National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Booker T. Washington National Monument

Natural Resource Condition Assessment

Natural Resource Report NPS/BOWA/NRR—2017/1558

ON THE COVER
View of Booker T. Washington National Monument.
Photo courtesy of Todd Lookingbill

Booker T. Washington National Monument

Natural Resource Condition Assessment

Natural Resource Report NPS/BOWA/NRR—2017/1558

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Contents

Page

Figures....vii

Tables....xi

Appendices....xiii

Executive Summary....xv

Background and Context....xv

Approach....xvi

Current Condition of Natural Resources....xviii

Air quality....xx

Water quality....xx

Biological integrity....xxi

Landscape dynamics....xxi

Acknowledgments....xxiii

List of Acronyms....xxv

Chapter 1. NRCA Background Information....1

Chapter 2. Introduction and Resource Setting....5

2.1 History and Enabling Legislation....5

2.1.1 Geographical Setting....7

2.1.2 Visitation Statistics....9

2.2 Natural Resources....10

2.2.1 Watershed Context....10

2.2.2 General Resource Features....11

2.2.3 Resource Issues Overview....18

2.3 Resource Stewardship....23

2.3.1 Management Directives and Planning....23

2.3.2 Status of Supporting Science....26

Chapter 3. Study Scoping and Design....29

Contents (continued)

Page

3.1 Preliminary Scoping ... 29

3.2 Study Design ... 29

3.2.1 Indicator Framework, Focal Study Resources, and Indicators ... 29

3.2.2 Reporting Areas ... 30

3.2.3 General Approach and Methods ... 31

Chapter 4. Natural Resource Conditions ... 33

4.1 Air Quality ... 33

4.1.1 Ozone ... 33

4.1.2 Wet Nitrogen Deposition ... 35

4.1.3 Wet Sulfur Deposition ... 38

4.1.4 Visibility ... 40

4.1.5 Mercury Deposition ... 43

4.2 Water Quality ... 44

4.2.1 Dissolved Oxygen ... 44

4.2.2 Water Temperature ... 46

4.2.3 Water pH ... 48

4.2.4 Nitrate ... 49

4.2.5 Macroinvertebrates ... 51

4.3 Biological Integrity ... 54

4.3.1 Birds ... 54

4.3.2 Fish ... 61

4.3.3 Mammals and Herpetiles ... 65

4.3.4 Forest Regeneration ... 70

4.3.5 Invasive Plant Species ... 74

4.4 Landscape Dynamics ... 76

4.4.1 Forest Landcover ... 76

Contents (continued)

Page

4.4.2 Riparian Buffer ... 80

4.4.3 Impervious Surface ... 83

4.4.4 Grassland Patches ... 86

Chapter 5. Discussion ... 89

5.1 Booker T. Washington National Monument Context for Assessment ... 89

5.2 Park Natural Resource Condition ... 89

5.2.1 Air Quality ... 89

5.2.2 Water Quality ... 90

5.2.3 Biological Integrity ... 91

5.2.4 Landscape Dynamics ... 92

5.3 Overall Park Condition ... 93

Chapter 6. Literature Cited ... 95

Figures

Page

Figure 2.1. Protected Areas within 30km of BOWA (WDPA 2011). 8

Figure 2.2. Roanoke River watershed (NHD 2016). 11

Figure 2.3. Bedrock geology for BOWA (SSURGO 2016). 12

Figure 2.4. Topography for BOWA (NED 2016). 13

Figure 2.5. Soil associations for BOWA (Van Lear 2009). 14

Figure 2.6. Surface waters of BOWA (NHD 2016). 16

Figure 2.7. Vegetation of BOWA (Patterson 2008). 17

Figure 2.8. Housing density within 3km buffer of BOWA from 1970-2010 (NPScape 2011). 20

Figure 2.9. Comparison of 2010 housing density for 3km and 30km buffers around BOWA (NPScape 2011). 20

Figure 2.10. Housing density within 30km buffer of BOWA from 1970-2010 (NPScape 2011). 21

Figure 2.11. Comparison of housing density within 30km buffer of BOWA from 1970 and 2010 (NPScape 2011). 21

Figure 2.12. Viewshed from the historic core (NLCD 2011). 25

Figure 3.1. Vital signs and indicators framework. 30

Figure 3.2. NPS Natural Resource Condition standard symbology. 32

Figure 4.1. National patterns of ozone concentrations, average annual 4th highest daily maximum 8-hour ozone concentrations in ppb, 1999-2008 (NPS ARD 2010a). 33

Figure 4.2. Five-year average values of annual 4th highest 8-hour concentration for BOWA (NPS ARD n.d.; 2011a, b, c, d; NPS ARD 2012a, b; NPS ARD 2014; NPS ARD 2017a, b). 35

Figure 4.3. Five-year average values in total nitrogen wet deposition (kg/ha/yr) for BOWA (NPS ARD 2011f, g, h, i, j; 2012e, f; 2014a, b; 2017c, d). 37

Figure 4.4. Total nitrogen deposition estimates for the MIDN (Sullivan et al. 2011a). 38

Figure 4.5. Five year average values of total sulfur wet deposition (kg/ha/yr) for BOWA (NPS ARD 2010b; 2011e, 2012e, f, 2014a, b; 2017e, f). 40

Figures (continued)

Page

Figure 4.6. National patterns in haziest day haze index (dv) for the United States, 1999-2008 (NPS ARD 2010a). 41

Figure 4.7. Five-year average values of haze index (dv) for BOWA (NPS 2011k, n, o; 2012c, d; 2014c; 2017g, h). 42

Figure 4.8. Mercury deposition in BOWA (NADP MDN 2014). 44

Figure 4.9. Map of water quality monitoring sites in BOWA (Dammeyer and Weed 2017). 45

Figure 4.10. Monthly DO levels at sampling sites in BOWA (MIDN I&M Program). 46

Figure 4.11. Monthly water temperature at sampling sites in BOWA (MIDN I&M Program). 48

Figure 4.12. Monthly stream pH values at sample sites within BOWA (MIDN I&M Program). 49

Figure 4.13. Monthly nitrate concentrations from sampling sites in BOWA (MIDN I&M Program). 51

Figure 4.14. Virginia Stream Condition Index (VSCI) scores in BOWA (MIDN I&M Program). 53

Figure 4.15. Non-insect benthic macroinvertebrates in Jack-O-Lantern Branch (Save our Streams Monitoring Program). 53

Figure 4.16. Non-insect benthic macroinvertebrates in Gills Creek (Save our Streams Monitoring Program). 54

Figure 4.17. Bird survey points in BOWA (Johnson 2014a). 58

Figure 4.18. Chub sampling sites (points) and fish sampling transects (lines) in BOWA (Atkinson 2008). 63

Figure 4.19. Chub nest observations in BOWA from volunteer nest monitoring (Kelso 2014b). 65

Figure 4.20. Mammal sampling locations in BOWA (Pagels et al. 2005). 67

Figure 4.21. Amphibian and reptile sampling locations in BOWA (Mitchell 2006). 68

Figure 4.22. I&M forest vegetation monitoring plots in BOWA (Comiskey et al. 2009). 71

Figure 4.23. Weighted seedling density for BOWA forest monitoring plots (MIDN I&M Program). 73

Figures (continued)

Page

Figure 4.24. Foliar damage percentages for BOWA forest monitoring plots (MIDN I&M Program). ... 73

Figure 4.25. Deer browse percentages for BOWA forest monitoring plots (MIDN I&M Program). ... 74

Figure 4.26. Land cover for BOWA (NLCD 2011). ... 78

Figure 4.27. Trends in forest landcover for BOWA and surrounding region: 1-km buffer, 15-km buffer, and 30-km buffer (NLCD 2001, 2006, 2011). ... 79

Figure 4.28. Land cover for 30-km buffer surrounding BOWA (NLCD 2011). ... 80

Figure 4.29. Forested and non-forested riparian areas around streams of BOWA (NLCD 2011). ... 82

Figure 4.30. Percent of riparian zone that was forested (NLCD 2001, 2006, 2011). ... 83

Figure 4.31. Impervious surface cover for the park and surrounding HUC10 watershed (NLCD 2011). ... 84

Figure 4.32. Impervious surface coverage trends for BOWA, HUC10, and HUC12 watersheds (NLCD 2001, 2006, 2011). ... 85

Figure 4.33. Large patches of grassland located in BOWA with area of patch provided in acres (NLCD 2011). ... 88

Tables

Page

Table E.1. Summary results of the assessment by indicator. xviii

Table E.2. Key findings and recommendations for air quality in BOWA. xx

Table E.3. Key findings and recommendations for water quality in BOWA. xxi

Table E.4. Key findings and recommendations for biological integrity in BOWA. xxi

Table E.5. Key findings and recommendations for landscape dynamics in BOWA. xxii

Table 2.1. Percent cover of vegetation classes in BOWA (Patterson 2008). 16

Table 2.2. Inventories conducted at BOWA. 27

Table 2.3. Monitoring programs at BOWA. 27

Table 3.1. Summary of indicators and metrics evaluated for BOWA. 31

Table 4.1. Species at risk of foliar injury from ozone in BOWA (NPS Ozone Injury Assessment 2004). 34

Table 4.2. Birds of conservation concern observed in BOWA (NPS 2009, Johnson 2014a,b). 56

Table 4.3. BCI scores for BOWA (Johnson 2014a,b). 60

Table 4.4. Abundance of bluehead and creek chub in BOWA from NPS fish inventory (Atkinson 2008). 64

Table 4.5. Mammal and herpetofauna attainment scores and condition summary. 69

Table 4.6. Seedling height class categories and associated weighted score to estimate stocking index (McWilliams et al. 2005). 72

Table 4.7. Number of exotic invasive indicator plant species observed in BOWA forest monitoring plots (MIDN I&M Program). 76

Table 5.1. Summary of air quality indicators and threshold attainment for BOWA. 90

Table 5.2. Key findings and recommendations for air quality in BOWA. 90

Table 5.3. Summary of water quality indicators including threshold attainment for BOWA. 90

Table 5.4. Key findings and recommendations for water quality in BOWA. 91

Table 5.5. Summary of biological integrity indicators including threshold attainment for BOWA. 91

Tables (continued)

Page

Table 5.6. Key findings and recommendations for biological integrity in BOWA. 92

Table 5.7. Summary of landscape dynamic indicators including threshold attainment for BOWA. 92

Table 5.8. Key findings and recommendations for landscape dynamics in BOWA. 93

Table 5.9. Summary of park vital signs including attainment average of indicators for BOWA. 93

Appendices

Page

Appendix A: List of butterfly species found at BOWA 113

Appendix B: List of bird species found at BOWA 115

Appendix C: List of fish species found at BOWA 119

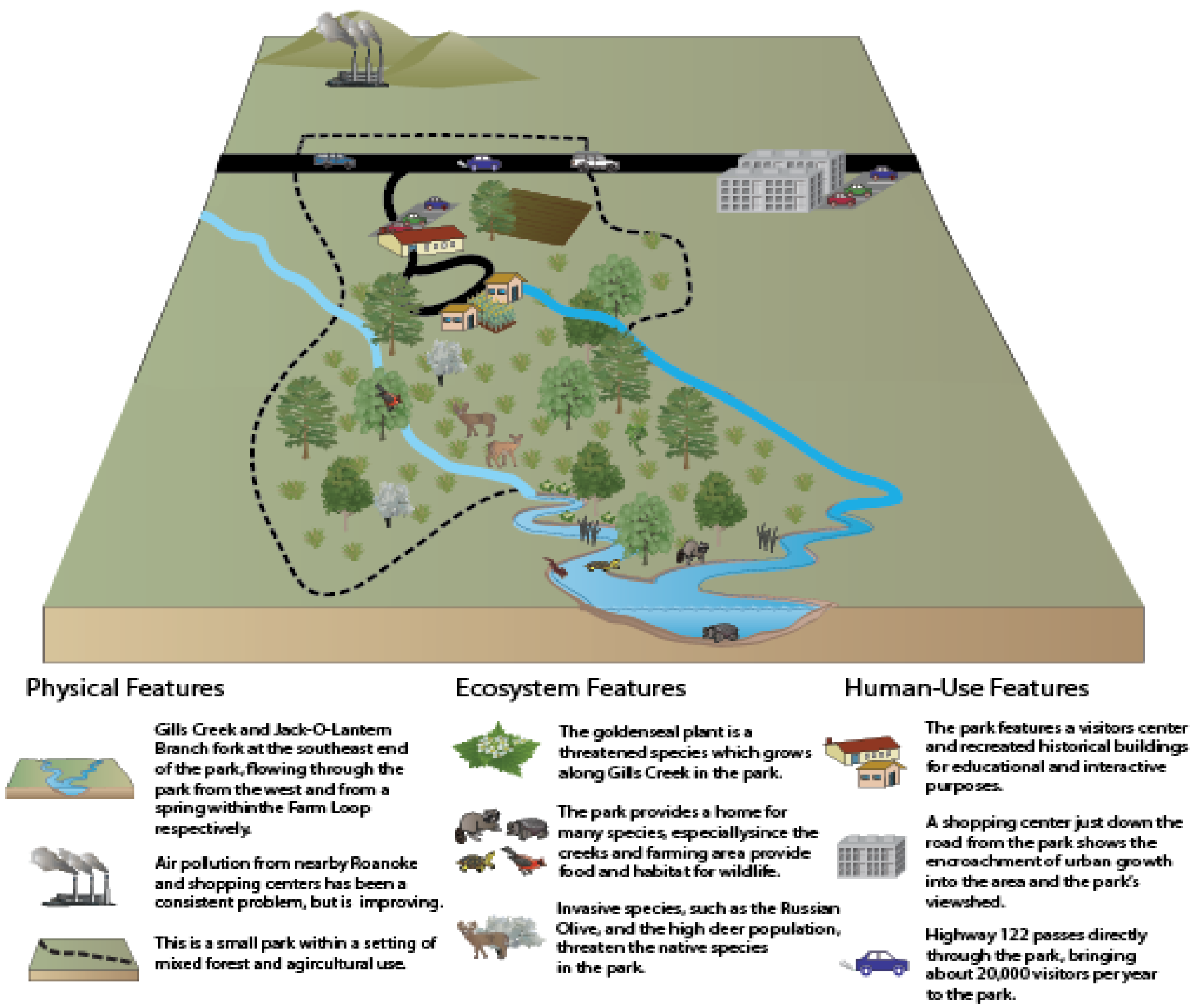
Appendix D: List of mammal species found at BOWA 121

Appendix E: List of herpetile species found at BOWA 123

Executive Summary

Background and Context

Natural Resource Condition Assessments (NRCAs) are reports formulated to assess and record park resource conditions, as an accompaniment to more targeted threat-based assessments. NRCAs report on the current and trending conditions, data gaps, and confidence levels for selected park natural resource indicators. The report can be used by park managers to address park priorities, identify data needs for resources, and further communicate park resource conditions to wider audiences. The goal of the report is to provide information based on scientific data and analysis, which can then be used in park planning and partnerships.



Conceptual diagram of key characteristics of BOWA.

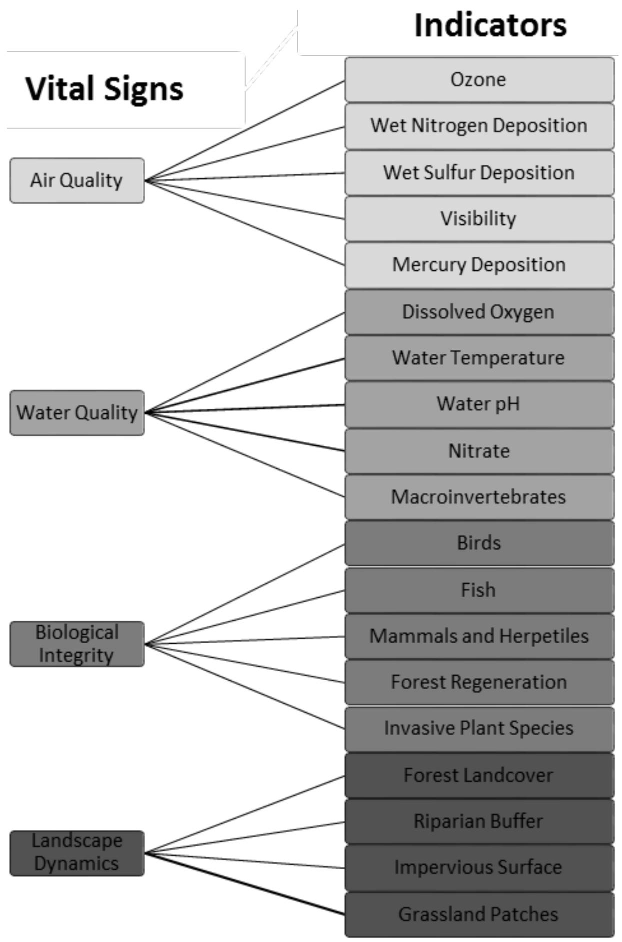
Booker T. Washington National Monument (BOWA) memorializes the birthplace of one of America's most influential African Americans, Booker T. Washington. The site was established as a National Monument by Congress in 1956. Today, BOWA is a 239-acre park that contains many interpretive replicas of buildings and farm installations, as well as a visitor's center and an old school building. The park is located within the Piedmont physiographic region of Virginia, and is situated within the Roanoke River and Albemarle-Pamlico Sound watersheds. Both of these watersheds cover portions of Virginia and North Carolina. Threats to the park's natural resources are found inside the park (e.g., invasive species, erosion), outside the park boundaries (e.g., water contamination), and throughout the greater region (e.g., air pollution).

Approach

Data were assembled from multiple divisions within the National Park Service (NPS) including BOWA park staff, the Air Resources Division (ARD), and the Inventory and Monitoring (I&M) Program. Additional data were collected by volunteers, state agencies, and academic researchers. Condition scores were calculated for the entirety of the park, utilizing the broad spectrum of data available from all sources.

