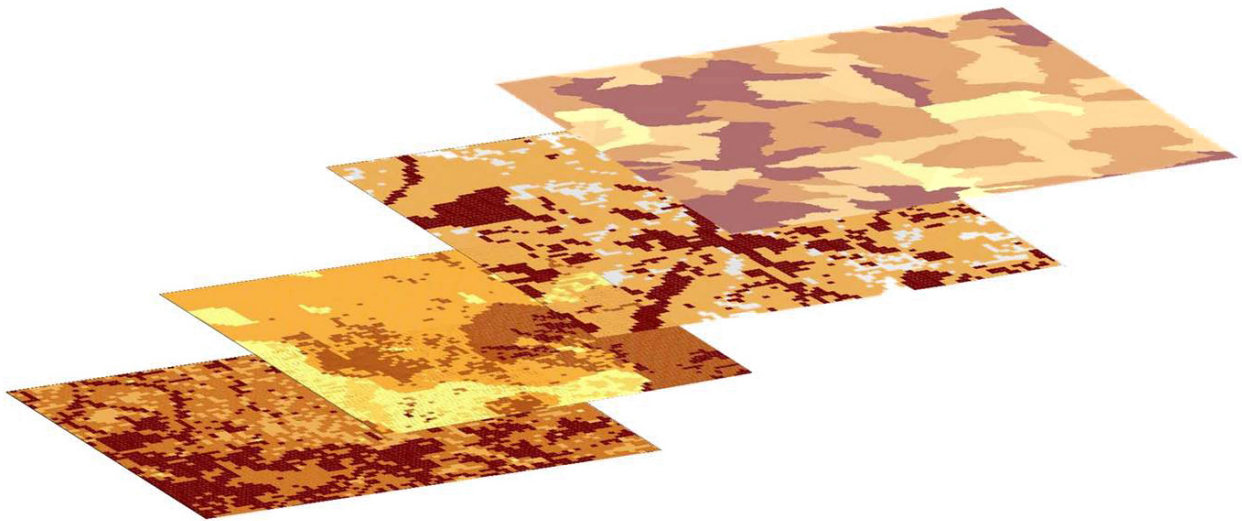


F. Landscape and Ecological Integrity

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Summary

Section F. *Landscape and Ecological Integrity* provides the detailed descriptions, methods, datasets, results, and limitations for the assessments of Landscape Condition, Landscape Intactness, and Cumulative Impacts of Change Agents.

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1. Introduction

There is little debate that humans have dramatically impacted the landscape, particularly in the last 200 years. How we measure the impact, however, has been widely debated and discussed (Baldwin et al. 2009, Steinitz 1990, Anderson 1991, Danz et al. 2007, Girvetz et al. 2008, Alberti 2010). Many attempts at mapping and quantifying the “human footprint” exist (Forman and Alexander 1998, Trombulak and Frissell 2000, Theobald 2001, Sanderson et al. 2002, Theobald 2004, Theobald 2005, Theobald 2010). Additionally, it is largely recognized that merely the presence or absence of humans does not mean that the ecosystem is or is not operating in its peak condition. The presence or absence of human modification is only one of three criteria thought to define ecological integrity (Noss 2004). *Ecological resistance* (the ability to resist changes and stay intact regardless of the modification) and *resilience* (the ability to recover quickly, and without loss of function, following a disturbance) are equally important in quantifying the integrity of an ecosystem. Unfortunately, appropriate measures of resistance and resilience are difficult to identify, and often require intensive surveying and research effort. Human footprint on the other hand, is easily measurable. Further, the human footprint is the one factor that land managers have the most control over.

The BLM originally proposed an ecological integrity assessment as one of the integrated datasets created for the Rapid Ecoregional Assessments (REAs). However, due to the reasons stated above, most REAs have assessed what they call *ecological intactness*. After multiple discussions with the AMT and representatives at the BLM National Operations Center (NOC), we were approved to assess *Landscape Integrity* (LI) instead of ecological intactness or ecological integrity. Given that Alaskan landscapes are largely intact, landscape integrity better captures the impacts of human modification on the landscape without assuming that ecological integrity is compromised.

We define Landscape Integrity to include three different descriptions of the landscape: landscape condition, landscape intactness, and potential cumulative impacts (Figure F-1). It should also be noted that landscape condition is used in other sections to provide a measure of status for each CE. More information and interpretation of CE status can be found in Section H. Details and methods for each of these are described in more detail below.

