Yukon River Lowlands – Kuskokwim Mountains – Lime Hills Rapid Ecoregional Assessment Technical Supplement

Technical supplement to the final report prepared for:

Bureau of Land Management

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It is the mission of the Bureau of Land Management to sustain the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations.

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YUKON RIVER LOWLANDS – KUSKOKWIM MOUNTAINS – LIME HILLS RAPID ECOREGIONAL ASSESSMENT

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Note on Structure of Technical Supplement

We have partitioned the final report for this Rapid Ecoregional Assessment (REA) into two distinct documents. The first is a summary report that outlines the key findings of the Yukon River Lowlands – Kuskokwim Mountains – Lime Hills (YKL) REA. This Technical Supplement is the second document; it is intended for readers with interest and expertise in the various components of the REA who want to understand specific details regarding the methods, results, applications, limitations, and data gaps of the YKL REA.

We have organized the Technical Supplement into five main sections: Introduction (Section A), Change Agents (Section B), Landscape and Ecological Integrity (Section C), Conservation Elements (Section D), and Data Gaps and Omissions (Section E). We did this to assist readers in more quickly navigating to sections of interest. Additionally, given the comprehensive nature of this assessment and the broad range of topics presented, a single document would be cumbersome. Therefore, we present the findings of our assessment in discrete sections, each written with enough detail and description so that our results can be replicated and understood within the context of regional land management.

Tables of contents, figures, and tables with associated page numbers are listed at the beginning of each of the five main sections.

Technical Supplement Contents

A. Introduction to the Technical Supplement

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Summary

Section A. *Introduction to the Technical Summary* provides an overview of the REA process, general methodological approaches, description of the YKL REA area, YKL conservation elements and change agents, limitations for the assessments of landscape ecological integrity.

Section A Contents

Figures

Tables

Acronyms Used in This Document:

ACEC	Area of Critical Environmental Concern
ACS	American Community Survey
ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AFS	Alaska Fire Service
ASGDC	Alaska State Geo-spatial Data Clearinghouse
AKDOLWD	Alaska Department of Labor and Workforce Development
AEA	Alaska Energy Authority
AKGAP	Alaska Gap Analysis Program
AKNHP	Alaska Natural Heritage Program
ALFRESCO	Alaska Frame-based EcoSystem Code
AMT	Assessment Management Team
ANILCA	Alaska National Interest Lands Conservation Act
ANCSA	Alaska Native Claims Settlement Act
ARDF	Alaska Resource Data File
ASI	Arctic Social Indicators
ATV	All Terrain Vehicle
AVEC	Alaska Village Electric Cooperative
AVCP	Alaska Village Council Presidents
AWC	Anadromous Waters Catalog
BLM	Bureau of Land Management
BpS	Biophysical Setting
CA	Change Agent
CE	Conservation Element
CPI	Consumer Price Index
CSIS	Community Subsistence Information System
DEM	Digital Elevation Model
EPA	Environmental Protection Agency
EIS	Environmental Impact Statement
ESRI	Environmental Services Research Institute
FAA	Federal Aviation Administration
GAP	Gap Analysis Project
GCM	Global Circulation Model
GIPL	Geophysical Institute Permafrost Lab
GIS	Geographic Information System
GMU	Game Management Unit
HUC	Hydrologic Unit Code
IK/AK	Indigenous Knowledge/Aboriginal Knowledge
ISER	Institute of Social and Economic Research
LCM	Landscape Condition Model
LEK	Local Ecological Knowledge

LK	Local Knowledge
MAGT	Mean Annual Ground Temperature
MQ	Management Question
NANA	Northwest Arctic Native Association
NED	National Elevation Dataset
NHD	National Hydrography Dataset
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPR-A	National Petroleum Reserve-Alaska
NPS	National Park Service
NOS REA	North Slope Rapid Ecoregional Assessment
NWR	National Wildlife Refuge
PCE	Power Cost Equalization
PRISM	Parameter-elevation Regressions on Independent Slope Models
REA	Rapid Ecoregional Assessment
REF	Renewable Energy Fund
SNAP	Scenarios Network for Alaska and Arctic Planning
STATSGO	State Soil Geographic Database
Tech Team	Technical Team
TEK	Traditional Ecological Knowledge
TK	Traditional Knowledge
TTL	Tribal Traditional Lifeways
TNC	The Nature Conservancy
USFS	United States Forest Service
USGS	United States Geological Survey
UA	University of Alaska
USFWS	United States Fish and Wildlife Service
YKL	Yukon Lowlands – Kuskokwim Mountains – Lime Hills

1. What is a Rapid Ecoregional Assessment?

The Bureau of Land Management (BLM) recently developed a landscape approach to enhance management of public lands (BLM 2014). 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 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 (Bryce 2012).

REAs evaluate questions of regional importance identified by land managers, and assess the status of regionally significant ecological resources, as well as agents of change that are perceived to impact those ecological resources. The resulting synthesis of regional information is intended to assist management and environmental planning efforts at multiple scales. REAs have two primary purposes:

- To provide landscape-level information needed in developing habitat conservation strategies for regionally significant native plants, wildlife, and fish and other aquatic species; and
- 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 at near-term (year 2025) and long-term (year 2060).

