Rural Airport Obstructions Planning and Analysis

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Executive Summary

The Alaska Department of Transportation and Public Facilities is responsible for managing obstructions to airports, and their associated airspace, on 237 state-owned and operated airports throughout Alaska. Obstructions to airspace, such as trees in the approach of a runway, can be hazardous to the flying public. Managing obstructions on rural, unattended, Alaskan airports is complicated by the sheer number of airports and diversity of habitat surrounding those airports. This report reviews the subject and outlines the elements that must be included to develop a program to manage rural airport obstructions.

The Federal Aviation Administration has established, through its regulations and design criteria, various protected airspace surfaces and zones around airports and airport related facilities. These protected surfaces and zones are intended to ensure protection of the flying public by minimizing the potential for aircraft to strike trees, utility poles, buildings and other structures that may be in the vicinity of the airport. This report defines and explains the various airspace surfaces and zones that are typical in rural Alaska.

Determining obstructions to airspace must be completed at each airport on an individual basis. First, survey or photogrammetry data needs to be collected including the elevations of the ground surface, buildings, and obstructions (i.e., structures and tree/vegetation canopy height). This report discusses considerations in using existing data and collection of new data. The use of drones is also revolutionizing airport survey, and the use of this technology is also explored.

After survey or photogrammetry data has been collected, it must be analyzed and compared with three-dimensional computer models of airport surfaces. This analysis assigns elevations to all protected airspace surfaces and compares them to identified object elevations. The comparison of elevations between the protected airspace surfaces and the tops of the obstructions/vegetation allows for a determination of the location and extent of surface penetrations. Since vegetation grows, a buffer is applied to account for future vegetation growth. For example, woody vegetation within ten feet of protected airspace might be expected to become a future penetration.

Once obstructions are identified, they can be managed. Vegetation management has a dominant role in managing obstructions to airport airspace. Vegetation grows and must be actively maintained to keep it clear of protected airspace. This report, and an accompanying GIS datafile, provides classification of vegetation throughout Alaska. This mapping can help inform vegetation management, as it allows project managers to see what plant communities surround the airport.

This report also details a ‘bank’ of obstruction recommendations and mitigation measures that can be used to manage airport obstructions. Vegetation management at public use airports is a continuous process, which can only be successful if the initial removal plan addresses long-term maintenance issues. Typically, a contractor completes the initial removal of airspace penetrations, while the airport staff completes the ongoing maintenance of these areas. It is the ongoing maintenance component that is of primary concern, since the protected airspace surfaces must be kept clear of penetrations for many years after the initial removal project, and funding may not be available in the future to revisit these areas.

To develop a planning level estimate of costs for vegetation management at airports in rural Alaska, this report provides a review of recent project costs for vegetation management programs at Alaska airports.

Abbreviations

3D	three dimensional
AC	Advisory Circular
ADIP	Airport Data and Information Portal
ALP	Airport Layout Plan
ArcGIS	Aeronautical Reconnaissance Coverage Geographic Information System
CAD	computer aided design
CMOS	complementary metal oxide semiconductor
COA	Certificate of Authorization
DCCE	Department of Commerce Community and Economic
DEM	digital elevation model
DOT&PF	Department of Transportation and Public Facilities
ESRI	Environmental Systems Research Institute
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
GIS	Geographic Information Systems
GNSS	Global Navigation Satellite System
IFSAR	interferometric synthetic aperture radar
ILS	instrument landing system
LAS	LASer file format
LDP	low distortion projection
LIDAR	light detection and ranging
LISP	list processing programming language
NAD 83	North American Datum 1983
NAVAID	Navigational Aid
NAVD 88	North American Vertical Datum of 1988
NDB	non-directional beacon
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration
NSRS	National Spatial Reference System
OPUS	Online Positioning User Service
PAPI	precision approach path indicators
RGB	red, green, blue
RPZ	Runway Protection Zone
TERPS	Terminal Procedures
TIF	tagged image format
TIN	Triangular Irregular Networks
UAS	Unmanned Aerial Systems

USGS	U.S. Geologic Survey
VASI	visual approach slope indicator

1.0 INTRODUCTION

The purpose of this report is to develop a statewide program to manage airspace obstructions for rural Alaska Department of Transportation and Public Facilities (DOT&PF) airports. The goal is to maintain safe airspace through the removal of obstructions that currently penetrate, or are expected to penetrate, protected airspace in and around rural airports. This report will help facilitate long-term management of the airspace by framing the program as a long-term maintenance program. To that end, this report will serve as a guide for obstruction removal and subsequent management practices that aim to minimize the potential for adverse impacts to the environment.

Obstruction removal and management must be undertaken to comply with the following regulations:

- Title 14 Code of Federal Regulations (CFR), FAR Part 77 – Safe, Efficient Use, and Preservation of the Navigable Airspace
- Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5300-13– Airport Design
- FAA Order 6750.16 – Siting Criteria for Instrument Landing Systems
- FAA Order 8260.3 – United States Standards for Terminal Procedures (TERPS)
- FAA Order JO 6850.2 – Visual Guidance Lighting Systems
- FAA AC 150/5340-30– Design and Installation Details for Airport Visual Aids.

The following outlines, by chapter, this report's discussion of obstruction identification, removal, and mitigation:

- Chapter 2 reviews the protected airport surfaces.
- Chapter 3 outlines the survey element of obstruction analysis.
- Chapter 4 details the geospatial processes required to perform an obstruction analysis.
- Chapter 5 reviews an accompanying Aeronautical Reconnaissance Coverage Geographic Information System (ArcGIS) database that compiles vegetation and climatic growth data from existing resources throughout the State. This can be used to help guide vegetation management strategies at Alaskan airports.
- Chapter 6 provides a "bank" of generally recommended obstruction management methods. These can be used as best management practices for airports into the future.
- Chapter 7 provides a review of mitigation measures important to consider in obstruction management programs.
- Chapter 8 is a planning level cost estimate for implementing obstruction removal in rural Alaska.

2.0 AIRPORT SURFACES

The FAA has established, through its regulations and design criteria, various protected airspace surfaces and zones around airports and airport related facilities. These protected surfaces and zones are intended to ensure protection of the flying public by minimizing the potential for aircraft to strike trees, utility poles, buildings, and other structures that may be in the vicinity of the airport.

The following section defines and explains the various airspace surfaces and zones that are typical around an Alaskan airport and are laid out in the Airport Layout Plan (ALP). The intent of this discussion is to provide the reader with some background as to the nature of the surfaces and the reasons behind the need to clear these surfaces of vegetative obstructions. It is not a comprehensive list of surfaces at a particular airport of interest.

2.1 FEDERAL AVIATION REGULATION (FAR) – PART 77 SURFACES

This regulation, commonly referred to as FAR Part 77, establishes a set of imaginary surfaces, centered along airport runways, that must remain free of obstructions. These imaginary surfaces are shown graphically in Figure 1 and Figure 2. The actual dimensions (i.e., width, length, slope) of these surfaces at a given airport are dependent upon a host of factors including the type of runway surface, the runway “approach category,” the types of electronic equipment located at the airport that are available to help guide the aircraft into the airport during inclement weather, and the type of aircraft that typically utilize the runway. Of particular importance to understanding these concepts is the approach category of the runway. In general, the more complex the approach (i.e., precision versus non-precision versus visual), the more demanding the imaginary surfaces. This variation in dimensions relative to these factors ensures that the imaginary surfaces for a large commercial transport facility such as the Ted Steven Anchorage International Airport will be dramatically different from those at a regional airport such as Kotzebue or a smaller airport such as Noatak. The regulations ensure that protection of imaginary surfaces is commensurate with the size and function of the airport.

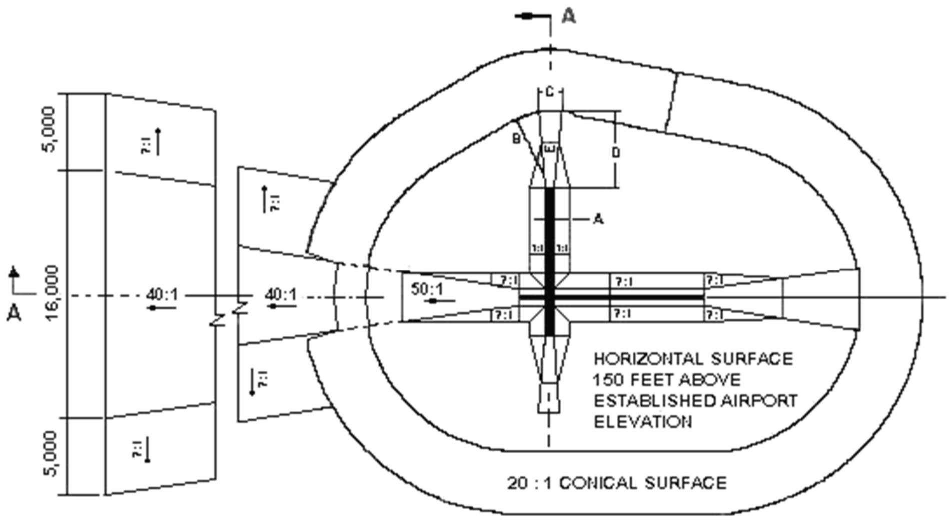


Figure 1 Part 77 Surfaces Example (Plan View, NOAA 2020a)

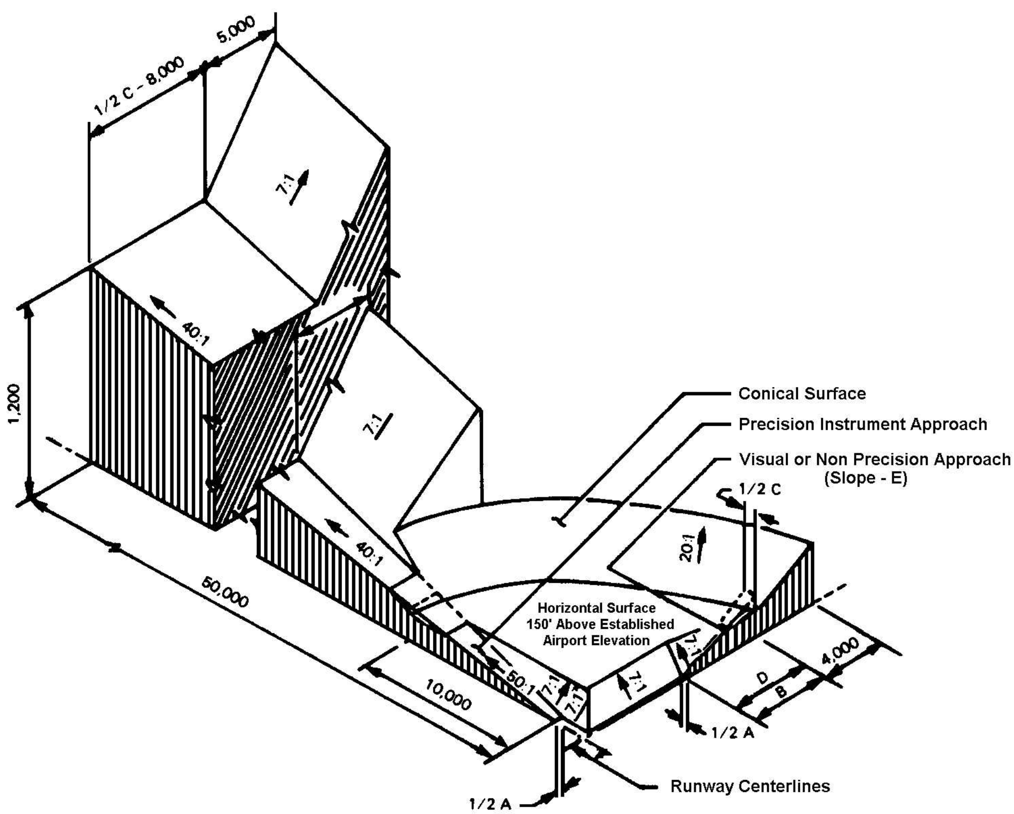


Figure 2 Part 77 Surfaces Example (Cross-section View, NOAA 2020b)

2.1.1 Primary Surface

This surface is a rectangular shaped surface that is longitudinally centered on each runway and extends 200 feet beyond each runway end. The elevation of this surface is the same as that for the runway centerline, thus any object, including vegetation, that is within the primary surface and is at a higher elevation than the runway, is a penetration of navigable airspace and in violation of FAR Part 77. For runways with a precision approach, there is a wider protected surface (e.g., 500 feet either side of the runway centerline). For runways with non-precision approaches there is a narrower protected surface (e.g., 125 feet on either side of the runway centerline). Specific dimensions vary for each airport.