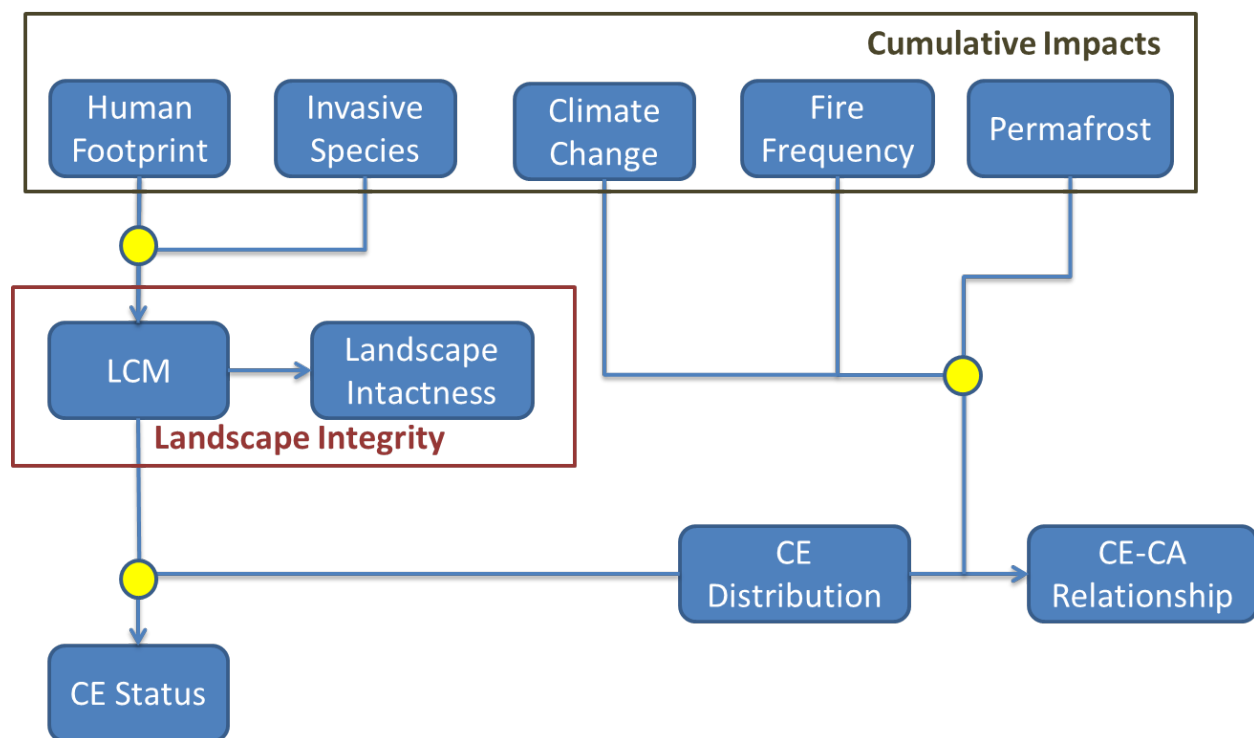


Figure F-1. Process model describing the various integrated products developed in this REA to explore the integrity of this region.

2. Landscape Condition

The Landscape Condition Model (LCM) is a simple yet robust way to measure the impact of the human footprint on a landscape (Comer and Hak 2009). The LCM weights the relative influence of different types of human footprints based on factors such as permanence and the nature of the activity. Permanent human modification is weighted the highest, while temporary use, like snow roads and snowmachine trails, receives less weight. Intensive land uses like mining is also weighted higher than less intensive land uses like hunting or trapping cabins. These weights are summed across the landscape and coalesced into a single surface identifying how impacted a given area is due to human modification. The LCM was specifically requested by AMT members for this REA to compliment the LCM developed for the Seward Peninsula and Yukon Kuskokwim REAs. The LCM, unlike the other models in this section, is provided at both its native resolution (60 m) and as a 5th-level HUC summary.

2.1. Methods

Human Land Use Data

The LCM was originally developed to understand landscape condition across the contiguous United States, and therefore includes many datasets that either do not exist in Alaska or are not common modifications to Alaska landscapes (see Comer and Hak 2012 for a complete table of required datasets for LCM). Thus, we modified the data inputs to fit data availability and utility. Additionally, there are some forms of transportation that are unique to Alaska (at least in scale; e.g., using frozen rivers as snow machine trails) and therefore needed to be included in the LCM. Table F-1 is a list of the datasets used for the LCM, while Table F-2 details how the specific datasets were modeled in the LCM. In addition to the source datasets listed below, current human development footprints were also developed for the region (see Section E).

Table F-1. Source datasets for analysis of Landscape Condition.

Dataset Name	Data source
Transportation routes; including local roads, industrial roads, and the Dalton highway.	AK Department of Transportation
Industrial lines; including power lines, phone lines and transmission lines	AK Department of Natural Resources
Oil and gas wells	Audubon Alaska
Current mines (Red Dog mine)	USGS-AK Resource Data File
Introduced plant species	AKEPIC

Model Parameters

There are two key parameters in the LCM that determine how a defined human modification of the landscape impacts the condition of that landscape. The first is the site impact score that indicates how

intense a human modification is to the landscape. The impacts are normalized to be on a score of 0 (for biggest impact, or lowest condition score) to 1 (least impact, or highest condition score). The second is the decay distance that indicates the distance at which the impact to the landscape is no longer experienced. Both of these parameters are defined in the original LCM through an exhaustive literature and expert review. The limitation is that these impacts are generically implemented across the contiguous U.S. and Alaska through previous REAs, and therefore do not include the potentially unique impact that land uses have on systems in Alaska. However, when available, we updated both the site impact score and decay distance values based on literature of impacts to systems in Alaska. Specifically, the decay distance associated with major roads is thought to be much larger due to the extensive use of ATVs and snowmachines by Alaskans (Strittholt et al. 2006). We extend this increase to some of the other road types as well as the urban land uses, as snowmachine and ATV use is not excluded to major roads.

Table F-2. List of datasets and parameters assigned to different human land uses for use in the Landscape Condition Model.

Theme	Data Source	Description	Site Impact Score	Est. Relative Stress	Decay Distance (m)
<i>Transportation</i>					
Alternative Transportation Routes	Digitized using aerial imagery (BDL-GINA)	Lower Coleville River	0.7	Low	500
Local Roads	AK DOT, refined using aerial imagery (BDL-GINA)	Local roads within villages	0.2	High	500
Haul Road	AK DOT	Dalton Highway	0.05	Very High	5000
<i>Urban and Industrial Development</i>					
High Density Development	Digitized using aerial imagery (BDL-GINA)	Oil facilities	0.05	High	2000
Medium Density Development	Digitized using aerial imagery (BDL-GINA)	Village footprints	0.5	Medium	1000
Medium Density Development	North Slope Borough	Hunting/fishing camps	0.5	Medium	1000
Powerline/Transmission lines	AK DNR	Current industrial lines	0.5	Medium	500
Oil /gas Wells	Audubon Alaska	Current, non-exploratory oil and gas wells	0.5	Medium	500
Current Mines	USGS-ARDF	Red Dog mine	0.05	Very High	1500

Theme	Data Source	Description	Site Impact Score	Est. Relative Stress	Decay Distance (m)
<i>Managed and Modified Land Cover</i>					
Introduced Plant Species	AKEPIC	Same dataset used in Invasive Species CA analysis	0.5	Medium	200

Surface Creation

Once site impact scores and decay distances are defined, a series of GIS-based models generate multiple layers of landscape condition. To create a continuous surface representing the combined landscape condition, we mosaicked the various raster datasets using the “minimum” function. This allowed multiple land uses to be considered for any given cell, but assigned the lowest condition score (highest impact) to the cell. This created a continuous surface of human modification for the region. To aid in our core analysis, the LCM was then summarized at 5th-level HUCs and bracketed into equal interval quantiles (for ease in interpretation) representing categories of condition. Condition classes are defined in Table F-3.

Table F-3. Classification of Landscape Condition Model.

