OREGON LIDAR ACQUISITION PRIORITIZATION PLAN: 3DEP ANALYSIS PRIORITIZATION RESULTS

OREGON ELEVATION FRAMEWORK IMPLEMENTATION TEAM (E-FIT)
DATA ACQUISITION ADVISORY COMMITTEE (DAAC)
PRIORITIZATION PLAN TASK FORCE

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1	5/10/14	Ian Madin	DOGAMI	Original draft
2	6/6/14	Tyler Duffy	City of Springfield	Document info, formatting, strategy and methodology adjustments.
3	6/20/2014	Tyler Duffy	City of Springfield	Methodology, analysis, results based on adjusted methodology.
4	6/23/14	Brandt Melick	City of Springfield	Review, minor edits and recommendations.
5	8/19/2014	Bob DenOuden	DAS GEO	Incorporate DAAC edits and recommendations

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Related Agreements and Reference Documents

Title	Description	Location
3D Elevation Program Initiative Plan	E-Fit Stewardship Plan	http://www.oregon.gov/DAS/CIO/GEO/fit/elevation/docs/3DEP%20Plan%20Ver%201.0.pdf
3D Elevation Program (3DEP) – Summary for Oregon	3DEP Oregon Summary Report	http://pubs.usgs.gov/fs/2014/3014/pdf/fs2014-3014.pdf
E-FIT Charter	Charter and Bylaws	http://www.oregon.gov/DAS/CIO/GEO/fit/elevation/
Final Report of the National Enhanced Elevation Assessment (NEEA)	NEEA Final Report	http://www.dewberry.com/Consultants/GeospatialMapping/FinalReport-NationalEnhancedElevationAssessment

1. Project Purpose and Overview

Since 2007, The Oregon Department of Geology and Mineral Industries (DOGAMI) has collected lidar data for Oregon by using the Oregon Lidar Consortium (OLC) to build funding partnerships to collect large blocks of high lidar quality data at the best possible price. In the 2007-2009 and 2009-2011 biennia, the state contributed a total of $2M to the program, and OLC partners contributed an additional $7.8 M. In the 2011-2013 and 2013-2015 biennia, the state contributed no funds, and OLC partners provided funds totaling $4.5 M in 2011-2013, and $2 M in 2013-2015 to date. The OLC lidar acquisition program (including its predecessor, the Portland Lidar Consortium) has made good progress, collecting lidar over approximately 30% of the state, some 19 million acres. This coverage includes:

- 94% of the state's population
- 100% of the coast
- 60% of Oregon's highways
- 81% of endangered Oregon Coho salmon habitat

When state seed money was available, the OLC prioritized the coast and Willamette Valley, and areas with significant problems with watershed health, like the Klamath Basin. Without state seed money acquisition is driven by the interests of the funding partners, which may not always serve the priorities of the state as a whole. The lidar collection program will face a very different funding landscape in 2015-2017, as the US Geological Survey (USGS) starts the 3D Elevation Program (3DEP), a national lidar data acquisition funding program. 3DEP has a goal of completing lidar coverage of the lower 48 U.S. states within 8 years and will be run cooperatively with the states. States will be required to develop a prioritization plan and then submit nationally competitive proposals for project funding.

The purpose of this project is for the Oregon Elevation Framework Implementation Team (E-FIT) to develop a prioritization plan for the state during 2014 in order to be well-positioned for participation in the 2015 3DEP program. The E-FIT has formed a Data Acquisition Advisory Committee (DAAC), which draws from a wide range of Oregon stakeholders and LIDAR users, and is working closely with the DOGAMI lidar program to complete this prioritization plan.

2. Strategies, Agreements, and Assumptions

In order to be competitive in the 2015 3DEP program, Oregon needs to develop a prioritization plan by the end of 2014. The prioritization plan developed for consideration of 3DEP funding will evolve to meet the following short, mid, and long-term E-FIT needs:

A. USGS 3DEP draft pre-proposal by August 2014
B. State legislative process by September, 2014
C. Ongoing state elevation data framework process

This document reports on analysis conducted for the purpose of meeting goal A., with consideration given to goals B. and C. in developing analysis methods.

In order to maximize the value of analysis efforts and meet deadlines several factors have been taken into consideration in the design and implementation of the lidar acquisition prioritization analysis. The following strategies, agreements, and assumptions shaped the development of the analysis:

- Prioritization Plan Assumptions and Strategies:
    - The DAAC created a task force to follow guidance, implement recommendations, and perform analysis

    - The DAAC provided guidance and recommendations for the selection of data inputs for the analysis, methods for the analysis, as well as the relative weighting factor assigned to each data input in order to ensure a collaborative effort
    - A simple, reusable, and easy to modify analytical model was developed to support short term analysis needs of 3DEP and long term needs of the E-FIT
    - For the 3DEP Proposal, the analysis parameters and methodology should align as closely as possible with USGS 3DEP stated goals and requirements (highlighted below)
    - For the E-FIT, additional feedback is required from the DAAC regarding analysis methods (data inputs, weighting, etc.). See list of methodology considerations in Section 5.

- Analysis Assumptions and Strategies:
    - Large areas without lidar should be ranked higher than large areas with lidar for the following reasons
        - the 3DEP program's documents suggest a higher level of interest in funding projects that cover large contiguous areas
        - DAAC survey feedback suggests acquiring lidar data for large project areas is preferable to filling in smaller gaps
    - Analysis will be raster based, with a cell size of 90m
    - Project area units of analysis (zones) will be based on watershed boundaries to coincide with realistic data needs, rather than orthogonal tiles that do not coincide with geographies of interest
    - Point and line features will be buffered to the distances indicated in Table 4 in order to strengthen their representation in the raster analysis

Furthermore, the *3D Elevation Program - Summary for Oregon* (Carswell, 2014) has highlighted the following benefits of a nationally funded program that may or may not reflect USGS criteria for funding:

- "Economy of scale – Acquisition of data covering larger areas reduces costs by 25 percent"
- "A systematic plan…"
- "Higher quality data and national coverage…"

The same document also highlights the following factors as dependencies for successful implementation of the program:

- "Increased partnerships among Federal, State, Tribal, and local governments"
- "Partnerships that acquire elevation data to the program's specifications across larger project areas"
- "Support for the program from government and other stakeholders"

These points have been taken into consideration in the development and design of the prioritization plan.

3. Lidar Acquisition Prioritization Analysis Methodology

A. Overview of Methods

In order to determine the relative priority of project areas for future lidar data acquisition, the DAAC task force performed a raster-based weighted sum overlay analysis. To accomplish this, twenty-seven individual datasets were used to produce eight thematic raster layers. The thematic raster layers were each assigned a weight and used as input to the weighted sum analysis.

To produce the thematic layers, raster datasets were reclassified to represent a presence (cell value = 1) or absence (cell value = 0) of a feature of interest, with the exception of the existing lidar coverage layer, which was assigned a cell value of -1. This was done to avoid assigning a high priority to project areas for which lidar data is already available.

Raster datasets that comprised each theme were then added using map algebra to produce the thematic raster datasets. The cell values of the thematic layers were then used as inputs to a weighted sum overlay, which multiplied cell values by a weighting factor derived from the results of a survey circulated among the Oregon E-FIT and added the resultant values together to produce a single output raster layer. Cell values from the weighted sum overlay output were then summed within for each project area in order to calculate the total representation of features of interest within that zone. The resulting sums for each project area were then grouped into five classes using natural breaks (Jenks). The end product is a map with project areas assigned relative priority that ranges from very low to very high (Figure 3) and a table that ranks project areas by priority as determined by the analysis (Table 3). A conceptual model of the analysis methods can be found in Exhibit 1 at the end of this document.

B. Community Survey

In order to determine which datasets to use and the relative importance (weight) of each data theme, the DAAC task force created an online survey and solicited input from E-FIT and DAAC members on May 27, 2014 on four items.

