Appendix F – Benefit Cost Analysis Process

Cost Estimates for Data Acquisition

It is well known that costs for aerial data acquisition are higher when acquiring imagery, LiDAR or IFSAR of small or irregularly shaped areas. USGS obtained average cost estimates from its GPSC2 (Geospatial Products and Services Contract) prime contractors for different size areas and determined that costs are minimized when rectangular blocks of 5,000 square miles or larger are mapped. For new elevation data to be acquired, Dewberry assumed acquisition of 1-degree cells only (1 degree latitude by 1 degree longitude) which are nearly 4,000 square miles for most of the 48 conterminous states. To get the best price, aerial acquisition firms would be hired to acquire two or more of the 1-degree cells.

Table F.1. Estimation of Costs per Square Mile for the Five Quality Levels

A	B	C	D	E	F
Quality Level	**$/mi^2**	**QA/QC**	**Subtotal**	**USGS**	**Total $/mi^2**
QL1 LiDAR (48 states)	$453.25	$67.99	$521.24	$26.06	$547.30
QL2 LiDAR (48 states)	$277.00	$41.55	$318.55	$15.93	$334.48
QL3 LiDAR (48 states)	$209.25	$31.39	$240.64	$12.03	$252.67
QL4 1-m Image DEM (48 states)	$134.00	$20.10	$154.10	$7.71	$161.81
QL5 IFSAR (Alaska)	$90.00	Included	$90.00	$4.50	$94.50
QL5 IFSAR (49 states)					$80.00

Outside the 48 conterminous states, Dewberry assumes that the costs for LiDAR on distant islands will be higher than shown in Table F.1, but actual costs are unknown without a rigorous search for airplanes with camera ports (preferably already located on these islands) and without detailed flight planning. LiDAR costs per square mile for Puerto Rico and the U.S. Virgin Islands will be moderately higher; costs for Hawaii will be much higher, perhaps doubled; and costs for Guam, American Samoa and the Northern Marianas Islands will be much higher and potentially unaffordable.

Estimated total costs (FY 2011 dollars) by Quality Level for the 50 states are as follows:

- QL1 LiDAR: $1.646B for 48 states; $7.0M for Hawaii; unaffordable for major portions of Alaska
- QL2 LiDAR: $1.006B for 48 states; $4.3M for Hawaii; unaffordable for major portions of Alaska
- QL3 LiDAR: $760M for 48 states; $3.2M for Hawaii; unaffordable for major portions of Alaska
- QL4 Image DEMs: $487.8M for 49 states if and where stereo imagery is already available; N/A for Alaska where stereo airborne imagery is not available.
- QL5 IFSAR: $241M for new data of 49 states; $54M for new data of the remaining 85% of Alaska; $47.6M for placing NEXTMap® USA (49 states) data, currently 2 to 6 years old, in the public domain (actual cost subject to any potential negotiations).

Most-Requested Elevation Data Requirements

Over half of federal, state, local and tribal managers were unable to estimate dollar benefits for Functional Activities with *mission-critical* requirements for enhanced elevation data. To better help consider these requirements in developing the scenarios, Dewberry produced a series of maps that depict the most-requested Quality Level and update frequency, for each 1-degree cell, for federal, state, nongovernmental, and combined Functional Activities. The most-requested requirements are based on the most-requested combined total area for each Quality Level and update frequency based on all Functional Activities that intersect each 1-degree cell.

The most-requested Quality Levels and update frequencies, aggregated by federal, state and nongovernmental users and shown in Figures F.1 thorough F.8 below, had no bearing on the Benefit Cost Analyses. Instead, the Benefit Cost Analyses utilized the required Quality Level and update frequency for each of 553 individual Functional Activities, using the methodology explained in the Executive Summary (see Table 1.5).

Because so many federal users were unable to estimate dollar benefits for their Functional Activities, the most-requested Quality Level requirements for federal agencies only, in addition to dollar benefits for federal agencies only, were considered for implementation scenarios 2 and 2A that focused on federal requirements. For approximately 20 1-degree cells in scenarios 2 and 2A only, the most-requested Quality Levels did override the Quality Levels that would yield higher net benefits. The most-requested Quality Levels and update frequencies had no bearing on implementation scenarios 1, 1A, 3, 3A, 4 and 4A.

- Figures F.1 through F.8 are shown primarily to contrast federal, state and nongovernmental organizations, with a nationwide view (all organizations combined). States have wide differences and often more-demanding requirements for their individual state Functional Activities. Figure F.1 is the federal maps of the most-requested Quality Level for each 1-degree cell. For federal organizations, the most-requested Quality Levels for each 1-degree cell were factored into the development of implementation scenarios 2 and 2A. QL3 LiDAR was the most-requested by federal agencies for approximately 90 percent of the lower 49 states.
- Figure F.2 is the federal map of the most-requested update frequency for each 1-degree cell. For federal organizations, the most-requested update frequencies for each 1-degree cell were factored into the development of implementation scenarios 2, 3 and 4 which all utilize uniform update frequencies of 6-10 years. Update frequency of 6-10 years was the most-requested by federal agencies for almost 100% of the lower 49 states.
- Figure F.3 is the state map of the most-requested Quality Level for each 1-degree cell. For state organizations, the most-requested Quality Levels for each 1-degree cell were not factored into the development of any implementation scenario but were used to compare with Figure F.11 (Quality Levels to obtain highest net benefits for state governments) which were factored into the development of implementation scenario 4. Quality Levels better than QL3 (i.e., QL1 and QL2) were the most-requested by states for over half of the lower 49 states.
- Figure F.4 is the state map of the most-requested update frequency for each 1-degree cell. For state organizations, the most-requested update frequencies for each 1-degree cell were not factored into the development of implementation scenario; but Figure F.4 shows that most state users require their elevation data to be updated more frequently than in any of the eight scenarios. The most-requested update frequencies were widely variable for the states, to include all five update frequencies, i.e., annual, 2-3 years, 4-5 years, 6-10 years, and >10 years.

- Figure F.5 is the nongovernmental organization map of the most-requested Quality Level for each 1-degree cell. For nongovernmental organizations, the most-requested Quality Levels for each 1-degree cell were not factored into the development of any implementation scenario, but Figure F.5 can be used to contrast how nongovernmental organization Quality Levels compare with federal Quality Levels shown in Figure F.1. QL3 LiDAR was the most-requested by nongovernmental organizations for approximately 75 percent of the lower 49 states.
- Figure F.6 is the nongovernmental organization map of the most-requested update frequency for each 1-degree cell. For nongovernmental organizations, the most-requested update frequencies for each 1-degree cell were not factored into the development of any implementation scenario, but Figure F.6 can be used to contrast how nongovernmental organization update frequencies compare with federal update frequencies shown in Figure F.2. Update frequency of 6-10 years was the most-requested by nongovernmental organizations for approximately 85% of the lower 49 states.
- Figure F.7 is the combined federal, state and nongovernmental organization map of the most-requested Quality Level for each 1-degree cell. For all organizations combined, the most-requested Quality Levels for each 1-degree cell were not factored into the development of any implementation scenario, but Figure F.7 can be used to contrast the combined most requested Quality Levels with federal Quality Levels shown in Figure F.1. QL3 LiDAR was the most-requested by all users combined for approximately 80 percent of the lower 49 states.
- Figure F.8 is the combined federal, state, and nongovernmental organization map of the most-requested update frequency for each 1-degree cell. For all organizations combined, the most-requested update frequencies for each 1-degree cell were not factored into the development of any implementation scenario, but Figure F.8 can be used to contrast the combined most requested update frequencies with federal Update Frequencies shown in Figure F.2 which were factored into the development of implementation scenarios 2, 3 and 4. Update frequency of 6-10 years was the most-requested by all users combined for approximately 95 percent of the lower 49 states.

In determining the most-requested Quality Level, Dewberry determined that results would be distorted if each (often small) polygon was individually counted that intersected a 1-degree cell for a particular Functional Activity. Instead, for each of the 458 Functional Activities, Dewberry accumulated the proportional number of square miles required for each Quality Level and update frequency for each 1-degree cell. This provides an accurate assessment of the most-requested Quality Level and most-requested update frequency for each 1-degree cell.