LCM Score	Condition Class
0.0 – 0.2	Very Low
0.2 – 0.4	Low
0.4 – 0.6	Moderate
0.6 – 0.8	High
0.8 – 1.0	Very High

Future Landscape Condition

Different from other REAs in Alaska, we worked closely with the North Slope Science Initiative Scenarios project to incorporate future human footprint estimates from their scenario exercises (see Section E). Instead of near and long-term futures, we use the interim “Medium” and “High” development oil and gas scenarios generated as part of that effort. The NSSI scenarios project is currently ongoing and the development scenarios provided should be considered interim products that may be change. It is also important to note that the NSSI scenarios show different plausible futures through the year 2040, which is different than our near and long-term time steps of 2025 and 2060, respectively. Due to the scope of the NSSI scenarios project that focused on energy development and supporting activities on the North Slope, and the anticipated lack of population change in the villages, our future human footprint is largely driven by changes in oil and gas infrastructure. Future oil and gas infrastructure associated with the Medium Scenario develops part of the Greater Mooses Tooth region of NPR-A, and further expands the

development currently at Point Thompson. The Liberty drilling pads are expanded, and there is a new pipeline built connecting offshore activities to the Point Thompson region in the Medium Scenario as well. Additionally, we included the road and relocation of Kivalina in the Medium Scenario. The High Scenario included all the same development of the Medium Scenario, but expanded the Greater Mooses Tooth development to include a pipeline connecting to development on Smith Bay, develops a pipeline and road from the potential Chukchi Sea facilities, and develops a pipeline connecting Umiat to other oil and gas infrastructure. Although offshore activities are included in the NSSI scenarios, we did not include those developments given our terrestrial focus. Additionally, we assumed all current oil infrastructure would continue to operate into the future. Given the uncertainty in future human footprint models, especially in the High Scenario, the results should be considered representative of potential changes to overall landscape condition.

2.2. Results

Current and Future Human Footprint

As expected, the landscape condition for the region is very high, and is expected to remain high. Human modification is highly localized and although the activity is sometimes intense, the overall landscape condition is very high (Figure F-2). Although the range of scores is similar to other applications of the LCM, the majority of the REA has scores that are well above most of the contiguous U.S. Average score in the North Slope is 0.987 for the current landscape. In the Medium Scenario, the average LCM score for the region is unchanged. In the High Scenario, the average landscape condition score for the North Slope study area is anticipated to be 0.986.

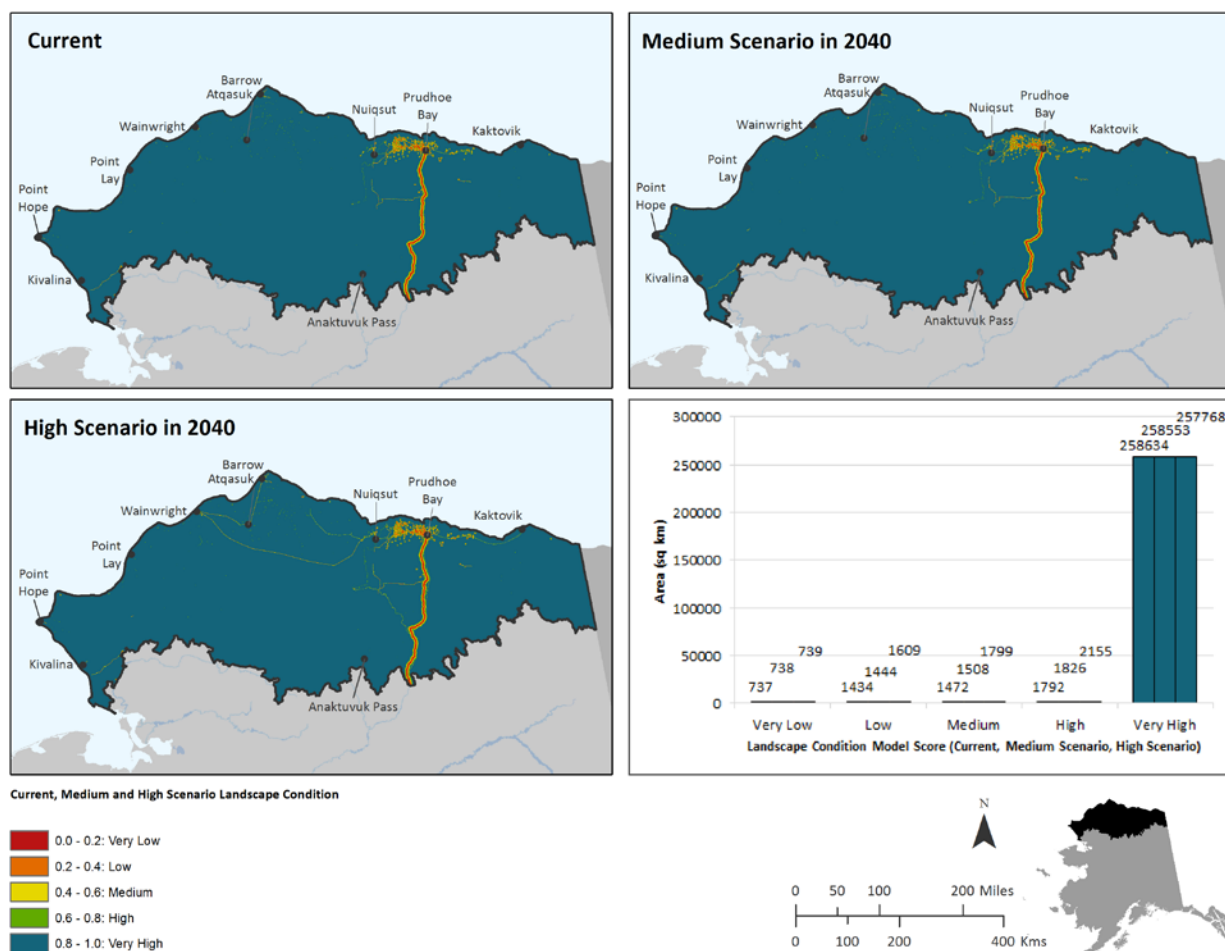


Figure F-2. Current (2015), Medium (2040), and High Scenario (2040) landscape condition.

Summarized LCM

When summarized at the 5th-level HUCs for the region, patterns in the landscape condition become very apparent. Most of the current reduction in landscape condition can be traced back to the Dalton Highway and oil infrastructure around Prudhoe Bay (Figure F-3). Overall, condition scores are still quite high, and the lowest LCM score for any HUC in the North Slope is 0.61 for current and future time periods. Small changes in summarized landscape condition are due to the new pipelines from Wainwright to Greater Mooses Tooth and Umiat to TAPS.