A number of REAs are underway or have recently been completed in Alaska. These include the Seward Peninsula (Harkness et al. 2012), North Slope (in-progress), and the Central Yukon (in-progress).

2. Approach and Process

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

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

MQs focus REAs on pertinent management and planning concerns for the region. 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. Although a basic list of CAs is provided by the BLM, MQs can also identify regionally-specific CAs to be considered in the analysis. One important strength of this approach is the integration of current management concerns and current scientific understanding into a comprehensive regional assessment.

The core REA analysis refers to the status and distribution of CEs and CAs and the intersection of the two. The core REA analysis addresses the following five questions:

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

2.1. Change Agents (CAs)

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, and climate change, as well as localized impacts such as development, infrastructure, and extractive energy development. CAs can impact CEs at the point of occurrence as well as through indirect effects. CAs are also expected to interact with other CAs to have increased or secondary effects. Although they are listed separately, most anthropogenic CAs generally occur in concert with one another. Mining and energy development, for example, require other CAs like transportation and transmission infrastructure.

2.2. Conservation Elements (CEs)

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

The selected conservation elements are limited to a suite of specific CEs that, if conserved, represent key ecological resources and thus indicate ecological condition. Most CEs are defined through the "coarse-filter / fine-filter" approach suggested by BLM guidelines; an approach 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

Terrestrial and Aquatic Coarse-Filter CEs represent the dominant ecological patterns of the ecoregion. Coarse-filter CEs include regionally significant terrestrial vegetation types and aquatic ecosystems within the assessment area. They represent the habitat requirements of most characteristic native species, ecological functions, and ecosystem services.

Fine-Filter Conservation Elements

Fine-Filter CEs represent species that are critical to the assessment of the ecological condition of the Yukon-Kuskokwim-Lime Hills study area for which habitat is not adequately represented by the Coarse-Filter CEs. Fine-Filter CEs selected for the REA are represented by regionally significant mammal, bird, and fish species.

A list of CAs and Coarse-Filter and Fine-Filter CEs is given in Table A-1.

Table A-1. Elements of the YKL REA.

Change Agents

CAs	
• Climate – Temperature – Precipitation – Thaw date – Freeze date – Cliomes • Permafrost – Ground temperature – Active layer depth • Fire (return interval)	• Invasive Species and Forest Defoliators • Anthropogenic factors – Subsistence – Natural Resource Extraction – Transportation and communication infrastructure • Recreation

Coarse-Filter Conservation Elements

Terrestrial Coarse-Filter CEs	
• Deciduous Forest • White Spruce or Black Spruce Forest • Tall Shrub • Low Shrub	• Dwarf Shrub • Herbaceous Wetlands • Large Floodplains
Aquatic Coarse-Filter CEs	
• Streams • Connected Lakes	• Disconnected Lakes

Fine-Filter Conservation Elements

Terrestrial Fine-Filter CEs	
• Moose (*Alces alces*) • Caribou (*Rangifer tarandus*) • Muskox (*Ovibus moschatus*) • American beaver (*Castor canadensis*)	• Gray wolf (*Canis lupis*) • American peregrine falcon (*Falco peregrinus anatum*) • Trumpeter swan (*Cygnus buccinators*) • Olive-sided flycatcher (*Contopus cooperi*)
Aquatic Fine-Filter CEs	
• Chinook salmon (*Oncorhynchus tshawytscha*) • Chum salmon (*Oncorhyncus keta*)	• Sheefish (*Stenodus leucichthys*) • Northern pike (*Esox lucinus*) • Dolly Varden (*Salvelinus malma*)

2.3. Management Questions

MQs reflect critical resource and management concerns in the region and focus the REA. MQs aid in refining the scope of this assessment and ensuring that the results are useful to current management needs. The BLM defined a preliminary set of MQs in the Statement of Work for this REA. These questions were generally broad in scope, and too numerous for the BLM target of 30-50 questions. In order to refine and shorten this list, BLM State and Field Offices were asked to review the MQs for clarity and relevancy, and to prioritize questions. This review resulted in rewording of questions, separation of compound questions, and spurred additional questions of interest.

Review of several iterations of each question resulted in a list of questions that were most relevant to land managers. All iterations of the questions were considered and, when possible, original (BLM) phrasing was retained. Nine questions that were ranked as low priority by the BLM, and deemed out of scope by our team, were omitted from further consideration. One-hundred and thirty one questions remained after this omission. This list was re-evaluated to determine if questions 1) addressed scales deemed either too fine or coarse, 2) required data known to not be available or would require substantially longer time than 18 months to collect, 3) were redundant with existing questions, or 4) were too broad or vague to answer accurately. Through workshops and multiple iterations with the Assessment Management Team (AMT) – a volunteer team of representatives from various agencies and organizations that are responsible for land management within the YKL study area, 50 MQs were selected for analysis as part of this assessment. MQs ranged from very specific questions about food availability for certain species, to general questions about how mineral development might affect species. Below we list all 50 MQs addressed in this assessment (Table A-2). A full description of the methods used to address these questions, as well as our findings from our analyses of these MQs can be found in the following topical sections (e.g., MQs related to Vegetation Communities are addressed in the Terrestrial Coarse-Filter CE section D-1).