1) Importance of thematic layers to use in the analysis. A 3-level Likert scale was used to rank themes.
2) Importance of specific datasets to include in each thematic layer in the analysis. A 5-level Likert scale was used.
3) Suggestions for additional datasets to use that were not listed on survey.
4) Whether it is more important to collect data in small project areas to complete coverage for a region or to collect data in large project areas for which there is currently no lidar data available. A 5-level Likert scale was used.

Summary tables of the survey results appear in the Table 5 below.

C. Acquisition Tiling and Project Area Prioritization

To date, OLC project boundaries have been driven by the needs of funding partners, resulting in the project areas shown below in Figure 1. At the OLC project level, data are tiled by USGS 7.5 minute quadrangles, and as a result some quadrangles have complete or partial coverage assembled from up to 3 different projects flown at different times. Fortunately, all data have been collected by the same vendor and to the same specifications, so the datasets are practically seamless. The DAAC has reached a consensus to collect data in project areas that are based on watershed boundaries. The project areas

used in this analysis are illustrated below in Figure 1.One argument for this tiling is that 3DEP has stated a preference for large projects and the watersheds as delineated below have an average area of approximately 2900 square miles. DAAC survey results also support an emphasis placed on large project areas, as summarized in Table 1 below.

Figure 1. Existing Oregon Lidar Consortium project areas (OLC, 2014) and a proposed watershed boundary tiling scheme developed by DOGAMI. Project areas are based on 4th and 6th field HUC boundaries.

Table 1. Survey results for project area size preference.

Project Area Size Preference	Votes	% Total
Large Blocks	5	42%
Neutral	4	33%
Small Gaps	3	25%
Total	**12**	**100%**

D. Thematic Layers

LIDAR collection prioritization is based on uses and needs. Drawing from the National Enhanced Elevation Assessment (NEAA) and consultation with the Oregon lidar user community, a suite of geographic themes was developed that represents the various needs and uses. This approach allows for project areas to be rated for each need or use. Themes can then be weighted and used to arrive at a ranked prioritization of the project areas.

The themes were derived from the Oregon summary from the NEAA (Figure 2). This approach ensures that the prioritization plan aligns with the uses and needs that were identified by USGS through polling of numerous Federal, State, Local, and NGO users and holding a series of user meetings. Eight themes were established that include the ten main business uses shown below in Figure 2, with each theme serving to represent several uses. The themes, the business uses they represent, and their constituent data layers are listed below. The themes are generally composed of data layers that are publically available, statewide, and comprehensive. Polygon features have been included in the analysis as is, while point and line features were buffered (see Table 3 for distances) to amplify their presence in the analysis. See Exhibits 2 through 9 for visual representations of the themes used in this analysis.

Figure 2. Oregon business uses for lidar from the NEAA, ranked by estimated annual benefits (Carswell, 2014, p. 3).

Rank	Business use	Annual benefits (millions)
1	River and stream resource management	$18.45
2	Forest resources management	8.12
3	Water supply and quality	6.27
4	Infrastructure and construction management	3.48
5	Wildfire management, planning and response	2.48
6	Natural resources conservation	2.19
7	Geologic resource assessment and hazard mitigation	1.51
8	Flood risk management	1.47
9	Agriculture and precision farming	0.80
10	Coastal zone management	0.39
	Other	0.57
	Total	45.73

The thematic layers used in the analysis, along with their relative weights (derived from survey results) are summarized below.

Table 2. Thematic data layers used in the prioritization analysis. Percent influence was calculated by dividing the number of vote points for a theme by the total number of vote points.

Theme	Sum of Point Values	% Influence
Water	56	16%
Natural Hazards	52	15%
Critical Habitat	46	13%
Forest	46	13%
Completeness	44	12%
Infrastructure	44	12%
Agriculture	36	10%
Population	31	9%
Total	355	100%

E. Data Inputs

The individual datasets used in the analysis were determined through a collaborative DAAC effort. The datasets were then evaluated on their importance in the survey. Because datasets from more than one source were included, the results of this survey largely served to aid in deciding between similar datasets (e.g. DEQ 303(d) Water Quality Limited Streams v. all NHD Streams), as well as to eliminate extraneous datasets from the analysis. Datasets that received less than 50% of the total points were eliminated from the analysis. The DAAC task force recommends that the full DAAC review and evaluate the narrowed-down list of datasets based on their relative importance within a theme, and also the relative weighting of the themes. A summary of datasets used in the analysis appear in Table 3, below.

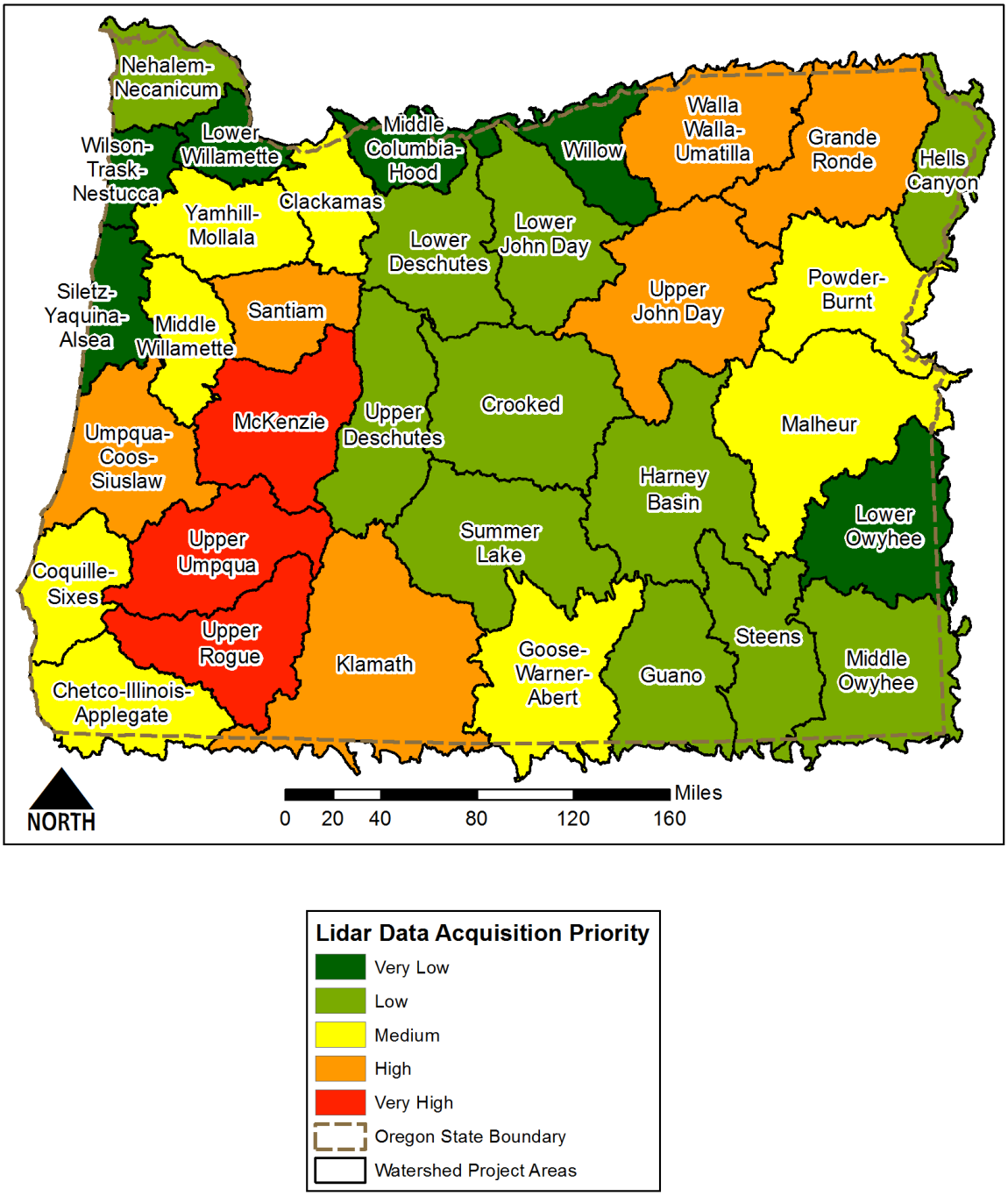
Table 3. Datasets used in project area prioritization analysis. *Denotes that the dataset does not clearly fit into a thematic data layer.

