and pollution, as well as localized impacts such as development, infrastructure, and extractive energy development. CAs act differentially on individual CEs, and for some CEs, may have neutral or positive effects, but in general are expected to cause negative impacts. CAs can

impact CEs at the point of occurrence as well as through indirect effects. CAs are also expected to act synergistically with other CAs to have increased or secondary effects. Change Agents in the region can be broadly organized as:

- Climate Change
- Fire
- Invasive Species
- Insect and Disease
- Anthropogenic Uses

Climate Change

Climate change drives multiple types of change in the REA, and is also part of feedback loops with other CAs (such as fire). Basic climate data includes mean monthly historical and projected temperature and precipitation and/or projections of autumn freeze, spring thaw, and season length based on temperature data. Comparison of historical and projected data yields data on monthly, annual, or seasonal shifts in temperature, precipitation, and/or freeze, thaw, and season length.

An assessment of climate change impacts on terrestrial habitats (with mammals and birds secondarily influenced by habitat change) is integral to the REA. This includes broad-scale assessment of potential changes in habitat (changes to coarse-filer CEs) driven by climate change, using a climate-envelope approach where such assessment is possible.

This assessment will likely include a qualitative discussion of the potential effects of climate change on aquatic habitats (with fish secondarily influenced). Direct modeling of water temperature will be undertaken only if pertinent data and models can be identified, which will be described in the forthcoming methods memo.

Fire

Fire is a natural feature of the landscape in this region, and part of historical and existing ecosystem processes. However, as a CA, fire can be specifically examined in terms of changing fire dynamics on the landscape, driven by a changing climate. Assessment of fire as a CA includes analysis of spatially and temporally explicit historical fire data. It also includes creation and analysis of model outputs of projected fire frequency by region, on a roughly spatial basis and/or a percentage/risk basis pixel by pixel or HUC by HUC. It does not include fire severity (for which there is no data) or exact spatial/temporal predictions of future fires, since the stochastic nature of fire starts and fire behavior is better represented via averaging outputs across multiple model runs. It also does not include historical or projected lightning, except in broadly qualitative terms based on literature review, due to lack of consistent past data and lack of reliable models for projected lightning.

Fire modeling allows for some assessment of impacts on terrestrial habitats (with mammals and birds secondarily influenced by habitat change); including fire-induced changes in broad habitat type (deciduous forest, black spruce forest, white spruce forest, grass/tundra, and snow/ice/rock) as well as

in mean age (successional stage) of each cover type. It does not allow for assessment of impacts to most vegetation at the species level or at the level of fine-scale vegetation classifications used elsewhere in the project. However, the recent development of fire model parameters for three different tundra classes via the ALFRESCO (Alaska Frame-based Ecosystem Code) model may provide useful data for this region (Rupp et al. 2001, Rupp et al. 2006).

Fire modeling can also be coupled with analysis of fire impacts on permafrost, based on qualitative information from the literature on the influence of fire on permafrost. This analysis will not include separate fire-linked spatial predictions.

Permafrost

With mean annual temperatures well below freezing across the region, permafrost is considered continuous. However, localized thaw (complete permafrost loss) is possible in warmer areas, particularly in lake basins. Deepening of the active layer is likely region-wide. Modeling of soil thermal dynamics is crucial for this REA, since changes in these dynamics are likely to have implications for shifts in vegetation and hydrology. Permafrost could be considered a CE, but is instead treated as a CA as intersections of permafrost with CEs are crucial to projecting their future. Soil thermal dynamics are also linked to several management questions.

Invasive Species

Invasive species are included as CAs in all BLM Rapid Ecoregional Assessments due to their widespread capacity to disrupt ecological processes and degrade biological resources. Invasive species have been documented to cause ecological and economic impacts to some areas in the state and other northern regions (*see* Carlson and Shephard 2007; Schwörer et al. 2012; Sanderson et al. 2012). In many parts of Alaska, including remote portions of the Central Yukon study area, invasive species are not considered an immediate threat. Terrestrial invasive plant species, however, have become well established around the human footprint within the Central Yukon study area (Figure 13).

Examples of invasive species impacts in Alaska include extensive transformation of nutrient-rich, high productivity, forb-graminoid communities into nutrient-poor ericaceous tundra communities in the Aleutians due to seabird declines following fox and rat introductions (Croll et al. 2005). The establishment of sweetclover, which reaches high densities on stretches of the Nenana, Knik, Matanuska, and Stikine river floodplains, inhibits recruitment of native species (Spellman & Wurtz 2011); sweetclover also alters native plant-pollinator networks (Schneller and Carlson 2012). The expansion of waterweed, *Elodea*, in the Fairbanks area is associated with declines in grayling habitat (Lisuzzo 2012).

Floodplain and wetland habitats may be most susceptible to invasion by non-native plants in the Central Yukon study area in the future. Aquatic systems (lakes, ponds, and slow moving, clearwater streams) could be impacted by the establishment of the waterweed *Elodea*, currently known from the Tanana watershed. Establishment and population increases of invasive species are likely to be accelerated due to current trajectories of climate change, increases in development, and forest fire frequency and

intensity. Ecological impacts are largely specific to individual non-native species (*see* Carlson et al. 2008); the impacts may include alterations of ecological processes, such as nutrient cycling or fire regimes, as well as effects on individual native species.

Insects and Disease

Dominant tree and shrub species across Alaska are subject to damage, defoliation, and mortality due to a variety of disease agents (wood decay and canker fungi, root disease, etc.) and native insects (bark beetles and woodborers, sawflies, leaf miners, etc.). Insect defoliators and diseases have potential to be a change agent and historically have caused significant alterations to native plant communities in Alaska. Large-scale defoliation and mortality of dominant boreal forest communities can result in cascading effects on plant communities and wildlife and can even alter salmon spawning habitats (Fricker et al. 2006; Tremblay et al. 2011). Additionally, insect and disease impacts are closely associated with climate. For example, seasonally above normal temperatures are responsible for outbreaks of leaf miners and spruce beetles that can result in increased wildfire activity. Thus, interactions between climate change, fire, and insects and disease are likely to influence the distribution of CEs in the future.

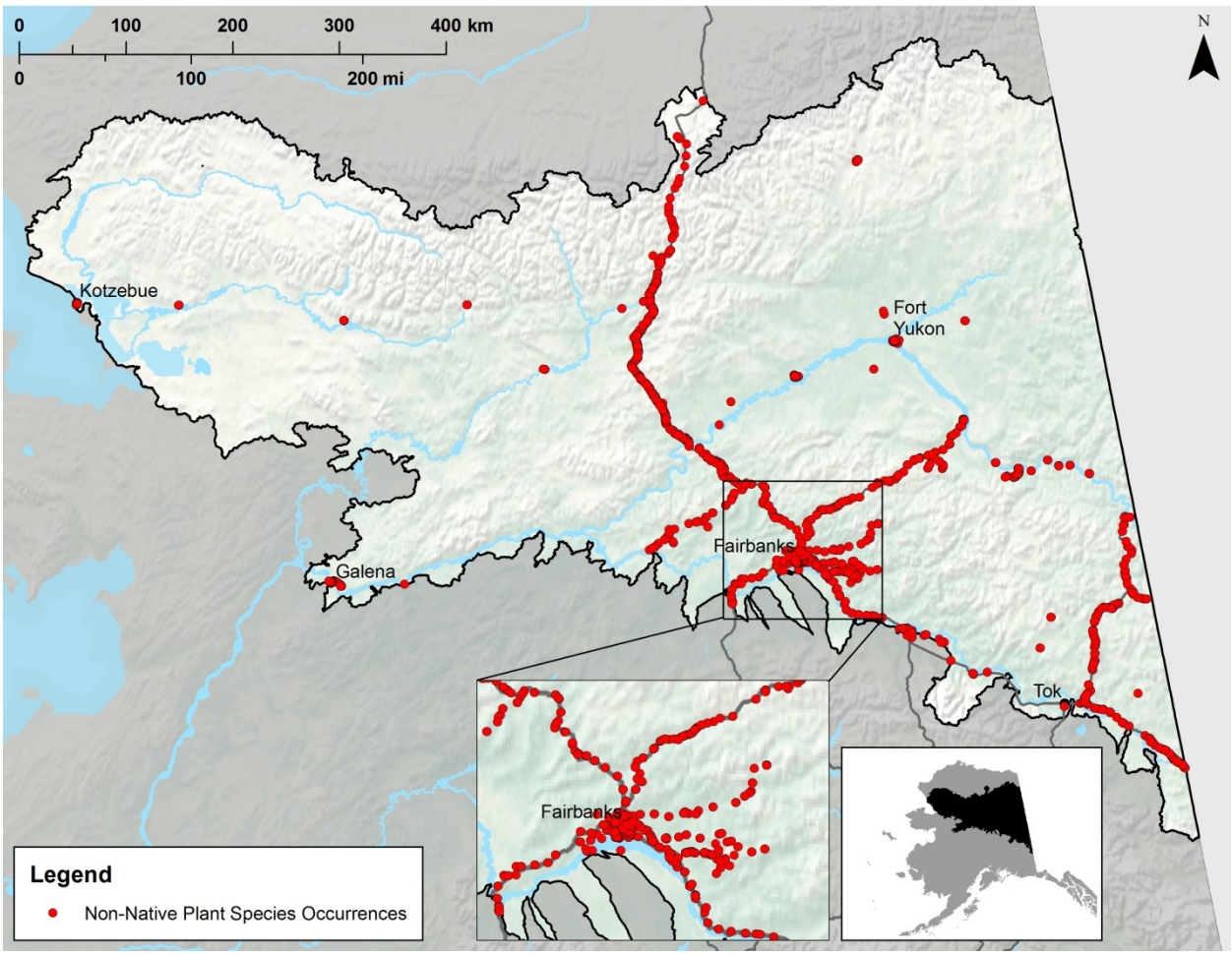

Figure 13. Non-native plant occurrences in the Central Yukon Ecoregion.

Anthropogenic Uses

Human use of land and other resources for purposes of development, subsistence, and other human needs are termed anthropogenic uses. Such uses can directly affect habitats as well as species. In addition to direct habitat conversion and fragmentation, anthropogenic uses can affect density of prey, which can impact subsistence hunting. Anthropogenic uses can be complementary to each other. Some uses such as development can be beneficial to local subsistence communities by providing income for equipment and fuels, and new roads that expand access to hunting areas, thus aiding and facilitating other anthropogenic uses such as subsistence. Land uses are often additive as well, as mining and energy development cannot occur without road and energy infrastructure. Thus, their impact largely depends on the complexity of the activity. Additionally, these uses have political and financial uncertainties, further adding to the complexity of measuring potential impacts.