The next four pages display Figures F.1 through F.8, paired to show the most-requested Quality Levels and most-requested update frequencies for each 1-degree cell for:

- Federal organizations only
- States organizations only
- Nongovernmental organizations only
- All organizations combined

Maps of Federal Agency Most-Requested Quality Levels and Update Frequencies

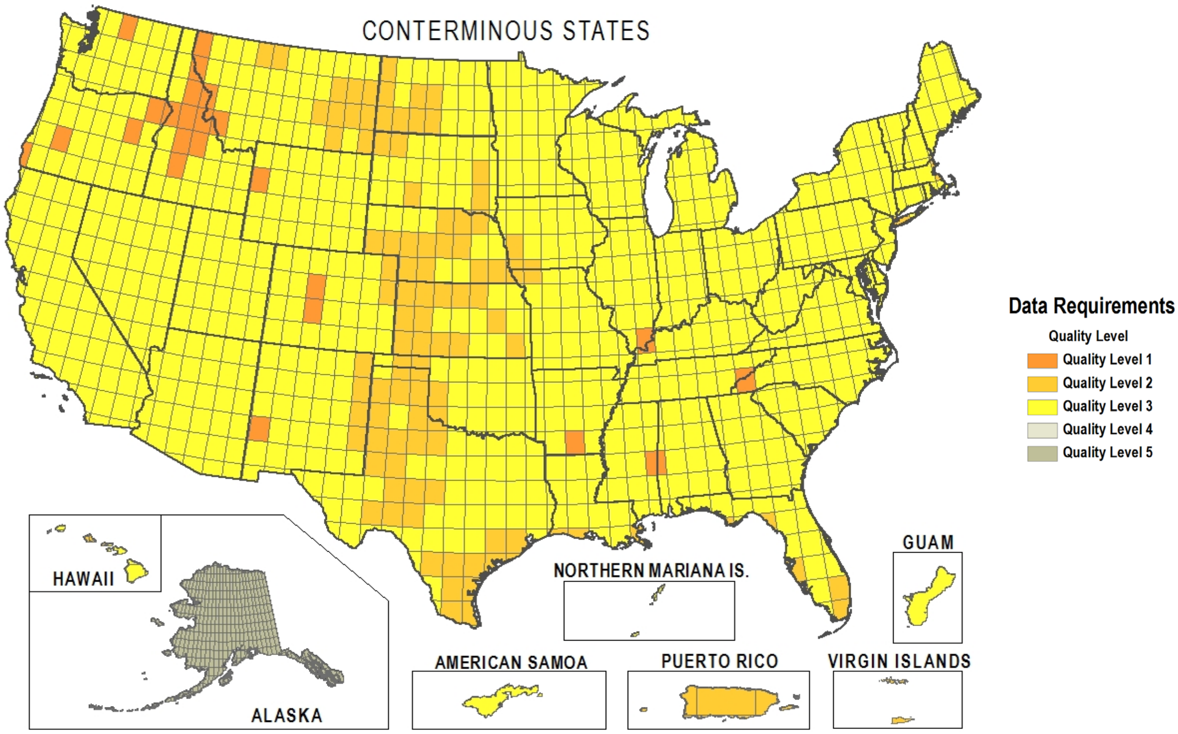

Figure F.1. Quality Levels most-requested by federal government agencies only.

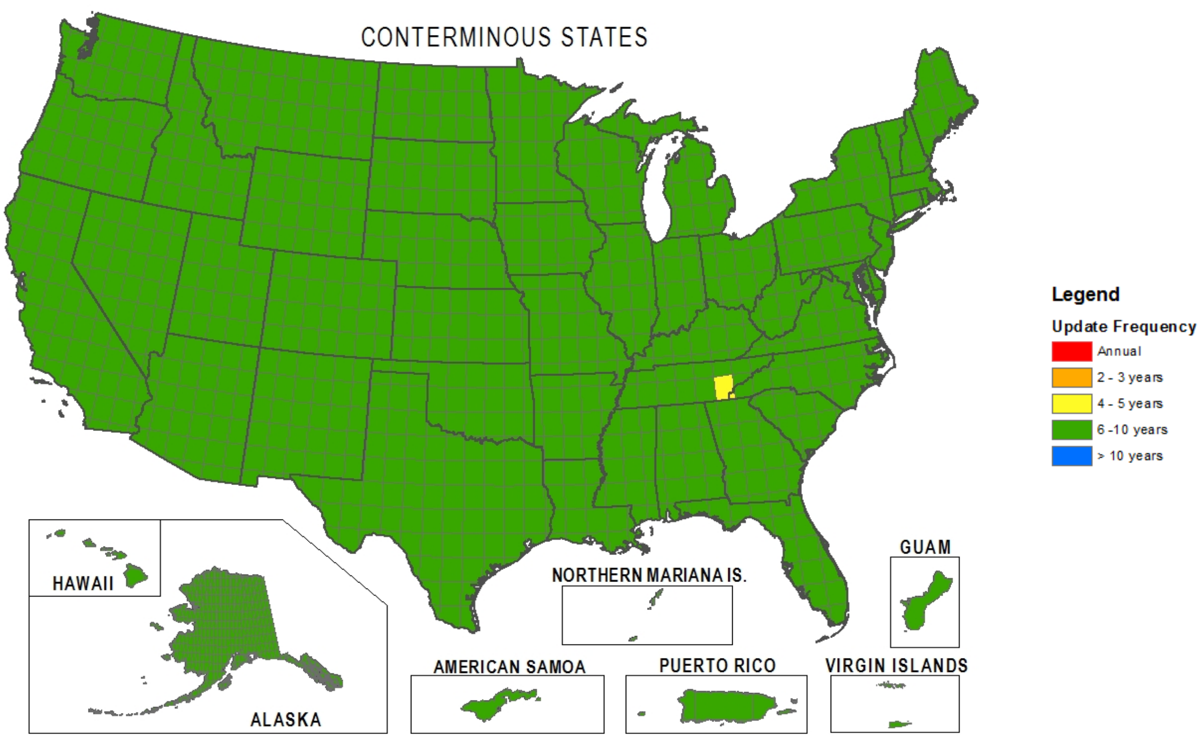

Figure F.2. Update frequencies most-requested by federal government agencies only.

Maps of State Most-Requested Quality Levels and Update Frequencies

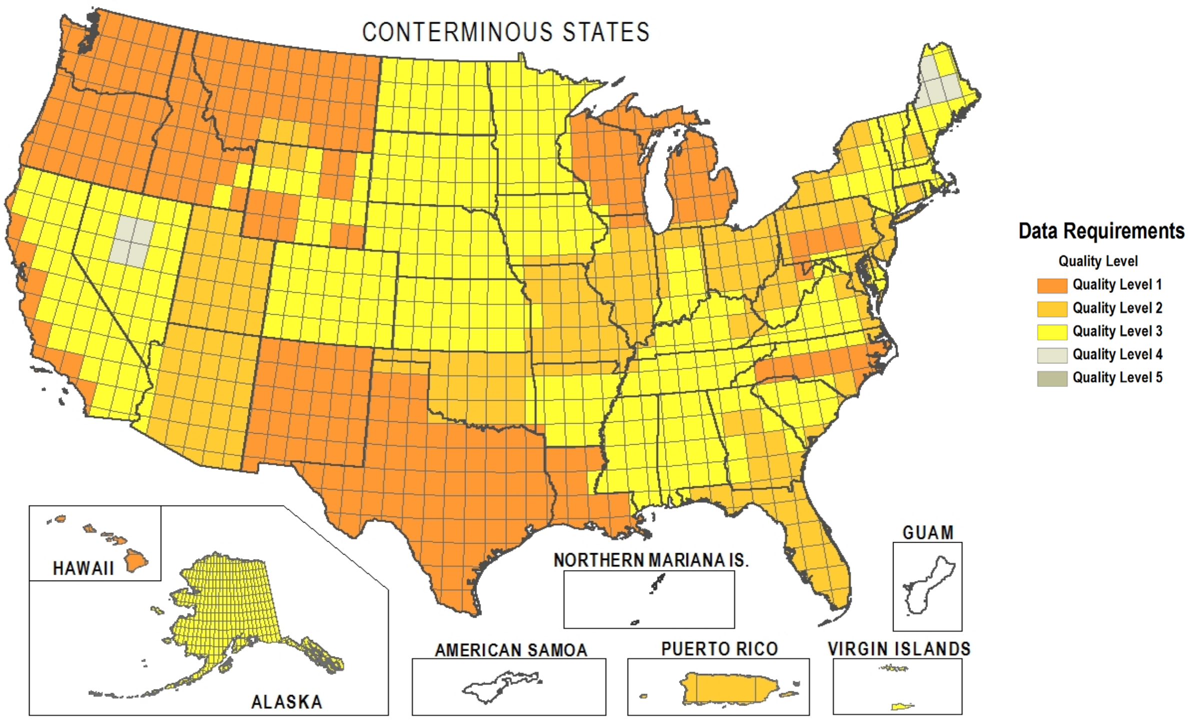

Figure F.3. Quality Levels most-requested by states only.

