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Natural Resource Stewardship and Science

Stephen Mather Wilderness

An Update of the 2015 Wilderness Character Baseline and Completion of the 2020 Wilderness Character Monitoring Reporting Summary

Natural Resource Report NPS/NOCA/NRR—2022/2452

ON THE COVER
Two backpackers hiking Sahale Arm Trail in North Cascades National Park
NPS / JACK OELFKE

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Abstract

The Wilderness Act of 1964 created a legislative mandate to preserve wilderness character on protected federal lands encompassed under the law, leading to the network of lands managed as wilderness that exist today within the National Wilderness Preservation System. Wilderness management policy and practice has evolved to focus on wilderness character monitoring as a means of understanding if the preservation of wilderness character is being achieved.

In 2020 staff at the North Cascades National Park Service Complex completed a baseline assessment of wilderness character to begin tracking trends in wilderness character for the Stephen Mather Wilderness. Baseline values were established in 2015 for 22 of the 24 monitoring measures developed within the five tangible qualities of wilderness character—Untrammeled, Natural, Undeveloped, Solitude or Primitive and Unconfined Recreation, and Other Features of Value—and baseline values established in 2020 for the remaining two measures. The first 5-year trend monitoring was completed for those 22 measures with a 2015 baseline and a 2020 monitored value and is discussed in this report.

Comparison of data between the 2015 baseline year and 2020 monitoring periods showed that most measures of wilderness character either showed improvement (7 measures) or were stable (13 measures), with two measures showing a declining trend. A 2020 baseline value was completed for two additional measures, and one original measure was revised in response to changed protocols, resulting in a revised 2015 baseline value for that measure.

Introduction

Background

As noted in "Keeping it Wild in the National Park Service" (National Park Service Wilderness Character Integration Team, 2014), "The key to effective wilderness stewardship…..is tracking change in wilderness character over time." The development of a wilderness character monitoring program within the context of the five tangible qualities of wilderness character (Untrammeled, Natural, Undeveloped, Solitude or Primitive and Unconfined Recreation, and Other Features of Value) provides a transparent, consistent means of tracking trends in wilderness character for a specific wilderness area.

In 2012 staff of the North Cascades National Park Service Complex (North Cascades National Park, Lake Chelan National Recreation Area, and Ross Lake Recreation Area) began to develop monitoring measures that reflect wilderness character concerns for the park and to create a baseline inventory for the park. Further guidance from "Keeping it Wild 2" (Landres, et al., 2015) informed park staff in those efforts. In 2020 the park completed "The Stephen Mather Wilderness: Wilderness character baseline assessment" (Riegel and Oelfke, 2020), hereafter referred to as the "baseline report". The baseline report identified 24 separate measures to be used to track wilderness character over time within the park's Stephen Mather Wilderness, and established 2015 baseline values for 22 of the 24 measures. Two measures required additional inventory data before baseline values could be established. That inventory information was completed by the end of the 2020 field season, and thus all 24 measures now have a baseline value. In addition, indicative of the growing pains of establishing a new monitoring program, one measure underwent a protocol change since completion of the baseline report, and the new methodology (and baseline value) is documented here. Similarly, the 2015 baseline value for one other measure requires revision to reflect data that should have been included, but was missed, in the baseline report.

For background information on the process followed by the park in establishing the 24 monitoring measures, along with specific definitions and protocols relevant for each measure, refer to the baseline report. For example, the baseline report identifies the specific actions that will be considered as "trammeling" for the Untrammeled quality, or identifies specific installations considered for the Undeveloped quality, etc.

Purposes of this report

There are four primary purposes of this report:

1. Provide the baseline values for two measures that lacked a 2015 baseline value in the baseline assessment report
2. Revise the measure protocol and associated baseline value that tracks changes in Visibility, a measure that utilizes data from the NPS Air Resources Division, given the change in methodology they now recommend;
3. Change the 2015 baseline value for one measure to reflect missing data unknown at the time of the baseline assessment report; and

4. Complete the first five-year trend comparison of wilderness character measures, using those 22 measures (of 24) that have both a 2015 baseline value and a 2020 value.

Note that Items 1–3 above finalize the baseline data year for the park with 22 measures having a baseline year of 2015, and two measures with a baseline year of 2020.

Discussion

Each of the four primary purposes above are discussed in detail as follows:

1. Identification of baseline value for two measures

In the baseline report two measures had insufficient data to establish a baseline value: Measure 2-1, "Index of non-indigenous plant species", required additional fieldwork to identify the baseline value, and Measure 4-3 "Five-year average of the annual number of hours of NPS use of aircraft" underwent a slight change in methodology in 2018 which required delaying the baseline value identification until 2020. Each Measure is discussed in detail as follows:

Measure 2-1, Index of non-indigenous plant species

Per the baseline report, the intent of this measure is "track over time the number and impact of non-native plant species found along the trail system in wilderness". Field work was completed in 2019 and 2020 along the remaining identified wilderness trails that required a baseline inventory. As new species of invasive plants were identified, staff (the park botanist or North Coast/Cascades Network Invasive Plant Management Team staff) then provided a "professional judgement" ranking of the potential impact of each invasive species, per the baseline report protocol for the measure. Table 1 provides the number of species found on trails segments in the 2006, 2019, and 2020 surveys, and the cumulative number of unique non-native species found in the surveys. Over all inventory years a total of 46 non-native plant species were identified. Table 2 lists the individual non-native species found and the I-rank (Invasive Species Rank from the NatureServe Explorer database) or professional judgement score assigned to each species, which are then summed to reach the index score for this measure. A species considered to have a high impact is weighted a "3"; medium impact a "2"; and Low/Unknown impact a "1". A full list of identified invasive plant species, per trail surveyed within wilderness, is provided in Appendix A.

Table 1. Trail segments and number of unique non-native species found (2006, 2019–2020 surveys).

Trail Name	Number of Non-native Species on Trail Segment	Cumulative Count of Unique Non-native Species
1. Big Beaver	12	12
2. East Bank	11	5
3. Ruby Arm	18	13
4. Panther to Thunder from State Highway 20	5	2
5. Cascade Pass, from parking lot to pass	3	0
6. Chilliwack	9	0
7. Copper Ridge	3	0
8. Brush Creek-Stillwell CG	8	1
9. Easy Pass-Fisher Creek – Thunder Creek – Colonial CG	17	6
10. Park Creek-Fisher Creek, including Meadow Cabin spur trail	11	1
11. Bridge Creek	15	3

Table 1 (continued). Trail segments and number of unique non-native species found (2006, 2019–2020 surveys).

Trail Name	Number of Non-native Species on Trail Segment	Cumulative Count of Unique Non-native Species
12. Rainbow Creek-McAlester Pass	15	3
13. Boulder Creek-War Creek Pass	12	0
14. McGregor Mtn	7	0
15. Purple Creek-War Creek Pass	7	0
16. Fireweed Camp-McAlester Pass-South Pass	8	0
Total number of unique non-native species	**–**	**46**

Table 2. Invasive species, I-rank or professional judgement value, and summed index.

Common Name	Species Name	I-rank	Professional Judgement Rank
European horse-chestnut	*Aesculus hippocastanum*	–	1
Red top	*Agrostis alba*	2	–
Hair grass	*Aira caryophyllea*	1	–
Lesser burdock	*Arctium minus*	–	3
Smooth brome	*Bromus inermis*	–	2
Cheatgrass	*Bromus tectorum*	3	–
Knapweed	*Centaurea* sp.	3	–
Sticky chickweed	*Cerastium glomeratum*	–	1
Canada thistle	*Cirsium arvense*	3	–
Bull thistle	*Cirsium vulgare*	2	–
Scotch broom	*Cystisus scoparius*	2	–
Orchard grass	*Dactylis glomerata*	–	2
Herb Robert	*Geranium robertianum*	–	3
St. John's wort	*Hypericum perforatum*	3	–
Prickly lettuce	*Lactuca serriola*	1	–
Everlasting peavine	*Lathyrus latifolius*	–	3
Oxeye Daisy	*Leucanthermum vulgare*	–	3
Wall lettuce	*Mycelis muralis*	–	1
Reed canary grass	*Phalaris arundnacea*	–	3
Timothy	*Phleum pratense*	2	–
English plantain	*Plantago lanceolata*	2	–
Common plantain	*Plantago major*	–	1
Annual bluegrass	*Poa annua*	1	–
Bulbous bluegrass	*Poa bulbosa*	–	3

Table 2 (continued). Invasive species, I-rank or professional judgement value, and summed index.

Common Name	Species Name	I-rank	Professional Judgement Rank
Compressed bluegrass	*Poa compressa*	2	–
Perennial bluegrass	*Poa pratensis*	2	–
Smartweed	*Polygonum* spp.	–	1
Self heal	*Prunella vulgaris*	–	1
Creeping buttercup	*Ranunculus repens*	3	–
Cut leaved blackberry	*Rubus laciniatus*	–	3
Sheep sorrel	*Rumex acetosella*	2	–
Curly dock	*Rumex crispus*	1	–
Sand spurrey	*Spergularia rubra*	–	1
Spiny sow thistle	*Sonchus asper*	–	2
European mountain ash	*Sorbus acuparia*	–	2
Common chickweed	*Stellaria media*	1	–
Common tansy	*Tanacetum vulgare*	1	–
Dandelion	*Taraxacum officinale*	–	1
Yellow salsify	*Tragopogon dubius*	2	–
Purple salsify	*Tragopogon porrifolius*	–	2
Rabbitfoot clover	*Trifolium arvense*	–	2
Red clover	*Trifolium pratense*	1	–
White clover	*Trifolium repens*	2	–
Speedwell	*Veronica* sp.	–	1
Vicia	*Vicia* sp.	–	1
Six-week brome	*Vulpia* sp.	–	1
Column subtotal score	**–**	**42**	**44**
		Total index score	**86**

Thus, the 2020 baseline value for Measure 2-1, the index of non-native plant species within wilderness, is 86.

