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Open File Report #132

Quantitative Aquatic Condition Benchmarks to Evaluate Management Objectives in Wadeable Streams in the Glennallen Field Office

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Cover photo:

The late Dan Larson collecting lotic AIM data in Revine Creek in Alaska.

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Quantitative Aquatic Condition Benchmarks to Evaluate Management Objectives in Wadeable Streams in the Glennallen Field Office

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Abstract

The Bureau of Land Management (BLM) Glennallen Field Office manages approximately 4.3 million acres of public lands located in south-central and southeast Alaska, including 8,710 miles of stream habitat. This report summarizes results from lotic habitat assessments completed on public lands within the East Alaska RMP area. Assessments were completed using the Assessment, Inventory, and Monitoring (AIM) field protocol for wadeable lotic systems. The primary goals of this research were to: (1) develop quantifiable benchmarks to assess stream condition and trend; and (2) establish quantitative baseline conditions for the chemical, physical, and biological attributes of BLM-managed wadable streams and rivers. To establish quantitative, baseline conditions, a subset of stream reaches was selected using a randomized spatially balanced probability-based survey design. To determine if the randomly selected reaches represented minimally disturbed conditions, each reach was evaluated for anthropogenic (human-caused) impacts upstream. Using the lotic AIM protocol, data were collected from 46 stream reaches during July and August in 2016, 2017, and 2019. This report highlights data for the lotic AIM indicators bank overhead cover, floodplain connectivity, bank stability, and riparian vegetation cover and complexity. Quantitative condition benchmarks are presented using the range of minimally disturbed condition indicator values. These baseline conditions will be compared to lotic AIM sampling data in the future to determine changes in lotic condition and trend over time.

1. Introduction

The Bureau of Land Management (BLM) manages approximately 245 million acres of public lands (BLM 2023) that sustain a variety and abundance of resources. Riparian-wetland areas, though they comprise less than 9 percent (BLM 2015) of the total land base, are the most productive and important habitat on BLM-managed lands. In Alaska, the BLM manages approximately 69.2 million acres, or approximately 18.5%, of Alaska's land area (373 million acres), more than 178,000 miles of perennial streams and rivers, and nearly 2.5 million acres of lakes (which includes lotic and riparian habitat).

The Glennallen Field Office manages approximately 4.3 million acres of public lands located in south-central and southeast Alaska, along with 8,710 miles of streams, 75,120 acres of lakes, and 235,017 acres of wetlands (BLM 2024a). Most extractive land uses on BLM lands managed by the Glennallen Field Office are near aquatic habitats, with 32 miles of streams located within active mining claims. The extent of historically mined stream miles is currently unknown. An additional 870 miles of stream habitats are near roads, off-highway vehicle (OHV) trails, and rights-of-way. High-priority stream habitats include those within federally designated wild and scenic rivers (839 miles) or that have been identified as providing habitat for regionally important fisheries or anadromous fish (480 miles). These 2,189 (870 + 839 + 480) miles comprise roughly 25% of the stream habitats within the Glennallen Field Office.

The "East Alaska Resource Management Plan Amendment, Delta River Special Recreation Management Area: Decision Record and Approved Plan" (East Alaska RMP, 3.9 million acres) (BLM 2013) and "Ring of Fire Record of Decision and Approved Management Plan" (Ring of Fire RMP, 445,000 acres) (BLM 2008) guide the Glennallen Field Office in managing these lands. This report summarizes results from lotic habitat assessments completed on BLM-managed lands within the East Alaska RMP area.

The aquatic resources in the East Alaska RMP area are diverse and include habitat for anadromous and resident fish species, as well as two wild and scenic rivers—the Gulkana and the Delta Rivers. The outstandingly remarkable values of the Gulkana's wild segment include fish and wildlife, recreational, and scenic, and the Delta's are fish and wildlife, cultural, recreational, and scenic. Outstandingly remarkable values are values among those listed in section 1(b) of the Wild and Scenic Rivers Act and make the river worthy of special protection. Accurately and adequately expressing a river's outstandingly remarkable value(s) provides a foundation for planning, management, and monitoring activities within a federally designated wild and scenic river corridor.

The Federal Land Policy and Management Act of 1976 requires the BLM to manage the public lands under the principles of multiple use and sustained yield. This is supported by maintaining a current inventory of the condition and trend of public land resources. This information serves as the foundation for decision-making and planning and is increasingly important due to rising demands on public lands (e.g., mining, rights-of-way, recreation, sport and subsistence hunting) and landscape-level climatic changes. The balance between resource uses and ecological integrity is achieved through direction found in BLM resource management plans (RMPs) and their associated step-down plans. These plans and standards include management decisions for aquatic habitat by program areas within the Glennallen Field Office (BLM 2004, 2006a, 2006b, 2013). In addition, qualitative monitoring goals, objectives, and management actions were developed for each program. These goals and objectives provide overarching guidance regarding the inventory and monitoring of aquatic resources but do not provide any measurable criteria.

RMP effectiveness monitoring is a component of the land use plan evaluation as described in the BLM "Land Use Planning Handbook" (H-1601-1). RMP effectiveness monitoring is the process of (1) tracking the implementation of land use planning decisions (implementation monitoring) and (2) collecting data/information necessary to evaluate the effectiveness of land use planning decisions (effectiveness monitoring) (BLM 2005, 2016).

Similar to RMP effectiveness monitoring, individual permitted activities occurring at local scales require monitoring information to ensure compatibility of the action with the RMP goals and objectives. In the past, RMP monitoring utilized a mixture of qualitative and quantitative data from local-scale monitoring efforts to describe progress toward meeting RMP objectives. While this approach utilized the best available data to draw conclusions, making inferences to landscape condition and trend from these types of data sources is statistically inappropriate given the several biases associated with extrapolating authorization-specific monitoring to large geographic areas.

The effectiveness of BLM RMPs is determined by the status and trend of aquatic resources relative to the objectives identified in the plans. Data to inform the effectiveness of the RMPs is collected using the BLM Assessment, Inventory, and Monitoring (AIM) field protocol for wadeable lotic systems (BLM Technical Reference 1735-2) (BLM 2021). Beginning in Alaska in 2016, the BLM initiated lotic AIM data collection on lands within boundaries managed by the Glennallen Field Office. Through standardized data collection and analysis, this framework integrates both local- and landscape-level aquatic monitoring activities to inform BLM management decisions and planning activities more effectively. It provides an approach for establishing baseline conditions followed by repeat sampling to describe condition and trend over time providing insights into changes in resource status (e.g., natural vs anthropogenic stressors).

The lotic AIM sampling methodology is systematic, transparent, and repeatable for collecting, analyzing, and interpreting stream habitat data. The sample design is a probability-based selection of stream and river reaches from the National Hydrography Dataset (NHD), which represents the water drainage network of the United States. AIM provides standardized methods to characterize the affected environment, analyze alternatives, and develop design features and avoidance or mitigation strategies to reduce conflict during National Environmental Policy Act (NEPA) compliance processes. Data from AIM are also used to assess the effectiveness of RMPs and minimization measures associated with permitted activities.

The primary goals of lotic AIM sampling on the lands managed by the Glennallen Field Office include:

1. Develop quantifiable benchmarks to assess stream condition and trend.
2. Establish quantitative baseline conditions for the chemical, physical, and biological attributes of BLM-managed wadable streams and rivers for future implementation and effectiveness monitoring within the East Alaska RMP area and future land use plans.

Aquatic resources managed by the BLM—riparian and wetland areas, lakes, streams, and aquifers—are among the most important, productive, and diverse resources in the nation, providing sustained value to the American public. They provide habitat for myriad species of plants, fish, and wildlife; provide ecosystem services such as drinking water, pollination, and nutrient cycling; attenuate effects of wildfires, floods, and drought; and are key to the vitality of local economies and communities (BLM 2024c).