2.1.2 Approach Surface

The approach surface dimensions and slopes for the runway ends depend on a runway's classification and published approach procedures. In general, an approach surface begins at the end of the primary surface (which, as described in Section 2.1.1, extends 200 feet beyond the runway end), and extends outward and upward at a variable slope. As it proceeds outward from the runway end, it gradually widens. The inner width of the approach surface is equal to the width of the primary surface, and the outer width depends upon the runway.

For example, a precision instrument approach with a 50:1 slope will have a length of 10,000 feet out from the end of the primary surface, changing to a 40:1 slope for an additional 40,000 feet. The inner width of this surface will be 1,000 feet and the outer width may be 16,000 feet.

A non-precision approach may have a 34:1 slope with a length of 10,000 feet. The inner width of this surface may be 1,000 feet, and the outer width may be 3,500 feet.

A visual runway may have a 20:1 slope with a length of 5,000 feet. The inner width of the approach surface may be 250 feet, and the outer width may be 1,250 feet.

An understanding of the approach slope is critical in comprehending the extent of the clearing that must be completed to address Part 77. At a slope of 20:1 and a runway elevation of 100 feet, an object that is 200 feet from the end of the primary surface must remain below elevation 110 feet. For a 34:1 approach slope, this same object must remain below elevation 106 feet. For a 50:1 slope, the object must remain below elevation 104 feet.

2.1.3 Transitional Surfaces

The transitional surface defines the areas to the "sides" of the runways beyond the primary surface edge. Typically, the extent of the penetrations within the transitional surfaces are less than the approach surfaces simply due to the increased slope of the surface (7:1). However, where ground topography rises within the transitional surface, it is not uncommon for extensive areas of penetrations to exist.

The transitional surface is a plane with a 7:1 slope that extends upward and outward from the sides of the primary and approach surfaces. The transitional surface terminates at the intersection with a horizontal surface set 150 feet above the airport reference elevation.

2.1.4 Horizontal Surface

This horizontal surface is 150 feet above the runway, extending for 5,000 feet for visual runways (and 10,000 for all other runways) from each end of the primary surface of runways.

2.1.5 Conical Surface

This conical surface extends from the horizontal surface in a cone, upwards at a 20:1 slope for a horizontal distance of 4,000 feet.

2.2 OTHER PROTECTED AIRSPACE SURFACES

In addition to the FAR Part 77 surfaces described above, several other protected surfaces are defined by FAA regulations. These additional surfaces are intended to provide safety clearances between incoming aircraft and objects that may be in the aircraft flight path. Two common surfaces are described below.

2.2.1 Navigational Aids

The dimension and slopes of these surfaces vary and are directly related to the types of navigational aids, both electronic and visual, which are currently installed at the airport. Navigational aids (NAVAIDs) installed at the airports may include, but not be limited to, a Visual Approach Slope Indicator (VASI), Precision Approach Path Indicators (PAPI), a Non-Directional Beacon (NDB), and Instrument Landing System (ILS) critical areas. Obstruction clearing slopes and critical area dimensions for NAVAIDs are detailed on the airport's ALP.

2.2.2 Terminal Instrument Procedures (TERPS)

The FAA has also established many protected airspace surfaces which are outlined in a body of regulations known as the United States Standard for Terminal Instrument Procedures, commonly referred to as TERPS. Depending on the individual circumstances for each airport, the imaginary surfaces established under TERPS may be more or less stringent than FAR Part 77 surfaces. A complete description of all the various protected airspace surfaces which come into play at each airport is impractical in a document of this nature.

If obstructions to the Part 77 Approach Surfaces are off-airport or outside of the airport's control, the TERPS for each runway approach must be reviewed to determine that obstructions do not penetrate their protective surfaces. FAA AC 150/5300-13 Airport Design defines approach and departure surfaces (not to be confused with Part 77 surfaces) necessary to protect the runway approaches during visual and instrument meteorological conditions. These approach surfaces, typically with 20:1 slopes, define limits that must be cleared of obstacles and are based on aircraft size (large or small); visibility minimums; day only or day and night operations; and aircraft approach speed. Obstructions penetrating these surfaces must be removed or the airport risks instrument procedures for these runways being labeled not authorized either for night operations or at all. The DOT&PF typically coordinates with property owners to mitigate these obstructions or work with FAA for mitigation alternatives that may include displacing the runway threshold for the affected ends.

3.0 PROCESS OF DETERMINING OBSTRUCTIONS

Determining obstructions must be completed at each airport on an individual basis. First, survey or photogrammetry data needs to be developed that includes the elevations of the ground surface, buildings, and obstructions (i.e., structures and tree/vegetation canopy height). This chapter discusses considerations in using existing data and collecting new data. The use of drones is also revolutionizing airport survey, and the use of this technology is further explored in this chapter.

This report does not consider conducting a full aeronautical survey, primarily due to the cost and size of this method. The geographic extent of the entire airspace can exceed 30 square miles (including the full horizontal, conical, and outer approach surfaces). Entire airspace evaluation of this nature would be best suited for traditional aircraft-based remote sensing techniques as outlined in FAA AC 150/5300-17, Standards for Using Remote Sensing Technologies in Airport Surveys.

3.1 UTILIZING EXISTING SURVEY DATA

Existing survey data can be used to help plan the field survey effort. By first performing airspace analysis with existing data, areas of interest for additional field work can be established. This analysis can then be used to estimate the level of effort required for new data collection and for planning the logistics of data acquisition (e.g., aircraft survey area or drone flight lines).

Existing survey can also be used to allow field crews to be more efficient in the field. Desktop analysis can create imaginary surfaces, which can allow field crews to load the surfaces into their field data collectors and determine penetrations of ground surveyed obstacles in real-time.

3.1.1 Determine Data Age, Quality, and Accuracy Requirements

Existing survey data must first be reviewed for age, data type, and accuracy. In many cases the available existing data will be below current quality thresholds. This does not mean the data is not useful, it can still be useful to help identify areas requiring new survey data. As an example, if existing terrain and imagery indicate that the terrain slopes away without vegetation on one end of the runway, but there is a hill or trees at the other end of the runway, this information can be used to better focus the field teams' efforts.

3.1.2 Existing Terrain Data

Existing terrain data can vary widely in accuracy and resolution (e.g., point density). It is beyond the scope of this document to detail every type of data that might be available for a given airport, but the most common types include:

- US Geologic Survey (USGS) Digital Elevation Model (DEM) data: Available for the entire state of Alaska, however resolution and accuracy are generally poor.

- LIDAR (Light Detection and Ranging) or IFSAR (Interferometric Synthetic Aperture Radar) data: Available in some cases. The accuracy and resolution tend to be much better than USGS DEM data.
- Traditional aerial mapping and/or ground survey terrain data: Available on a case-by-case basis. Data should be verified for accuracy but may provide the best local information for an airport.

3.1.3 Existing Obstacle Data

Existing obstacle data can be developed from a variety of sources. The FAA maintains the official obstacle data for a given airport on the FAA Airport Data and Information Portal (ADIP). This represents the most up-to-date data loaded into the FAA obstacle database and will include any prior aeronautical survey data.

Occasionally there have been aeronautical surveys performed on remote Alaskan airports by FAA that DOT&PF may not have readily available or be aware of. It is worthwhile to work in the FAA data portals to download and inspect this data.

If LIDAR data is available, additional data analysis may be worth the effort. LIDAR “first return” data may have existing obstacle information, which would represent tops of objects and vegetation. This can be a valuable cost savings for airports that have recent LIDAR information.

Depending on the jurisdiction, some boroughs, cities, and towns are conducting their own traditional aerial mapping, drone data, and ground survey data. These may represent sufficient data for a preliminary analysis, and it is worthwhile to coordinate with the local government to determine if there are any adequate datasets.

3.1.4 Existing Land Boundary and Ownership Data

For purposes of obstruction management, land boundary and ownership information is very important in the context of implementing management techniques. Protected airspace usually extends far beyond land owned by the airport. Obstructions that penetrate protected airspace off airport property must be resolved through negotiations with the landowner.

Potential sources of airport boundary layers include acquisition plats and property plans, ALP Property Maps or Exhibit A’s, Recorded Survey Plats, Department of Natural Resources Data, Department of Commerce Community and Economic (DCCE) Community Mapping, and Borough/City Geographic Information Systems (GIS) Maps.

3.1.5 Georeferencing and Coordinate System Conversion Considerations

Georeferencing and coordinate conversions can be one of the biggest challenges when using existing data. It is important to have reliable survey-grade Global Position System (GPS) derived three-dimensional (3D) positions on the runway thresholds, at least three property corners, and a sampling of terrain and obstacles to use as checks on existing data. If this is not available prior to performing coordinate system transformations, it will need to be collected by the ground survey team. Be aware that existing data cannot be verified until this check is performed.

It is also important to understand that in Alaska, even data on the same datum such as North American Vertical Datum of 1988 (NAVD 88), can vary by several feet depending on the method, epoch, and geoid model used to establish it. Only ground survey verification of common control points can determine with confidence what the true vertical relationship is from mixed data sources. Another way to improve the local accuracy of lower quality terrain data, such as U.S. Geological Survey (USGS) digital elevation model (DEM) data, is to apply a datum adjustment to match the grade of the runway or other known vertical terrain data from survey grade sample data.

3.1.6 Verification, Combining, and Parsing of Existing Survey Data

Once transformed, datum-adjusted, and verified against survey grade data, the existing data can be merged and parsed. For most airports, this merging will result in more recent and higher quality data within the airport property and Runway Protection Zones (RPZs), and lower grade data for the outer airspace.

Once data is merged, the information regarding the source, age, and accuracy of the individual data sets can be lost. It is important to keep accurate records of the merging workflow, and keep descriptive information, or metadata, with the merged datasets so that future users understand the limitations of the data.

3.1.7 Desktop Determination of Vegetation Height for Ongoing Monitoring and Maintenance

Once the best available datasets have been merged, a desktop evaluation can take place. If tree top data is not available, an approximation can be made by viewing ortho imagery from common sources such as Google Earth and applying a vertical shift to the terrain data to represent the approximate treetops. This is a rough estimation, but the resulting analysis can provide areas of penetration, or areas of interest, that can then be targeted for a combination of ground survey and aerial/drone survey to collect accurate data.

3.2 COLLECTING NEW SURVEY DATA

3.2.1 Determining Scope of New Survey Data Collection

It is important to limit the scope and budget of new survey data collection to that needed for obstruction management. This typically focuses on those portions of airspace falling within airport property and the runway protection zones. The specific imaginary surfaces evaluated will thus be limited to the primary, transitional, certain portions of horizontal, and the inner portions of the various approach and departure surfaces. For some airports, scope may be further limited by including only those obstacles falling within a specific height above the airport, or limited to a specific distance from runway, depending on the specific circumstances and funding availability.

3.2.2 Optimizing Field Methods for Single-Trip Data Collection

Data collection needs to be planned beforehand to limit the costs of each effort. When determining the best method of collection, consider the required accuracy and efficiency of operations. For example, drone sensors may not meet the desired accuracy requirements of certain critical airport features, such as thresholds, and man-made obstacles requiring obstruction lights. So, drone surveys often need to also include ground surveys. Best-practice is to use ground surveyed positions of these critical features as a sample dataset and quality control of the drone derived positions. This method ensures precise and redundant 3D positioning. Sending a small cross-trained team that can do both ground and drone surveys can result in significant cost savings.

3.2.3 Methods of Data Collection

Obstacle height is a combination of vegetation/obstruction height and terrain height. It is therefore important to have a base terrain height layer to build the vegetation height estimations and models onto.

Methods for collecting these heights can include satellite or airborne interferometric synthetic aperture radar (IFSAR), aerial LIDAR, drone LIDAR, drone RGB (red, green, and blue) camera, traditional aerial mapping, and ground survey. While each of these methods is available, drone LIDAR, a drone RGB camera, and ground survey are likely the most cost effective for the limited areas of interest involved in this analysis.

3.2.4 Survey Control, Horizontal and Vertical Datums, and Coordinate Systems

It is critically important to begin each ground and drone survey with Global Navigation Satellite System (GNSS) derived Online Positioning User Service (OPUS) positioning and/or checks of airport control to verify the 3D accuracy within the National Spatial Reference System (NSRS). OPUS provides reliable positioning, typically within about 3-centimeter accuracy, relative to the National Oceanic and Atmospheric Administration (NOAA) Continuously Operating Reference Stations Network, managed by NOAA/National Geodetic Survey (NGS).