Measure 4-3, Five-year average of the annual number of hours of NPS use of aircraft

Per the baseline report, this measure is intended to "track over time changes in the NPS use of aircraft over the entire Park Complex, given so much (94%) of the Complex is designated Wilderness and that virtually all overflights over the Complex will be heard within some part of the designated Wilderness". The baseline report further describes the protocol. Park staff changed the protocol beginning 2019 to record all NPS flight hours over the Complex rather than attempt to tease out when or if a flight included time over non-Wilderness, and thus the baseline value for this measure is based on two years of data (2019–2020). Only NPS flights are tracked– obtaining non-agency

overflight data was inconsistent over time and the data is not considered reliable enough to include as part of this measure. Table 3 summarizes the 2019–2020 annual number of hours of NPS flights.

Table 3. Annual number of hours of NPS use of aircraft, 2020 baseline value.

Data Year	Total Flight Hours – NPS
2019	74.9
2020	32.6
Average	**54.3**

Thus, the 2020 baseline value for the five-year average of the annual number of hours of NPS use of aircraft over wilderness is 54.3 hours.

2. Revision of Measure 2-7, Visibility protocol and baseline value

The baseline report includes four Measures that reflect air quality conditions in the park and are recommended by the NPS Wilderness Stewardship Division to be included in a park's wilderness character monitoring program. The NPS Air Resources Division (ARD) provides the methods and annual data results, and thus are a highly useful and consistent data source for this program. ARD is now recommending a new visibility measure be adopted that is better at evaluating trends in the natural environment from human-caused change. The complete Measure protocol text for the revised Measure 2-7, Visibility, is provided in Appendix B, but noted here is that the 2015 baseline value has changed due to this protocol change, as shown in Table 4.

Table 4. Visibility data, 2015 baseline.

Data Year	Averaging Period	Visibility (dv)
2015	2011–2015	10.6

3. Correcting the 2015 baseline value for one measure

Since completion of the baseline report additional information for one measure was identified that should have been included for that measure. Measure 3-2, "Number of administrative structures, installations, or developments", did not include all the road segments that fall within designated wilderness, and under-counted the number of Knaack storage boxes stationed in wilderness. Most Knaack boxes are used to store trails maintenance equipment tools and related materials. Permanent roads are prohibited in designated wilderness, but unfortunately the official map that accompanied the designation of the Stephen Mather Wilderness included segments of three separate roads that lie within the wilderness boundary. As such, two additional road segments (Babcock and Upper Goodell Campground roads) and two other Knaack storage box locations (Park Creek, Reynolds) should have been included in the 2015 baseline. Table 5 shows a corrected accounting of all the administrative facilities as of 2015 within the Stephen Mather Wilderness. As a reminder, research installations are accounted for separately under Measure 3-1.

Table 5. Administrative structures, installations, and developments in 2015.

Type	Number	Locations
Administrative Structures	5	Copper Lookout, Desolation Lookout, Sourdough Lookout, Meadow Cabin East, Meadow Cabin West
Developed Administrative Camps	10	Boston Basin, Boundary, Fireweed, Juanita Lake, Luna, McAlester, Pelton Basin, Skagit Queen, Stiletto, Thornton Lake
Radio Repeaters	4	Desolation, McGregor, Ruby, Copper Ridge
Developed Helipads	1	Fireweed
Roads	3	Thornton Lakes road (1 mile), Babcock road (0.6 mile), Upper Goodell Campground road (0.3 mile)
Knaack Boxes	38	Desolation Lookout, 39 Mile Stock, Luna Admin, Beaver Pass Stock, Stillwell (2), Twin Rock Stock, Boundary Admin, Copper Lookout, US Cabin Stock (2), Indian Creek, Graybeal Stock (2), Thornton Lake Trail, McAllister Stock Camp (2), Junction Stock Camp, Skagit Queen Admin, Thunder Basin Stock (2), Thunder Basin Hiker, Fisher Admin, Five Mile Camp, Fireweed Admin, Stiletto Admin, Boston Basin Admin, McAlester Pass Admin, McAlester Stock Camp, Bench Creek, Rainbow Meadows Group, Rainbow Lake Admin, Juanita Lake Admin, Pelton Basin Admin, Pelton Basin Camp (2), Park Creek, Reynolds
Total	61	–

Thus, the corrected 2015 baseline value for the number of administrative structures, installations, and developments within wilderness is 61.

Given the changes and additions to the 2015 baseline measures and values described above, Table 6 provides an updated overview of all the wilderness character measures and related information.

Table 6. Overview of selected measures, 2015 wilderness character baseline.

Quality	Indicator	Measure Number	Measure	Weight (%)	2015/2020 [a] Baseline Value
Untrammeled	Actions authorized by the federal land manager that intentionally manipulate the biophysical environment	1-1	Five-year average of the annual number of authorized actions that intentionally manipulate vegetation, fish and wildlife, and naturally occurring fires.	100	12.2 actions
	Actions not authorized by the federal land manager that intentionally manipulate the biophysical environment	1-2	Five-year average of the annual number of unauthorized actions that intentionally manipulate the biophysical environment	100	0.4 actions

[a] Baseline value established in 2020

Table 6 (continued). Overview of selected measures, 2015 wilderness character baseline.

Quality	Indicator	Measure Number	Measure	Weight (%)	2015/2020 [a] Baseline Value
Natural	Plants	2-1	Index of non-indigenous plant species	100	86 [a]
	Animals	2-2	Index of non-native aquatic species (non-native fish, amphibians)	50	28
	Animals	2-3	Index of non-native terrestrial animal species detected	50	10
	Air and Water	2-4	Ozone exposure to vegetation	25	2.0 ppm-hrs
	Air and Water	2-5	Wet Nitrogen Deposition	25	3.4 kg/ha
	Air and Water	2-6	Wet Sulfur Deposition	25	2.1 kg/ha
	Air and Water	2-7	Visibility – haze on mid-range days	25	10.6 deciviews
	Ecological Processes	2-8	Departure from the natural fire regime in the frequent fire interval region since 1960	100	3.45 return intervals
Undeveloped	Presence of non-recreational structures, installations, and developments	3-1	Number of scientific structures, installations, or developments	50	239 installations
	Presence of non-recreational structures, installations, and developments	3-2	Number of administrative structures, installations, or developments	50	61 installations
	Presence of inholdings	3-3	Acres of inholdings	100	147.42 acres
	Use of motor vehicles, motorized equipment, or mechanical transport	3-4	Five-year average of the annual number of helicopter landings and deliveries	100	183 landings/deliveries
Solitude or Primitive and Unconfined Recreation	Remoteness from sights and sounds of human activity inside wilderness	4-1	Percent of campsites that meet wilderness management privacy standards	100	45%
	Remoteness from sights and sounds of human activity outside wilderness	4-2	Percent time externally derived noise is audible in the Wilderness	50	10%

[a] Baseline value established in 2020

Table 6 (continued). Overview of selected measures, 2015 wilderness character baseline.

Quality	Indicator	Measure Number	Measure	Weight (%)	2015/2020 [a] Baseline Value
Solitude or Primitive and Unconfined Recreation (continued)	Remoteness from sights and sounds of human activity outside wilderness	4-3	Five-year average of the annual number of hours of NPS use of aircraft	50	54.3 hours [a]
	Facilities that decrease self-reliant recreation	4-4	Number of all recreational structures associated with wilderness camps	100	589 structures
	Management restrictions on visitor behavior	4-5	Number of designated camps where campfires are prohibited	33.3	25 camps
	Management restrictions on visitor behavior	4-6	Number of designated camps or cross-country zones where bear canisters are required	33.3	15 camps/zones
	Management restrictions on visitor behavior	4-7	Percent of wilderness available for unconfined camping opportunities	33.3	70%
Other Features of Value	Deterioration or loss of integral historic or cultural features	5-1	Average condition value of listed or eligible structures	50	2.08 condition value
	Deterioration or loss of integral historic or cultural features	5-2	Average condition value of listed or eligible archeological sites	50	3 condition value
	Iconic Features	5-3	Average cumulative volume change of four monitored glaciers	100	−10.27 mwe

[a] Baseline value established in 2020

4. A trend comparison of wilderness character measures for 2015–2020

Following is a summary of wilderness character monitoring for the Stephen Mather Wilderness in the North Cascades National Park Service Complex, for the period of 2015–2020. The trend comparison considers those 22 of 24 measures that have 2015 baseline values established; the remaining two measures are not included in this analysis, but will be used in the next five-year comparison in 2025. The definition of significant change for each measure is provided for each specific measure in the baseline report.