Below we list all 50 MQs addressed in this assessment (Table A-2). MQs ranged from very specific questions about food availability for certain species, to general questions about how mineral development might affect species. MQs included in this assessment fall into two broad categories: those that are redundant with the core analysis required by the REA process and those that are extraneous to the core analysis. MQs that are listed within an unnumbered subsection in this technical supplement are redundant with the core analysis; these MQs are indicated in Table A-2 by an asterisk (*) next to the section number. In most cases MQs that are extraneous to the core analysis include their own methods, results, and limitations and data gaps.

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

Vegetation Communities		
1	*What are the possible impacts on vegetation communities from climate change?*	Section D-1.3*
2	*What is the current distribution of vegetation communities?*	Section D-1.11
3	*How and where will changes in permafrost impact vegetation?*	Section D-1.3*
Wildlife		
4	*What is the current distribution of primary winter forage (lichen) for caribou in the region, and how is that expected to change?*	Section D-2.5*

5	*Where are caribou calving grounds in the region, and how are they expected to change?*	Section D-2.5*
6	*What is the current seasonal distribution of moose in the region?*	Section D-2.4*
7	*What is the current distribution of primary winter forage (willow) for moose in the region, and how is that expected to change?*	Section D-2.4*
8	*Is there musk ox habitat in the region, and if so, how might it change in the future?*	Section D-2.7*
9	*What is the current distribution of migration corridors for caribou, and how are they likely to change in the future?*	Section D-2.5*
10	*Where are key prey species located in the region?*	Section D-2.14
11	*What is the current distribution of the American Peregrine Falcon in the region, and how is that expected to change?*	Section D-2.11*
12	*Where is habitat for sensitive species that are also conservation elements?*	Section D-2.13
13	*What are the current types and potential impacts of diseases in ungulate populations (caribou, moose), and how are these impacts expected to change in the future?*	Section D-2.6
14	*How, where, and when could Essential Fish Habitat (EFH) be affected by predicted changes in climate?*	Section D-4.3* Section D-4.4*
15	*Where and how might mineral resource development affect fishery habitat?*	Section D-4.8
Abiotic Factors		
16	*What are the current soil thermal regime dynamics?*	Section B-3.3*
17	*Based on the predictions of the best available climate models and soil temperature models, how will soil thermal regimes change in the future?*	Section B-3.3*
18	*Where are predicted changes in soil thermal regimes associated with communities and transportation routes?*	Section B-3.4
19	*How might changes in temperature, precipitation, evapotranspiration, and soil thermal dynamics affect general hydrology and hydrology-dependent CEs such as waterfowl in the region?*	Section D (All)
20	*What are the projected monthly, seasonal, and annual temperature, precipitation, and length of warm and cold seasons for the REA, and how do these projections vary across time, across the region, and across varying global greenhouse gas emissions scenarios?*	Section B-1.3*
21	*Where will climate change impact CEs, including subsistence species?*	Section B-1.4*
22	*What is the fire history of the ecoregion?*	Section B-2.3*
23	*What climatic conditions are likely to result in significant changes to fire activity?*	Section B-2.3*
24	*What is the current frequency (return interval) and the likely future frequency for fire in the ecoregion and broad sub-regions?*	Section B-2.3*
Biotic Factors		
25	*What is the current distribution and area (percent of land with infestations) of introduced and invasive species in the YKL?*	Section B-4.3*
26	*Which areas are most likely to be susceptible to infestation by invasive plant species currently?*	Section B-4.3*

27	*Which areas are most likely to be susceptible to infestation by invasive plant species in the future, specifically in relationship to climate change and proposed development?*	Section B-4.3*
28	*What are the likely vectors for new infestations or spread of existing infestations?*	Section B-4.4
29	*What is the current distribution of forest pest outbreaks in the ecoregion?*	Section B-4.5
Anthropogenic Factors		
30	*What are current socioeconomic conditions in YKL communities?*	Section B-5.4
31	*What are the projected socioeconomic conditions in the future?*	Section B-5.5
32	*How could community economic profiles vary with respect to development scenarios (including mines) in the near future (including access to subsistence, energy sources, and other resources)?*	Section B-5.5
33	*What are the potential impacts of renewable energy projects on local economies the region?*	Section B-5.5
34	*How might change in transportation corridors impact communities?*	Section B-5.5
35	*Where are current subsistence harvest areas?*	Section B-5.6
36	*What do ADFG harvest data and TEK/LTK show about how harvest amounts, types of fish/animals/plants, and harvest seasons changed in the recent past (including beavers)?*	Section B-5.6
37	*How could larger community populations affect subsistence resources?*	Section B-5.7
38	*What are general (sport) harvest levels of salmon, moose, and caribou in the recent past?*	Section B-5.10
39	*Where are current sport hunt areas?*	Section B-5.10
40	*What have been the commercial harvest levels of salmon over the past 10 years?*	Section B-5.8
41	*Where are current commercial fish harvest areas?*	Section B-5.8
42	*Where is the current human footprint in the region?*	Section B-5.3*
43	*What is current land status in the region?*	Section B-5.3*
44	*Where are unsettled land claims?*	Section B-5.3*
45	*Where is recreation activity highest?*	Section B-5.9
46	*Where are areas of energy and resource extraction currently and likely to occur in the future?*	Section B-5.3*
47	*Where are planned sites for alternative/renewable energy?*	Section B-5.3*
48	*Where is planned transportation/communication infrastructure to be located?*	Section B-5.3*
49	*How might recreational use in the region change over time?*	Section B-5.9
50	*Are there areas in the REA that are impacted by mercury contamination?*	Section B-5.11