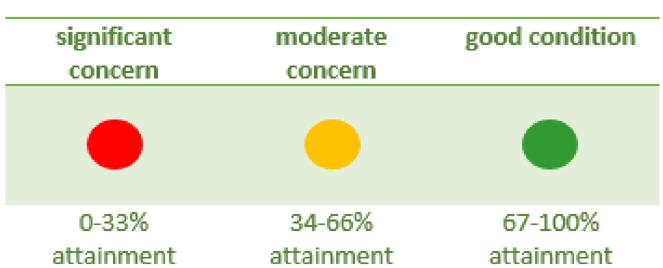
Collaboration with park staff was integral to the success of the collection and analysis of the data. An initial scoping meeting, site visits, and follow-up meetings allowed for a continual exchange of data and background information. These meetings helped identify the natural resources that were to be included as indicators, assign metrics for assessment, and provide context on factors impacting natural resources within the park.

Efforts were made to integrate NPS I&M ecological monitoring metrics associated with the following 'Vital Signs' into the assessment: Air Quality, Water Quality, Biotic Integrity, and Landscape Dynamics. A total of 19 indicators were analyzed in this report. Assessing resource condition within BOWA required setting a reference or threshold level for each metric. These thresholds were derived from scientific literature, where possible. However, when information was not available to support peer-reviewed ecological thresholds, regulatory and management-based thresholds were used.



Indicators and organizational framework used in assessing BOWA.

A metric attainment score of 100% indicated that the metric met the threshold identified to maintain the resource in all instances. Once all the attainment scores were calculated, an unweighted mean was calculated to assess the condition of each Vital Sign category for the park as a whole. The quantitative score corresponded to a qualitative rating: Significant Concern (0-33%), Moderate Concern (34-66%), and Good (67-100%). Scores were color-coded according to standard NPS NRCA symbology: red (Significant Concern), yellow (Moderate Concern), and green (Good Condition).



Scoring criteria used for condition assessment.

Current Condition of Natural Resources

Overall, the natural resources of BOWA were found to warrant **moderate concern**, reaching 64% of desired thresholds (Table E.1).

Table E.1. Summary results of the assessment by indicator.

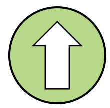
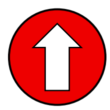
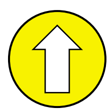
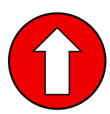
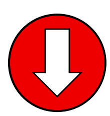
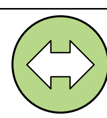
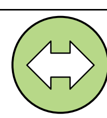
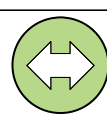
Priority Resource or Value	Indicator of Concern	Specific Measure	Condition Status/ Trend	Resource Condition	Threshold & Source	Attainment
Air Quality	Ozone	Ozone Concentration		63.7 ppb	<60 ppb good condition, 60-75 ppb moderate, >75 ppb significant concern (NPS ARD standards).	75% attainment
Air Quality	Wet Nitrogen Deposition	Precipitation Concentration		3.2 kg/ha/yr	<1 kg/ha/yr good condition, 1-3 kg/ha/yr moderate, >3 kg/ha/yr significant concern (NPS ARD standards).	0% attainment
Air Quality	Wet Sulfur Deposition	Precipitation Concentration		2.1 kg/ha/yr	<1 kg/ha/yr good condition, 1-3 kg/ha/yr moderate, >3 kg/ha/yr significant concern (NPS ARD standards).	45% attainment
Air Quality	Visibility	Haze Index Score		8.6 dv	<2 dv good condition, 2-8 dv moderate, >8 dv significant concern (NPS ARD standards).	0% attainment
Air Quality	Mercury Deposition	Mercury Concentration		5.3 ng/L	<2 ng/L in rainwater good condition (U.S. EPA).	0% attainment
Water Quality	Dissolved Oxygen	Dissolved Oxygen (DO) Concentration		10.8 mg/L	>5.0 mg/L good condition (VADEQ 2010)	100% attainment
Water Quality	Water Temperature	Temperature (ºC)		11.2°C	≤31°C good condition (VADEQ 2010)	100% attainment
Water Quality	Water pH	pH		7.3	pH range of 6.0-9.0 good condition (VADEQ 2010)	100% attainment

Table E.1 (continued). Summary results of the assessment by indicator.

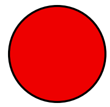
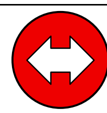
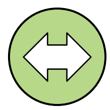
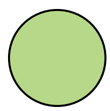
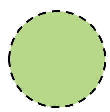
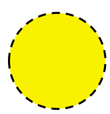
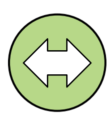
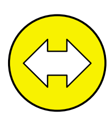
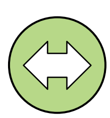
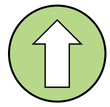
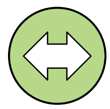
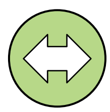
Priority Resource or Value	Indicator of Concern	Specific Measure	Condition Status/ Trend	Resource Condition	Threshold & Source	Attainment
Water Quality	Nitrate	Nitrate (NO_3) Concentration		7 of 24 samples < 1.0 mg/L (mean = 1.5 mg/L)	≤1 mg/L good condition (Wazniak et al. 2004)	29% attainment
Water Quality	Macro-invertebrates	Virginia Stream Condition Index (VSCI)		52.5	>60 good condition (Burton and Gerritsen 2003)	0% attainment
Biological Integrity	Birds	Bird Community Index (BCI) Score		0.81	BCI score (O'Connell et al. 2003)	81% attainment
Biological Integrity	Fish	Fish Density		3.95 fish/m^2	≥2.24 fish/m^2 good condition, 2.24-0.88 fish/m^2 moderate concern, <0.88 fish/m^2 significant concern (Southerland et al. 2007).	100% attainment
Biological Integrity	Mammals	Species Counts/ Richness		26 species detected	39 mammal species expected to occur (Pagels et al. 20005)	67% attainment
Biological Integrity	Amphibians & Reptiles	Species Counts/ Richness		18 species detected	46 herpetile species expected to occur (Mitchell 2006)	39% attainment
Biological Integrity	Forest Regeneration	Weighted Seedling Density		6 of 8 plots had greater than 2 seedlings/m^2	>2 seedlings/m^2 significant concern (Comiskey and Wakamiya 2011)	75% attainment
Biological Integrity	Invasive Plant Species	Indicator Species		5 of 8 plots had fewer than 2 indicator species	<2 indicator species per plot (Tierney et al. 2016)	62.5% attainment
Landscape Dynamics	Forest Land Cover	% Forest Cover		65%	>59% good condition, 59-30% moderate, <30% significant concern (Turner et al. 2001).	100% attainment

Table E.1 (continued). Summary results of the assessment by indicator.

Priority Resource or Value	Indicator of Concern	Specific Measure	Condition Status/ Trend	Resource Condition	Threshold & Source	Attainment
Landscape Dynamics	Riparian Buffers	% Forested Buffer Cover		82%	70% forest cover in 100-m riparian buffers (Sprague et al. 2006).	100% attainment
Landscape Dynamics	Impervious Surface	% of Impervious Surface Cover		0.4%	< 2% impervious cover good condtion; 2-10% moderate condition; >10% poor condtion (Arnold and Gibbons 1996; Lussier et al. 2008).	100% attainment
Landscape Dynamics	Grassland Patches	Area of Continuous Grassland Patches		One patch greater than 10ha	At least one patch ≥ 40ha optimal condition, ≥ 10ha good condition, ≥ 5ha fair condition (Watts 2000; Peterjohn 2006).	70% attainment

Air quality

Air quality was the most degraded resource, warranting **significant concern**. Air quality is largely the product of regional factors, meaning the park has limited control over trends. However, increased educational efforts within the park could raise awareness, and air quality is trending towards improvement (Table E.2).

Table E.2. Key findings and recommendations for air quality in BOWA.

Key Findings	Recommendations
• Regional degradation of air quality • Improving conditions for many indicators	• Spread awareness throughout the region • Educate the public on the causes and effects of air pollution

Water quality

Water quality was assessed to be in **moderate condition**, with nitrate and macroinvertebrates being potential areas of concern. Elevated nitrate levels indicate the potential for eutrophication in aquatic ecosystems (Table E.3). However, both of these indicators were near desired threshold conditions, and small changes in condition would improve these scores significantly. It is notable that macroinvertebrate condition was of concern but the physical measures of stream condition were not, indicating some source of degradation not captured in the assessment.

Table E.3. Key findings and recommendations for water quality in BOWA.

Key Findings	Recommendations
• Water temperature, pH and DO in generally good condition • High nitrate (NO_3) concentrations • Macroinvertebrate indicator values are near desired threshold levels	• Take steps to decrease the potential for eutrophication • Prevent cows from entering Jack-O-Lantern Branch • Continue and increase monitoring of macroinvertebrates as an integrative measure of stream quality with special attention on species that have not yet been documented in the park

Biological integrity

Biological integrity was assessed to be in **good condition**. Invasive species constitute a potential future threat to biological integrity, while lack of data made calculating a trend difficult for most of the indicators (Table E.4). Continued monitoring and inventory would greatly improve efforts to identify trends in these resources.

Table E.4. Key findings and recommendations for biological integrity in BOWA.

Key findings	Recommendations
• Presence of invasive plant species, but at lower densities than some of the other parks in the region • Minimal data to assess mammals, herpetofauna, and fish • Minimal data on vegetation pests • Relatively healthy fish population includes several species endemic to the Roanoke River Basin	• Continue and increase treatment of known invasive species problems such as Japanese stiltgrass; increase monitoring of treatment effectiveness • Increase monitoring and survey efforts for herpetofauna • Monitor white-tailed deer densities, which are a regional problem • Coordinate with other parks to prepare for hemlock woolly adelgid and emerald ash borer

Landscape dynamics

Landscape dynamics were also assessed to be in **good condition**, with either improving or stable trends (Table E.5). In general, more spatially detailed and longer-time series of data is needed to fully understand the trends in many of the indicators.

Table E.5. Key findings and recommendations for landscape dynamics in BOWA.

Key Findings	Recommendations
• Large grassland patches are supportive of grassland bird community • As a small park, external development has the potential to impact park natural resources • While impervious surfaces, riparian buffers, and forest cover within the park are stable and in good condition, these indicators are near thresholds of concern and the park's immediate surrounding areas show a trend toward increased urban development • Park likely suffers from light and sound pollution but currently no data are available to assess	• Consider connectivity of forest resources when conducting any management activities that would result in the loss of forest cover in the park • Work with neighbors to minimize impacts of future development outside of park's borders • Preserve healthy riparian forest buffers inside park and along its boundary • Continue to practice mowing techniques that will protect the integrity of large grassland patches • Gather data on night skies and soundscapes

Acknowledgments

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List of Acronyms

ARD	Air Resources Division
BCI	Bird Community Index
BOWA	Booker T. Washington National Monument
DO	Dissolved Oxygen
GIS	Geographic Information System
GRTS	Generalized Random-Tessellation Stratified sampling strategy
HUC	Hydrologic Unit Code
I&M	Inventory and Monitoring Program
IMPROVE	Interagency Monitoring of Protected Visual Environments
MDN	Mercury Deposition Network
MIDN	Mid-Atlantic Network
NADP	National Atmospheric Deposition Program
NLCD	National Land Cover Dataset
NPS	National Park Service
NRCA	Natural Resource Condition Assessment
NTN	National Trends Network
PIF	Partners in Flight
VSCI	Virginia Stream Condition Index
WHO	World Health Organization

Chapter 1. NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter "parks." NRCAs also report on trends in resource condition (when possible), identify critical data gaps, and characterize a general level of confidence for study findings. The resources and indicators emphasized in a given project depend on the park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators, and availability of data and expertise to assess current conditions for a variety of potential study resources and indicators.

NRCAs Strive to Provide…

- *Credible condition reporting for a subset of important park natural resources and indicators*
- *Useful condition summaries by broader resource categories or topics, and by park areas*

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement—not replace—traditional issue-and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- Are multi-disciplinary in scope;[1]
- Employ hierarchical indicator frameworks;[2]
- Identify or develop reference conditions/values for comparison against current conditions;[3]
- Emphasize spatial evaluation of conditions and GIS (map) products; [4]
- Summarize key findings by park areas; and [5]
- Follow national NRCA guidelines and standards for study design and reporting products.

Although the primary objective of NRCAs is to report on current conditions relative to logical forms of reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as well as influences on resource conditions. These influences may include past activities or conditions that provide a helpful context for

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[1] The breadth of natural resources and number/type of indicators evaluated will vary by park.

[2] Frameworks help guide a multi-disciplinary selection of indicators and subsequent "roll up" and reporting of data for measures ⇨ conditions for indicators ⇨ condition summaries by broader topics and park areas

[3] NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-up response (e.g., ecological thresholds or management "triggers").

[4] As possible and appropriate, NRCAs describe condition gradients or differences across a park for important natural resources and study indicators through a set of GIS coverages and map products.

[5] In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested.

understanding current conditions, and/or present-day threats and stressors that are best interpreted at park, watershed, or landscape scales (though NRCAs do not report on condition status for land areas and natural resources beyond park boundaries). Intensive cause-and-effect analyses of threats and stressors, and development of detailed treatment options, are outside the scope of NRCAs.
Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in existing data and knowledge bases across the varied study components.

The credibility of NRCA results is derived from the data, methods, and reference values used in the project work, which are designed to be appropriate for the stated purpose of the project, as well as adequately documented. For each study indicator for which current condition or trend is reported, we will identify critical data gaps and describe the level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject-matter experts at critical points during the project timeline is also important. These staff will be asked to assist with the selection of study indicators; recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

NRCAs can yield new insights about current park resource conditions, but, in many cases, their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is both credible and has practical uses for a variety of park decision making, planning, and partnership activities.

Important NRCA Success Factors

- *Obtaining good input from park staff and other NPS subject-matter experts at critical points in the project timeline*
- *Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ⇨ indicators ⇨ broader resource topics and park areas)*
- *Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings*

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What an NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide current condition estimates and help establish reference conditions, or baseline values, for some of a park's vital signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same vital signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

NRCA Reporting Products…

Provide a credible, snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

- *Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations* ***(near-term operational planning and management)***
- *Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values* ***(longer-term strategic planning)***
- *Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public* ***("resource condition status" reporting)***

Over the next several years, the NPS plans to fund an NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information visit the NRCA Program website.

[6] An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.

[7] While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

[8] The I&M program consists of 32 networks nationwide that are implementing "vital signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

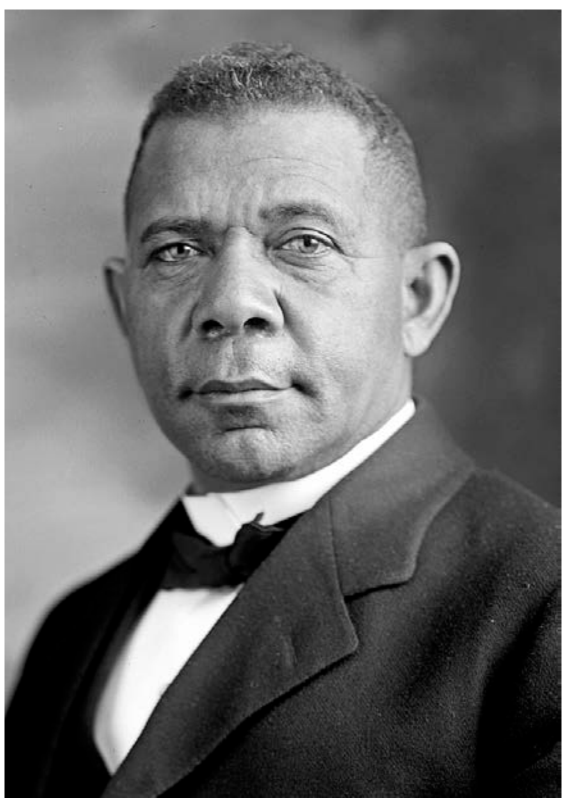
Chapter 2. Introduction and Resource Setting

2.1 History and Enabling Legislation

Booker T. Washington National Monument (BOWA) commemorates the birthplace of Booker T. Washington, one of the most influential African Americans of the late 19th and early 20th centuries.

In 1856, Booker T. Washington was born into slavery on the site, which was then a small tobacco plantation owned by the Burroughs family. He lived there with his mother, sister and brother until the end of the Civil War in 1865. Washington's father's identity remains unknown. After the Civil War and Emancipation, Washington's mother moved with her children to Malden, West Virginia to join her husband Washington Ferguson, who had gone there seeking work. As a child in Malden, Washington worked long days in a salt mine to help support his family and largely taught himself how to read and write. At the age of 16 he journeyed nearly 500 miles by himself, with little money and no idea of what lay ahead, to enroll in the Hampton Institute.

Washington excelled at Hampton. After receiving his degree, he worked for several years as a teacher in West Virginia before returning to Hampton to teach. At only 25 years of age, he was recommended by the principal of Hampton to develop a new school in Alabama—The Tuskegee Normal and Industrial Institute (which later became Tuskegee University). The institute was established July 4, 1881. There, Washington built, both literally and figuratively, one of the premier educational institutions for African Americans in the United States.



Photograph of Booker T. Washington (photo credit: Harris & Ewing).

More than a decade after the establishment of the Tuskegee Institute, Washington was invited to give the inaugural address at the 1895 Cotton States and International Exhibition. Hailed as one of the most influential speeches in American history, Washington argued for a measured approach to race relations in the post-reconstruction era that eased the predominantly white audience:

> *Our greatest danger is that in the great leap from slavery to freedom we may overlook the fact that the masses of us are to live by the productions of our hands, and fail to keep in mind that we shall prosper in proportion as we learn to dignify and glorify common labour, and put brains and skill into the common occupations of life; shall prosper in proportion as we learn to draw the line between the superficial and the substantial, the ornamental gewgaws of life and the useful. No race can prosper till it learns that there is as much dignity in tilling a field as in writing a poem. It is at the bottom of life we must begin, and not at the top. Nor should we permit our grievances to overshadow our opportunities."*

In the climax to the speech, Washington seemed to advocate an approach to race relations in the United States that placed whites and African Americans together in work, but separate in society:

> *In all things that are purely social we can be as separate as the fingers, yet one as the hand in all things essential to mutual progress."*

The address turned out to be wildly popular to the largely white audience in attendance, but was seen as too accommodating to white interests by his African American contemporaries. Labeling this speech the "Atlanta Compromise," W. E. B. Du Bois, for instance, felt that Washington had made unforgivable compromises in accepting segregation while arguing for education and economic advancement for blacks, rather than advocating strongly for their political and social equality. Many others, however, felt that he worked within the constraints of his time to advocate for and achieve significant advances in the areas of education and economic empowerment for African Americans. Between 1895, when he delivered the famous speech, and his death in 1915, he was arguably the single most influential American in the areas of race relations and black education. He served as an advisor to presidents, politicians, philanthropists, and business leaders. To this day, Washington's philosophies and actions continue to spark lively, and sometimes heated debates, which opens up many potential doors to interpretation of the site, which maintains the feel of a mid-19th century, middle-class tobacco farm.

