



Path Distance Analysis to Determine Accessibility for Long-term Vegetation Monitoring Program, Lake Clark National Park and Preserve

Natural Resource Technical Report NPS/SWAN/NRTR—2008/126



ON THE COVER

Coastal area of Lake Clark National Park and Preserve.

Photograph by: Amy Miller, NPS-SWAN

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Introduction

Alaskan national parks include some of the last remaining wilderness areas of the world. In order to protect and manage these parks, National Park Service (NPS) managers need to know how and why park ecosystems change over time, and what amount of change is within the historic range of variability. The Service's Inventory and Monitoring (I&M) Program addresses this need by providing park managers with information on status and trends for key elements of park ecosystems. The Southwest Alaska Network (SWAN), one of 32 monitoring networks in the I&M Program, has identified a suite of physical and biological elements for monitoring. Many of these require ground-based sampling.

Proper monitoring of natural resources is usually very expensive and time-consuming, yet sampling designs should provide reliable information in a cost-efficient manner. As outlined in the SWAN Vital Signs Monitoring Plan (Bennett et al., 2006), ground-based monitoring in national parks in southwest Alaska is particularly challenging because these parks are comprised of large, remote wilderness areas that are difficult to access except perhaps via floatplane, ski plane, helicopter, or boat, any of which is dependent on weather conditions. Consequently, practical considerations, such as accessibility and cost, will limit design alternatives that can be realistically implemented in these parks. For ground-based monitoring, we wanted a sampling design that was flexible enough to allow continued sampling within a restricted range of high-priority areas, even if funding were to drop to levels too low to support the full program.

This report outlines the development of a ground-based sampling approach for vegetation monitoring using path-distance analysis in a GIS. Although the SWAN will use remotely sensed data to monitor vegetation change at the landscape scale, targeted, ground-based sampling will be required to monitor change at the finer scale of plant associations. The approach described here was developed to ensure that travel to sampling sites would be feasible. The vegetation types targeted for sampling comprise at least 5% cover in the parks where they occur, and are considered representative of the local vegetation within a given elevation zone. Thus, constraints on access should not compromise our ability to sample these types, but rather ensure the sustainability of the monitoring program. We used Lake Clark National Park and Preserve (NP&P) as a pilot park within the SWAN to test this sampling selection process. If the sampling approach proves successful, it could be used for ground-based monitoring in other national parks in Alaska, or in any large, remote wilderness area with limited access.

We used Geographic Information Systems (GIS) analysis to delineate areas for sampling on the landscape. A GIS can serve as an invaluable tool in a) identifying areas that are most likely accessible for ground-based sampling, and b) preparing tabular data with attributes of physical characteristics to be used in the sample design. We used spatial models, primarily the Path Distance analysis tools in ArcGIS, to identify areas of accessibility in the park. The preparation of the tabular data relied on a series of combining tools in ArcGIS¹, as outlined in this report.

¹ ArcGIS commands are used to describe the methods used and are indicated in a separate font.

GIS Analysis Objectives

The GIS analysis used to delineate access areas must be documented, repeatable, adjustable, and produce a tabular dataset of points with the following characteristics:

- Universal Transverse Mercator (UTM) and Alaska Albers Equal Area coordinate values in NAD83 datum
- Points must be spaced 30 meters apart and attributed with relative costs associated with travel
- Points must be assigned relevant physical attributes such as elevation, slope, and land cover classification
- Points must be in tabular format that can be exported to sample selection programs or statistical software
- Coordinates from table must be easily importable into ArcGIS for review after they have been selected in statistical programs.

Path Distance Analysis

Path Distance analysis is a method to calculate the minimum accumulative travel cost from a source point to surrounding locations within a specified area. It compensates for the actual surface distance by using horizontal and vertical factors (elevation) that influence the total cost. We used Path Distance analysis to develop a GIS layer for areas in Lake Clark NP&P that would be accessible for ground-based sampling. The SWAN parks are remote, expansive, and generally lack infrastructure (roads, trails) for travel. As a consequence, ground-based sampling within SWAN park units is mostly limited to areas that can be accessed by small fixed-wing aircraft (e.g., Cessna 206) or by boat, and from those points by foot, within a reasonable time and under safe conditions.

We used source points, or starting points, for foot travel that included large lakes, trails, and coastal areas where boat or plane landings were known to be possible. Park pilots and other park staff assisted by indicating which lakes were feasible for landing under most weather conditions, and on which portions of the coast they could land at low tide. In addition, park staff verified the location of trails, cabins, and campsites that might be used as indicators of access.

We also identified inhibitors, such as steep slopes or dense vegetation that increased travel “cost” by either time or effort. Path Distance analysis was used to merge GIS layers that identified areas of accessibility and ranked them by their relative costs to travel. We then exported these points to a freeware program (S-Draw; <http://www.west-inc.com/computer.php>) that selected spatially balanced, random samples.

GIS parameters (input data layers) to determine the cost of travel included:

- Areas accessible by aircraft, boat or foot
- Cover class (land cover classification)
- Slope derived from elevation
- Walking distance from areas of access

GIS parameters to determine inhibitors included:

- Glaciers
- Large rivers
- Steep slopes
- Non-NPS lands

See Appendix A for a specific list of datasets used for each processing step.

Methods

ArcGIS version 9.2 was used to implement the Path Distance analysis. The Path Distance analysis is a raster-based tool. Therefore, most procedures use a raster with a 30-meter grid cell size.

The following are the primary steps used to prepare for and use the Path Distance analysis:

- Design and document the procedures using ModelBuilder.
- Identify source points of access using existing GIS layers and interviews with park staff.
- Classify a selected list of GIS layers on a scale of 0-10 (0 = easy; 10 = impassible) to quantify the costs associated with travel.
- Use the Spatial Analyst toolbox to perform the Path Distance analysis.
- Identify the areas that sampling should not or cannot occur, such as natural or land-ownership barriers, within close proximity to existing cabins or campsites, or out of range for walking from the source points.
- Add the necessary attributes (e.g., elevation) to the resulting points to be used in the sample design, or for other analyses.

Design and Document the Procedures Using ModelBuilder

ModelBuilder is an ArcGIS tool used to design, document and automate GIS procedures by providing a graphical flow diagram of the GIS procedures. It preserves the set of tasks, the workflow, and the parameters used. Output from one task can be used as the input for the next task, parameters can be changed, and a set of procedures can be implemented again.

In addition, each tool and parameter used can be documented as a “Help” file within the model itself (Figure 1). We used ModelBuilder to establish and document the procedures used.

The appendices provide the full output from this design, including documentation.