Within the baseline report is a description of the "data adequacy" for each of the 24 monitoring measures, based largely on what was known/understood about the data quantity and quality when the baseline values were established in 2015. For the 2020 trend monitoring data, data collection protocols were followed according to the protocols established in the baseline report, and thus data adequacy for the 2020 monitoring data is also considered adequate based on the quantity and quality of data acquired using the established monitoring protocols.

Figure 1 provides a summary of the trend comparison from 2015 to 2020 for those 22 measures with a 2015 baseline value. Specific details for each of the measures follows the figure.

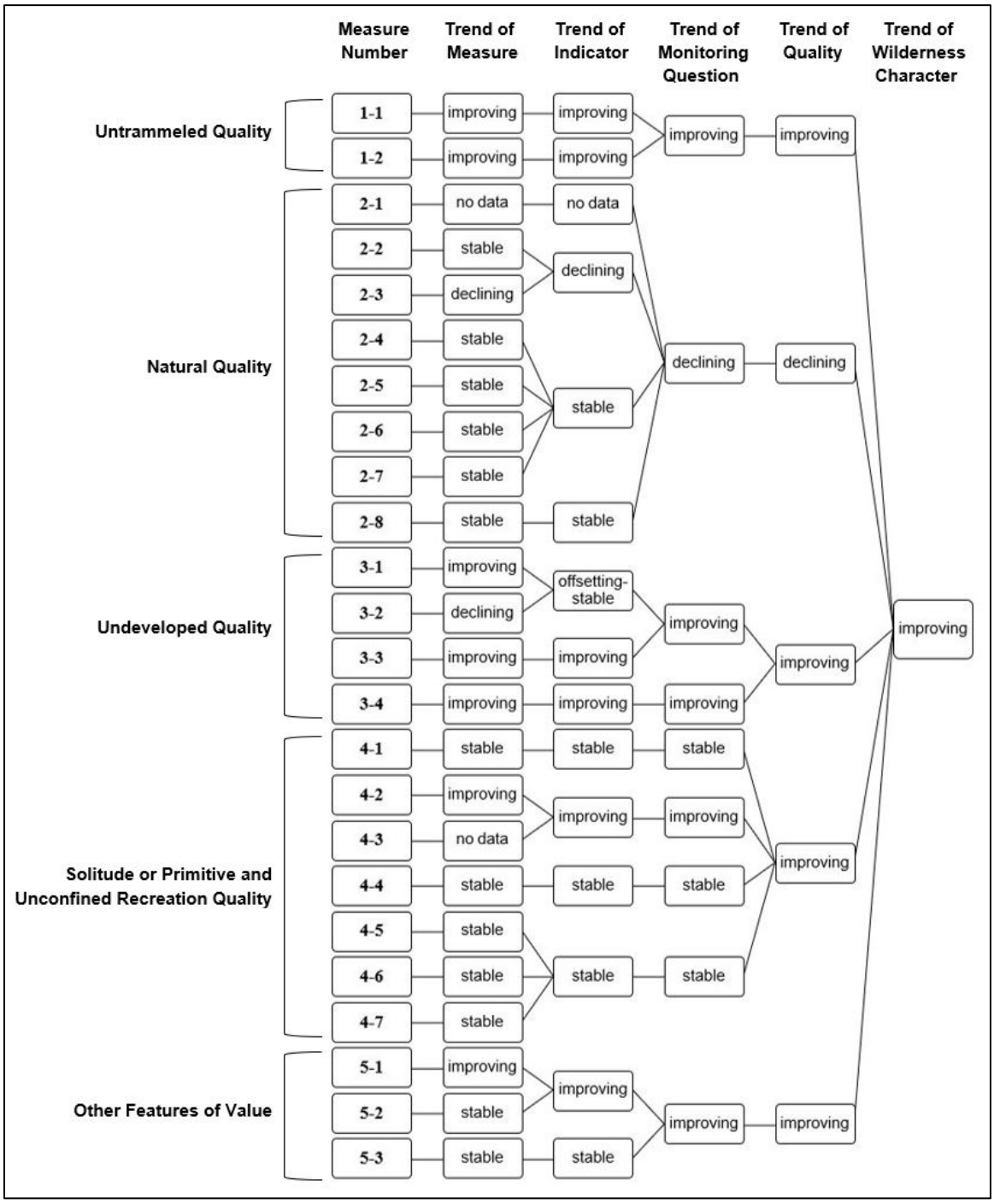

Figure 1. Wilderness character trend, 2015–2020.

In Figure 1, a significant trend for any wilderness character measure in a positive direction is termed as “improving”, in a negative direction as “declining”, and in a stable condition as “stable”.

Following protocols in the Keeping it Wild 2 report (Landres et al., 2015), Figure 1 provides a determination of the trend in each measure, indicator, monitoring question, and quality moving left to right across the figure, according to the following rules:

1. All the trends in the measures of one indicator are combined, with each improving measure offsetting each declining measure.
2. The overall trend in the indicator is "improving" if there are more improving than declining trending measures, and the overall trend is "declining" if there are more declining trending measures (regardless of the number of stable measures).
3. If there are an equal number of improving and declining trending measures, the overall trend in the indicator is referred to as "offsetting stable".
4. If all the measures are stable, the resulting trend in the indicator is also "stable".

By applying the same rules, the resulting trends in the indicators are then used to derive the trends in the monitoring questions and each of the five qualities, ultimately leading to the overall trend in wilderness character for the Stephen Mather Wilderness.

The underlying monitoring data necessary for determining trends for each of the measures in Figure 1, along with a brief statement on what constitutes a "significant" trend for each measure, follows Figure 1 in the discussion about each quality.

Untrammeled Quality

Monitoring Question: What are the trends in actions that intentionally control or manipulate the "earth and its community of life" inside wilderness?

Indicator: Actions authorized by the federal land manager that intentionally manipulate the biophysical environment

Measure 1-1:
Five-year average of the annual number of authorized actions that intentionally manipulate vegetation, fish and wildlife, and naturally occurring fires.

2015 Baseline Assessment Value = 12.2 actions (61 actions/5 yrs = 12.2)

2020 Monitoring Interval Value = 6.8 actions (34 actions/5 yrs – 6.8)

Discussion:
The number of authorized trammeling actions decreased between the 2015 and 2020 reporting periods. Table 7 summarizes the number of trammeling actions from 2011–2015 that created the 2015 baseline value and the actions from 2016–2020 that provide the 2020 comparison value.

Table 7. Summary comparison of all authorized actions that intentionally manipulate vegetation, fish and wildlife, and naturally occurring fires, 2015 to 2020.

Data Year	Vegetation	Fish and Wildlife	Suppressed Fires	Total
2011	0	7	0	7
2012	2	6	1	9
2013	2	7	4	13
2014	1	5	1	7
2015	5	7	13	25
5-year total	**–**	**–**	**–**	**61**
2016	3	5	0	8
2017	2	3	0	5
2018	2	6	4	12
2019	1	4	2	7
2020	2	0	0	2
5-year total	**–**	**–**	**–**	**34**

The significant drop in authorized trammeling actions reflects two trends in park ecological intervention work: 1) a general reduction in the number of fish eradication operations in the high elevation lakes between the two time periods, given many of the easier-accessed project lakes were completed early (before 2016) in that program (see NPS, 2008 for description of this issue); and 2) a significant drop in the number of wildland fires that were suppressed for this time period, which reflects both a lower number of fire starts but also a more concerted effort of park management to

allow naturally-ignited fires to burn and play a natural role on the park landscape rather than suppress them.

Trend:

Improving. The baseline report identifies a change of 5% or more in either direction of the baseline value (12.2) as a significant trend. The 2020 value is greater than a 5% change and represents an "improving" trend.

Indicator: Actions not authorized by the federal land manager that intentionally manipulate the biophysical environment

Measure 1-2:

Five-year average of the annual number of unauthorized actions that intentionally manipulate the biophysical environment.

[2015] Baseline Assessment Value = 0.4 actions

[2020] Monitoring Interval Value = 0 actions

Discussion:

For the baseline period of 2011–2015 two illegal fish stocking actions occurred. No unauthorized actions were discovered or documented for the period of 2016–2020.

Trend:

Improving. The baseline report identifies any change of the baseline value (0.4) as a significant trend. The 2020 value is greater than a 5% change and represents an "improving" trend.

Natural Quality

Monitoring Question: What are the trends in the natural environment from human-caused change?

Indicator: Plants

Measure 2-1:
Index of non-indigenous plant species

[2015] Baseline Assessment Value = Not available

[2020] Monitoring Interval Value =

Discussion:
Note: As discussed earlier in this report, the baseline value for this measure was not established until 2020, hence this measure is not able to provide a trend comparison at this time.

Trend:
N/A

Indicator: Animals

Measure 2-2:
Index of non-native aquatic species (non-native fish, amphibians)

[2015] Baseline Assessment Value = 28

[2020] Monitoring Interval Value = 28

Discussion:
No additional non-native species were identified in wilderness waters between 2016–2020, nor were any species eliminated, and thus the value remains the same as the baseline value. Table 8 shows the identified non-native species and impact assessment for the 2015 baseline value.

Table 8. Non-native aquatic species, distribution rating, impact rating, and index score.