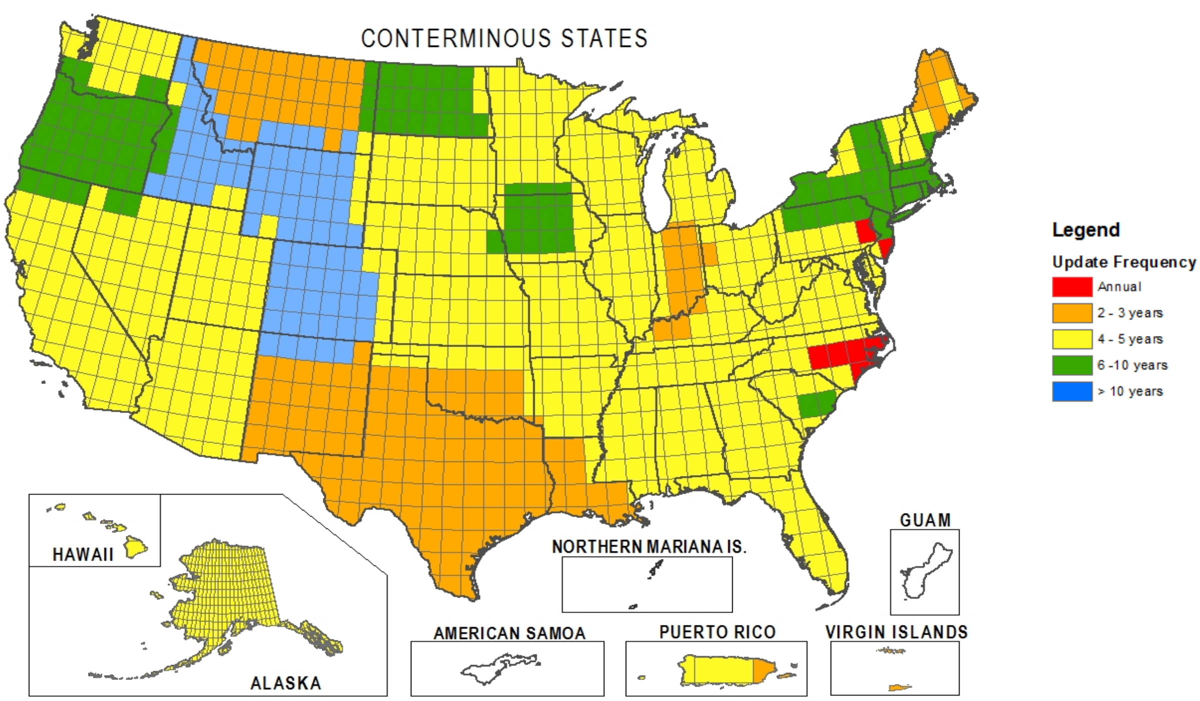

Figure F.4. Update frequencies most-requested by states only.

Maps of Nongovernmental Most-Requested Quality Levels and Update Frequencies

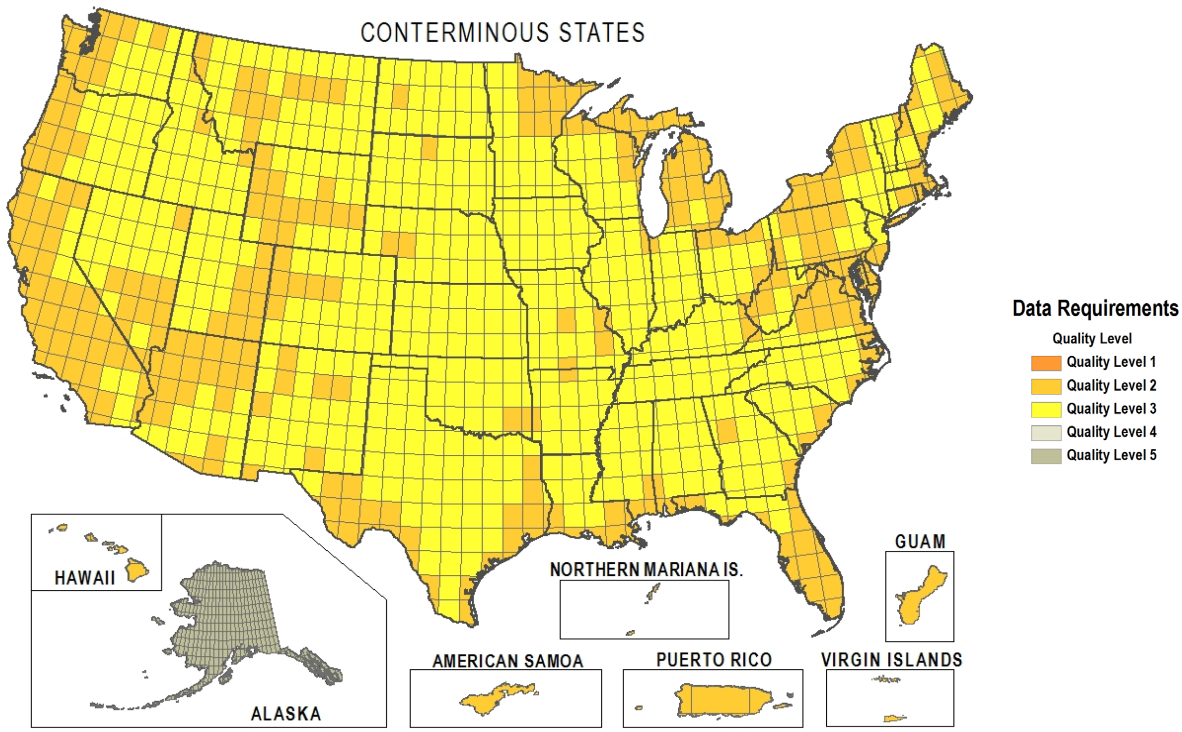

Figure F.5. Quality Levels most-requested by nongovernmental organizations only.

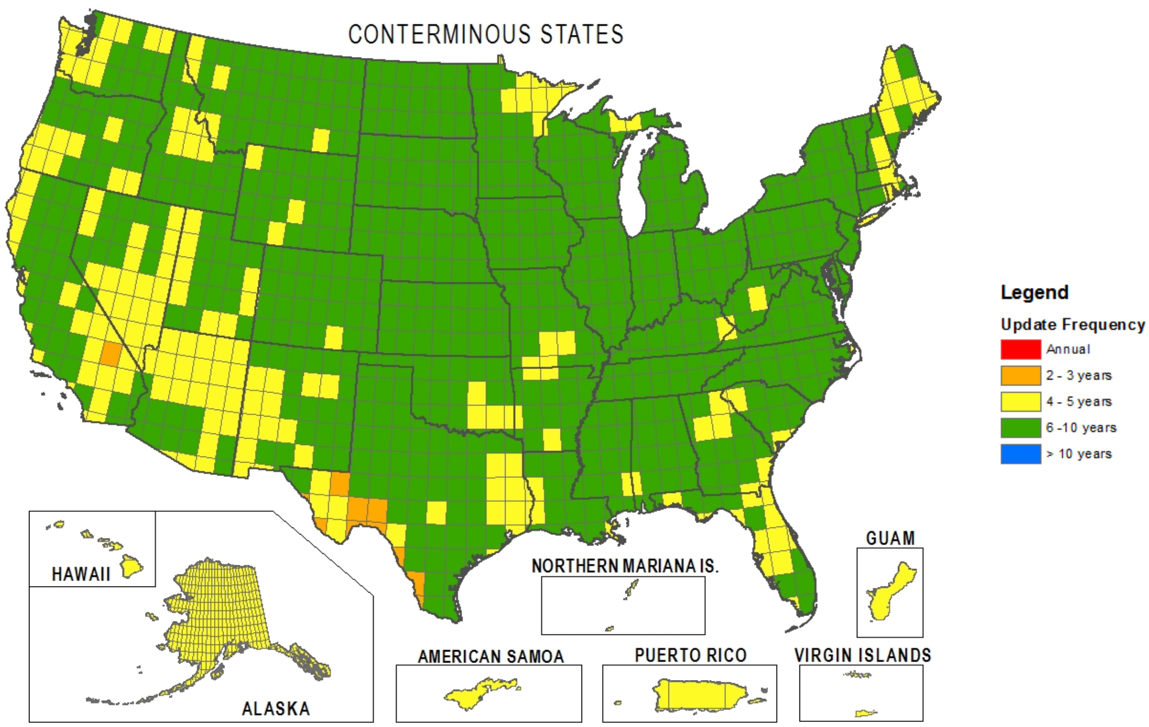

Figure F.6. Update frequencies most-requested by nongovernmental organizations only.