Theme	Dataset Description	Data Used	Buffer Distance
Agriculture	Agriculture (NLCD 2011)	Cultivated Crops	N/A
Critical Habitat	Critical Habitat (ODFW)	Compiled Crucial Habitat Rank = 1	N/A
Forest	Forest (NLCD 2011)	Deciduous, Evergreen, and Mixed Forest	N/A
Infrastructure	Dams (OWRD)	Dam points for dams with height >= 10ft and storage >= 9.2 acre feet	200m
Infrastructure	Highways (ODOT)	All	100m
Infrastructure	Oregon Bridges (ODOT)	All (Bridge Points)	100m
Infrastructure	Railways (ODOT)	All	100m
Infrastructure	Electric Substations (DOGAMI)	All	100m
Infrastructure	Electrical Towers (DOGAMI)	All	100m
Infrastructure	Electrical Transmission Lines (DOGAMI)	All	100m
Infrastructure	Wind Farms (DOGAMI)	All	N/A
Natural Hazard	Landslide Database (SLIDO-3)	Historic Landslide Points	100m
Natural Hazard	Flood Zones (FEMA)	Flood Zones A; AE	100m
Natural Hazard	Tsunami Evacuation Zones (DOGAMI)	All	100m
Natural Hazard	Active Faults (DOGAMI)	All	1000m
Natural Hazard	Volcanic Vents (DOGAMI)	All	1000m
Natural Hazard	Slope (Percent)*	Slope > 50%	N/A
Natural Hazard	Wildfire Risk (ODF Fire Threat Index)	FTI > 25%	N/A
Natural Hazard	Oregon Coast* (NOAA)	All	1000m
Population	Population (2010 Census)	Population density > 0.1/acre	N/A
Water	NHD Streams (USGS)	All	100m
Water	Lakes (USGS)	All	100m
Water	Drinking Water Protection (Ground; OWRD)	All	N/A
Water	Drinking Water Protection (Surface; OWRD)	All	N/A

F. Analysis Results

The values obtained from the weighted sum analysis were grouped into five classes using natural breaks (Jenks) classification. The classes were then assigned a relative priority ranking, ranging from very low to very high. The results are illustrated below in Figure 3.

Figure 3. Lidar Data Acquisition Project Area Priority Ranking



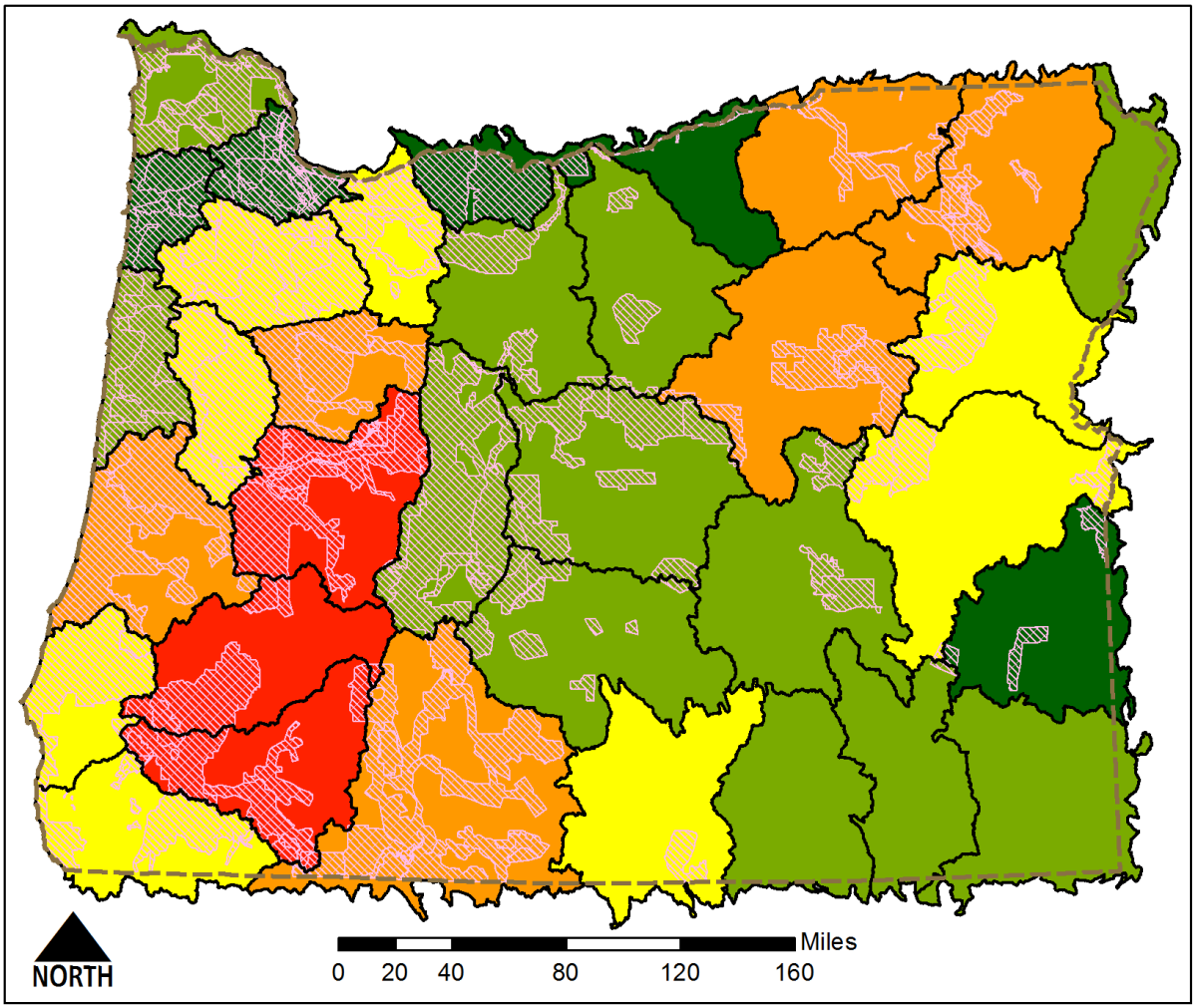
A more detailed priority ranking is summarized below in Table 4. Rankings were derived from the values resulting from the weighted sum analysis.

Table 4. Priority rankings for all 34 project used in the weighted sum analysis.

Priority Rank	Project Area (Subbasin)	Priority Rank	Project Area (Subbasin)
1	Upper Umpqua	18	Nehalem-Necanicum
2	McKenzie	19	Harney
3	Upper Rogue	20	Guano
4	Grande Ronde	21	Crooked
5	Upper John Day	22	Summer Lake
6	Umpqua-Coos-Siuslaw	23	Steens
7	Santiam	24	Hells Canyon
8	Walla Walla-Umatilla	25	Lower John Day
9	Klamath	26	Lower Deschutes
10	Coquille-Sixes	27	Middle Owyhee
11	Malheur	28	Upper Deschutes
12	Chetco-Illinois-Applegate	29	Siletz-Yaquina-Alsea
13	Clackamas	30	Lower Owyhee
14	Yamhill-Molalla	31	Lower Willamette
15	Goose-Warner-Abert	32	Willow
16	Middle Willamette	33	Wilson-Trask-Nestucca
17	Powder-Burnt	34	Middle Columbia-Hood

Lidar coverage has been overlaid on the analysis results in Figure 4 for reference.

Figure 3. Analysis results overlaid with existing lidar coverage.



Lidar Data Acquisition Priority

- Very Low
- Low
- Medium
- High
- Very High
- Lidar Data Available or In Development
- Oregon State Boundary
- Watershed Project Areas

4. **Methodology Considerations and Discussion Items For Meeting Future E-FIT Goals**

The DAAC task force recommends that the following items be addressed at some point as this prioritization plan evolves. Note that not all of items will be addressed in the initial effort to inform the 3DEP Proposal, as this plan will be refined over time to meet short, medium, and long term goals of the E-FIT.