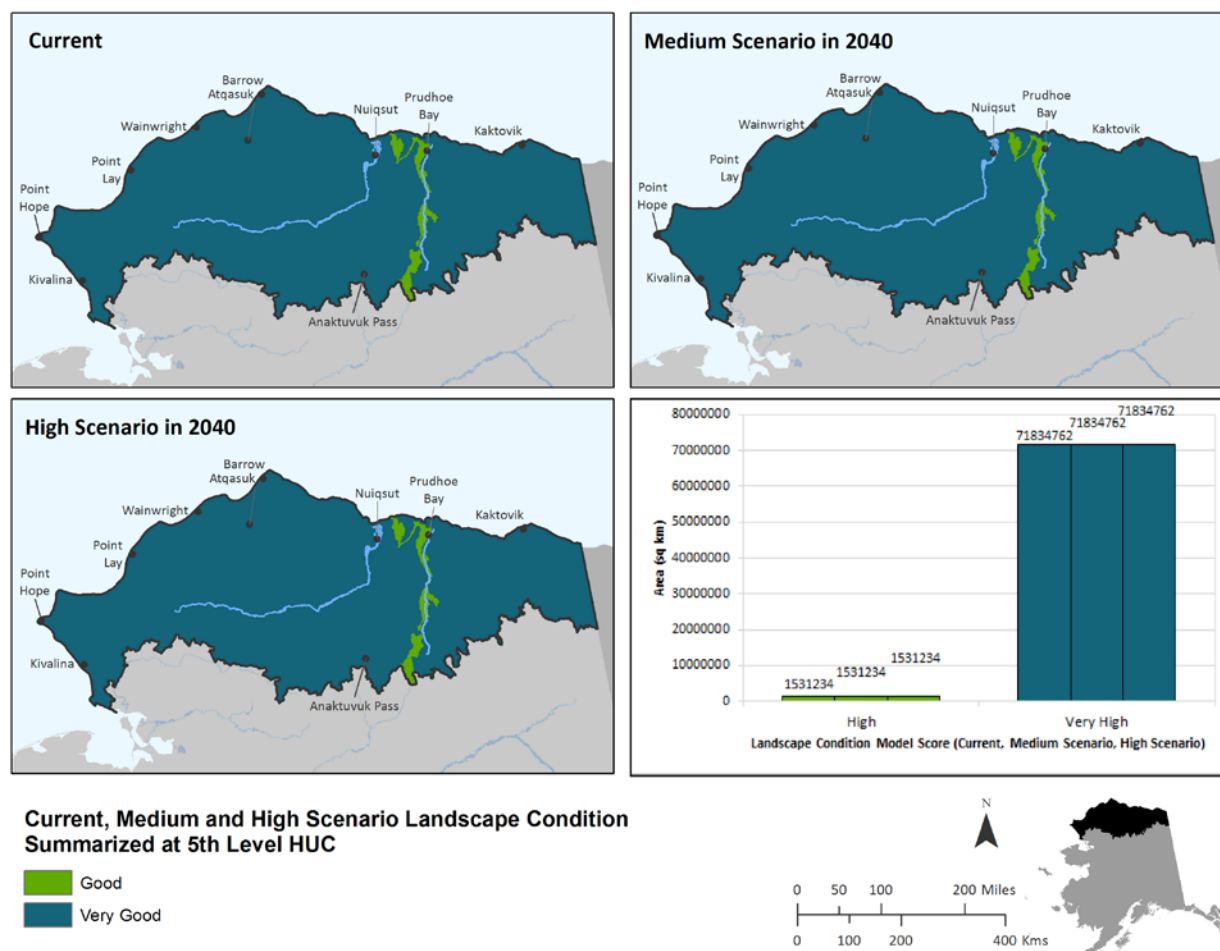


Figure F-3. Current (2015), Medium (2040), and High Scenario (2040) landscape condition at 5th-level HUC resolution.

2.3. Applications

Given the highly pristine condition of the North Slope, management needs in this REA are quite different than those in the contiguous U.S. Instead of monitoring and managing for increasing ecological condition, managers in Alaska have to be aware of how their land use plans impact the current condition. This creates some novel opportunities for monitoring the impacts of various land uses (since the baseline condition can also be considered the reference condition, a luxury that most landscapes in the U.S. do not have). Furthermore, it provides an opportunity to identify ways in which land use plans can still move forward without compromising the overall landscape condition. The LCM provides a robust way to quickly weight the potential impacts of a new project on the overall condition of a landscape, thus providing a useful land use planning tool.

As seen in Table F-4, landscape condition varies by land status classification. Although most of the lands managed by the State of Alaska have very high condition, it is apparent that the State manages the majority of the lower condition lands. BLM also manages a large portion of the lower condition areas;

however, it represents a very small portion of the land they manage. Proportionately, military lands represent the most degraded landscapes on the North Slope, but they also manage very little of the landscape. Overall, landscape condition by land status mirrors the regional patterns.

Table F-4. Current landscape condition relative to land management status (areas in km²).

Land Management Status	Very Low Condition	Low Condition	Moderate Condition	High Condition	Very High Condition
Bureau of Land Management	246	306	284	426	96,108
Fish and Wildlife Service	1	6	11	18	45,796
Military	6	21	13	10	30
National Park Service	0	21	31	46	29,045
Native Patent or IC	5	57	66	152	22,855
Native Selected	-	-	0	1	1,673
Private	-	-	0	-	-
State Patent or TA	516	1,009	1,008	1,026	45,925
State Selected	0	1	1	1	3,006

2.4. Limitations and Data Gaps

Although the LCM utilizes our best available knowledge related to impacts of human land use on a landscape, there are some necessary generalizations made. Not all landscapes respond the same way to specific land uses (i.e. roads likely have a larger impact on wetlands than uplands), and thus the LCM serves as a *relative* measure of impact. Along these lines, little empirical data exist for the impacts of specific land uses on ecosystem components that exist in Alaska. Additionally, the nature of human land use on the North Slope is quite different than in other regions, especially given the extensive network of seasonal transportation routes. We did not include snow and ice roads in the LCM for two important reasons. First, there have been only a couple studies examining the impact of ice roads on environmental resources, and the results show from those select studies have shown little to no detectable impact to the environment (Adam and Hernandez 1977; Brown and Berg 1980; Johnson and Collins 1980). The impact of snow roads on ecosystem resources has yet to be studied. Second, there is no known method for modeling future snow and ice road development. Although we anticipate future snow and ice roads to be built and utilized as oil and gas infrastructure increases, we have no way of forecasting the location for use in the LCM.