Aquatic Species	Distribution Rating	X the Impact Rating	= Index Score
Rainbow trout	2	3	6
Westslope Cutthroat Trout	3	3	9
Yellowstone Cutthroat Trout	1	3	6
Brown Trout	1	3	3
Golden Trout	1	1	1
Brook Trout	1	3	3
Total – index measure value	**–**	**–**	**28**

Trend:

Stable. The baseline report identifies a change of 5% or more in either direction of the baseline value (28) as a significant change. No change in value between 2015 and 2020 was observed, and thus the trend is "stable."

Measure 2-3:

Index of non-native terrestrial species detected

[2015] Baseline Assessment Value = 10

[2020] Monitoring Interval Value = 13

Discussion:

Two additional wildlife species were identified as likely occurring within wilderness since 2015, the wild turkey and eastern cottontail. Table 9 shows the terrestrial species and impact assessment.

Table 9. Non-native terrestrial animal species, distribution rating, impact rating, and index score.

Terrestrial Animal Species	Distribution Rating	X the Impact Rating	= Index Score
Brown-headed cowbird	1	1	1
European starling	1	1	1
Barred owl	3	2	6
House sparrow	1	1	1
Eurasian collared dove	1	1	1
2015 – index measure value	**–**	**–**	**10**
Wild turkey [a]	1	1	1
Eastern cottontail [a]	1	2	2
2020 – index measure value	**–**	**–**	**13**

[a] Species added 2016–2020

Trend:

Declining. The baseline report identifies any change in either direction of the baseline value (10) as a significant trend. For this measure, two additional non-native species were identified and the index score increased, representing a "declining" trend.

Barred owl.

Indicator: Air and Water

Measure 2-4:
Ozone exposure to vegetation

[2015] Baseline Assessment Value = 2.0 ppm-hrs

[2020] Monitoring Interval Value = 2.9 ppm-hrs

Discussion:
The ozone exposure to vegetation level increased from 2.0 ppm-hrs to 2.9 ppm-hrs. Table 10 shows the comparison in monitoring years for this measure.

Table 10. Ozone exposure to vegetation data, 2015 and 2019 five-year average values.

Reporting Year	Averaging Period	Ozone (ppm-hrs)
2015	2011–2015	2.0
2020	2016–2019	2.9

Trend:
Stable. The NPS Air Resources Division provides data for this measure, and directed that "Any change of 2 parts per million-hrs or more in either direction form the baseline data is considered significant". The difference between 2015 and 2020, while concerning, has not reached the identified significant change threshold, and thus the trend remains "stable".

Measure 2-5:
Wet Nitrogen Deposition

[2015] Baseline Assessment Value = 3.4 kg/ha

[2020] Monitoring Interval Value = 3.4 kg/ha

Discussion:
The wet nitrogen deposition remained at 3.4 kg/ha from baseline to the 2014–2018 averaging period, the most recent data available from the NPS Air Resources Division. Table 11 shows the comparison in monitoring years for this measure.

Table 11. Wet nitrogen deposition data, 2015 and 2019 five-year average values.

Reporting Year	Averaging Period	Wet N Deposition (kg/ha)
2015	2011–2015	3.4
2020	2014–2018	3.4

Trend:
Stable. The NPS Air Resources Division defines a significant change in wet nitrogen deposition values as "Any change of 0.5 kg/hr/yr or more in either direction from the baseline data value is considered significant." Given the values between the two monitoring periods are equal, the trend remains "stable."

Measure 2-6:
Wet Sulphur Deposition

[2015] Baseline Assessment Value = 2.1 kg/ha

[2020] Monitoring Interval Value = 1.8 kg/ha

Discussion:
Wet sulphur deposition values decreased from 2.1 to 1.8 kg/ha for the 2014–2018 averaging period, the most recent data available from the NPS Air Resources Division. Table 12 shows the comparison in monitoring years for this measure.

Table 12. Wet sulphur deposition data, 2015 and 2019 five-year average values.

Reporting Year	Averaging Period	Wet S Deposition (kg/ha)
2015	2011–2015	2.1
2020	2014–2018	1.8

Trend:
Stable. The NPS Air Resources Division defines a significant change in wet Sulphur deposition values as "Any change of 0.5 kg/ha/yr or more in either direction from the baseline data value is considered significant". Given the change between the monitoring period is less than 0.5 kg/ha/yr, the trend is considered "stable."

Measure 2-7:
Visibility – haze on most-impaired days

[2015] Baseline Assessment Value = 10.6 dv

[2020] Monitoring Interval Value = 9.7

Discussion:
As noted earlier in this report, this measure methodology was changed to better track visibility trends in the natural environment. Five-year (2011–2015) averaging values for the 2015 baseline were established (10.6 dv), and the averaging period 2016–2019 values were 9.7 dv. Table 13 shows the comparison in monitoring years for this measure.

Table 13. Visibility data, 2015 and 2020 five-year average values.

Reporting Year	Averaging Period	Visibility (dv)
2015	2011–2015	10.6
2020	2016–2019	9.7

Trend:
Stable. The NPS Air Resources Division defines a significant change in Visibility values as any change of 1 dv or more in either direction from the baseline data value (Ksienya Taylor, NPS ARD, personal communication, 2021). The difference between the two monitoring periods is 0.9 dv in an increasing trend, but slightly less than a significant change. As such, the trend is "stable."

Indicator: Ecological Processes

Measure 2-8:
Departure from the natural fire regime in the frequent fire interval regime since 1960

[2015] Baseline Assessment Value = 3.45 return intervals

[2020] Monitoring Interval Value = 3.76 return intervals

Discussion:
The number of fire return intervals missed has increased between the two monitoring periods, from 3.45 to 3.76 return intervals. Table 14 shows the comparison in monitoring years for this measure.

Table 14. Departure from natural fire regime in frequent fire return interval.

Data Year	Data Analysis Years	Modern Mean Fire Return Interval	Number of Fire Returns Missed	DepartureClass
2015	1960–2015	99.99 years	3.45	High
2020	1960–2020	108.93 years	3.76	High

Trend:

Stable. The baseline report identifies a significant change in the number of fire returns missed as a change from one "departure class" to another, such as from High to Moderate. In both the 2015 and 2020 reporting years, the number of fire returns missed remains in the "High" departure class, hence the trend is "stable."

Undeveloped Quality

Monitoring Question: What are the trends in non-recreational physical development?

Indicator: Presence of non-recreational structures, installations, and developments

Measure 3-1:
Number of scientific structures, installations, or developments

[2015] Baseline Assessment Value = 239 installations

[2020] Monitoring Interval Value = 222 installations

Discussion:
The number of scientific installations in wilderness decreased between the 2015 and 2020 reporting years. A notable decrease in Whitebark Pine legacy plots occurred, while other small increases in plot installations for various monitoring programs occurred, as shown in Table 15.

Table 15. Scientific installations in 2015 and 2020.

Type	Subtype	Number – 2015 Baseline	Number – 2020
Weather Stations	SC	9 [a]	9
	SNOTEL	5	5
	NPS	2	2
Water Gauges	–	1	1
Water Temp Sensors	Streams	18	22
	Lakes	13	14
Air Temp Sensors	Alpine talus	12	12
Wildlife Cameras	–	6	8
Sampling Plots	Glaciers	4	4
	FIA	46	47
	Forest	12	12
	Subalpine	9	13
	Whitebark Pine Legacy	35	6
	Fire Effects	22	22
	Fire Ecology	45	45
Total	–	239	222

[a] Was listed as “10” in 2015 baseline report but one of the locations—Park Creek—was no longer present by the end of 2015. Baseline total of 239 installations was correct.

SNOTEL = SNOwpack TELemetry; SC = Snow Course; FIA = Forest Service’s Forest Inventory and Analysis

Some Air Temp sensors locations have more than one installation site

Trend:

Improving. The baseline report identifies a significant change as a 5% change in either direction from the baseline number of 239 installations. The observed changed from baseline is approximately 7% fewer installations, thus the trend in "improving".

Wildlife camera installation.

Measure 3-2:

Number of administrative structures, installations, or developments

[2015] Baseline Assessment Value = 61 installations

[2020] Monitoring Interval Value = 68 installations

Discussion:

As discussed earlier, the 2015 baseline value was adjusted from 57 to 61 to account for structures missed in the baseline report. The number of installations increased by 7 by 2020 through the addition of one administrative backcountry camp at Cottonwood, two Knaack boxes, and four trail counters in 2020 to aid in the understanding of visitor use levels on certain high use trails. Table 16 shows the corrected baseline count and the 2020 installations count, by type, and includes the addition of the trail counters as a new type of administrative installation deployed since the 2015 baseline.

Table 16. Administrative structures, installations, and developments, 2015 and 2020.

Type	2015 Number	2020 Number
AdministrativeStructures	5	5
Developed Administrative Camps	10	11, addition of Cottonwood Camp
Radio Repeaters	4	4
Developed Helipads	1	1
Roads	3	3
Knaack Boxes	38	40, addition of Park Crk and Reynolds camp boxes
Other instrumentation (such as trail counters)	0	4 trail counters
Total	**61**	68

Trend:

Declining. The baseline report identifies a significant change from the baseline value (61) if the number of installations changes by more than 5% in either direction. The observed increase in installations is more than 5%, and thus the trend is "declining."

Indicator: Presence of Inholdings

Measure 3-3:

Acres of inholdings

[2015] Baseline Assessment Value = 147.42

[2020] Monitoring Interval Value = 126.76

Discussion:

The number of inholding acres decreased by 20.66 acres when the NPS obtained the remaining interest in the Boston Lode property. Only the two Webster properties remain as inholdings within designated wilderness. Table 17 shows the inholding acreage status.