As of March 2021, the current FAA/NGS specified horizontal datum is NAD83(2011) (epoch 2010.00), and the vertical datum is NAVD88 using Geoid12B (Alaska). All new survey data should be referenced to these, or more current, datums.

It is up to DOT&PF to choose what map projections to use for each airport. The pros and cons of various map projections are outside the scope of this document; however, it would be most efficient to use coordinate systems with definitions available in the coordinate systems libraries of the technicians performing the analysis. The most common coordinate systems used in Alaska historically has been the Alaska State Plane Zones. Local projections such as Low Distortion Projection (LDP) coordinate systems can offer advantages in better matching of distances with true ground distances.

3.2.5 Ground Survey of Critical Airport Information

It is critically important to survey the runway thresholds, the runway profiles, and the navigational aids using precise ground survey methods. Accurate data is required to build spatially accurate imaginary surfaces. The grade of the runway centerline profile and positions of the visual aids are needed to generate accurate imaginary surfaces and to establish runway siting surfaces. These ground-surveyed critical features are ideal points to use as quality control checks of drone or aerial collected survey data.

It is important to remember that historic publications, such as ALP sheets, can have erroneous geographic coordinates. Updating the critical airport information with a ground survey can be an important quality control element of the program.

3.2.6 Discussion on Final Location of Thresholds

Special consideration should be given to the possibility of non-standard runway lighting and/or runway markings. With respect to inboard and outboard threshold lights, standard FAA guidance using trimlines and offsets per FAA AC 150/5300-18 does not always apply to Alaskan airports. Many Alaskan gravel runways have turnaround-taxiways with outboard lights and placing thresholds in-line with outboard lights per AC 150/5300-18 can result in runways that are too long and RPZs that are too short. It is critically important to always include a review of surveyed thresholds with airport engineering, airport planning, and the FAA to ensure their concurrence. Placing the thresholds incorrectly can have adverse impacts on the airspace analysis and operational safety of the runway.

3.2.7 Surveying of Land Boundary Data

Often the historic airport boundary plats and property plans are referenced to a historic basis of bearing and may be on a local ground coordinate system. While a retracement survey is needed for a survey grade boundary, in this case three or more corners surveyed using GPS will usually be sufficient to translate and rotate the record boundary geometry to achieve enough spatial accuracy to delineate ownership for obstruction management activities.

3.3 DRONE SURVEY

A cost-effective alternative to traditional aerial survey techniques, or crews on the ground, is the implementation of drone surveys. Imagery and other sources of data acquired from drones can be processed into digital elevation models that can be used to derive a surface model for the project site, as well as extract values for tree canopy height and other airport obstruction heights. Furthermore, the quality of these derived products can inform vegetation obstructions at the species level. Drones are safe to use when flown by a competent licensed FAA Part 107 pilot, are easily portable, and are increasingly becoming more affordable.

The application of drones for mapping and monitoring airport obstructions will require compliance with the DOT&PF Unmanned Aerial Systems (UAS) Operations Manual and coordinating with the existing DOT&PF UAS Steering Committee. Currently, only DOT&PF surveyors are authorized to perform drone operations under the existing FAA Certificate of Authorization (COA) assigned to DOT&PF. The DOT&PF

Northern Region employs several competent pilots and has access to a fleet of drone tools to complete this work, which include:

- Phantom 4 RTK with 1-inch complementary metal oxide semiconductor (CMOS) camera,
- M300 RTK with Zenmuse P1 camera and Zenmuse H20T sensor (a Livox sensor is currently under testing),
- eBeeX RTK with S.O.D.A. 3D camera.

For the purposes of identifying airport obstructions under 500 acres, any combination of the above tools is effective for monitoring and capturing real-time growth rates and encroachment of obstructions at DOT&PF airports. The kinematic capabilities for each of these tools provides real-time centimeter-level positioning data for improved absolute accuracy on image metadata and reduces the quantity of ground control targets needed, thus increasing the efficacy of surveys.

3.3.1 Field Implementation

Criteria to consider when choosing the correct aircraft is that the eBeeX is a fixed wing aircraft and would have the greatest flight time availability but will require a swatch of space suitable for a safe landing. The Phantom 4 and M300 RTK systems are multirotor aircraft and will have less flight time in comparison to the eBeeX but will have more flexibility for take-off and landing locations.

The general workflow for these applications may require the field/aerial survey staff to set up a base station that can be linked to the aircraft. It is highly recommended to have ground surveyed control targets for quality control purposes. It is recommended to strategically place targets close to the ground of priority vegetation monitoring areas without compromising vertical visibility. Given that DOT&PF is primarily focused on obstructions, it is recommended to fly a “cross-hatch” pattern to produce the best results of obstruction distribution.

3.3.2 Data Analysis

Once all data is collected, a “rover” file, which is from raw satellite data, can be retrieved from the drone memory card and the “base” file, which is typically the nearest base station relative to the flight, can be used to correct the positions of the data collected. The corrected data can be applied to adjust the location of the actual drone sensor/camera at the exact time that the photo was captured.

Once the field data is collected and processed, DOT&PF can use their preferred photogrammetry software to produce a suite of products including orthomosaics, digital surface models, 3D meshes, and 3D point clouds of the site for their monitoring needs.

3.3.3 Subcontracting

The operations of drones at airports by private companies is not widely allowed by the FAA and, as such, very few private companies have experience in doing so. Any contractor operating on behalf of DOT&PF will be expected to have similar capabilities to DOT&PF (e.g., necessary equipment, software, workflows, training, proper certification, visual observers). The subcontractor will need to be experienced at gathering and delivering adequate data, using the DOT&PF UAS Operations Manual, and implementing safety plans for safely operating drones within the National Airspace System. DOT&PF should also expect subcontractors to know:

- Notices to Airmen
  - How to read and understand them
  - The local airport's expectations for creating and issuing them for drone airport operations
- Communicating with Air Traffic Control
  - How to contact the pertinent entity for the location at which they are operating (i.e., Are they operating at an Air Traffic Control Towered airport? Are they operating at an Air Route Traffic Control Center controlled airport? What is the general operating frequency of the airport? What is the Common Traffic Advisory Frequency (CTAF) for the airport?)
  - How to contact the correct air traffic controller for an emergency in active airspace.
- The use of radios
  - Contractors using the airspace must maintain a 20-30-minute update schedule on the local airspace radio frequency throughout the operation.

These are prerequisites that will ensure the safe operation of drones within active airports. Any contractors should be vetted to ensure that certified FAA Part 107 pilots meet these criteria in addition to any knowledge required for the monitoring of vegetation obstructions.

4.0 GEOSPATIAL PROCESS

After survey or photogrammetry data has been collected, it must be analyzed and compared to 3D computer models of the Part 77, TERPS, and various other surfaces, that can be developed for each airport. This analysis assigns elevations to all of the protected airspace surfaces and compares them to the identified object elevations. The comparison of elevations between the protected airspace surfaces and the tops of the obstructions/vegetation allows for a determination of the location and extent of surface penetrations. A buffer is applied to account for future vegetation growth. For example, woody vegetation within ten feet of protected airspace might be expected to become a penetration.

Geospatial analysis is often overlooked or integrated into the responsibilities of a field survey team. Airport obstruction analysis is a distinct subset of geospatial skills and can highly benefit from teams experienced in completing this work.

4.1 COMPUTER-AIDED DESIGN (CAD) ANALYSIS

4.1.1 Pros/Cons of CAD (Civil3D) Analysis

The majority of work performed on Alaskan airports has traditionally been in CAD, and the current version of CAD used by DOT&PF is Civil3D. Civil3D is used by engineers for creating design plans, and by aviation planners for creating and updating ALPs. Survey data deliverables are most often prepared using Civl3D as well, so this makes Civil3D a convenient and suitable environment for performing airspace analysis. The type of analysis commonly performed in Civil3D can be described as “vector” analysis. Obstacles are stored as individual XYZ points, and terrain is stored as Triangular Irregular Networks (TINs). Civil3D is less commonly used for GIS based “raster” analysis. Aeronautical Survey data is maintained by the FAA in a GIS format as well, so work in CAD will likely require some conversions of data formats.

4.1.2 Building Imaginary Surfaces

The imaginary surfaces can be created in Civil3D, using 3D feature lines and offsets to construct TIN surfaces for each imaginary surface. Automated methods can be utilized as well, including CAD scripting languages such as LISP (list processing). Once created in Civil3D, imaginary surfaces can be exported in LandXML format, then imported and used in other software packages, such as GIS.

4.1.3 Terrain Analysis

Once imaginary surfaces have been created in Civil3D, obstruction analysis can be easily performed. If performing terrain surface analysis, the areas of penetration (i.e., obstruction areas), can be displayed by creating a volume surface between the imaginary and terrain. The zero contour of this volume surface is the perimeter of obstruction areas, that can be hatched. The contours of the volume surface represent the magnitude of penetration.

4.1.4 Obstacle Analysis

Individual obstacle points can be evaluated by performing stepwise workflow. Points can be resaved, adding a consistent value to obstacle point numbers to differentiate them later, extracting elevations from imaginary surfaces to the points, and then exporting the modified points to a spreadsheet. In the spreadsheet the surface extracted point elevations can be subtracted from the original points elevations, resulting in the penetration value.

While straightforward, this method can be cumbersome when analyzing several different imaginary surfaces. GIS and scripting languages can automate and simplify the process (Section 4.2).

4.1.5 Vegetative Obstruction Areas Analysis

The method for determining tree penetrations in Civil3D is similar to terrain and point penetration analysis described above and depends on the source data. If reasonably accurate estimates for tree heights are known, and a terrain surface already exists, then a copy of the terrain surface can be renamed to represent the approximate tree canopy, and the surface raised by the approximate tree height. A volume surface between this and the imaginary surfaces will represent penetration values of the calculated tree canopy surface. If individual trees have survey positions, then the standard obstacle analysis method described above can be used. Both methods are recommended to increase quality control.

4.2 GIS ANALYSIS

4.2.1 Pros/Cons of GIS Analysis

GIS allows for raster analysis, vector analysis, or a hybrid of the two methods. For example, GIS analysis can incorporate vegetation growth models over large geographic areas. This type of modelling will typically be performed using raster format, where DEM terrain layers are stored using square pixels. DEM surfaces are typically displayed in GIS software as color images with surface shaders. GIS DEMs can also be displayed using traditional contours much like in Civil3D, or a combination of color shaded image and contours. The 3D analyst extension of Environmental Systems Research Institute (ESRI) ArcGIS is primarily a raster surface toolset.

The disadvantage of using rasters for modeling imaginary surfaces, terrain surfaces, and tree-canopy surfaces, is that file sizes tend to be much larger than vector-based formats used in Civil3D.

4.2.2 Software Options

There are numerous GIS software options, however, the two most used in Alaska by DOT&PF and DOT&PF’s consultants will be discussed in this section. The first option is ESRI ArcGIS. There are many geoprocessing tools available in the ArcGIS Toolbox that can be used to perform both raster and vector obstruction analysis. ESRI software also comes with the ArcPy, a site package that allows for use of the very powerful and free Python scripting language (Section 4.2.7). Aviation-specific add-on packages are also available for an additional fee for streamlining the obstruction analysis.

Another commonly used option is Blue Marble's Global Mapper software. Global Mapper provides a user interface that is considered more intuitive for users who have not worked within ArcGIS extensively, and it is also a less costly option compared to ArcGIS.

4.2.3 Building Imaginary Surfaces

The method for building imaginary surfaces in GIS is similar to Civil3D, however GIS does not provide as efficient a geometry editing environment as CAD. Many users prefer to perform geometry editing in Civil3D, then export the imaginary surfaces in LandXML format, then import these into GIS. Others will rely on add-on aviation packages that offer "off the shelf" tools for airspace analysis. Once the vector TIN surfaces have been built, they can be readily converted to DEM rasters for use in vegetation modelling.

4.2.4 Terrain Analysis

Surface analysis within GIS will be similar to Civil3D analysis, using the 3D analyst geoprocessing extension within ESRI ArcGIS to subtract the imaginary surface from the terrain surfaces. This analysis can be in either vector TIN format or in Raster DEM format. Raster DEM format is preferred as it allows for the application of growth modeling and forecasting tools over large regions. Color shaded images or "heat maps" can be created showing penetration of the tree canopy over time.