2.4. Project Team

The Alaska Natural Heritage Program (AKNHP) served as the lead for this REA, with close collaboration from the Scenarios Network for Alaska and Arctic Planning (SNAP), Institute of Social and Economic Research (ISER), and Meg King and Associates. Throughout this document this team is collectively referred to as the University of Alaska (UA) Team. The UA Team as a whole was responsible for assessing the current and potential future status of CEs at the ecoregional scale and their relationships to CAs, as well as addressing the Management Questions (MQs), identifying data gaps, and delivering data to the BLM. Project leads are identified for the various sections reflecting the multi-disciplinal expertise and knowledge used in assessing this region.

2.5. Land Owners and Stakeholders

The UA team and BLM State and Field offices coordinated three community meetings, one in Galena, Newhalen, and Aniak. The purpose of these meetings was to inform the general public about the REA process, its expected outcomes, and gather input on conservation elements, change agents, and management questions. Information on regional concerns gathered at these meetings resulted in eight additional proposed management questions (each of them identified in the next section), three additional conservation elements, and an additional change agent.

3. Description of Rapid Ecoregional Study Area

The assessment area includes three ecoregions in interior Alaska: Yukon Lowlands, the Kuskokwim Mountains, and the Lime Hills (Figure A-1). These ecoregions are defined by Nowacki et al. (2001) and represent a unified mapping approach that blends traditional approaches with regionally-specific knowledge and ecological goals.