Riparian vegetation zones are transitional areas between terrestrial and aquatic ecosystems that provide important habitat and influence many physical and ecological processes, including flood dissipation, nutrient cycling, shade, and cover to reduce thermal loading (Naiman and Decamps 1997). The condition of riparian vegetation directly influences the condition, quality, and maintenance of aquatic habitat. Riparian functions are grouped into four broad categories of habitat, water quality, water quantity, and food supply. Riparian vegetation maintains river health by providing mechanical support to soil through root systems. The complexity, hydraulic resistance, and stability provided by riparian vegetation to streams affects the size, shape, and distribution of the stream channel and habitat features such as pools, riffles, and undercut banks. Riparian plants filter sediments and nutrients, provide shade, stabilize streambanks, provide cover in the form of large and small woody debris, and promote infiltration and recharge of the alluvial aquifer (Orth and White 1993; Wesche 1993).

Riparian habitats also provide leaf litter and detritus to rivers and streams, supporting the primary production that is the basis of the aquatic food web (Cummins 1974). An example of a riparian food supply is the detritus (decomposed vegetative matter) from decaying leaves, twigs, etc., which fall into the stream and provide a key energy source fueling the base of the aquatic food chain. The riparian vegetation also helps maintain the floodplain hydrologic connectivity and water quality and quantity between mainstem stream channels, side channels, tributaries, backwater sloughs, and hyporheic (groundwater) zones.

Water quality functions performed by riparian vegetation include filtering sediment and contaminant delivery from uplands. Deposition of upland fine sediment in pool habitat negatively impacts water depths and structural diversity of the channel. Healthy riparian vegetation also serves to reduce accelerated bank erosion and turbidity, maintaining high water quality required by many aquatic organisms. As a result of these water quality functions, spawning beds for fish and microhabitats for macroinvertebrates remain relatively free of damaging fine sediment deposits.

The ecological processes of floodplains are responsible for much of the diversity, productivity, and health of the streams and rivers. The benefits of floodplains include fish and wildlife habitat protection, natural flood and erosion control, improved water quality maintenance, groundwater recharge, and biological productivity. Floodplain connectivity is the interface between a river and the land adjacent to it. Floodplain connectivity is a driving force for many of the geomorphic and ecologic functions (Wohl 2004; Shields et al. 2010).

2. Methods

2.1 Study Area

The East Alaska RMP area is comprised of several different large ecosystems (ecoregions) primarily defined by climate and topography, with refinements from vegetation patterns, lithology, and surficial deposits (Nowacki et al. 2001). Ecoregions denote areas of similarity in the mosaic of biotic, abiotic, terrestrial, and aquatic ecosystem components. This ecoregion framework is derived from Omernik (1987) and from mapping done in collaboration with U.S. Environmental Protection Agency regional offices, other federal agencies, state resource management agencies, and neighboring North American countries (Omernik and Griffith 2014). The descriptions of these ecoregions (Gallant et al. 1995) are used in this report to describe the environment of the study area.

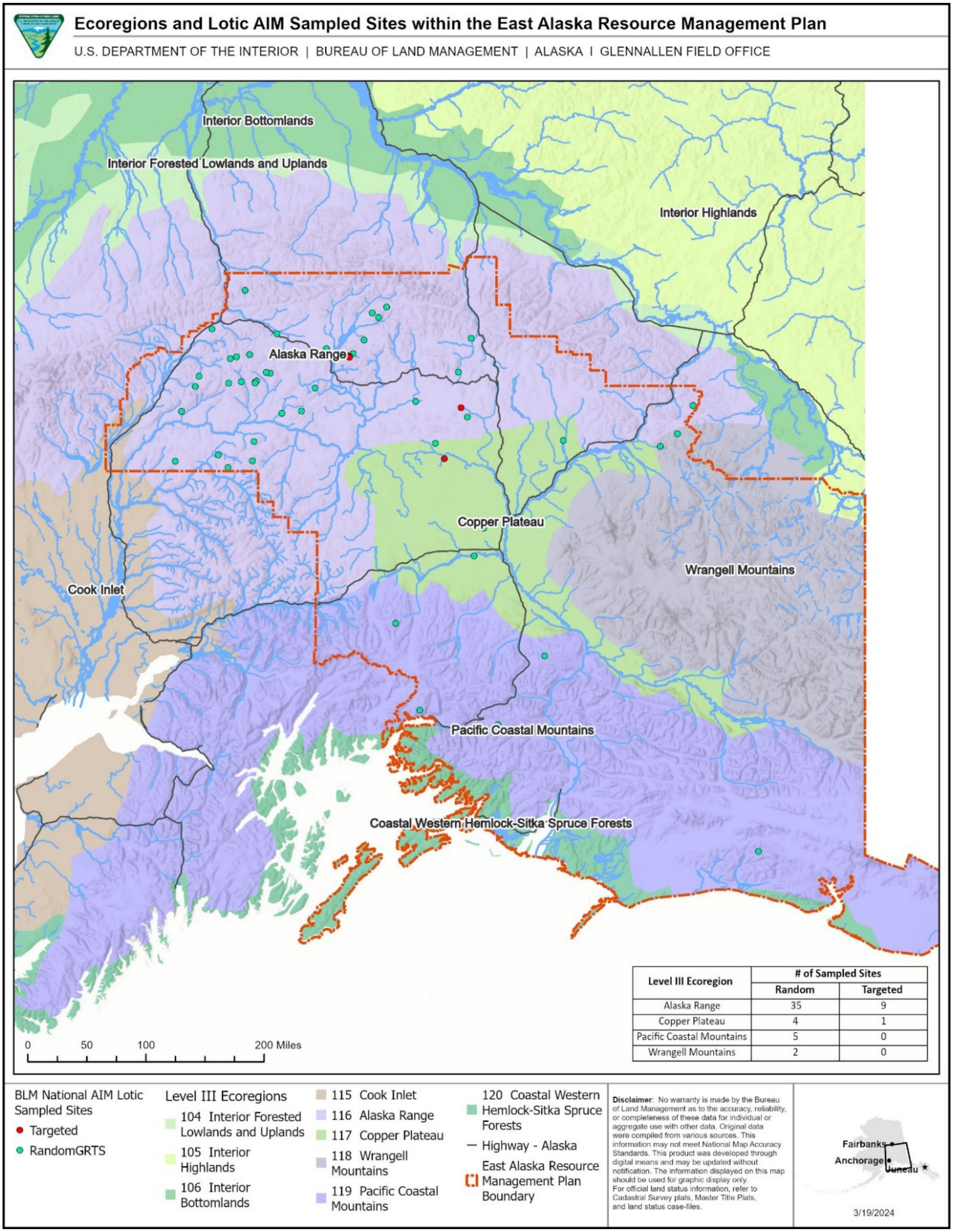
The East Alaska RMP area has diverse landscapes with seven ecoregions overlapping the study area: Alaska Range, Wrangell Mountains, Copper Plateau, Pacific Coastal Mountains, Coastal Western Hemlock-Sitka Spruce Forests, Interior Forested Lowlands and Uplands, and Interior Bottomlands. Sampled lotic AIM reaches randomly fell within four different ecoregions throughout the field office with 35 reaches in the Alaska Range, 5 reaches in the Pacific Coastal Mountains, 4 reaches in the Copper Plateau, and 2 reaches in the Wrangell Mountains (Figure 1).