4.2.5 Obstacle Analysis

Point feature obstruction analysis within GIS will be similar to Civil3D analysis, using such ESRI geoprocessing tools as InterpolateShape_3d, AddField_management, UpdateCursor, and JoinField_management. These tools can be used to add and populate penetration and imaginary surfaces height fields to point feature classes, thereby analyzing multiple surfaces against a single obstacle point feature class that represents a surveyed dataset. During this analysis, the Near_analysis tool can be used to generate station and offset values for each obstacle point as well. The output of this analysis can be exported to an ASCII file using the ExportXYv_stats tool, and then a formatted spreadsheet can be used to keep track of and sort obstacles in most-adverse order for each surface analyzed.

4.2.6 Vegetative Obstruction Areas Analysis

The simplest method of vegetation obstruction analysis would be a snapshot analysis, where the vegetation layer at a given moment of time is analyzed. GIS provides more sophisticated growth modelling algorithms that can be used to estimate the changes in airspace penetrations over time. As information on growth rate and forest stand type is refined over time, the models become more accurate. This future modeling ability is the strongest advantage for GIS over Civil3D.

4.2.7 Automation of GIS Analysis

With the advent of the ESRI ArcPy site package, Python scripting has become an efficient means of leveraging the power of ArcGIS analysis. Many geoprocessing tools can be run in sequence and combined with geometry calculations to streamline tasks such as obstruction analysis. In the simplest form, each manually run geoprocessing step within ArcGIS can be saved as a "Python snipit", and eventually combined into powerful and functional programs. Using such tools also allows for the entire geoprocessing methodology to be documented for future reference, eliminating many chances of user error during the processing workflows.

4.3 DATA FORMAT CONVERSIONS

4.3.1 CAD to GIS, and GIS to CAD

The processing described in Chapter 4 is a synopsis of most commonly used methods with commonly used software options. There is significant overlap in functionality with all the software options listed, so precise workflows depend largely on the familiarity and efficiency of technicians assigned to the project. As an example, the majority of geoprocessing tools found in ArcGIS can also be found within the Planning and Analysis Civil3D workspace. With this interoperability, there will almost certainly be a requirement to export/import data between the CAD and GIS environments. Two of the most common GIS export utilities in Civil3D are the Export to LandXML tool, and the Map Export tool. Two of the most common import tools within Civil3D are the Create Surface from DEM tool, and the Map Import tool. Within ArcGIS the LandXMLToTin_3d and the ExportXYv_stats tools are very useful in data conversions.

Global Mapper software is known for the ability to import and export a vast array of GIS and CAD file formats. Another key feature of Global Mapper is the ability to easily resample and/or reproject data files so that they can be brought into CAD. This can require much smaller file sizes than GIS software.

4.3.2 Common File Types for Raster Data Sources

Probably the most universal file format for storing and displaying raster DEM files is the TIF file format. This format is equally functional in Civil3D, ArcGIS, and Global Mapper. Native raster formats within ESRI such as ESRI Grid and Geodatabase Raster, or add-on Civil3D formats such as MrSID may offer advantages in program efficiency but will require file conversion to utilize in non-proprietary software packages. While there are many other proprietary formats, data life and future useability should be considered. TIF format is universally excepted format that has been used successfully for the last several decades, while proprietary formats may have come and gone.

4.3.3 Point Cloud Formats and Conversions

When analyzing LIDAR data, the common file type is LAS (LASer). This file type can be imported for processing in Civil3D, ArcGIS, and/or Global Mapper Platforms. As with the airspace analysis workflows, user familiarity and efficiency will be important in choosing which software to use for LIDAR workflows. When working with LIDAR data, a very important concept is the classification of the point cloud data. Classified LIDAR data includes Bare Earth or Ground points, and First Return or Canopy points, and Water. The First Return or Canopy classification typically represent obstacles such as the tops of trees, buildings, poles, and towers. If working with raw LIDAR, users will need to become proficient in the classification workflow. Historically, LIDAR classification has been a specialty within the aerial mapping profession, however this skill is now also being utilized by drone users who employ LIDAR sensors.

4.3.4 Raster to Vector, Vector to Raster Conversions

As described above, a very common and useful workflow will be to create airspace imaginary surfaces in the Civil3D environment, then export them as either DEM raster surfaces, or as LandXML DTM surface files that can be used within ESRI software. These files can be utilized in their native vector DTM vector format or converted to raster DEM format for display as color shaded images and for more advanced 3D modeling of tree growth over time.

5.0 VEGETATION SPATIAL DATABASE

Vegetation is one of the most common airspace obstructions and requires regular maintenance to keep growing trees and shrubs out of protected airspace. This chapter describes the development of a vegetation management-focused spatial database in GIS. This spatial database is designed to provide project planners a tool to determine the types of vegetation communities involved in potential management activities at airport facilities across the state. Based on the vegetation communities present (e.g., mixed alder and cottonwood), and other environmental factors (e.g. wetlands) airport managers can plan vegetation management options (e.g., cut and chip alder, top and girdle cottonwood), estimate levels of effort, and schedule/budget tasks to meet project goals.

It is important to note this spatial database is a planning-level management tool and will not capture all of the site-specific vegetation and environmental dynamics.

5.1 VEGETATION AND LANDCOVER MAPPING

The Alaska Vegetation and Wetland Composite (Boggs et al. 2019) represents the best-available state-wide vegetation data. It is derived from 28 regional land cover maps developed over the last 31 years. This 30-meter pixel composite vegetation land cover data are classified to Level IV of Alaska Vegetation Classification (Viereck et al. 1992) and describes 343 coarse scale, and 2,756 fine scale, vegetation classifications. This dataset also includes wetland mapping from National Wetland Inventory (NWI) Wetland and Deepwater Classifications (Cowardin et al. 1979).

5.1.1 Vegetation Functional Classifications

The state-wide vegetation classifications have been created for a professional audience of botanists. The hundreds of classes are unnecessary for planning level vegetation management and may hinder understanding for non-specialists.

To facilitate planning-level discussions and scoping of vegetation management activities at rural airports, the 343 coarse functional classifications were functionally grouped into four classes: Forest, Tall Shrub, Low Shrub, and Minimal (Table 1).

Table 1 Functional Classifications

Functional Classifications	Description	Course Classification Example
Forest	Dominant mature trees	Closed Sitka Spruce
Tall Shrub	Dominate shrubs > 5 ft	Alder (Closed) (Southern Alaska)
Low Shrub	Dominate shrubs < 5 ft	Low Betula nana
Minimal	Minimal management activities necessary. Heights < 3 ft	Herbaceous (Mesic) (Southern Alaska)

These four functional classifications are intended to be more user friendly and help correlate to specific management practices discussed later in this report. The more detailed coarse and fine scale classifications remain in the database to allow a fuller vegetation dataset to be used, when desired.

5.1.2 Ecoregions

Due to Alaska's sheer size, vegetation grows in several types of ecoregions. These ecoregions can influence vegetation growth, and the frequency it may need to be managed. Nowacki et al. (2001) defines 32 ecoregions, based largely on their vegetation patterns, climatic patterns, and geologic setting and processes. These 32 ecoregions are further grouped into three broad geographic ecoregions:

- Polar
- Boreal
- Maritime

These three ecoregions are used in combination with the functional classifications to provide a distilled, user friendly data analysis for vegetation management.

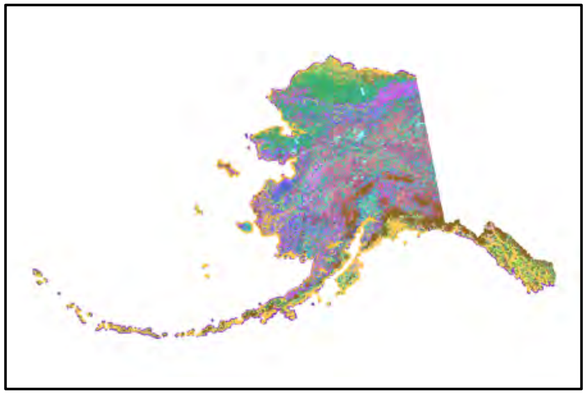
The following figures (Figure 3 – 11) illustrate the workflow process used to distill the statewide vegetation and ecoregion datasets into practical airport information. Figure 3 is the Statewide Alaska Vegetation & Wetland Composite symbolized for the 343 coarse scale vegetation classifications. Figure 4 is the same statewide vegetation data, simplified to four functional classifications (i.e., Forest, Tall Shrub, Low Shrub, Minimal).

Figure 5 depicts the Alaskan ecoregions. Figure 6, 7, and 8 are the functional classifications for each ecoregion. It is of interest to that the Polar ecoregion in particular has a large quantity of 'minimal' functional classifications.

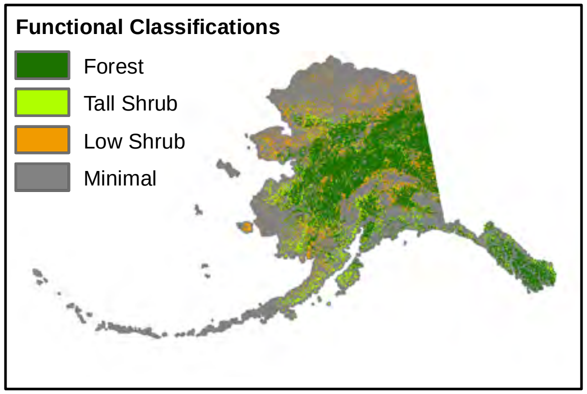
Figure 9 shows the DOT&PF airports in Alaska.

To provide an example of what the classification looks like at a representative rural airport, Figure 10 and 11 show zoomed in views of the Chelatna Lake Airport. It becomes evident at this scale that the vegetation mapping has taken place on 30-meter pixels.

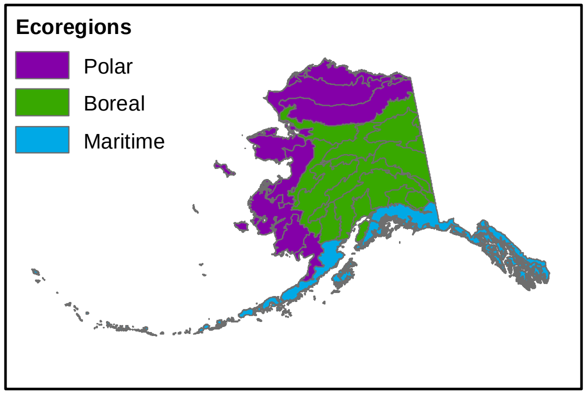
Inside the accompanying ArcGIS data, the vegetation data has been further refined as described in Section 5.2.



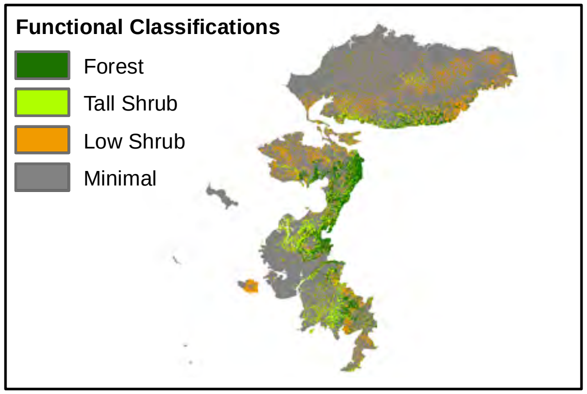
3. Statewide Alaska Vegetation & Wetland Composite



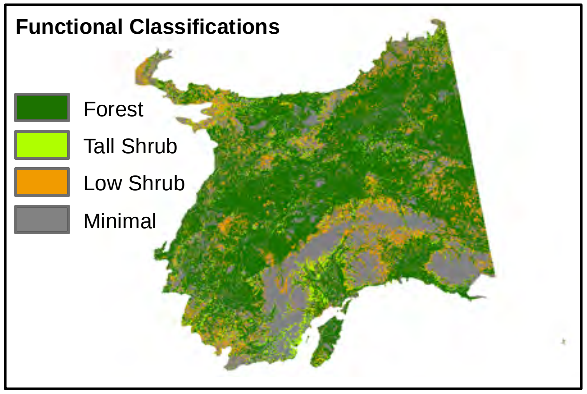
4. Reclassified Composite (Forest, Tall Shrub, Low Shrub, Minimal)



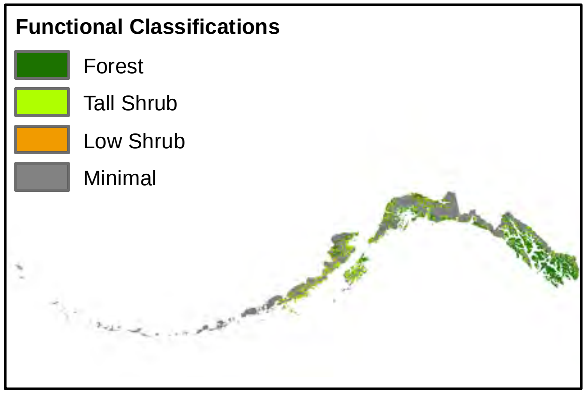
5. Statewide Ecoregions (Polar, Boreal, Maritime)