Maps of Combined Most-Requested Quality Levels and Update Frequencies

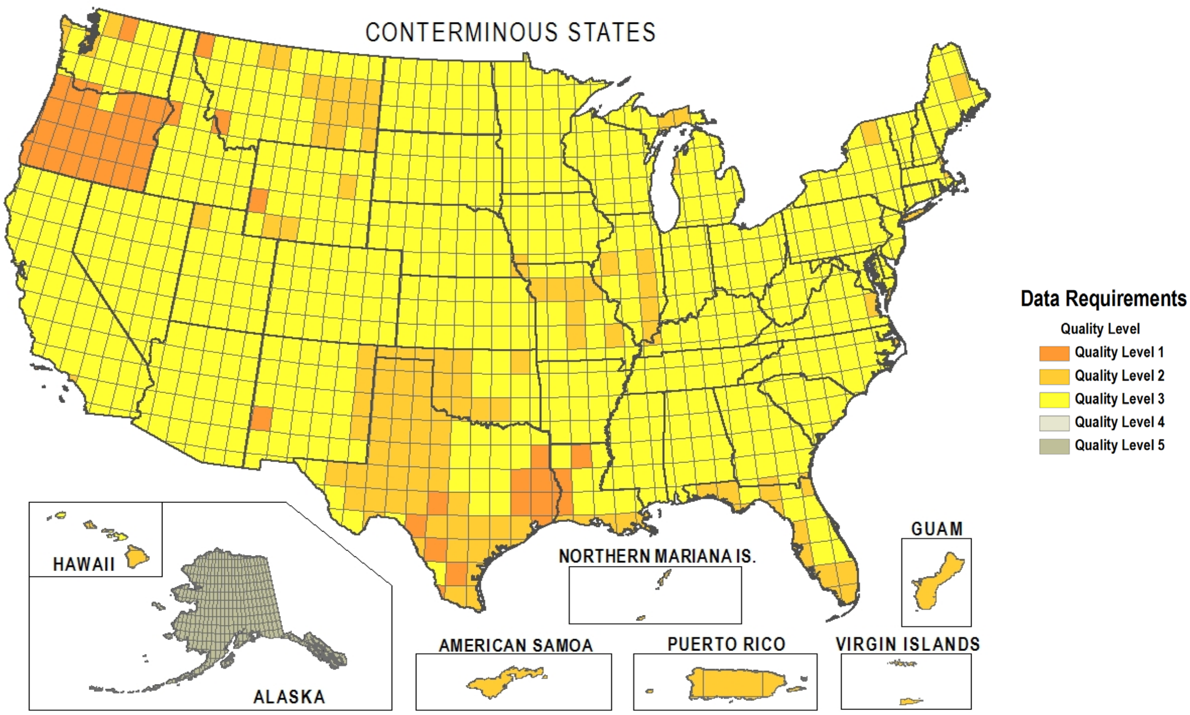

Figure F.7. Quality Levels most-requested by federal, state and nongovernmental organizations combined.

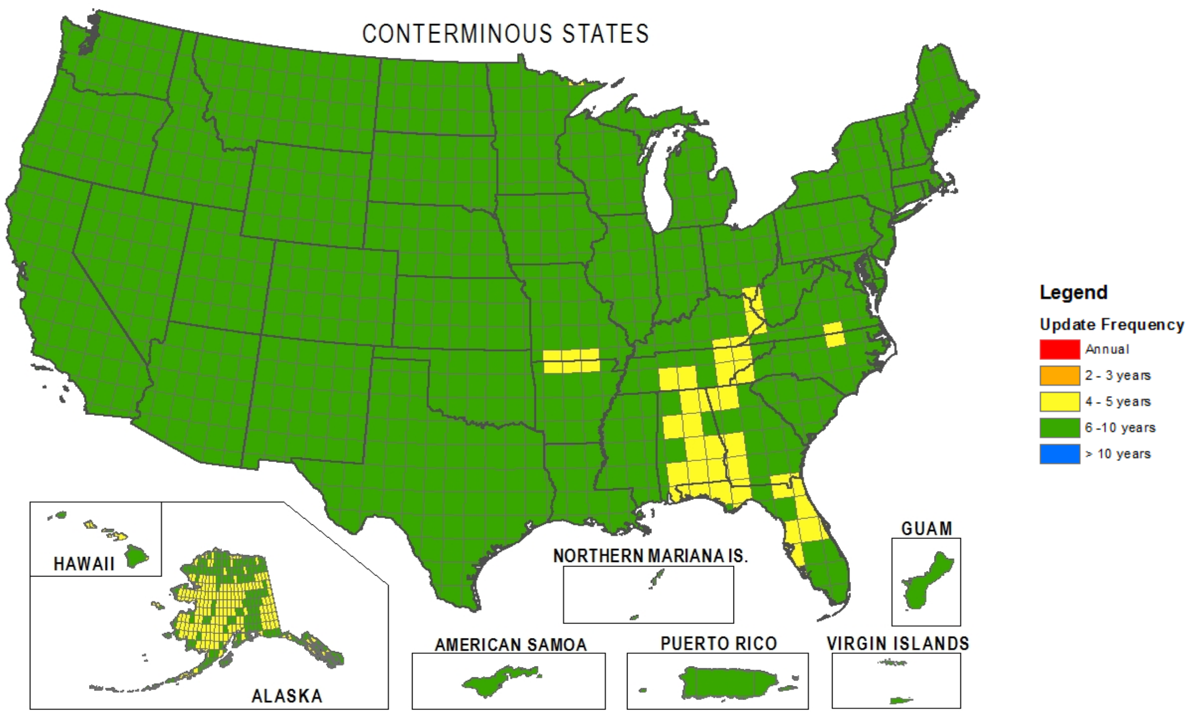

Figure F.8. Update frequencies most-requested by federal, state and nongovernmental organizations combined.

Explanation of Perceived Anomalies with Most-Requested Maps

Dewberry chose several example locations to evaluate and explain perceived anomalies – one isolated QL1 LiDAR cell in northern Washington and twelve QL1 LiDAR cells in Idaho and adjoining states.

Question 1: In Figure F.1, why is QL1 LiDAR the most-requested for a single isolated 1-degree cell in northern Washington, but QL3 LiDAR in neighboring 1-degree cells?

Explanation 1: The most-requested requirements are based on the most-requested combined total area for each Quality Level and update frequency based on all Functional Activities that intersect each 1-degree cell. Table F.2 compares the QL1 cell in question (cell 934) with the neighboring QL3 cell (cell 935) just east of the QL1 cell; green is the most-requested. For cell 934, total combined area requirements for QL1 LiDAR are only slightly higher (32,492 mi^2) than for QL3 LiDAR (32,083 mi^2) but enough to cause QL1 LiDAR to be the most-requested Quality Level for cell 934. These changes were primarily caused by differences in required Quality Levels between adjoining cells 934 and 935 with three Functional Activities: (1) NPS Preservation and Protection of Natural and Cultural Resources, (2) USGS Volcano Hazards, and (3) DHS Infrastructure Protection. Table F.2 shows that the total combined area requirements for cell 934 are slightly more for QL1 LiDAR (32,492 mi^2) than for QL3 LiDAR (32,083 mi^2), whereas the opposite is true for cell 935 and all other 1-degree cells in the state of Washington; furthermore, the higher requirements for QL1 LiDAR for cell 934 are primarily caused by the three Functional Activities listed above.

Table F.2. Comparison of Most-Requested Quality Levels for Adjoining Cells in Northern Washington

Quality Level Required	Cell 934		Cell 935	
	Number of Functional Activity Requirements	Total Combined Area Requirements	Number of Functional Activity Requirements	Total Combined Area Requirements
QL1 LiDAR	14	32,492 mi^2	12	27,288 mi^2
QL2 LiDAR	13	25,051 mi^2	11	20,515 mi^2
QL3 LiDAR	19	32,083 mi^2	14	33,397 mi^2

Question 2: In Figure F.1, why is QL1 LiDAR the most-requested for twelve 1-degree cells in Idaho and western Montana, but QL3 LiDAR in neighboring 1-degree cells?

Explanation 2: Many Functional Activities specify QL1 requirements in the Idaho area that are similar to QL1 requirements nationwide, including requirements from DISDI, DOE, FAA, FERC, NSF, NRC, and USGS (Geologic Mapping); these all contributed to the combined total area requirements for QL1 but did not distinguish Idaho from surrounding areas. For the twelve 1-degree cells in question, the following Functional Activities specified QL1 requirements more-specific to the Idaho area and, collectively, caused QL1 LiDAR to be the most-requested for these twelve 1-degree cells in Idaho and western Montana. Neighboring cells had larger combined total area requirements for QL3 than for either QL2 or QL1. This concept is demonstrated in Explanation 1 above.

- USFS, Forest Inventory and Assessment
- USFS, Wildfire Management
- USFS, Infrastructure Management

- USGS, Seismic Hazards,
- USGS, Landslide Hazards
- USGS, Volcano Hazards
- USGS, Mapping, Monitoring and Assessment of Biological Carbon Stocks
- USGS, Mapping, Monitoring and Assessment of Habitat

Benefit Estimates

Two widely used methods for performing Benefit Cost Analyses are: (1) Net Benefits (NB) where costs are subtracted from the benefits (NB = benefits minus costs), and (2) Benefit/Cost Ratio (BCR) where the benefits are divided by the costs (B/C Ratio = benefits/costs).