The Alaska Range ecoregion includes the mountains of south-central Alaska, which are high, steep, and covered with glaciers, rocky slopes, and ice fields. Elevations vary from broad valleys at 600 meters to peaks greater than 3,900 meters. Glaciers, that still remain in some places, have shaped these mountains, so cirques and U-shaped valleys are common features due to extensive glaciation. Streams and rivers, heavy with sediment, run swiftly down mountain ravines and braid across valley bottoms. The Alaska Range permafrost is discontinuous and vegetation is sparse, with dwarf scrub communities. Communities of willow, birch, and alder occupy the more protected lower slopes and valley bottoms. Spruce forests occur in some valleys and lower slopes, with white spruce dominating and black spruce interspersed in areas with poorer drainage. About 7% of the ecoregion is wetlands.

The Pacific Coastal Mountains ecoregion is characterized by steep and rugged mountains along the southeastern and south-central coast of Alaska and receives more precipitation annually than either the Alaska Range or Wrangell Mountains ecoregions. Glaciated during the Pleistocene, most of the ecoregion is still covered by glaciers and ice fields. Most of the area is barren of vegetation, but where plants do occur, dwarf and low scrub communities dominate.

The Copper Plateau ecoregion is characterized by rolling to hilly moraines and nearly level alluvial plains where a glacial lake was. Elevation ranges from 420 to 900 meters. The basin is bounded by the Talkeetna Mountains on the west, the Wrangell Mountains on the east, the Alaska Range on the north, and the Chugach Mountains on the south. The Copper River Basin has shallow, discontinuous permafrost that results in poorly drained soils and numerous wetlands and thaw lakes. Black spruce forests and woodlands dominate the landscape. Wetlands, which occupy about 36% of the ecoregion, also include low scrub bog communities with birch and ericaceous shrubs and wet, graminoid, herbaceous communities dominated by sedges. Well-drained sites have coniferous forests dominated by white spruce or broadleaf forests dominated by black cottonwood and quaking aspen. Stream and river riparain corridors are lined with cottonwood, willow, and alder. Spring floods are common along drainages.

The Wrangell Mountains ecoregion consists of steep, rugged mountains of volcanic origin that are extensively covered by ice fields and glaciers. Most slopes are barren of vegetation. Dwarf scrub tundra communities, consisting of mats of low shrubs, forbs, grasses, and lichens, predominate where vegetation does occur. The climate has harsh winters and short summers.



Level III Ecoregion	# of Sampled Sites	
	Random	Targeted
Alaska Range	35	9
Copper Plateau	4	1
Pacific Coastal Mountains	5	0
Wrangell Mountains	2	0

Figure 1. The management boundary of the East Alaska RMP and EPA level III ecoregions that fall within the boundary. Sampled lotic AIM reaches fall within four of the five ecoregions in the management plan boundary.

Ecoregions provide important context for considering data across wide spatial scales even if sample locations are minimal in some ecoregions. For this research, the sample design was not stratified at the ecoregion level but was implemented at the extent of the East Alaska RMP. The information on ecoregions is provided to aid in describing the enviroment and understanding the complexity of the landscape and riverscape found within the East Alaska RMP area.

2.2 Sampling Methodology

To establish quantitative, baseline conditions for the chemical, physical, and biological attributes of stream habitats managed by the BLM located within the East Alaska RMP, a subset of stream reaches was selected from the target population for sampling using a randomized spatially balanced probability-based survey design. Specifically, the Generalized Random Tessellation Stratified (GRTS) design allocated 50 sampled reaches across the landscape in proportion to the linear extent of stream size categories (Olsen 2005). The stream size categories were based on Strahler stream order categories: small streams are 1st and 2nd order streams; large streams are 3rd and 4th order streams; and rivers are 5th order and greater (Strahler 1952). Four reaches were unable to be sampled due to weather impacting helicopter access, resulting in a total of 46 reaches sampled (Figure 2).

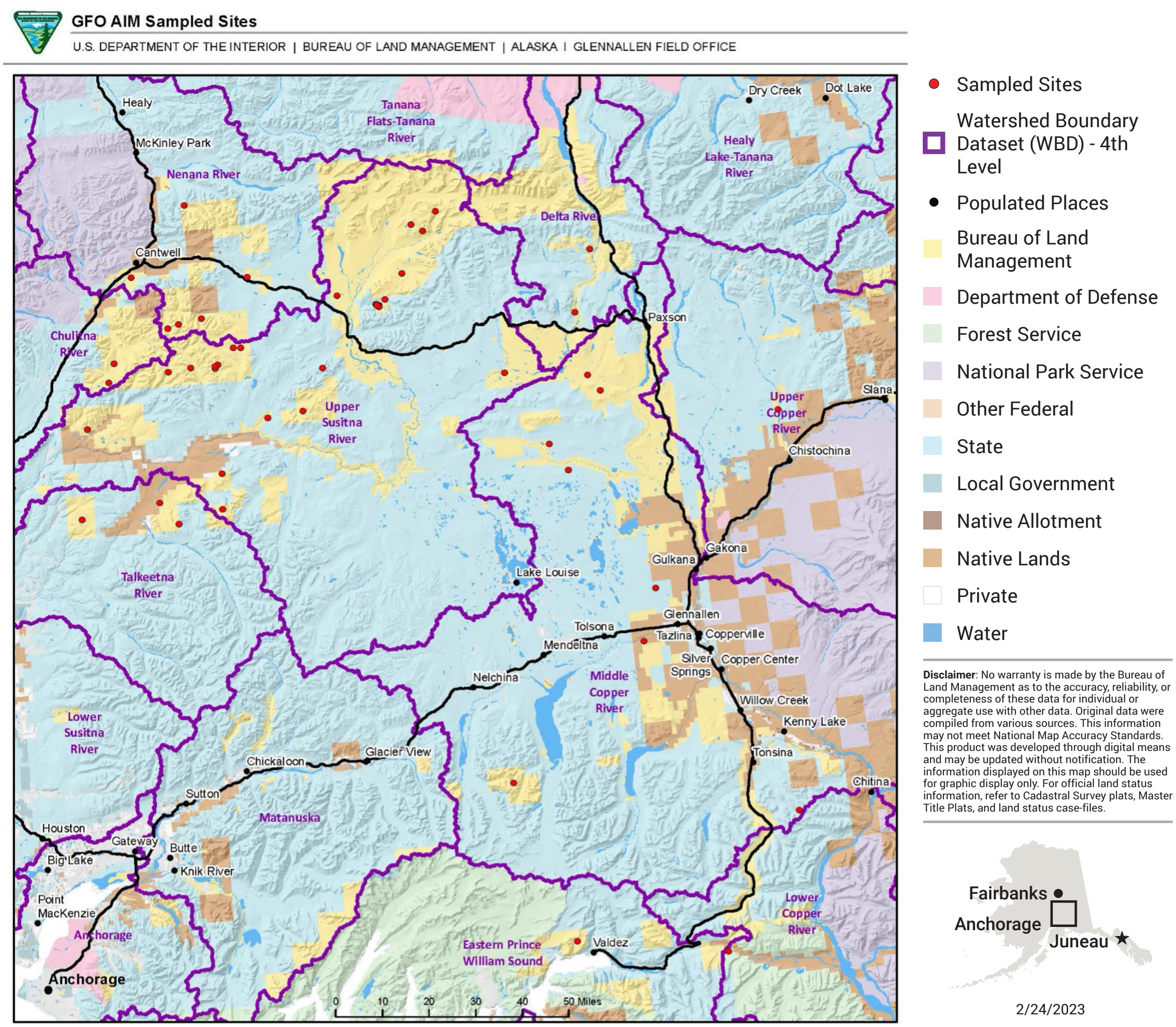


Figure 2. Map of the 46 sampled reaches across lands managed in the East Alaska RMP area.