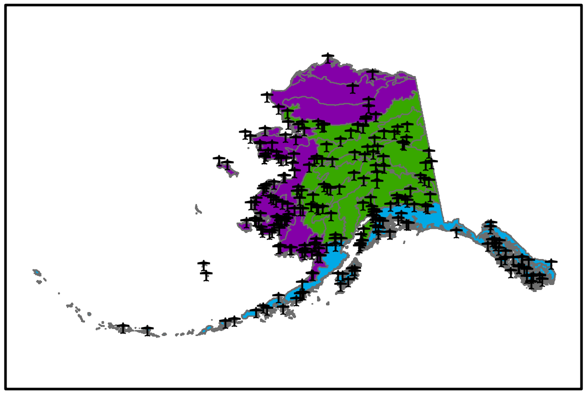
6. Reclassified Composite for Polar Ecoregion



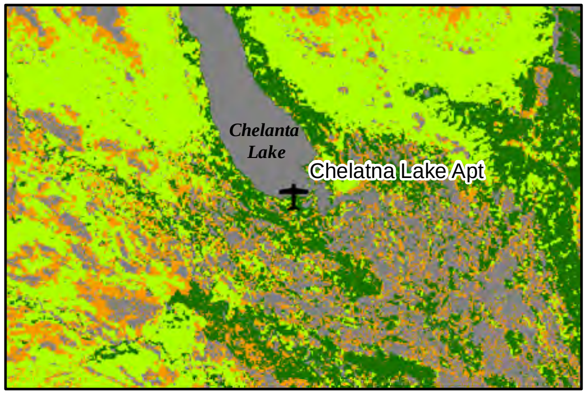
7. Reclassified Composite for Boreal Ecoregion



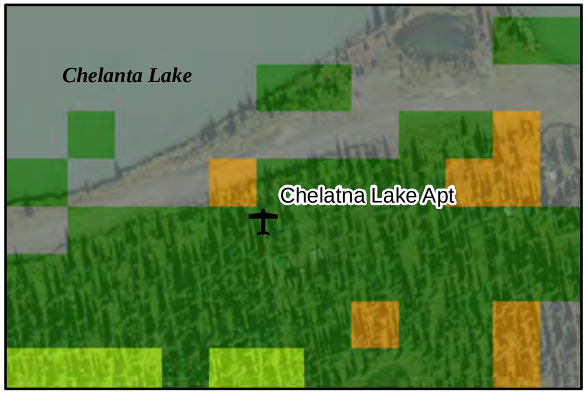
8. Reclassified Composite for Maritime Ecoregion



9. DOT&PF Airports in Alaska



10. Reclassified Vegetation at Chelatna Lake Airport



11. Zoomed- In Reclassified Vegetation at Chelatna Lake Airport

5.2 VEGETATION GROWTH

The vegetation mapping provides an estimate of dominate species surrounding airports in rural Alaska.

Height estimates and growth rates of dominant species for climax communities were also developed from available forestry and botany research. This provides valuable planning tools for obstruction management programs. Low Shrub and Minimal functional classifications were not included in these estimates due to their minimal impact on airspace obstructions.

To determine the average maximum height of dominant species in a climax community, each Forest and Tall Shrub coarse vegetation class was reviewed for the dominate species (Viereck et al. 1992, Boggs et al. 2019). Table 2 provides the average maximum height those species would grow in a climax community (Viereck et al. 1992, Boggs et al. 2019). These heights are planning level estimates. Actual heights will vary due to site conditions and the age of the stand. Importantly, individual plants in a stand may significantly exceed these average heights. This metric in intended as a useful planning level guide for programmatic decision making.

Determining growth rates for vegetation classes is more difficult due to a number of factors. First, site variability has a major determinant on the speed of vegetation growth. Slope, aspect, and other local conditions highly influence available moisture, nutrients, and sunlight, even at small scales. For example, willows may grow significantly faster on a gentle south-facing slope relative to a steep north-facing slope.

Second, vegetation grows at different rates over their life stage. Almost all published growth estimates are for seedlings and the initial 1-3 years of ‘juvenile’ growth (Table 3). Additionally, freshly cut vegetation can experience very high rates of growth, as root systems and soil nutrients are used for fast growth.

This report focuses on growth estimates for seedlings and juvenile growth, as they are the most useful for airport vegetation managers. These rates provide valuable planning tools to estimate the frequency of return for maintenance and operations. It is important to note that actual growth rates will be different for an individual airport. Tracking vegetation height changes through the DOT&PF’s airport inspection program will allow these growth rates to be calibrated with local data.

The maximum height and growth rate information is incorporated into the GIS database, to allow planners to analyze vegetation size information for particular airports. Since this is a planning exercise, the heights and growth rates have also been rounded to accommodate cross habitat comparisons.

For airport operations, the most important finding is to emphasize the dramatic growth that Tall Shrubs can experience after clearing. Alders and willows can grow 2 - 8 feet per year in ideal environments (Table 3), particularly with well-established root systems. This can have significant implications for obstruction management.

With the high resolution of plant community mapping, it was not necessary to correlate growth rates based on ecosystems. The mapped plant communities are regionally specific, for example hemlock grows in Southeast Alaska, and black spruce grows in Interior Alaska. Since the stand specific literature presented in Table 2 and 3 is derived from the same ecosystems, the growth rates are already tailored to the local communities.

Table 2 Coarse Classifications' Dominant Species and Growth Rate

	Aspen	Balsam Poplar	Black Cottonwood	Paper Birch	Mountain Hemlock	Western Hemlock	Sitka Spruce	Lodgepole Pine	Western Red Cedar	White Spruce	Black Spruce	Alder	Willow
Initial Seedling Growth Rate (ft/year)	2	1	2-5	2	Slow	1-2	Slow	2	2-8	2"	2"	1-6	2-8
Average Maximum Height (ft)	48	30-100	100-160	20-60	75-100	100-150	210	45-150	100-130	80-100	30-35	10-40	5-65
Deciduous Forest (Open-Closed)	X	X	X	X									
Deciduous Forest (Open-Closed) (Seasonally Flooded) (Southern Alaska)		X	X										
Deciduous Forest (Woodland-Closed) (Southern Alaska)	X	X	X	X									
Hemlock (Woodland-Closed)					X	X							
Hemlock-Sitka Spruce (Woodland-Closed)					X	X	X						
Needleleaf Forest (Open-Closed) (Seasonally Flooded) (Southern Alaska)		X	X				X						
Needleleaf Forest (Woodland-Closed) (Southern Alaska)								X	X				
Needleleaf Forest (Woodland-Open) (Peatland) (Southern Alaska)					X	X	X						
Sitka Spruce (Woodland-Closed)							X			X	X		
White Spruce or Black Spruce (Open-Closed)										X	X		
White Spruce or Black Spruce (Woodland)										X	X		
White Spruce or Black Spruce/Lichen (Woodland-Open)										X	X		
White Spruce or Black Spruce-Deciduous (Open-Closed)		X		X						X	X		
Low-Tall Shrub (Southern Alaska)												X	X
Tall Shrub (Open-Closed)												X	X

**Table 2 Citations:

Aspen: Howard, Janet L. 1996.
Balsam Poplar: Burns, R.M. and Honkala, B.H., 1990; Harris, Holly T. 1990
Black Cottonwood: Oregon Wood Innovation Center. 2021; Steinberg, Peter D. 2001.
Paper Birch: Uchytil, Ronald J. 1991a.
Mountain Hemlock: Burns, R.M. and Honkala, B.H., 1990; Tesky, Julie L. 1992b.
Western Hemlock: Tesky, Julie L. 1992c.
Sitka Spruce: Burns, R.M. and Honkala, B.H., 1990; Griffith, Randy Scott. 1992
Lodgepole Pine: Burns, R.M. and Honkala, B.H., 1990; Anderson, Michelle D. 2003
Western Red Cedar: Burns, R.M. and Honkala, B.H., 1990; Tesky, Julie L. 1992d
White Spruce: Abrahamson, Ilana. 2015.
Black Spruce: Fryer, Janet L. 2014.
Alder: Oregon Wood Innovation Center. 2021. Fryer 2011; Matthews, 1992; Uchytil 1989a,b;
Willow: Alaska Department of Natural Resources and United States Department of Agriculture. Undated; Anderson, Michelle D. 2001; Esser, Lora L. 1992a, b, c; Fryer 2015; Innes, 2014; Tesky, Julie L. 1992a; Uchytil, Ronald J. 1991b; Uchytil, Ronald J. 1992a, b

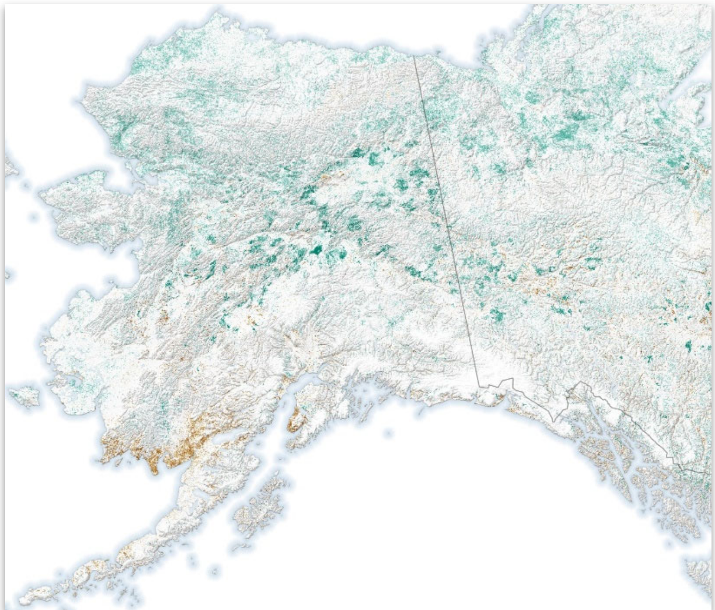
Table 3 Summary of Maximum Height and Growth Rate

Coarse Vegetation Class	Average Maximum Height (ft)	Initial Seedling Growth Rate (ft/yr.)
Forest		
Deciduous Forest (Open-Closed)	160	2 - 5
Deciduous Forest (Open-Closed) (Seasonally Flooded) (Southern Alaska)	160	2 - 5
Deciduous Forest (Woodland-Closed) (Southern Alaska)	160	2 - 5
Hemlock (Woodland-Closed)	150	2
Hemlock-Sitka Spruce (Woodland-Closed)	210	2
Needleleaf Forest (Open-Closed) (Seasonally Flooded) (Southern Alaska)	210	2 - 5
Needleleaf Forest (Woodland-Closed) (Southern Alaska)	150	2 - 8
Needleleaf Forest (Woodland-Open) (Peatland) (Southern Alaska)	210	1 - 2
Sitka Spruce (Woodland-Closed)	210	1/6 (2 in)
White Spruce or Black Spruce (Open-Closed)	100	1/6 (2 in)
White Spruce or Black Spruce (Woodland)	100	1/6 (2 in)
White Spruce or Black Spruce/Lichen (Woodland-Open)	100	1/6 (2 in)
White Spruce or Black Spruce-Deciduous (Open-Closed)	100	2
Tall Shrub		
Low-Tall Shrub (Southern Alaska)	65	2 - 8
Tall Shrub (Open-Closed)	65	2 - 8
Low Shrub	5	N/A
Minimal	3	N/A

5.2.1 Vegetation Growth Changes into the Future

While it is difficult to know the precise rates at which vegetation will change in height at rural airports in Alaska, extensive research has been done to understand how vegetation may change in response to climate. For example, Potter and Alexander (2020) used satellite imagery to develop state-wide vegetation productivity indices (e.g., Normalized Vegetation Difference Index). Their research revealed that many parts of the state have increasing vegetation cover while other parts, particularly the southwest, have significant decreases in vegetation cover over the last two decades (see Figure 12).

Figure 12 Changes in Vegetation Cover and Productivity (Potter and Alexander, 2020)



Note: Green values indicate increases in vegetation cover and productivity while brown values indicate loss of vegetation cover and productivity.