In 1945, Sidney Phillips, one of Washington's former students at Tuskegee, purchased the property comprising Washington's birthplace. Phillips planned to develop the site as a memorial where he would carry out a wide range of educational and promotional activities. As he explained:

> *In memory, then, of this great man, the Booker T. Washington Birthplace Memorial plans to restore the cabin in which he was born; to send out memorial shrubbery throughout the country; to set up a Better Workers' Institute; to establish a model demonstration farm; to set up a museum of Negro accomplishments in handicraft, music, arts, and science; to establish a radio station which will carry coast-to-coast*

broadcasts based on the teachings of Booker T. Washington; and to plan for the erection of a consolidated elementary school for Negro children and a regional vocational school for Negro youth" (French et al. 2007).

After breaking ground on the memorial April 5, 1946—what would have been Washington's 90th birthday—Phillips testified before the United States House of Representatives in favor of a bill that would establish a Booker T. Washington commemorative half dollar. The proceeds of the sale of this commemorative coin would be set aside to help fund an "industrial training school there to train Negro youth below the high school and college level, and especially World War II veterans" (French et al. 2007). The bill passed easily, and President Truman signed it into law in the fall of 1946, making Booker T. Washington the first African American to be portrayed on any currency in the United States.

Nearly six years after testifying before congress, Phillips and the trustees of the Booker T. Washington Birthplace Memorial donated six acres of land along the western boundary of what is now the park for the construction of one of Franklin County's last segregated schools for black children. The school opened in 1954—seven months after the Brown v. Board of Education Supreme Court decision that declared "separate but equal" public schools to be unconstitutional—and operated until it was closed for desegregation in 1966. The school, operating 100 years after Washington was freed from slavery, offers both physical and emotional links between Booker T. Washington and the continuing struggles of race and equality in America.

In 1955 the rest of the Booker T. Washington Birthplace Memorial was donated to the United States federal government. In April 1956—on the one-hundredth anniversary of Booker T. Washington's birth at the site—the United States Congress recognized the remainder of the site as the Booker T. Washington National Monument. The following year, the NPS took responsibility for its administration. The site has been operated as a national monument since that date with the following stated mission:

Booker T. Washington National Monument preserves and protects the birth site and childhood home of Booker T. Washington while interpreting his life experiences and significance in American history as the most influential African American between 1895 and 1915. The park provides a resource for public education and a focal point for continuing discussions about the legacy of Booker T. Washington and the evolving context of race in American society" (NPS 2008).

In 2002, the United States Congress voted to expand the site through the purchase of an adjacent 15-acre parcel in order to provide an additional buffer between the park and nearby development.

2.1.1 Geographical Setting

BOWA is located in Franklin County, Virginia just east of the Blue Ridge Parkway within Virginia's fifth Congressional District. It comprises a total of 239 acres located in the rolling hills of the Virginia Piedmont region, approximately 35 km (22 mi) southeast of Roanoke, 80 km (50 mi) southwest of Lynchburg, and 250 km (155 mi) west of Richmond. The park is situated in the region where the Blue Ridge Mountains descend to Smith Mountain Lake (elevation 795 ft). It is within 30 km (18 mi) of both the Blue Ridge Way National Trail to the northwest and Grassy Hill State Nature Preserve to the southwest (Figure 2.1). Precambrian metamorphic schist, granite, and gneiss characterize the geology of the area. Gills Creek and Jack-O-Lantern Branch are the only two permanent waterways in the park, and lie within the greater Roanoke River watershed. This region lies within a humid subtropical climate characterized by hot, humid summers and mild winters. July is the hottest month with an average high temperature of 86° F, while January is the coolest month with an average high of 44° F. The record high was 105° F in 1936 and the record low was -12° F in 1917. Winter months are drier than summer months, as precipitation ranges from an average of 7.89 cm (3.11 in) in December to 9.1 cm (3.57 in) in May (Davey et al. 2006, Knight et al. 2016). The area's natural resources include fields and forests, plants, animals, and water. Farming and logging are the region's traditional industries.

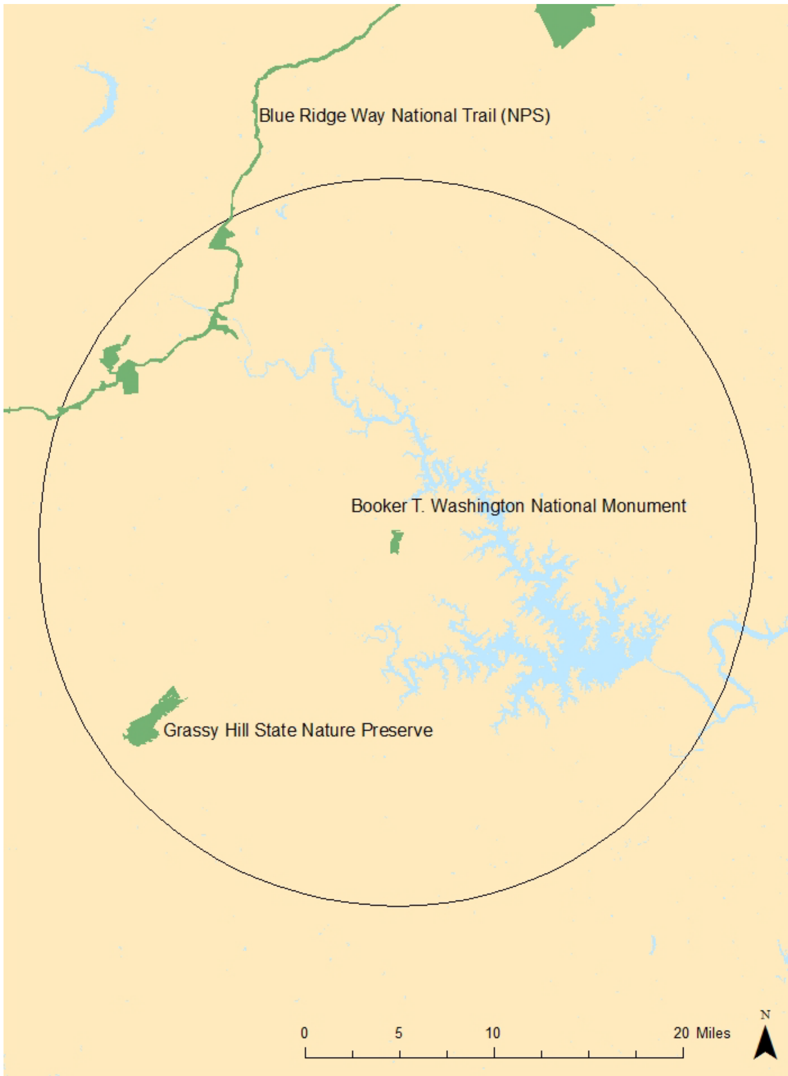


Figure 2.1. Protected Areas within 30km of BOWA (WDPA 2011).

The 97-hectare (239-acre) park contains NPS-owned roads, trails, and buildings, including a visitor center, administrative offices located within a former school building, an 1890s tobacco barn, reconstructed plantation outbuildings, two marked archeological sites, three small cemeteries, and two walking trails that loop through the cabin area, meadows, and woodlands. Twentieth-century replicas include a slave cabin, smoke house, blacksmith shop, hog pen, duck lot, and chicken house. All replicas are highly conjectural, and their designs derive from anecdotal evidence and general historic precedent. No replica of the main plantation house exists, but stones outline the confirmed general location and dimensions of the foundation. Of primary significance to the park is preservation of the public experience of the mid-19th century plantation setting where Booker T. Washington lived as a slave. A primary concern and priority of the park is working with adjacent landowners to preserve the viewshed and agricultural setting.

2.1.2 Visitation Statistics

From 2000 to 2016, the number of visitations to the National Monument has ranged from 16,357 to 27,205 visitors per year (NPS 2016). BOWA employs a total of 10 permanent, term, and seasonal staff (Sims 2016). The park works with dozens of volunteers who collectively dedicate thousands of hours to the park.

While there is little recent data on the breakdown of park visitors, in summer 1995, the Cooperative Park Studies Unit at the University of Idaho conducted a Visitor Study at BOWA (Patterson 1996). The study's 239 questionnaires yielded information on the demographics and preferences of summertime park visitors. Visitors reported traveling primarily as families (80%), with the largest generational clusters being visitors 15 years or younger (27%) and 41-50 years old (22%). While visitors reported traveling from 27 states in the surveys, 45% of visitors reported residence in Virginia. Smaller percentages came from North Carolina (9%), Pennsylvania (6%), and Maryland (5%). Eighty-four percent of visitors were visiting the National Monument for the first time, and nearly 90% stayed for between one and two hours. Because this survey was conducted in the summer, however, it does not account for student groups for whom the park provides curriculum materials throughout the school year.

There are a wide variety of activities in which patrons can engage while visiting BOWA. The visitor center contains various exhibits, an audio-visual presentation that orients visitors to Washington's life, and a sales area containing books and related items that focus on African American history. Beyond the visitor center there is the quarter-mile Plantation Trail that loops through the historic area and passes by reconstructions of the nineteenth-century farm buildings similar to those that stood on the Burroughs Plantation when Washington would have lived there. The longer Jack-O-Lantern Branch Heritage Trail is a 1.5-mile loop through the fields and forests of the park. A picnic area in a wooded setting offers visitors picnic tables, trash cans, and a water fountain. Finally, a farm area with sheep, pigs, horses, and chickens sets the stage for exploring this recreated 1850s tobacco farm, and a garden area displays agricultural techniques that owners and slaves used on a typical subsistence garden of Piedmont Virginia of the 1850s. According to Patterson's (1996) survey, 82% of patrons visited the farm area, 80% watched the slide show, 65% shopped in the bookstore, 47% viewed the roadside and trailside exhibits, 19% walked the Jack-O-Lantern trail, and 13% ate in the picnic area.

Salamander sampling at Gills Creek (Photo by Heather Courtenay).

2.2 Natural Resources

2.2.1 Watershed Context

BOWA is located within the northwestern portion of the Upper Roanoke River sub-watershed. The Roanoke River flows into the Albemarle-Pamlico Sound, the second largest estuary in the U.S. The Roanoke River's headwaters lie in the Blue Ridge Mountains, and the river flows in a southeasterly direction through Virginia into North Carolina, where it eventually drains into the Albemarle-Pamlico Sound (Figure 2.2). Gills Creek is the main outflow for the park, flowing directly into Smith Mountain Lake, where it eventually joins the Roanoke River. The Jack-O-Lantern Branch is spring-fed, and flows along the eastern boundary of the park, where it joins Gills Creek on the southern park boundary line (Figure 2.2).

The Roanoke River was dammed in the 1950s, creating the Roanoke Rapids Reservoir Dam, and has many lakes and reservoirs along its length. The river is well-known for its spring floods, which bring new soil to its floodplains, allowing for fertile farmland (Roanoke River Basin 2013). The watershed covers 9,768 square miles in North Carolina and Virginia, and has a human population of about 1 million. Many anadromous fish used to populate the river before it was dammed; now they are stopped below the Roanoke Rapids Reservoir Dam.

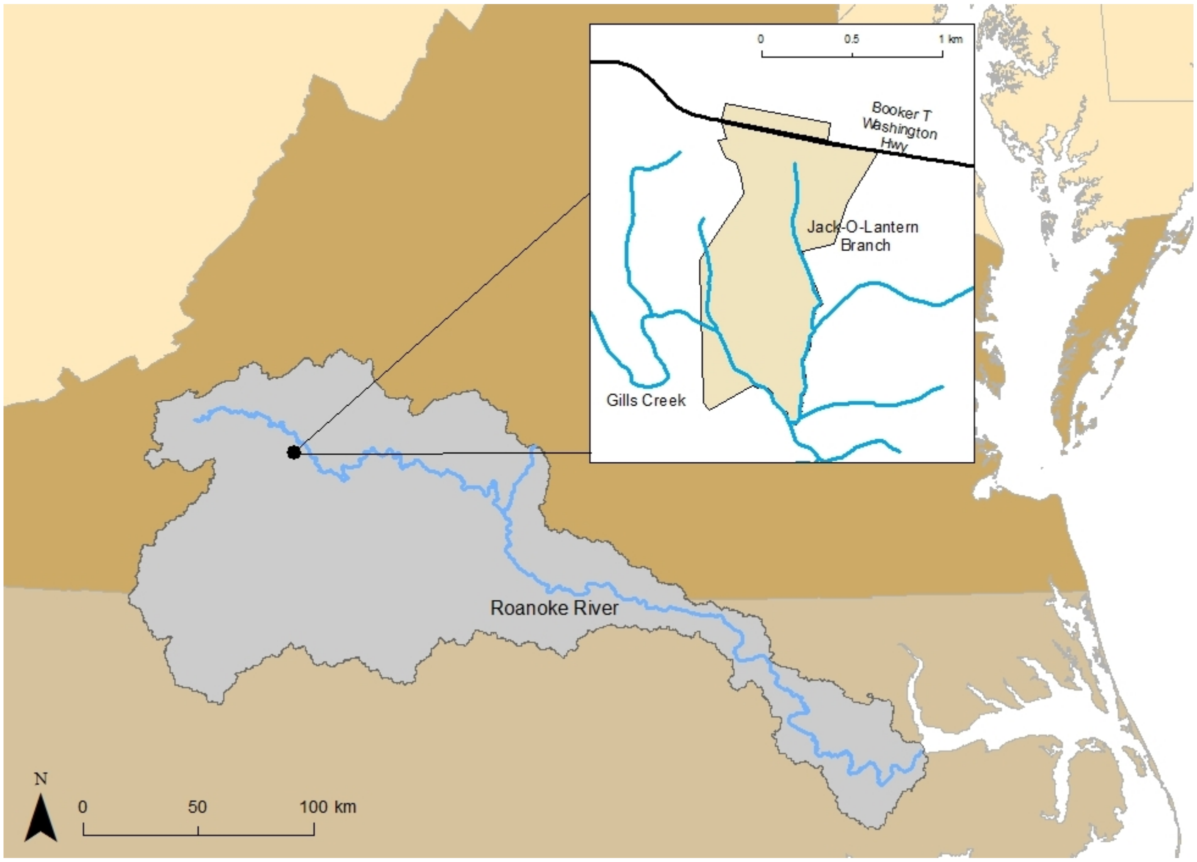


Figure 2.2. Roanoke River watershed (NHD 2016).

2.2.2 General Resource Features

<u>Geology</u>

BOWA lies along the western edge of Virginia's Piedmont physiographic province, and near the eastern edge of the Blue Ridge province. The Fries Fault lies just to the west of the monument, delineating the Piedmont from the Blue Ridge. The underlying bedrock is mainly comprised of metamorphic schist, granite, and gneiss (Figure 2.3) (Thornberry-Ehrlich 2010).

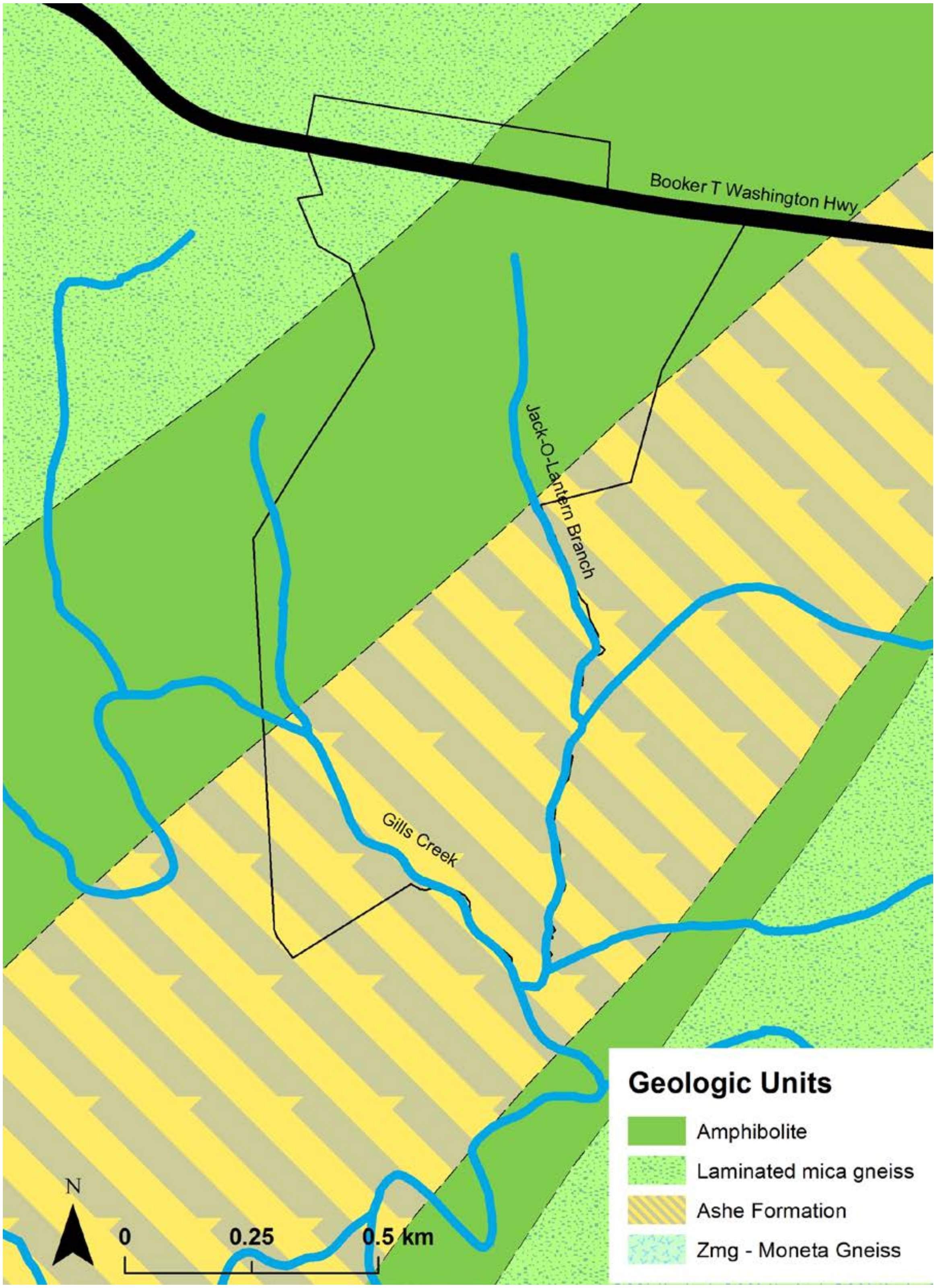


Figure 2.3. Bedrock geology for BOWA (SSURGO 2016).