Anthropogenic uses can also be affected by other CAs (for example, permafrost thaw and erosion). This project will provide an inventory of existing anthropogenic uses in the region and, where GIS data are available, estimated footprints will be mapped. A summary of existing data and maps for the proposed resource extraction projects – permitted or in the permitting process – will be included in the assessment. Other land uses (such as remote fly-in tourism) will rely on tabular data. The categories of anthropogenic use to be assessed are:

- Subsistence hunting and fishing
- Non-subsistence hunting and fishing – Commercial and sport fishing, Sport hunting
- Natural Resource Extraction – Mining, Gravel Extraction, and Forest Products
- Infrastructure – Energy, Transportation, Communication
- Contaminated Sites
- Recreation

Subsistence: Subsistence forms a substantial component of the economies for a majority of the communities in the region. All remote rural communities in the region depend on subsistence resources. Such resources are scattered throughout the region on the land and in the sea (in the western part of the region). In addition to sea mammals and fishing in the Bearing Sea, other subsistence species harvested include various species of fish, birds, plants, and big game animals, primarily caribou. Subsistence forms a principal source of food and it is an important cultural and social activity. As described above, development of any sort impacts the land available for subsistence. People in the region are constantly deal with difficult priorities in maintaining this delicate balance.

Clearly, Alaska Natives are a small minority in more connected, urban, and incorporated communities. They form the majority in remote rural communities that are not incorporated and not connected by road. As in other parts of remote rural Alaska, subsistence plays a major role in local economies and social and cultural lives of people in these remote communities. Large tracts of undisturbed land is necessary for viable populations of subsistence resources, and consequently is important for people in these remote communities.

Subsistence uses are often in direct conflict with other resource extraction activities. The CYR region is home to some of the largest mining operations in the state such as Fort Knox mine, Pogo mine, Red Dog mine, and a large resource rich prospect called Ambler mining district.

- **Non-subsistence hunting and fishing – Commercial and sport fishing, Sport hunting:** Commercial fishing has a relatively small presence in the region, with a short coast line and no major inland lakes. The Yukon and Tanana (the second largest tributary of Yukon) are the main water bodies for commercial fishing. Communities along the Alcan Highway consistently report higher pounds harvested and higher estimated gross earnings from commercial fishing. Sport fishing is also more prevalent along the Tanana river, with more points of access.
- **Natural Resource Extraction**: The region is mineral rich and is home to a few large mining operations. In addition, Fairbanks also serves as a staging hub for the interior and North Slope mining, oil, and gas extraction industries. There is substantial number of jobs and income generated by this industry and has a significant impact on the ecology of the region. Gravel is extensively used for many construction activities involving various uses. Gravel extraction is not a significant economic driver, but has noticeable impact on the ecology of the region.
- **Transportation and communications infrastructure**: Air transport is the predominant mode of transportation in much of the region. Eastern and southeastern parts of the region are connected by road. In addition, Yukon river is a major transportation route. Dalton highway connecting Fairbanks to Prudhoe Bay is primarily used for freight transport to the oil and gas developments on the North Slope. The trans-Alaska pipeline to transport crude oil across the state passes through the region along the Dalton Highway. Other transportation infrastructure – existing and planned local roads, airports, ports, and local summer and winter trails that are used for subsistence purposes – is small in comparison to other areas of the U.S., and located within the community footprints. Communication infrastructure includes broadband and cellular service towers and related infrastructure. Energy infrastructure include large coal-based power generation installations in the Fairbanks North Star Borough, a geothermal installation, some wind power in the Northwest Arctic Borough, at least one biomass installation located in Tok, and many small diesel generators in other communities.
- **Recreation**: A number of state parks in the vicinity of Fairbanks and along the Alcan Highway are frequently visited for recreation. Five national parks in remote parts of the region are accessible air from the nearest communities. Tourism plays a significant role in the local economy of the region. With reliable transportation links to Fairbanks, the region is accessible, and offers diverse opportunities for recreation.

These human interactions with aquatic and terrestrial resources have been, and will continue to be, a critical component of resource sustainability. Climate change, fire, development projects, and commercial/sport hunting and fishing can have both positive and detrimental effects on access to subsistence resources, animal and plant populations and health. This symbiotic relationship between humans and the regional flora and fauna creates a more defined link between human wellbeing and species management, beyond what is typically observed in regions outside of Alaska.

Next Steps

We have presented the final list of Management Questions, Conservation Elements, and Change Agents affirmed by the AMT, the next step in the REA process is data discovery and methods models. Our goal with data discovery is to identify and obtain existing tabular and spatial data to assist us in answering the Management Questions, refining distribution models for both coarse-filter and fine-filter CEs, and developing the CA data layers. During this process, we will also identify areas that are data deficient. As such, data discovery will continue to help us refine our project scope. Our goal of the methods model is to develop an approach of analyses, including methods, process models, and spatial tools. We anticipate providing a data discovery and methods models table for review at the methods AMT workshop in January 2015.

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Appendix A. Original list of Management Questions delivered to UA team by BLM.

Broad Category	Sub Category	Topic	Recommended Management Question	Recommended Analysis
Conservation Element	Climate Change	Fire	How is climate change likely to alter the fire regime in the following large scale vegetation communities; upland tundra, lowland tundra, upland forest, lowland forest, as well as riparian zones within each? How reliable are these predictions? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special emphasis on specific ecosystems. Perhaps defining these vegetation communities (for this and other questions below) is better done as Coarse Scale CE (but this can serve as an example).
Conservation Element	Climate Change	Permafrost	How is climate change likely to alter permafrost distribution, active layer depth, precipitation regime, and evapotransporation in this region? What are the expected associated changes to vegetation communities (specifically upland tundra, lowland tundra, upland forest, lowland forest, as well as riparian zones within each) and CE habitat ? How reliable are these predictions? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special emphasis on specific ecosystems.
Conservation Element	Climate Change	Hydrology	How will changes in precipitation, evapotranspiration, and active layer depth alter surface water availability and therefore ecosystem function (specifically in lowland tundra, lowland forest, and riparian zones within each)? How reliable are these projections? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special emphasis on specific ecosystems.

Conservation Element	Climate Change	Hydrology	How will expected changes in permafrost distribution and active layer depth alter the hydrological cycle in the region? How will these manifest as changes to terrestrial and aquatic CE habitat quality and quantity (specifically upland tundra, lowland tundra, upland forest, lowland forest, as well as riparian zones within each)? How reliable are these predictions? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special emphasis on connection between permafrost and hydrology.
Conservation Element	Climate Change	Seasonality	How is climate change affecting the timing of snow melt and snow onset, spring breakup and green-up, and growing season length? How does this vary between upland tundra, lowland tundra, upland forest, lowland forest, and riparian zones? How is this likely to change in the future and how reliable are these projections? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special emphasis on specific ecosystems.
Conservation Element	Climate Change	Vegetation	What are the major vegetation successional pathways for upland and lowland forest and tundra vegetation classes? What are the most common disturances impacting each and how do these disturbances impact successional trajectories? How are these pathways likely to change in response to climate change, with special emphasis on increased shrub cover and treeline changes? How reliable are these projections? Are there other data/models which provide information that is different than the output presented?	Literature search and text report. GIS depiction of projected changes in shrub cover and treeline advance

Conservation Element	Climate Change	Vegetation	Where are refugia for unique vegetation communities (eg. hotsprings, bluffs, sand dunes) and what are the wildlife species associated with them? Which unique vegetation communities (and specifically, which rare plant species) are most vulnerable to significant alteration due to climate change? How reliable are these projections? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special refugia analysis and emphasis on unique vegetation and wildlife communities. Rare Plant habitat modelling using Max Ent.
Conservation Element	Baseline Info	Soils	Where are the areas of greatest topographic and soils diversity?	GIS analysis.
Conservation Element	Climate Change	Erosion	What are the current locations and rates of inland erosion and how might these change in the future? In areas likely to be subject to erosion (including [but not limited to] flooding in riparian zones and fire affected areas) what are the expected changes to habitat and cultural sites? How reliable are these projections? Are there other data/models which provide information that is different than the output presented?	GIS depiction of areas likely to be affected by erosion (riparian zones and burn scars) overlain with known cultural sites and CE habitat with projections of flood and fire based on climate change.
Conservation Element	Climate Change	Fish	What are baseline characteristics and trends (historic based on data and TEK as well as future based on anticipated development) in quality and quantify of fish habitat (lakes and streams) as well as fish distribution and movement?	Deduce historic trends in each of the above by analyzing historic data and compiling records of TEK. Inherent REA analysis to project future trends.
Conservation Element	Climate Change	Caribou	How will caribou winter and summer habitat be affected by climate change? Specifically, what evidence exists for increased shrub cover and what are the likely impacts on caribou habitat? How will projected changes alter caribou utilization patterns? How reliable are these projections? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special emphasis on specific questions.

Conservation Element	Climate Change	Caribou	What are caribou seasonal distribution and movement patterns? How are they related to season and weather? How might these shift in relation to climate change and development (especially roads)? Where is future development likely to most impact hunter access to caribou populations? Are there other data/models which provide information that is different than the output presented?	Literature review specific to the region. GIS depiction of distribution, likely habitat and current and future access routes to caribou populations.
Conservation Element	Climate Change	Moose	For moose populations in this region what is historic, current and historic distribution and density? What major drivers behind the shifts in moose distribution have been identified? What is the history of moose harvest by subsistence users per given area within the region?	Inherent REA product with special attention to when moose populations became established (where not previously detected).
Conservation Element	Climate Change	Sheep	Where is primary sheep habitat located and how does sheep distribution shift in response to season and weather? How might these shift in relation to climate change and development (especially roads)? Where is future development likely to most impact hunter access to sheep populations?	Literature review specific to the region. GIS depiction of likely habitat and current and future access routes to sheep populations.
Subsistence	Socioeconomic	Food security	What additional baseline data (i.e. drivers) are needed for fish, birds, and other terrestrial species for enhancing food security (health and safety of subsistence food)? What are known drivers and what drivers require more information?	Analysis output should be aimed specifically to provide driver information necessary for full food security analysis. www.iccalaska.org/servlet/content/Traditional%20Knowledge.html
	Socioeconomic	Ecology	What are the major ecosystem services provided by the lands and waters within this REA? What factors influence their value and can any of the services be quantified?	Full scale ecosystem service analysis by ISER.