- Datasets to include in analysis should be reexamined or further refined
    - Some themes contain datasets that amplify a presence of what is essentially the same feature
        - Wetlands/Streams
    - The following data sets do not fit into existing thematic layers
        - State Parks (omitted from analysis)
        - Slope (included in Natural Hazards theme)
        - Coast (erosion) (included in Natural Hazards theme)
- Data inputs should be reevaluated via survey or other means to determine the relative importance (weight) of a dataset within a theme and the relative importance of each theme. This is recommended for the following reasons:
    - The survey that was conducted contained datasets that duplicate feature classes from differing sources, e.g. DEQ 303(d) Water Quality Limited Streams/NHD Streams. This may produce misleading results.
    - There is already a weighting scheme in place for each thematic layer. Since all datasets were evaluated without regard to their theme, the survey results as they stand would have the effect of duplicating this weighting.
- The DAAC should discuss in greater detail the parameters of certain data inputs. In this analysis, definition queries were used to isolate classes of data using best judgment. Datasets for which to discuss parameters:
    - Flight date of existing lidar data (not factored into this analysis)
    - 1-6 Compiled Crucial Habitat Rank
    - Slope %
    - Fire Threat Index

EXHIBIT 1: CONCEPTUAL MODEL OF ANALYSIS METHODS

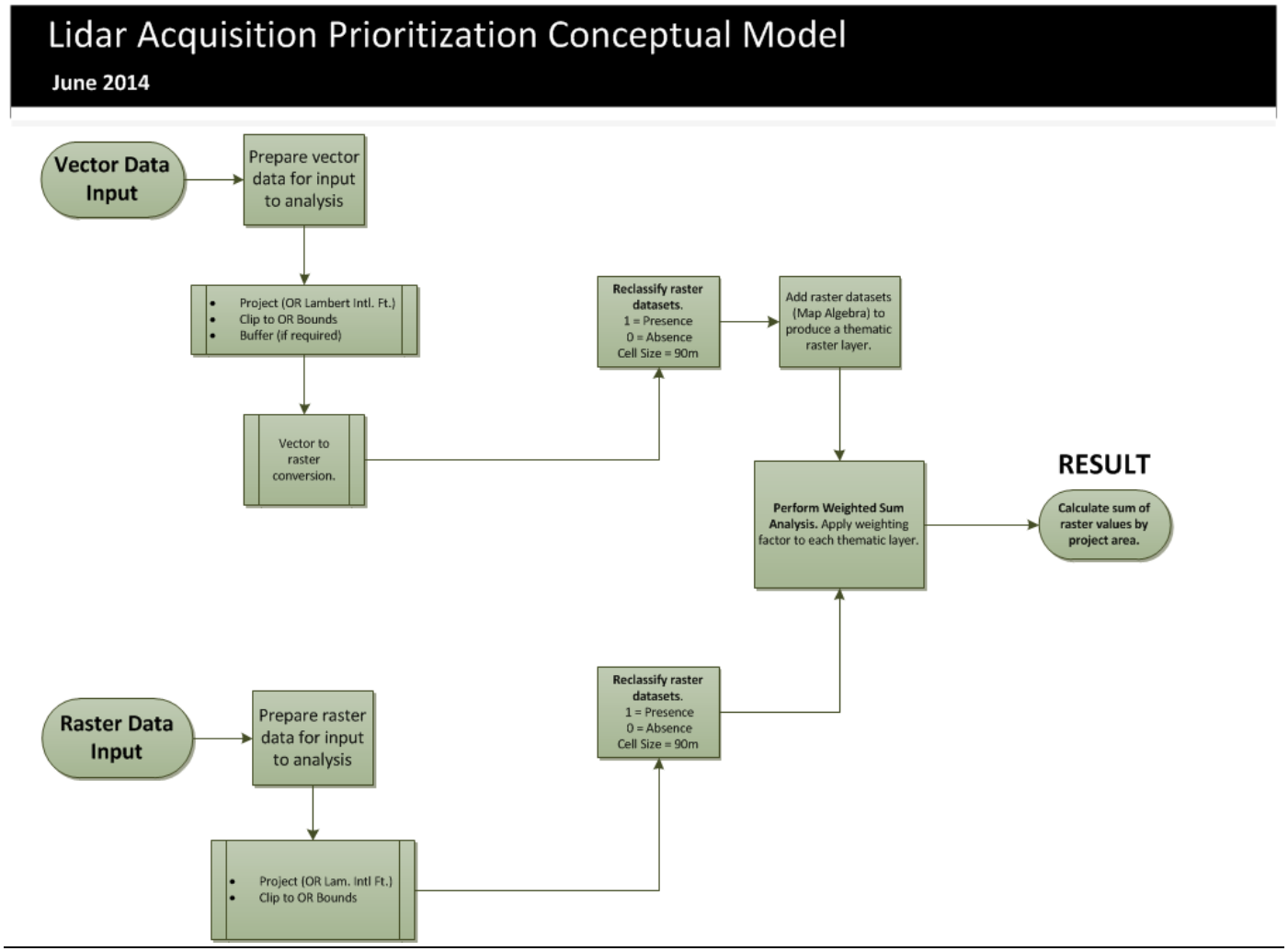
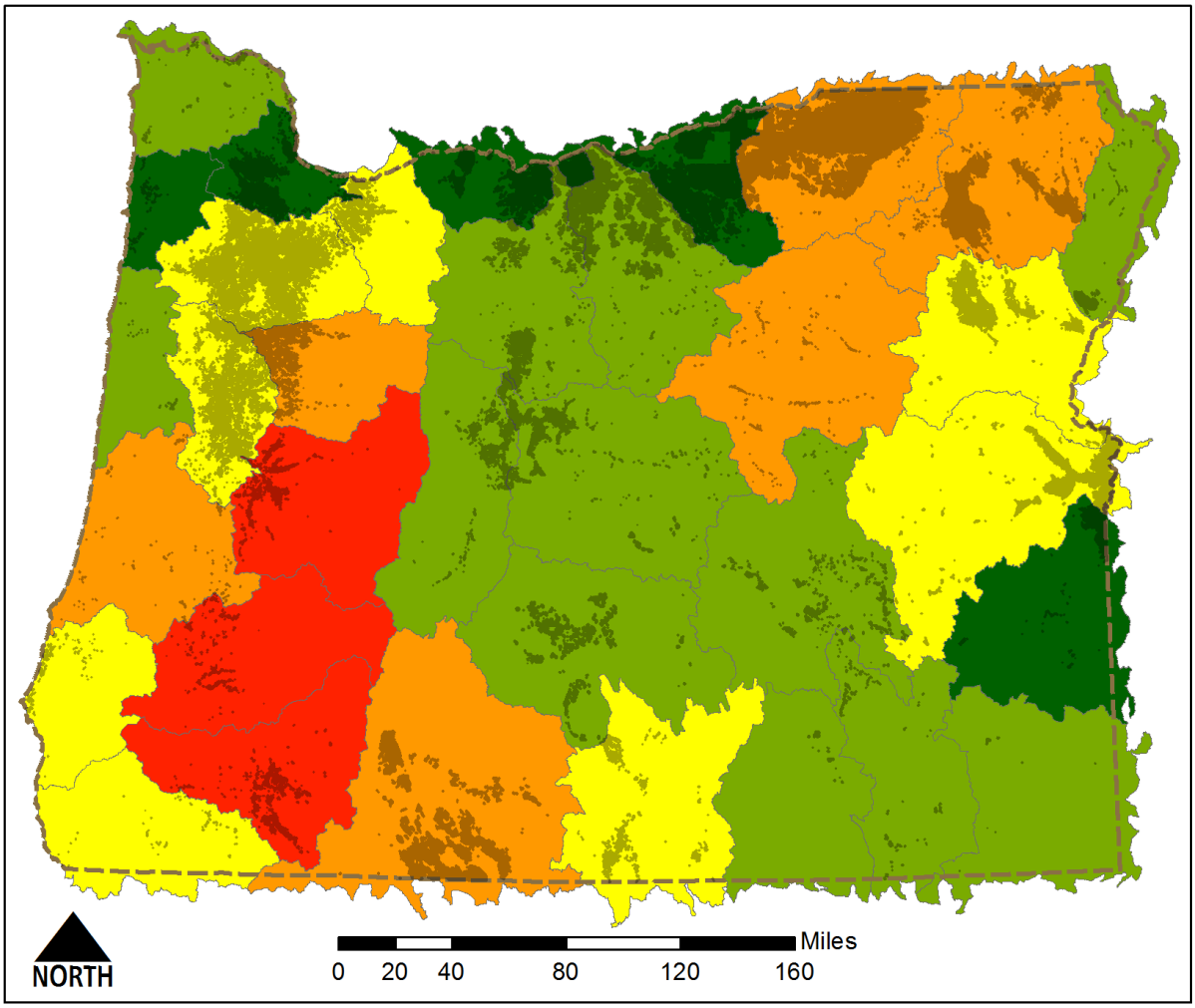
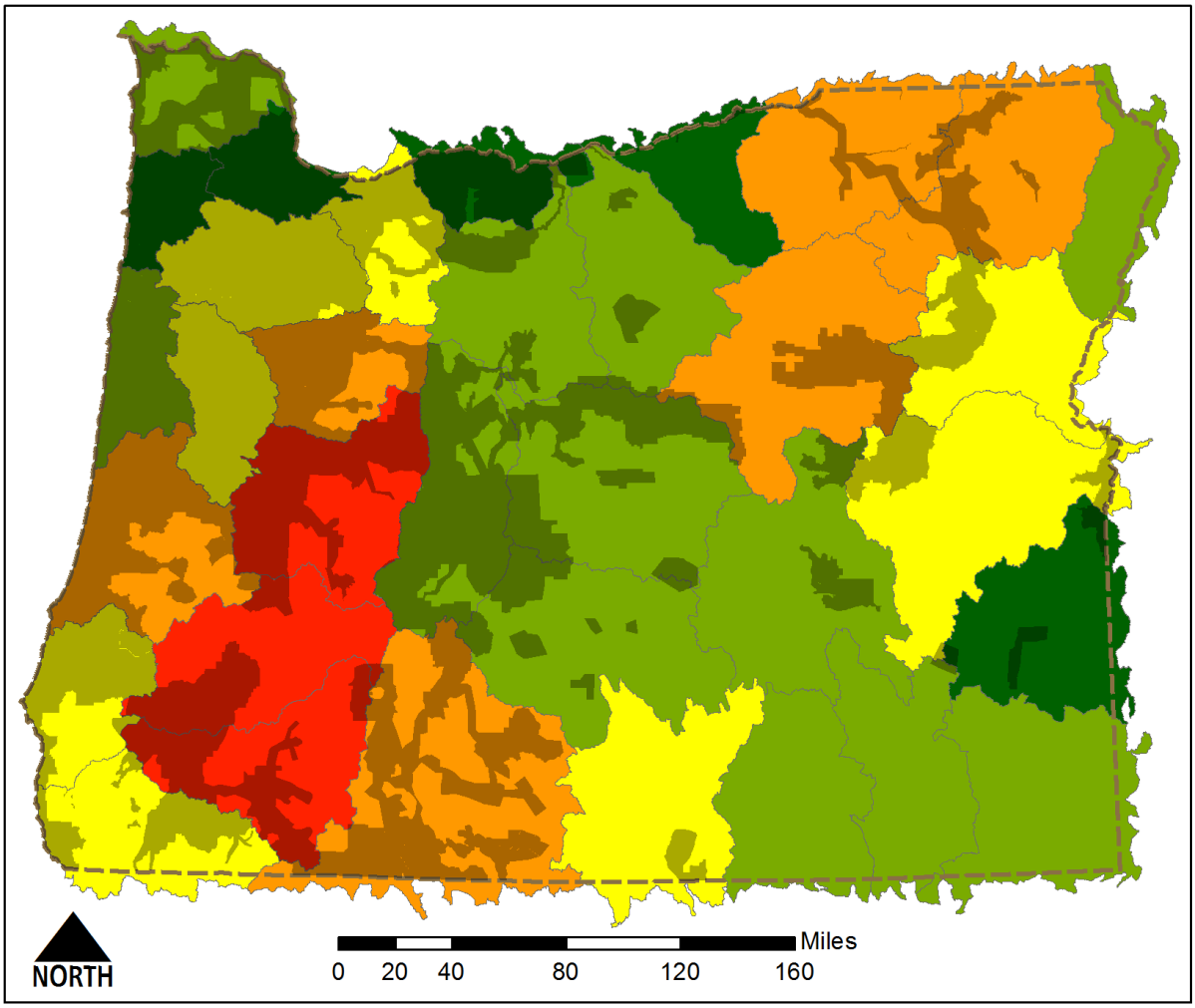