Topography

Generally, BOWA is characterized by gently rolling hills and sloping valleys. The elevation ranges between 260 meters (853 feet) above sea level - where Gills Creek and Jack-O-Lantern Branch meet at the southeast edge of the park - to 300 meters (985 feet) above sea level near the park's entrance road (Figure 2.4) (Thornberry-Ehrlich 2010).

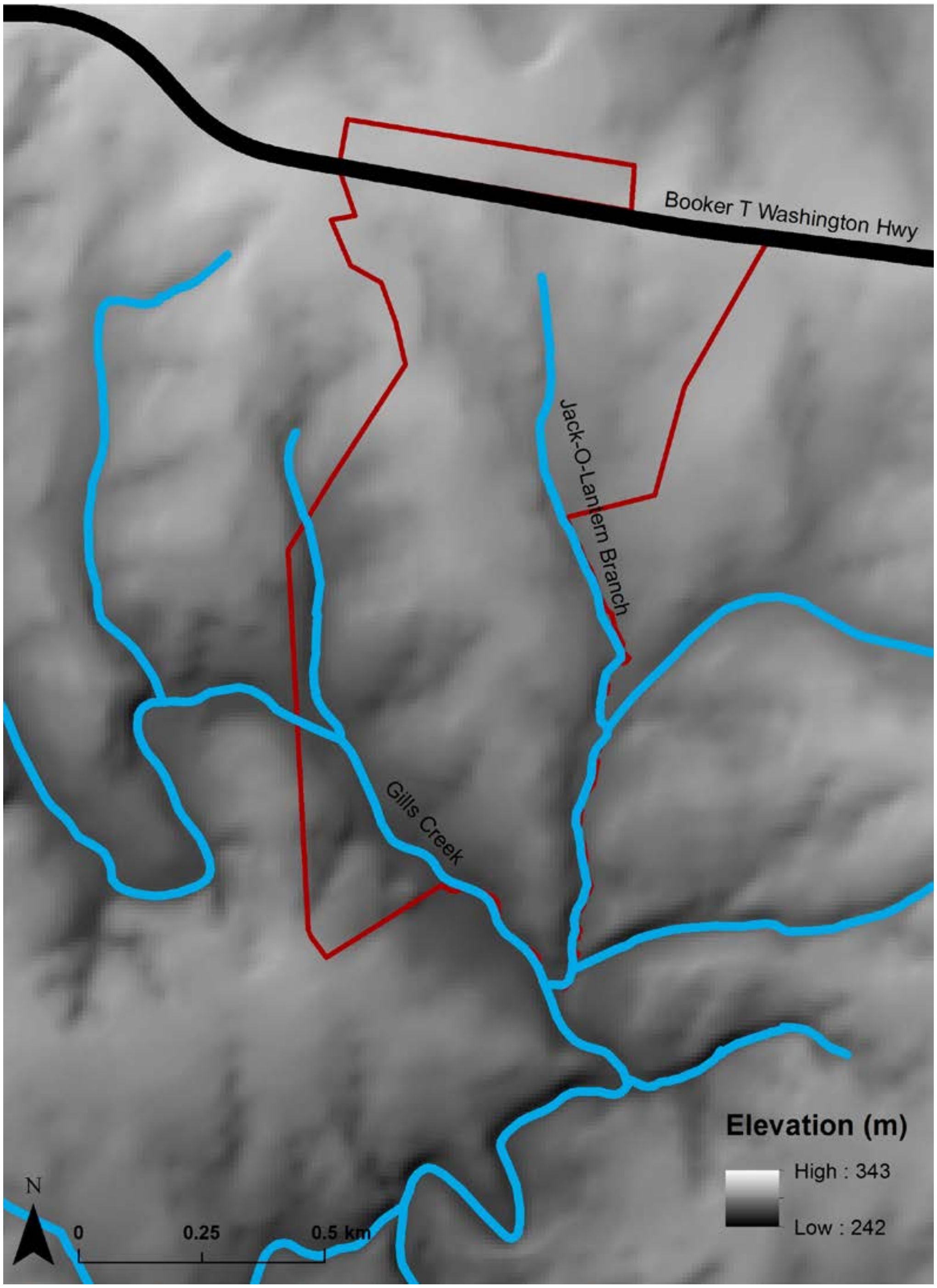


Figure 2.4. Topography for BOWA (NED 2016).

Soils

The Soil Survey Geographic database includes a survey for Franklin County, where BOWA is located. Using the Web Soil Survey tool, types and locations of soils within the park were determined. Most of the unique soil series found within the park are of the Alfisol order with a small portion of the park's soil in the Inceptisol order (Van Lear 2009).

Upland soils are primarily of the Clifford Series, a very deep, well-drained soil (Figure 2.5). The surface layer consists of a brown fine sandy loam. The subsoil has layers of yellowish red clay loam, red clay, and red clay loam. It is formed from mica schist and gneiss and metagraywacke (Van Lear 2009). Bluemount, Spriggs, Hickoryknob, Minnieville, Oredna, and Redbrush series are also present (Van Lear 2009).

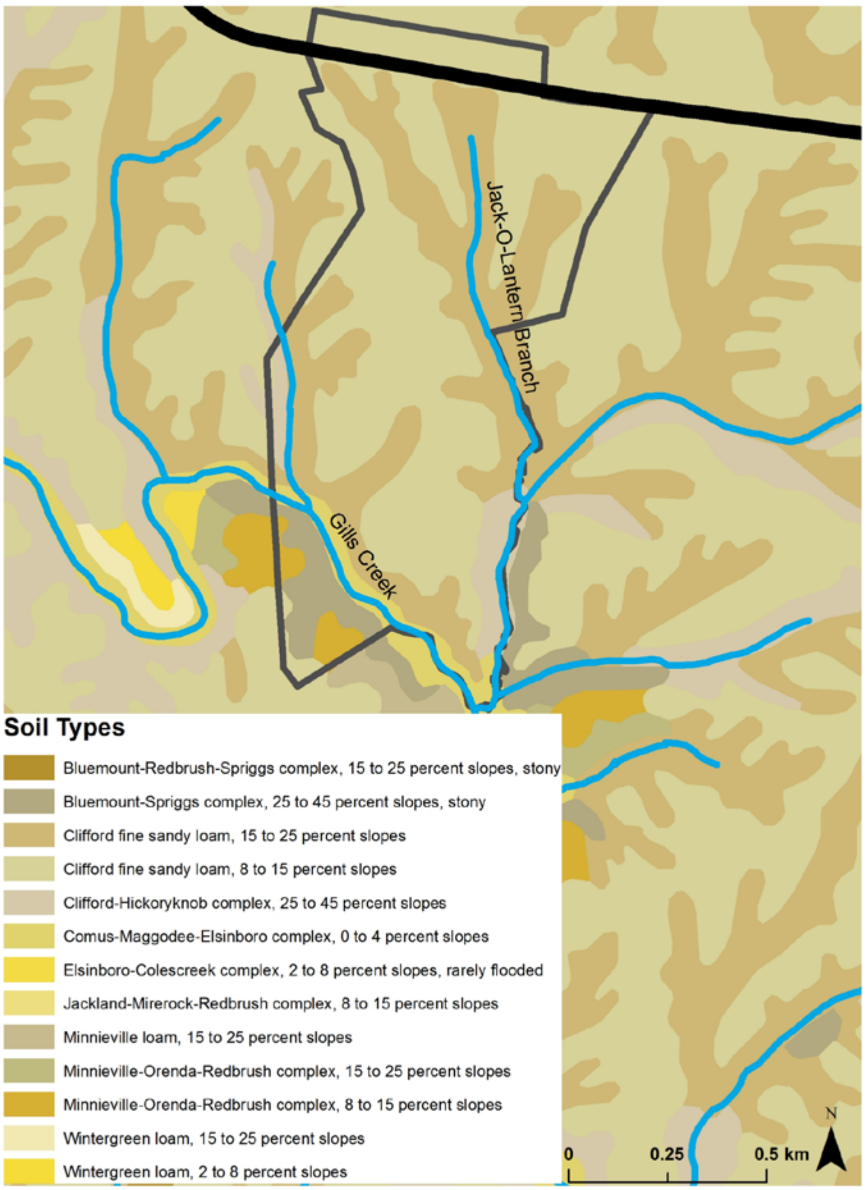


Figure 2.5. Soil associations for BOWA (Van Lear 2009).

Soil of the Comus-Maggodee-Elsinboro Series is found along Gills Creek. Comus Series is very deep and well-drained (Van Lear 2009). It has a surface layer of dark brown fine sandy loam overlaying subsoil with a layer of brown channery loam and a layer of yellowish brown fine sandy loam. Soil of the Maggodee Series is very deep and moderately-drained. It has a surface layer of dark brown and dark yellowish-brown fine sandy loam and subsoil with several layers of loams containing masses of oxidized iron. Elsinboro Series soils are very deep and well-drained. They have a surface layer of brown loam and subsoil containing a layer of strong brown clay loam and strong brown sandy clay loam (Van Lear 2009).

Surface Waters

Four streams, fed in part by five cold springs, drain out of BOWA and all are within the Albemarle-Pamlico Estuary watershed. Descriptions of the streams can be found in Patterson (2008). The two named streams, Gills Creek and Jack-O-Lantern Branch, are also the largest streams and the only permanent waterways in the park (Figure 2.6). Gills Creek flows into the park from the north, forming the western boundary, and Jack-O-Lantern Branch is formed from three springs near the center of the park and flows along the eastern boundary to join Gills Creek on the southern boundary line. One unnamed stream enters the park from the outside to join Jack-O-Lantern Branch, while the other unnamed stream enters the park near the northern boundary and flows into Gills Creek. The park also features several cold springs and seeps. Gills Creek is the largest water body in the park, and flows for 1.1 km (0.68 mi) through the park with an average depth of 1.17 m (3.85 ft) and an average width of 8.73 m (28.6 ft) (Patterson 2008).

Vegetation

Vegetation community mapping in BOWA identified ten map classes representing seven United States National Vegetation Classifications, one nonstandard, park-specific vegetation class, and two Anderson Level II land-use categories (Table 2.1, Figure 2.7) (Patterson 2008). Classification was based on leaf-on aerial photography from October 22, 2001, leaf-off aerial photography from February 19, 2002, and field sampling from June, July, and September 2002. A formal thematic accuracy assessment was not completed. The park falls in an area of transition between the Piedmont and Blue Ridge physiographic regions, leading to an overlap of species commonly found in both regions (Patterson 2008). The entire park was at one time in agricultural use. The relatively recent abandonment of the agricultural fields has resulted in almost 31% of the park's land covered by early successional or transitional vegetation (Patterson 2008). Additionally, the park hosts a diverse wildflower population, which provides habitat for many insect species, and contributes to the overall scenic quality of the park. Among the park's many wildflowers species are pink lady slipper (*Cypripedium acaule*) and goldenseal (*Hydrastis canadensis*). The pink lady slipper is a member of the orchid family and is considered endangered or threatened in some states, though not in Virginia. The goldenseal, a once commonly-found plant, has since been overexploited for its therapeutic properties. The large and diverse vegetation and wildflower populations provide habitat for a sizable butterfly population (Appendix A).

Figure 2.6. Surface waters of BOWA (NHD 2016).

Table 2.1. Percent cover of vegetation classes in BOWA (Patterson 2008).

Vegetation Class	Cover Area in Park (hectares)	Percent Cover in Park
Acidic Oak – History Forest	20.69	23%
Inner Piedmont/Lower Blue Ridge Basic Mesic Forest	3.40	4%
Cultural Meadow	26.46	29%
Dense Hardwood Regeneration	1.25	1%
Other Urban or Built-Up Land	4.13	4%
Piedmont/Mountain Alluvial Forest	6.74	7%
Successional Tuliptree Forest	6.26	7%
Successional Virginia Pine Forest	20.95	23%
Transportation, Communications, and Utilities	0.91	1%
White Pine Plantation	0.63	1%

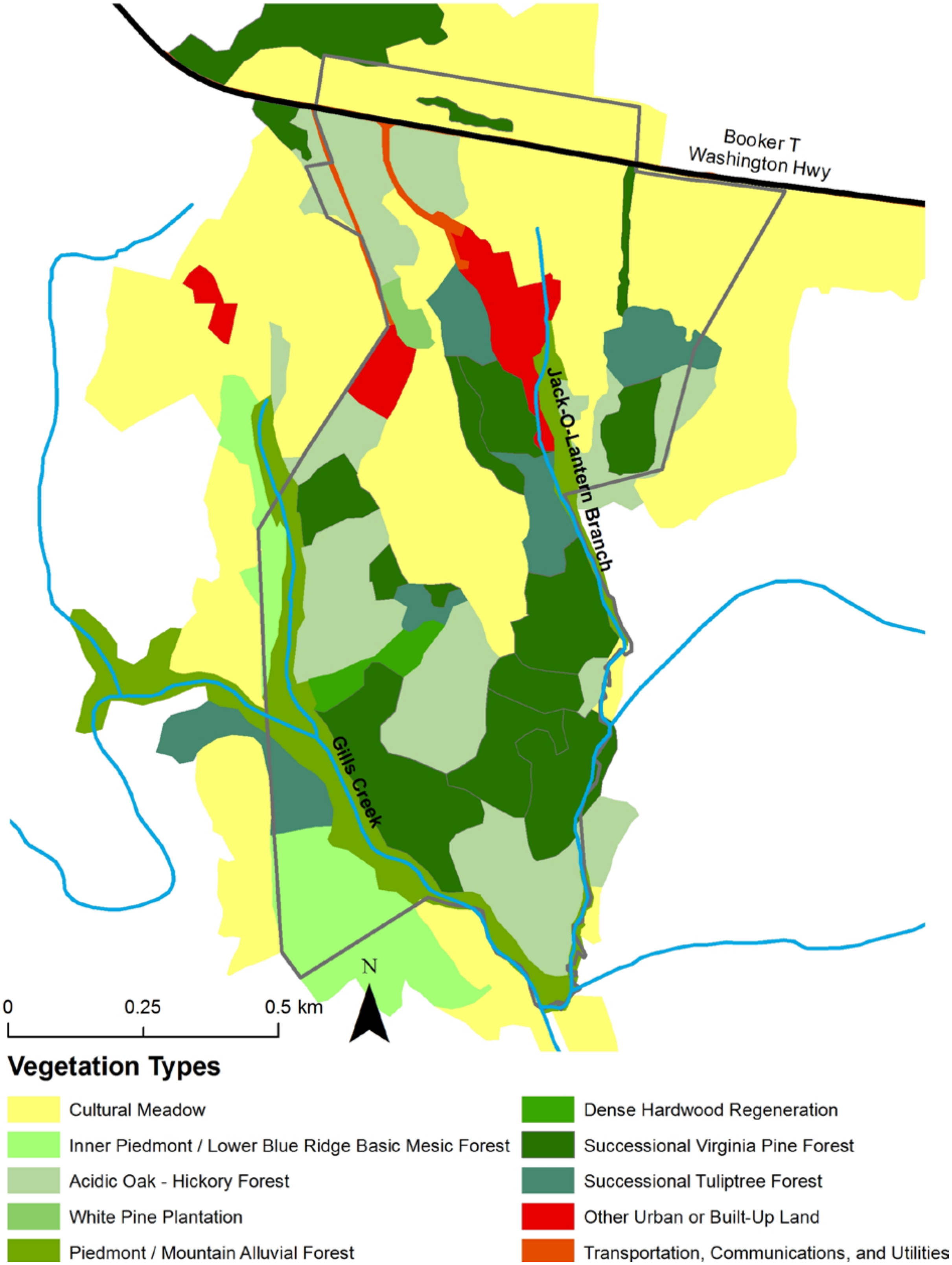


Figure 2.7. Vegetation of BOWA (Patterson 2008).

2.2.3 Resource Issues Overview

Threats to BOWA include invasive species, development within the watershed, air pollution, climate change, and light and sound pollution. These stressors are present inside the park, in the immediate area surrounding the park, and in the region at large. Significant stressors are described in this section.

Erosion along the bank of Gills Creek (Photo by Todd Lookingbill).

Invasive Species

Vegetation mapping in BOWA in the mid-2000s identified ten non-native species, seven of which are considered invasive by the Virginia Department of Conservation and Recreation (Patterson 2008). At the time of this mapping effort, 31% of park land was covered by early successional or transitional vegetation that exhibit a high cover of invasive species (Patterson 2008). Invasive plants are also notable in the Acidic Oak-Hickory Forest, Basic Mesic Forest, and Piedmont/Mountain Alluvial Forest vegetation classes. Invasive plant species found in the park include tree-of-heaven (*Ailanthus altissima*), Russian olive (*Elaeagnus angustifolia*), multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), and Japanese stiltgrass (*Microstegium vimineum)* (Comiskey 2013). Johnsongrass (*Sorghum halepense*) is also present in open areas of the park. Currently, chemical and mechanical methods are being used to control the spread of invasive species.