Data collection occurred during the months of July and August in 2016, 2017, and 2019. Field sampling followed the AIM protocol for wadeable lotic systems (BLM Technical References 1735-1 and 1735-2) (BLM 2015, 2021). The AIM protocol for wadeable streams is based on reaches where data is collected along 11 main transects and 10 intermediate transects within a sample reach (Figure 3). Increasing sampling efficiency in the field was required to limit the high cost of helicopter operations, so the standard 210 stream particle measurements was reduced to 105. This was later adopted as the standard methodology for Alaska AIM applications (Miller et al. 2021).

2.3 Establishing Minimally Disturbed Conditions and Condition Benchmarks

To determine if the 46 randomly selected reaches represented minimally disturbed conditions (MDCs), each reach was evaluated for anthropogenic (human-caused) impacts upstream. Watersheds were delineated upstream of lotic AIM reaches using spatial data and were evaluated for anthropogenic disturbances, including roads, rights-of-way, Trans-Alaska Pipeline System, culverts, and mining. Additionally, Google Earth and other Alaska-specific imagery were used to verify spatial data layers and to document any potential missing disturbances. From the imagery, several OHV trails and winter snowmachine trails were identified that were not associated with any BLM corporate spatial data layers. Snowmachine trails were not considered in the analysis to determine reference reaches, as these trails are only used in the winter when the ground is snow-covered and the streams and rivers are frozen. These winter trails are fully vegetated during the summer and are assumed not to contribute sediment from erosion to the streams.

Nine reaches were found to have upstream anthropogenic activities including current and historic placer mining, roads, OHV trails, and rights-of-way. The nine reaches were ranked using reference thresholds identified by Ode et al. (2016). In Ode et al. (2016), the authors did not describe quantified thresholds for OHV trails; therefore, road length, OHV trail length, and rights-of-way lengths were combined into one linear length metric. The number of road stream crossings, OHV trail stream crossings, and rights-of-way stream crossings were combined into one stream crossing metric. The combined road and stream crossing metrics met the reference condition standards identified by Ode et al. (2016), resulting in retention of the nine reaches within the MDC dataset.

The range of variability from the 46 reference reaches was used to characterize minimally disturbed conditions (Stoddard et al. 2006). These reaches are thought to represent the natural range of variability (i.e., the range of environmental heterogeneity across the landscape inclusive of naturogenic impacts such as riverbank slumping from permafrost melting, wildfire, floods, and other nature-

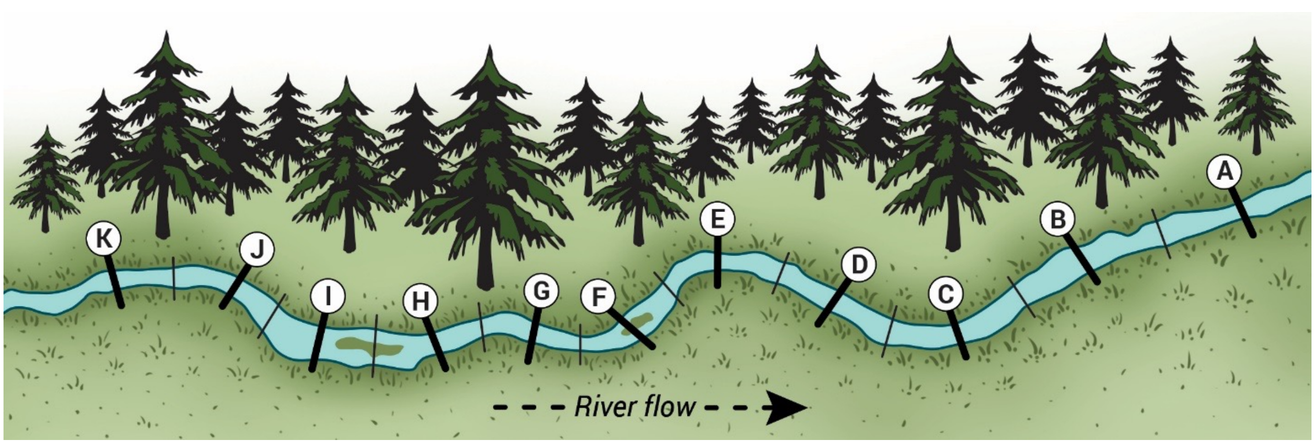


Figure 3. The AIM protocol for wadeable streams is conducted on a stream reach that includes 11 main transects (A-K) and 10 intermediate transects spaced evenly between the main transects.

derived disturbances or stressors). As time advances and repeat sampling is conducted under the GRTS design, further quantification of natural variability across time will be possible. Data collected at these reaches under the AIM program is used to calculate a variety of indicators that correspond to chemical, physical, and biological condition. For a detailed rationale of the development and selection of indicators, refer to BLM Technical Reference 1735-2 (BLM 2021).

The MDC data can inform the development of land management objectives for aquatic resources, as well as impact thresholds associated with proposed development to ensure sustained yield and productivity of aquatic resources on public lands. One approach uses minimally disturbed condition to establish condition benchmarks for indicators most responsive to the land uses being authorized. Benchmarks are indicator values used to assess whether a site (reach) or collection of sites (reaches) is meeting or not meeting standards based on how observed conditions compare to site potential in the absence of anthropogenic constraints (Miller et al. 2021).

Condition benchmarks are used to determine if observed values at assessed reaches are within the range of desired conditions (properly functioning), outside the range (nonfunctioning), or somewhere in the middle (functioning at risk). For example, for indicators thought to increase in response to disturbance (e.g., fine sediment, floodplain connectivity), the 75th and 95th percentiles of the MDC distribution were used to determine when the classification of an indicator value changes to functioning at risk or nonfunctioning, respectively. Specifically, indicator values less than the 75th percentile represent properly functioning conditions; indicator values between the 75th and 95th percentiles represent functioning at risk conditions; and indicator values greater than the 95th percentile represent nonfunctioning conditions. Similarly, for indicators thought to decrease in response to disturbance (e.g., bank stability, vegetative complexity), the 25th and 5th percentiles were used to determine the minimum indicator value a reach can have before it is classified as functioning at risk or nonfunctioning, respectively. The actual percentiles used (e.g., 95th versus 90th percentile for major departure) can change for a particular region based on the BLM land use plan objectives and tradeoffs of balancing resource use versus resource conservation. For example, a wild and scenic river designated for its high-quality aquatic resources might require the use of a higher percentile.

This report highlights quantitative condition benchmarks for bank overhead cover (canopy cover), floodplain connectivity, bank stability, and riparian vegetation cover and complexity for the East Alaska RMP area using the range of minimally disturbed condition values among the 46 sampled lotic AIM reaches (Hughes et al. 1986; Paulsen et al. 2008). Appendix 1 contains the full list of lotic AIM indicators for which data were collected and their associated benchmark values.

3. Results

3.1 Inventory of Perennial Streams and Rivers

Based on the National Hydrography Dataset, the original target population of wadeable, perennial streams and rivers on lands managed by the BLM in the East Alaska RMP area is approximately 4,000 miles. Through field and desktop reconnaissance and field sampling, about 25% of streams (approximately 1,000 miles) were determined nontarget due to factors such as not on BLM-managed lands, having wetland characteristics, completely dry, or not wadeable (Figure 4).

The potential target population of wadeable streams and rivers was recalculated by removing the nontarget streams and rivers, resulting in approximately 3,000 miles. Of these approximately 3,000 miles, 17% (516 miles) of streams were inaccessible due to terrain; therefore, a definitive determination could not be made as to whether these streams are part of the target population. The status of approximately 30% (886 miles) of the streams were unknown, as no information was collected or provided about their status (e.g., nonwadeable, dry or intermittent flow). The remaining 53% (1,586 miles) are the target population from which sampling designs are based and inferences made (Figure 5).