Table 17. Wilderness inholdings in 2015 and 2020.

Inholding	2015 Acres	2020 Acres
Webster 1	4.98	4.98
Webster 2	121.78	121.78
Boston Lode	20.66	0, purchased by NPS
Total	**147.42**	**126.76**

Trend:

Improving. The baseline report identifies any change in the baseline value (147.42) as a significant change, and thus a reduction of acres represents an "improving" trend.

Monitoring Question: What are the trends in mechanization?

Indicator: Use of motor vehicles, motorized equipment, or mechanical transport

Measure 3-4:

Five-year average of the annual number of helicopter landings and deliveries

[2015] Baseline Assessment Value = 183 landings/deliveries

[2020] Monitoring Interval Value = 82 landings/deliveries

Discussion:

The number of helicopter landings/deliveries decreased significantly from 2015 to 2020, dropping approximately 55% between the two years. The five-year period from 2016–2020 saw a dramatic reduction in the amount of helicopter activity over wilderness, likely due to fewer fires in the park complex that required significant suppression effort and related aircraft use. Although Search and Rescue incidents appear to be increasing in the park complex, often involving some helicopter use and landings/deliveries, the singular drop in fire-related aircraft use—and associated landings/deliveries that can accompany that activity—is the primary reason for this drop in number by 2020. Table 18 shows the number of landings/deliveries for the two reporting periods.

Table 18. Five-year averages of the annual number of helicopter landings and deliveries in wilderness, 2015 and 2020.

Data Year	Number of Aircraft Landings	Number of Deliveries by Aircraft	Total Landings
2013	88	Unknown	–
2014	165	Unknown	–
2015	114	61	175
Baseline average	**122**	**61**	**183**
2016	59	12	71
2017	66	11	77
2018	73	50	123
2019	51	35	86
2020	33	20	53
2016–2020 5-yr average	**56.4**	**25.6**	**82**

Trend:

Improving. The baseline report identifies any change in the baseline value (183) represents a significant trend change, and thus this 55% drop in landings/deliveries represents an “improving” trend.

Solitude or Primitive and Unconfined Recreation Quality

Monitoring Question: What are the trends in outstanding opportunities for solitude?

Indicator: Remoteness from sights and sounds of human activity inside wilderness

Measure 4-1:
Percent of campsites that meet wilderness management privacy standards

[2015] Baseline Assessment Value = 45%

[2020] Monitoring Interval Value = 47%

Discussion:
For the 2015 baseline report the park had 188 campsites within wilderness, and 45% of those sites met the privacy standards of being out of sight of both the main trail and other campsites. In 2020, the number of campsites in wilderness had reduced to 177 with the closure of Flat Creek, Little Chilliwack, and McAllister campgrounds due to hazard tree and other issues, and the addition of the new Buckner Camp. The reduction in total campsite number within wilderness also reduced to 83 the number of campsites that meet privacy standards. With these changes, the number of campsites meeting privacy standards has risen to 47% by 2020. *It is important to note that the total number of campsites meeting wilderness privacy standards did not increase, only that because of multiple campsite closures by 2020, of the now available campsites the percentage meeting wilderness privacy standards did increase.* Table 19 shows the comparison of the percentage of wilderness campsites in 2015 and 2020 that meet wilderness privacy standards.

Table 19. Campsites meeting wilderness privacy standards.

Data Year	Total Number of Campsites in Wilderness	Number of Campsites that Meet Privacy Standards	Percent Meeting Privacy Standards
2015	188	85	45%
2020	177	83	47%

Trend:
Stable. The baseline report identifies a change of 5% or greater in either direction of the baseline value (45) as significant. The increase seen in 2020 remains less than a 5% change in the measure value, hence a “stable” trend.

Indicator: Remoteness from sights and sounds of human activity outside the wilderness

Measure 4-2:
Percent time externally derived noise is audible in the Wilderness

[2015] Baseline Assessment Value = 10%

[2020] Monitoring Interval Value = 3%

Discussion:

This measure utilizes a natural sounds monitor instrument to record noise, and the measure focuses on the external sounds of aircraft overflights at the Boundary Camp monitoring site location. Compared to 2015, in 2020 the amount of recorded aircraft noise dropped by 70%, to only 3% of the 24-hour percent time audible. This reduction is likely due to the significant reduction in aircraft travel in general, but commercial aircraft in particular, due to the COVID pandemic. Table 20 shows the comparison of the external sounds audible (aircraft overflights) between 2015 and 2020.

Table 20. Soundscapes monitoring data in 2015 and 2020, Boundary Camp Location.

Data year	24 Hour % Time Aircraft are Audible
2015	10.0
2020	3.0

Trend:

Improving. The baseline report identifies a change of 5% or more in the baseline value (10) in either direction as a significant change. For this measure, the 70% change in the measure value represents an "improving" trend.

Measure 4-3:

Five-year average of the annual number of hours of NPS use of aircraft

[2015] Baseline Assessment Value = Not available

[2020] Monitoring Interval Value =

Discussion:

Note: As discussed earlier in this report, the baseline value for this measure was not established until 2020, hence this measure is not able to provide a trend comparison at this time.

Trend:

N/A

Monitoring Question: What are the trends in outstanding opportunities for primitive and unconfined recreation?

Indicator: Facilities that decrease self-reliant recreation

Measure 4-4:

Number of all recreational structures associated with wilderness camps

[2015] Baseline Assessment Value = 589 structures

[2020] Monitoring Interval Value = 561 structures

Discussion:

Recreational structures are defined as toilets, signs, metal fire rings, hitchrails, and food storage wire or lockers. The number of recreational structures in wilderness camps decreased by 28, or slightly less than 5%. Table 21 shows the comparison of recreational structures in camps between 2015 and 2020.

Table 21. Recreational structures in wilderness camps in 2015 and 2020.

Data Year	Toilet Facilities	Food Storage Installations	Hitch Rails	Camp Signs	Metal Fire Rings	Total
2015	93	35	44	312	105	589
2020	95	27	39	306	94	561

Trend:

Stable. The baseline report identifies a 5% or greater change of the baseline value (589) in either direction as representing a significant change. The decline in recreational structures is slightly less than 5%, representing a "stable" trend.

Indicator: Management restrictions on visitor behavior

Measure 4-5:

Number of designated camps where campfires are prohibited

[2015] Baseline Assessment Value = 25 camps

[2020] Monitoring Interval Value = 26 camps

Discussion:

One additional camp (Heaton) had a campfire prohibition put in place during the monitoring period.

Trend:

Stable. The baseline report identifies a 5% change of the baseline value (25) in either direction as representing a significant change. A change of one camp is slightly less than 5%, thus representing a "stable" trend.

Measure 4-6:

Number of designated camps or cross-country zones where bear canisters are required.

[2015] Baseline Assessment Value = 15 camps/zones

[2020] Monitoring Interval Value = 15 camps/zones

Discussion:

No change occurred from 2015 to 2020.

Trend:

Stable. The baseline report identifies a 5% change of the baseline value (15) in either direction as representing a significant change. No change occurred, thus representing a "stable" trend.

Bear-proof food canister.

Measure 4-7:

Percent of wilderness available for unconfined camping opportunities

[2015] Baseline Assessment Value = 70%

[2020] Monitoring Interval Value = 70%

Discussion:

No change occurred from 2015 to 2020.

Trend:

Stable. The baseline report identifies a whole number change of the baseline value (70) in either direction as representing a significant change. No change occurred, thus representing a "stable" trend.

Other Features of Value Quality

Monitoring Question: What are the trends in the unique features that are tangible and integral to wilderness character?

Indicator: Deterioration or loss of integral cultural features

Measure 5-1:
Average condition value of listed or eligible structures

[2015] Baseline Assessment Value = 2.08

[2020] Monitoring Interval Value = 2.25

Discussion:
All structures were assessed for the 2020 monitoring period. Three structures were in an improved condition due to work that had been performed on them, including Sourdough Mountain Lookout, Perry Creek Shelter, and Deer Lick Cabin. One structure (Meadow Cabin East) deteriorated between the monitoring periods. Table 22 shows the comparison in condition values of these structures between 2015 and 2020.

Table 22. Condition value for listed or eligible structures, 2015 and 2020.

Structure Name	Condition Value - 2015	Condition Value - 2020
Copper Mountain Lookout	3	3
Desolation Peak Lookout	3	3
Sourdough Mountain Lookout	2	3
Beaver Pass Shelter	2	2
Perry Creek Shelter	1	2
Deer Lick Cabin	2	3
Gilbert's Cabin	1	1
Meadow Cabin, East	3	2
Meadow Cabin, West	2	2
Rock Cabin	2	2
Sulphide Cabin	1	1
Black Warrior Mine	3	3
Average condition value	**2.08**	**2.25**

Trend:
Improving. The baseline report defines any change of the baseline value (2.08) as a significant change. The increase of the condition value to 2.25 represents an “improving” trend.

Measure 5-2:
Average condition value of listed or eligible archeological sites

[2015] Baseline Assessment Value = 3

[2020] Monitoring Interval Value = 3

Discussion:
All three archeological sites were surveyed and retained a condition value of 3 (Good). Table 23 shows the comparison in condition values of these archeological sites between 2015 and 2020.