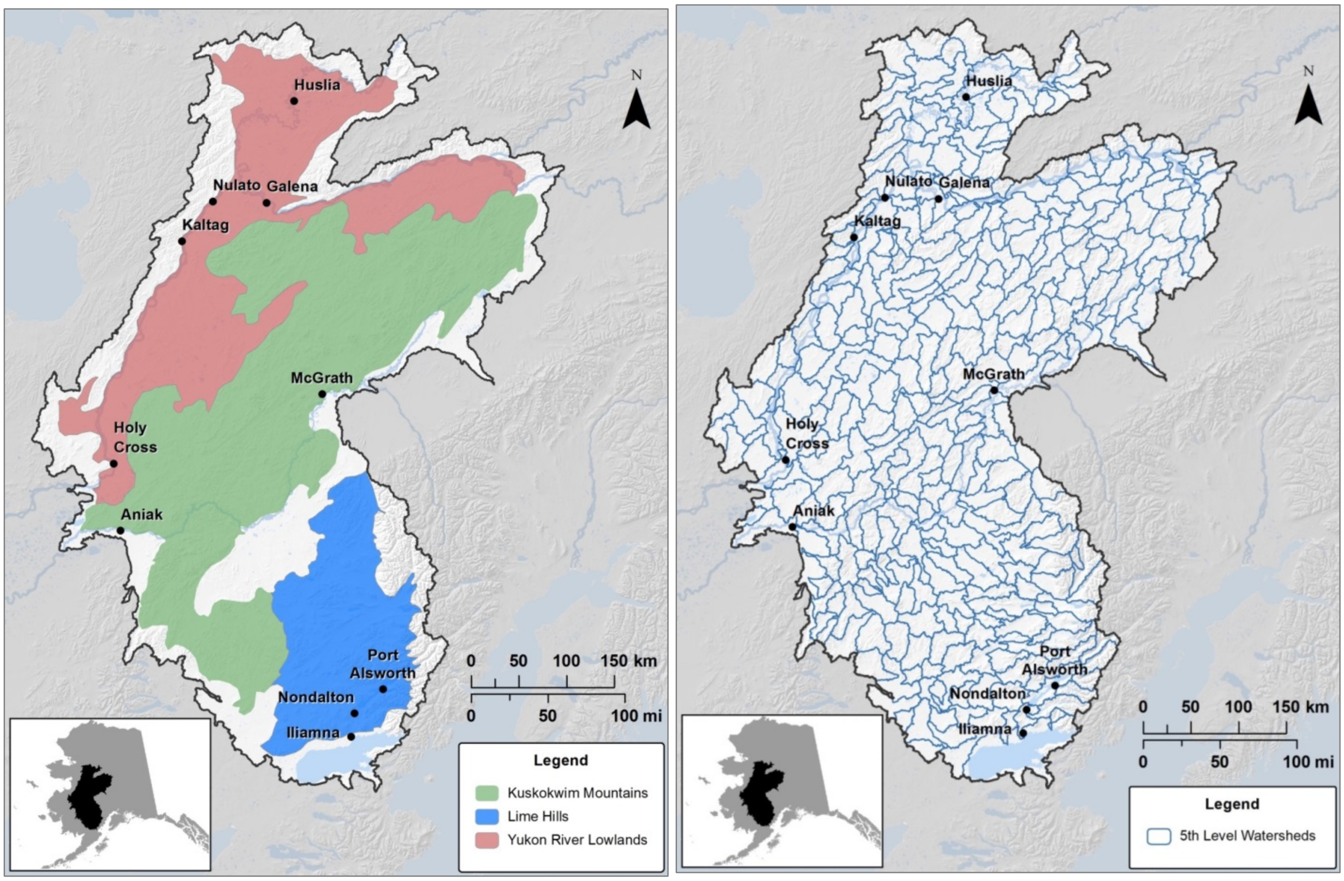

Figure A-1. Yukon River Lowlands, Kuskokwim Mountains, and Lime Hills Ecoregional boundaries and 5^{th} level watersheds.

Included in these ecoregions are two major river systems (Yukon and Kuskokwim), as well as approximately thirty small communities. Although none of the communities can be reached by road, Galena, McGrath, Aniak, and Illiamna serve as primary air-transportation hub communities for the region. The State Department of Natural Resources (41%), the BLM (26%), and the Fish and Wildlife Service (FWS) (18%) manage approximately 85% of the YKL study area (Table A-3, Figure A-2).

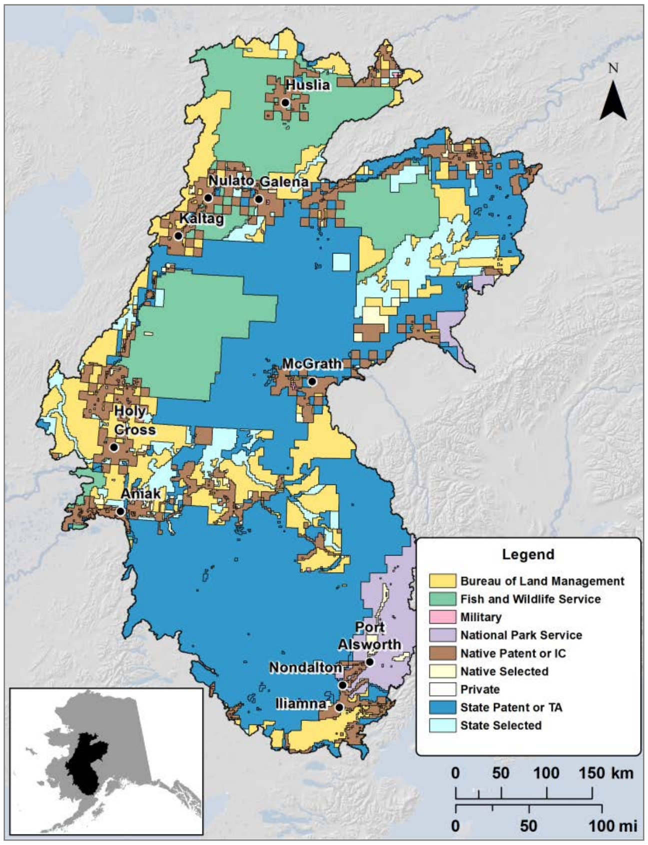

Figure A-2. Land Status in the YKL study area.

Table A-3. Current Land Status in the Study Area.

Land Status	Percent Cover
Bureau of Land Management (BLM)	15.41%
Fish and Wildlife Service (USFWS)	17.30%
Department of Defense (DOD)	0.07%
National Park Service (NPS)	4.02%
Alaska Native Corporation and Tribal Lands	11.91%
Alaska Native Corporation and Tribal Selected Lands	1.28%
Private	0.01%
State of Alaska Lands	43.46%
State of Alaska Selected Lands	6.53%

3.1. Yukon River Lowlands

An expansive wetland system is associated with the lower stretches of the Yukon and Koyukuk rivers in west-central Alaska. Although this area was unglaciated, meltwater floods deposited vast quantities of sediment within these riverine corridors during glacial retreat. Deep deposits of undifferentiated sediments underlie these floodplains and adjacent lowlands. A seasonally moist continental climate prevails with cool, moist summers and cold, dry winters. Permafrost is absent along the younger floodplains, but is thin, discontinuous, and relatively "warm" on the abandoned floodplains in the adjacent lowlands. Poor drainage caused by permafrost contributes to the prevalence of wet, organic-rich soils. Collapse-scar features from thawing permafrost are common. Water levels drop in the Yukon River and its tributaries in early fall during freeze-up and remain low until spring breakup when substantial ice-jam flooding can occur. The vegetation along the major rivers is highly productive and supports vigorous stands of white spruce and balsam poplar. Active floodplains and riverbars support tall stands of alders and willows. Robust wet sedge meadows and aquatic vegetation reside in infilling sloughs and oxbow ponds (Figure A-3a). The adjacent permafrost-dominated lowlands support black spruce woodlands, and birch-ericaceous shrubs and sedge-tussock bogs. Many flat organic surfaces are pockmarked with dense concentrations of lakes and ponds. These areas support large populations of moose and black bear, the oxbow sloughs and thaw ponds support abundant waterfowl, and the lowland forests are important to furbearers. The large rivers support important runs of chinook, chum, and coho salmon.