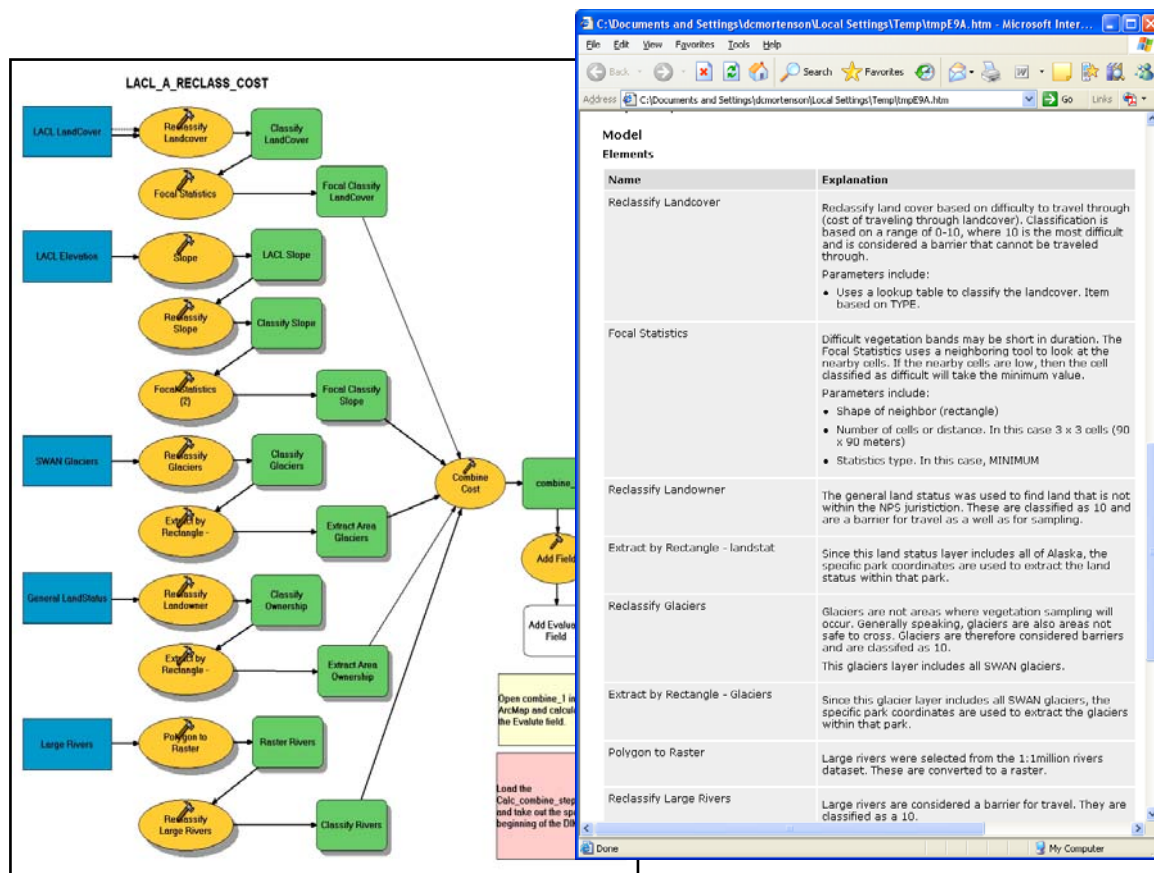


Figure 1. Example of ModelBuilder diagram and documentation for construction of an access layer in ArcGIS. Procedures were run interactively within these ModelBuilder diagrams.

Identify Source Points of Access Using Existing GIS Layers and Interviews with Park Staff

Model: LACL_Union_Access_Layers (Appendix A)

Points of access were identified in three steps: 1) initial estimation of accessible areas using GIS Overlay toolbox, 2) verification and validation by interviews with park staff, and 3) refinement of points of access and combination of these into one raster dataset. See Figure 2.

1) Initial Estimation

Datasets used to estimate the potentially accessible areas for sampling are as follows:

- Lakes larger than 100 acres (404,685.6 square meters)
- Cabins
- Campsites
- Trails
- Slope < 50 degrees
- Non-glaciers
- NPS lands

These datasets were Overlaid using the Union tool and provided a map of an initial estimation of potentially accessible areas. This step provided a proof of concept and a foundation for discussion. This method does not, however, account for a feasible route from a source point of access. Therefore, we needed to identify, verify and validate points of access to these potential sampling areas.

2) Verification and Validation with Park Staff

The map of the initial estimation of accessible areas in Step 1 was reviewed with park pilots and other park staff. Pilots were able to identify points of access to these areas by indicating which lakes were feasible for landing in most conditions, and portions of the coast that can be landed. In addition, trails were verified.

3) Identify Points of Access

After step 2, datasets used to determine the points of access are as follows:

- Selected large lakes identified by pilots
- Air strips verified by pilots
- Cabins
- Campsites
- Selected trails verified by park staff

Each of these GIS layers was Buffered to 30 meters. Next, the Buffered GIS layers were Unioned to create one GIS layer. The resulting GIS layer was then converted into a raster GRID using 30 meter cell size. All datasets converted to raster will use the 30 meter cell size parameter. Later in the process, these raster datasets will be converted to points and will be appropriately spaced 30 meters apart.

The resulting GRID dataset is used as the “seed” or starting points for determining accessible areas.

Lake Clark National Park & Preserve Points of Access

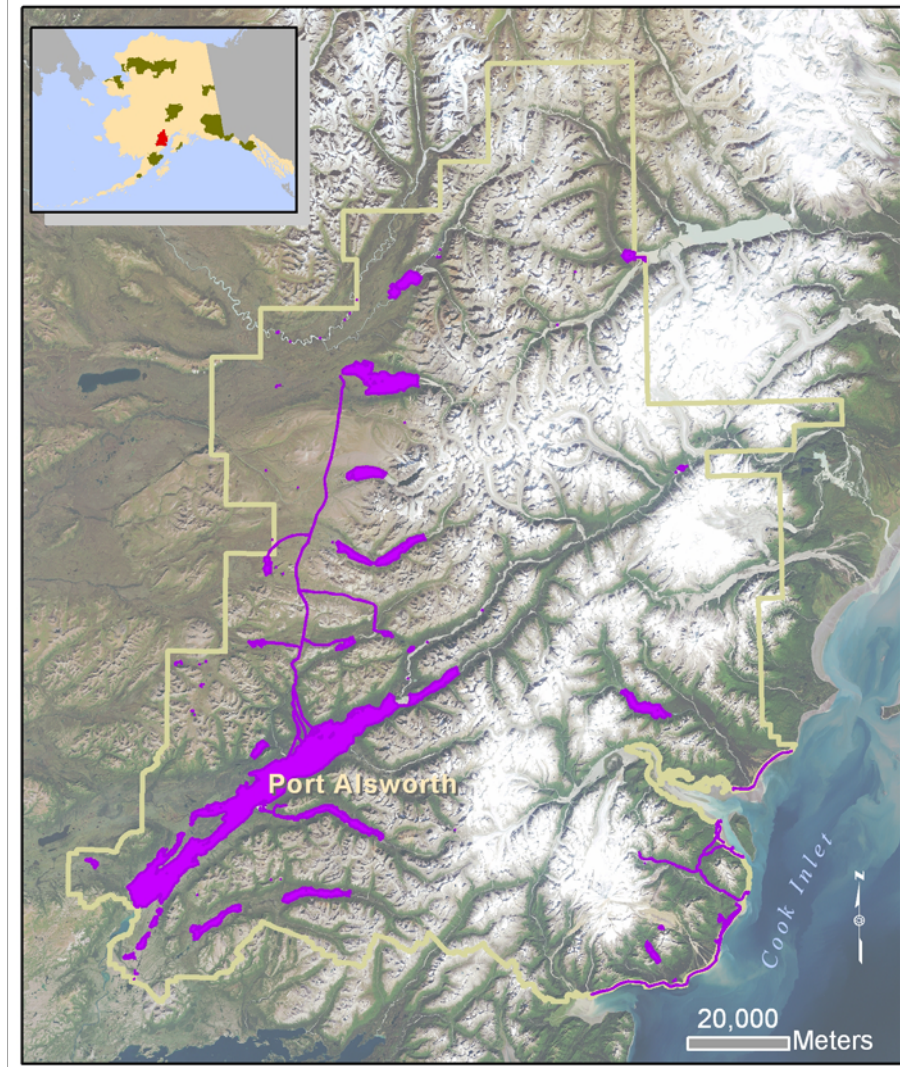


Figure 2. Source points (areas) for access by aircraft, boat or foot in Lake Clark NP&P.

Classify the Costs Associated with Travel for Each GIS layer

Model: LACL_A_Reclass_Cost (Appendix B)

Various physical features, including vegetation, topography (slope), glaciers, major river crossings, and land ownership limit the ability of field crews to travel by foot across the landscape. We rated these features subjectively on a scale of 0-10, where 0 = easy and 10 = impassible (Table 1). Dense vegetation or uneven terrain that impeded travel and/or visibility received a higher (more difficult) rating. Prime bear habitat received higher ratings due to safety concerns, particularly where visibility was limited (e.g., tall grasslands, alder, riparian areas).

Certain physical features that were assigned a higher rating were maintained as acceptable if the area was small (≤ 90 meters). For example, closed alder (rating = 9) is difficult to walk through, offers low visibility, poor GPS reception, and is often in prime bear habitat. However, if an alder stand is limited in extent, it may be acceptable to walk through it for a short distance, depending on the characteristics of the surrounding area. To account for these small pockets of high ratings (e.g., closed alder) surrounded by lower ratings (e.g., gravel and sparsely vegetated; rating = 2), the Focus Statistics tool was applied to the land cover and slope layers to mitigate the difficulty rating. The minimum cost was set using the Neighborhood settings as 90 meters by 90 meters.