Recognizing that benefits are degraded if users do not receive the Quality Level and update frequency required, Dewberry developed a procedure for degrading annual dollar benefits with reduced *value multipliers*, as explained in Tables 5.3 and 5.4 in the core report. Table F.3, below, shows how the *value multiplier* is degraded for a Functional Activity that has the most demanding requirement (QL1 LiDAR with annual updates) and receives something less than required with any of the other 24 alternatives. The *value multiplier* is 1.0 if the Quality Level and update frequency is equal to or better than required. The value multiple is degraded by half for every column to the right for Quality Level and for every row beneath for update frequency.

Table F.3. Benefits *Value Multipliers* with Poorer Quality Level and Update Frequency

Update Frequency	QL1 LiDAR	QL2 LiDAR	QL3 LiDAR	QL4 DEM	QL5 IFSAR
Annually	1	1/2	1/4	1/8	1/16
2-3 years	1/2	1/4	1/8	1/16	1/32
4-5 years	1/4	1/8	1/16	1/32	1/64
6-10 years	1/8	1/16	1/32	1/64	1/128
>10 years	1/16	1/32	1/64	1/128	1/256

Dewberry fully recognizes that there will be opposing opinions as to whether or not this *value multiplier* process is valid. Some will argue that if they need QL1 LiDAR, for example, QL2 LiDAR has little or no value for a specific Functional Activity. Others will say that QL1 is preferred because it is the best, but QL2 might be almost as good in most places where vegetation is not so dense. During its 40+ interviews and workshops, Dewberry heard arguments on all sides as pertains to Quality Level and update frequency requirements. It would be impossible to reconcile everyone's opinion for each of the hundreds of Functional Activities. Dewberry and USGS agreed that this value multiplier process may not be perfect in every case but it is approximately correct and serves the overall purpose of logically and consistently degrading the value of elevation data that are of poorer quality or update frequency than required for specific Functional Activities.

Maximum Net Benefits

Federal Agencies: To achieve the highest net benefits for federal agencies only, Dewberry determined the optimal Quality Level for each cell and island (Hawaii islands plus all U.S. territorial islands), as mapped at Figure F.9. Dewberry also determined the optimal update frequency for each cell and island, as mapped at Figure F.10. For federal agencies these Figures show that the highest net benefits accrue from QL2 LiDAR and update frequency of 6-10 years for most (approximately 80 percent) of the 48 contiguous states. The major federal statistics are as follows.

Total Costs: $124,048,646/year	**Total Benefits: $251,971,709/year**
Benefit/Cost Ratio: 2.031	**Net Benefits: $127,923,063/year**

State Governments: To achieve the highest net benefits for state governments only, Dewberry determined the optimal Quality Level for each cell and island, as mapped at Figure F.11. Dewberry also determined the optimal update frequency for each cell and island, as mapped at Figure F.12. As shown in Figure F.11, the QL1 LiDAR net benefits for Hawaii, Oregon, Texas, and Illinois were major factors in the development of implementation scenarios 4 and 4A. However, the variable state update frequencies shown at Figure F.12 had no bearing on final implementation scenarios because no scenario considered mixed update frequencies. The major state statistics are as follows:

Total Costs: $104,932,564/year	**Total Benefits: $505,700,537/year**
Benefit/Cost Ratio: 4.82	**Net Benefits: $400,767,973/year**

Nongovernmental Users: To achieve the highest net benefits for nongovernmental users, Dewberry determined the optimal Quality Level for each cell and island, as mapped at Figure F.13. Dewberry also determined the optimal update frequency for each cell and island, as mapped at Figure F.14. Although the different Quality Levels shown at Figure F.13 were insignificant factors in the implementation scenarios, the update frequencies shown at Figure F.14 were factors in the 15-year implementation scenarios 1A, 2A, 3A and 4A. The major nongovernmental statistics are as follows:

Total Costs: $60,446,480/year	**Total Benefits: $133,374,539/year**
Benefit/Cost Ratio: 2.206	**Net Benefits: $72,928,059/year**

Combined Federal/State/Nongovernmental: To achieve the highest net benefits for combined federal and state governments plus nongovernmental users, Dewberry determined the optimal Quality Level for each cell and island, as mapped at Figure F.15. Dewberry also determined the optimal update frequency for each cell and island, as mapped at Figure F.16. The different Quality Levels shown at Figure F.15 became the primary factors in selection of implementation scenarios 4 and 4A as unique scenarios. However, the different update frequencies shown at Figure F.16 were not used in any of the eight implementation scenarios because no scenario considered mixed update frequencies. The major combined statistics are as follows:

Total Costs: $213,205,963/year	**Total Benefits: $1,007,990,332/year**
Benefit/Cost Ratio: 4.728	**Net Benefits: $794,784,369/year**

Highest Net Benefits for Federal Government Agencies Only

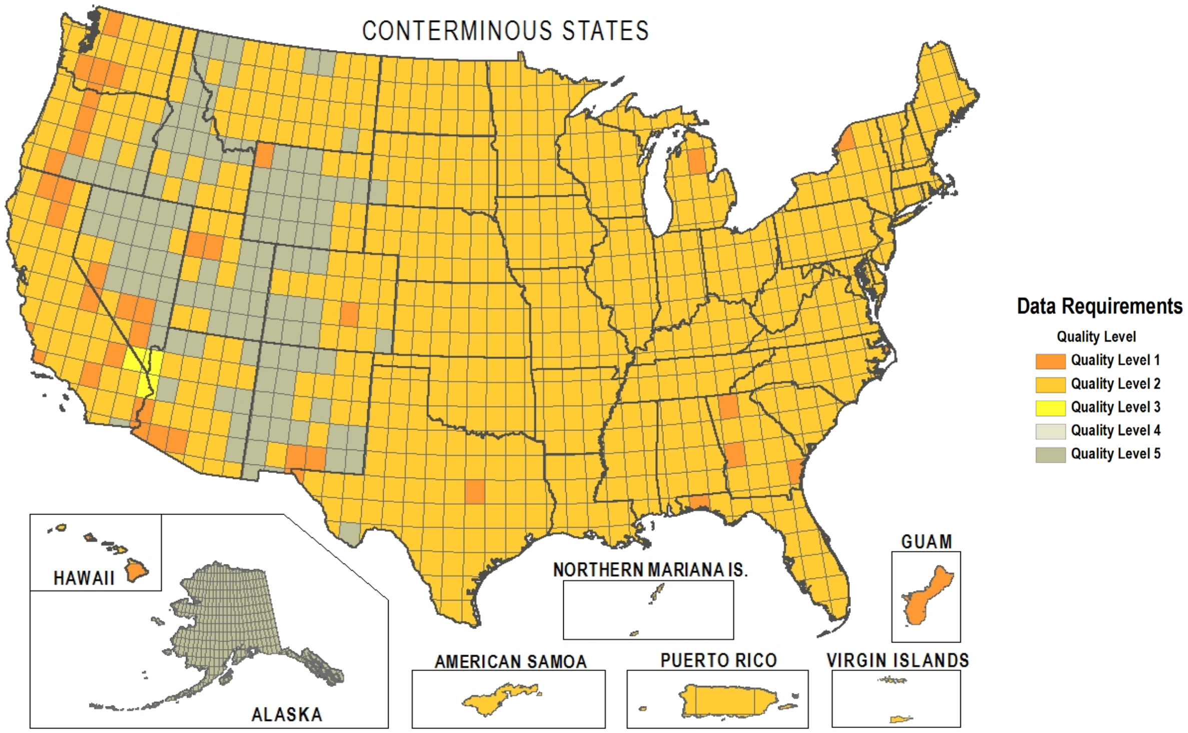

Figure F.9. Quality Levels to obtain highest net benefits for federal government agencies only.