Subsistence	Socioeconomic	Food harvest	Which subsistence species (aquatic and terrestrial) are being harvested by whom and where is harvest taking place? What are historic and projected trends in subsistence harvest of these species? How reliable are these predictions? What is the economic value (market equivalent) of these species?	Data compilation: ADFG current and historical hunt records, OSM current and historical hunt records. Ecosystem service analysis to estimate economic value of food obtained through subsistence harvesting.
Subsistence	Socioeconomic	Food harvest	What real and perceived limitations to access and/or collection of subsistence resources (aquatic and terrestrial) by local residents are caused by non-subsistence hunting and fishing activity? Where are controversial areas located? What solutions to conflicts are promoted by local resident subsistence users?	Literature/text product. GIS portrayal of subsistence use areas and high use hunting and fishing areas. Identification of data gaps.
Subsistence	Socioeconomic	Food harvest	What real and perceived limitations to access and/or collection of subsistence resources (aquatic and terrestrial) by local residents are associated with human infrastructure (mineral extraction, roads)? How might this change in response to planned future development, especially new roads? What solutions to conflicts are promoted by local resident subsistence users for specific limitations?	Literature/text product. GIS portrayal of subsistence use areas and current/proposed human infrastructure. Identification of data gaps. Ecosystem service analysis comparing future development benefits to loss in subsistence opportunity.
Subsistence	Socioeconomic	Reindeer	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? How would introduction of a reindeer herding program affect caribou and vegetation? What is the economic service of maintaining intact caribou habitat in comparison to the economic gain of reindeer herding (market value)?	Literature search and text report. GIS depiction of potentially high value reindeer herd locations. Ecosystem service analysis to estimate economic value of food obtained through subsistence harvesting. Reindeer as CE?

Development Impacts or Issues	Baseline Info	Visual Resources	What are the visual resource inventory classifications for the Utility Corridor and the remote western lands?	Conduct GIS viewshed analysis to establish visual resource inventory baseline for landscape scenic quality and contrast levels. Road accessible areas should follow the procedure in the BLM VRM handbook to establish VRI classifications. A GIS analysis can be used to establish VRI classifications in the in areas without road access.
Development Impacts or Issues	Socioeconomic	Landscape disturbance	Compare the footprint of all types of landscape disturbances (anthropogenic and natural) over the last 20 and 50 years. Where are these footprints located now? How and where is the anthropogenic footprint most likely to expand 20 and 50 years into the future? What is the viewshed of large anthropogenic features? How far can they be seen from the air and the ground?	Bar Chart Comparison (e.g. Square miles of gravel extraction, hardrock mining, fire, road footprints, gravel pads, village expansion). GIS depiction of anthropogenic footprint and projected footprint locations. Viewshed analysis of anthropogenic features. Combine efforts above into Visual Resource Management analysis (see manual link).
Development Impacts or Issues	Socioeconomic	Landscape disturbance	How will the viewshed and visual sensitivity change with the potential development of access roads to mining and energy operations? What are the visual impacts from gravel pits, pipelines, and other developments? How far can they be seen from the air and the ground?	Conduct GIS viewshed analysis to establish visual resource sensitivity levels to changes on the landscape.
Development Impacts or Issues	Ecology	Fish	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)? Specifically, what is the relative importance of headwater streams to stream ecology and watershed health? What percentage of headwater streams in the region are currently in an intact/pristine state? What is the ecological value of maintaining intact headwater streams?	Literature review specific to the region. GIS depiction of headwater stream location and disturbance history. ecosystem service approach to glean economic value of maintaining intact streams (especially headwater streams) vs development (disturbance) of headwater streams.

Development Impacts or Issues	Ecology	Fish	What have the past cumulative impacts of road construction and mineral extraction been on aquatic CE habitat and population dynamics? 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)?	Literature review specific to the region. GIS depiction highlighting waterway intersection with current and future development. ecosystem service analysis to compare the economic value of development (roads, pads, pipeline) vs maintenance of unaltered habitat and intact populations of aquatic CE species.
Development Impacts or Issues	Ecology	Mammals	What have the past cumulative impacts of road construction and mineral extraction been on terrestrial CE habitat and population dynamics? 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)? How reliable are these predictions?	GIS depiction of human footprint (current and future). ecosystem service analysis to compare the economic value of development (roads, pads, pipeline) vs maintenance of unaltered habitat and intact populations of terrestrial CE species.
Development Impacts or Issues	Ecology	Landscape disturbance	What and where are the impacts of mineral and gravel extraction development (i.e. gravel pad and road construction) on vegetation communities and hydrology (known impacts include burial, dust, saline runoff and altered soil moisture)? How and where might these impacts spread as the anthropogenic footprint expands?	GIS exercise showing likely areas to be impacted by development (including actual development and adjacent areas likely to be impacted).
Development Impacts or Issues	Ecology	Landscape disturbance	WHICH BLM LANDS CREATE IMPORTANT LINKAGES BETWEEN CONSERVATION SYSTEM UNITS (VIA ROADS AND WATERWAYS)? WHICH BLM LANDS PROVIDE TRANSPORTATION DEVELOPMENT LINKAGES (ROADS) FOR NON-CONSERVATION SYSTEM UNIT LANDS?	GIS exercise on habitat connectivity to inform the following two questions.

Development Impacts or Issues			Where should potential roads to Ambler, Nome, Umiat, and Stevens village (100 foot wide road or utility corridors from the Dalton Highway) be placed in order to protect conservation system units (as far away as possible from the CSUs)?	GIS exercise which may be performed solely in house (BLM GIS).
Development Impacts or Issues			Where should potential roads to Ambler, Nome, Umiat, and Stevens village (100 foot wide road or utility corridors from the Dalton Highway) be placed in order to protect existing human infrastructure (as far away as possible from existing infrastructure)?	GIS exercise which may be performed solely in house (BLM GIS).
Development Impacts or Issues	Socioeconomic	Landscape disturbance	Where are the locations of geological substrates suitable for extraction (e.g. precious metals, gravel) and locations suitable/unsuitable for infrastructure development (e.g. roads, maintenance stations)?	GIS depiction of known high value areas and areas with elevational contours amenable to road construction
Development Impacts or Issues	Climate Change	Seasonality	How will climate-related changes in snow cover, active layer depth, and breakup affect regulation (specifically the allowed timing of) of winter travel on BLM managed lands? How will these projected changes affect how BLM regulates permittee access (specifically the timing of access)? How reliable are these projections? Are there other models which provide information that is different than the output presented?	Analyze based on current winter restrictions to overland travel (i.e. staging will not be allowed until October 1 of each year. Winter cross country travel will only be allowed when there is a snow cover of 12" and frost depth to 6" for overland moves in the foothills and 12" freeze/6" snow on the coastal plain.) GIS depiction of waterways likely to be used for winter transport and projections of breakup timing

Appendix B. Second round of Management Questions (MQs) sent to AMT for ranking of MQs for the Delphi survey process.

Instructions: Please only place an 'X' in the columns to select your top and mid 20 Management Questions and indicate those that should be removed. The 'Effort Required by UA' field describes the anticipated amount of effort required. The 'In Scope?' field describes opinions by UA team if the MQ is within the scope of an REA. If there are comments or questions, provide feedback in the 'Feedback' column.

Conservation Element	Change Agent	MQ #	Recommended Management Question	Effort Required by UA	In Scope?	Possible Approach	Feedback
Terrestrial		AH1	What rare, but important. habitat types that are too fine to map at the REA scale 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)?	n/a	n/a		
Terrestrial (Vegetation)	Climate	G1	Where are refugia for unique vegetation communities (eg. hotsprings, bluffs, sand dunes) and what are the wildlife species associated with them?	Moderate	Yes	spatial	swamps and peaks?
Terrestrial (Vegetation)	Climate	G2	Which unique vegetation communities (and specifically, which rare plant species) are most vulnerable to significant alteration due to climate change?	Moderate	Yes	literature review	Core question?
Terrestrial (Vegetation)	Soil Thermodynamics	B2	What are the expected associated changes to dominant vegetation communities and CE habitat ?	Low	Yes	spatial and literature review	from every CA or just climate change? / Core Question?
	Land Use and Development	U3	How and where is the anthropogenic footprint most likely to expand 20 and 50 years into the future?	Low	Yes	spatial	

Terrestrial (Vegetation)	Fire	A1	How is climate change likely to alter the fire regime in the dominant vegetation classes and riparian zones?	Low	Yes	spatial	Core Question?
Terrestrial (Vegetation)	Climate	E1	How is climate change affecting the timing of snow melt and snow onset, spring breakup and green-up, and growing season length?	Low	Yes	spatial	
	Land Use and Develop ment	IN5	Where should potential roads to Ambler, Nome, Umiat, and Stevens village (100 foot wide road or utility corridors from the Dalton Highway) be placed in order to protect conservation system units (as far away as possible from the CSUs)?	Substantial effort.	No	spatial	Comment 1) Drop the questions related to corridor development (IN5, AB1, and Z2) from the list. I think, and the mgrs, that this would be really complicated in the long run despite it's high importance to management. Comment 2) Would reword question. Where can they be placed to protect CE and ecosystem function? There are important habitats outside of conservation units. As far as possible from CSUs is not necessarily the best for the ecosystem as awhole./ Also, where are the swatches with the most species diversity? Where are the swatches with the least species diversity?
Aquatic (Fish)	Land Use and Develop ment	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)?	Moderate effort (if data available).	Yes	spatial	

Terrestrial (Mammals)	Land Use and Development	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)?	Substantial effort (if data available).	Yes	spatial and literature review	A very worthy goal but would be a huge amount of effort to address in a meaningful way.
Aquatic (Fish)	Land Use and Development	J1	What are baseline characteristics and trends (historic based on data and TEK as well as future based on anticipated development) in quality and quantify of fish habitat (lakes and streams) as well as fish distribution and movement?	Substantial effort for TEK data. Moderate effort for baseline fish distribution data (if data available).	Yes	spatial and literature review	
Terrestrial (Caribou)	Climate/ Land Use and Development	L3	How might caribou seasonal distribution and movement patterns shift in relation to climate change ?	Substantial effort for a literature review. Further substantial effort to model future distributions (contested results in previous REAs).	Yes	spatial and literature review	Speculation would be of only limited use and probably ultimately incorrect.