Japanese honeysuckle and Japanese stiltgrass are particularly troublesome because of their shade tolerance and aggressive growth habits. They can be opportunistic invaders of the older, more intact forest communities, grabbing a foothold where roads, trails, tip-up mounds, downfalls, and other gap-disturbances have affected mineral soil. Once established, these colonies are able to more easily expand or spread into nearby microhabitats. Japanese honeysuckle is especially destructive to native vegetation because of its rapid, twining growth and dense, semi-evergreen foliage that enables it to shade out its competitors. Its vines frequently strangle shrubs and tree saplings and over-grow more delicate herbs in a variety of settings. Japanese stiltgrass grows most often in recently-disturbed areas in a variety of habitats including floodplains, mesic forests, meadows, and roadsides (Redman 1995). After quickly establishing itself and forming dense patches, the shade-tolerant grass native to Asia can disrupt forest succession by preventing the establishment of trees - particularly those with small seeds - and herbaceous plants (Flory and Clay 2010).

Development

BOWA is located in a historically agricultural landscape; however, development has increased in the surrounding area in recent decades (Figure 2.8 - Figure 2.11). This is in part due to the proximity of the popular Smith Mountain Lake to the east of the park. This development has the potential to affect the local water quality and quantity of runoff. North of the park is a large septic field which could overflow into Jack-O-Lantern Branch in the event of a flood. To the east of the park is the relatively new Westlake Shopping Center, which contains large swaths of impervious surface. With a population of about 22,000 out of the total 56,000 in Franklin County, Smith Mountain Lake represents a significant source of stress to the park’s watershed. The closest developments are partially visible from the park during the winter. With much of the land surrounding the park available for development, these stressors could increase significantly in the coming years. Erosion along the streambeds has already led to increased sedimentation in both Gills Creek and Jack-O-Lantern Branch. In addition to the nearby housing development, cows from a bordering farm have access to Jack-O-Lantern Branch, and often find their way into the park. Upstream dairy operations are also an ongoing threat and concern for aquatic ecosystems in the park. Additionally, in recent years, there was a significant manure spill and fish kill on Gills Creek, temporarily compromising the health of the waterway.

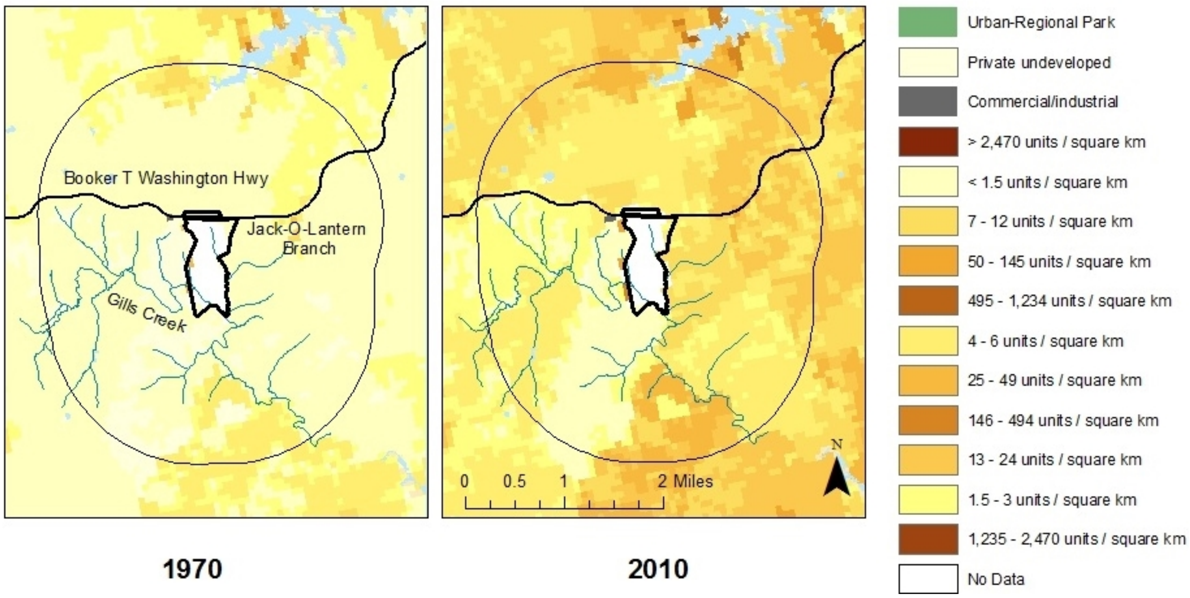


Figure 2.8. Housing density within 3km buffer of BOWA from 1970-2010 (NPScape 2011).

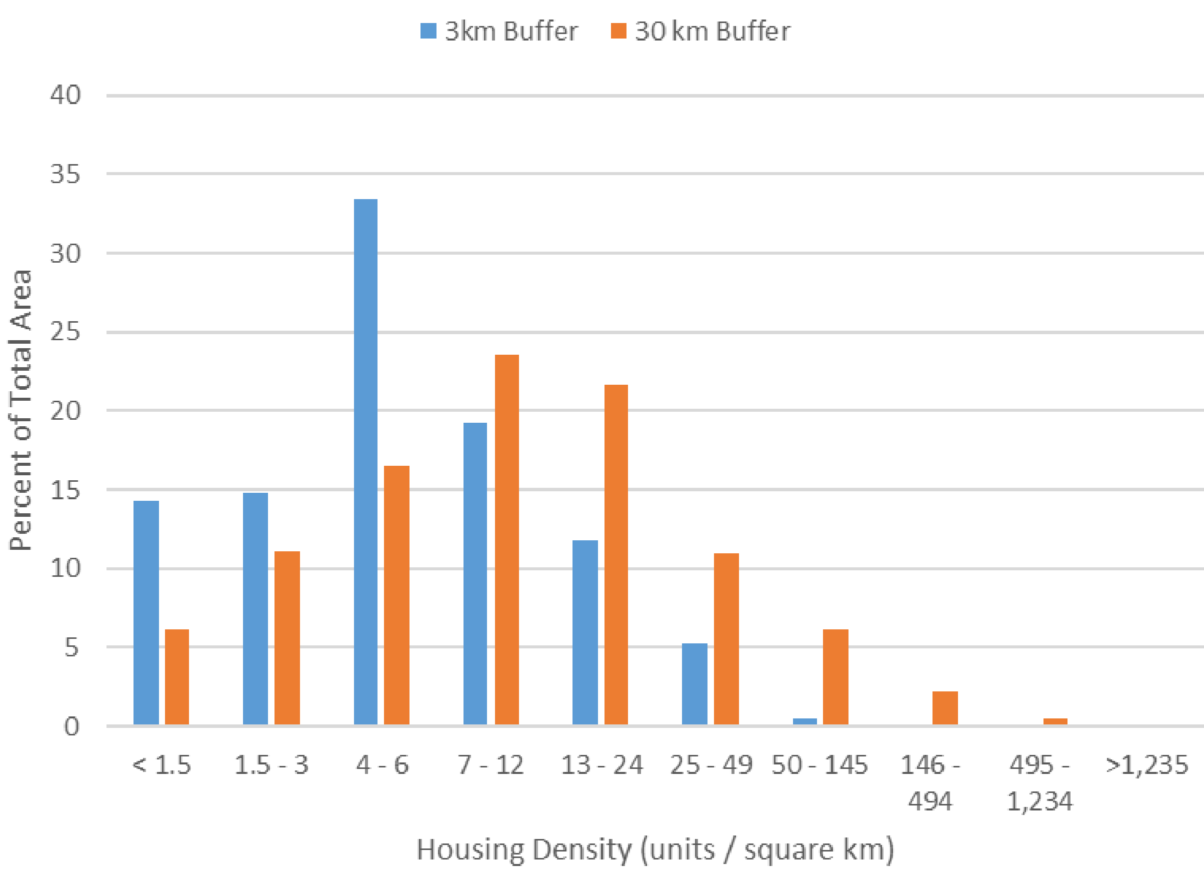


Figure 2.9. Comparison of 2010 housing density for 3km and 30km buffers around BOWA (NPScape 2011).

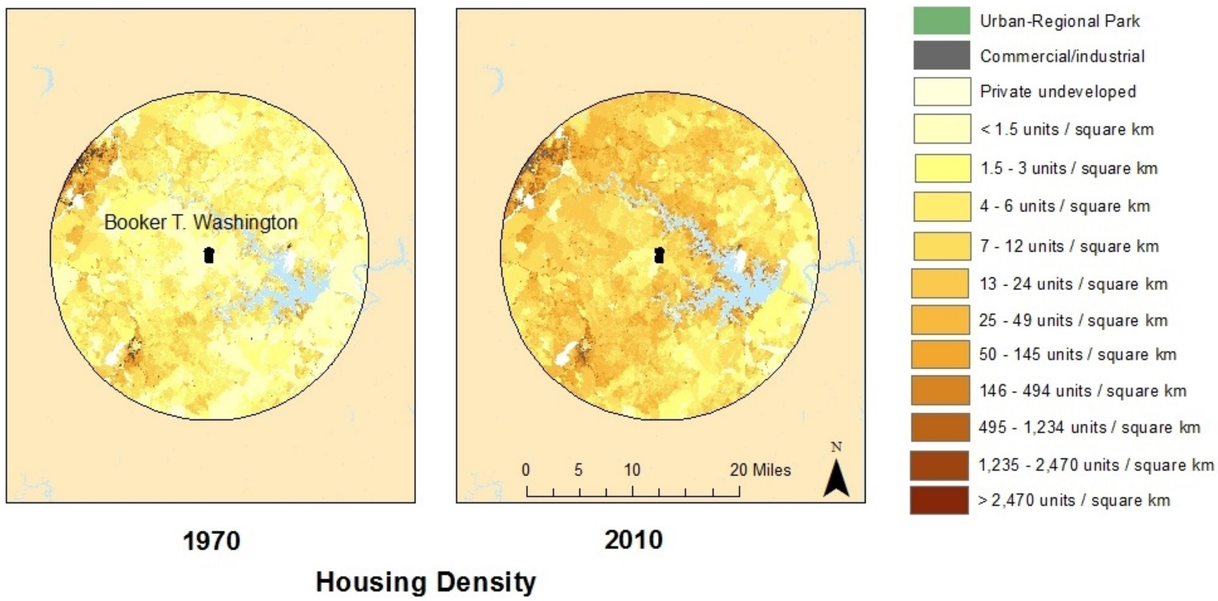


Figure 2.10. Housing density within 30km buffer of BOWA from 1970-2010 (NPScape 2011).

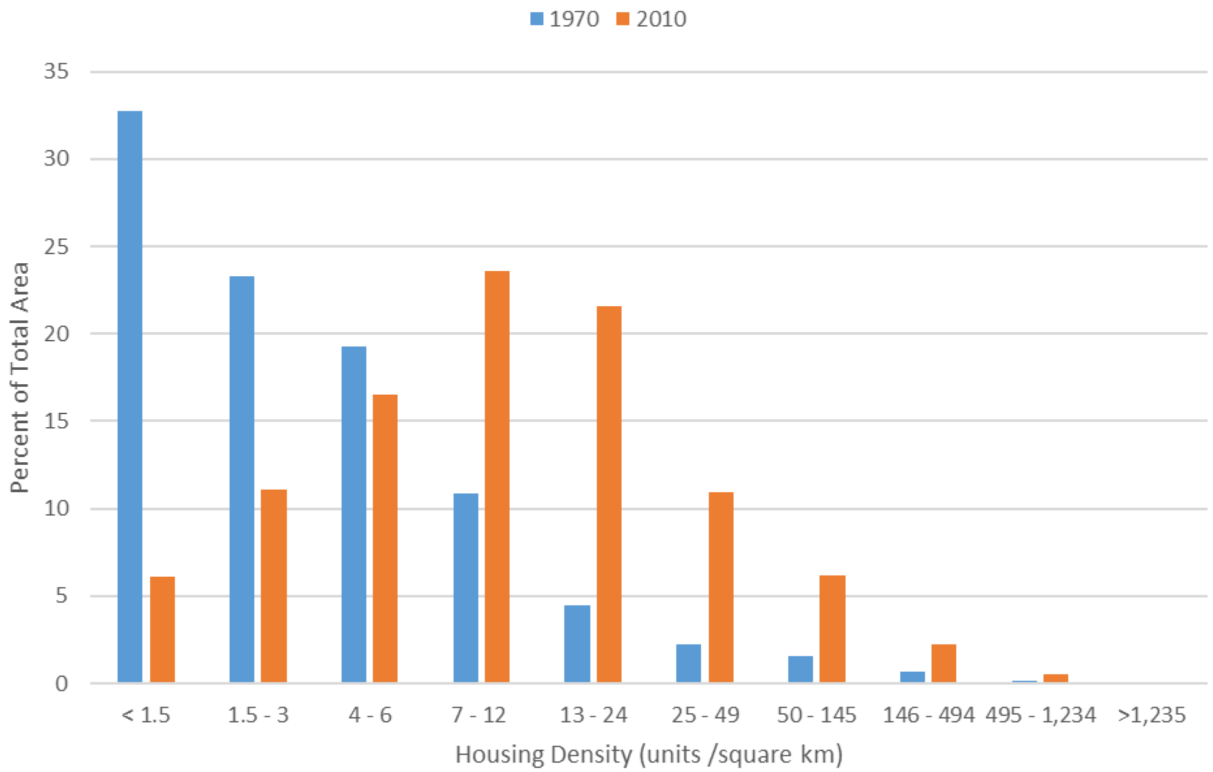


Figure 2.11. Comparison of housing density within 30km buffer of BOWA from 1970 and 2010 (NPScape 2011).

<u>Degraded Air Quality</u>

The East Coast of the United States has some of the worst air pollution in the country, with poor visibility, elevated ozone concentrations, and elevated rates of nitrogen and sulfur deposition

(Driscoll et al. 2001, NPS ARD 2010a). Air quality affects the health of humans, as well as that of terrestrial and aquatic ecosystems. It is influenced by fossil fuel combustion (e.g., cars or coal power generation), as well as other factors, such as smelters and forest fires. Elevated ozone concentrations are known to cause premature defoliation of plants (Kline et al. 2008). Nitrogen and sulfur deposition can acidify and fertilize waters and soils, which affects nutrient cycling, vegetation structure, stream biodiversity and surface water eutrophication (Sullivan et al. 2011b). Air pollutants can be transported long distances (e.g., sulfate can be transported more than 500 km [300 mi]) making management of these threats difficult at the local scale.

Climate Change

Global changes in atmospheric chemistry are driving changes in temperature, precipitation, and storms. Direct influences on the park could involve the possibility of more severe flooding, which could cause the large septic field north of the park to overflow into Jack-O-Lantern Branch. Increased storm activity could have negative effects on habitats and stream erosion. Given the current uncertainty in future climate scenarios, it is equally likely that increased drought will have negative impacts on the park. These impacts may include the loss of native species, the degradation of terrestrial and aquatic habitats, and the proliferation of species, including non-native invasive species, not currently found in the park. Additionally, changing climate conditions may modify the range and distribution of certain plant species and vegetation communities throughout the region. Changes in precipitation amount and timing is also a potential threat to aquatic resources throughout the region, and fluvial regimes will likely be affected with changing climate conditions. Disturbance regimes will likely be altered, resulting in the spread of invasive plants, pests, and pathogens. Changes in water temperature that may occur with changing climate conditions will likely threaten cold-water species, like fish and macroinvertebrates, and may result in the expansion of non-native fish populations and associated diseases (NPS Inventory & Monitoring 2010).

Light and Sound Pollution

The lower 48 states of the continental U.S. have some of the highest levels of artificial lighting in the world. The lack of dark night skies has ecological impacts on wildlife habitat quality, species interactions, and migration patterns (Rich and Longcore 2006). Park soundscapes have also been highly degraded throughout the U.S. due to development outside park boundaries (Miller 2008). Properly functioning soundscapes are important for intra-species communication, territory establishment, courting and mating, nurturing and protecting young, predation and predator avoidance, and effective use of habitat (Miller 2008). Both light and noise pollution can also distract visitors from their appreciation of the park's natural resources and the purpose of its cultural areas—the tranquility of historic settings and the solemnity of memorials, and sacred sites. Increased development in the neighboring area, such as Westlake Towne Center, has the potential to increase light and sound pollution in BOWA both through increased traffic on Route 122, which cuts through the park, and noise and light from the town center itself.

Nearby developments increase both light and sound pollution in BOWA (Photo by Todd Lookingbill).

2.3 Resource Stewardship

2.3.1 Management Directives and Planning

> *Booker T. Washington National Monument preserves and protects the birth site and childhood home of Booker T. Washington while interpreting his life experiences and significance in American history as the most influential African American between 1895 and 1915. The park provides a resource for public education and a focal point for continuing discussions about the legacy of Booker T. Washington and the evolving context of race in American society."* (NPS 2000)

<u>Fundamental resources</u>

Fundamental resources and values are the features, systems, processes, experiences, scenes, sounds, or other resources that collectively capture the essence of the park and warrant primary consideration by managers because they are critical to achieving the park's purpose. The NPS is steward to many of America's most important natural and cultural resources and is charged with their preservation for the enjoyment of present and future generations. BOWA, like many other units in the NPS, has highly valued cultural resources - i.e., the material evidence of past human activities. These resources are finite and nonrenewable and begin to deteriorate almost from the first moment of their creation. Conforming to the spirit of the NPS Organic Act of 1916 and various historic preservation laws, park management activities must reflect awareness of the irreplaceable nature of these material resources. Under the guidance of the NPS Inventory and Monitoring (I&M) Program, the park has also begun a major undertaking to develop baseline data for fish, reptiles and amphibians, birds, mammals, and vascular plants. Park cultural and natural resource management involves research, evaluation, documentation, registration of park resources, and setting priorities that ensure these resources are preserved, protected, and interpreted to the public. The Booker T. Washington National Monument

General Management Plan (GMP) (NPS 2000) describes the park's vision for providing a culturally-compelling visit that immerses one in the childhood of Booker T. Washington, and providing services and facilities that enhance the visitor experience. To meet these goals, four alternative management options were described in the GMP. Each alternative provides a different approach for protecting and preserving resources, providing a high quality visitor experience and facilities, and creating partnerships with external community organizations to maximize resources and achieve the park's mission to preserve and interpret the site's historic and cultural significance. The alternatives are organized by mission goals, management zones, and management prescriptions. Ultimately, Alternative C (below) was adopted. A park Foundation Document is currently in draft form.