Approximately 13% of Alaska has undergone some environmental change between 1984 and 2015 with the majority of change observed in lowlands, coastal, riverine, and boreal ecosystems (Pastick et al. 2019). In particular, some boreal forest sub-regions of the state have experienced a decrease in evergreen tree cover and an increase in deciduous tree cover, in addition to expansion of shrub and herbaceous vegetation above tree lines (Potter and Alexander, 2020). For example, the presence of tall shrub cover has significantly increased from above 600-meter elevation to about 750-meter at the western end of the Chugach–St. Elias Mountains near Anchorage (Potter and Alexander, 2020; Dial et al. 2016). The western Kenai Peninsula on the Cook Inlet has also experienced a rapid introduction of woody vegetation into wetlands while peatlands have become dry enough to host black spruce and woody shrubs in the past 70 years (Berg et al. 2009; Potter and Alexander, 2020).

More generally, earlier seasonal vegetation greening (sometimes more than one day per year) and seasonal productivity has been observed between the years 2000 and 2018 in the northeastern Brooks Range Mountains, the southern coastal areas of Alaska, and the western Arctic Coastal Plain (Potter and Alexander, 2020). In contrast, earlier detected vegetation greening but lower seasonal productivity has been observed in the watersheds of Bristol Bay and in the Cook Inlet lowlands of southwestern Alaska (Potter and Alexander, 2020). Significantly later vegetation greening (sometimes more than one day per year) has been observed within areas burned by wildfires after the year 2000 in the Yukon-Kuskokwim and Interior Alaska Highlands, as well as the Porcupine River, Tanana River, and Lower Kuskokwim River valleys (Potter and Alexander, 2020).

Overall, the region most vulnerable to vegetation change is the Intermontane Boreal, though continued environmental shifts to the Pacific Mountain Transition, Bering Taiga, Alaska Range Transition, Coastal Rainforest, Bering Tundra, Coast Mountains Transition, and the Arctic Tundra are anticipated (Pastick et al. 2019). Climate change projections for Alaska suggest wildfire will be the dominant driver shifting Interior-boreal forests from conifer- to deciduous-dominated forests (Wolken et al. 2011). Warming temperatures in the Southcentral- and Kenai-boreal forests will likely increase the frequency and severity of spruce beetle outbreaks and associated wildfires and influence the establishment of invasive plant species (Wolken et al. 2011, Potter and Alexander, 2020). In coastal-temperate forest regions, hydrologic changes related to more rapidly melting glaciers and rising elevation of the winter snowline will alter discharge in many rivers, which will have significant consequences for terrestrial ecosystem shifts (Wolken et al. 2011).

5.3 MAINTENANCE IMPLICATIONS

State-wide vegetation maps have inherent limitations and can benefit from inclusion of site-specific data. Extensive vegetation research exists in Alaska but focuses on climate change and does not make species specific predications about change in vegetation height. The vegetation mapping, heights, and growth rates provided in the attached database will become more accurate as the DOT&PF update the data with observations in the field. Field observations can provide more robust information on changing vegetation communities and growth rates for more accurate predictions of when vegetation treatments are necessary.

6.0 OBSTRUCTION RECOMMENDATIONS

Vegetation management at public use airports is a continuous process, which can only be successful if the initial removal plan addresses the long-term maintenance needs. Typically, a contractor completes the initial removal of penetrations, while the airport staff completes the maintenance of these areas. The ease of maintenance usually determines the long-term viability of the clearing project. It is consistent and ongoing maintenance that is of primary concern to the airports, since the protected airspace surfaces must be kept clear of penetrations for many years after the initial removal project, and funding is not typically available in the future to revisit these areas.

This section details a “bank” of obstruction recommendations that can be used to manage airport obstructions. This list is not comprehensive, as every potential situation cannot be anticipated for every individual airport. These can serve as general guidelines, which can be modified and adopted to specific airports’ needs.

With proper commitments to maintenance on a regular basis, the need for additional major obstruction management efforts in the future is significantly reduced with an associated cost savings and overall safety benefit for the airport and surrounding areas.

6.1 OBSTACLE MANAGEMENT (NON-VEGETATION)

6.1.1 Obstacle Removal

Description: The preference for all penetrations to protected airspace is obstacle removal. This can include encouraging the removal of powerline poles, cell towers, and other obstructions. Some obstructions, such as buildings or terrain, are more difficult to remove.

Methodology: Obstacle removal methodology and costing would be individually tailored for each situation.

6.1.2 Obstacle Lighting

Description: FAA regulations allow for the use of lights to mark obstructions in lieu of clearing in a limited number of situations. Use of obstruction lights must be reviewed by the FAA to ensure that the lighting will provide for an equivalent level of safety for pilots, passengers and people on the ground in comparison to the removal of the obstruction. Runways with visual approaches may use lighting in the approach surface when the ability to clear the obstructions is unavailable due to environmental, financial, and/or property issues.

Methodology: Obstacle lighting methodology and costing would be individually tailored for each situation.

6.2 INITIAL MECHANICAL REMOVAL

Initial mechanical removal is based primarily on the height of the obstructions relative to the elevation of the protected surface. Where vegetation at shrub height penetrates the navigable airspace, then complete removal of the woody species, typically through mowing, is specified. However, where only trees have the ability to penetrate, selective removal and protection of the shrub layer is specified.

Mechanical methods are preferred to be used only during periods of dry or frozen ground conditions where the tracked or rubber-tired vehicles will not cause disturbance of the soils. This significantly reduces the extent of disturbed ground and minimizes or avoids soil disturbance and reduces the threat of sedimentation.

6.2.1 Upland Removal of All Woody Vegetation

Description: Vegetation includes the full range of upland species and tree size. This removal method is reserved for those areas where even shrub species penetrate the protection zones, and thus maintenance to below shrub level is required for the protection of the airspace.

Methodology: It is recommended that these areas be clear-cut to facilitate long-term maintenance. Removal shall consist of clearing the surface of the ground of the designated areas and disposal of all trees, down timber, logs, snags, brush, undergrowth, hedges, heavy growth of grass or weeds, debris, rubbish of any nature, and natural obstructions. Stumps will be cut flush with the surface of the ground to allow for subsequent mowing of these areas with the appropriate all-terrain equipment.

Equipment to remove vegetation in these areas will include chain saws, mechanical shears, rotary mowers, and large-scale flail mowers that are capable of shredding entire trees. After cutting of vegetation, removal of materials will be completed with skidders, chippers, and small dump trucks where access allows.

Work around wetlands will need to be individually tailored and permitted.

Where size of vegetation allows, and the project desires to mow vegetation, the resultant bark and wood mulch may be allowed to remain on the surface, if in compliance with permitting. No vegetation cut by means other than mowing will be allowed to be chipped directly onto the ground and allowed to remain.

The goal of removal is to establish an herbaceous and/or low shrub layer. Saplings will be subject to periodic removal as part of the long-term maintenance of the areas.

6.2.2 Upland Removal of Vegetation Over 25 Feet High

Description: Effort is focused on the removal of vegetation over 25 feet high.

Methodology: The location of these areas allows for vegetation 25 feet in height or less to remain, which includes the tall/short sapling layers, shrub layer and groundcover. Where it is more efficient to remove smaller trees in the process of removing those over 25 feet in height, the project will be allowed to do so.

Trees less than 25 feet in height, that are damaged during the removal of taller trees, shall also be removed.

Removal shall also include removal and disposal from the project site of all downed timber, logs, snags, debris, and rubbish of any nature.

Work around wetlands will need to be individually tailored and permitted.

The project shall preserve existing vegetation less than 25 feet in height to the greatest extent possible. Removal of vegetation less than 25 feet in height shall be allowed only when necessary to affect the removal of taller vegetation and alternatives of similar effort that protect the low vegetation have been exhausted.

All rutting created by the project's operations shall be regraded. Any rutting and soil disturbance on slopes shall be regraded and stabilized immediately by seeding and mulching as deemed necessary. Seeding specifications must be utilized during the completion of this project.

Clearing will likely be completed using a tracked mechanical shear in combination with a skidder to remove the logs. Typically, staging areas are established within uplands where logs produced by the shear are transported. Since all large debris is to be removed, a chipper will be located in each staging area to reduce branches for transport. No wood fiber from chipping operations will be allowed to remain on the airport property.

6.2.3 Wetland Removal of Vegetation Over 15 Feet High

Description: Includes removal of vegetation taller than 15 feet from delineated wetlands. Limits of wetland areas need to be shown clearly on the plans and be flagged in the field. This work may need to be individually permitted.

Methodology: No ground equipment of any size other than hand-held will be allowed to enter designated wetlands at any time, unless the project can demonstrate that no ground disturbance will occur. Equipment to remove vegetation in these areas may include chain saws, rotary mowers, and large-scale flail mowers that are capable of shredding entire trees.

All cut vegetation shall be removed from the project area and disposed of off airport property. Where size of vegetation allows, vegetation may be mowed (if no ground disturbance will occur), resultant bark and wood mulch may be allowed to remain if in compliance with permitting.

Mowing will not be allowed within wetland areas where an understory growth exists that would be damaged by the mowing of vegetation. Bark and wood mulch will not be allowed to remain on the surface of any open water areas.

After cutting, removal of vegetation from wetland areas shall be performed in a manner that avoids ground disturbance. Hand clearing may be required in areas of wetland soils. Additionally, hand clearing may be required adjacent to stream channels where vehicles may collapse slopes or otherwise harm the stream. Felled trees shall be cut to sufficiently small lengths so that dragging will not disturb the ground surface, or to lengths that will allow for hand carrying. High-lead removal will be allowed, provided that base supports for cables are outside of wetland areas.

The intent is to protect, to the extent practicable, vegetation 15 feet in height or less within or adjacent to wetland areas, resulting in a community of vegetation that continues to provide wetland functions and values, but remains below the FAR Part 77 surfaces with minimal maintenance.

For completion of clearing, mainly chain saws and/or tracked shears will be used to cut the vegetation, with skidders used to transport the debris to upland staging areas when soil conditions allow.

6.2.4 Wetland Removal of Vegetation Over 5 Feet High

Description: Includes removal of vegetation taller than 5 feet from delineated wetlands, allowing only the low shrub and groundcover layers to remain. Limits of wetland areas need to be shown clearly on the plans and be flagged in the field. This work may need to be individually permitted.

Methodology: No ground equipment of any size other than hand-held will be allowed to enter designated wetlands at any time, unless the ground is sufficiently frozen and the project can demonstrate that no ground disturbance will occur. Equipment to remove vegetation in these areas will include chain saws, rotary mowers, and large-scale flail mowers that are capable of shredding entire trees.

Where size of vegetation allows, and the project desires to mow vegetation, the resultant bark and wood mulch may be allowed to remain on the surface, if in compliance with permitting. No vegetation cut by means other than mowing will be allowed to be chipped directly onto the ground and allowed to remain. All cut vegetation shall be removed from the project area and disposed of off airport property.

Mowing will not be allowed within wetland areas where an understory growth exists that would be damaged by the mowing of vegetation. Bark and wood mulch will not be allowed to remain on the surface of any open water areas.

After cutting, removal of vegetation from wetland areas shall be performed in a manner that avoids ground disturbance. Hand clearing may be required in areas where wetland soils are not frozen to a sufficient depth to support the necessary vehicles. Additionally, hand clearing may be required adjacent to stream channels where vehicles may collapse slopes or otherwise harm the stream. Felled trees shall be cut to sufficiently small lengths so that dragging will not damage the ground surface, or to lengths that will allow for hand carrying. High-lead removal will be allowed, provided that base supports for cables are outside of wetland areas.

The intent of this approach is to protect, to the extent practicable, vegetation 5 feet in height or less within or adjacent to wetland areas, resulting in a community of vegetation that continues to provide wetland functions and values, but remains below the FAR Part 77 surfaces with minimal maintenance.

For completion of the clearing, mainly chain saws and/or tracked shears will be used to cut the vegetation, with skidders used for transport of the debris to upland staging areas when soil conditions allow. Work will be completed under frozen ground conditions to reduce or eliminate tire rutting.

6.2.5 Top and Girdle

Description: Areas that have only mature trees as the penetrating vegetation, are not accessible through areas of stable soil, or do not contain stable soils can be selected for Top and Girdle. This variation of the logging technique involves determining how much of the tree is an obstruction, climbing the tree and cutting the top of the tree below the obstruction level. Once the tree has been cut and lopped, the tree is girdled at waist level using a chain saw. Girdling is the process of cutting a ring of bark around a tree's outer circumference (cutting through the cambium). This removes the tree's ability to transport nutrients and liquid from the roots to the branches and leaves and vice versa, and results in the tree slowly dying while remaining standing. The tree is then girdled six inches to one foot above the first girdle.