EXHIBIT 2: AGRICULTURE THEME



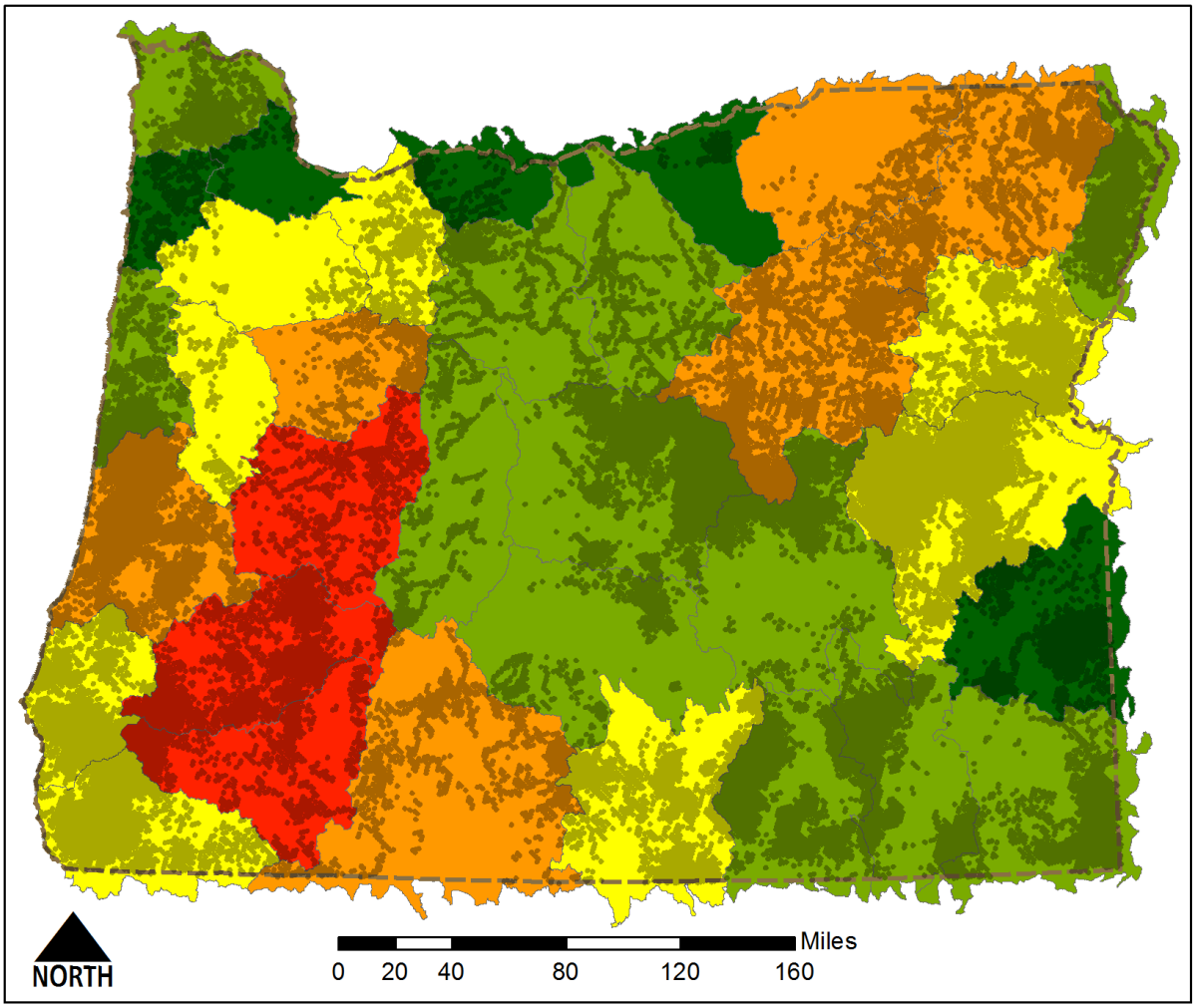
AgricultureTheme
Oregon State Boundary
Lidar Data Acquisition Priority
Very Low
Low
Medium
High
Very High