Terrestrial (Caribou)	Climate/ Land Use and Develop ment	L4	How might caribou seasonal distribution and movement patterns shift in relation to development (especially roads)?	Distribution: substantial effort. Movement patterns: substantial effort (if data available).	Yes	spatial	Alterations in seasonal distributions most important. / Prying the data from Pis will be a challenge on this one. There is already some good work that has been doen relative to the haul road and to the proposed Ambler road. / Speculation would be of only limited use and probably ultimately incorrect. / see latest paper by Dave Gustine http://uafcornerstone.net/wildfire_caribou/
Aquatic (Fish)	Land Use and Develop ment	W1	What have the past cumulative impacts of road construction and mineral extraction been on aquatic CE habitat and population dynamics?	Moderate effort (if data available).	Yes	literature review	
Terrestrial (Vegetation)	Land Use and Develop ment	Y1	What and where are the impacts of mineral and gravel extraction development (i.e. gravel pad and road construction) on vegetation communities and hydrology (known impacts include burial, dust, saline runoff and altered soil moisture)?	Moderate	Yes	spatial and literature review	
	Land Use and Develop ment	Z1	Which BLM lands create important linkages between conservation system units (via roads and waterways)?	Substantial effort.	No	spatial	Why would this not be in scope? Refer to work being done by Dawn Magness, FWS for the NWRLCC

	Land Use and Development	AC1	Where are the locations of geological substrates suitable for extraction (e.g. precious metals, gravel) and locations suitable/unsuitable for infrastructure development (e.g. roads, maintenance stations)?	Low	Potentially. HOWEVER, suitability for infrastructure development is out of scope (engineering study).	spatial	BLM working with USGS on mineral potential polygons so this would be duplication of effort; second part of question on infrastructure might be useful, but is out of scope. The first half of this question seems like duplication of effort. BLM is working with USGS to get mineral potential for the planning area. Might want to prioritize other questions over this one.
Terrestrial (Vegetation)	Soil Thermodynamics	B1	How is climate change likely to alter permafrost distribution, active layer depth, precipitation regime, and evapotranspiration in this region?	Low	Yes	spatial	
Terrestrial (Vegetation)	Climate	F3	How are these pathways likely to change in response to climate change, with special emphasis on increased shrub cover and treeline changes?	Low if using existing descriptions. HOWEVER, if more description is required: moderate effort and a substantial effort would be required to create state-and-transition models.	Yes	literature review	

Terrestrial (Caribou)	Climate	K1	How will caribou winter and summer habitat be affected by climate change?	Low	Yes	spatial and literature review	Why is effort to do this considered low, when it would depend on next three? / Will we be getting seasonal variations in the core products for animals that migrate?
Terrestrial (Caribou)	Climate/ Land Use and Develop ment	L1	What are caribou seasonal distribution and movement patterns?	Moderate	Yes	spatial	A bit of a moving target. In addition to random variation, alterations in migration patterns have been tied to weather and disturbance. The answer may be as vague as "it depends". Another issue may be getting Pis to cough up this sensitive data.
Terrestrial (Sheep)	Climate/ Land Use and Develop ment	N1	Where is primary sheep habitat located?	Low	Yes	spatial	
Terrestrial (Sheep)	Climate/ Land Use and Develop ment	N4	How might sheep distribution shift in relation to development (especially roads)?	Low	Yes	spatial	Would need to know how they react to roads to determine how their distribution would shift - is this known?
Terrestrial and Aquatic	Land Use and Develop ment	O1	What additional baseline data (i.e. drivers) are needed for fish, birds, and other terrestrial species for enhancing food security (health and safety of subsistence food)?	Current known data: substantial effort. Additional baseline data: out of scope.	Current known data: Yes. Addition al baseline data: NO.	literature review	I don't really understand this MQ. But assuring availability of subsistence foods into the future is certainly a highly important aspect of the REA and land use planning. Identifying data which is needed to assess this seems reasonable.
Terrestrial and Aquatic	Land Use and Develop ment	P1	What are the major ecosystem services provided by the lands and waters within this REA?	Substantial effort.	No	literature review	This seems large in scope to me / It seems that at least a general description of this is within scope.

Terrestrial and Aquatic	Land Use and Development	Q1	Which subsistence species (aquatic and terrestrial) are being harvested by whom and where is harvest taking place?	Moderate effort (potential data gaps).	Yes	literature review	
Terrestrial and Aquatic	Land Use and Development	S1	What real and perceived limitations to access and/or collection of subsistence resources (aquatic and terrestrial) by local residents are associated with human infrastructure (mineral extraction, roads)?	Real limitations: potential data gaps and 'real' is ambiguous. Physical limitations: moderate effort. Other limitations: substantial effort. Perceptual limitations: substantial effort.	Yes	literature review	
	Land Use and Development	U1	Compare the footprint of all types of landscape and landscape disturbances (anthropogenic and natural changed) over the last 20 and 50 years.	Low	Yes	spatial	
Aquatic (Fish)	Land Use and Development	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)?	Moderate effort (if data available).	Yes	literature review	

Terrestrial (Mammals)	Land Use and Development	X1	What have the past cumulative impacts of road construction and mineral extraction been on terrestrial CE habitat and population dynamics?	Moderate effort (if data available).	Yes	literature review	
	Climate	AD1	How will climate-related changes in snow cover, active layer depth, and breakup affect regulation (specifically the allowed timing of) of winter travel on BLM managed lands?	Moderate effort	Yes: HOWEVER, the resolution of the data may not be ideal.	spatial and literature review	Will be at very coarse scale - likely not useful to folks wanting paths on which to snowmobile.
Terrestrial (waterfowl)	Climate/ Land Use and Development	AE2	How might waterfowl (black scoter or trumpeter swan) distribution shift in relation to climate change?	Low	Yes	spatial	ditto previous/white-winged scoter not black
Terrestrial (Vegetation)	Soil Thermodynamics	D1	How will expected changes in permafrost distribution and active layer depth alter the hydrological cycle in the region?	Substantial	Yes. However, we will be limited to existing information and models.	spatial and literature review	I think its prohibitively difficult to do well in the alloted time
Terrestrial (Vegetation)	Soil Thermodynamics	D2	How will these manifest as changes to terrestrial and aquatic CE habitat quality and quantity (in dominant vegetation classes as well as riparian zones within each)?	Substantial	Yes. However, the resolution of the permafrost model is likely to limit	spatial and literature review	These what? From the previous question?

					our ability to address this question spatially at a meaningful scale.		
Terrestrial (Vegetation)	Climate	E2	How does [change in snow melt/onset, spring breakup and green up and season length] vary between dominant vegetation classes and riparian zones?	Low	Yes	spatial	So looking at variation in response to climate change by various plant types? I don't know why season length would be any different in forests vs open habitat (isn't it temperature derived?), but maybe I'm not understanding the question?
Terrestrial (Caribou)	Climate	K4	How will projected habitat changes alter caribou utilization patterns?	Moderate	Yes: HOWEVER, we will not be able to project how utilization patterns would change.	spatial	Sounds difficult, at best. Caribou habitat selection barely makes sense to caribou biologists.
Terrestrial (Moose)	Land Use and Development	M1	For moose populations in this region what is historic and current distribution and density?	Substantial effort (if data available).	No	literature review	Do we not have this info for much of the area?

Terrestrial (Sheep)	Climate/ Land Use and Development	N3	How might sheep distribution shift in relation to climate change?	Low	Yes	spatial	I think this is important but it will not be as straight forward as for some other species. Much of the habitat occupied by sheep are used because they have escape terrain (steep rocky habitat) or for historical reasons (have been occupied in the past - local population was eliminated -takes a while to repopulate). Some of this won't change underclimate change scenarios.
Terrestrial and Aquatic	Land Use and Development	O2	What are known drivers and what drivers require more information?	Substantial effort (we would include key data gaps).	Yes	literature review	
Terrestrial and Aquatic	Land Use and Development	P2	What factors influence their value and can any of the services be quantified?	Substantial effort.	No	literature review	I'm wondering why this is outside the scope of ISER?
Terrestrial and Aquatic	Land Use and Development	Q2	What are historic and projected trends in subsistence harvest of these species? How reliable are these predictions?	Substantial effort: anticipate significant data gaps.	Yes	literature review	You might look into it but I doubt these data are available.
Aquatic (Fish)	Land Use and Development	V3	What percentage of headwater streams in the region are currently in an intact/pristine state?	Low	Yes	spatial	What are cumulative effects of past and current development? Which watersheds most impacted? Which most important to protect from impacts?

	Land Use and Develop ment	Z2	Which BLM lands provide transportation development linkages (roads) for non-conservation system unit lands?	Substantial effort.	No	spatial	Comment 1) Drop the questions related to corridor development (IN5, AB1, and Z2) from the list. I think, and the mgrs, that this would be really complicated in the long run despite it's high importance to management. Comment 2) Question is unclear. Does this mean what areas are suitable for transporation and utility corridors to link non-conservation system lands? If so I would have ranked it in top 20. Or does it mean where do these roads currently exist? If the second, then what we need is better and cleaned up data. / Also, where are the least ecologically important or sensitive areas and where can we maximize future colocated transportation corridors to state, BLM and native corpotation lands?
	Land Use and Develop ment	AB1	Where should potential roads to Ambler, Nome, Umiat, and Stevens village (100 foot wide road or utility corridors from the Dalton Highway) be placed in order to protect existing human infrastructure (as far away as possible from existing infrastructure)?	Substantial: Could be addressed using products of core analysis.	No	spatial	Drop the questions related to corridor development (IN5, AB1, and Z2) from the list. I think, and the mgrs, that this would be really complicated in the long run despite it's high importance to management. Since limited human infrastructure, this seems a lower priority. Protection of ecosystems that provide subsistence resources is higher.