Methodology: Top and Girdle removal provides for protection of the other vegetative layers as well as the soils. It is considered to be a minimal impact option, since the disturbance is limited to the impact of the trees on the underlying soils and vegetation, the stem density to be cut is typically low, and much of the vegetative community is preserved. No soil or vegetation impacts occur between the management site and the staging site as the felled trees are slashed and left in place. Maintenance is limited to the application of a spot foliar treatment to the stumps to control regrowth.

Partial removal of the canopy while preserving the other vegetative layers is a goal for the Top and Girdle removal. Other removal methods can achieve this result, but with a higher degree of soil alteration or cost. High-lead logging is one concept that has been utilized. It involves the installation of a cable network suspended in the air by poles or other trees. Felled trees are attached to the cable, and then hauled out through the air. While the hauling method does not involve soil disturbance, transport of the logs to the cable area, or the movement of the cable end to the logging area both can involve a higher degree of soil alteration than the slashing and leaving the felled trees in place. Also, the labor involved with constructing the cable system requires that large areas of logs be removed to offset the costs.

6.2.6 Cut and Chip

Description: This removal method is specified where tall shrubs, tree saplings, and small trees are the obstructing vegetation, and preservation of a low shrub layer is an objective.

Methodology: This method will include hand cutting of target woody vegetation in the most sensitive areas. Additionally, this method is specified where soil conditions prohibit equipment access, requiring the hand carrying or cabling of trees to a staging location for processing and removal from the project site. No wood chips will be deposited on the surface of the ground.

Vegetation subject to cut and chip removal is highly selective, and results in the protection of the shrub and groundcover layers.

All native shrubs in these areas are to be preserved and protected to the extent practicable. All downed timber, logs, snags, debris, and rubbish of any nature shall be removed as part of the initial vegetation removal. No equipment will be allowed within wetland buffers unless the project can demonstrate that no soil disturbance will occur. All rutting created by removal efforts will be regraded. Any rutting and soil disturbance that may occur on slopes shall be regraded and stabilized immediately. Where optimal working conditions occur, soil disturbance can be completely avoided.

6.2.7 Drop and Lop

Description: An alternative to Cut and Chip, this method processes the slash in place around the tree.

Methodology: Reduction of slash using chainsaws to moveable lengths is completed, and then the debris is hand-scattered to prevent a mulching effect. This is typically practiced where the targets are within interior locations and it is infeasible to drag the slash the distance necessary for further processing.

This technique can work well when the airport intends to preserve the vegetation but remove selected obstructions over a large area.

All native shrubs in these areas are to be preserved and protected to the extent practicable. No equipment will be allowed within wetland buffers unless the project can demonstrate that no soil disturbance will occur. All rutting created by removal efforts will be regraded. Any rutting and soil disturbance that may occur on slopes shall be regraded and stabilized immediately. Where optimal working conditions occur, soil disturbance can be completely avoided.

6.2.8 Clear and Grub

Description: This method includes removal of all woody vegetation to ground level.

Methodology: Grubbing shall involve the mechanical removal of all root systems, and the entire area will then be graded, topsoiled and seeded. All grubbing debris will be removed from the site. Grubbing within any wetland area is generally not recommended. Erosion control barriers are typically established along the downslope area to protect adjacent wetlands. This removal method can provide for easier long-term maintenance of the area.

6.3 MOWING

6.3.1 Mowing Grass Areas

Description: Mowing in grass areas is a regularly performed airport maintenance operation to maintain those areas in proximity to runways, taxiways, safety areas, and other operational areas of the airport.

Methodology: These areas are mowed to provide clear lines of sight and to prevent woody vegetation from encroaching into these areas. Standard tractor-type equipment is used. Vegetation in these areas is generally maintained at 12 inches or less.

6.3.2 Mowing Woody Vegetation

Description: This removal method is reserved for those areas where even saplings and tall shrub species are able to penetrate the protected airspace, which typically occurs in areas in close proximity to the primary surface, and within the initial section of the approach surface.

Methodology: Mowing is only used where stable soils are present under dry or frozen conditions, or where only a short reach is required over unstable areas to access the target vegetation. Flail mowers can reach approximately 15 feet over unstable areas. Only saplings/shrubs area able to be processed using flail mowing; large diameter trees require removal by some other means prior to applying the flail mowing to remaining vegetation.

Mowing will be performed by mechanical shredding of woody vegetation down to near ground level using a tracked or tired vehicle that exerts low ground pressures. In areas where the establishment of a low shrub layer is proposed, mowing will be restricted to saplings and tall shrubs. Vegetation is converted to a fine, evenly spread mulch. Erosion control barriers are not typically required in these areas however the use of seed and mulch to protect areas with no groundcover is specified. This removal method will result in the re-establishment of a low shrub layer or grassland habitat, and saplings will be subject to periodic removal as part of the long-term maintenance of the areas.

When the occurrence of tree species with a diameter exceeding 6 inches becomes too high, mechanized felling then replaces the flail mowing equipment.

6.4 CHEMICAL VEGETATION MANAGEMENT

Chemical application can be an effective vegetation management in some circumstances. Dominant species within both the upland and wetland areas at airports are capable of rapid re-growth from stumps, stems, and/or root systems. These sprouts have the capacity for rapid growth since the full mature root systems remain in the ground providing the necessary ingredients for growth. Additionally, the sprouts are often multi-stemmed, resulting in more penetrations to the surface than the original vegetative community, and a higher density of stems to maintain. Some of the species capable of this type of re-growth that are commonly found at airports include willow, quaking aspen, and cottonwood.

This maintenance issue has been a problem for many years in various vegetation management situations including power line rights-of-way, roadsides, and railroad corridors. Chemical control of these situations has developed as the preferred method in terms of the intensity of the labor involved, durability of the control, longevity of the application, environmental impacts, and cost. Since these efforts have been ongoing for many years, research and development of the chemical controls have been constant, resulting in a variety of safe and beneficial applications. Additionally, the research has developed a variety of types of these controls with differing properties, allowing for the selection of best suited for the intended situation. Data accumulated over many years regarding these modern herbicide types show that the proper use of chemical methods can provide an efficient means of control while protecting the environment. Chemical methods can prove to be a lower impact, more efficient option than continuous mechanical removal of stems. In general, the use of the chemical control alternative has the following advantages over several mechanical clearings:

- There is an increased longevity of the original vegetation removal since new growth must generate new root systems, as opposed to regrowth utilizing mature and expansive root systems.
- The frequency of mechanical removal (primarily brush mowing) is decreased, thus improving the overall landscape of the site by eliminating stumps, slash, etc.
- Maintenance of the areas is significantly decreased, thus reducing the overall costs of vegetation management over the long term.
- Chemical controls are selective, allowing shrubs and groundcover to remain without injury after the completion of the application.
- Access to the management site is not an issue when chemical applications are used since a backpack sprayer is the common form of equipment used for the application.

With all chemical treatment, it is important that a professional who is licensed in accordance with all applicable state and federal regulations conduct all applications. There are permitting and notification requirements with using herbicides. This person will be responsible for the proper mixing, handling, and application of the product.

6.4.1 Herbicide Foliar Treatments

Description: Foliar treatments are conducted at least one growing season after the initial mechanical or hand removal of vegetation from the target areas. This treatment consists of applying a designated amount of spray (as per the manufacturer’s recommendations) to the regrowth to cover about 50-60 percent of the existing foliage using a low-pressure sprayer.

Methodology: The application is to an individual sprout and is not broadcast over a wide area. It is not necessary to wet the entire plant, thus reducing herbicide volumes. The regrowth should be between 2 and 6 feet in height when treated, with a maximum height of 10 feet. This height range should be achieved during the growing season following the cutting. By spraying after the first growing season, the amount of herbicide used is significantly reduced, thus also protecting non-target species. Typical spray volumes are 15-25 gallons per acre of the herbicide/water mixture. Applications will be conducted during the growing season and during calm conditions to limit the mortality of non-target species.

Work around wetlands may need to be individually tailored and permitted.

6.4.2 Herbicide Cut and Dab Treatments

Description: The application of herbicides to freshly cut vegetation as a cut surface, frill-and-inject, and/or basal treatment.

Methodology: The use of the cut-and-dab technique is specified for the control of certain species or targeted individual plants. This technique involves cutting the target stem using various hand-held equipment then applying a dab of herbicide directly to the cut surface using a nozzle or fabric swab. This method has high target specificity and typically uses low herbicide volumes. The concentration of the herbicide mixture is typically higher than that of the foliar spray, so volumes of the full-strength herbicide used over a given area are comparable between the two methods. It is the low incidence of non-target mortality that makes this an attractive technique for use on the sensitive, off-airport conservation properties.

This technique can have a lower success rate as compared to foliar treatments following at least one season of regrowth. Over the long-term, the improved success of the selected application technique will result in lower herbicide volumes and improved project longevity. Cut surface treatments typically require a more concentrated solution of herbicide (up to a 50 percent solution compared to 7-15 percent solutions for foliar applications). The higher concentrations combined with the lower success rate results in overall higher volumes of herbicide, increased project costs, and more intensive labor. However, the cut surface treatments are considered to have a higher environmental sensitivity due to the high target specificity.

6.5 METHODOLOGIES GENERALLY NOT RECOMMENDED

6.5.1 Push Trees Over / Pull Trees Down

Soil disturbance is excessive, as the root mass is removed from the ground with the attached soil, requires heavy machinery access to each individual tree, and cannot be used in wetland situations since it involves disturbance of the soil. There is high potential for the spread of invasive species when using this technique.

6.5.2 Shear Trees with Bulldozer

While this method allows the root mass to remain in the ground, machinery access to each individual tree is required. A bulldozer exerts force on the soils to remove the tree, increasing the potential to alter the soils as compared to other available methods. Ground pressures developed by a bulldozer are much higher than those for typical logging machinery. Thus, the areas where this technique can be used are limited.

6.5.3 Build an Impoundment

The creation of open water areas to flood the penetrating vegetation in close proximity to aircraft movement areas is contrary to FAA policy since open water resources attract waterfowl that pose a hazard to aircraft. Additionally, the standing dead timber created by flooding often remains a penetration to the airspace and must be removed anyway. Ultimately, this alternative would replace one aircraft hazard (obstructions) with another (wildlife attraction).

7.0 MITIGATION MEASURES

The primary goals of mitigation measures are to:

- Remove identified and potential penetrations to all defined airspace surfaces at the airport in a safe and orderly manner according to the contract documents, environmental permits, and all applicable state and federal laws and regulations.
- Conduct obstruction management in a manner that protects all sensitive environmental resources (e.g., wetlands, bird habitat), requires minimal maintenance, and does not become a future penetration.
- Be sensitive to stakeholders of the airport who may be affected by any change in the vegetative community.
- Control the spread of existing nuisance plant species through a combination of project timing, methodology, and restoration.
- Protect the airport from erosion and sedimentation impacts during the operations and maintenance.

The following is a listing of the mitigation measures that will help to achieve obstruction management goals, while also addressing the mitigation goals as listed above.

7.1 EROSION CONTROLS

Erosion controls will be important to incorporate into mitigation measures. The installation of these controls shall be according to the manufacturer's specifications and shall be completed concurrently with the appropriate remediation measures. The project should work to the extent practicable to ensure that all necessary precautions are employed to avoid soil disturbance that could result in environmental damage.

7.2 SEEDING SPECIFICATIONS

Areas of ground disturbance will be further protected through seeding and remediation, as necessary and practicable. The existing vegetative mat should be preserved to the extent practicable. Seed mixes can be used that match DOT&PF specifications for the local area, as appropriate.

7.3 STAGING AREAS

Staging areas (the locations to be used for debris storage) should be specified for those areas where the proximity to wetland boundaries, property lines, and/or steep slopes make the pre-designation of such areas necessary to protect these resources. Debris should be removed from the staging areas after completion of each project.

7.4 LIMITED ACCESS AREAS

All access and movement by vehicles associated with obstruction management must adhere to airfield safety policies and regulations. Access routes do not relieve the operator from meeting all restrictions and regulations regarding movement in and around the airport.

7.5 WILDLIFE HABITAT

FAA AC 150/5200-33, Hazardous Wildlife Attractants on or Near Airports, states, “caution should be exercised to ensure that land use practices on or near airports do not enhance the attractiveness of the area to hazardous wildlife.”