A view of a lane through the meadows at BOWA (Photo by Todd Lookingbill).

Alternative A: Continuation of Current Management

Alternative A, the 'no action' alternative, maintains the status of the park as set forth by the previous GMP. The cabin area would be used as the main on-site interpretation area, the visitor center for orientation and information, and the old school building for administration. This alternative would eventually lead to overcrowding and threats to cultural and natural resources due to nearby development.

Alternative B: Park as a Pilgrimage for Education and Racial Relations

Alternative B seeks to establish the park as a commemoration of Booker T. Washington's work in education and race relations. While cultural and natural resource maintenance would remain unchanged, many buildings would change purpose. The school building would be restored as the new visitor center, while the current visitor center would become an interactive library. A new Life Walk would celebrate Washington's achievements, and new administrative and maintenance facilities would be built. There would be an increased focus on maintaining the park's rural viewshed, particularly near the school building, and partnerships with outside organizations would reflect that. The circulation of the park would be redesigned so that visitors would begin at the school building, and staff for maintenance and other programs would be increased. In this alternative, community partnerships would focus on maintaining the rural setting of the park and surrounding area.

Alternative C: Booker T. Washington's Life – ***ADOPTED PLAN***

Alternative C was ultimately chosen as the new General Management Plan direction for BOWA. This plan involves acquiring a 15-acre parcel on the east side of the park to include the remaining land from the Burroughs Plantation to help preserve the viewshed (Figure 2.12). This land was acquired in 2003. This alternative also entails expanding the visitor center and increasing programs to focus on Washington's life on the plantation, which occurred in 2009, along with the addition of a multi-use room.

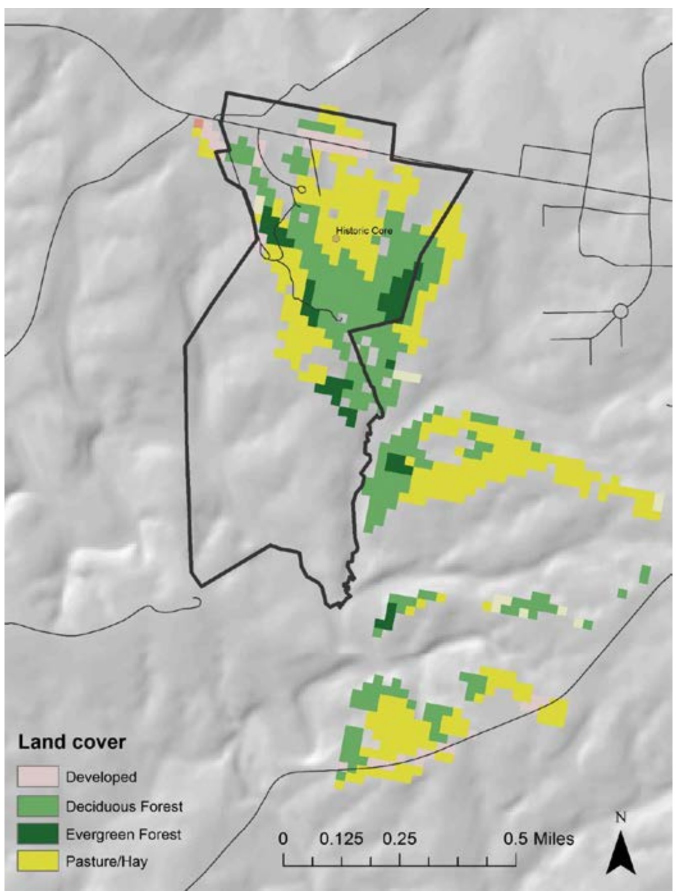


Figure 2.12. Viewshed from the historic core (NLCD 2011).

The number of outreach programs would increase to bring in school groups and the larger community. New on-site exhibits were developed in 2014. In this alternative, efforts to maintain the agricultural setting of the park would be heightened. A portion of the school building would be restored for events and interactive programs, and the maintenance shop and yard would be relocated. Staff would increase to support research and education opportunities, and partnerships with outside organizations would focus on educational connections and preserving the rural setting.

Alternative D: Segregated School as Focal Point

This alternative includes much of the same proposals as Alternative C. The main difference between the two is the rehabilitation and restoration of the old segregated school building that was built on the property in the 1960s to meet the separate but equal standards for public schools. The updated school building would serve as a new visitor's center, providing an expanded space for increased educational visitor programs and allow the cultural significance of this building to be incorporated into the park's cultural resources. The old visitor's center would be removed and land returned to its previous agricultural state. A new administrative building would be built in a discrete location so as to not detract from the visitor experience. As with plan C, the park would pursue the acquisition of the 15-acre parcel of land remaining from the former Burroughs Plantation at the northeast border of the park, and community partnerships would be made to better protect the park from encroaching development.

2.3.2 Status of Supporting Science

The NPS I&M Program was formed to address the Natural Resource Challenge of 1999 – a country-wide effort to better understand, measure, and improve the health of park ecosystems (Fancy et al. 2009). The goals of the I&M Program are to:

1) Inventory NPS natural resources to determine their nature and status.
2) Monitor ecosystems within parks to better understand their dynamics and condition, as well as to provide reference points for comparisons with altered environments.
3) Establish the I&M Program as a standard practice throughout the park system that transcends traditional boundaries.
4) Integrate natural resource information into NPS management.
5) Share NPS accomplishments and information with other organizations to form partnerships for attaining common goals.

BOWA is one of 10 parks in NPS I&M Mid-Atlantic Network (MIDN). Numerous resource inventories have been conducted in the park (Table 2.2) and the long-term monitoring of these Vital Signs is meant to act as a warning system to identify declines in ecosystem health and species viability (Comiskey and Callahan 2008). The Vital Signs used by the MIDN include a range of physical, chemical, and biological elements and processes that represent an overview of the condition of park resources (Table 2.3).

Table 2.2. Inventories conducted at BOWA.

Inventory	Description	Literature Cited
Air Quality and Related Values	The air quality inventory provides information on the pollutants present in the park and allows for their impact on park resources to be evaluated.	Sullivan et al. 2011a,b.
Amphibians and Reptiles	Survey of all amphibians found in the park allowing for planning for any species of concern.	Mitchell 2006.
Avian Species	Survey of all birds found in the park allowing for planning for any species of concern.	NPS 2009.
Fish	Survey of all fish in the park allowing for planning for any species of special concern and as a measure of ecosystem function.	Atkinson 2008.
Geology	Description of the underlying geology of the park and its effects on the park.	Thornberry-Ehrlich 2010.
Mammals	Survey of all mammals found in the park allowing for planning for any species of special concern.	Pagels et al. 2005.
Vegetation	Survey and mapping of plant communities in the park. Also assesses the impact of white-tailed deer and invasive species on the vegetation of the park.	Patterson 2008.
Weather and Climate	Evaluates the park’s climate variations and its effects on the park’s resources	Imhoff and Person 2016.

Table 2.3. Monitoring programs at BOWA.

Monitoring Program	Description	Status
Air Quality	Monitor different metrics of air pollution on a yearly basis.	Network wide reports beginning in 2003
Avian Species	Determine trends in breeding birds in the park.	2009-present
Vegetation	Determine trends in composition and health of park vegetation.	2007-present
Weather and Climate	Records yearly weather and climate trends.	2007-present
Water Quality	Collects information on water quality parameters such as DO, temperature, and pH	2010-present
Benthic Macroinvertebrates	Monitors aquatic invertebrates as a measure of stream health	2009-present

Chapter 3. Study Scoping and Design

This chapter documents the study scoping process and methods used to conduct the assessment. It summarizes the study design, input from parks and other NPS subject matter experts, and the approach used to “roll up” indicator scores for a more holistic assessment of overall conditions.

3.1 Preliminary Scoping

Preliminary scoping of the BOWA NRCA began in June 2014 with a meeting of park staff, MIDN I&M personnel, and active volunteers with expertise in the park’s resources. At the meeting, park management objectives were discussed in detail. Initial cataloging of natural resource values and stressors to the park began. Project goals were also discussed and park staff provided a guided tour of the site.

The compilation of data began immediately following this initial meeting. Archived data for park resources were organized into an electronic library comprised of management reports, hard data files, and GIS data, which provided the primary sources for the assessment. Datasets were obtained from multiple divisions within the NPS including the park, ARD, MIDN I&M Program, NPScape; U.S Environmental Protection Agency (EPA); and regional scientific experts and volunteers who have worked in the park, among others.

Planning and exchange of data continued through a series of follow-up emails and phone calls with park staff and the NPS I&M Program. The outcomes of these discussions were the final selection of natural resource indicators to be included in the assessment, the key metrics to assess the condition of these resources, and the selection of desired or target values for the metrics. These conversations also provided the context of current conditions and background information not necessarily available in published form. Efforts were made to integrate indicators from the NPS I&M Vital Signs into this assessment, when possible. Strong collaboration with park natural resource staff was essential to the success of this assessment, and park staff invested significant time to assist in the selection of indicators, compilation of data, and interpretation of findings.

3.2 Study Design

3.2.1 Indicator Framework, Focal Study Resources, and Indicators

Indicators form the basis of this condition assessment. The NPS I&M Program has previously developed a number of ecological monitoring indicators grouped as Vital Signs to represent key physical, chemical, and biological elements and processes of park ecosystems that are representative of the overall health or condition of park resources. The I&M Vital Signs are grouped hierarchically with the highest hierarchical level including 1. Air and Climate, 2. Water, 3. Biological Integrity, 4. Landscapes, 5. Human Use, and 6. Geology and Soil. For the purpose of calculating natural resource conditions in BOWA, the first four of these Vital Sign categories were used, though general features of 'Human Use' and 'Geology and Soil' are discussed throughout the report. For the assessment, four to five specific metrics were evaluated for each of the Vital Sign categories (Figure 3.1).

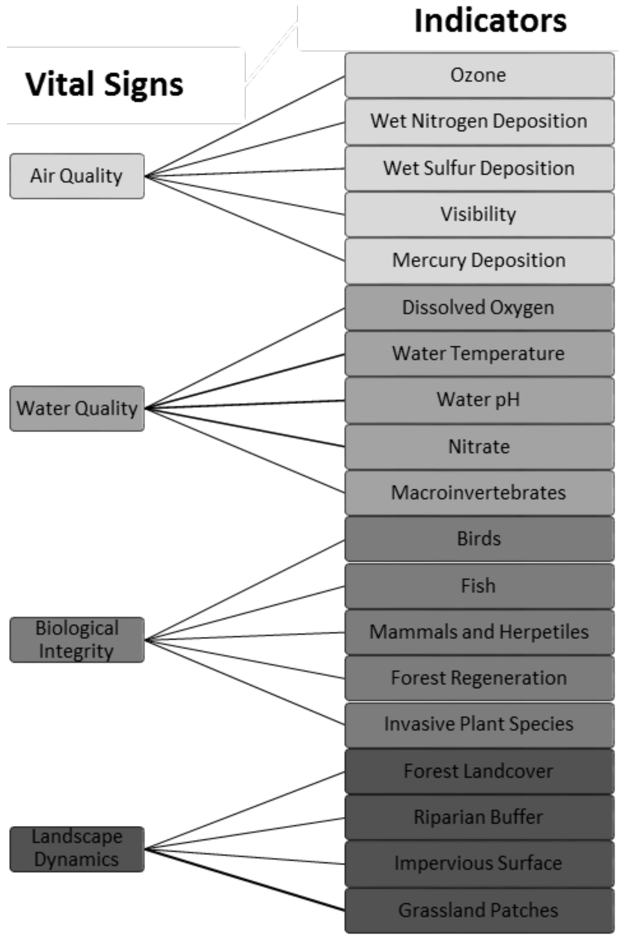


Figure 3.1. Vital signs and indicators framework.

Detailed information on indicator relevance and context, specific metrics used, assessment methods, reference condition, current condition, and trend are provided for each indicator in Chapter 4. Each indicator section also contains an assessment of data gaps and level of confidence in the assessment of that indicator, which is given as a qualitative rating (i.e., high, moderate, low) based on best professional judgment. Differences in the level of confidence of each of the individual indicators were not taken into consideration in aggregating the indicators to attain Vital Sign and park-level scores. The estimates of uncertainty could be used to prioritize future data collection and research to improve the confidence in future assessments.

3.2.2 Reporting Areas

The reporting area for the NRCA was BOWA's legislative boundary. Data are sometimes provided for larger areas that buffer the park, such as the surrounding watersheds, but this information is provided solely as context. All data used for the final assessment of park condition were collected from within the park boundaries, with the exception of air quality data, which were derived from the closest air monitoring stations outside the park.

3.2.3 General Approach and Methods

A total of 19 indicators were reviewed in this assessment (Table 3.1). The approach for assessing resource condition within the park required establishment of a reference condition (threshold) for each metric. Ideally, thresholds were ecologically based and derived from scientific literature. However, when data were not available to support peer-reviewed ecological thresholds, regulatory or management-based thresholds were used. The "Data gaps and level of confidence" subsections of Chapter 4 outline instances when best professional judgment was used in consultation with park staff to define thresholds.

Table 3.1. Summary of indicators and metrics evaluated for BOWA.

Priority Resource (Level 1 Vital Sign)	Indicator of Concern	Specific Measure
Air Quality	Ozone	Ozone Concentration
Air Quality	Wet Nitrogen Deposition	Concentration in Precipitation
Air Quality	Wet Sulfur Deposition	Concentration in Precipitation
Air Quality	Visibility	Haze Index Score
Air Quality	Mercury Deposition	Mercury Concentration
Water Quality	Dissolved Oxygen	Dissolved Oxygen (DO) Concentration
Water Quality	Water Temperature	Temperature
Water Quality	Water pH	pH Values
Water Quality	Nitrate	Nitrate (NO_3) Concentration
Water Quality	Macroinvertebrates	Index of Biologic Integrity
Biological Integrity	Birds	Bird Community Index
Biological Integrity	Fish	Fish Density
Biological Integrity	Mammals, Amphibians, & Reptiles	Species Richness
Biological Integrity	Forest Regeneration	Seedling Density
Biological Integrity	Invasive Plant Species	Presence/Absence of Indicator Species
Landscape Dynamics	Forest Land Cover	Percent of Land Cover that is Forest
Landscape Dynamics	Riparian Buffers	Percent of Riparian Buffer that is Forest
Landscape Dynamics	Impervious Surface	Percent Land Cover that is Impervious Surface Cover
Landscape Dynamics	Grassland Patches	Size of Largest Patch

Metric scores were calculated based on the percentage of sites or samples that met or exceeded threshold values for each metric. A metric attainment score of 100% reflected that the metric *at all sites and at all times* met the threshold identified to maintain natural resources. Conversely, a score of 0% indicated that *no sites at any sampling time* met the threshold value. In some cases where more than one threshold was available for a metric (e.g., a desired condition and a worst-case condition), multiples threshold were used in the assessment. Once the attainment score was calculated for each metric, an unweighted mean was then calculated for each Vital Sign to determine the condition of each category. An unweighted mean of the four Vital Sign categories was then calculated to assess the overall condition of the park. Attainment scores for each metric are presented in Chapter 4 and synthesized further in Chapter 5.

Indicators were assigned qualitative ratings corresponding to their quantitative scores based on recommended NPS guidance (Figure 3.2): a 0-33% condition attainment score warranted significant concern, a 34-66% condition attainment score was associated with moderate concern, and an indicator with a 67-100% condition attainment score was considered in good condition. Key findings and recommendations were summarized for each Vital Sign category.

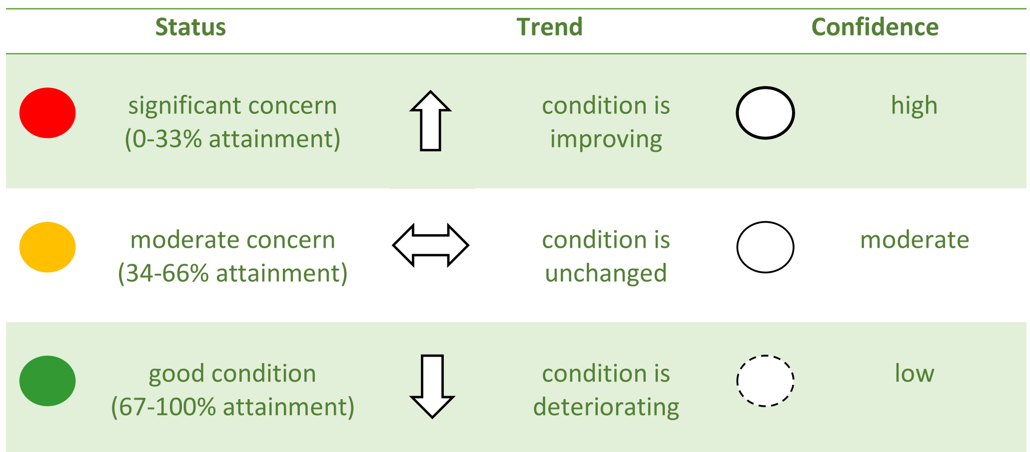


Figure 3.2. NPS Natural Resource Condition standard symbology.