Terrestrial (Vegetation)	Climate	C1	How will changes in precipitation, evapotranspiration, and active layer depth alter surface water availability and therefore ecosystem function (dominant vegetation classes)?	Low	Yes. However, we will be limited to existing information and models.	spatial and literature review	
Terrestrial (Soils)		H1	Where are the areas of greatest topographic and soils diversity?	Substantial	Potentially	spatial	Greatest habitat or vegetation community diversity?
Terrestrial	Climate/ Social Thermodynamics	I2	In areas likely to be subject to erosion (including [but not limited to] flooding in riparian zones and fire affected areas) what are the expected changes to habitat and cultural sites?	Low: if data are available. HOWEVER, if limited data then literature review: moderate effort.	Yes	spatial and literature review	
Terrestrial (Caribou)	Climate	K3	What are the likely impacts of increased shrub cover on caribou habitat?	Moderate effort	Yes	literature review	
Terrestrial (Caribou)	Climate/ Land Use and Development	L5	Where is future development likely to most impact hunter access to caribou populations?	Low	Yes	spatial	Three questions here: Where is future development most likely? Where will it affect caribou habitat? What will be effects on access? First two most important. Third less so.
Terrestrial (Moose)	Land Use and Development	M2	What major drivers behind the shifts in moose distribution have been identified?	Substantial effort (if data available).	Yes	literature review	

Terrestrial and Aquatic	Land Use and Development	R1	What real and perceived limitations to access and/or collection of subsistence resources (aquatic and terrestrial) by local residents are caused by non-subsistence hunting and fishing activity?	Substantial effort (significant data gaps and limitations).	Yes. HOWEVER, perceived limitations would be limited to existing information and could be considered out of scope.	literature review	Wow, that's a $69,000 question that I'm sure everyone would love to know. Seems difficult to actually quantify.
Terrestrial and Aquatic	Land Use and Development	R2	In which areas are the real and perceived limitations to access and/or collection of subsistence resources (as a result of non-subsistence hunting and fishing activity) occurring?	Low	Yes	literature review	Controversial how? Reword R1 to get this issue covered. Does not make sense when separated out: *Controversial issues are located in reference to subsistence areas*. This question was **updated** by BLM 9/12/14 to reflect original intent.
Terrestrial and Aquatic	Land Use and Development	S2	How might [real and perceived limitations] change in response to planned future development, especially new roads?	Obvious physical limitations: low additional effort.	Yes	literature review	Quantifying real change seems difficult, at best.
Terrestrial (Reindeer/Caribou/Vegetation)		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?	Moderate	Yes	spatial	

	Land Use and Development	U2	Where are these footprints located now?	Low (data gap potential)	Yes	spatial	
Aquatic (Fish)	Land Use and Development	V2	Specifically, what is the relative importance of headwater streams to stream ecology and watershed health?	Moderate effort (if data available).	Yes	literature review	
Terrestrial (Vegetation)	Land Use and Development	Y2	How and where might these impacts spread as the anthropogenic footprint expands?	Moderate	Yes	spatial	
	Climate	AD2	How will these projected changes affect how BLM regulates permittee access (specifically the timing of access)?	Substantial	No	literature review	
Terrestrial (waterfowl)	Climate/ Land Use and Development	AE1	Where is primary waterfowl (black scoter or trumpeter swan) habitat located?	Low	Yes	spatial	Don't understand the how to answer this question as BLSC largely don't occur in the CY area, and for the most part their distribution is disjunct from TRUS. The more interior scoter species are Surf and White-winged. BLSC is primarily W AK in distribution. Also, TRUS are undergoing logistic growth in the state; there should be greater concern for species with declining trends. As for where primary waterfowl habitat is, I believe we already have a pretty good sense of this in AK / white-winged scoter not black
Terrestrial (waterfowl)	Climate/ Land Use and Development	AE3	How might waterfowl (blackscoter or trumpeter swan) distribution shift in relation to development (especially roads)?	Low	Yes	spatial	ditto previous / white-winged scoter not black

Terrestrial (Vegetation)	Climate	F1	What are the major vegetation successional pathways for upland and lowland forest and tundra vegetation classes?	Low if using existing descriptions. HOWEVER, if more description is required: moderate effort and a substantial effort would be required to create state-and-transition models.	Yes	literature review	
Terrestrial (Vegetation)	Climate	F2	What are the most common disturbances impacting each and how do these disturbances impact successional trajectories?	Low if using existing descriptions. HOWEVER, if more description is required: moderate effort and a substantial effort would be required to create state-and-transition models.	Yes	literature review	

Terrestrial	Climate/ Social Thermodynamics	I1	What are the current locations and rates of inland erosion and how might these change in the future?	Substantial effort and would be highly speculative. HOWEVER, moderate effort for a simple GIS model of erosion-prone areas.	Yes	spatial	Erosion around lake edges and river banks? Yikes, speculative indeed. / Which areas of permafrost are closest to the thawpoint?
Terrestrial (Caribou)	Climate	K2	What evidence exists for increased shrub cover?	Moderate effort	Yes	literature review	Will likely be answered when addressing distribution of shrub and effects of shrubification?
Terrestrial (Caribou)	Climate/ Land Use and Development	L2	How are caribou seasonal distribution and movement patterns related to season and weather?	Moderate	Yes: HOWEVER, we are limited to only existing information, and interpretation would likely be limited to overall climatic patterns.	spatial	Not convinced this will be useful at the scale of overall mean temperature / precip for the region.
Terrestrial (Moose)	Land Use and Development	M3	What is the history of moose harvest by subsistence users per given area within the region?	Moderate	Yes	literature review	

Terrestrial (Sheep)	Climate/ Land Use and Development	N2	How does sheep distribution shift in response to season and weather?	Moderate	Yes: HOWEVER, we are limited to only existing information, and interpretation would likely be limited to overall climatic patterns.	spatial	This would require radiotracking data to answer. There are three data sets for radio collared sheep within this REA that I am aware of (and 2 additional just outside). Although a worthy goal, I'm not sure if this is the instrument to answer that question (i.e. might be difficult to get the dat from all the PIs) / See comment for same question pertaining to caribou
Terrestrial (Sheep)	Climate/ Land Use and Development	N5	Where is future development likely to most impact hunter access to sheep populations?	Low	Yes	spatial	
Terrestrial and Aquatic	Land Use and Development	R3	What solutions to conflicts are promoted by local resident subsistence users?	Substantial effort (significant data gaps).	No	literature review	
Terrestrial (Reindeer/Caribou/Vegetation)		T2	How would introduction of a reindeer herding program affect caribou and vegetation?	Moderate	Yes.	literature review	
Aquatic (Fish)	Land Use and Development	V4	What is the ecological value of maintaining intact headwater streams?	Moderate effort	Yes	literature review	

	Land Use and Development	AF1	What are the visual resource inventory classifications for the Utility Corridor and the remote western lands?	Substantial	No	spatial	BLM doing in house VRM inventory / VRM may be an important management issue, but not an ecological one.
	Land Use and Development	AG1	How will the viewshed and visual sensitivity change with the potential development of access roads to mining and energy operations?	Substantial	No	spatial	
	Land Use and Development	AG2	What are the visual impacts from gravel pits, pipelines, and other developments?	Substantial	No	spatial	
	Land Use and Development	AG3	How far can they be seen from the air and the ground?	Substantial	No	spatial	Lower priority
Terrestrial and Aquatic	Land Use and Development	Q3	What is the economic value (market equivalent) of these species?	Substantial effort.	No	economic analysis	
Terrestrial and Aquatic	Land Use and Development	S3	What solutions to conflicts are promoted by local resident subsistence users for specific limitations?	Substantial effort (potential significant data gap).	No	literature review	
Terrestrial (Reindeer/Caribou/Vegetation)		T3	What is the economic service of maintaining intact caribou habitat in comparison to the economic gain of reindeer herding (market value)?	Substantial effort (potential significant data gap).	No	economic analysis	Quantifying the economic benefit of caribou in the region to subistence and non-local hunters seems overly ambitious.
	Land Use and Development	U4	What is the viewshed of large anthropogenic features? How far can they be seen from the air and the ground?	Substantial effort	No	spatial	Who cares?

Appendix A: Original list of Management Questions delivered to UA team by BLM.

Broad Category	Sub Category	Topic	Recommended Management Question	Recommended Analysis
Conservation Element	Climate Change	Fire	How is climate change likely to alter the fire regime in the following large scale vegetation communities; upland tundra, lowland tundra, upland forest, lowland forest, as well as riparian zones within each? How reliable are these predictions? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special emphasis on specific ecosystems. Perhaps defining these vegetation communities (for this and other questions below) is better done as Coarse Scale CE (but this can serve as an example).
Conservation Element	Climate Change	Permafrost	How is climate change likely to alter permafrost distribution, active layer depth, precipitation regime, and evapotransporation in this region? What are the expected associated changes to vegetation communities (specifically upland tundra, lowland tundra, upland forest, lowland forest, as well as riparian zones within each) and CE habitat ? How reliable are these predictions? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special emphasis on specific ecosystems.
Conservation Element	Climate Change	Hydrology	How will changes in precipitation, evapotranspiration, and active layer depth alter surface water availability and therefore ecosystem function (specifically in lowland tundra, lowland forest, and riparian zones within each)? How reliable are these projections? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special emphasis on specific ecosystems.

Conservation Element	Climate Change	Hydrology	How will expected changes in permafrost distribution and active layer depth alter the hydrological cycle in the region? How will these manifest as changes to terrestrial and aquatic CE habitat quality and quantity (specifically upland tundra, lowland tundra, upland forest, lowland forest, as well as riparian zones within each)? How reliable are these predictions? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special emphasis on connection between permafrost and hydrology.
Conservation Element	Climate Change	Seasonality	How is climate change affecting the timing of snow melt and snow onset, spring breakup and green-up, and growing season length? How does this vary between upland tundra, lowland tundra, upland forest, lowland forest, and riparian zones? How is this likely to change in the future and how reliable are these projections? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special emphasis on specific ecosystems.
Conservation Element	Climate Change	Vegetation	What are the major vegetation successional pathways for upland and lowland forest and tundra vegetation classes? What are the most common disturances impacting each and how do these disturbances impact successional trajectories? How are these pathways likely to change in response to climate change, with special emphasis on increased shrub cover and treeline changes? How reliable are these projections? Are there other data/models which provide information that is different than the output presented?	Literature search and text report. GIS depiction of projected changes in shrub cover and treeline advance

Conservation Element	Climate Change	Vegetation	Where are refugia for unique vegetation communities (eg. hotsprings, bluffs, sand dunes) and what are the wildlife species associated with them? Which unique vegetation communities (and specifically, which rare plant species) are most vulnerable to significant alteration due to climate change? How reliable are these projections? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special refugia analysis and emphasis on unique vegetation and wildlife communities. Rare Plant habitat modelling using Max Ent.
Conservation Element	Baseline Info	Soils	Where are the areas of greatest topographic and soils diversity?	GIS analysis.
Conservation Element	Climate Change	Erosion	What are the current locations and rates of inland erosion and how might these change in the future? In areas likely to be subject to erosion (including [but not limited to] flooding in riparian zones and fire affected areas) what are the expected changes to habitat and cultural sites? How reliable are these projections? Are there other data/models which provide information that is different than the output presented?	GIS depiction of areas likely to be affected by erosion (riparian zones and burn scars) overlain with known cultural sites and CE habitat with projections of flood and fire based on climate change.
Conservation Element	Climate Change	Fish	What are baseline characteristics and trends (historic based on data and TEK as well as future based on anticipated development) in quality and quantify of fish habitat (lakes and streams) as well as fish distribution and movement?	Deduce historic trends in each of the above by analyzing historic data and compiling records of TEK. Inherent REA analysis to project future trends.
Conservation Element	Climate Change	Caribou	How will caribou winter and summer habitat be affected by climate change? Specifically, what evidence exists for increased shrub cover and what are the likely impacts on caribou habitat? How will projected changes alter caribou utilization patterns? How reliable are these projections? Are there other data/models which provide information that is different than the output presented?	Inherent REA product with special emphasis on specific questions.