Table 23. Condition value for listed or eligible archeological sites, 2015 and 2020.

Archeological Site Name	Number	Condition Value - 2015	Condition Value - 2020
Cascade Pass #01	45CH221	3	3
Copper Ridge #7	45WH484	3	3
Desolation Chert Quarry	45WH224	3	3
Average Condition Value	**–**	**3**	**3**

Trend:
Stable. The baseline report defines any change of the baseline value (3.0) as a significant change. Because the condition value is the same for the two reporting years, the trend is "stable".

Indicator: Deterioration or loss of other integral site-specific features of value

Measure 5-3:
Average cumulative volume change of four monitored glaciers

[2015] Baseline Assessment Value = (−10.27)

[2020] Monitoring Interval Value = (−11.44)

Discussion:
This long-term glacier monitoring program, begun in 1992, reflects the iconic nature of this resource to the Stephen Mather Wilderness. As shown in Table 24 and Figure 2, glacial volume continues to decline over time, although worth noting is the slight increase in volume in 2020, albeit likely only a short-term event.

Table 24. Cumulative volume change (mwe) for the four monitored glaciers.

Data Year	Noisy Creek Glacier	Silver Glacier	N. Klawatti Glacier	Sandalee Glacier	Average
2011	−8.03 [a]	−8.26 [a]	−8.22 [a]	−6.66 [a]	−7.79 [a]
2012	−7.41 [a]	−7.77 [a]	−7.75 [a]	−5.96 [a]	−7.22 [a]
2013	−8.18 [a]	−8.13 [a]	−8.66 [a]	−6.25 [a]	−7.80 [a]
2014	−8.37 [a]	−8.39 [a]	−8.87 [a]	−6.47 [a]	−8.03 [a]

[a] Provisional data, subject to remapping of glacier surfaces.

Note: Volume change values are in units of meter water equivalent (mwe)

Table 24 (continued). Cumulative volume change (mwe) for the four monitored glaciers.

Data Year	Noisy Creek Glacier	Silver Glacier	N. Klawatti Glacier	Sandalee Glacier	Average
2015	−11.92 [a]	−9.51 [a]	−11.20 [a]	−8.47 [a]	−10.27 [a]
2016	−12.68 [a]	−8.93 [a]	−11.78 [a]	−7.78 [a]	−10.29 [a]
2017	−13.09 [a]	−8.61 [a]	−12.40 [a]	−7.85 [a]	−10.48 [a]
2018	−13.97 [a]	−8.73 [a]	−12.94 [a]	−7.92 [a]	−10.89 [a]
2019	−15.12 [a]	−8.96 [a]	−14.37 [a]	−9.54 [a]	−12.00 [a]
2020	−14.78 [a]	−9.11 [a]	−13.87 [a]	−8.00 [a]	−11.44 [a]

[a] Provisional data, subject to remapping of glacier surfaces.

Note: Volume change values are in units of meter water equivalent (mwe)

Figure 2. Comparative photo pair of Silver Glacier, 1958 to 2006. This illustrates the long-term trend of glacier volume loss on all the glaciers in the wilderness.

Trend:

Stable. The baseline report defines a change of greater than 3 mwe from the baseline value of (−10.27) in either direction as a significant change. The change measured in 2020 is less than a change of 3 mwe, thus the trend is “stable”.

Table 25 provides a summary of the 2015 baseline value and the 2020 monitored value for the wilderness character measures for the park.

Table 25. Wilderness character measures and their 2015 baseline and 2020 monitored values.

Quality	Measure Number	Measure	2015 Baseline Value	2020 Value
Untrammeled	1-1	Five-year average of the annual number of authorized actions that intentionally manipulate vegetation, fish andwildlife, and naturally occurringfires.	12.2 actions	6.8 actions
	1-2	Five-year average of the annual number of unauthorizedactions that intentionally manipulate the biophysical environment	0.4 actions	0.0 actions
Natural	2-1	Index of non-indigenous plantspecies	–	86
	2-2	Index of non-native aquaticspecies (non-native fish, amphibians)	28	28
	2-3	Index of non-native terrestrialanimal species detected	10	13
	2-4	Ozone exposure to vegetation	2.0 ppm-hrs	2.9 ppm-hrs
	2-5	Wet Nitrogen Deposition	3.4 kg/ha	3.4 kg/ha
	2-6	Wet Sulfur Deposition	2.1 kg/ha	1.8 kg/ha
	2-7	Visibility – haze on most-impaired days	10.6 deciviews	9.7 deciviews
	2-8	Departure from the natural fireregime in the frequent fire interval region since 1960	3.45 return intervals	3.76 return intervals
Undeveloped	3-1	Number of scientific structures, installations, or developments	239 installations	222 installations
	3-2	Number of administrative structures, installations, ordevelopments	61 installations	68 installations
	3-3	Acres of inholdings	147.42 acres	126.76 acre
	3-4	Five-year average of the annual number of helicopterlandings and deliveries	183 landings/deliveries	82 landings/deliveries
Solitude or Primitive and Unconfined Recreation	4-1	Percent of campsites that meet wilderness management privacy standards	45%	47%
	4-2	Percent time externally derivednoise is audible in the Wilderness	10%	3%
	4-3	Five-year average of the annual number of hours of NPSuse of aircraft	–	54.3 hrs
	4-4	Number of all recreationalstructures associated withwilderness camps	589 structures	561 structures
	4-5	Number of designated camps where campfires are prohibited	25 camps	26 camps
	4-6	Number of designated campsor cross-country zones wherebear canisters are required	15 camps/zones	15 camps/zones
	4-7	Percent of wilderness availablefor unconfined camping opportunities	70%	70%

Table 25 (continued). Wilderness character measures and their 2015 baseline and 2020 monitored values.

Quality	Measure Number	Measure	2015 Baseline Value	2020 Value
Other Features of Value	5-1	Average condition value oflisted or eligible structures	2.08 conditionvalue	2.25 condition value
	5-2	Average condition value of listed or eligible archeologicalsites	3.0 condition value	3.0 condition value
	5-3	Average cumulative volumechange of four monitored glaciers	−10.27 mwe	−11.44 mwe

Early season wildflowers, Bridge Creek Trail.

Trend Summary Discussion

As seen in Figure 1 and Table 25, at this first 5-year interval marker of tracking wilderness character trends in the Stephen Mather Wilderness, results are encouraging. Four of the five qualities of wilderness character show an improving trend, or improvement of wilderness character, with the notable exception of the Natural Quality. However, considerable caution is necessary, as it will take a longer period of time to evaluate if the measures chosen are both suitable and effective in tracking wilderness character trends over time.

A brief discussion on results seen for each Quality includes:

Untrammeled Quality:

This quality showed an improving trend. As noted earlier, the significant drop in trammeling actions is encouraging, and was driven in large part by fewer fish removal actions in high elevation lakes and fewer suppression actions taken on fires. It should be noted, however, that fish removal actions are an important part of improving the ecological integrity of aquatic systems in wilderness, approved through a park-specific EIS decision-making process, and thus are expected to continue. Of greater caution is understanding the fire suppression trend. Management of natural fires within wilderness ideally leads to fewer suppression actions, but those decisions are complex and can vary from year to year due to the national fire situation. Decisions on whether to suppress a fire or allow it to burn naturally are often influenced by the national fire situation, well beyond the wilderness boundaries. In this short-term window of 2015–2020, however, the park was able to suppress fewer fires and manage more of them for resource benefits, a positive outcome for both Wilderness and the natural landscape.

Natural Quality:

This is the only quality that showed a declining trend, largely due to the trend related to invasive species of wildlife, and terrestrial wildlife in particular. Almost all the measures were stable, and thus the declining trend for wildlife caused the overall natural quality to be declining. Worth noting is that for the two invasive animal species that were added to the list between 2015 and 2020, both species were seen near the wilderness boundary edge, hopefully a sign they have not (and perhaps will not) establish well within designated wilderness.

Undeveloped Quality:

Overall this quality showed an improving trend (albeit with one measure showing a declining trend), with significant improvement shown in the decrease in helicopter landings/deliveries, although the caution is again made about the low amount of natural fire suppression activities during this 5-year period, which directly influences the number of landings/deliveries. A notable success for the park and wilderness was the reduction in acreage of private inholdings in wilderness, especially given this is a permanent improvement for this aspect of wilderness character.

Solitude or Primitive and Unconfined Recreation Quality:

This quality showed an improving trend. Perhaps more so than the other qualities, the measures in this quality likely will be the slowest to change significantly over time, with the lone exception being

the measure that tracks the NPS helicopter usage, as that measure will likely fluctuate year to year due the number of fires and search/rescue operations, both of which can be highly variable. One interesting measure trend was Measure 4-2, which tracks external aircraft noise in wilderness. The 2020 value was dramatically lower than the 2015 value, and provides perhaps the clearest impact of the global COVID pandemic on activities that affect Wilderness. The type of aircraft noise this measure tracks includes commercial overflights, which were sharply reduced in 2020 due to the pandemic. Commercial flights appeared to be nearing pre-COVID levels already by spring, 2021, and expectations are that this measure in 2025 will be similar to higher than the 2015 baseline.

Other Features of Value:

This quality showed an improving trend, driven by the improvements made by park staff in some of the historic structures that have high cultural value in the wilderness.