EXHIBIT 3: COMPLETENESS THEME



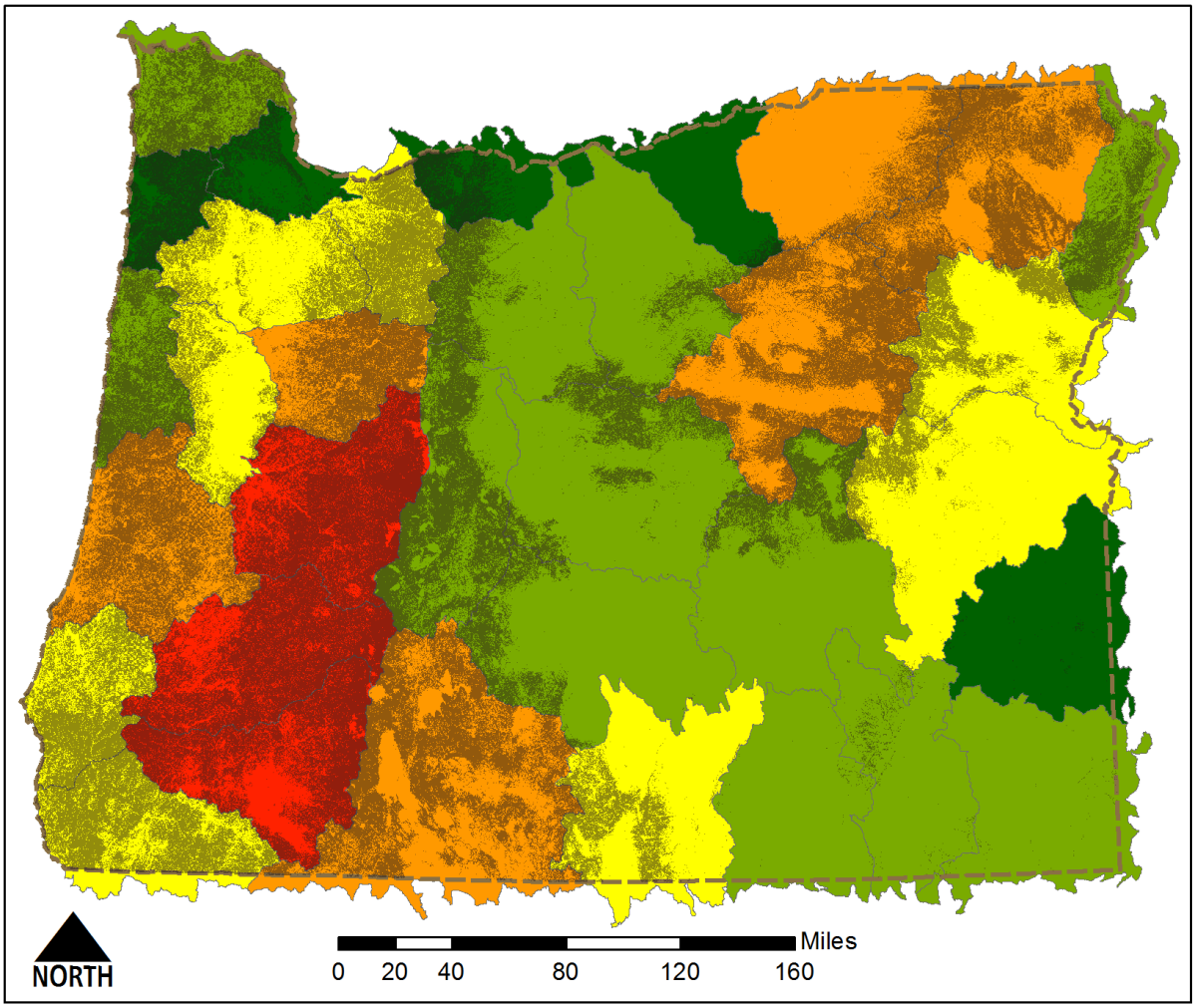
Completeness Theme
Oregon State Boundary
Lidar Data Acquisition Priority
Very Low
Low
Medium
High
Very High

EXHIBIT 4: CRITICAL HABITAT THEME



Critical Habitat Theme
Oregon State Boundary
Lidar Data Acquisition Priority
Very Low
Low
Medium
High
Very High