Additionally, some attempt has been made to map local community roads, as many are missing from the Alaska Department of Transportation dataset, and could not be extracted from other datasets. Thus, accurately mapped local road data are identified as a data gap. Additionally, we excluded trail data from this analysis do to the poor quality and unreliability of the data. Accurately mapped and attribute trail

information is an important data gap identified in this analysis, and would allow for a more accurate estimate of landscape condition.

Finally, although this data is provided at a 60 m resolution, results and analysis should be interpreted at a broader scale. The LCM, like other datasets from this REA, is best considered in the context of the entire assessment area, or summarized at the 5th-level HUCs.

3. Landscape Intactness

Merely considering the condition without considering the landscape context may misrepresent the actual impact of different human activities on the overall Landscape Integrity. Most importantly, landscape condition should not be assessed at a particular location without some explicit consideration of the surrounding environment (Scott et al. 2004). Landscape intactness provides a quantifiable and readily assessable measure of naturalness. More simply, landscape intactness is a measure of how fragmented an intact landscape might be. Modeling landscape intactness provides a way to assess the relative landscape condition across a region to identify if the areas with degraded conditions are isolated or connected, which could then be used to assess how resilient an area might be to future changes.

3.1. Methods

There is no universal definition of an intact (versus non-intact) landscape. Thus, we chose to define intactness based on the *a priori* assumption that most of the North Slope study area is unmodified by humans. Previous efforts have identified intact landscapes as those with a landscape condition similar to what you find in nearby national parks or wilderness areas (Scott et al. 2004). Given the exceptionally high condition found in national parks within the North Slope, we defined intact landscapes as those with the top quantile condition score. We extracted areas from the LCM with a score of 0.8 or higher as our “intact” landscapes. This calculation is performed on the raw LCM output (60 m cell resolution) so that smaller and localized fragmentation would be captured. Areas that meet the condition criteria were then lumped together and total area of contiguous high condition landscape was calculated.

Large Intact Blocks

The high condition blocks were labeled as large intact blocks (LIBs) and assigned values based on previous studies in Alaska that have defined intact landscapes (Strittholt et al. 2006, Geck 2007). LIBs that are greater than or equal to 50,000 acres are to coincide with the Global Forest Watch program from the World Resources Institute and their Intact Forest Landscapes (Strittholt et al. 2006). We consider these LIBs as having the highest landscape condition and intactness, and thus are labeled as the highest landscape integrity. Blocks that are less than 50,000 acres but greater than or equal to 10,000 acres correspond to previous wilderness area designations studies (Geck 2007), and are considered to have high landscape integrity. Third, we identified all the blocks that are less than 10,000 acres as potentially vulnerable to disturbances.

3.2. Results

Results from the landscape intactness models largely mirror the results from the LCM. However, a substantial amount of small, fragmented areas were indeed identified throughout the region (Table F-5). Most of these fragmented habitats are located around communities and oil and gas developments.

Table F-5. Current and future landscape integrity categories for the North Slope study area.

Designation	Size Threshold	Current (km ²)	Medium Scenario (km ²)	High Scenario (km ²)
Highest Landscape Integrity	≥ 50,000 acres	258,321	258,220	257,258
High Landscape Integrity	< 50,000 acres, ≥ 10,000 acres	69	69	225
Vulnerable to change	< 10,000 acres	92	112	138

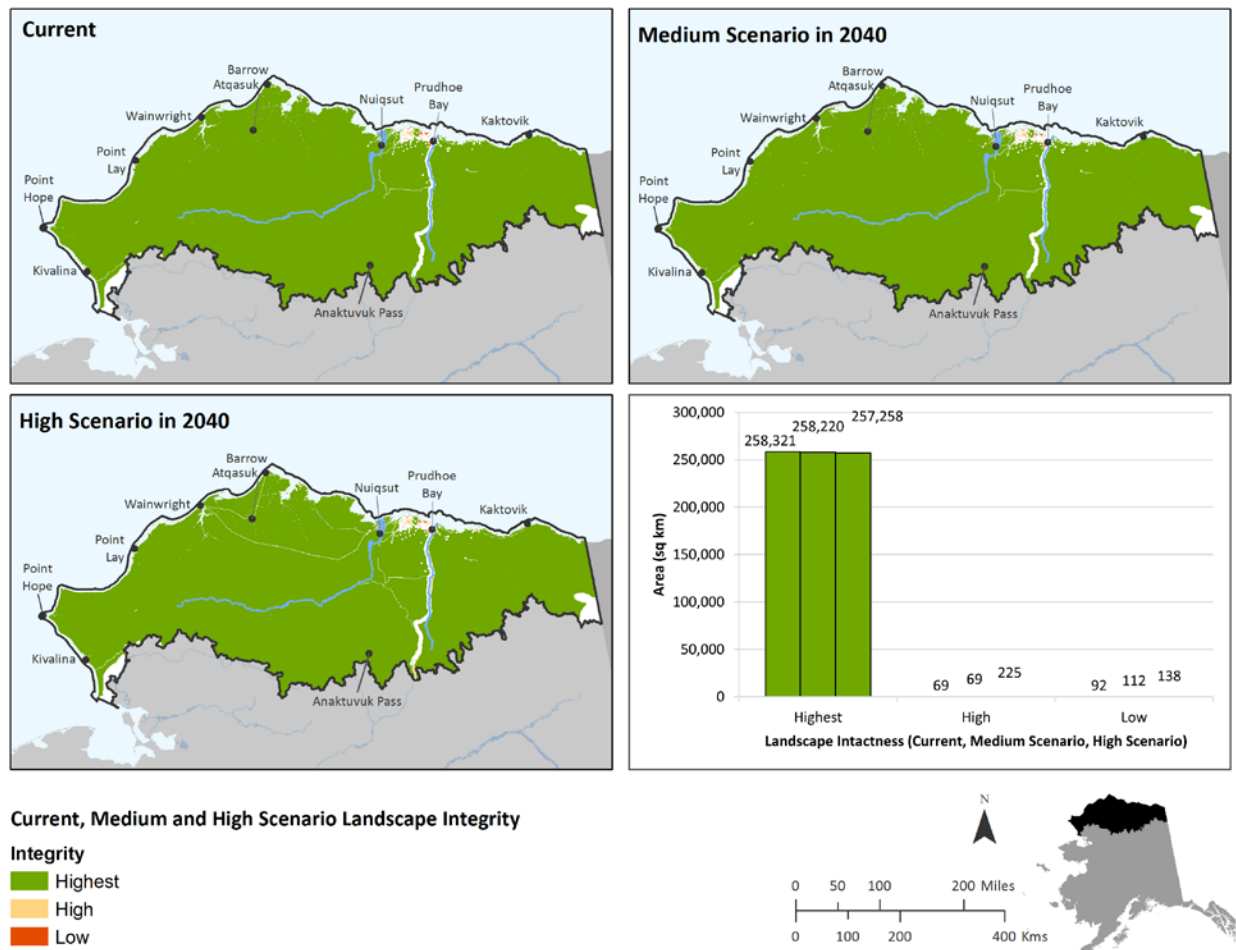


Figure F-4. Current (2015), Medium (2040) and High Scenario (2040) landscape intactness for the North Slope study area.