Table 1. Classification used for assigning costs to foot travel in Lake Clark NP&P. A difficulty rating of 10 denotes an impassible feature or, in the case of land ownership, lands that are excluded from sampling. The rating of 0 denotes easy travel in most cases or no information in cases of clouds and shadows.

Physical Features	Condition	Rating
Slope (degrees)	0-5	0
	5-10	1
	10-20	2
	20-30	3
	30-40	7
	40-50	8
	> 50	10
Glaciers	All glaciers	10
Land Ownership	All non-NPS land or selected lands	10
Large Rivers	All large rivers which cannot be crossed by field crews	10
Land Cover	Fresh Water-Clear ²	0
	Water - Silty and/or Shallow ²	0
	Cloud & Cloud Shadow ²	0
	Prostrate Shrub Tundra	1
	Fellfield	1
	Lichen Tundra	1
	Sedge Dominated Mesic Tundra	2
	Gravel and Sparsely Vegetated	2
	Dwarf Shrub Tundra	3
	Bedrock	3
	Ice and Snow	3
	Spruce Woodland	4
	Open Spruce	5
	Salt Marsh	5
	Marine Mudflats	5
	Low Shrub	5
	Closed Interior Spruce	6
	Grasslands	6
	Closed Coastal Spruce	7
	Closed Birch Forest	7
	Closed Mix Forest	7
	Open Mix Forest	7
	Open Populus Forest	7
	Open Birch Forest	7
	Closed Populus Forest	8
	Open Alder	8
	Willow shrub	8
	Sedge & Shrub Bog Meadow	8
	Wet Sedge Meadow	8
	Emergent Marsh	8
	Closed Alder	9
	Marine Waters	10

² Water is controlled by the hydrography GIS layer. Lakes, large rivers and streams are deleted in a later step, as these will not be sampled. No classification can be made with cloud or shadow cover.

Our next step was to evaluate these ratings and create a single, overall rating for each raster cell. If any attribute was considered impassible (rating = 10), the overall rating will remain as impassible. However, attributes with medium ratings (3-5) needed to be more carefully evaluated. This evaluation was performed with the following criteria:

- Large rivers, glaciers, land ownership, slope or land cover rated as 10 remained a 10. These features were considered impassible.
- Slope rated ≤ 3 adopted the land cover rating. Slope in this case is considered relatively easy and not a concern. Land cover is the driving concern.
- Land cover > 5 adopted the land cover rating. Land cover in this case was the driving concern.
- Slope > 3 and land cover ≤ 5 were averaged. In this case, slope and land cover were in the medium range of difficulty, with neither being the stronger driving concern.

The Visual Basic script used to automate this process is shown in Figure 3. The output from this classification is the evaluated cost of access (Figure 4).

```
dim lngValue as long

if [class_lgrvr] = 10 or [class_glacier] = 10 or _
[class_lstat] = 10 or [class_slope] = 10 or [class_lc] = 10
then
    lngValue = 10
else
    if [class_slope] <= 3 then
        lngValue = [class_lc]
    else
        if [class_lc] > 5 then
            lngValue = [class_lc]
        else
            lngValue = ([class_lc] + [class_slope]) / 2
        end if
    end if
end if
__esri_field_calculator_splitter__
lngValue
```

Figure 3: Visual Basic script for overall rating of travel costs of large rivers, glaciers, land status, slope, and landcover.

Lake Clark National Park & Preserve Evaluated Cost of Access

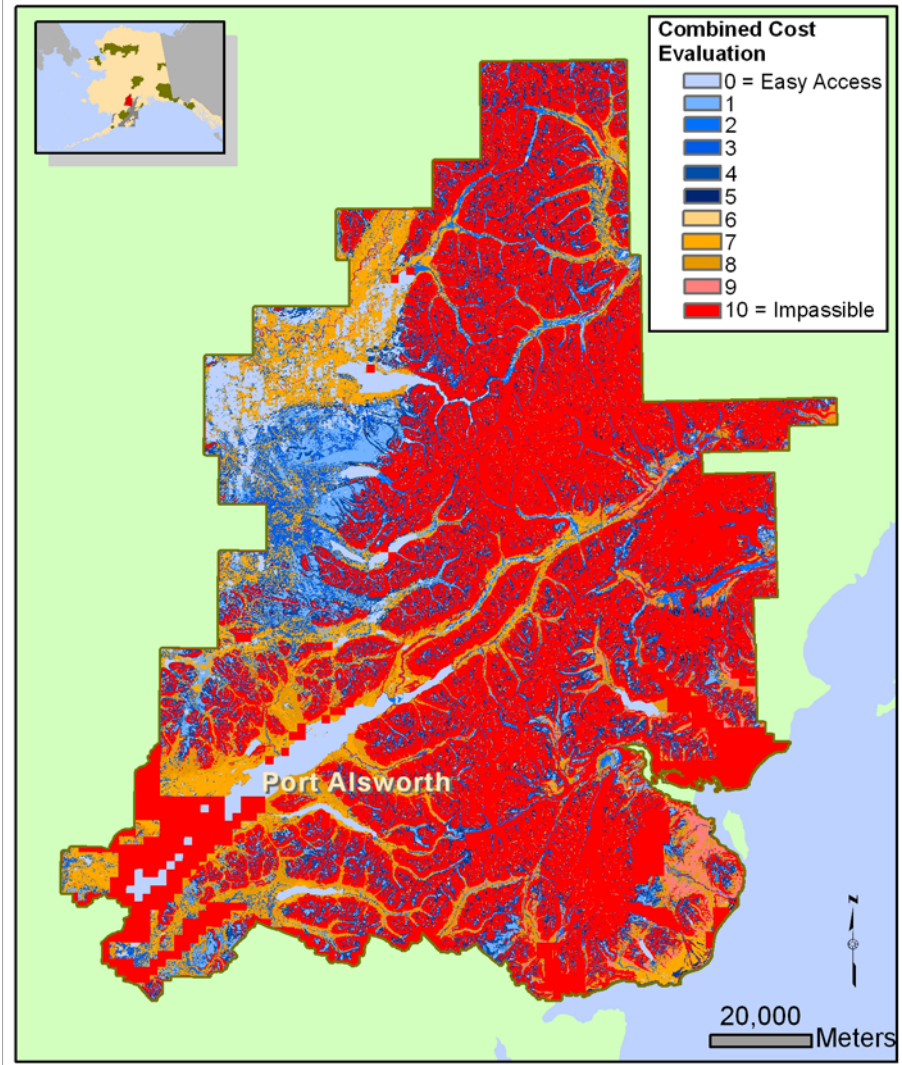


Figure 4. Map of evaluated cost of access for Lake Clark NP&P.

Use the Spatial Analyst Toolbox to Perform the Path Distance Analysis

Model: LACL_B_Reclass_Cost_Continued (Appendix C)

The Spatial Analyst, Path Distance analysis was used to calculate the least accumulative cost distance (based on the combined cost rating) to the accessible areas, while accounting for the surface distance and vertical cost factors (elevation). The result was a raster with accumulating cost values measured in units that combined the distance from the source points and the cost of travel. The calculations for these units are complex and are best described in the ESRI software documentation. Simplified, the higher the cumulative rating, the shorter the distance from the source points one can travel. Likewise, if the cumulative rating stays relatively low, the greater distance one can travel. We visually tested this concept in ArcMap using 5,000 meters as a guideline for the maximum distance away from a point of access, equivalent to a cumulative rating of $\leq 15,000$ (Figure 5).

Identify the areas that sampling should not or cannot occur, such as natural or land-ownership barriers, within close proximity to existing cabins or campsites, or out of range for walking from source points.

Model: LACL_C_Set_Null_Layers (Appendix D)

While we needed to sample within a reasonable distance from a source point, these source points themselves needed to be eliminated from the sample selection. We removed source points associated with cabins and campsites to avoid sampling in areas of human disturbance. Likewise, we removed lakes and other water bodies, as well as riparian areas that were not representative of vegetation on the larger landscape (Miller et al., in preparation). Riparian areas are also prime habitat for bears and pose a likely disturbance to the sample site and a hazard for field work. We delineated the areas to be eliminated by creating Buffers around source point features and performing a Union on all buffers to create one null GIS layer (Layer 1).