EXHIBIT 5: FOREST THEME



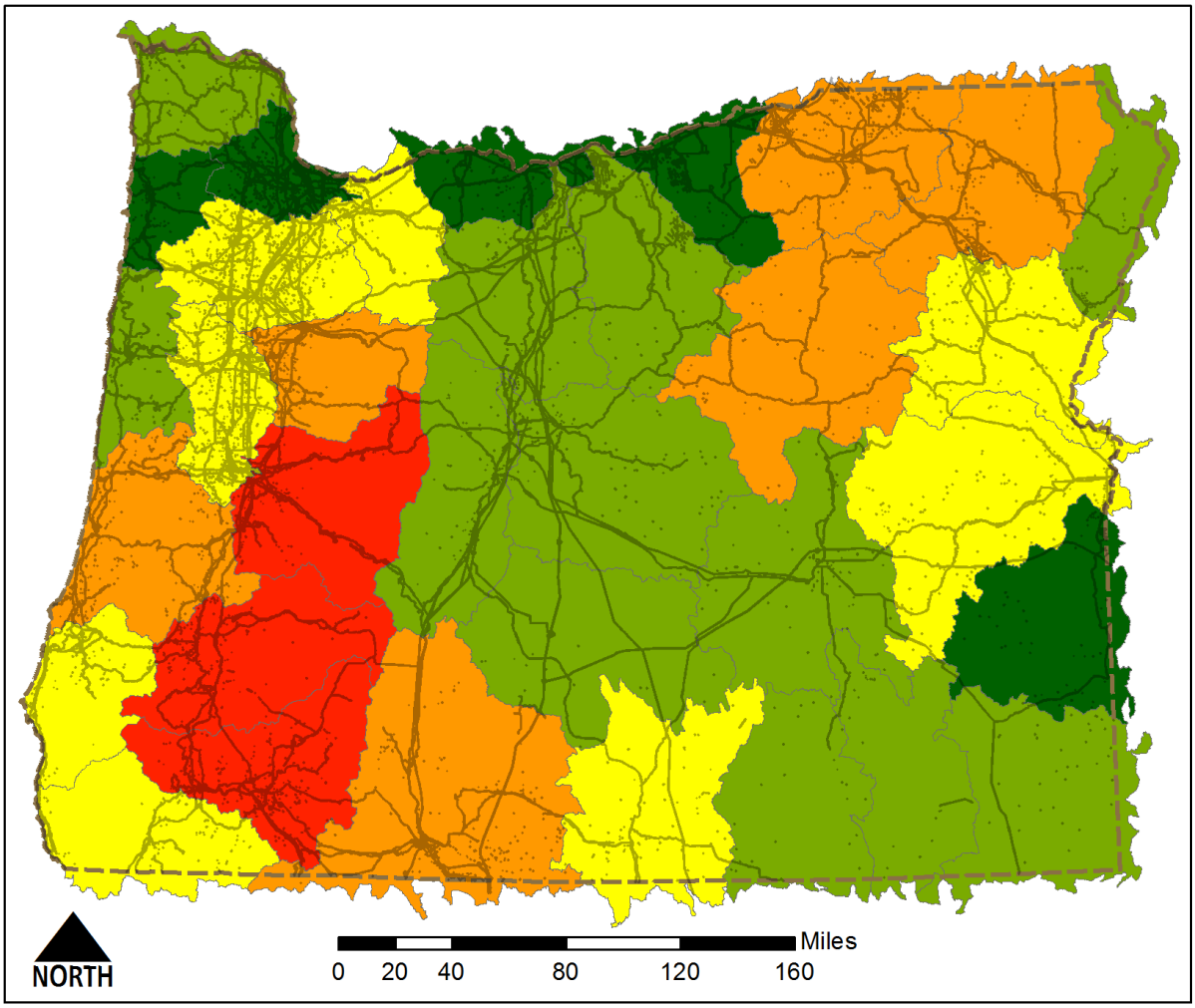
Forest Theme

Oregon State Boundary

Lidar Data Acquisition Priority

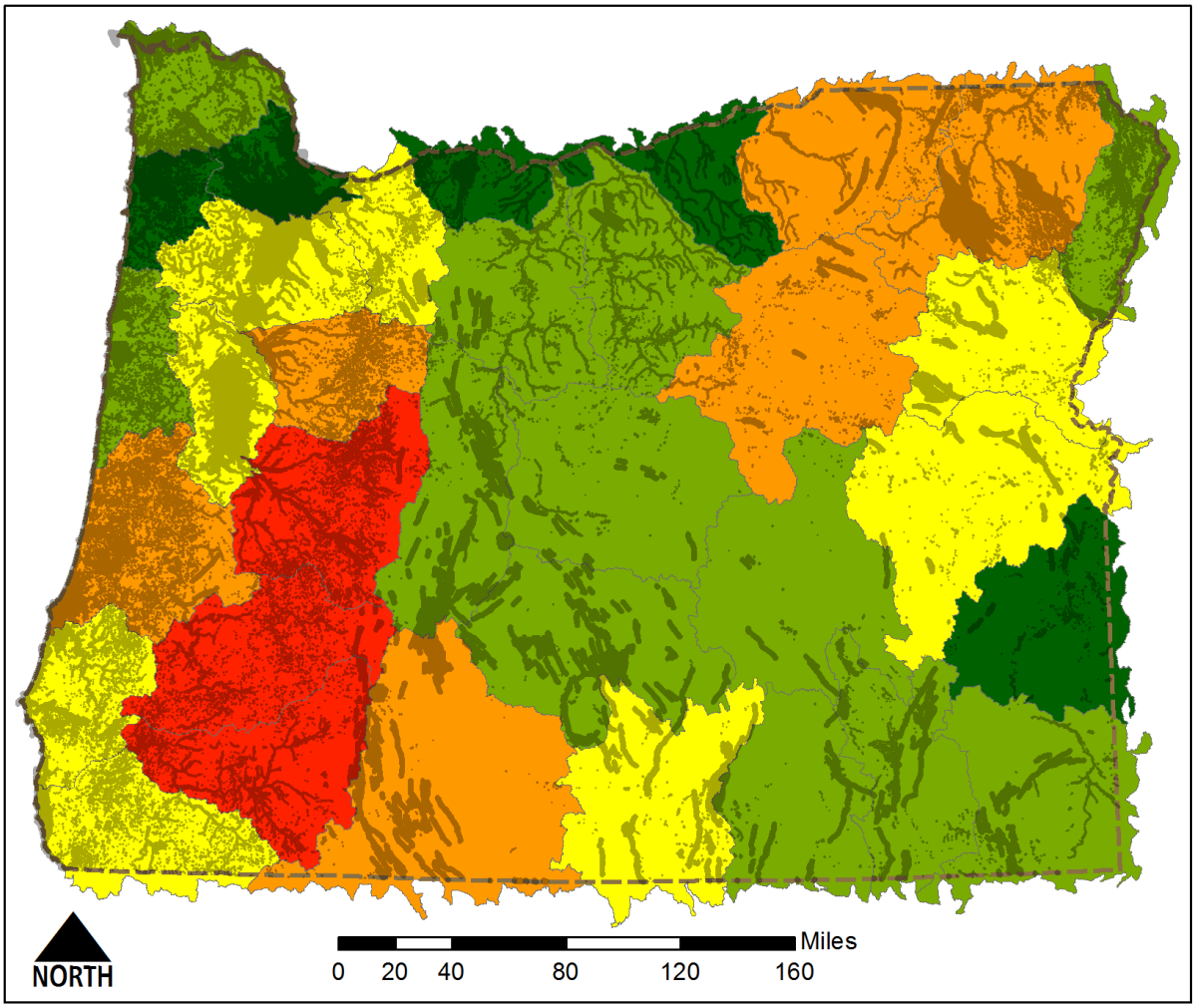
- Very Low
- Low
- Medium
- High
- Very High

EXHIBIT 6: INFRASTRUCTURE THEME



Infrastructure Theme
Oregon State Boundary
Lidar Data Acquisition Priority
Very Low
Low
Medium
High
Very High

EXHIBIT 7: NATURAL HAZARD THEME



NaturalHazardTheme
Oregon State Boundary
Lidar Data Acquisition Priority
Very Low
Low
Medium
High
Very High