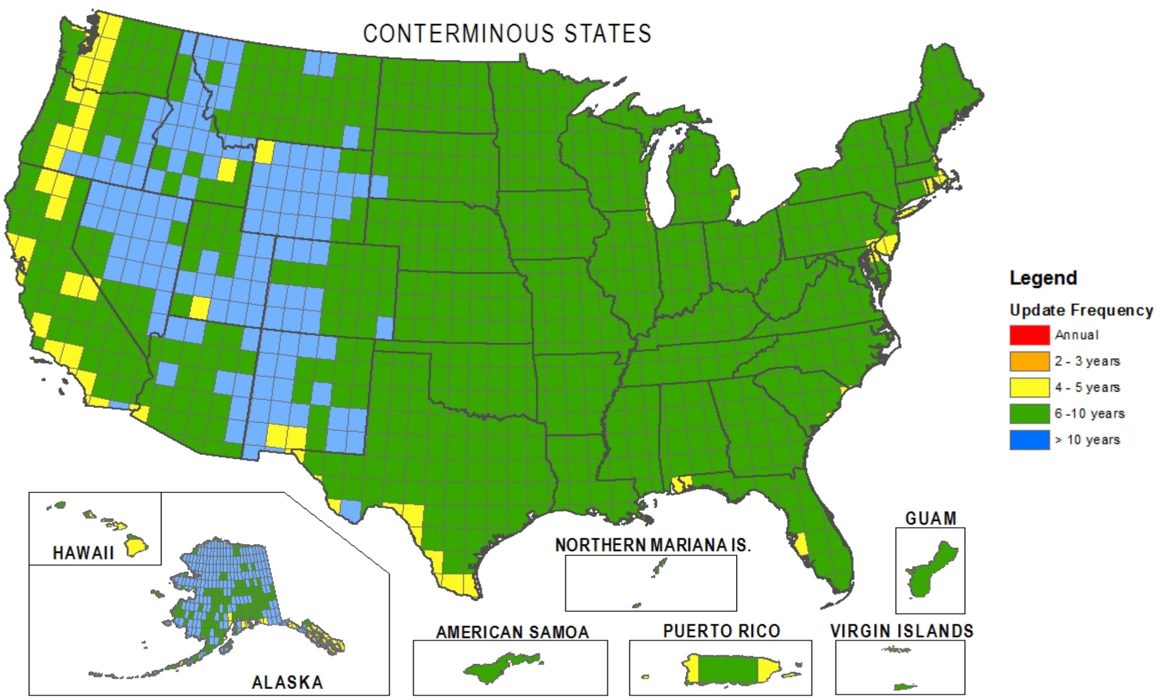

Figure F.10. Update frequencies to obtain highest net benefits for federal government agencies only.

Highest Net Benefits for State Governments Only

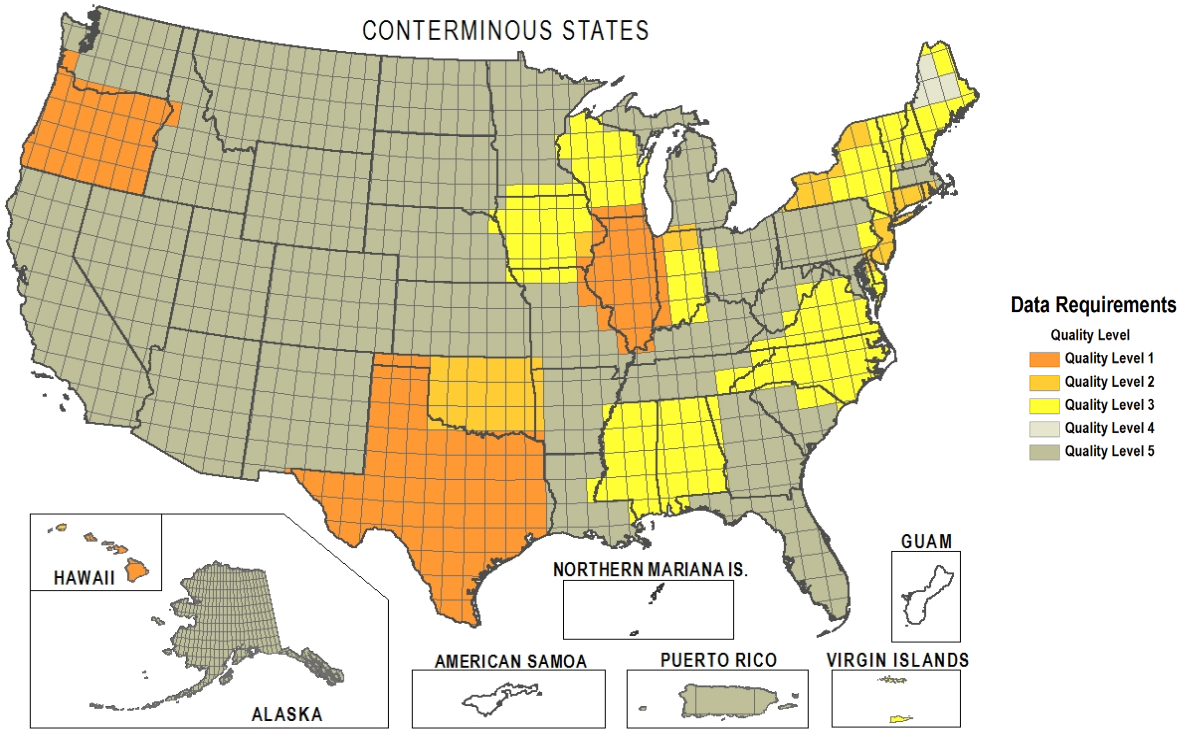

Figure F.11. Quality Levels to obtain highest net benefits for state governments only.

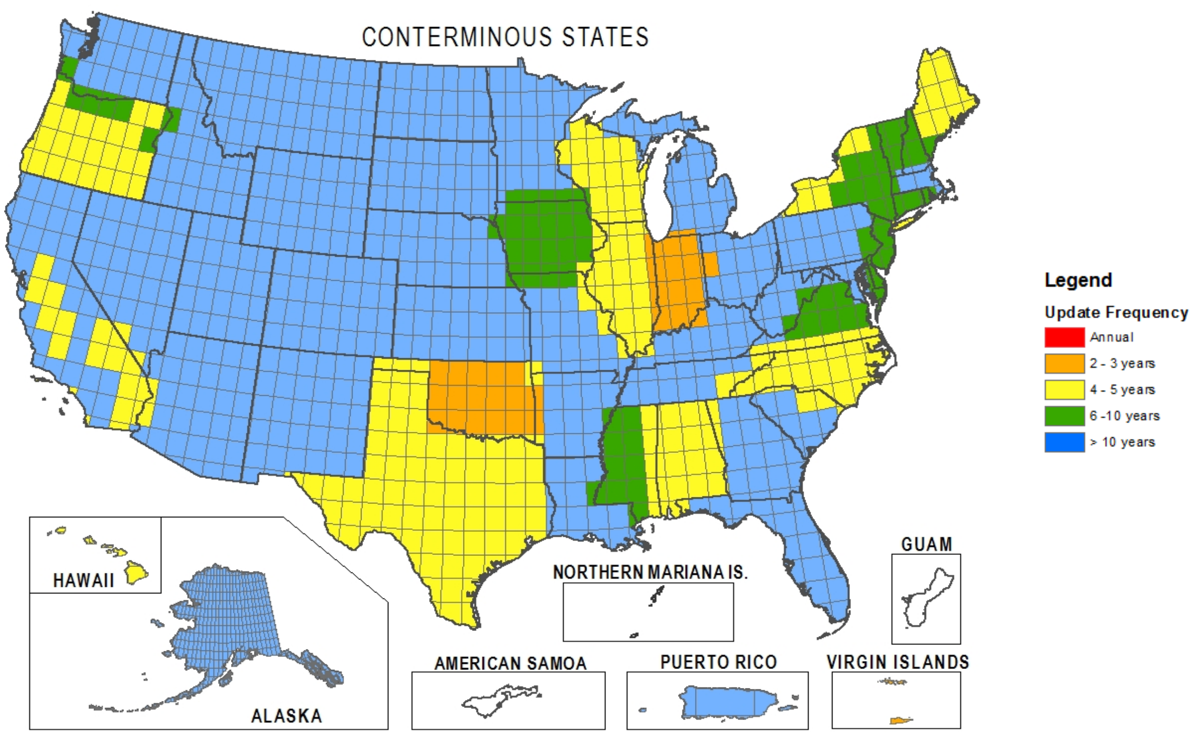

Figure F.12. Update frequencies to obtain highest net benefits for state governments only.