Noted above is the COVID pandemic effect to at least one measure (aircraft overflight noise), and it will be interesting to see if the 2025 values for the four air quality related measures (Measures 2-4 to 2-7) show any improvement. Global air quality improved dramatically in 2020 as the global economy shutdown due to COVID, and we would expect to see the 2020 measured values show up in the 2025 trend analysis.

Finally, this project of long-term trend monitoring of wilderness character is a multi-divisional staff effort that will require such continued participation into the future to be successful. Strong, coordinated oversight is needed to ensure timely monitoring and collection of data for the 24 measures, some of which only need a data point every five years while others need annual data collection. The collection, storage, analysis, and reporting of data on a five-year cycle will aid park management in meeting its wilderness stewardship needs.

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Appendix A. Summary of Trail and Backcountry Camps Survey of Non-Native Plant Species, 2006, 2019, and 2020

Table 26. Non-native plant species along major wilderness trails, Stephen Mather Wilderness (2006, 2019). Impact risk determined either from NatureServe or professional judgement from local botanists.

Trail	Common Name	Species Name	Percent Cover/Area Surveyed	Invasive Species Impact Risk [a]	Professional Judgement
1. Big Beaver	Wall lettuce	*Mycelis muralis*	<1%	–	1
	English plantain	*Plantago lanceolata*	<1%	2	–
	Common plantain	*Plantago major*	<1%	–	1
	Annual bluegrass	*Poa annua*	1–25%	1	–
	Compressed bluegrass	*Poa compressa*	1–25%	2	–
	Perennial bluegrass	*Poa pratensis*	1–25%	2	–
	Creeping buttercup	*Ranunculus repens*	<1%	3	–
	Cut leaved blackberry	*Rubus laciniatus*	<1%	–	3
	Sheep sorrel	*Rumex acetosella*	<1%	2	–
	Red clover	*Trifolium pratense*	26–50%	1	–
	White clover	*Trifolium repens*	26–50%	2	–
	Speedwell	*Veronica* sp.	<1%	–	1
2. East Bank	Smooth Brome	*Bromus inermus*	1–10%	–	2
	Cheatgrass	*Bromus tectorum*	<1%	3	–
	St. John's wort	*Hypericum perforatum*	1–25%	3	–
	Wall lettuce	*Mycelis muralis*	1–3%	–	1
	Reed Canary Grass	*Phalaris arundinacea*	</%	–	3
	English plantain	*Plantago lanceolata*	1–15%	2	–
	Common plantain	*Plantago major*	<1%	–	1
	Annual bluegrass	*Poa annua*	<1%	1	–
	Sheep sorrel	*Rumex acetosella*	<1%	2	–
	Common Tansy	*Tanacetum vulgare*	<1%	1	–
	Red clover	*Trifolium pratense*	<1%	1	–
3. Ruby Arm	European Horse-chestnut	*Aesculus hippocastanum*	<1%	–	1
	Lesser burdock	*Arctium minus*	1–5%	–	3
	Canada Thistle	*Cirsium arvense*	1–20%	3	–
	Orchard grass	*Dactylis glomerata*	1–80%	–	2
	Everlasting pea vine	*Lathyrus latifolius*	1–80%	–	3

[a] low=1, 2=medium, 3=high

Table 26 (continued). Non-native plant species along major wilderness trails, Stephen Mather Wilderness (2006, 2019). Impact risk determined either from NatureServe or professional judgement from local botanists.

Trail	Common Name	Species Name	Percent Cover/Area Surveyed	Invasive Species Impact Risk [a]	Professional Judgement
3. Ruby Arm (continued)	Oxeye Daisy	*Leucanthemum vulgare*	<1%	–	3
	Timothy grass	*Phleum pretense*	1–50%	2	–
	Annual bluegrass	*Poa annua*	1–25%	1	–
	Smartweed	*Polygonum* spp.	<1%	–	1
	Creeping buttercup	*Ranunculus repens*	1–50%	3	–
	Curly dock	*Rumex crispus*	1–15%	1	–
	European mountain ash	*Sorbus acuparia*	<1%	–	2
	Common tansy	*Tanacetum vulgare*	<1%	1	–
	Salsify	*Tragopogon porrifolius*	1%	–	2
	Rabbitfoot clover	*Trifolium arvense*	1–50%	–	2
	Red clover	*Trifolium pratense*	<1%	1	–
	White clover	*Trifolium repens*	<1%	2	–
	Six-week brome	*Vulpia* sp.	<1%	–	1
4. Panther	Herb Robert	*Geranium robertianum*	–	–	3
	Wall lettuce	*Mycelis muralis*	–	–	1
	Annual bluegrass	*Poa annua*	<1%	1	–
	Perennial bluegrass	*Poa pratensis*	–	2	–
	Spiny sow thistle	*Sonchus asper*	–	–	2
5. Cascade Pass	Orchard grass	*Dactylis glomerata*	<1%	–	2
	Annual bluegrass	*Poa annua*	<1%	1	–
	White clover	*Trifolium repens*	<1%	2	–
6. Chilliwack	Wall lettuce	*Mycelis muralis*	1–3%	–	1
	Common plantain	*Plantago major*	<1%	–	1
	Annual bluegrass	*Poa annua*	<1%	1	–
	Perennial bluegrass	*Poa pratensis*	1–25%	2	–
	Sheep sorrel	*Rumex acetosella*	1–20%	2	–
	Curly dock	*Rumex crispus*	<1%	1	–
	Red clover	*Trifolium pratense*	26–50%	1	–
	White clover	*Trifolium repens*	–	2	–
	Six-week brome	*Vulpia* sp.	<1%	–	1

[a] low=1, 2=medium, 3=high

Table 26 (continued). Non-native plant species along major wilderness trails, Stephen Mather Wilderness (2006, 2019). Impact risk determined either from NatureServe or professional judgement from local botanists.

Trail	Common Name	Species Name	Percent Cover/Area Surveyed	Invasive Species Impact Risk [a]	Professional Judgement
7. Copper Ridge	Perennial bluegrass	*Poa pratensis*	<1%	2	–
	Curly dock	*Rumex crispus*	<1%	1	–
	Red clover	*Trifolium pratense*	<1%	1	–
8. Brush Creek-Stillwell CG	Wall lettuce	*Mycelis muralis*	–	–	1
	English plantain	*Plantago lanceolata*	<1%	2	–
	Common plantain	*Plantago major*	<1%	–	1
	Annual bluegrass	*Poa annua*	<1%	1	–
	Perennial bluegrass	*Poa pratensis*	–	2	–
	Sheep sorrel	*Rumex acetosella*	–	2	–
	Dandelion	*Taraxacum officinale*	–	–	1
	Red clover	*Trifolium pratense*	<1%	1	–
9. Easy Pass-Fisher Creek-Thunder Crk-Colonial CG	Hair grass	*Aira caryophylla*	<1%	1	–
	Knapweed	*Centaurea* sp.	<1%	3	–
	Sticky chickweed	*Cerastium glomeratum*	<1%	–	1
	Prickly lettuce	*Lactuca serriola*	<1%	1	–
	English plantain	*Plantago lanceolata*	<1%	2	–
	Common plantain	*Plantago major*	<1%	–	1
	Annual bluegrass	*Poa annua*	<1%	1	–
	Compressed bluegrass	*Poa compressa*	<1%	2	–
	Perennial bluegrass	*Poa pratensis*	<1%	2	–
	Self heal	*Prunella vulgaris*	–	–	1
	Creeping buttercup	*Ranunculus repens*	<1%	3	–
	Sheep sorrel	*Rumex acetosella*	<1%	2	–
	Common chickweed	*Stellaria media*	<1%	1	–
	Common tansy	*Tanacetum vulgare*	<1%	1	–
	Red clover	*Trifolium pratense*	<1%	1	–
	White clover	*Trifolium repens*	<1%	2	–
	Speedwell	*Veronica* sp.	<1%	–	1
10. Park Creek-Fisher Creek Jct, including Meadow Cabin spur tail	Wall lettuce	*Mycelis muralis*	<1%	–	1
	English plantain	*Plantago lanceolata*	<1%	2	–
	Annual bluegrass	*Poa annua*	<1%	1	–
	Perennial bluegrass	*Poa pratensis*	<1%	2	–

[a] low=1, 2=medium, 3=high

Table 26 (continued). Non-native plant species along major wilderness trails, Stephen Mather Wilderness (2006, 2019). Impact risk determined either from NatureServe or professional judgement from local botanists.