3.3. Applications

Landscape integrity mirrors the landscape condition for this region, but also highlights the potential to fragment even the largest regional resources. Most areas in the North Slope have both high condition

and high intactness, leading us to conclude that the landscape integrity is currently quite high. However, our future forecasts do identify the potential for increased fragmentation and degraded integrity. There is a steady decrease in the highest integrity class, and a 50% increase in the low landscape integrity category over time. Thus, while the overall landscape integrity is still quite high, in smaller more localized areas, there is certainly potential for increased fragmentation of potentially important regional resources. At minimum, the increase in low integrity areas can be used to help identify new monitoring locations in order to understand the role of fragmentation in the larger landscape, especially given the potential for other stressors to act upon those regions.

3.4. Limitations and Data Gaps

While considered a robust way to measure naturalness, there are some key assumptions made in the conceptualization of landscape intactness. Landscape intactness assumes that systems that are not physically impacted by humans are indeed intact. While there are philosophical reasons to question this, there is also increasing evidence that the multitude of indirect impacts humans can have on an environment is substantially higher than previously thought. Impacts from climate change that have already occurred, as well as impacts from global systems (atmospheric nitrogen deposition, particulate matter deposition, etc.) all could be modifying systems in ways that are not captured by the human footprint. Additionally, while obvious at a local scale, human footprints are not always well mapped or captured in a geospatial framework. This is especially true for historical human use (i.e., aboriginal use, or even modern historical use prior to the establishment of environmental monitoring programs). Thus, our landscape intactness model assumes that 1) the current and historical human footprint is accurately modeled for the region and 2) areas not impacted by the human footprint are indeed intact. This is especially relevant as one of the key outputs from an REA is a better understanding of the indirect impacts of human activity on ecosystems.

4. Cumulative Impacts

To provide a more comprehensive measure of potential impacts to the ecoregions, we summarize all the potential impacts to CEs (generalized to the 5th-level HUC) under what we call the Cumulative Impacts (CI) assessment. The measurement of cumulative impacts has become increasingly emphasized both in the academic literature (Walker 1987, Theobald et al. 1997, Nellemann and Cameron 1998, Belisle and St. Clair 2001) as well as regulatory requirements (NEPA, WGA, etc). Essentially, the CI presents a rolled-up dataset of all potential threats to the landscape to identify the locations within the REA that are likely to experience the most amount of change. This does not assess the likely collinearity of the change agents, but rather considers each change agent as a separate stressor that will differentially impact CEs and other resources in the study area. The inverse of this dataset could be seen as a landscape vulnerability index (LVI) that could be used to assist in future resource planning efforts.

4.1. Methods

The CI analysis included what we consider the primary CAs that are likely to have the largest and most direct impact on the overall ecoregion (Figure F-4). However, in order to “sum” the impacts we had to define meaningful changes in the CAs. Given that the CI analysis is not targeted on any one CE, we defined a “change” in the CA based on model variability (see Section C) and the potential to impact management decisions:

- Mean January Temperature
 - Variation in January temperature was substantially higher between the models, so the threshold for meaningful change was set at 2.4°C.
- Mean July Temperature
 - Variation in July temperature was much lower between models, so meaningful July temperature change was estimated at > 0.9° C.
- Annual Precipitation
 - Variation in precipitation estimates between the models was relatively minor as well, so meaningful change in precipitation set at > 10mm change in annual precipitation.
- Change in Permafrost
 - Change in permafrost was calculated based on the change in mean annual ground temperature (see Section C). Specifically, 5th-level HUCs where more than 10 cells (20 km²) were forecasted to increase above -1°C (i.e., the change from continuous to discontinuous permafrost) were identified as regions of permafrost change.
- Change in Active Layer
 - Change in the thickness of active layer was calculated based on the mean active layer thickness dataset (see Section C). Specifically, 5th-level HUCs where the active layer was expected to increase by 10cm or more were identified as regions of active layer change.
- Change in Relative Flammability

- The ALFRESCO model indicates that relative flammability will be higher in the Brooks Range, so any region with greater than 0 relative flammability was identified as significant change.
- Landscape Condition
 - Any changes in landscape condition at the 5th-level HUC were considered a significant change. For the CI model, the Medium Scenario was used in the near-term, while the High Scenario was used to forecast development in the long-term.
- Invasive Species Vulnerability
 - Any changes in invasive species vulnerability at the 5th-level HUC were considered a significant change.