Vegetation management can create habitat that enhances the area for hazardous wildlife. The creation of standing dead timber (snags), the formation of brush piles, and the creation of grass/shrub habitat are all examples that can attract wildlife. The obstruction management plan must be coordinated with the habitat modification recommendations of an airport’s Wildlife Hazard Mitigation Plan or coordinated with the species identified in the Wildlife Hazard Assessment.

7.6 ENVIRONMENTAL PERMITTING

While this report is a guide for obstruction management, and details vegetation removal projects at airports, it does not detail the environmental permitting that would be required to implement these projects. A wide variety of environmental laws exist to protect the existing conditions, and permit applications should be obtained prior to implementing any vegetation management actions. These requirements typically include performing obstruction management outside of active nesting times for migratory birds, as specified in the Migratory Bird Treaty Act established dates. It may also require completing required National Environmental Policy Act documentation, such as a Categorical Exclusion (CATEX) and obtaining approval from FAA before proceeding with selected methods.

7.7 LONG-TERM MAINTENANCE BY AIRPORT PERSONNEL

After the completion of the initial clearing and foliar treatments, some regrowth will remain, and tree saplings will become re-established. The number of saplings will initially be low; however, if no maintenance is practiced, the numbers can be unmanageable within several years after the initial treatments. Without maintenance, there will likely be a need for additional intensive mechanical and chemical management in the future to protect the Part 77 surfaces. Federal and/or state funding for additional management will likely not be granted since the policy of the agencies is typically to pay for the clearing of an area only one time.

It is anticipated that after a period of clearing/herbicide treatments, shrubs and saplings will begin to establish within most areas. Airports should establish a regular obstruction monitoring and maintenance program following the initial treatment. This can allow for a programmatic annual budget and scope to be established, with a regular set of airports needing to be monitored each year.

Through the use of hand clippers, chain saws, or brush trimmers, shrubs and saplings can be selectively removed from wetland areas, allowing an herbaceous shrub layer to remain. By protecting the shrub layer and enhancing shrub growth, sunlight will become a limiting factor for sapling establishment, thus reducing the maintenance effort.

7.8 YEARLY OPERATIONAL PLANS

The proposed vegetation management involves an initial removal of obstructions. It is usual to complete all of the necessary clearing in the first year. After the initial treatment, regular inspection of all management areas by airport personnel will be required, complete with the removal of vegetation such as tree saplings. By continuously eliminating tree saplings, a dense shrub cover will become established, suppressing future sapling growth. Only through regular maintenance by airport personnel will management areas remain free of obstructions. Lack of regular maintenance over even one year can be sufficient to create unmanageable conditions.

7.9 PUBLIC PARTICIPATION

Obstruction management may require outreach to the public and airport stakeholders. The airport will want to exercise its rights and needs to comply with FAA airspace regulations, while implementing a “good neighbor” policy in order to avoid negative impacts to stakeholders adjacent to the airport. Considerations for public participation may include the level of obstruction removal activity required, the use of herbicides, and the level of stakeholder interest concerning the airport.

8.0 COST ESTIMATE

Planning-level cost estimates can provide a useful indication of a program's required budget. Vegetation clearing programs contracted out by DOT&PF in the past can be used to help inform program managers about future costs. This chapter focuses on vegetation removal costs for the first year of a management plan. After the initial clearing is performed by a contractor, vegetation maintenance of all management areas will be conducted by airport personnel.

The primary factors effecting cost estimates for this work in Alaska include:

- **Biological region** – Vegetation type will determine the methods and difficulty of removal. Larger trees near coastal/maritime regions will likely result in higher cost due to vegetation density and tree size compared to a far northern treeless area.
- **Clearing Area** – Larger areas typically see scales of economy, resulting in lower price per unit area to be cleared.
- **Terrain** – Airports that have a need to clear trees and vegetation from swampy, mountainous, or other areas difficult to access will be more expensive to clear.
- **Mobilization** – The cost estimates here do not take into account costs and logistical difficulties to mobilize clearing equipment to remote communities, which will have to be determined on a case-by-case basis.

8.1 METHODS

Clearing prices from past aviation projects were pulled from AASHTOWare and BidTab IV (2015 to 2020) and were categorized by ecoregion, based on the airport location. Projects that were lump sum were excluded because the size of the project was difficult to determine.

There are a relatively low number of projects with available information (Table 4, Appendix A). This low number will cause the estimates to be inaccurate, but they are presented here as the best information currently available. The costs will also be not accurate because the projects are not directly comparable, as their scopes and payment methods all increase the level of uncertainty in cost estimating.

8.2 RESULTS

The costs listed in Table 4 are based on average bid prices (not low bid prices) and include contractor profit and overhead.

These are planning-level costs, which are dependent on the accuracy of the information available and assume that the project scopes are comparable to future work. Actual costs are anticipated to vary widely from these estimates. In addition, unit prices will need to be adjusted for clearing area, terrain, and mobilization to determine a final anticipated clearing cost for an airport.

Table 4 Project Costs by Ecoregion

Ecoregion	Subregion	Number of Projects	Average Bid Prices ($/acre)
Polar	Arctic Tundra, Bering Tundra	1	4,200
	Bering Taiga	8	3,900
Boreal	Alaska Range Transition	4	7,900
	Intermontane Boreal	6	10,900
Maritime	Coastal Rainforest	1	5,000

* Note the Maritime prices is likely significantly low, as only one project was available.

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APPENDIX A

Cost Estimate

AIRPORT	LEVEL_1 REGION	LEVEL_2 REGION	PAY ITEM	QUANTITY	UNIT	AVERAGE BID PRICE	TOTAL COST	COMMENT	YEAR
Anchorage	Boreal	Alaska Range Transition	P151.010.0000 - Clearing	2.30	AC	$ 6,000.00	$ 13,800.00		2020
Anchorage	Boreal	Alaska Range Transition	P151.030.0000 - Clearing & Grubbing	2.00	AC	$ 12,156.25	$ 24,312.50		2020
Anchorage	Boreal	Alaska Range Transition	P151.030.0000 - Clearing & Grubbing	31.00	AC	$ 4,937.50	$ 153,062.50		2020
Anchorage	Boreal	Alaska Range Transition	P151.030.0000 - Clearing & Grubbing	13.00	AC	$ 8,437.50	$ 109,687.50		2020
~~Anchorage~~	~~Boreal~~	~~Alaska Range Transition~~	~~P151.040.0000 - Clearing & Grubbing~~	~~1.00~~	~~LS~~	~~$ 3,500.00~~	~~$ 3,500.00~~	No LS Alt Qty listed	2020
~~Anchorage~~	~~Boreal~~	~~Alaska Range Transition~~	~~P151.040.0000 - Clearing & Grubbing~~	~~1.00~~	~~LS~~	~~$ 43,333.00~~	~~$ 43,333.00~~	No LS Alt Qty listed	2019
Coldfoot	Polar	Arctic Tundra	P151.010.0000 - Clearing	72.00	AC	$ 4,198.55	$ 302,295.60		2015
Newtok	Polar	Bering Taiga	P151.010.0000 - Clearing	21.00	AC	$ 3,017.00	$ 63,357.00		2020
Newtok	Polar	Bering Taiga	P151.010.0000 - Clearing	42.00	AC	$ 2,290.80	$ 96,213.60		2020
Kotlik	Polar	Bering Taiga	P151.020.0000 - Clearing	56.00	AC	$ 3,673.08	$ 205,692.35	1 LS = $205,692.35; LS Alt Qty = 56.00 AC	2019
~~Kotlik~~	~~Polar~~	~~Bering Taiga~~	~~P151.030.0000 - Clearing & Grubbing~~	~~2.10~~	~~AC~~	~~$ 17,916.93~~	~~$ 37,625.55~~	Removed Clearing & Grubbing	~~2019~~
Kasigluk	Polar	Bering Taiga	P151.010.0000 - Clearing	28.00	AC	$ 1,900.00	$ 53,200.00		2020
~~Kasigluk~~	~~Polar~~	~~Bering Taiga~~	~~P151.030.0000 - Clearing & Grubbing~~	~~3.00~~	~~AC~~	~~$ 9,000.00~~	~~$ 27,000.00~~	Removed Clearing & Grubbing	~~2020~~
Atmautluak	Polar	Bering Taiga	P151.010.0000 - Clearing	28.00	AC	$ 5,202.23	$ 145,662.44		2020
~~Atmautluak~~	~~Polar~~	~~Bering Taiga~~	~~P151.030.0000 - Clearing & Grubbing~~	~~2.00~~	~~AC~~	~~$ 14,816.26~~	~~$ 29,632.52~~	Removed Clearing & Grubbing	~~2020~~
Nunapitchuk	Polar	Bering Taiga	P151.010.0000 - Clearing	24.00	AC	$ 5,088.71	$ 122,129.04		2020
~~Nunapitchuk~~	~~Polar~~	~~Bering Taiga~~	~~P151.030.0000 - Clearing & Grubbing~~	~~1.00~~	~~AC~~	~~$ 18,841.48~~	~~$ 18,841.48~~	Removed Clearing & Grubbing	~~2020~~
South Naknek	Polar	Bering Taiga	P151.010.0000 - Clearing	19.30	AC	$ 3,632.53	$ 70,107.83		2019
~~Toksook Bay~~	~~Polar~~	~~Bering Taiga~~	~~P151.030.0000 - Clearing & Grubbing~~	~~11.00~~	~~AC~~	~~$ 11,168.87~~	~~$ 122,857.57~~	Removed Clearing & Grubbing	~~2019~~
Aniak	Polar	Bering Taiga	P151.010.0000 - Clearing	87.00	AC	$ 6,300.00	$ 548,100.00		2017
~~St. Michael~~	~~Polar~~	~~Bering Taiga~~	~~P151.020.0000 - Clearing~~	~~1.00~~	~~LS~~	~~$ 137,328.57~~	~~$ 137,328.57~~	No LS Alt Qty listed	2016
~~White Mountain~~	~~Polar~~	~~Bering Tundra~~	~~P151.040.0000 - Clearing & Grubbing~~	~~1.00~~	~~LS~~	~~$ 68,035.00~~	~~$ 68,035.00~~	No LS Alt Qty listed	2018
~~White Mountain~~	~~Polar~~	~~Bering Tundra~~	~~P151.040.0000 - Clearing & Grubbing~~	~~1.00~~	~~LS~~	~~$ 35,797.00~~	~~$ 35,797.00~~	No LS Alt Qty listed	2018
~~Gustavus~~	~~Maritime~~	~~Coastal Rainforests~~	~~P151.040.0000 - Clearing & Grubbing~~	~~1.00~~	~~LS~~	~~$ 350,000.00~~	~~$ 350,000.00~~	No LS Alt Qty listed	2020
Cordova	Maritime	Coastal Rainforests	P151.030.0000 - Clearing & Grubbing	7.00	AC	$ 22,819.50	$ 159,736.50		2016
Fairbanks	Boreal	Intermontane Boreal	P151.010.0000 - Clearing	0.40	AC	$ 9,375.00	$ 3,750.00		2020
McGrath	Boreal	Intermontane Boreal	P151.010.0000 - Clearing	4.00	AC	$ 5,088.71	$ 20,354.84		2020
McGrath	Boreal	Intermontane Boreal	P151.030.0000 - Clearing & Grubbing	4.00	AC	$ 27,166.80	$ 108,667.20		2020
Crooked Creek	Boreal	Intermontane Boreal	P151.010.0000 - Clearing	79.20	AC	$ 9,579.38	$ 758,686.90		2019
Kiana	Boreal	Intermontane Boreal	P151.010.0000 - Clearing	24.00	AC	$ 12,800.00	$ 307,200.00		2018
Galena	Boreal	Intermontane Boreal	P151.010.0000 - Clearing	7.00	AC	$ 1,500.00	$ 10,500.00		2016
~~Hughes~~	~~Boreal~~	~~Intermontane Boreal~~	~~P151.020.0000 - Clearing~~	~~1.00~~	~~LS~~	~~$ 236,000.00~~	~~$ 236,000.00~~	No LS Alt Qty listed	2015
							$ -		

LEVEL_2 REGION	AVG. UNIT PRICE (ACRE)	AVG. UNIT PRICE (MSF)	# OF ENTRIES
ALASKA RANGE TRANSITIONAL	$ 7,882.81	$ 180.96	4
ARCTIC TUNDRA	$ 4,198.55	$ 96.39	1
BERING TAIGA	$ 3,888.04	$ 89.26	13
BERING TUNDRA	-	-	-
COASTAL RAINFORESTS	$ 5,000.00	$ 114.78	1
INTERMONTANE BOREAL	$ 10,918.32	$ 250.65	6