EXHIBIT 8: POPULATION THEME

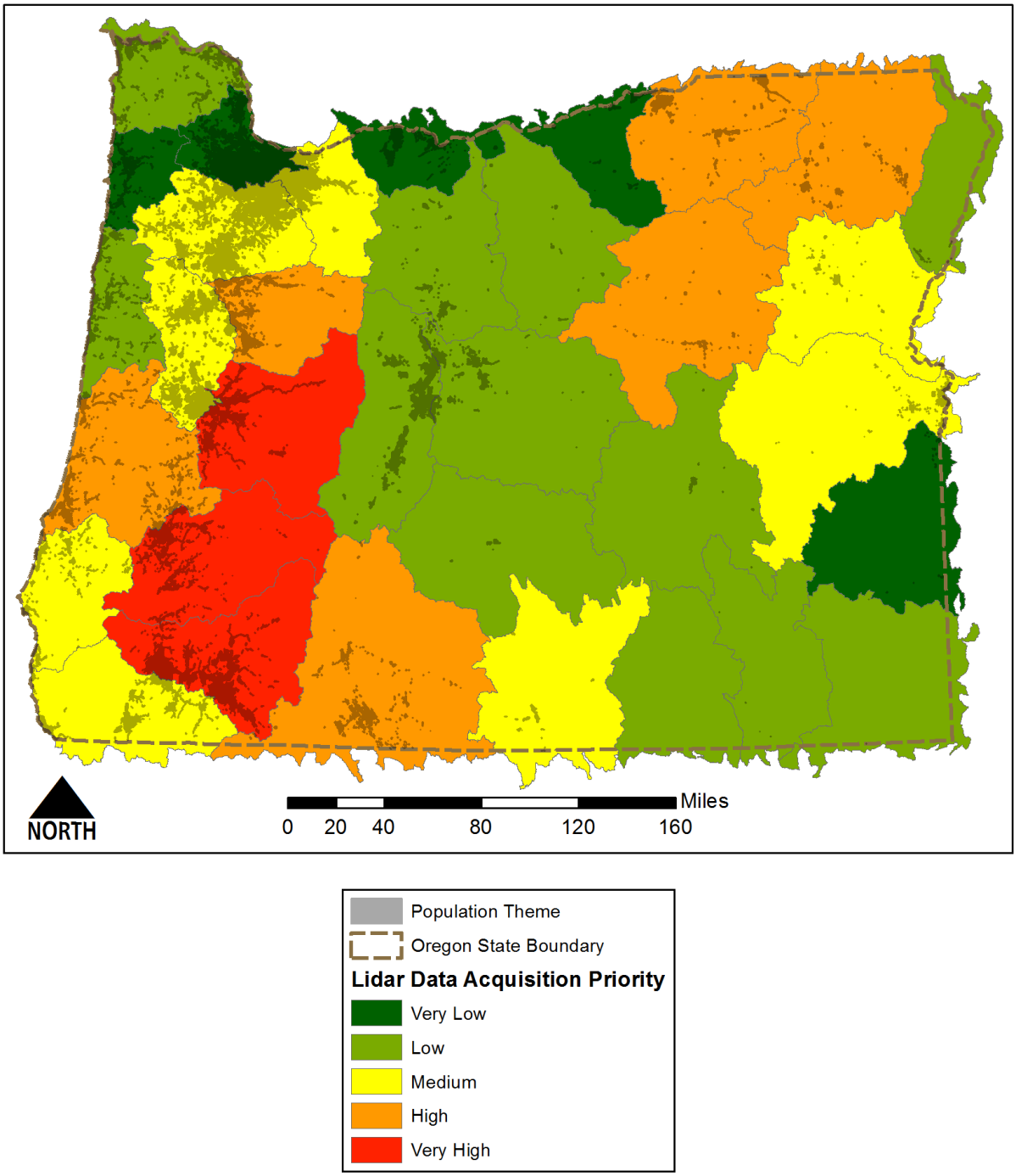


EXHIBIT 9: WATER THEME

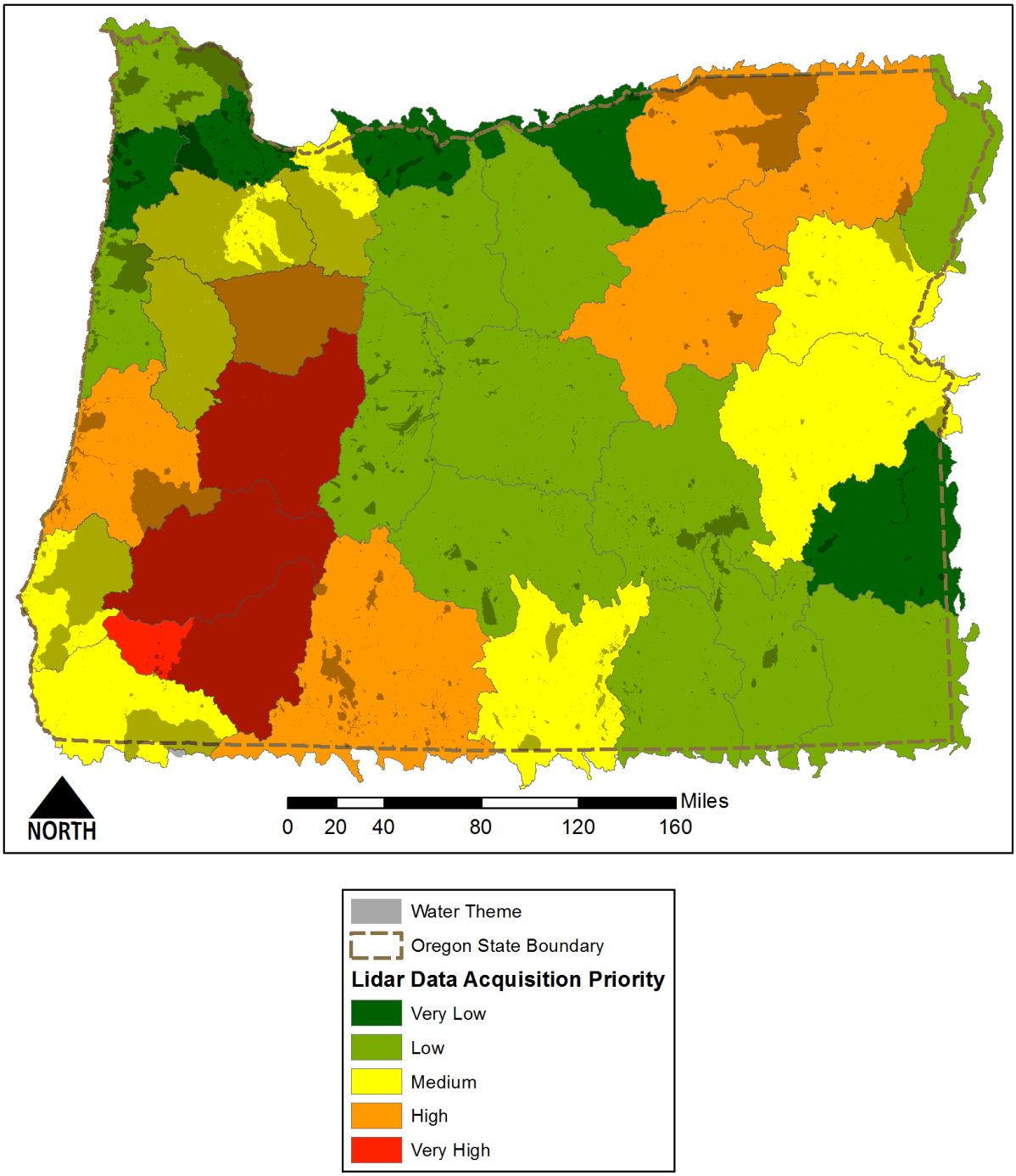


Table 5: Elevation FIT data acquisition prioritization survey results summary

Please rate the importance of each of the data themes below relative to the prioritization of elevation data acquisition							
Select a rating (5 = highest importance)							
Answer Options	5	4	3	2	1	Response Count	SUM
NHD rivers and lakes	8	2	2	0	0	12	54
Flood zones (DFIRM and Q3 A and AE zones)	7	3	1	1	0	12	52
SLIDO3 (landslides)	7	2	2	1	0	12	51
Slope	5	5	1	1	0	12	50
Wetlands	6	3	2	1	0	12	50
Dams	6	1	4	1	0	12	48
Tsunami Inundation (XXL scenario)	5	4	1	2	0	12	48
Current lidar coverage areas	5	2	4	1	0	12	47
Critical habitat	6	1	2	3	0	12	46
Forest	5	3	2	1	1	12	46
1km buffer on the coast to represent erosion hazards	4	3	3	1	1	12	44
Bridges	3	2	6	1	0	12	43
Wildfire Risk	4	3	2	2	1	12	43
Quaternary Faults	4	2	3	2	1	12	42
DEQ Water Quality limited streams and lakes	3	2	4	3	0	12	41
Groundwater Protection Areas	2	5	2	1	2	12	40
State Parks	3	2	3	4	0	12	40
Surface Water Protection areas	2	4	2	3	1	12	39
Urban-wildland interface	2	4	3	1	2	12	39
Highways	0	4	5	3	0	12	37
Cost to complete remaining lidar within watershed	3	1	4	1	3	12	36
Gas lines	2	2	3	4	1	12	36
Transmission lines, towers, substations	2	1	5	3	1	12	36
Agriculture	0	4	5	0	3	12	34
Quaternary volcanoes	2	1	2	5	2	12	32
Railroads	0	1	6	5	0	12	32
Airports	0	1	5	4	2	12	29
Urban Growth Boundaries	0	2	5	1	4	12	29
Population (at 2010 Census Block level)	0	1	5	3	3	12	28
Wind Farms	0	1	5	3	3	12	28
light sources at night (proxy for population/infrastructure)	0	1	2	4	5	12	23
Fiber	0	1	1	5	5	12	22

Please rate the categories relative to their importance in the prioritization of elevation data acquisition					
Answer Options	Very Important	Moderately Important	Not Important	Response Count	sum
Water	10	2	0	12	56
Natural Hazards	9	2	1	12	52
Forests	7	3	2	12	46
Critical Habitat	7	3	2	12	46
Infrastructure	5	6	1	12	44
Completeness	5	6	1	12	44
Agriculture	2	8	2	12	36
Population	1	8	2	11	31

It is more important to acquire data to fill in the large areas in Oregon where no lidar data is available than it is to complete smaller areas adjacent to existing lidar data	
Answer Options	Response Count
Strongly agree	2
Agree	3
Neutral	4
Disagree	2
Strongly Disagree	1