Highest Net Benefits for Nongovernmental Users Only

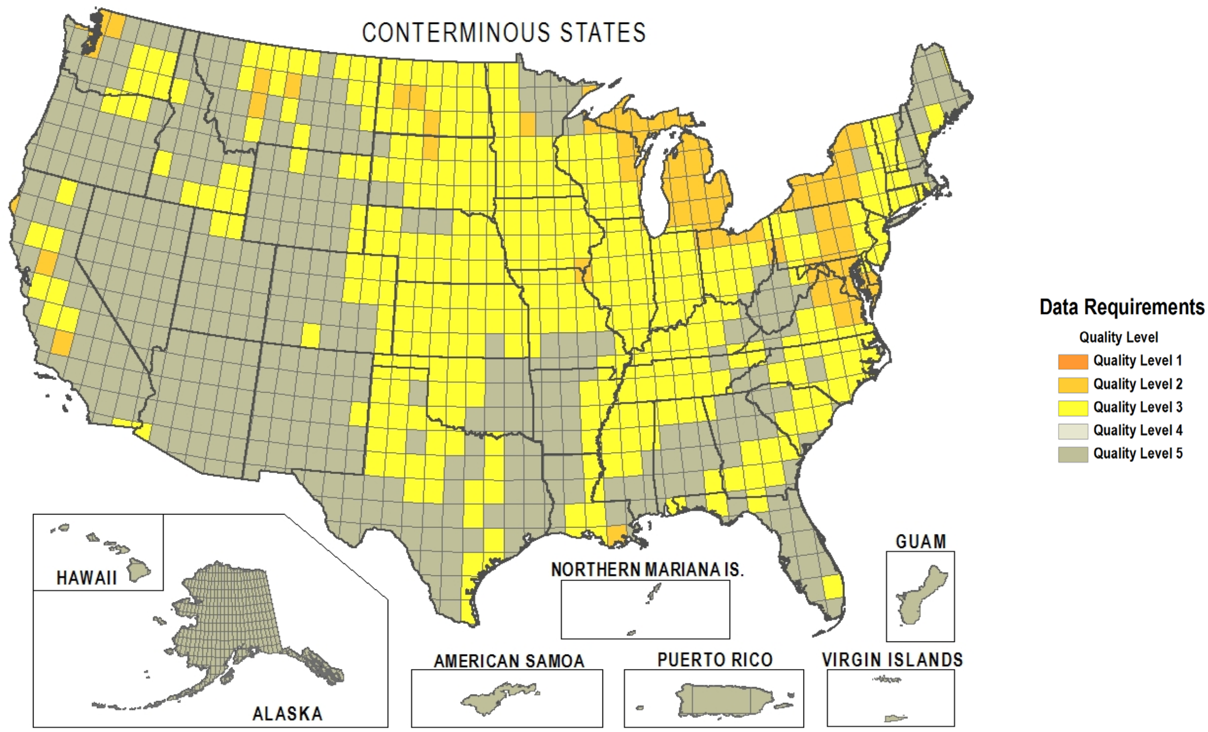

Figure F.13. Quality Levels to obtain highest net benefits for nongovernmental users only.

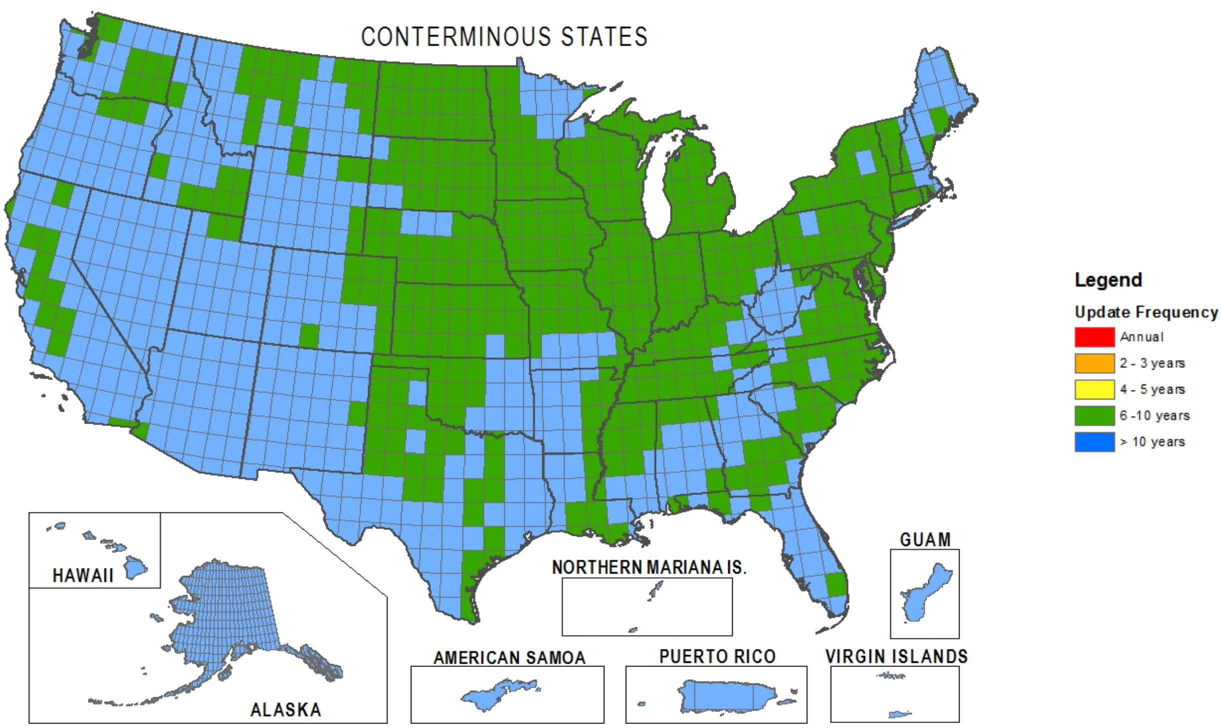

Figure F.14. Update frequencies to obtain highest net benefits for nongovernmental users only.

Highest Net Benefits for Combined Federal, State and Nongovernmental Users

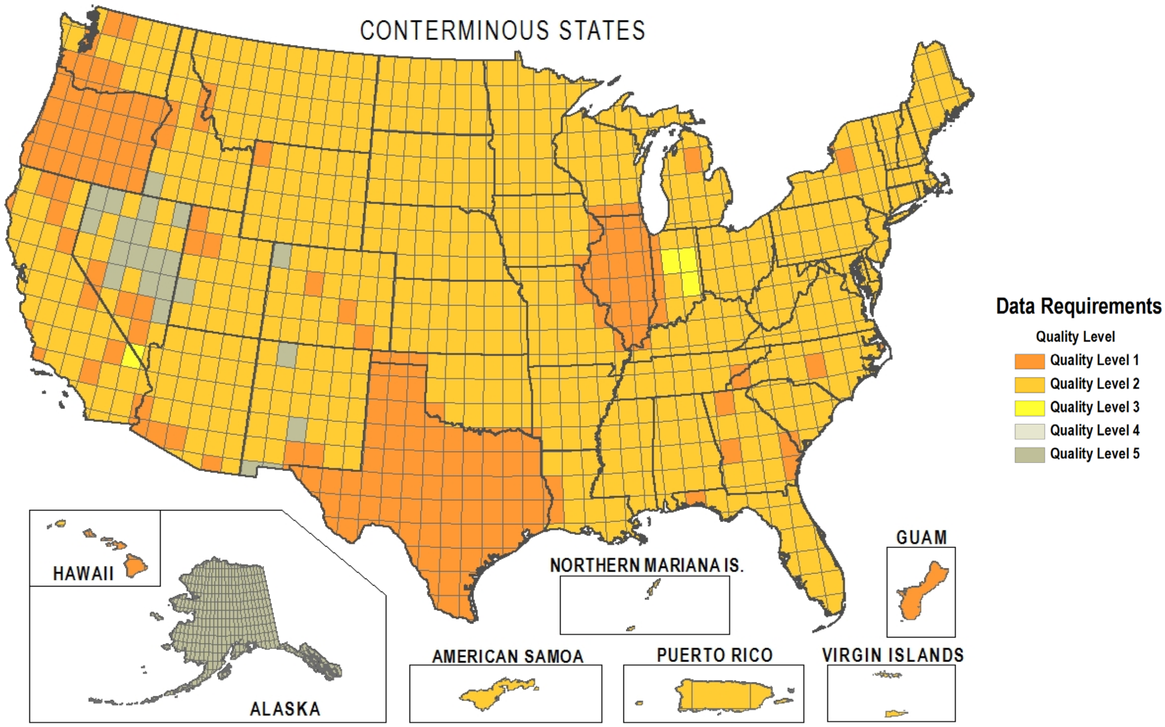

Figure F.15. Quality Levels to obtain highest net benefits for combined federal, state and nongovernmental users.