3.2 Characterizing Baseline Conditions and Benchmarks

Data collected for lotic AIM indicators describes current lotic conditions across the East Alaska RMP area. These baseline conditions will be compared to lotic AIM sampling data in the future to determine whether lotic conditions are changing over time and, if so, how they are changing. This report highlights the indicators bank overhead cover (canopy cover), bank stability, floodplain connectivity, and riparian

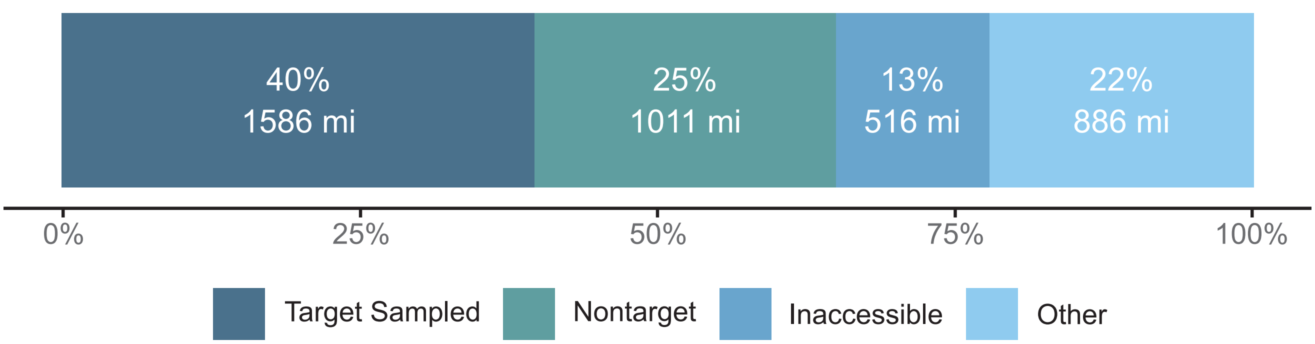


Figure 4. Percent of BLM-managed stream miles that were target-sampled, nontarget, inaccessible, and other for the East Alaska RMP area as part of the lotic AIM implementation. Estimates are based on the National Hydrography Dataset and field sampling.

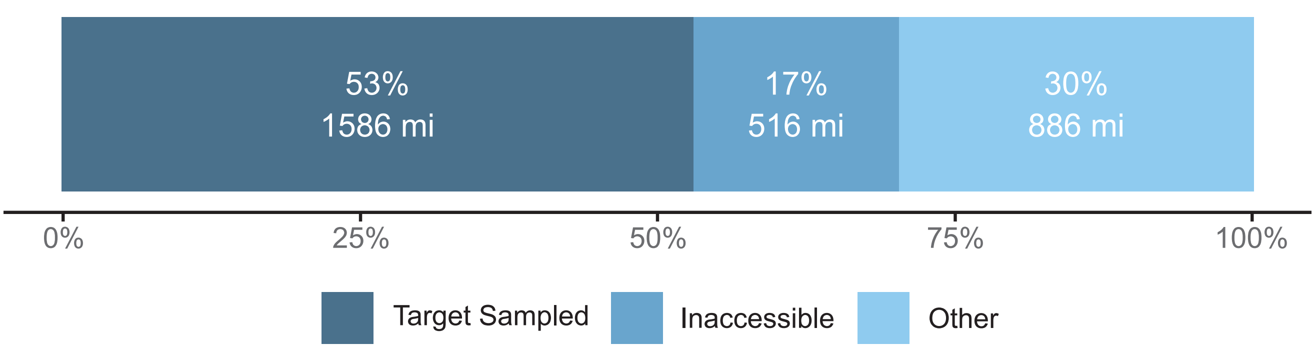


Figure 5. Percent of BLM-managed stream miles that were target-sampled, inaccessible, and other after removing nontarget streams and rivers.

vegetation cover and complexity to highlight some characteristics of lotic and riparian habitat that will be important to continue monitoring into the future for the East Alaska RMP area. Establishing baseline conditions is the first step in trend monitoring. Repeat sampling using lotic AIM methodologies approximately 10 years from now will show whether lotic and riparian conditions are changing, and if so, how those conditions are changing.

Bank overhead cover (canopy cover) directly measures the amount of aerial shade provided by riparian vegetation and other features, such as rocks and boulders, to provide thermal refugia (Beschta 1997; Johnson and Jones 2000). Bank overhead cover measurements also provide direct information on the amount of potential leaf litter and terrestrial organisms as a food source (Cummins 1974).

Bank overhead cover is measured with a convex densiometer that displays 17 intersections. The observer counts the total number of intersections covered by any form of vegetation or any object that creates shade such as a boulder. Bank overhead cover is the average of measurements taken at both left and right banks at all 11 main transects (Figure 3), and values can range from 0% to 100% (BLM 2021). Across the 46 reaches, a minimum value of 0% cover and a maximum value of 98% cover was observed, with a median of 62% cover and the 25th and 5th percentiles equal to 23% and 1%, respectively (Figure 6).

Bank stability measurements assess the

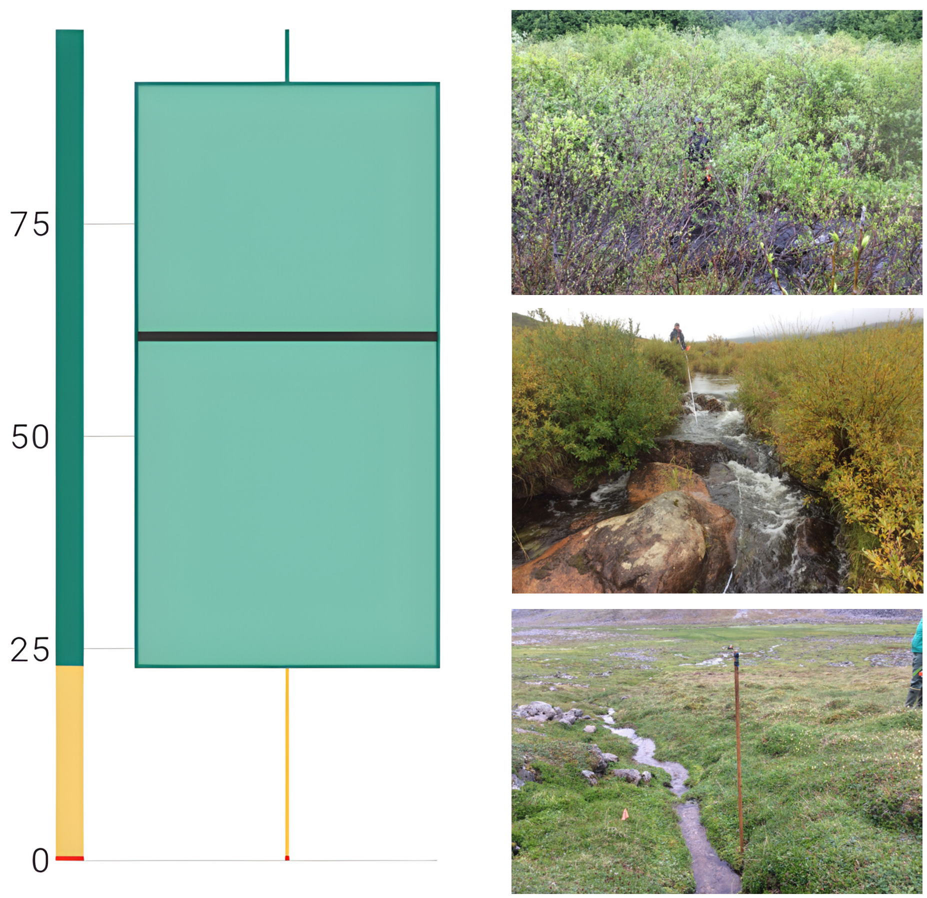


Figure 6. Box plot illustrating the range of variability for the lotic AIM indicator bank overhead cover (canopy cover) across 46 reaches that are in minimally disturbed condition. Bank overhead cover values below the 25th and 5th percentiles are classified as functioning at risk and nonfunctioning, respectively, and are illustrated in yellow and red. Values above the 25th percentile are considered functioning and are illustrated in green. The top image reflects conditions near the 95th percentile; the middle image represents typical conditions at the 40th percentile; and the bottom image represents minimal conditions at the 0 percentile.