Chapter 4. Natural Resource Conditions

4.1 Air Quality

4.1.1 Ozone

Relevance and context

Ozone, a secondary atmospheric pollutant, is not directly emitted but formed by a sunlight-driven chemical reaction on nitrous oxides and volatile organic compounds that are emitted largely from burning fossil fuels (Haagen-Smit and Fox 1956). Ozone in the troposphere can cause a number of health-related issues for humans, such as lung inflammation and reduced lung function, both of which can result in hospitalization. Ozone concentrations of 120 ppb can be harmful to human lungs, even with short exposures during heavy exertion, such as jogging; similar issues can occur from prolonged exposure to ozone concentrations of 80 ppb (McKee et al. 1996). Nationally, the distribution of tropospheric ozone is relatively high in the Mid-Atlantic United States (Figure 4.1) (NPS ARD 2010a).

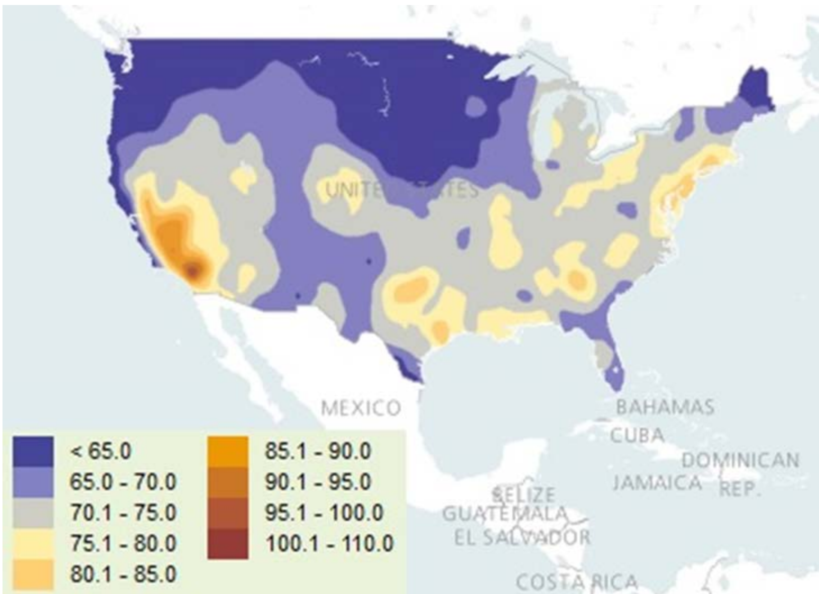


Figure 4.1. National patterns of ozone concentrations, average annual 4th highest daily maximum 8-hour ozone concentrations in ppb, 1999-2008 (NPS ARD 2010a).

A wide variety of Eastern U.S. vegetation on NPS lands may be vulnerable to ozone pollution (Lovett et al. 2009). One study, in which 28 plant species, including American sycamore (*Plantanus occidentalis*), were exposed to ozone for periods of time between 3 and 6 weeks, showed foliar impacts including premature defoliation in all species at ozone concentrations between 60 and 90 ppb (Kline et al. 2008). Several plant species in the park are at risk of foliar injury as a result of high ozone levels (Table 4.1) (NPS 2004). Ozone can also negatively affect the pollination process by destroying the scent-bearing molecules released by flowers to attract pollinators, and ozone pollution may be playing a role in the recent collapse of honeybee and bumblebee colonies in the U.S. (McFrederick et al. 2008).

Table 4.1. Species at risk of foliar injury from ozone in BOWA (NPS Ozone Injury Assessment 2004).

Scientific Name	Common Name	Family
Fraxinus americana	White ash	Oleaceae
Fraxinus pennsylvanica	Green ash	Oleaceae
Liriodendron tulipifera	Yellow-poplar	Magnoliaceae
Parthenocissus quinquefolia	Virginia creeper	Vitaceae
Pinus taeda	Loblolly pine	Pinaceae
Pinus virginiana	Virginia pine	Pinaceae
Platanus occidentalis	American sycamore	Platanaceae
Prunus serotina	Black cherry	Rosaceae
Rhus copallina	Flameleaf sumac	Anacardiacea
Robinia pseudoacacia	Black locust	Fabaceae
Sambucus canadensis	American elder	Caprifoliaceae
Sassafras albidum	Sassafras	Lauraceae

Data and methods

Ozone is not measured within the park boundary but is interpolated from nearby stations by kriging, a statistical interpolation process. The closest assessment point to the park is located in Vinton, Virginia, 25 km (16 mi) northwest of the park (Comiskey and Callahan 2008). Data were provided by NPS ARD as the annual 4th highest daily maximum 8-hour average ozone concentration measured (H. Salazar, personal communication). These annual values are aggregated by NPS ARD to provide average values for 5-year intervals. The 5-year average for 2011-2015 was assessed against the threshold (ozone standard) to assess current condition. For assessment of trends, NPS ARD estimates of the 5-year average values dating back to the 1995-1999 analysis window were considered (NPS ARD n.d.; 2011a, b, c, d; NPS ARD 2012a, b, NPS ARD 2014; NPS ARD 2017a,b).

Threshold

Tropospheric ozone is regulated under the Clean Air Act, and the U.S. EPA is required to set standard concentrations for ozone (U.S. EPA 2004). In 1997, the ozone standard was set by the National Ambient Air Quality Standards (NAAQS) as 80 ppb for the 3-year average annual 4th highest daily maximum 8-hour ozone concentrations (U.S. EPA 2006). This standard has subsequently been lowered to 70 ppb (NAAQS 2008), with a current proposal for further reduction to an acceptable range of 60-70 ppb (NAAQS 2010). For this assessment, multiple threshold concentrations were used: concentrations >75 ppb were assigned an attainment score of 0%, concentrations <60 ppb were assigned an attainment score of 100%. Concentrations between 60-75 ppb were scaled linearly from 0 to 100% between these two reference points.

Current condition and trend

BOWA's 2011-2015 ozone value of 63.7 ppb indicates good condition based on comparison to the thresholds of 75.0 ppb and 60 ppb. The 63.7 ppb value represents a current attainment score of 75% for the park. However, ozone levels have been improving over the past decade. From the NPS Air

Quality estimates (five-year averages), the interpolated 4th highest daily maximum 8-hour ozone concentration for the park has decreased for 11 successive 5-year periods from 86.2 ppb in 1995-1999 to 63.7 ppb in 2011-2015 (Figure 4.2). This reported trend is consistent with regional trends of declining tropospheric ozone concentrations (NPS ARD 2010a).

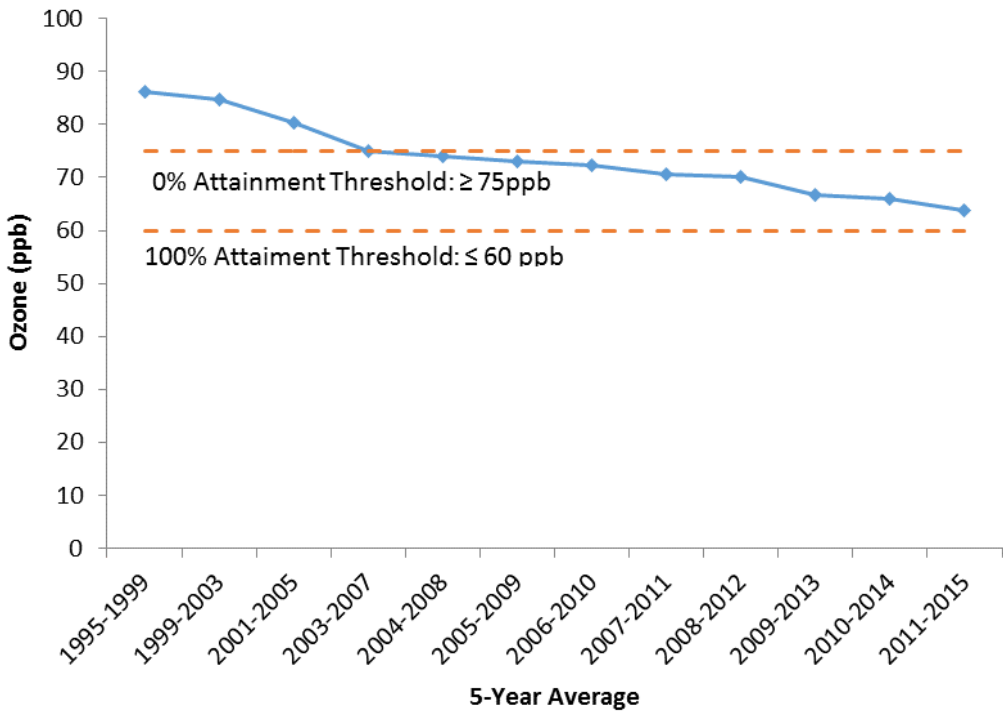


Figure 4.2. Five-year average values of annual 4th highest 8-hour concentration for BOWA (NPS ARD n.d.; 2011a, b, c, d; NPS ARD 2012a, b; NPS ARD 2014; NPS ARD 2017a, b).

Data gaps and level of confidence

Most MIDN parks, including BOWA, do not have on-site ambient air quality monitoring stations. Though in most cases, there are monitoring stations nearby from which data can be obtained. However, these regional air data must be translated to park-level estimates. Although the data used for this assessment represent 5-year average values, which were compared to thresholds that were based on NAAQS 3-year average concentrations, there is no reason to believe this difference would bias the results. The degree of confidence in the assessment for both human health data and vegetation health data is moderate, because estimates are based on interpolated data from more distant ozone monitors.

Sources of expertise

Holly Salazer, NPS Northeast Region Air Resources Coordinator

4.1.2 Wet Nitrogen Deposition

Relevance and context

Atmospheric deposition is the accumulation of airborne particles and gases on the earth's surface. This process can occur either through precipitation (wet deposition) or as a result of atmospheric settling, impaction, and adsorption (dry deposition) (Porter and Morris 2007). Deposited material includes a wide variety of natural and anthropogenic pollutants, including inorganic elements and compounds (e.g., nitrogen, sulfur, basic cations, mercury and other metals) and organic compounds (e.g., pesticides and herbicides). For this assessment, we considered only wet deposition of total nitrogen and total sulfur.

During the 1940s and 1950s, the United States and Britain recognized that coal burning emissions from large-scale industry, such as power plants and steel mills, were degrading air quality in major cities, which was significantly impacting human health. By the early 1970s, the US EPA had established the National Ambient Air Quality Standards (NAAQS) (Porter and Johnson 2007). The National Atmospheric Deposition Program (NADP) has monitored wet deposition through testing of snow and rain samples for over 20 years (Sullivan et al. 2011b). Once deposited, pollutants can have significant effects on ecosystems, in addition to human health (Porter and Morris 2007). These impacts result largely from the acidification and nutrient fertilization of waters and soils, and include such measurable effects as the disruption of nutrient cycling, changes to vegetation structure, loss of stream biodiversity, and the eutrophication of streams and coastal waters (Driscoll et al. 2001; Porter and Johnson 2007).

Data and methods

Data used for the park assessment were based on concentrations kriged from nearby stations. These concentrations were multiplied by annual average precipitation (30-year average derived from 1971-2000 provided in Daly et al. 2002) to estimate the total annual amount of nitrogen deposited. These estimates were derived by NPS ARD from monitoring stations in Natural Bridge, Virginia, about 60 km (38 mi) from BOWA and Eggleston, Virginia, about 80 km (50 mi) from BOWA (Comiskey and Callahan 2008). Current condition was assessed based on the average annual deposition between 2011 and 2015. For assessment of trends, NPS ARD estimates of the five-year average values dating back to the 2001-2005 analysis window were used (NPS ARD 2011e, f, g, h, i, j, 2012e, f; 2014a, b; 2017c, d).

Threshold

Background levels of nitrogen deposited (both wet and dry) by natural sources in the Eastern U.S. have been estimated at 0.5 kg/ha/yr, which equates to a wet deposition of approximately 0.25 kg/ha/yr (Porter and Morris 2007; NPS ARD 2011f,g). NPS ARD has established wet nitrogen deposition guidelines as <1 kg/ha/yr indicating good condition, 1-3 kg/ha/yr indicating moderate concern, and >3 kg/ha/yr indicating significant concern (NPS ARD 2011f,g). While there is no evidence of ecosystem harm at deposition rates less than 1 kg/ha/yr, sensitive ecosystems show responses to wet nitrogen deposition rates as little as 1.5 kg/ha/yr (Fenn et al. 2003). For this assessment, multiple thresholds were used; ≥3 kg/ha/yr was considered to be of significant concern (score of 0%), deposition rates ≤ 1 kg/ha/year were considered good condition (attainment score of 100%), and deposition between 1 kg/ha/yr and 3 kg/ha/yr were scaled linearly from 0 to 100% between these two reference points.

Current condition and trend

Based on the threshold value of 3 kg/ha/yr, the 2011-2015 3.20 kg/ha/yr value of total nitrogen wet deposition in the park indicates a rating of significant concern and yields a current attainment score of 0%. Total nitrogen wet deposition in BOWA has decreased from a value of 4.04 kg/ha/yr for 2001-2005 to 3.20 kg/ha/yr for 2011-2015 (Figure 4.3). This reflects an improving trend consistent with U.S.-wide reductions in emissions over the past decades (Driscoll et al. 2001), and is consistent with decreasing trends in most parks in the Eastern U.S. (NPS ARD 2010a). Additional reductions in nitrogen wet deposition are still needed to reduce negative impacts on natural resource condition (Porter and Johnson 2007). Sullivan et al. (2011a) found BOWA to be ranked moderate in nitrogen pollutant exposure, and to have very low ecosystem sensitivity to nitrogen enrichment. This is due in part to the fact that smaller parks (> 100mi^2), like BOWA, contain only limited pollution-sensitive resources (Sullivan et al 2011a).

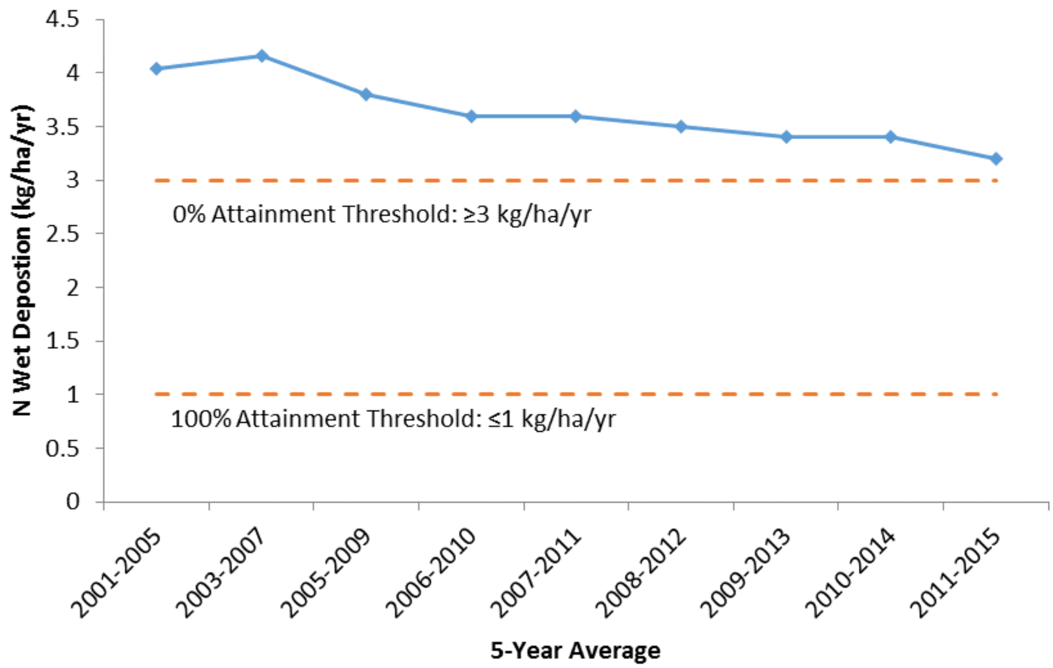


Figure 4.3. Five-year average values in total nitrogen wet deposition (kg/ha/yr) for BOWA (NPS ARD 2011f, g, h, i, j; 2012e, f; 2014a, b; 2017c, d).

Data gaps and level of confidence

Many of the parks in the MIDN, including BOWA, are miles from the closest NADP/National Trends Network (NTN) monitoring stations, requiring considerable interpolation to derive park-based estimates (Figure 4.4). The distance between monitoring stations and the park is problematic because variability in wind patterns and localized meteorology may significantly affect pollutant deposition. The closest monitoring site to BOWA is approximately 60 km (38 mi) from the park (Comiskey and Callahan, 2008), in Natural Bridge, Virginia (site #VA99). Confidence in the current assessment is moderate because estimates are based on interpolated data from off-site monitoring stations, balanced against the high quality of the data being collected and the quantitative rigor with which the NPS ARD program derives the deposition estimates.