Conservation Element	Climate Change	Caribou	What are caribou seasonal distribution and movement patterns? How are they related to season and weather? How might these shift in relation to climate change and development (especially roads)? Where is future development likely to most impact hunter access to caribou populations? Are there other data/models which provide information that is different than the output presented?	Literature review specific to the region. GIS depiction of distribution, likely habitat and current and future access routes to caribou populations.
Conservation Element	Climate Change	Moose	For moose populations in this region what is historic, current and historic distribution and density? What major drivers behind the shifts in moose distribution have been identified? What is the history of moose harvest by subsistence users per given area within the region?	Inherent REA product with special attention to when moose populations became established (where not previously detected).
Conservation Element	Climate Change	Sheep	Where is primary sheep habitat located and how does sheep distribution shift in response to season and weather? How might these shift in relation to climate change and development (especially roads)? Where is future development likely to most impact hunter access to sheep populations?	Literature review specific to the region. GIS depiction of likely habitat and current and future access routes to sheep populations.
Subsistence	Socioeconomic	Food security	What additional baseline data (i.e. drivers) are needed for fish, birds, and other terrestrial species for enhancing food security (health and safety of subsistence food)? What are known drivers and what drivers require more information?	Analysis output should be aimed specifically to provide driver information necessary for full food security analysis. www.iccalaska.org/servlet/content/Traditional%20Knowledge.html
	Socioeconomic	Ecology	What are the major ecosystem services provided by the lands and waters within this REA? What factors influence their value and can any of the services be quantified?	Full scale ecosystem service analysis by ISER.

Subsistence	Socioeconomic	Food harvest	Which subsistence species (aquatic and terrestrial) are being harvested by whom and where is harvest taking place? What are historic and projected trends in subsistence harvest of these species? How reliable are these predictions? What is the economic value (market equivalent) of these species?	Data compilation: ADFG current and historical hunt records, OSM current and historical hunt records. Ecosystem service analysis to estimate economic value of food obtained through subsistence harvesting.
Subsistence	Socioeconomic	Food harvest	What real and perceived limitations to access and/or collection of subsistence resources (aquatic and terrestrial) by local residents are caused by non-subsistence hunting and fishing activity? Where are controversial areas located? What solutions to conflicts are promoted by local resident subsistence users?	Literature/text product. GIS portrayal of subsistence use areas and high use hunting and fishing areas. Identification of data gaps.
Subsistence	Socioeconomic	Food harvest	What real and perceived limitations to access and/or collection of subsistence resources (aquatic and terrestrial) by local residents are associated with human infrastructure (mineral extraction, roads)? How might this change in response to planned future development, especially new roads? What solutions to conflicts are promoted by local resident subsistence users for specific limitations?	Literature/text product. GIS portrayal of subsistence use areas and current/proposed human infrastructure. Identification of data gaps. Ecosystem service analysis comparing future development benefits to loss in subsistence opportunity.
Subsistence	Socioeconomic	Reindeer	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? How would introduction of a reindeer herding program affect caribou and vegetation? What is the economic service of maintaining intact caribou habitat in comparison to the economic gain of reindeer herding (market value)?	Literature search and text report. GIS depiction of potentially high value reindeer herd locations. Ecosystem service analysis to estimate economic value of food obtained through subsistence harvesting. Reindeer as CE?

Development Impacts or Issues	Baseline Info	Visual Resources	What are the visual resource inventory classifications for the Utility Corridor and the remote western lands?	Conduct GIS viewshed analysis to establish visual resource inventory baseline for landscape scenic quality and contrast levels. Road accessible areas should follow the procedure in the BLM VRM handbook to establish VRI classifications. A GIS analysis can be used to establish VRI classifications in the in areas without road access.
Development Impacts or Issues	Socioeconomic	Landscape disturbance	Compare the footprint of all types of landscape disturbances (anthropogenic and natural) over the last 20 and 50 years. Where are these footprints located now? How and where is the anthropogenic footprint most likely to expand 20 and 50 years into the future? What is the viewshed of large anthropogenic features? How far can they be seen from the air and the ground?	Bar Chart Comparison (e.g. Square miles of gravel extraction, hardrock mining, fire, road footprints, gravel pads, village expansion). GIS depiction of anthropogenic footprint and projected footprint locations. Viewshed analysis of anthropogenic features. Combine efforts above into Visual Resource Management analysis (see manual link).
Development Impacts or Issues	Socioeconomic	Landscape disturbance	How will the viewshed and visual sensitivity change with the potential development of access roads to mining and energy operations? What are the visual impacts from gravel pits, pipelines, and other developments? How far can they be seen from the air and the ground?	Conduct GIS viewshed analysis to establish visual resource sensitivity levels to changes on the landscape.
Development Impacts or Issues	Ecology	Fish	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)? Specifically, what is the relative importance of headwater streams to stream ecology and watershed health? What percentage of headwater streams in the region are currently in an intact/pristine state? What is the ecological value of maintaining intact headwater streams?	Literature review specific to the region. GIS depiction of headwater stream location and disturbance history. ecosystem service approach to glean economic value of maintaining intact streams (especially headwater streams) vs development (disturbance) of headwater streams.

Development Impacts or Issues	Ecology	Fish	What have the past cumulative impacts of road construction and mineral extraction been on aquatic CE habitat and population dynamics? 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)?	Literature review specific to the region. GIS depiction highlighting waterway intersection with current and future development. ecosystem service analysis to compare the economic value of development (roads, pads, pipeline) vs maintenance of unaltered habitat and intact populations of aquatic CE species.
Development Impacts or Issues	Ecology	Mammals	What have the past cumulative impacts of road construction and mineral extraction been on terrestrial CE habitat and population dynamics? 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)? How reliable are these predictions?	GIS depiction of human footprint (current and future). ecosystem service analysis to compare the economic value of development (roads, pads, pipeline) vs maintenance of unaltered habitat and intact populations of terrestrial CE species.
Development Impacts or Issues	Ecology	Landscape disturbance	What and where are the impacts of mineral and gravel extraction development (i.e. gravel pad and road construction) on vegetation communities and hydrology (known impacts include burial, dust, saline runoff and altered soil moisture)? How and where might these impacts spread as the anthropogenic footprint expands?	GIS exercise showing likely areas to be impacted by development (including actual development and adjacent areas likely to be impacted).
Development Impacts or Issues	Ecology	Landscape disturbance	WHICH BLM LANDS CREATE IMPORTANT LINKAGES BETWEEN CONSERVATION SYSTEM UNITS (VIA ROADS AND WATERWAYS)? WHICH BLM LANDS PROVIDE TRANSPORTATION DEVELOPMENT LINKAGES (ROADS) FOR NON-CONSERVATION SYSTEM UNIT LANDS?	GIS exercise on habitat connectivity to inform the following two questions.

Development Impacts or Issues			Where should potential roads to Ambler, Nome, Umiat, and Stevens village (100 foot wide road or utility corridors from the Dalton Highway) be placed in order to protect conservation system units (as far away as possible from the CSUs)?	GIS exercise which may be performed solely in house (BLM GIS).
Development Impacts or Issues			Where should potential roads to Ambler, Nome, Umiat, and Stevens village (100 foot wide road or utility corridors from the Dalton Highway) be placed in order to protect existing human infrastructure (as far away as possible from existing infrastructure)?	GIS exercise which may be performed solely in house (BLM GIS).
Development Impacts or Issues	Socioeconomic	Landscape disturbance	Where are the locations of geological substrates suitable for extraction (e.g. precious metals, gravel) and locations suitable/unsuitable for infrastructure development (e.g. roads, maintenance stations)?	GIS depiction of known high value areas and areas with elevational contours amenable to road construction
Development Impacts or Issues	Climate Change	Seasonality	How will climate-related changes in snow cover, active layer depth, and breakup affect regulation (specifically the allowed timing of) of winter travel on BLM managed lands? How will these projected changes affect how BLM regulates permittee access (specifically the timing of access)? How reliable are these projections? Are there other models which provide information that is different than the output presented?	Analyze based on current winter restrictions to overland travel (i.e. staging will not be allowed until October 1 of each year. Winter cross country travel will only be allowed when there is a snow cover of 12" and frost depth to 6" for overland moves in the foothills and 12" freeze/6" snow on the coastal plain.) GIS depiction of waterways likely to be used for winter transport and projections of breakup timing

Appendix B: Second round of Management Questions (MQs) sent to AMT for ranking of MQs for the Delphi survey process.

Instructions: Please only place an 'X' in the columns to select your top and mid 20 Management Questions and indicate those that should be removed. The 'Effort Required by UA' field describes the anticipated amount of effort required. The 'In Scope?' field describes opinions by UA team if the MQ is within the scope of an REA. If there are comments or questions, provide feedback in the 'Feedback' column.