The datasets used to eliminate areas were as follows:

- A 100 meter Buffer was set around known access locations such as cabins, campsites, common landing areas, and trails.
- Riparian areas were eliminated from the sampling area by creating a Buffer of 30 meters around the hydrography GIS layer.
- Water bodies (e.g., lakes, ponds), including source points, were eliminated from the sampling area.

The Path Distance analysis helps to model the cost of travel, but it is not based on actual time required to cover distances on the ground. The results to this point still included areas that were excessively far from source points to reach by foot. Maximum Buffer distances of 1500 meters (e.g., beach landings), 3000 meters (majority of features), and 5000 meters (e.g., lakes in open areas) were manually assigned to the access GIS layer. This created a maximum distance GIS layer (Layer 2).

The null GIS layer (Layer 1) of the Unioned Buffered features was Erased with the maximum distance GIS layer (Layer 2) to create a linear maximum extent GIS layer (Layer 3). Layer 3 was used to Clip the Path Distance analysis GIS layer (Figure 5).

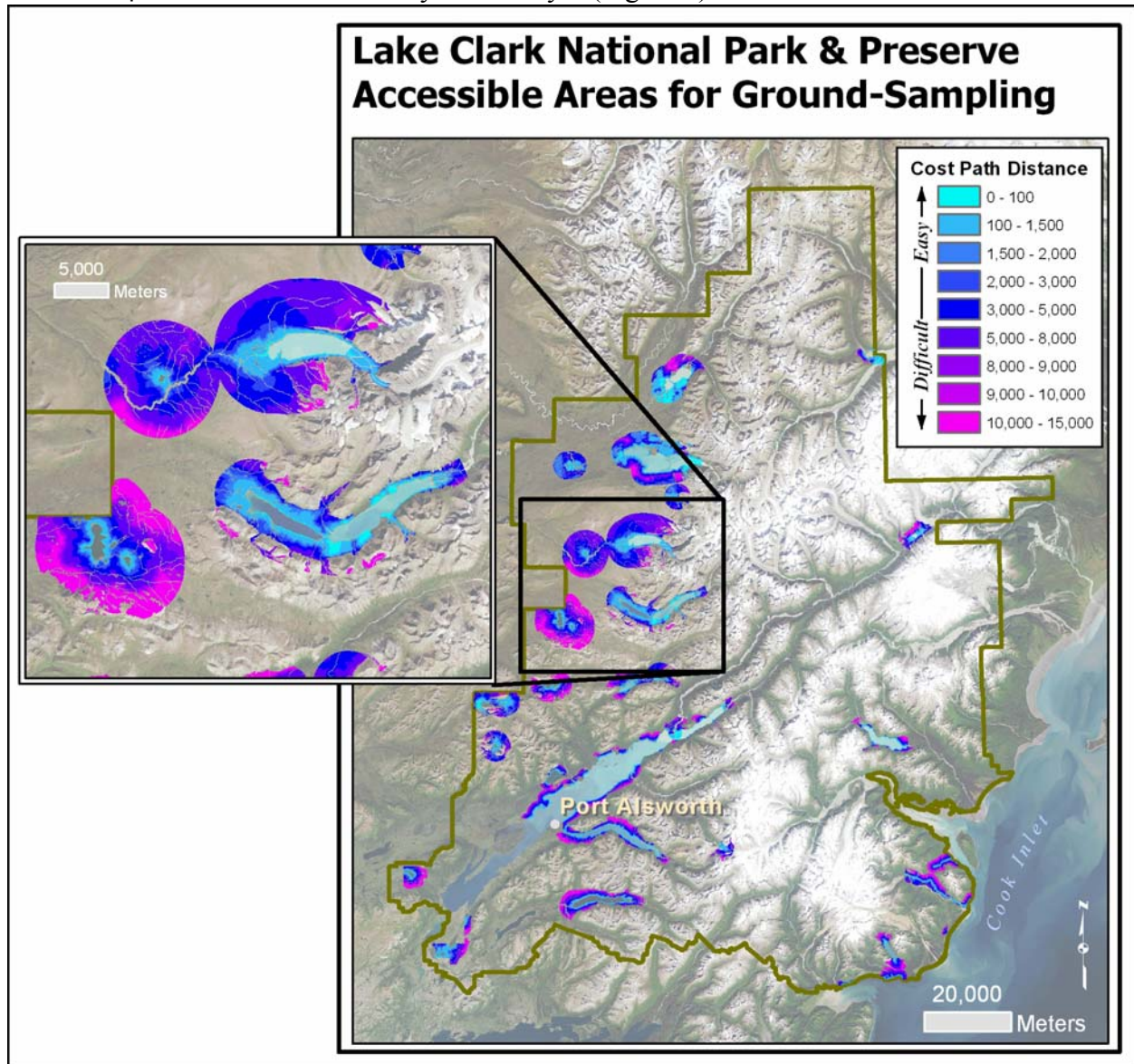


Figure 5. Accessible areas after Path Distance analysis and elimination of null areas for Lake Clark NP&P. Inset map provides a closer view of the results. The majority of Lake Clark NP&P is inaccessible due to glaciers, steep terrain, and a limited number of access points.

Add the Necessary Attributes to the Resulting Points for Sample Design

Model: LACL_D_Add_Attributes (Appendix E)

The final product is a tabular dataset with user-defined fields that can be exported to the relevant software programs for analysis. In our application, these fields included UTM coordinates, Alaska Albers Equal Area coordinates; slope; elevation; and landcover code.

The attributes were prepared by using an interchange of raster (GRID), shapefiles, coverages, and geodatabases. Most of our procedures have used the ArcGIS ToolBox commands. ArcGIS is a redesign of Arc/Info and still lack fluid interchange of commands between the two. Some commands designed for GRID and coverages, which use INFO to store their attributes, can only be done in Arc/Info Workstation. Hence, the process of transferring attributes from the raster GRID to a shapefile that can be used in ArcMap is less than straightforward.

The final raster GRID, which contained the slope, elevation, and land cover code attributes, was converted to a point shapefile. This point shapefile was then converted into a point coverage. Both GRID and coverages use INFO to store their attributes. We used the JOIN command to join the GRID INFO file with the point coverage INFO file. This task was completed by using an AML program (listed in Appendix E). It is not readily possible to JOIN the attributes from the raster (GRID) to the point shapefile directly (shapefiles use .dbf to contain their attributes).

Alaska Albers Equal Area coordinates were calculated for all points in the coverage using the ArcGIS Tables, Add XY Coordinates function. The UTM coordinates were added to the point coverage in ArcMap using the AlaskaPak³ Add XY Coordinates, where the map projection of UTM can be used instead of re-projecting the entire coverage. A unique ID field was also added for each point while in ArcMap.

This point coverage was converted to a geodatabase that used MS Access as the container for the attributes. The attributes could then be exported into a stand-alone MS Access database, so as not to interfere with the geodatabase. Attributes from this stand-alone database could then be read directly into the analytical software program, SAS (www.sas.com), which was used to convert the data into a format that could be inputted into the plot-selection program, S-Draw (<http://www.west-inc.com/computer.php>). S-Draw was then used to generate a spatially balanced, random sample of plots from accessible areas, stratified by elevation.

Results and Discussion

We found that based on our criteria, 11% of Lake Clark NP&P was accessible for ground-based sampling. This was due largely to the vast glaciers, steep terrain, and limited points of access. Although the land area selected for vegetation sampling in Lake Clark NP&P represents only about a tenth of the park, it nevertheless accounts for a much larger proportion of the vegetated land area and supports large expanses of the plant associations of interest for monitoring. We argue that costs to monitoring incurred by constraints on access are offset by our ability to

³ AlaskaPak is a custom ArcMap tool developed by NPS.

sample these vegetation types efficiently and cost-effectively through time. In other words, by constraining the area in which we sample, we can better ensure the longevity of our monitoring program. The sample sites generated by the plot-selection program, S-Draw, were reviewed in ArcMap and were field tested by SWAN personnel in 2007.

The ModelBuilder provided an excellent means for designing, documenting, and implementing the process that can be understood by beginning and advanced GIS users. The Path Distance tool provided a reasonable estimation of accessible areas in mid-elevation (450 m -900 m) portions of interior Lake Clark NP&P, where low-stature vegetation and limited topographic relief minimized travel costs.