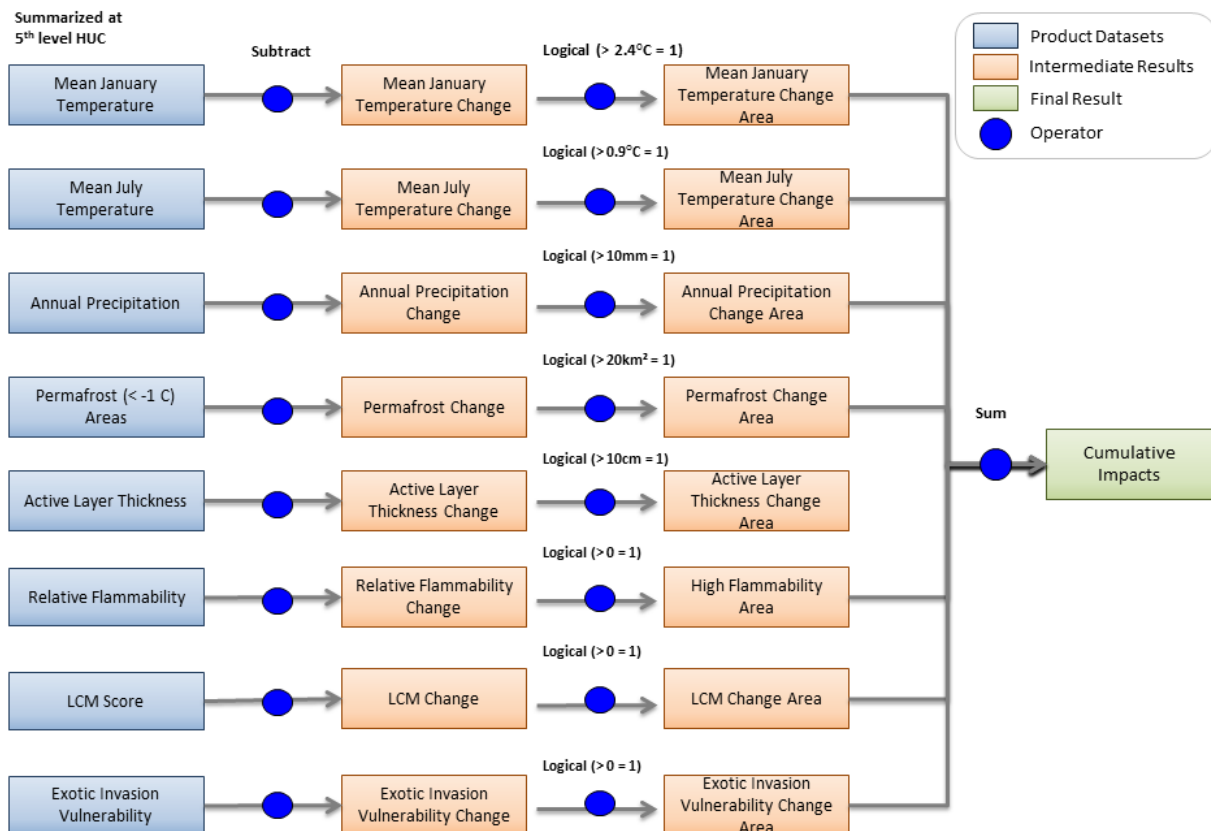


Figure F-5. Process model for Cumulative Impacts (CI) assessment in the North Slope REA. Each product dataset was first summarized at the 5th-level HUC for the current, near-term and long-term to calculate areas of change.

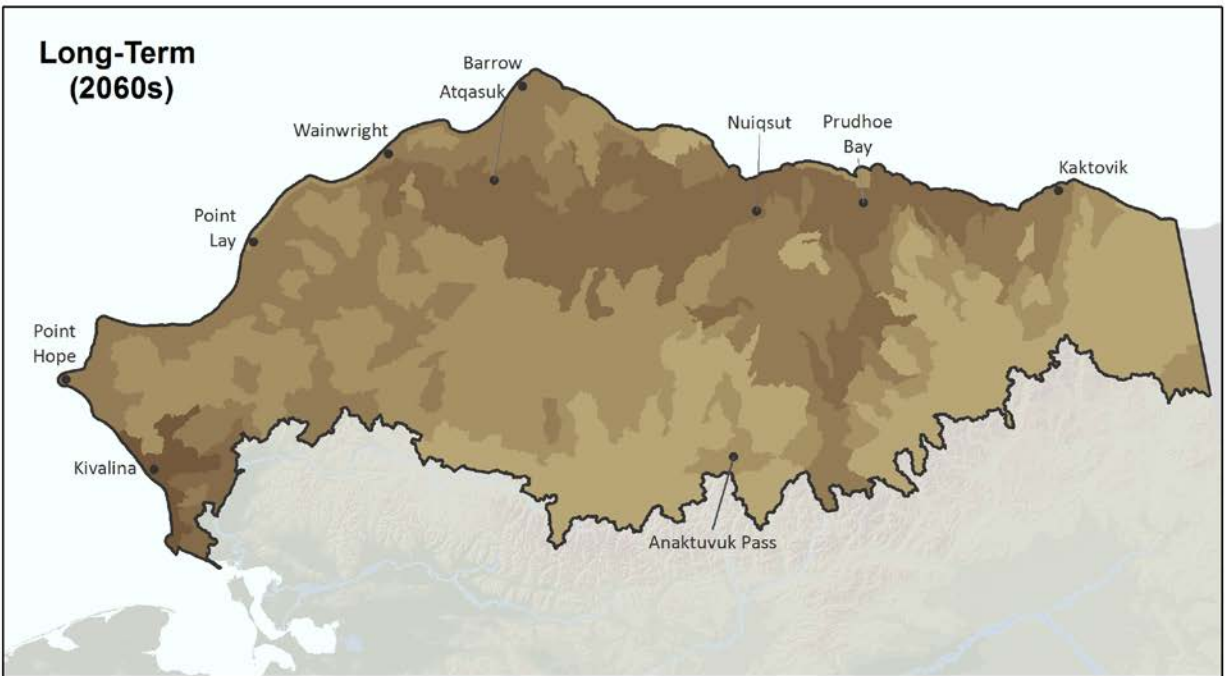
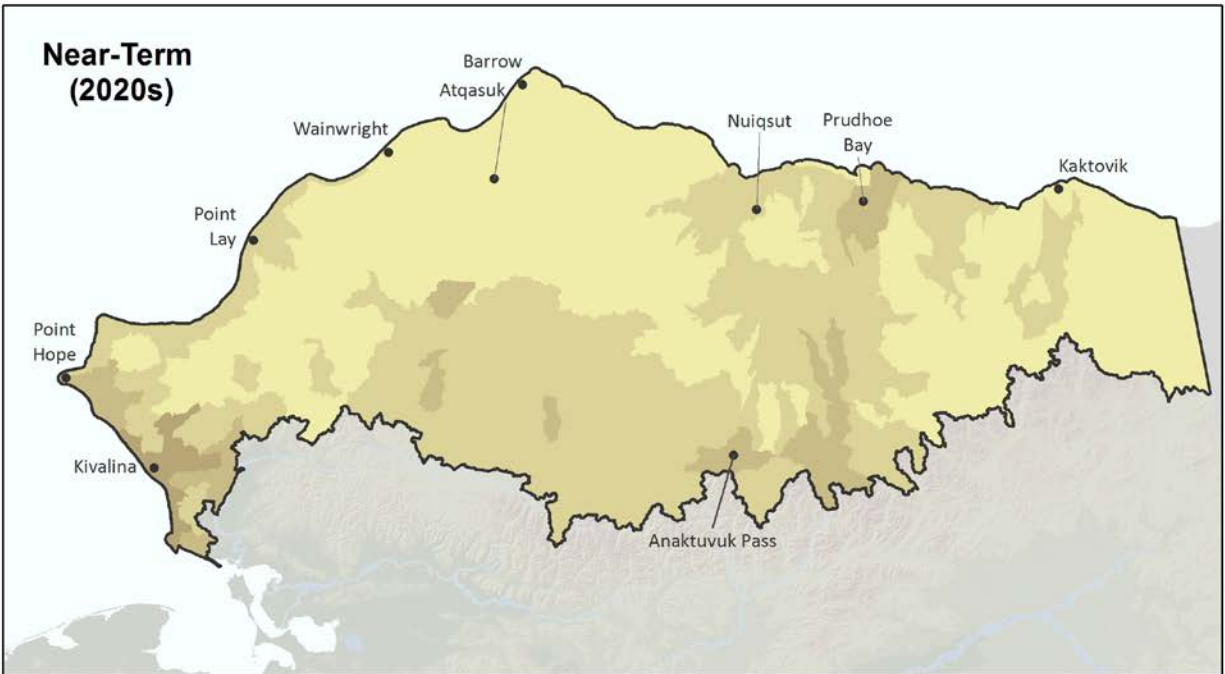
4.2. Results