susceptibility of streambanks to both natural and accelerated erosion rates associated with anthropogenic activities. Streambank erosion mostly occurs during bankfull discharge events, which is the discharge associated with the greatest amount of sediment transport and that has the largest influence on channel morphology (Wolman and Miller 1960). Anthropogenic activities that increase stream power (e.g., flow alteration, improperly sized culverts) or alter the composition and cover of stabilizing riparian vegetation can increase streambank erosion rates (Knapp and Matthews 1996; Coles-Ritchie et al. 2007; Oliver et al. 2012). Streambank erosion is a source of fine sediment loading and channel widening. Elevated fine sediment loading can reduce the suitability of the stream bottom environment for aquatic organisms such as fish and macroinvertebrates (Henley et al. 2000). Bank erosion can also alter channel morphology (e.g., width-to-depth ratios) and subsequent habitat quality through changing the balance between the sediment and water supply and thus the transport competence of a stream or river (Lane 1954; Thies 2017). The composition and cover of vegetation and other features, such as large woody debris and boulders, significantly influence streambank erosion. Therefore, the lotic AIM protocol quantifies both streambank cover and the presence of any erosional features (e.g., fractures, slumps, sloughs) related to bank stability.

The methods for evaluating bank stability and cover were modified in 2019 to better align the lotic AIM methods with Multiple Indicator Monitoring (BLM Technical Reference 1737-23)

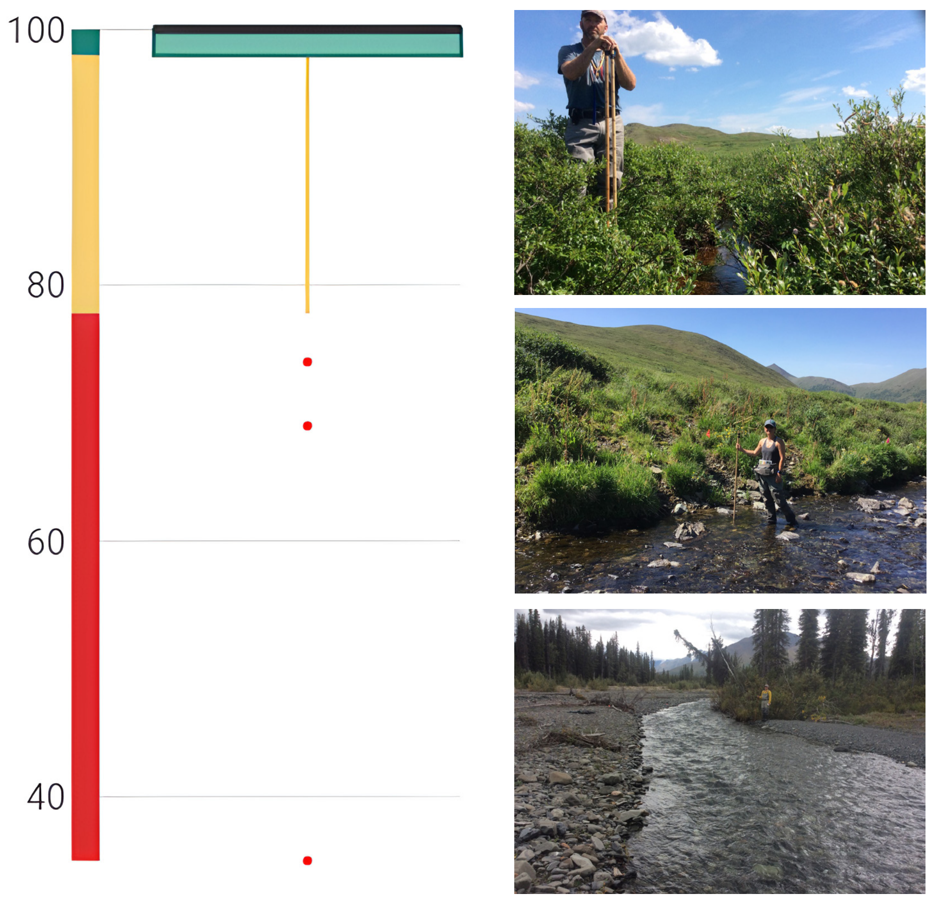


Figure 7. Box plot illustrating the range of variability for the lotic AIM indicator bank stability across 46 reaches that are in minimally disturbed condition. Bank stability values below the 25th and 5th percentiles are classified as functioning at risk and nonfunctioning, respectively, and are illustrated in yellow and red. Values above the 25th percentile are considered functioning and are illustrated in green. The top image reflects conditions near the 100th percentile; the middle image represents typical conditions at the 20th percentile; and the bottom image represents minimal conditions at the 4th percentile.

(Burton et al. 2011). This change occurred during the field office-wide sampling and resulted in streambank cover data that were not compatible (basal cover versus aerial cover). Therefore, this report focuses on bank stability and not both bank stability and cover, while recognizing that cover remains an important component of overall bank stability and erosion susceptibility.

Bank stability is the number of plots classified as “stable” divided by the total number of plots across the reach and is reported as a percent ranging from 0 to 100. The stable designation is derived from the absence of observable erosional features. Across the 46 reaches, a minimum value of 35% and a maximum and median value of 100% was observed, with the 25th and 5th percentiles equal to 98% and 78%, respectively (Figure 7).

Disconnected floodplains (poor floodplain connectivity) can negatively impact nutrient retention, dissipation of stream energy, riparian ecosystem development and maintenance, and biological diversity (Knighton 1998; Leopold et al. 1992).

Floodplain connectivity is computed from the difference in elevation of the bankfull height and the first flat depositional feature at or above bankfull. Floodplain connectivity values typically range from 1 (non-incision: low bank height is equal to bankfull stage) to approximately 3 (significant incision: low bank height is greater than bankfull stage height) (BLM 2021). For the 46 reaches sampled, a minimum value of 1.00, a maximum value of 2.56, and a median value of 1.44 was observed. The 75th and 95th percentiles are equal to 1.57 and 1.96,