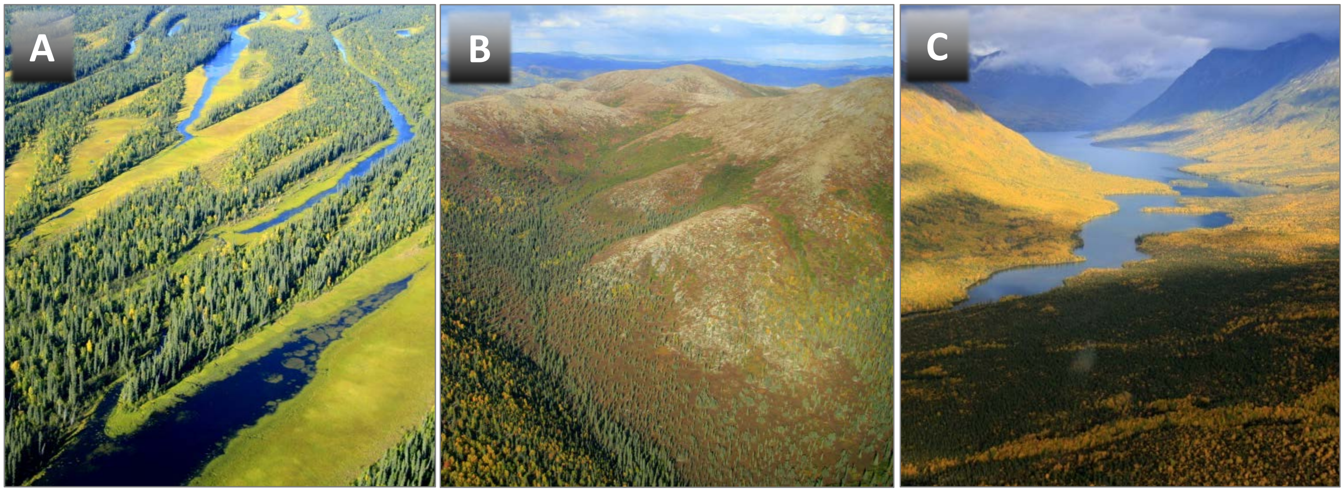

Figure A-3. Yukon River Lowlands: abandoned floodplains of mixed deciduous - spruce forests, tall willow, and wetland habitats (a). Kuskokwim Mountains: mosaic of tundra barrens, low shrub and tall shrub, spruce and deciduous woodland habitats (b). Lime Hills: glacially dissected mountains, and lakes, with deciduous and spruce shrubland and forest habitats (c).

3.2. Kuskokwim Mountains

This terrain is comprised of old, low rolling mountains that have eroded largely without the aid of recent glaciations (Figure A-3b). A continental climate prevails with seasonal moisture provided by the Bering Sea during the summer. Mountains are composed of eroded bedrock and rubble, whereas intervening valleys and lowlands are composed of undifferentiated sediments. Thin to moderately thick permafrost underlies most of the area. Boreal forests dominate, grading from white spruce, birch, and aspen on uplands to black spruce and tamarack in lowlands. Tall willow, birch, and alder shrub communities are scattered throughout, particularly where forest fires burned in the recent past. Rivers meander through this undulating landscape following fault lines and highly eroded bedrock seams. These mountains support abundant moose, bears, beavers, and scattered caribou herds.

3.3. Lime Hills

The Lime Hills are glacially dissected mountains extending from the west side of the Alaska Range. The effects of substantial glaciation are etched in the surface topography through a repeated sequence of sharp mountain ridges with steep headwalls and broad U-shaped valleys (Figure A-3c). The ridges and mountainsides are covered with colluvial rubble, while the valleys contain glacial moraines and outwash with some alluvial deposits along rivers. The continental climate is moderated somewhat by maritime influences of the Bering Sea and North Pacific Ocean. The area is underlain by isolated masses of permafrost. Vegetation is predominately tall and low shrub communities of willow, birch, and alder. Spruce forests and woodlands are confined to valley bottoms and mountain toeslopes. These habitats support moose, bears, caribou, and various furbearers.

3.4. Assessment Boundary and Scale

The assessment boundary, following BLM guidelines, constitutes the three component ecoregions and any 5^{th} level hydrologic units that intersect the ecoregion boundaries (Figure A-3). Four additional 5^{th} level hydrologic units were included in the study area to close two gaps in the boundary. This was agreed to by the BLM to facilitate seamless integration with neighboring REA efforts and to ensure that regionally important resources that may exist just outside of the ecoregion boundaries are included in the analysis.

3.5. Ecoregional Conceptual Model

The Ecoregional Conceptual Model portrays an understanding of critical ecosystem components, processes, and interactions necessary for the maintenance of sustainable ecosystems (Figure A-4). By summarizing known and accessible 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 illustrate 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.