Trail	Common Name	Species Name	Percent Cover/Area Surveyed	Invasive Species Impact Risk [a]	Professional Judgement
10. Park Creek-Fisher Creek Jct, including Meadow Cabin spur tail (continued)	Creeping buttercup	*Ranunculus repens*	<1%	3	–
	Sheep sorrel	*Rumex acetosella*	<1%	2	–
	Common chickweed	*Stellaria media*	<1%	1	–
	Red clover	*Trifolium pratense*	<1%	1	–
	White clover	*Trifolium repens*	<1%	2	–
	Speedwell	*Veronica* sp.	<1%	–	1
	Vicia	*Vicia* sp.	<1%	–	1
11. Bridge Creek	Red top	*Agrostis alba*	<1%	2	–
	Orchard grass	*Dactylis glomerata*	<1%	–	2
	Wall lettuce	*Mycelis muralis*	<1%	–	1
	Timothy	*Phleum pratense*	<1%	2	–
	English plantain	*Plantago lanceolata*	<1%	2	–
	Common plantain	*Plantago major*	<1%	–	1
	Annual bluegrass	*Poa annua*	1–25%	1	–
	Bulbous bluegrass	*Poa bulbosa*	<1%	–	3
	Canada bluegrass	*Poa compressa*	–	2	–
	Perennial bluegrass	*Poa pratensis*	<1%	2	–
	Sheep sorrel	*Rumex acetosella*	<1%	2	–
	Sand spurrey	*Spergularia rubra*	<1%	–	1
	Dandelion	*Taraxacum officinale*	–	–	1
	White clover	*Trifolium repens*	<1%	2	–
	Speedwell	*Veronica* sp.	<1%	–	1
12. Rainbow Creek-McAlester Pass	Cheatgrass	*Bromus tectorum*	–	3	–
	Canada thistle	*Cirsium arvense*	–	3	–
	Bull thistle	*Cirsium vulgare*	–	2	–
	Scotch Broom	*Cystisus scoparius*	–	2	–
	Orchard grass	*Dactylis glomerata*	–	–	2
	St. John's wort	*Hypericum perforatum*	–	3	–
	Prickly lettuce	*Lactuca serriola*	–	1	–
	Wall lettuce	*Mycelis muralis*	–	–	1
	English plantain	*Plantago lanceolata*	–	2	–
	Bulbous bluegrass	*Poa bulbosa*	–	–	3
	Sheep sorrel	*Rumex acetosella*	–	2	–

[a] low=1, 2=medium, 3=high

Table 26 (continued). Non-native plant species along major wilderness trails, Stephen Mather Wilderness (2006, 2019). Impact risk determined either from NatureServe or professional judgement from local botanists.

Trail	Common Name	Species Name	Percent Cover/Area Surveyed	Invasive Species Impact Risk [a]	Professional Judgement
12. Rainbow Creek-McAlester Pass (continued)	Dandelion	*Taraxacum officinale*	–	–	1
	Salsify	*Tragopogon dubius*	–	2	–
	Red clover	*Trifolium pratense*	–	1	–
	White clover	*Trifolium repens*	–	2	–
13. Boulder Creek-War Creek Pass	Cheatgrass	*Bromus tectorum*	–	3	–
	Canada thistle	*Cirsium arvense*	–	3	–
	Orchard grass	*Dactylis glomerata*	–	–	2
	Prickly lettuce	*Lactuca serriola*	–	1	–
	Wall lettuce	*Mycelis muralis*	–	–	1
	Common plantain	*Plantago major*	–	–	1
	Bulbous bluegrass	*Poa bulbosa*	–	–	3
	Sheep sorrel	*Rumex acetosella*	–	2	–
	Dandelion	*Taraxacum officinale*	–	–	1
	Salsify	*Tragopogon dubius*	–	2	–
	Red clover	*Trifolium pratense*	–	1	–
	White clover	*Trifolium repens*	–	2	–
14. McGregor Mtn	Cheatgrass	*Bromus tectorum*	–	3	–
	Orchard grass	*Dactylis glomerata*	–	–	2
	Wall lettuce	*Mycelis muralis*	–	–	1
	Bulbous bulbosa	*Poa bulbosa*	–	–	3
	Sheep sorrel	*Rumex acetosella*	–	2	–
	Red clover	*Trifolium pratense*	–	1	–
	White clover	*Trifolium repens*	–	2	–
15. Purple Creek-War Creek Pass	Cheatgrass	*Bromus tectorum*	–	3	–
	Orchard grass	*Dactylis glomerata*	–	–	2
	Wall lettuce	*Mycelis muralis*	–	–	1
	Bulbous bluegrass	*Poa bulbosa*	–	–	3
	Salsify	*Tragopogon dubius*	–	2	–
	Red clover	*Trifolium pratense*	–	1	–
	White clover	*Trifolium repens*	–	2	–
16. Fireweed Camp – McAlester Lake to South Pass	Orchard grass	*Dactylis glomerata*	<1%	–	2
	English plantain	*Plantago lanceolata*	<1%	2	–
	Common plantain	*Plantago major*	<1%	–	1

[a] low=1, 2=medium, 3=high

Table 26 (continued). Non-native plant species along major wilderness trails, Stephen Mather Wilderness (2006, 2019). Impact risk determined either from NatureServe or professional judgement from local botanists.

Trail	Common Name	Species Name	Percent Cover/Area Surveyed	Invasive Species Impact Risk [a]	Professional Judgement
16. Fireweed Camp – McAlester Lake to South Pass (continued)	Annual bluegrass	*Poa annua*	1–25%	1	–
	Perennial bluegrass	*Poa pratensis*	<1%	2	–
	Sheep sorrel	*Rumex acetosella*	<1%	2	–
	Sand spurrey	*Spergularia rubra*	<1%	–	1
	White clover	*Trifolium repens*	1–25%	2	–

[a] low=1, 2=medium, 3=high

Appendix B. Revised Protocol Text for Measure 2-7, Visibility

Measure 2-7: Visibility

Natural Quality ~ Air and Water

Measure Definition

This measure is intended to track over time changes in visibility conditions in the Wilderness. Particles in the atmosphere—from both natural and human-caused sources (e.g., wildfire smoke, power plants)—scatter and absorb light, creating a haze that limits how far and how well we can see. Unfortunately, the clarity of Park views is affected by human-caused pollution in virtually all national parks, including wilderness areas, across the country.

This measure tracks haze on most impaired days expressed using a haze index in deciviews. Most impaired days are the 20% of sampled days in a given year where measured visibility has the highest contribution from anthropogenic pollution relative to natural conditions. Annual haze index measures are averaged over a 5-year period for monitoring sites with at least 3-years of complete annual data. This measured 5-year average is used for Class I parks and additional parks with in-park visibility monitors, including North Cascades NP.

Data Sources

NPS Air Resources Division reports 5-year visibility averages for park units on an annual basis. Note that due to quality assurance and data analysis procedures, there is usually a 1-year lag time between the current year and the most recent available 5-year average value. To get data values:

- Go to the NPS Explore Air Data Website. (site expected to be available in 2021)
- Select "Visibility" from the Parameter drop-down.
- Select 5-year averages and open the selection pane.
- Choose "Park" for scope and select "North Cascades National Park" from the drop-down.
- Choose the latest available end-year and export the data set in a convenient format.
- Report the value from the DV_IMP_5YA column.

The measured 2011–2015 5-year average haze index on most impaired days is 10.6 dv at North Cascade NP. The Clean Air Act sets a goal of eliminating human-caused visibility impairment by 2064 from Class I areas, which includes the Stephen Mather Wilderness. Fifteen-year averages (2000–2014) of the natural haze levels on the most impaired days are used to derive 2064 goal estimates. At North Cascades NP, the estimated 2064 goal value is 6.9 dv. The recorded 2015 baseline value (10.6 dv) for wilderness character is 3.7 dv above the estimated 2064 goal. A difference of more than 1 dv above the 2064 goal is a concern for the National Park Service.

Note: in these reports, air quality values are listed for all three units of the North Cascades National Park Service Complex. For the purpose of this measure, the data value for North Cascades National Park (referred to in the reports as "North Cascades NP") will be used.

Data Adequacy

Data quality is based on the availability of a representative air quality monitor in or near a NPS unit. All estimated 5-year average values have moderate (score=2) data quality unless there is a representative monitor within 150 kilometers of park boundaries and within +/− 100 feet or 10% of maximum and minimum park elevation. Units with a measured 5-year average or a representative monitor have high (score=3) data quality. Data quantity is complete (score=3) for available estimated or measured 5-year average values because they are derived from visibility data that meet required completeness criteria of the NPS Air Resources Division.

There are no IMPROVE stations in the Stephen Mather Wilderness, but there is one station located at a non-wilderness site in the Ross Lake National Recreation Area that is less than one mile from the Wilderness boundary.

The NPS Air Quality Division considers data quality to be “high” (score=3) and data quantity as “complete” (score=3) given the in-Park location of the monitoring station. Data adequacy is high (score=6) because data quantity is complete and data quality is high.

Data Frequency

For the purpose of wilderness character monitoring, a measure value will be reported for the 2015 baseline year and for every fifth subsequent calendar year. The raw data used to calculate the measure value might be collected on a different schedule or schedules.

Trend Assessment

Any change of one deciview or more in either direction from the baseline data value (10.6 dv) is considered significant. This threshold was developed by the NPS Air Resources Division.

At the end of each five-year wilderness character monitoring cycle, a trend in wilderness character (upward, downward, or stable) will be reported for this measure. This trend will be determined in the following way: The raw measure values for the current assessment year (2020, 2025, etc.) and the 2015 baseline year will be compared. An upward trend in wilderness character will be reported for this measure if there is a net decrease of one deciview between 2015 and the current assessment year. A downward trend in wilderness character will be reported if there is a net increase of one deciview between 2015 and the current assessment year. A stable trend in wilderness character will be reported if there is less than one deciview change (positive or negative) between 2015 and the current assessment year.

Compiled Data

Table 27 records the most recently available measure value as of December 31, 2015.

Table 27. Most recently available visibility data in 2015.

Data Year	Averaging Period	Visibility (dv)
2015	2011–2015	10.6

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.

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