When taken together, the CI of the various CAs identify some key areas where change to the landscape is likely to be the greatest. In the near-term there are only a few watersheds where three to four CAs are likely to cumulatively impact the environment, and they are located near Kivalina (associated with the relocation effort) and watersheds in the mountain to foothill transition (Figure F-5). The majority of the study area is expected to see no or very limited change in the near-term (Table F-6). However, in the

long-term, far more impacts are expected (Figure F-6). Most of the long-term change is expected to occur in the coastal plains and in the southwest portion of the study area. Relocation of Kivalina combines with anticipated changes in permafrost, active depth layer, relative flammability, and other CAs. Equally important is the observation that no region is forecasted to have less than three CAs change in the long-term, suggesting that the entirety of the North Slope is expected to experience some landscape-level stressors.

Table F-6. Cumulative Impact scores (summarized at watersheds) within the North Slope study area.

CI Score	Near-Term Area (km ²)	Near-Term (%)	Long-Term Area (km ²)	Long-Term (%)
0	133,284	50%	-	0%
1	109,850	42%	-	0%
2	17,508	7%	-	0%
3	3,455	1%	65,090	25%
4	-	0%	81,496	31%
5	-	0%	68,232	26%
6	-	0%	45,824	17%
7	-	0%	3,455	1%
8		0%	0	0%



Cumulative Impacts in the Near-Term and Long-Term Future

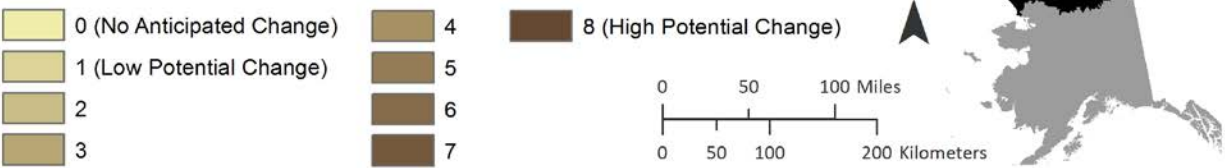


Figure F-6. Cumulative impact assessment for the North Slope study area summarized at the 5th-level HUC (moderate-sized watershed).

4.3. Applications

As mentioned above, the CI analysis is a broad-scale assessment of the potential overlap of key change agent thresholds. This is meant to merely highlight the areas of the REA that are likely to change the most. The CI analysis can be seen as landscape vulnerability index to help guide monitoring efforts. Watersheds with the highest CI score are prime candidates for monitoring efforts, especially efforts that target overall ecological function and health.

As shown in Table F-7, all land management agencies in the North Slope study area will likely have to address the cumulative impact of the CAs in the future. The Bureau of Land Management, being the largest land manager in the region, is likely to be faced with the largest amount of land that is vulnerable to multiple CAs, followed by the State of Alaska, the U.S. Fish and Wildlife Service, and Native lands. Of particular note is that proportionately, Native lands are likely to see 4 or 5 CAs influencing over 80% of their lands (Table F-7).

Table F-7. Areas (in km²) of the region expected to undergo cumulative impacts, organized by land management agency. A score of 3 means only three change agent are anticipated to change significantly by 2060. Therefore, areas with a lower score can be interpreted as having less landscape stressors than other areas with higher scores. Note: because the assessment boundary includes a buffer out to the barrier islands, the total area here is less than the total study area.

Land Management Status	CI = 3	CI = 4	CI = 5	CI = 6	CI = 7
Bureau of Land Management	1,112	44,655	23,852	27,051	695
Fish and Wildlife Service	30,476	8,376	6,216	766	< 1
Military	-	-	66	14	< 1
National Park Service	18,139	5,378	3,843	1,477	327
Native Patent or IC	4,663	7,727	7,767	2,556	419
Native Selected	16	676	828	75	79
Private	-	-	< 1	-	-
State Patent or TA	9,278	9,932	18,859	10,730	695
State Selected	706	1,422	691	29	161

4.4. Limitations and Data Gaps

The collinearity between the different change agents means that this analysis could overestimate impacts to the landscape (i.e. active layer thickness is certainly correlated to mean July temperature, but are included as two distinct stressors in this analysis). However, impacts to any given CE from changes in mean July temperature is certainly different than impacts to the same CE than changes in active layer thickness. Thus, while the two are correlated, the impact to regional resources can in fact be different. Additionally, some CAs are spatially restricted (i.e. fire is only on the south side of the Brooks Range) and is therefore not correlated with climatic variables across the entire region. Therefore, although the CI

ignores the collinearity between CAs, it does provide a cumulative assessment of potential landscape stressors that would require different resource management strategies.

Additionally, while some of the thresholds for meaningful change are derived from a statistical analysis, similar robust estimates of actual change were not available for all CAs. For example, the impact of fire on the North Slope assumes that any area with high flammability is likely to generate a management response. Thus, this analysis should be used primarily as a landscape planning tool, and not an impact model that would guide specific management actions.

Finally, given the cross-disciplinary nature of the REA analyses, there exists a high potential for error. Modeled outputs are placed into other models, each with different assumptions, potentially propagating errors throughout. However, using GIS as a common platform assists in identifying errors early in the modeling process, and (by creating intermediate data products) provides a transparent process in which critical review of our assumptions can be made. Thus, while many of these models were never designed to interact, we feel confident that all our modeling efforts represent the best available knowledge about the system and potential impacts.

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