One of the challenges in performing a Path Distance analysis is in developing the classification used for assigning costs (Table 1). In our case, ratings were relatively subjective and not necessarily easy to quantify. Further field testing in 2008 and 2009 should provide information regarding the suitability of cost ratings for land cover types representative of low elevation (< 450 m) and coastal areas of Lake Clark NP&P. Following the 2007 field season, for example, we elected to incorporate riparian areas into the null GIS layer (Layer 1). Streamside vegetation had been selected for sampling in several instances (i.e., had membership in the point coverage) in 2007, in spite of the fact that riparian areas are limited in extent and are not representative of the more common upland plant associations that ground-based monitoring was intended to capture.

The utility of the nearest-neighbor analysis used to reclassify cost for limited areas of high cost (e.g., steep slopes or patches of dense vegetation) will also require field testing across a number of environments. Heterogeneity in vegetation types at lower elevations, and poor resolution in the existing Digital Elevation Models (DEMs), topographic and hydrographic GIS layers, and land cover maps likewise confound our ability to model site accessibility in these large, remote parks. However, the access layer created through Path Distance Analysis is a vast improvement on the simple buffering of source points, and we expect that future refinements will be incorporated as we continue to test the model in the field.

Literature Cited

- Bennett, A. J., W. L. Thompson, and D. C. Mortenson. 2006. Vital signs monitoring plan, Southwest Alaska Network. National Park Service, Anchorage, AK.
- Miller, A. E., W. L. Thompson, D. C. Mortenson, and C. Moore. Protocol for ground-based monitoring of vegetation in Southwest Alaska Network – DRAFT. In preparation, 2008. National Park Service, Anchorage, AK

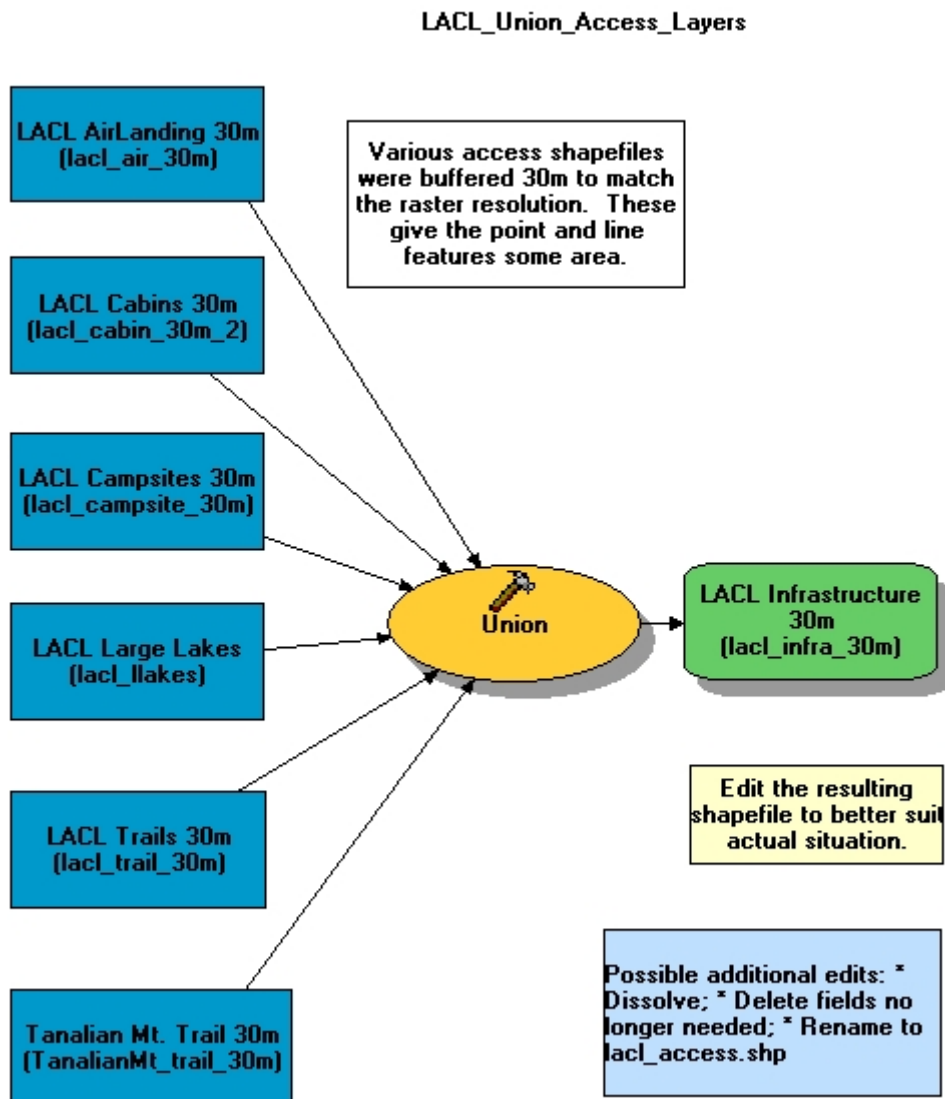
Appendix A: *Model: LACL_Union_Access_Layers*

**ModelBuilder Documentation
For
Identifying Source Points of Access**

LACL_Union_Access_Layers

A number of layers indicate areas of access. These include lakes and beaches where small aircraft (Cessna 206 or similar size) can land and known access locations such as cabins, campsites or trails. Point and line features were buffered to 30 meters to match the raster cell size of the final product.

Illustration



Accessible areas within Lake Clark National Park and Preserve (LACL).

Usage Tips

Output shapefile may need to be edited to better suite actual situation.

Possible additional edits may include DISSOLVE; deleting fields no longer needed; and renaming.

Model Elements

Name	Explanation
Union	UNION the access shapefiles to create one master areas of access (entry points of access).

Datasets Used:

Dataset Name Input	Description	Date Acquired for Analysis
laci_air_30m	A 30 meter buffer around the beach air strips identified during the weather station site selection process. Information compiled by Bruce Giffen, AKRO.	Created: 3/23/2007
laci_cabin_30m_2	A 30 meter buffer around cabins, such as private lodges and ranger stations.	Source: 5/2005 Acquired: 5/27/2007
laci_campsite_30m	A 30 meter buffer around the 1999 campsite inventory conducted by LACL staff.	Source: 1999 Acquired: 2007
laci_llakes	Large lakes (over 100 acres) identified by park pilots as safe for landing a fixed-winged aircraft, such as a Cessna 206. Original lakes selected from the 1:63360 SWAN National Hydrologic Dataset (NHD).	Source: 1950's Acquired: 3/27/2007
laci_trail_30m	Combination of the proposed Johnson River trail, Tanalian River trail, Telaquana Trail, and other laci trails. A 30 meter buffer was generated.	Source: 1997 Acquired: 2007
TanalianMt_trail_30m	A 30 meter buffer around the Tanalian Mountain Trail.	Created: 4/4/2007
Result		
laci_infra_30m	A 30 meter buffer around all points (areas) of access for Lake Clark NP&P.	6/2007
Laci_access	Laci_infra_30m renamed.	6/2007