Conservation Element	Change Agent	MQ #	Recommended Management Question	Effort Required by UA	In Scope?	Possible Approach	Feedback
Terrestrial		AH1	What rare, but important. habitat types that are too fine to map at the REA scale 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)?	n/a	n/a		
Terrestrial (Vegetation)	Climate	G1	Where are refugia for unique vegetation communities (eg. hotsprings, bluffs, sand dunes) and what are the wildlife species associated with them?	Moderate	Yes	spatial	swamps and peaks?
Terrestrial (Vegetation)	Climate	G2	Which unique vegetation communities (and specifically, which rare plant species) are most vulnerable to significant alteration due to climate change?	Moderate	Yes	literature review	Core question?
Terrestrial (Vegetation)	Soil Thermodynamics	B2	What are the expected associated changes to dominant vegetation communities and CE habitat ?	Low	Yes	spatial and literature review	from every CA or just climate change? / Core Question?
	Land Use and Development	U3	How and where is the anthropogenic footprint most likely to expand 20 and 50 years into the future?	Low	Yes	spatial	

Terrestrial (Vegetation)	Fire	A1	How is climate change likely to alter the fire regime in the dominant vegetation classes and riparian zones?	Low	Yes	spatial	Core Question?
Terrestrial (Vegetation)	Climate	E1	How is climate change affecting the timing of snow melt and snow onset, spring breakup and green-up, and growing season length?	Low	Yes	spatial	
	Land Use and Develop ment	IN5	Where should potential roads to Ambler, Nome, Umiat, and Stevens village (100 foot wide road or utility corridors from the Dalton Highway) be placed in order to protect conservation system units (as far away as possible from the CSUs)?	Substantial effort.	No	spatial	Comment 1) Drop the questions related to corridor development (IN5, AB1, and Z2) from the list. I think, and the mgrs, that this would be really complicated in the long run despite it's high importance to management. Comment 2) Would reword question. Where can they be placed to protect CE and ecosystem function? There are important habitats outside of conservation units. As far as possible from CSUs is not necessarily the best for the ecosystem as awhole./ Also, where are the swatches with the most species diversity? Where are the swatches with the least species diversity?
Aquatic (Fish)	Land Use and Develop ment	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)?	Moderate effort (if data available).	Yes	spatial	

Terrestrial (Mammals)	Land Use and Develop ment	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)?	Substantial effort (if data available).	Yes	spatial and literature review	A very worthy goal but would be a huge amount of effort to address in a meaningful way.
Aquatic (Fish)	Land Use and Develop ment	J1	What are baseline characteristics and trends (historic based on data and TEK as well as future based on anticipated development) in quality and quantify of fish habitat (lakes and streams) as well as fish distribution and movement?	Substantial effort for TEK data. Moderate effort for baseline fish distribution data (if data available).	Yes	spatial and literature review	
Terrestrial (Caribou)	Climate/ Land Use and Develop ment	L3	How might caribou seasonal distribution and movement patterns shift in relation to climate change ?	Substantial effort for a literature review. Further substantial effort to model future distributions (contested results in previous REAs).	Yes	spatial and literature review	Speculation would be of only limited use and probably ultimately incorrect.

Terrestrial (Caribou)	Climate/ Land Use and Develop ment	L4	How might caribou seasonal distribution and movement patterns shift in relation to development (especially roads)?	Distribution: substantial effort. Movement patterns: substantial effort (if data available).	Yes	spatial	Alterations in seasonal distributions most important. / Prying the data from Pis will be a challenge on this one. There is already some good work that has been doen relative to the haul road and to the proposed Ambler road. / Speculation would be of only limited use and probably ultimately incorrect. / see latest paper by Dave Gustine http://uafcornerstone.net/wildfire_caribou/
Aquatic (Fish)	Land Use and Develop ment	W1	What have the past cumulative impacts of road construction and mineral extraction been on aquatic CE habitat and population dynamics?	Moderate effort (if data available).	Yes	literature review	
Terrestrial (Vegetation)	Land Use and Develop ment	Y1	What and where are the impacts of mineral and gravel extraction development (i.e. gravel pad and road construction) on vegetation communities and hydrology (known impacts include burial, dust, saline runoff and altered soil moisture)?	Moderate	Yes	spatial and literature review	
	Land Use and Develop ment	Z1	Which BLM lands create important linkages between conservation system units (via roads and waterways)?	Substantial effort.	No	spatial	Why would this not be in scope? Refer to work being done by Dawn Magness, FWS for the NWRLCC

	Land Use and Development	AC1	Where are the locations of geological substrates suitable for extraction (e.g. precious metals, gravel) and locations suitable/unsuitable for infrastructure development (e.g. roads, maintenance stations)?	Low	Potentially. HOWEVER, suitability for infrastructure development is out of scope (engineering study).	spatial	BLM working with USGS on mineral potential polygons so this would be duplication of effort; second part of question on infrastructure might be useful, but is out of scope. The first half of this question seems like duplication of effort. BLM is working with USGS to get mineral potential for the planning area. Might want to prioritize other questions over this one.
Terrestrial (Vegetation)	Soil Thermodynamics	B1	How is climate change likely to alter permafrost distribution, active layer depth, precipitation regime, and evapotranspiration in this region?	Low	Yes	spatial	
Terrestrial (Vegetation)	Climate	F3	How are these pathways likely to change in response to climate change, with special emphasis on increased shrub cover and treeline changes?	Low if using existing descriptions. HOWEVER, if more description is required: moderate effort and a substantial effort would be required to create state-and-transition models.	Yes	literature review	

Terrestrial (Caribou)	Climate	K1	How will caribou winter and summer habitat be affected by climate change?	Low	Yes	spatial and literature review	Why is effort to do this considered low, when it would depend on next three? / Will we be getting seasonal variations in the core products for animals that migrate?
Terrestrial (Caribou)	Climate/ Land Use and Develop ment	L1	What are caribou seasonal distribution and movement patterns?	Moderate	Yes	spatial	A bit of a moving target. In addition to random variation, alterations in migration patterns have been tied to weather and disturbance. The answer may be as vague as "it depends". Another issue may be getting Pis to cough up this sensitive data.
Terrestrial (Sheep)	Climate/ Land Use and Develop ment	N1	Where is primary sheep habitat located?	Low	Yes	spatial	
Terrestrial (Sheep)	Climate/ Land Use and Develop ment	N4	How might sheep distribution shift in relation to development (especially roads)?	Low	Yes	spatial	Would need to know how they react to roads to determine how their distribution would shift - is this known?
Terrestrial and Aquatic	Land Use and Develop ment	O1	What additional baseline data (i.e. drivers) are needed for fish, birds, and other terrestrial species for enhancing food security (health and safety of subsistence food)?	Current known data: substantial effort. Additional baseline data: out of scope.	Current known data: Yes. Addition al baseline data: NO.	literature review	I don't really understand this MQ. But assuring availability of subsistence foods into the future is certainly a highly important aspect of the REA and land use planning. Identifying data which is needed to assess this seems reasonable.
Terrestrial and Aquatic	Land Use and Develop ment	P1	What are the major ecosystem services provided by the lands and waters within this REA?	Substantial effort.	No	literature review	This seems large in scope to me / It seems that at least a general description of this is within scope.

Terrestrial and Aquatic	Land Use and Development	Q1	Which subsistence species (aquatic and terrestrial) are being harvested by whom and where is harvest taking place?	Moderate effort (potential data gaps).	Yes	literature review	
Terrestrial and Aquatic	Land Use and Development	S1	What real and perceived limitations to access and/or collection of subsistence resources (aquatic and terrestrial) by local residents are associated with human infrastructure (mineral extraction, roads)?	Real limitations: potential data gaps and 'real' is ambiguous. Physical limitations: moderate effort. Other limitations: substantial effort. Perceptual limitations: substantial effort.	Yes	literature review	
	Land Use and Development	U1	Compare the footprint of all types of landscape and landscape disturbances (anthropogenic and natural changed) over the last 20 and 50 years.	Low	Yes	spatial	
Aquatic (Fish)	Land Use and Development	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)?	Moderate effort (if data available).	Yes	literature review	

Terrestrial (Mammals)	Land Use and Development	X1	What have the past cumulative impacts of road construction and mineral extraction been on terrestrial CE habitat and population dynamics?	Moderate effort (if data available).	Yes	literature review	
	Climate	AD1	How will climate-related changes in snow cover, active layer depth, and breakup affect regulation (specifically the allowed timing of) of winter travel on BLM managed lands?	Moderate effort	Yes: HOWEVER, the resolution of the data may not be ideal.	spatial and literature review	Will be at very coarse scale - likely not useful to folks wanting paths on which to snowmobile.
Terrestrial (waterfowl)	Climate/ Land Use and Development	AE2	How might waterfowl (black scoter or trumpeter swan) distribution shift in relation to climate change?	Low	Yes	spatial	ditto previous/white-winged scoter not black
Terrestrial (Vegetation)	Soil Thermodynamics	D1	How will expected changes in permafrost distribution and active layer depth alter the hydrological cycle in the region?	Substantial	Yes. However, we will be limited to existing information and models.	spatial and literature review	I think its prohibitively difficult to do well in the alloted time
Terrestrial (Vegetation)	Soil Thermodynamics	D2	How will these manifest as changes to terrestrial and aquatic CE habitat quality and quantity (in dominant vegetation classes as well as riparian zones within each)?	Substantial	Yes. However, the resolution of the permafrost model is likely to limit	spatial and literature review	These what? From the previous question?

					our ability to address this question spatially at a meaningful scale.		
Terrestrial (Vegetation)	Climate	E2	How does [change in snow melt/onset, spring breakup and green up and season length] vary between dominant vegetation classes and riparian zones?	Low	Yes	spatial	So looking at variation in response to climate change by various plant types? I don't know why season length would be any different in forests vs open habitat (isn't it temperature derived?), but maybe I'm not understanding the question?
Terrestrial (Caribou)	Climate	K4	How will projected habitat changes alter caribou utilization patterns?	Moderate	Yes: HOWEVER, we will not be able to project how utilization patterns would change.	spatial	Sounds difficult, at best. Caribou habitat selection barely makes sense to caribou biologists.
Terrestrial (Moose)	Land Use and Development	M1	For moose populations in this region what is historic and current distribution and density?	Substantial effort (if data available).	No	literature review	Do we not have this info for much of the area?