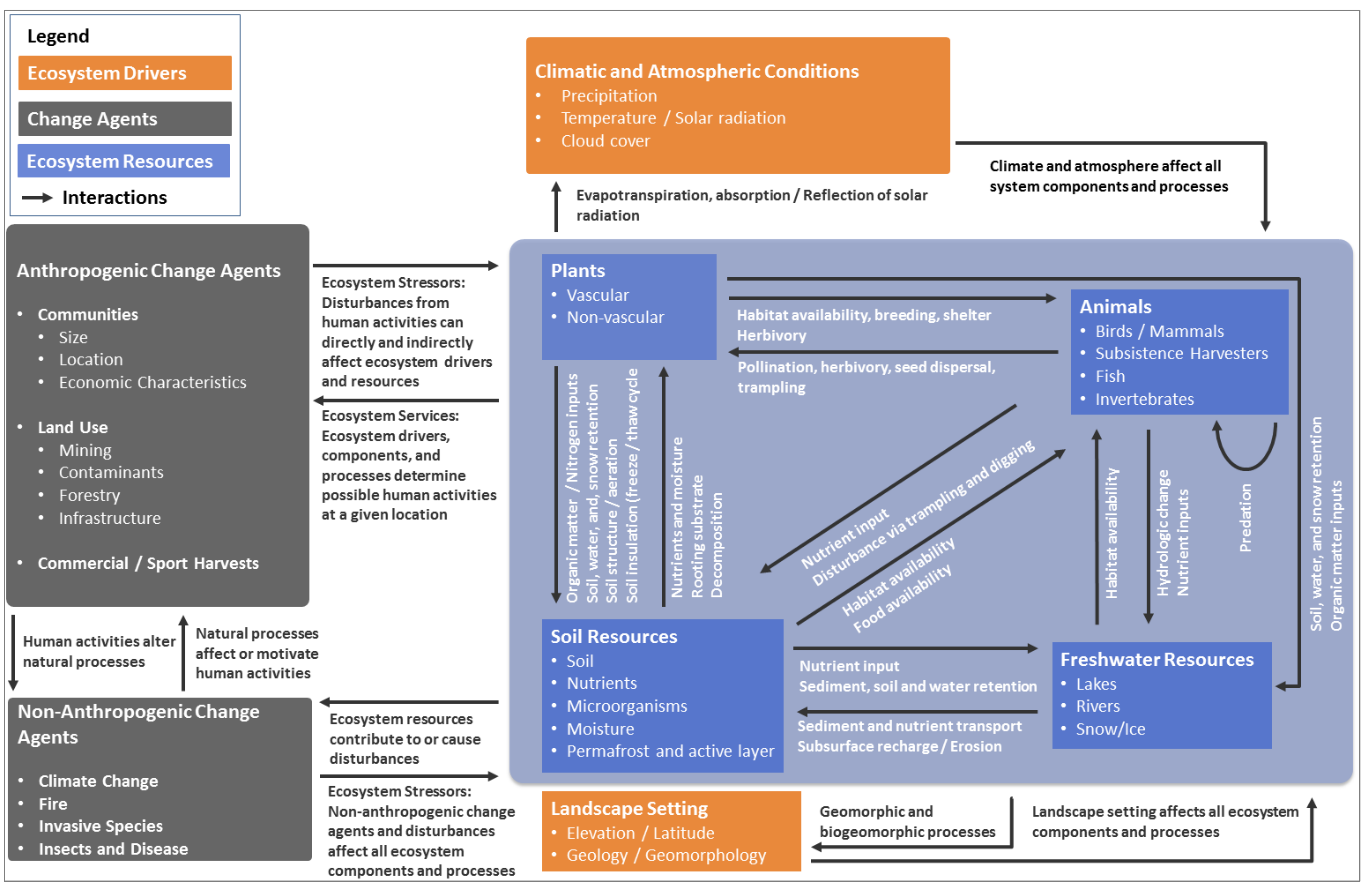

Figure A-4. Ecoregional Conceptual Model for YKL REA.

The Ecoregional Conceptual Model for the YKL study area provides a coarse-scale interpretation of key ecological resources (used to derive CEs), drivers, and CAs of the Yukon River Lowlands, Kuskokwim Mountains, and Lime Hills. The model is divided into the following components:

- **Principal ecosystem resources**, including vegetation, animals, soil resources, and freshwater resources.
- **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 CAs** (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 Ecoregional Conceptual Model served as a framework for identifying CEs, developing interactions between CEs and CAs, and measuring the cumulative impacts of all the CAs on all the CEs, providing a measure of overall current and future ecological integrity.

The CAs identified in the model are used as the primary change agents in the REA. In addition, many of our CEs were derived from the pathways in which ecosystem resources interact with each other. This conceptual model serves as a framework for measuring the cumulative impact of all the CAs on all the CEs, providing a measure of overall current and future ecological integrity.

4. Assessing Current and Future Conditions

In addition to performing the core analysis between CEs and CAs, we examined the general landscape to understand and describe overall conditions. Key to this assessment was an evaluation of landscape integrity, by modeling landscape condition and intactness. Landscape condition examines the level of human modification on the landscape, while intactness provides a measure of fragmentation across the region. When taken in combination with CE distributions (Figure A-5), our assessment can be used to infer overall ecological integrity of the region.