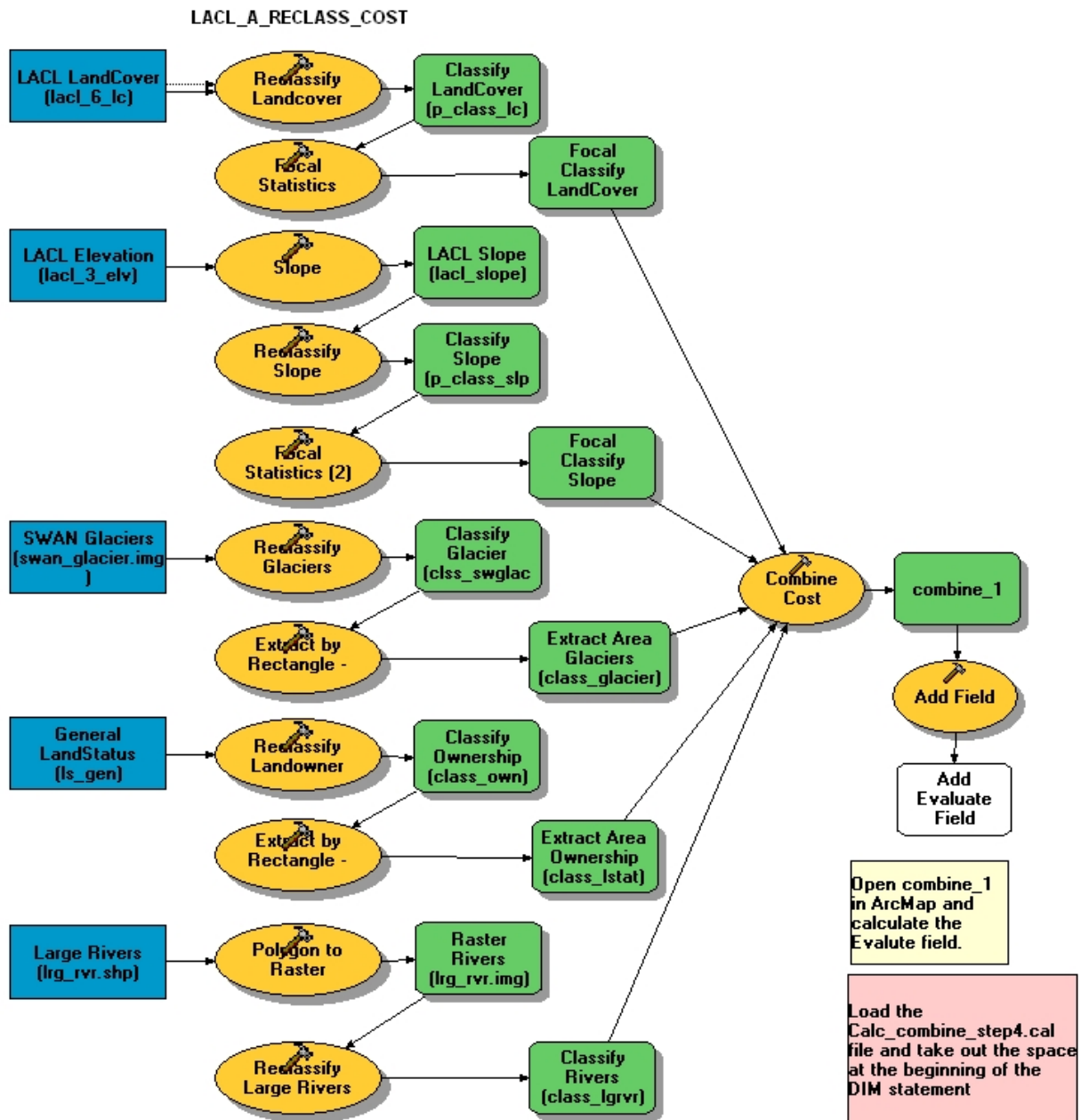
Appendix B: *Model: LACL_A_Reclass_Cost*

**ModelBuilder Documentation
For
Classifying Travel Cost to GIS Layers**

LACL_A_Reclass_Cost

Step 1 in reclassifying the cost for path distance analysis. These are combined and an overall cost is assigned. A path distance analysis is run to eliminate areas of too high of cost or surrounded by too high of cost (10).

Illustration



Usage Tips

After the model has run, open combine_1 in ArcMap and calculate the "Evaluation" field.

To do so, load the calc_step4.cal file and take out the space at the beginning of the DIM statement.

```
dim IValue as long
```

```
if [class_lgrvr] = 10 or [class_glacier] = 10 or [class_lstat] = 10 or [class_slope] = 10 or [class_lc] = 10  
then
```

```
Ivalue = 10
```

```
else
```

```
if [class_slope] <= 3 then
```

```
Ivalue = [class_lc]
```

```
else
```

```
if [class_lc] > 5 then
```

```
Ivalue = [class_lc]
```

```
else
```

```
Ivalue = ([class_lc] + [class_slope]) / 2
```

```
end if
```

```
end if
```

```
end if
```

```
__esri_field_calculator_splitter__
```

```
Ivalue
```

Command line syntax

LACL_A_Reclass_Cost

Parameters

Expression	Explanation
------------	-------------

Command Line Example

Scripting syntax

LACL_A_Reclass_Cost ()

Parameters

Expression	Explanation
------------	-------------

Script Example

Model Elements

Name	Explanation
------	-------------

Reclassify Landcover	Reclassify land cover based on difficulty to travel through (cost of traveling through landcover). Classification is based on a range of 0-10, where 10 is the most difficult and is considered a barrier that cannot be traveled through. Parameters include: • Uses a lookup table to classify the landcover. Item based on TYPE.
Focal Statistics	Difficult vegetation bands may be short in duration. The Focal Statistics uses a neighboring tool to look at the nearby cells. If the nearby cells are low, then the cell classified as difficult will take the minimum value. Parameters include: • Shape of neighbor (rectangle) • Number of cells or distance. In this case 3 x 3 cells (90 x 90 meters) • Statistics type. In this case, MINIMUM
Reclassify Landowner	The general land status was used to find land that is not within the NPS jurisdiction. These are classified as 10 and are a barrier for travel as well as for sampling.
Extract by Rectangle - landstat	Since this land status layer includes all of Alaska, the specific park coordinates are used to extract the land status within that park.
Reclassify Glaciers	Glaciers are not areas where vegetation sampling will occur. Generally speaking, glaciers are also areas not safe to cross. Glaciers are therefore considered barriers and are classified as 10. This glaciers layer includes all SWAN glaciers.
Extract by Rectangle - Glaciers	Since this glacier layer includes all SWAN glaciers, the specific park coordinates are used to extract the glaciers within that park.
Polygon to Raster	Large rivers were selected from the 1:1million rivers dataset. These are converted to a raster.
Reclassify Large Rivers	Large rivers are considered a barrier for travel. They are classified as a 10.

Slope	Calculate the slope in DEGREES.
Reclassify Slope	Classifies the slope on the level of difficulty for travel based on a 1-10 scale, where 10 is a barrier. A lookup table is used.
Focal Statistics (2)	Difficult slope bands may be short in duration. The Focal Statistics uses a neighboring tool to look at the nearby cells. If the nearby cells are low, then the cell classified as difficult will take the minimum value. Parameters include: • Shape of neighbor (rectangle) • Cells (3 x 3 cells or 90 x 90 meters) • MINIMUM
Combine Cost	All the classification layers are combined into one raster file. This raster file is used to calculate the overall difficulty rating.
Add Field	The field "EVALUATE" is added to the raster attribute table. The user should go into ArcMap to calculate the attributes. dim lvalue as long if [class_lgrvr] = 10 or [class_glacier] = 10 or [class_istat] = 10 or [class_slope] = 10 or [class_lc] = 10 then lvalue = 10 else if [class_slope] <= 3 then lvalue = [class_lc] else if [class_lc] > 5 then lvalue = [class_lc] else lvalue = ([class_lc] + [class_slope]) / 2 end if end if end if __esri_field_calculator_splitter__ lvalue

Datasets Used:

Dataset Name Input	Description	Date Acquired for Analysis
laci_6_lc	Landcover map for Lake Clark NP&P using Spot multispectral imagery and other refinements.	Source: 6/1997 Acquired: 4/2007
laci_3_elv	Extracted from the National Elevation Dataset (NED). This is 30 meter resolution.	Source: 12/18/2002 Acquired: 4/2007
swan_glacier	Extracted from the 1:63,360 USGS delineation of glaciers (hydro layer).	Source: 1950's Acquired: 2007
ls_gen	Extracted from the statewide land status coverage.	Source: 2/2005 Acquired: 3/2007
lrg_rvr	Selected from the hydro layer where WTRTYP = '2'	Source: 1950's Acquired: 3/2007
Result		
combine_1	Combination of all the classifications and associated attributes into one GRID file. Additional attributes and calculations are made within ArcMap.	Created: 2007