Terrestrial (Sheep)	Climate/ Land Use and Develop ment	N3	How might sheep distribution shift in relation to climate change?	Low	Yes	spatial	I think this is important but it will not be as straight forward as for some other species. Much of the habitat occupied by sheep are used because they have escape terrain (steep rocky habitat) or for historical reasons (have been occupied in the past - local population was eliminated -takes a while to repopulate). Some of this won't change underclimate change scenarios.
Terrestrial and Aquatic	Land Use and Develop ment	O2	What are known drivers and what drivers require more information?	Substantial effort (we would include key data gaps).	Yes	literature review	
Terrestrial and Aquatic	Land Use and Develop ment	P2	What factors influence their value and can any of the services be quantified?	Substantial effort.	No	literature review	I'm wondering why this is outside the scope of ISER?
Terrestrial and Aquatic	Land Use and Develop ment	Q2	What are historic and projected trends in subsistence harvest of these species? How reliable are these predictions?	Substantial effort: anticipate significant data gaps.	Yes	literature review	You might look into it but I doubt these data are available.
Aquatic (Fish)	Land Use and Develop ment	V3	What percentage of headwater streams in the region are currently in an intact/pristine state?	Low	Yes	spatial	What are cumulative effects of past and current development? Which watersheds most impacted? Which most important to protect from impacts?

	Land Use and Develop ment	Z2	Which BLM lands provide transportation development linkages (roads) for non-conservation system unit lands?	Substantial effort.	No	spatial	Comment 1) Drop the questions related to corridor development (IN5, AB1, and Z2) from the list. I think, and the mgrs, that this would be really complicated in the long run despite it's high importance to management. Comment 2) Question is unclear. Does this mean what areas are suitable for transporation and utility corridors to link non-conservation system lands? If so I would have ranked it in top 20. Or does it mean where do these roads currently exist? If the second, then what we need is better and cleaned up data. / Also, where are the least ecologically important or sensitive areas and where can we maximize future colocated transportation corridors to state, BLM and native corpotation lands?
	Land Use and Develop ment	AB1	Where should potential roads to Ambler, Nome, Umiat, and Stevens village (100 foot wide road or utility corridors from the Dalton Highway) be placed in order to protect existing human infrastructure (as far away as possible from existing infrastructure)?	Substantial: Could be addressed using products of core analysis.	No	spatial	Drop the questions related to corridor development (IN5, AB1, and Z2) from the list. I think, and the mgrs, that this would be really complicated in the long run despite it's high importance to management. Since limited human infrastructure, this seems a lower priority. Protection of ecosystems that provide subsistence resources is higher.

Terrestrial (Vegetation)	Climate	C1	How will changes in precipitation, evapotranspiration, and active layer depth alter surface water availability and therefore ecosystem function (dominant vegetation classes)?	Low	Yes. However, we will be limited to existing information and models.	spatial and literature review	
Terrestrial (Soils)		H1	Where are the areas of greatest topographic and soils diversity?	Substantial	Potentially	spatial	Greatest habitat or vegetation community diversity?
Terrestrial	Climate/ Social Thermodynamics	I2	In areas likely to be subject to erosion (including [but not limited to] flooding in riparian zones and fire affected areas) what are the expected changes to habitat and cultural sites?	Low: if data are available. HOWEVER, if limited data then literature review: moderate effort.	Yes	spatial and literature review	
Terrestrial (Caribou)	Climate	K3	What are the likely impacts of increased shrub cover on caribou habitat?	Moderate effort	Yes	literature review	
Terrestrial (Caribou)	Climate/ Land Use and Development	L5	Where is future development likely to most impact hunter access to caribou populations?	Low	Yes	spatial	Three questions here: Where is future development most likely? Where will it affect caribou habitat? What will be effects on access? First two most important. Third less so.
Terrestrial (Moose)	Land Use and Development	M2	What major drivers behind the shifts in moose distribution have been identified?	Substantial effort (if data available).	Yes	literature review	

Terrestrial and Aquatic	Land Use and Development	R1	What real and perceived limitations to access and/or collection of subsistence resources (aquatic and terrestrial) by local residents are caused by non-subsistence hunting and fishing activity?	Substantial effort (significant data gaps and limitations).	Yes. HOWEVER, perceived limitations would be limited to existing information and could be considered out of scope.	literature review	Wow, that's a $69,000 question that I'm sure everyone would love to know. Seems difficult to actually quantify.
Terrestrial and Aquatic	Land Use and Development	R2	In which areas are the real and perceived limitations to access and/or collection of subsistence resources (as a result of non-subsistence hunting and fishing activity) occurring?	Low	Yes	literature review	Controversial how? Reword R1 to get this issue covered. Does not make sense when separated out: *Controversial issues are located in reference to subsistence areas*. This question was **updated** by BLM 9/12/14 to reflect original intent.
Terrestrial and Aquatic	Land Use and Development	S2	How might [real and perceived limitations] change in response to planned future development, especially new roads?	Obvious physical limitations: low additional effort.	Yes	literature review	Quantifying real change seems difficult, at best.
Terrestrial (Reindeer/Caribou/Vegetation)		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?	Moderate	Yes	spatial	

	Land Use and Development	U2	Where are these footprints located now?	Low (data gap potential)	Yes	spatial	
Aquatic (Fish)	Land Use and Development	V2	Specifically, what is the relative importance of headwater streams to stream ecology and watershed health?	Moderate effort (if data available).	Yes	literature review	
Terrestrial (Vegetation)	Land Use and Development	Y2	How and where might these impacts spread as the anthropogenic footprint expands?	Moderate	Yes	spatial	
	Climate	AD2	How will these projected changes affect how BLM regulates permittee access (specifically the timing of access)?	Substantial	No	literature review	
Terrestrial (waterfowl)	Climate/ Land Use and Development	AE1	Where is primary waterfowl (black scoter or trumpeter swan) habitat located?	Low	Yes	spatial	Don't understand the how to answer this question as BLSC largely don't occur in the CY area, and for the most part their distribution is disjunct from TRUS. The more interior scoter species are Surf and White-winged. BLSC is primarily W AK in distribution. Also, TRUS are undergoing logistic growth in the state; there should be greater concern for species with declining trends. As for where primary waterfowl habitat is, I believe we already have a pretty good sense of this in AK / white-winged scoter not black
Terrestrial (waterfowl)	Climate/ Land Use and Development	AE3	How might waterfowl (blackscoter or trumpeter swan) distribution shift in relation to development (especially roads)?	Low	Yes	spatial	ditto previous / white-winged scoter not black

Terrestrial (Vegetation)	Climate	F1	What are the major vegetation successional pathways for upland and lowland forest and tundra vegetation classes?	Low if using existing descriptions. HOWEVER, if more description is required: moderate effort and a substantial effort would be required to create state-and-transition models.	Yes	literature review	
Terrestrial (Vegetation)	Climate	F2	What are the most common disturbances impacting each and how do these disturbances impact successional trajectories?	Low if using existing descriptions. HOWEVER, if more description is required: moderate effort and a substantial effort would be required to create state-and-transition models.	Yes	literature review	

Terrestrial	Climate/ Social Thermodynamics	I1	What are the current locations and rates of inland erosion and how might these change in the future?	Substantial effort and would be highly speculative. HOWEVER, moderate effort for a simple GIS model of erosion-prone areas.	Yes	spatial	Erosion around lake edges and river banks? Yikes, speculative indeed. / Which areas of permafrost are closest to the thawpoint?
Terrestrial (Caribou)	Climate	K2	What evidence exists for increased shrub cover?	Moderate effort	Yes	literature review	Will likely be answered when addressing distribution of shrub and effects of shrubification?
Terrestrial (Caribou)	Climate/ Land Use and Development	L2	How are caribou seasonal distribution and movement patterns related to season and weather?	Moderate	Yes: HOWEVER, we are limited to only existing information, and interpretation would likely be limited to overall climatic patterns.	spatial	Not convinced this will be useful at the scale of overall mean temperature / precip for the region.
Terrestrial (Moose)	Land Use and Development	M3	What is the history of moose harvest by subsistence users per given area within the region?	Moderate	Yes	literature review	

Terrestrial (Sheep)	Climate/ Land Use and Development	N2	How does sheep distribution shift in response to season and weather?	Moderate	Yes: HOWEVER, we are limited to only existing information, and interpretation would likely be limited to overall climatic patterns.	spatial	This would require radiotracking data to answer. There are three data sets for radio collared sheep within this REA that I am aware of (and 2 additional just outside). Although a worthy goal, I'm not sure if this is the instrument to answer that question (i.e. might be difficult to get the dat from all the PIs) / See comment for same question pertaining to caribou
Terrestrial (Sheep)	Climate/ Land Use and Development	N5	Where is future development likely to most impact hunter access to sheep populations?	Low	Yes	spatial	
Terrestrial and Aquatic	Land Use and Development	R3	What solutions to conflicts are promoted by local resident subsistence users?	Substantial effort (significant data gaps).	No	literature review	
Terrestrial (Reindeer/Caribou/Vegetation)		T2	How would introduction of a reindeer herding program affect caribou and vegetation?	Moderate	Yes.	literature review	
Aquatic (Fish)	Land Use and Development	V4	What is the ecological value of maintaining intact headwater streams?	Moderate effort	Yes	literature review	

	Land Use and Development	AF1	What are the visual resource inventory classifications for the Utility Corridor and the remote western lands?	Substantial	No	spatial	BLM doing in house VRM inventory / VRM may be an important management issue, but not an ecological one.
	Land Use and Development	AG1	How will the viewshed and visual sensitivity change with the potential development of access roads to mining and energy operations?	Substantial	No	spatial	
	Land Use and Development	AG2	What are the visual impacts from gravel pits, pipelines, and other developments?	Substantial	No	spatial	
	Land Use and Development	AG3	How far can they be seen from the air and the ground?	Substantial	No	spatial	Lower priority
Terrestrial and Aquatic	Land Use and Development	Q3	What is the economic value (market equivalent) of these species?	Substantial effort.	No	economic analysis	
Terrestrial and Aquatic	Land Use and Development	S3	What solutions to conflicts are promoted by local resident subsistence users for specific limitations?	Substantial effort (potential significant data gap).	No	literature review	
Terrestrial (Reindeer/Caribou/Vegetation)		T3	What is the economic service of maintaining intact caribou habitat in comparison to the economic gain of reindeer herding (market value)?	Substantial effort (potential significant data gap).	No	economic analysis	Quantifying the economic benefit of caribou in the region to subistence and non-local hunters seems overly ambitious.
	Land Use and Development	U4	What is the viewshed of large anthropogenic features? How far can they be seen from the air and the ground?	Substantial effort	No	spatial	Who cares?