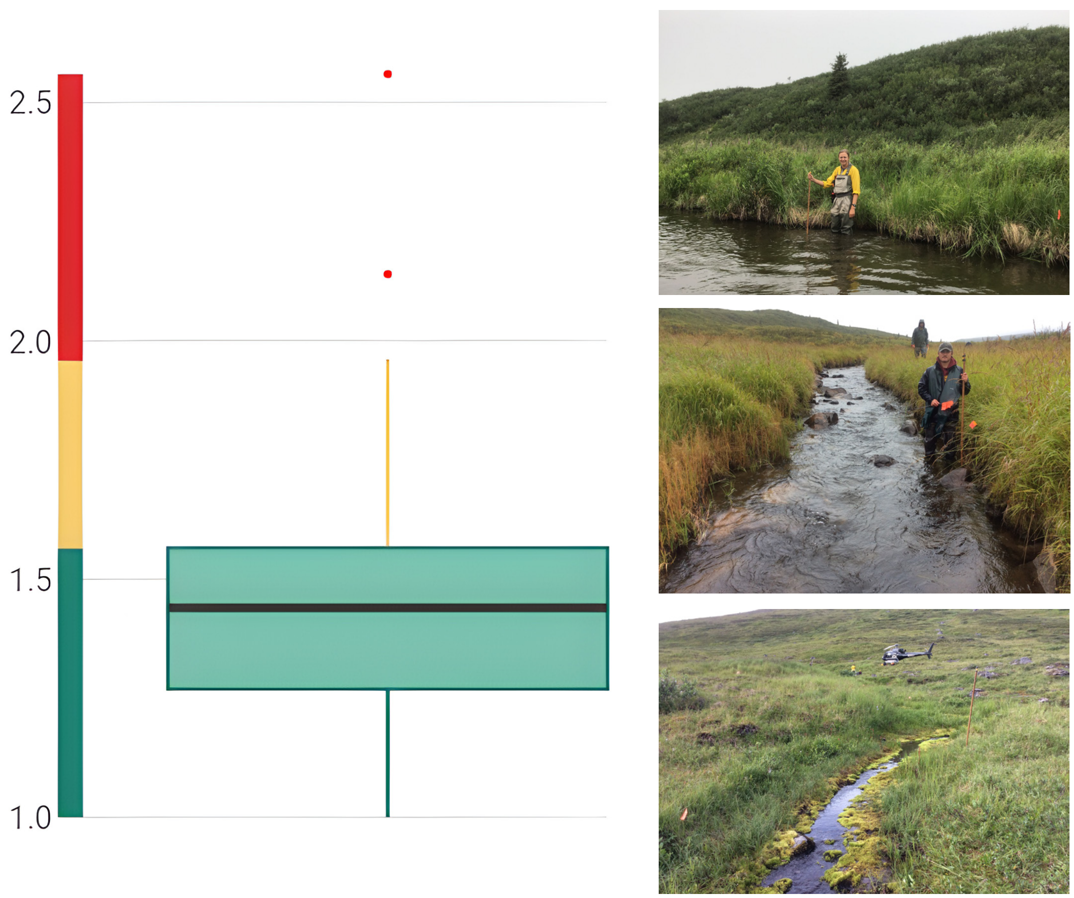


Figure 8. Box plot illustrating the range of variability for the lotic AIM indicator floodplain connectivity across 46 reaches that are in minimally disturbed condition. Floodplain connectivity values of 1.57 and 1.96 correspond to the 75th and 95th percentiles and are classified as functioning at risk (yellow) and nonfunctioning (red), respectively. The top image reflects conditions near the 95th percentile; the middle image represents typical conditions at the 42nd percentile; and the bottom image represents conditions at the 2nd percentile.

respectively (Figure 8). The benchmarks for randomly sampled streams suggest a low degree of naturally occurring incision throughout lands managed in the East Alaska RMP area.

Maintaining an intact riparian corridor is fundamental to a stable stream channel and supports both chemical and biological stream functions (Harman et al. 2012; Perucca et al. 2007). Riparian vegetation cover and complexity is determined by visually estimating the percentage of aerial cover for the three different layers, or strata, of vegetation (canopy, understory, and groundcover) and can range from 0 (< 10% vegetation cover) to 3.5 (> 87% vegetative cover for all three strata). For the 46 sampled reaches, a minimum value of 0.06 and a maximum value of 2.11 was observed, with the 25th and 5th percentiles equal to 0.87 and 0.21, respectively (Figure 9).

Figure 9. Box plot illustrating the range of variability for the lotic AIM indicator riparian vegetation cover and complexity across 46 reaches that are in a minimally disturbed condition. Riparian vegetation cover and complexity values below 0.87 and 0.21 (the 25th and 5th percentiles) are classified as functioning at risk and nonfunctioning, respectively, and are illustrated in yellow and green. The top image reflects conditions near the 93rd percentile; the middle image represents typical conditions at the 48th percentile; and the bottom image represents minimal conditions at the 0 percentile.

4. Summary

The lotic AIM protocol is used to evaluate conformance with land use plans, land health standards, habitat assessment for lotic species, distribution of invasive species, and identify trends in landscape characteristics over time. This research achieved two primary goals: (1) develop quantifiable benchmarks to assess stream condition and trend; and (2) establish quantitative baseline conditions for the chemical, physical, and biological attributes of BLM-managed wadable streams and rivers for future implementation and effectiveness monitoring within the East Alaska RMP area and future land use plans.

RMP monitoring is the process of (1) tracking the implementation of land use planning decisions (implementation monitoring) and (2) collecting data/information necessary to evaluate the effectiveness of land use planning decisions (effectiveness monitoring). In the past, RMP monitoring utilized a mixture of qualitative and quantitative data from local-scale monitoring efforts to describe progress toward meeting RMP objectives. While this approach utilized the best available data to draw conclusions, making inferences to landscape condition and trend from these types of data sources is statistically inappropriate given the several biases associated with extrapolating authorization-specific monitoring to large geographic areas. Thresholds for large-scale monitoring programs are most commonly established using reference conditions, which provide a benchmark for indicator or stressor values expected to occur in the absence of anthropogenic impacts (Stoddard et al. 2006; Herlihy et al. 2008; Hawkins et al. 2010).

The data in this report will support BLM managers using adaptive management by establishing quantitative thresholds, which if exceeded, will trigger changes in management actions (Cappuccio 2018). In addition, these data will help better understand the range of natural conditions in Alaska and meet the FLPMA requirement to maintain data on aquatic resources.

Appendix 1: Lotic AIM Indicators and Benchmarks for East Alaska RMP

This table provides information, including benchmark values, for lotic AIM indicators (instream and riparian area) collected at 46 reaches throughout the East Alaska RMP area.

Data Type	Indicator	Description	Predicted Response to Stress	Units	Range of Values (Min and Max)		5th Percentile	25th Percentile	75th Percentile	95th Percentile	Alaska Application Notes
Biodiversity and Riparian Habitat Quality	Percent overhead cover	Average % overhead cover provided by streambanks, vegetation, or other objects measured mid-channel (looking 4 directions) across 11 transects (min: 0, max: 100, n=44)	Decrease	%	0	89	0	0			
	Bank overhead cover	Average percent overhead cover provided by streambanks (left and right), vegetation, or other objects measured at the scour line of the left and right banks across 11 transects (min: 0, max: 100, n=22)	Decrease	%	0	98	0.63	23			
	Riparian vegetation cover and complexity	Aggregate measure of the average vegetative cover provided by three different vegetative height categories: canopy (> 5 m), understory (0.5-5 m), and ground (< 0.5 m). Each vegetative height category is then divided into two vegetation types (e.g., woody or nonwoody). Proportional cover was binned into four classes (0.875, 0.575, 0.25, and 0.05) per vegetation type, summed across the three heights, and then averaged across the left and right banks of 11 transects (min: 0, max: 2.6, n=132)	Decrease	# of individuals	0.06	2.11	0.21	0.87			
	Riparian vegetation understory cover	Measure of the average riparian vegetative cover provided by understory vegetation (0.5-5 m). Proportional cover was binned into four classes (0.875, 0.575, 0.25, and 0.05) and then averaged across the left and right banks of 11 transects (min: 0, max: 0.88, n=22)	Decrease	None							This indicator is covered under riparian vegetation cover and complexity