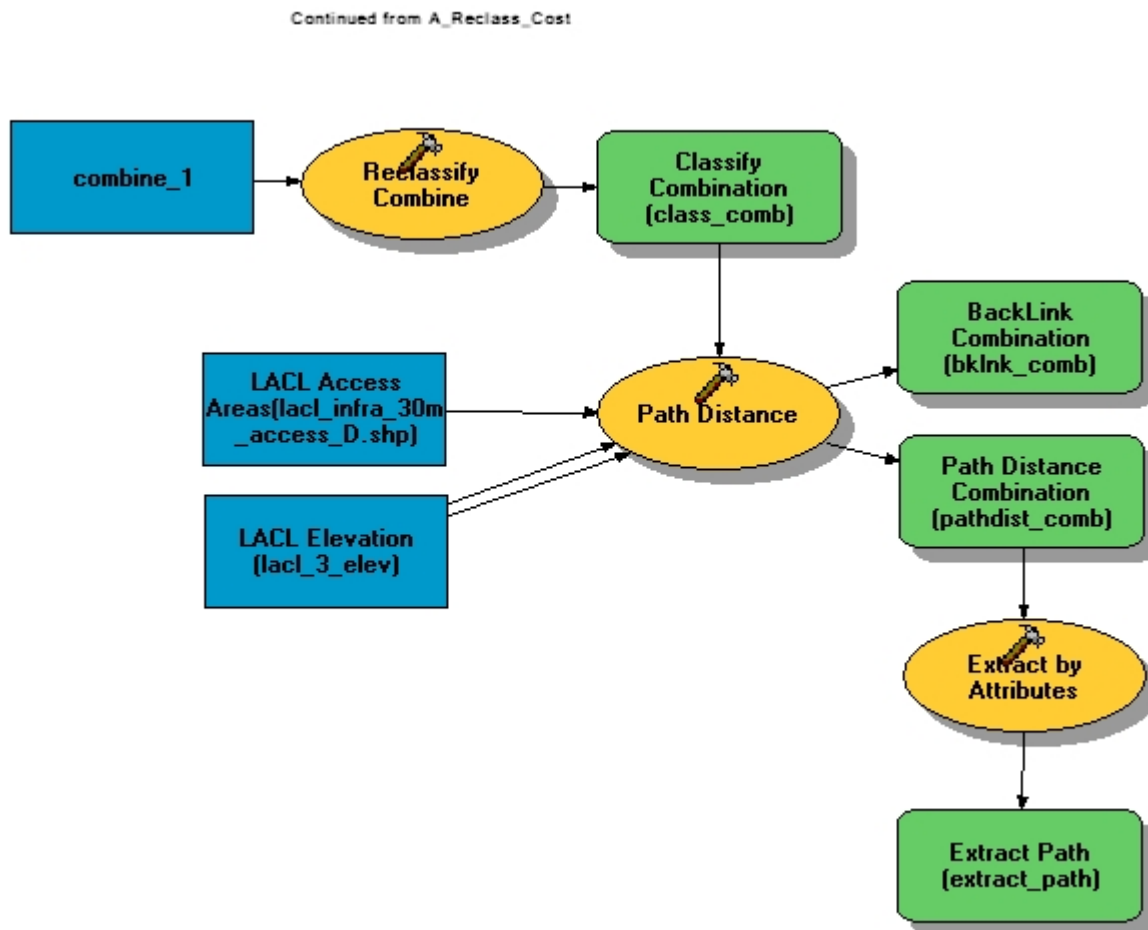
Appendix C: *Model: LACL_B_Reclass_Cost_Continued*

**ModelBuilder Documentation
For
Using Path Distance Analysis**

LACL_B_Reclass_Cost_Continued

This is step 2 in classifying the cost and path distance, which determines the path distance based on a relative difficulty scale from 1-10, elevation and slope. There is an interactive step between step 1 (LACL_A_Reclass_Cost) and this step.

Illustration



Continued classification necessary, after manual edits are complete.

Command line syntax

LACL_B_Reclass_Cost_Continued

Parameters

Expression	Explanation
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Command Line Example

Scripting syntax

LACL_B_Reclass_Cost_Continued ()

Parameters

Expression	Explanation
Model Elements	
Name	Explanation
Reclassify Combine	Uses the field EVALUATE to reclassify the raster, using the same values.
Path Distance	This procedure determines the relative cost of travel. Based on all of the combined features from class_comb (which includes slope, vegetation and a number of other barriers), the cost of travel is calculated. Elevation and slope are used to help determine distance. Parameters are: - Cost Raster: class_comb - the resulting EVALUATE - Surface Raster: Elevation - Verticle Factor: Elevation, Binary, Zero Factor = 1, Low cut angle = -60, high cut angle = 60.
Extract by Attributes	The path distance is a relative number based on a 1-10 cost raster. The resulting raster produces a large range of numbers. The values were classified in a display in ArcMap and compared to a buffered distance (ranging from 1500 - 5000 meters). By visual comparison, the value of 15000 units seemed to be the extent of travel range, combining both the distance and the difficulty. Parameters are: Value <=15000

Datasets Used:

Dataset Name Input	Description	Date Acquired for Analysis
combine_1	Input from the LACL_A_Reclass_Cost step. Combination of all the classifications and associated attributes into one GRID file. Additional attributes and calculations are made within ArcMap.	Created: 2007
laci_infra_30m	Derived from LACL_Union_Access_Layers. A 30 meter buffer around all points (areas) of access for Lake Clark NP&P.	Created: 6/2007
laci_3_elv	Extracted from the National Elevation Dataset (NED). This is 30meter resolution.	Source: 12/18/2002 Acquired: 4/2007
class_comb	Generated from the reclassification of the combine_1 layer. Used as input for the Path Distance analysis.	Created: 2007
Result		
bklink_comb	Back Link file generated from the Path Distance analysis.	Created: 2007
PathDist_comb	Path Distance analysis of the combined datasets.	Created: 2007
extract_path	Extracts the values ≤ 15000 .	Created: 2007

Appendix D: *Model: LACL_C_Set_Null_Layers*

**ModelBuilder Documentation
For
Areas not to be Included in Sampling**

LACL_C_Set_Null_Layers

Sets the areas to be null (no data), such as lakes, areas outside of distance range, known cabins and camps, and riparian zones. Sampling should not occur in these areas and need to be erased.

Illustration



Sets the areas to be null (no data), such as lakes, areas outside of distance range, known cabins and camps. Sampling should not occur in these areas and need to be erased.

Command line syntax

LACL_C_Set_Null_Layers

Parameters

Expression	Explanation
------------	-------------

Command Line Example

Scripting syntax

LACL_C_Set_Null_Layers ()

Parameters

Expression	Explanation
------------	-------------

Script Example

Model

Elements

Name	Explanation
Buffer Campsites 100m	Buffers the distance around known camp areas. This 100 meter buffer will help to eliminate putting sample points in known disturbed areas.
Buffer Cabins 100m	Buffers the distance around known cabins or lodges. This 100 meter buffer will help to eliminate putting sample points in known disturbed areas.
Buffer	
Union	All known disturbed areas or areas that are inappropriate for sampling (such as waterbodies) are UNIONED together. These will be calculated to NULL in a later step.
Erase	In an earlier step, the buffered distance from points of access were determined. This sets a linear maximum distance from these points. Anything outside of these points will be set to NULL in a later step. This step combines the area for null (outside of the buffered areas) and the null areas based on infrastructure and lakes (infra_null). The resulting dataset will be the area used to set the null areas.
Polygon to Raster	Processing step to convert from vector to raster.

Con	Takes the resulting accessible areas from the cost path analysis and erases the areas that are definitely out.
Buffer LACL Assess Start Points	Buffer the distance around the points of access (such as lakes, airstrips, etc.) an appropriate walking distance. This distance is based on local expertise and are generally classified as 1500 meters, 3000 meters, or 5000 meters. Parameters are: • Buffer field is buff_dist
Clip	Streams are clipped to the park boundary.
Buffer (2)	Buffered areas of 30 meters around streams represent riparian areas. Sampling should not occur in these areas.