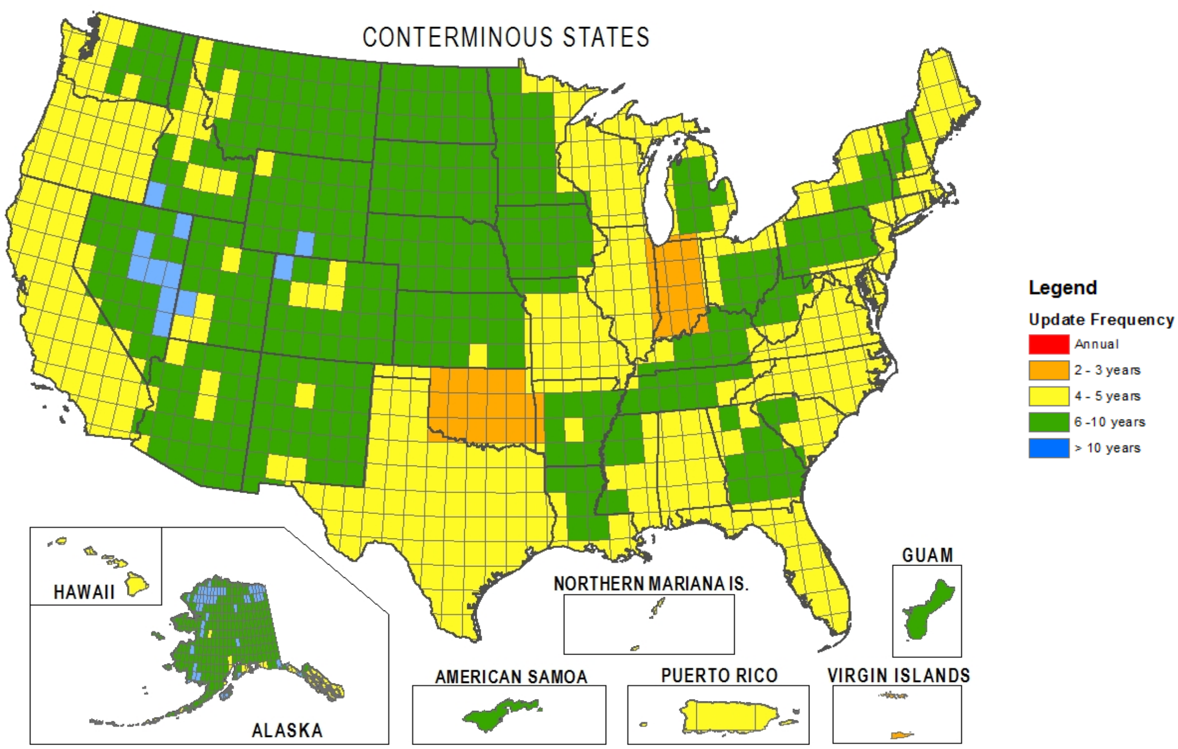

Figure F.16. Update frequencies to obtain highest net benefits for combined federal, state and nongovernmental users.

Explanation of Perceived Anomalies with Highest Net Benefits Maps

Dewberry chose one location to evaluate a perceived anomaly for determination of highest net benefits – an isolated QL1 LiDAR cell in northern Michigan.

Question: In Figure F.9, why does the single isolated cell in northern Michigan have the highest net benefits for QL1 LiDAR whereas adjoining cells have the highest net benefits from QL2 LiDAR?

Explanation: Table F.4 compares the QL1 cell in question (cell 779) with the neighboring QL2 cell (cell 778) just west of the QL1 cell (779); green shows the highest net benefits for each cell. A total of 49 Functional Activities intersected cell 778 in whole or in part; and a total of 52 Functional Activities intersected cell 779 in whole or in part. In comparing these two cells, there were many differences in square miles for the same Functional Activities within these two adjoining cells; for example, for the USFS Wildfire Management Functional Activity, cells 778 and 779 each have different square miles per cell requiring QL1 LiDAR and QL3 LiDAR, causing different benefits to accrue, by Quality Level, for each cell.

For cell 778, QL2 LiDAR with 6-10 year update frequency is clearly the option with the highest net benefits. However, for cell 779, although the QL2 benefits are more than tripled that of cell 778, the net benefits are $366,117 compared with slightly higher net benefits of $369,764 for QL1 with 6-10 year update frequency. Three Functional Activities are the primary reasons why QL1 net benefits were so much higher for cell 779 than for cell 778:

- The U.S. Army Corps of Engineers (USACE) has a Functional Activity named *Infrastructure and Construction Management* that contributed $127,000 in QL1 LiDAR benefits to cell 779 because of the presence of Camp Grayling Maneuver Training Center with 220 square miles of QL1 LiDAR requirements and benefits on cell 779 with benefits of $580/mi^2.
- The Defense Installation Spatial Data Infrastructure (DISDI) has a Functional Activity named *DoD Installation Geospatial Information and Services (IGI&S)* that contributed over $230,000 in QL2 benefits to cell 779 for similar reasons. DISDI's QL2 data still contributed $115,000 in benefits to the QL1 option for cell 779.
- The U.S. Forest Service (USFS) has a Functional Activity named *Forest Inventory and Assessment* that contributed an additional $8,000 in QL1 LiDAR benefits for cell 779.
- It is clearly the presence of Camp Grayling on cell 779 that most influenced the perceived anomaly, but just barely ($369,764 vs. $366,117).

Table F.4. Comparison of Maximum Net Benefits for Adjoining Cells in Northern Michigan

Cell 778			Cell 779		
Quality Level	Update Frequency	Highest Net Benefits	Quality Level	Update Frequency	Highest Net Benefits
QL1 LiDAR	6-10 years	$50,806	QL1 LiDAR	6-10 years	$369,764
QL2 LiDAR	6-10 years	$104,856	QL2 LiDAR	6-10 years	$366,117
QL3 LiDAR	6-10 years	$37,480	QL3 LiDAR	6-10 years	$162,700
QL4 Image DEM	6-10 years	$7,371	QL4 Image DEM	6-10 years	$69,604
QL5 IFSAR	6-10 years	$4,562	QL5 IFSAR	6-10 years	$35,728

Comparison of Quality Levels for 48 States

Dewberry used the power of the master geodatabase to evaluate all 25 options for uniform elevation data for 48 conterminous states in Table F.5. The highlighted options appear to offer some advantages. For all Quality Levels, the 4-5 year update frequency provides the higher Net Benefits (at higher total costs) whereas the 6-10 year update frequency provides the higher Benefit/Cost ratio (at lower total costs).

For the 2-3 year update frequency, total costs are divided by 2.5 to compute annual costs; for the 4-5 year update frequency, total costs are divided by 4.5 to compute annual costs; for the 6-10 year update frequency, total costs are divided by 8 to compute annual costs; and for the >10 year update frequency, total costs are divided by 15 to compute annual costs. For the 25-year implementation scenario 1, total costs are divided by 25. All costs are in 2011 dollars.

Table F.5. Comparison of Benefit/Cost Ratios and Net Benefits for all 25 Quality Level and Update Frequency Options

Option	Quality Level	Update Frequency	Annual Total Costs	Annual Total Benefits	Benefit/Cost Ratio	Net Benefits (Benefits - Costs)
1	1	Annual	$1,646,473,351	$1,110,536,274	0.674	($535,937,078)
2	1	2-3 years	$658,589,342	$1,109,659,361	1.685	$451,070,019
3	1	4-5 years	$365,882,967	$1,066,142,812	2.914	$700,259,846
4	1	6-10 years	$205,809,170	$800,026,145	3.887	$594,216,975
5	1	>10 years	$109,764,889	$402,919,306	3.671	$293,154,417
6	2	Annual	$1,006,234,985	$922,670,017	0.917	($83,564,968)
7	2	2-3 years	$402,493,993	$922,087,228	2.291	$519,593,236
8	2	4-5 years	$223,607,774	$887,614,099	3.970	$664,006,325
9	2	6-10 years	$125,779,374	$673,655,079	5.356	$547,875,706
10	2	>10 years	$67,082,332	$338,689,289	5.049	$271,606,957
11	3	Annual	$760,121,363	$696,805,551	0.917	($63,315,812)
12	3	2-3 years	$304,048,545	$696,498,734	2.291	$392,450,189
13	3	4-5 years	$168,915,859	$672,754,669	3.983	$503,838,811
14	3	6-10 years	$95,015,171	$501,474,593	5.278	$406,459,423
15	3	>10 years	$50,674,758	$251,836,889	4.970	$201,162,131
16	4	Annual	$486,782,118	$360,506,714	0.741	($126,275,405)
17	4	2-3 years	$194,712,846	$360,353,305	1.851	$165,640,459
18	4	4-5 years	$108,173,804	$345,947,265	3.198	$237,773,460
19	4	6-10 years	$60,847,765	$255,786,511	4.204	$194,938,746
20	4	>10 years	$32,452,141	$128,588,049	3.962	$96,135,908
21	5	Annual	$240,668,497	$189,766,744	0.788	($50,901,752)
22	5	2-3 years	$96,267,399	$189,690,040	1.970	$93,422,642
23	5	4-5 years	$53,481,888	$179,967,135	3.365	$126,485,247
24	5	6-10 years	$30,083,562	$131,448,499	4.369	$101,364,937
25	5	>10 years	$16,044,566	$66,071,646	4.118	$50,027,080

- Of the five QL1 LiDAR options, Option 3 shows the highest Net Benefits of all 25 options (~$700M/year), but a relatively low B/C Ratio of 2.914; Option 4 has a better B/C Ratio (3.887), but both the B/C Ratio and Net Benefits are lower than other options.

- Of the five QL2 LiDAR options, Option 8 provides excellent Net Benefits (~$664M/year) and reasonable B/C Ratio; Option 9 has the highest B/C Ratio of all options (5.356), indicating that it would provide "<u>the biggest bang for the buck</u>," and its Net Benefits are excellent (~$548M/year).
- Of the five QL3 LiDAR options, Options 13 and 14 compare closely with QL2 options 8 and 9.
- Of the five QL4 options, they all have Net Benefits and B/C Ratios poorer than other options.
- Of the five QL5 options highlighted in medium grey, they all have Net Benefits and B/C Ratios poorer than other options.