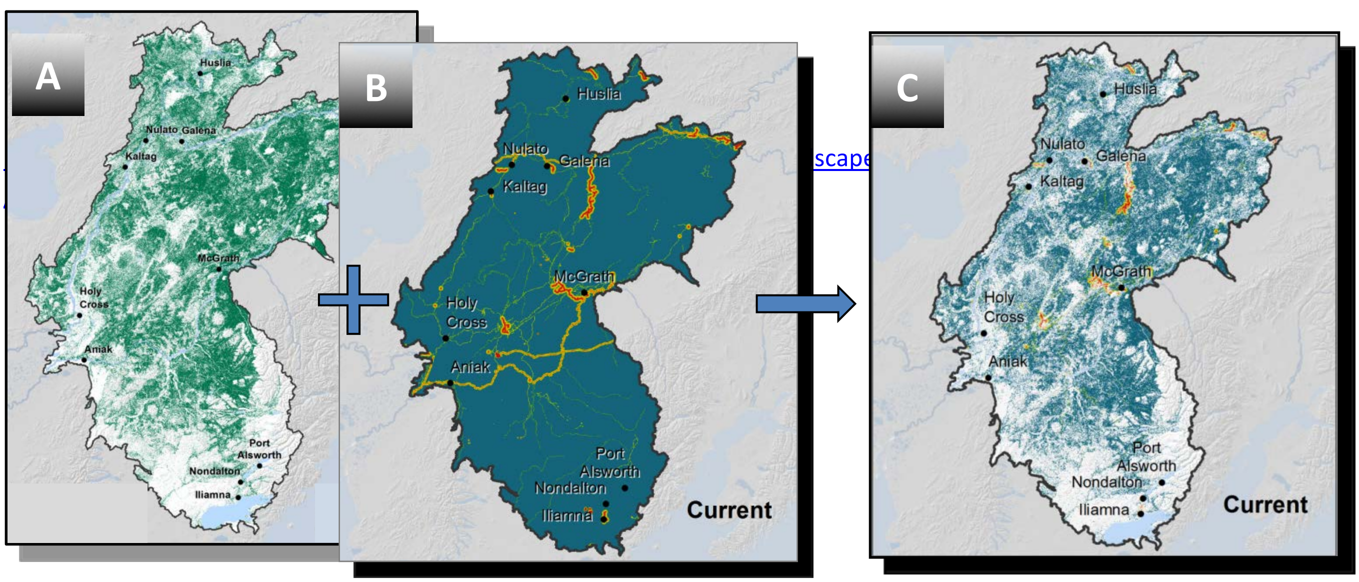

Figure A-5. Example process of assessing status of a CE. Distribution of a CE (spruce forest) (A) is overlaid with landscape condition (B) to generate the status (C). Green colors indicate high condition and warmer colors indicate lower condition.

Finally, we explore future landscape integrity and potential impacts to CEs through multiple measures of landscape change. First, we model future landscape condition using forecasts of the future human footprint. The future landscape condition was then used to inform future landscape intactness for a first look at future landscape integrity. Additionally, we developed a tool to examine the cumulative impacts of all the CAs to begin identifying vulnerable landscapes. Again, when compared to CE distributions, our assessment can provide a first look at potential future ecological integrity.

5. Scope, Intent, and Limitations

With all landscape-level assessments, it is important to define the scope and intent of a study. REAs are designed to synthesize existing information to be used as a regional planning tool. Regional planning tools are developed to support decision-making at a broad spatial scale. Thus, results from this work are not intended to be used to make site-specific management recommendations. However, this work can help place site-level decisions into a regional context.

Another consideration is that while this report synthesizes the best available scientific knowledge about the ecoregion, many of the results presented are derived from incomplete information. Furthermore, no new data collection was permitted by the REA process, and data availability is quite low in this region. Therefore information from outside of the REA was often used to develop and parameterize our models. Additionally, since theoretical and predictive models are simplified representations of complex ecological relationships, models do not incorporate all elements and relationships that are in fact operating on the landscape. The assumptions and limitations inherent in any modeling are important to understand, as these assumptions define the context in which the results are meaningful. We highlight the limitations and assumptions throughout this document in order to help the reader best understand the utility of these models. It is important to remember that model uncertainty can come from many different sources, including the raw data itself, and that interpretation should account for the regional-scale nature of this assessment.

Another key source of uncertainty is the inherent uncertainty in predicting future conditions. Specifically, human behavior and land use is very hard to predict, especially in the long-term. Thus, any future land use should only be considered as potential land uses. A more robust model of future land use would require an examination of multiple scenarios to bracket the uncertainty associated with future human behavior. This assessment is designed to provide a model of possible future conditions, but should not be considered a prediction, nor do we assign any probability or likelihood that any given land use would happen in the future. This is especially important to consider when interpreting the impacts of any given land use (like a potential road) on the condition of the landscape.

Finally, it is important to note that information contained in this assessment is not meant to serve as management guidelines, or be interpreted as recommendations on specific policies. This assessment is intended to summarize the current state of these ecoregions, and identify ways in which the landscape, and the dependent species and habitats, might change in the future. We make no predictions about where specific species or habitats will be in the future, nor do we assign any probability to any of our future models. Maps and outputs derived from predictive models should be considered representations of general patterns. We present here a synthesis of the current state of knowledge about how these ecoregions might change in the future so that land managers and other regional stakeholders can better plan for a changing environment.

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