Datasets Used:

Dataset Name Input	Description	Date Acquired for Analysis
Campsite_alb	LACL 1999 campsite inventory in Albers projection.	Source: 1999 Acquired: 2007
cabin_la_point	Cabins for Lake Clark	Source: 5/2005 Acquired: 5/27/2007
lrg_rvr	Selected from the hydro layer where WTRTYP = '2'	Source: 1950's Acquired: 3/2007
Streams	NHD flowlines for Alaska Peninsula.	Source: 6/2006 Acquired: 2007
laci_100m	100 meter buffer around the Lake Clark NP&P boundary. Used to clip with the streams.	Source: 7/2006 Acquired: 2007
Laci_access	Reviewed access layer by park personnel.	Acquired: 8/2007
extract_path	From LACL_B_Reclass_Cost_Continued step. Extracts the values <= 15000.	Created: 2007
Streams_buffer_union1	Union between the 30 meter buffer around NHD streams and the combined infrastructure (infra_null)	Created: 2007
swan_lake	All SWAN lake/ waterbodies.	Source: 3/2006
Result		
erase_area	Combined areas to be "erased" from the sampling areas.	Created: 2007

Appendix E: *Model: LACL_D_Add_Attributes*

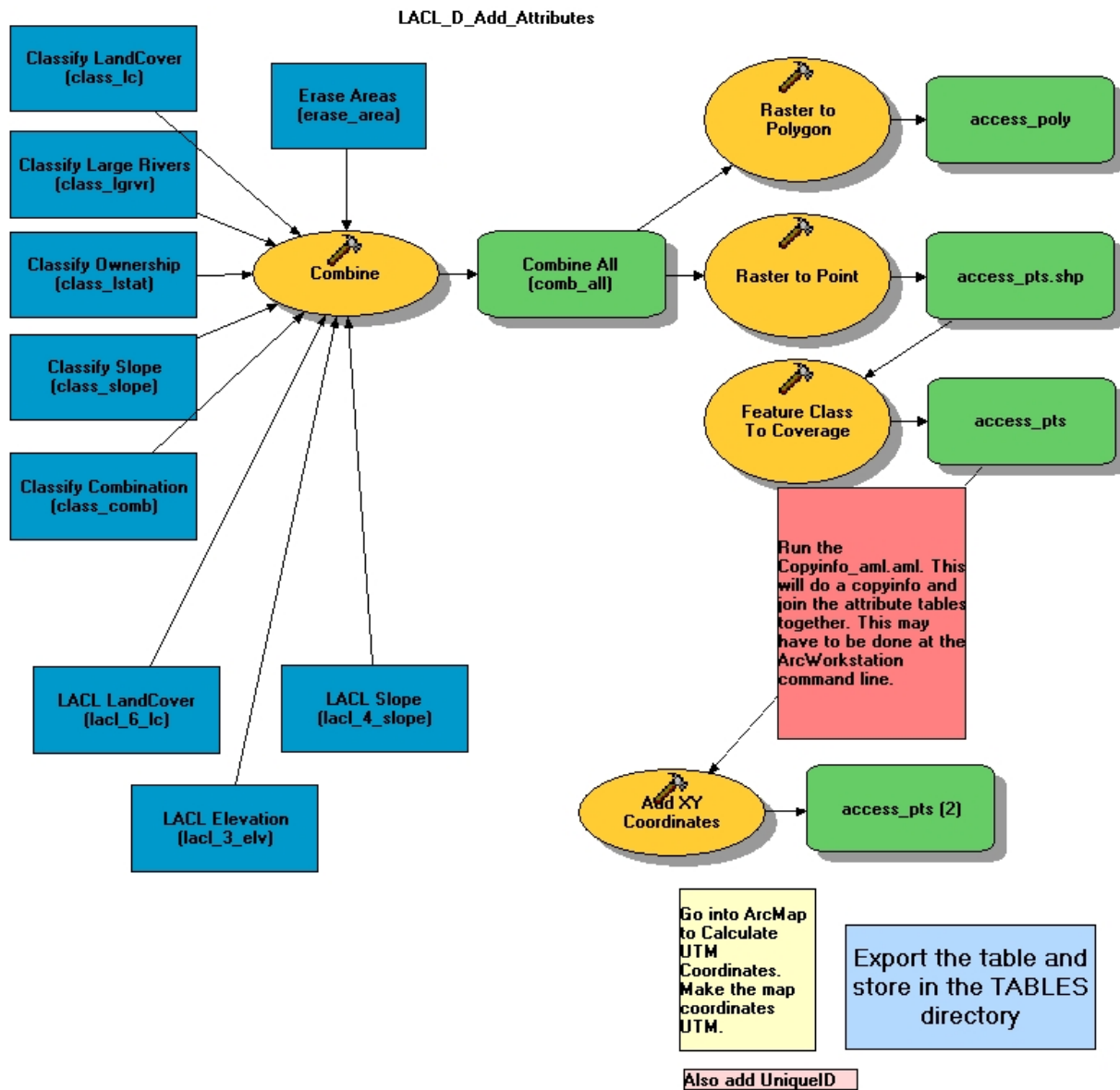
**ModelBuilder Documentation
For
Adding Attributes and Preparing Final Tabular Dataset**

ArcToolbox

LACL_D_Add_Attributes

Converts to a point shapefile, then to a point coverage. Attributes are combined and joined with the resulting coverage. Final info file is exported for statistical analyses (GRTS).

Illustration



Usage Tips

The raster tool COMBINE is perhaps the only raster tool that allows multiple attributes. Most tools only allow for one. This tool is used to combine all the attributes from the various sources so these can be exported to the final table.

This version of ArcGIS (9.2), does not yet have a fluid mechanism for joining the attributes from the raster info file (.VAT) with other tabular data. The following AML is run to join these attributes.

```
&s path <specify a directory>
```

```
copyinfo %path%comb_all.vat %path%comb_all.tab
```

```
additem %path%comb_all.tab %path%comb_all.tab grid_code 8 16 f 3
```

```
/* go into info and calc grid_code = value
```

```
joinitem %path%access_pts.pat %path%comb_all.TAB %path%access_pts.pat grid_code GRID_CODE
```

Command line syntax

LACL_D_Add_Attributes

Parameters

Expression	Explanation
------------	-------------

Command Line Example

Scripting syntax

LACL_D_Add_Attributes ()

Parameters

Expression	Explanation
------------	-------------

Script Example

Model Elements

Name	Explanation
Combine	Combines all the various attributes that are used for determining the vegetation sampling. This includes: • Difficulty classification for Land cover • Land cover • Difficulty Classification for large rivers • Difficulty Classification for land status

	• Difficulty Classification for slope • Slope • Elevation • Areas of elimination (erase) • Difficulty Classification Path Distance (cost)
Raster to Point	Converts the access raster file to a point shapefile.
Feature Class To Coverage	Converts the access points shapefile to a coverage. There appears to be more tools available for joining attributes from a raster to a coverage than there is from a raster to a shapefile.
Add XY Coordinates	Attributes should be joined prior to this next step. Add the XY coordinates. These will be in Albers projection. Go into ArcMAP and project the view in the appropriate UTM zone. Use the AlaskaPak tools to calculate the UTM coordinates. Also, use the AlaskaPak to calculate the UniqueID. Open the table, and export into the TABLES directory. This export will be used by the Network Statistician for the GRTS analysis.
Raster to Polygon	Convert to polygon, based on difficulty classification. Used for statistics in determining how much of the park is within scope of sampling based on access.

Datasets Used:

Dataset Name Input	Description	Date Acquired for Analysis
class_lc	Classified land cover from LACL_A_Reclass_Cost step.	2007
class_lgrvr	Classified large rivers from LACL_A_Reclass_Cost step.	2007
class_lstat	Classified land status from LACL_A_Reclass_Cost step.	2007
class_slope	Classified slope from LACL_A_Reclass_Cost step.	2007
class_comb	Generated from the reclassification of the combine_1 layer. Used as input for the Path Distance analysis.	Created: 2007
laci_6_lc	Landcover map for Lake Clark NP&P using Spot	Source: 6/1997

	multispectral imagery and other refinements.	Acquired: 4/2007
lacl_3_elv	Extracted from the National Elevation Dataset (NED). This is 30meter resolution.	Source: 12/18/2002 Acquired: 4/2007
lacl_4_slope	Slope generated from lacl_3_elv	Source: 12/18/2002 Acquired: 4/2007
erase_area	Combined areas to be “erased” from the sampling areas.	Created: 2007
Result		
access_pts	A point coverage, spaced 30 meters apart with all attributes associated to the points.	Created: 2007

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS D-40, February 2008

National Park Service
U.S. Department of the Interior



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