Data Type	Indicator	Description	Predicted Response to Stress	Units	Range of Values (Min and Max)		5th Percentile	25th Percentile	75th Percentile	95th Percentile	Alaska Application Notes
Biodiversity and Riparian Habitat Quality	Riparian vegetation ground cover	Measure of the average riparian vegetative cover provided by the ground cover vegetation (< 0.5 m). Proportional cover was binned into four classes (0.875, 0.575, 0.25, and 0.05) and then averaged across the left and right banks of 11 transects (min: 0, max: 0.88, n=22)	Decrease	None							This indicator is covered under riparian vegetation cover and complexity
	Invasive invertebrate species	Presence or absence of invasive macroinvertebrates	Increase	NA							In development
	Observed invertebrate richness	Observed macroinvertebrate richness standardized to model specific operational taxonomic units	Decrease	# of taxa							In development
	Expected invertebrate richness	Expected macroinvertebrate richness in the absence of anthropogenic impacts from the observed/expected (O/E) model	NA	# of taxa							In development
	OE macroinvertebrate	Biological condition was assessed using an O/E index. O/E models compare the macroinvertebrate taxa observed at reaches of unknown biological condition (i.e., test sites) to the assemblages expected to be found in the absence of anthropogenic stressors (see Hawkins et al. 2010 for details). The specific model used can be found in the OE MMI model used column and the model-specific metadata can be found at www.usu.edu/buglab/ (min: 0, max: 1.5)	Decrease	None							In development
	MMI macroinvertebrate	Biological condition was assessed using the MMI (multimetric index) model specified in the OE MMI model used column.	Decrease	None							In development

Data Type	Indicator	Description	Predicted Response to Stress	Units	Range of Values (Min and Max)		5th Percentile	25th Percentile	75th Percentile	95th Percentile	Alaska Application Notes
Biodiversity and Riparian Habitat Quality	OE MMI model used	The O/E or MMI model used to determine biological integrity	NA	NA							In development
Biodiversity and Riparian Habitat Quality	Macroinvertebrate count	This field indicates whether the reach's environmental gradients were within the range of experience of the model. A fail indicates the model potentially had to extrapolate, rather than interpolate, to accommodate one or more of the habitat variables. O/E scores and condition ratings should be interpreted cautiously if a reach failed the test of experience.	NA	# of individuals							In development
Biodiversity and Riparian Habitat Quality	Model applicability	Number of macroinvertebrates identified and resampled to a standardized fixed count (i.e., rarefaction). Samples with counts less than 200 macroinvertebrates can result from sampling and/or laboratory processing errors, but low counts can also be a signal of degraded biological condition. Additional samples should be taken to verify major or moderate departure from reference (min: 0, max: 400)	NA	# of individuals							In development
Water Quality	Specific conductance	Measured specific conductance value. The specific conductance is conductivity standardized to 25 degrees C (min: 0, max: 65,500, n=1)	Increase	µS/cm	19	871			160	644	
Water Quality	Predicted specific conductance	Site-specific predicted values for reference specific conductance values (Olson and Hawkins 2012) (min: 0, max: 65,500)	NA	µS/cm							In development
Water Quality	pH	Measured pH value (min: 0, max: 14, n=1)	Increase or decrease	SU	4.57	8.92	5.69	6.97	8.01	8.51	

Data Type	Indicator	Description	Predicted Response to Stress	Units	Range of Values (Min and Max)		5th Percentile	25th Percentile	75th Percentile	95th Percentile	Alaska Application Notes
Water Quality	Instantaneous temperature	Instantaneous water temperature measurement (n=1)	Increase	degrees Celsius	0.13	18.3			11.05	15.6	
Water Quality	Turbidity	Average water clarity as measured by the suspended solids in the water column (n=3)	Increase	NTU	0	85			0.95	5.97	
Watershed Function and Instream Habitat Quality	Percentage of pools	Percent of the sample reach (linear extent) classified as pool habitat as assessed using the core pool method (min: 0, max: 100, n=1)	Decrease	%	0	63.23	0	0			For the data collected in 2016, 21 reaches had no pools. For data collected in 2018 and 2019, 10 reaches had no pools and data results shown are from only 25 reaches that did have pools.
Watershed Function and Instream Habitat Quality	Residual pool depth	Average residual pool depth as assessed using the core pool method (n=variable depending on number of pools)	Decrease	meters	0.12	1.3	0.13	0.21			For the data collected in 2016, 21 reaches had no pools. For data collected in 2018 and 2019, 10 reaches had no pools and data results shown are from only 25 reaches that did have pools.
Watershed Function and Instream Habitat Quality	Pool frequency	Frequency of pools in the reach as assessed using the core pool method (n=1)	Decrease	# of pools/km	0	106.7	0	0			For the data collected in 2016, 21 reaches had no pools. For data collected in 2018 and 2019, 10 reaches had no pools and data results shown are from only 25 reaches that did have pools.

Data Type	Indicator	Description	Predicted Response to Stress	Units	Range of Values (Min and Max)		5th Percentile	25th Percentile	75th Percentile	95th Percentile	Alaska Application Notes
Watershed Function and Instream Habitat Quality	Large woody debris frequency	Frequency of large woody debris within the bankfull channel of the reach (n=1)	Decrease	# pieces/ 100 m	0	27	0	0			Out of 46 total reaches, 9 reaches had large woody debris.
	Large woody debris volume	Volume of large woody debris within the bankfull channel of the reach (n=1)	Decrease	m^3/ 100 m	0	17	0	0			Out of 46 total reaches, 9 reaches had large woody debris.
	Percent fines < 2 mm	Percent of 105 particles with a b-axis < 2 mm (min: 0, max: 100, n=105)	Increase	%	0	92			10	71	
	Percent fines < 6 mm	Percent of 105 particles with a b-axis < 6 mm (min: 0, max: 100, n=105)	Increase	%	0	92			12	72	
	Particle size (16th perc.) (D16)	Particle size corresponding to the 16th percentile of measured particles (min: 1, max: 4,098, n=105)	Decrease	mm	1	258	1	11			
	Particle size (84th perc.) (D84)	Particle size corresponding to the 84th percentile of measured particles (min: 1, max: 4,098, n=105)	Decrease	mm	1	1,000	16	86			
	Particle size (50th perc.) (D50)	Particle size corresponding to the 50th percentile of measured particles (min: 1, max: 4,098, n=105)	Decrease	mm	1	500	2	41			
	Geometric mean bed particle diameter	Exponential function[mean(log(particle diameter)]. This is a less frequently used metric of characterizing central tendency of substrate sizes but is the main metric used by the EPA for determining relative bed stability. It is less variable than a D50 and more biologically meaningful because it is more influenced by fine sediment (min: 1, max: 4,098, n=105)	Decrease	mm	2	355	3	34			

Data Type	Indicator	Description	Predicted Response to Stress	Units	Range of Values (Min and Max)		5th Percentile	25th Percentile	75th Percentile	95th Percentile	Alaska Application Notes
Watershed Function and Instream Habitat Quality	Bank stability	Percent of 42 banks lacking visible signs of active erosion (e.g., slump, slough, fracture) (min: 0, max: 100, n=42)	Decrease	%	35	100	78	98			
	Floodplain connectivity	The ratio of average floodplain height to average bankfull height taken from the thalweg (floodplain height + thalweg depth) / (bankfull height + thalweg depth). This is also known as Rosgen's bank height ratio (n=11)	Increase	None	1.00	2.56			1.57	1.96	
	Instream habitat complexity	Aggregate measure of average cover provided by boulders, overhanging vegetation, live trees and roots, large woody debris, small woody debris, and streambanks for stream fishes measured at 11 plots. Proportional cover was binned into four classes (0.875, 0.575, 0.25, and 0.5), averaged across transects, and then summed across six types of cover (min: 0, max: 2.3, n=66)	Decrease	None	0.03	1.56	0.1	0.25			
	Thalweg depth CV	Indicator of bed heterogeneity computed as the coefficient of variation of 100–300 thalweg depth measurements (n=1)	Decrease	None	0.17	0.66	0.19	0.23			
	Thalweg depth mean	Mean thalweg depth. Metric of how deep water was at the reach (min: 0, max: none, n variable depending on reach length (100–300))	Decrease	meters	0.02	0.89	0.03	0.18			

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