Sources of expertise
Holly Salazer, NPS Northeast Region Air Resources Coordinator

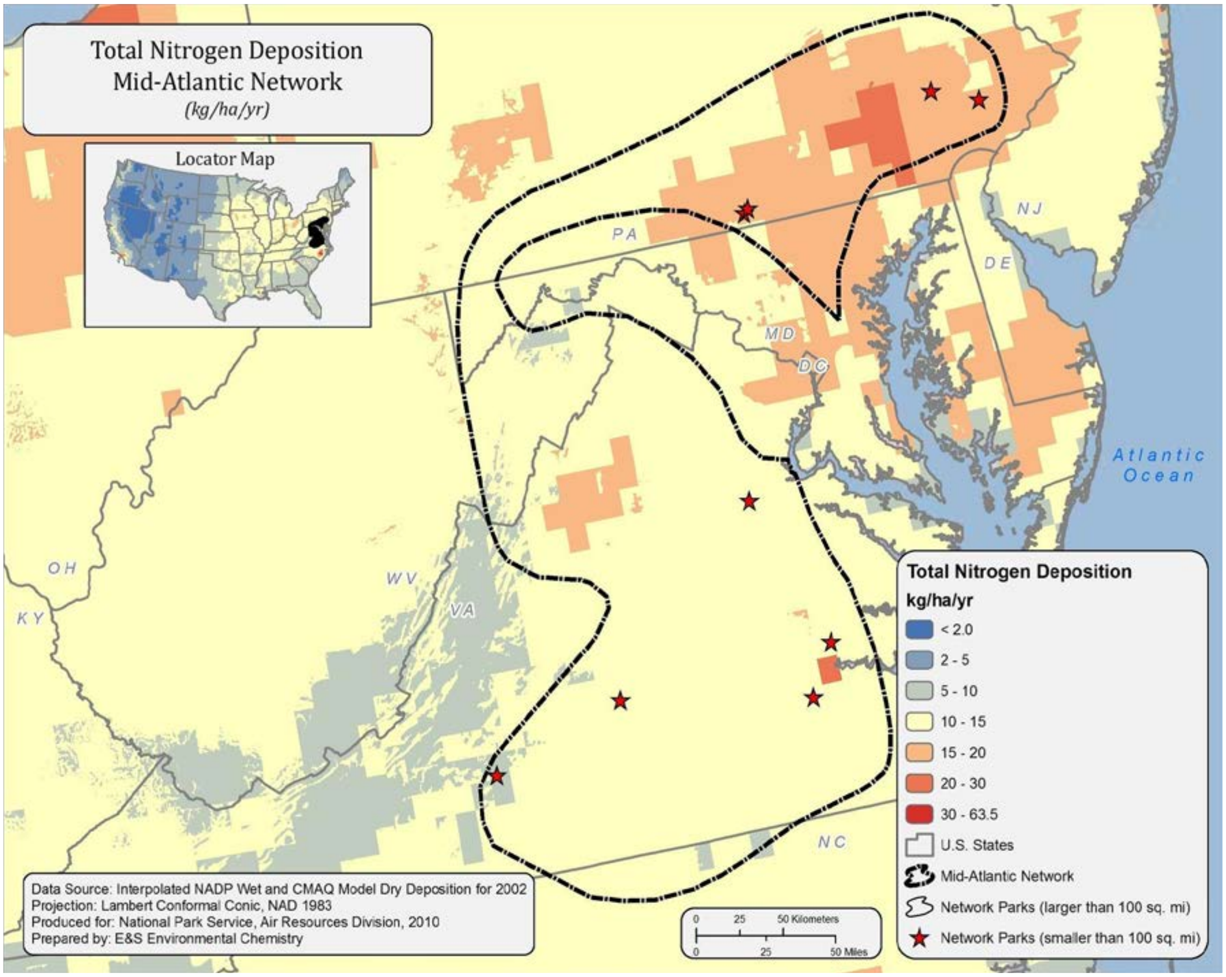


Figure 4.4. Total nitrogen deposition estimates for the MIDN (Sullivan et al. 2011a).

4.1.3 Wet Sulfur Deposition

Relevance and context
Wet deposition of sulfur in the park comes largely from upwind emissions of sulfate. Sixty percent of U.S. emissions of sulfate come from electric utilities, and 41% come from the seven Midwest states centered on the Ohio Valley (Driscoll et al. 2001). Once in the atmosphere, sulfate is highly mobile and can be transported distances greater than 500 km (311 mi) (Driscoll et al. 2001). As a consequence of its high mobility, sulfur deposition is higher in the Eastern United States than the Western United States. Estimating deposition levels and patterns requires detailed consideration of meteorology, atmospheric transport, atmospheric chemistry, precipitation patterns, and vegetative cover (Sullivan et al. 2011b).

Annual emissions of sulfate in the U.S. increased from 9 million metric tons in 1900 up to 28.8 million metric tons by 1973. After the establishment of Clean Air Act regulations, emissions were reduced to 17.8 million metric tons by 1996 (Driscoll et al. 2001). The effect of this emission reduction on deposition rates was substantial. Phase I of the sulfate reduction provision of the Clean Air Act ran from 1995 through 1999 and affected roughly 440 of the largest emitting utility facilities, most of which were in the Eastern United States. Phase II began in 2000, extending to all affected sources throughout the country (Driscoll et al. 2001). Large areas of the Eastern United States, however, still experience deposition levels well above those to be expected from natural sources alone (Driscoll et al. 2001). Wet sulfur deposition can cause acidification of soil, soil water, lakes, and streams, which in turn can affect fish, insect, and plant communities (Sullivan et al. 2011b).

Data and methods

Data used for the park assessment were spatially interpolated by NPS ARD from the closest NADP/NTN monitoring stations (NPS ARD 2012). The closest monitoring site to BOWA is in Natural Bridge, VA (site #VA99), about 60 km (38 mi) from the park. For current condition, the estimated average annual total sulfur wet deposition for the park for the five-year period from 2011-2015 was used (NPS 2017f). For the assessment of trends, five-year average values dating back to the 2001 to 2005 window were also analyzed (NPS ARD 2010b; 2011e, 2012e, f, 2014a, b; 2017e, f).

Threshold

Total background sulfur deposition from natural sources in the Eastern U.S. is 0.5 kg/ha/yr, which equates to a wet deposition of approximately 0.25 kg/ha/yr (Porter and Morris 2007; NPS ARD 2010a). NPS ARD has established wet sulfur deposition guidelines of <1 kg/ha/yr indicating good condition, 1-3 kg/ha/yr indicating moderate concern, and >3 kg/ha/ yr indicating significant concern. For this assessment, multiple thresholds were used: ≥3 kg/ha/yr was considered to be of significant concern (score of 0%), deposition rates ≤ 1 kg/ha/year were considered to be good condition (attainment score of 100%), and deposition between 3 kg/ha/yr and 1 kg/ha/yr were scaled linearly from 0 to 100% between these two reference points.

Current condition and trend

The 2011-2015 average annual sulfur wet deposition rate for the park was 2.1 kg/ha/yr, indicating moderate concern based on comparison to the thresholds of 3 kg/ha/yr and 1 kg/ha/yr. This represents a current condition of 45% attainment for the park. Factors such as land slope, the presence of high-elevation lakes and streams, acid-sensitive tree species, and low-order streams all increase a park's ecosystem sensitivity to acid deposition. BOWA's geography and low-elevation, paired with its geology, topography, and vegetation communities translate to a relatively low susceptible or sensitive to acidification effects, especially compared to other parks in the I&M Program (Sullivan et al. 2011b). Total sulfur wet deposition has decreased over time for the park from an estimated 5.02 kg/ha/yr for 2001-2005 (Figure 4.5).

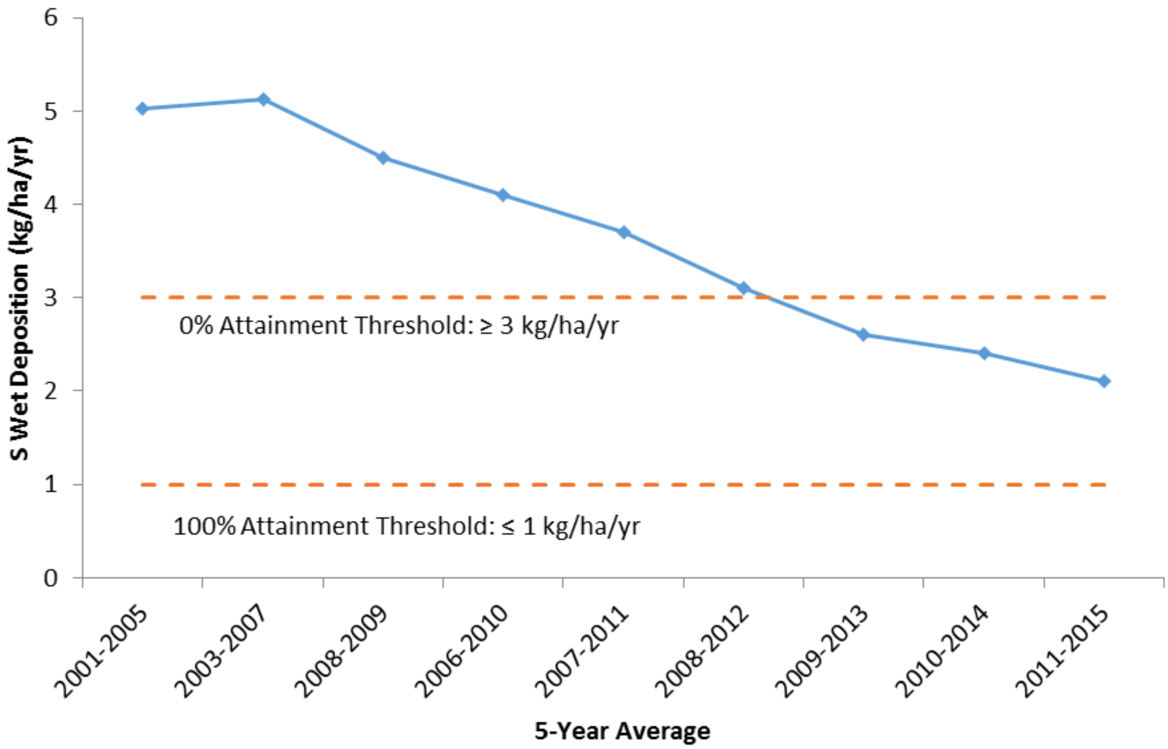


Figure 4.5. Five year average values of total sulfur wet deposition (kg/ha/yr) for BOWA (NPS ARD 2010b; 2011e, 2012e, f, 2014a, b; 2017e, f).

Data gaps and level of confidence

Many of the closest NADP/NTN monitoring stations within the MIDN are located far from the parks, requiring considerable interpolation to derive park-based estimates. The distance between monitoring stations and the parks is problematic because wind patterns and localized meteorology may significantly affect pollutant deposition. The closest monitoring site to BOWA is located in Natural Bridge, Virginia, about 60 km (38 mi) from the park (Comiskey and Callahan 2008). Based on the high quality of the data, balanced against the distance of the monitoring stations, confidence in the current assessment is moderate.

Sources of expertise

Holly Salazer, NPS Northeast Region Air Resources Coordinator

4.1.4 Visibility

Relevance and context

Improving visibility in national parks and wilderness areas has been of special concern to the NPS to protect the scenic vistas expected by visitors (Loomis and Garnand 1986; NPS 1986). Particles less than 2.5 m diameter (PM 2.5) are emitted as smoke from power plants, gasoline and diesel engines, wood combustion, steel mills, forest fires, and chemical reactions (U.S. EPA 2006). These particles can have significant health impacts on humans and can negatively affect visibility (U.S. EPA 2004b; Cheung et al. 2005). Although the presence of organic matter, soot, nitrates, and soil dust all impair visibility, the major cause of reduced visibility in the Eastern U.S. is sulfate particles formed from coal combustion (National Research Council 1993). Nationally, visibility is relatively low in the Eastern U.S. (Figure 4.6) (NPS ARD 2010a). The Clean Air Act includes reduced visibility as an indicator of broader air quality degradation linked to human activities (U.S. EPA 2004a). The Clean Air Act visibility goal requires improvement of visibility on the 20% haziest days and no degradation on the 20% clearest days.

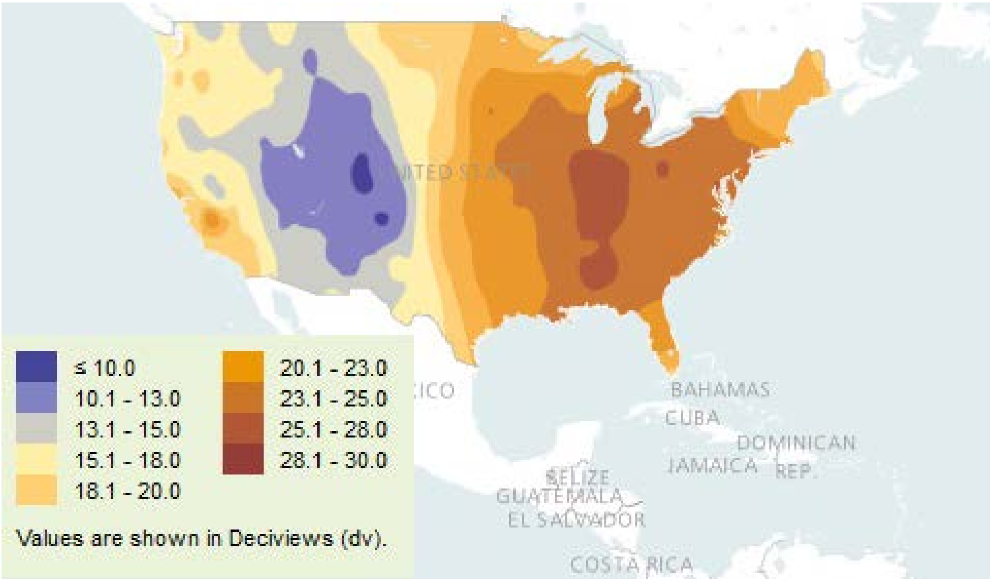


Figure 4.6. National patterns in haziest day haze index (dv) for the United States, 1999-2008 (NPS ARD 2010a).

Data and methods

Data used for the park assessment were statistically interpolated from a nearby Interagency Monitoring of Protected Visual Environments (IMPROVE) haze monitoring station in the James River Face Wilderness (IMPROVE Station JARI1) to the central point within BOWA (NPS ARD 2012c, d). The haze index, measured in deciviews (dv), indicates the difference between current group 50 visibility (the mean value of the 40th – 60th percentile data) and the natural group 50 visibility (estimated visibility in the absence of human-caused visibility impairment) (U.S. EPA 2003; NPS ARD 2011k). The current condition for the park was assessed using the average haze index value for the five-year period from 2011-2015 (NPS ARD 2017h). For assessment of trend, data dating back to 2001 were also analyzed (NPS ARD 2011k, n, 2012c, d; 2014c; 2017g, h).

Threshold

Based on NPS guidance, a calculated haze index where the visibility is ≥8 dv above a natural visibility condition was considered to be of significant concern, with a 0% attainment score; concentrations ≤ 2 dv above a natural visibility condition were considered to be in good condition, with a 100% attainment score (NPS ARD 2010a). Concentrations between 2-8 dv above a natural visibility condition were scaled linearly from 0 to 100% between these two reference points.

Current condition and trend

The park's 2011-2015 value of 8.6 dv indicates a condition of significant concern based on comparisons to a threshold of 8 dv (Figure 4.7). This value represents a current condition of 0% attainment for the park. The trend in these data indicates improving conditions for the park in recent years (Figure 4.7). The finding is consistent with national and regional trends. An assessment of 10-year trends in visibility within 163 NPS units throughout the country found that 12 park units showed significant improvement, five significant decline, and the remaining 146 showed no trend. Considering data from the haziest days in the Eastern U.S., several of the parks in Virginia, including BOWA, showed possible or significant improvement from 1999 to 2008 (NPS ARD 2010a).

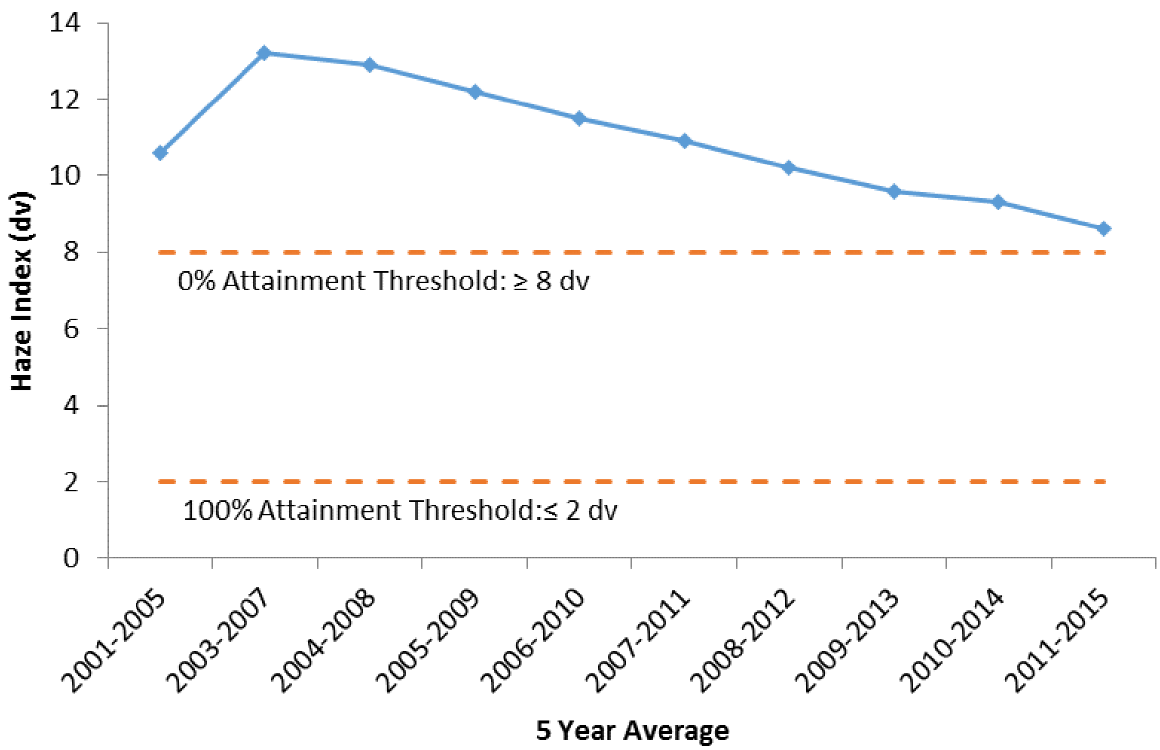


Figure 4.7. Five-year average values of haze index (dv) for BOWA (NPS 2011k, n, o; 2012c, d; 2014c; 2017g, h).

Data gaps and level of confidence

Data were collected from the IMPROVE JARI1 monitoring station in the nearby James River Face Wilderness in Natural Bridge, Virginia. This monitoring station is the closest station to BOWA boundaries and lies approximately 60 km (38 mi) from the park (Comiskey and Callahan 2008). The degree of confidence in this assessment is moderate.

Sources of expertise

Holly Salazer, NPS Northeast Region Air Resources Coordinator

4.1.5 Mercury Deposition

Relevance and context

Atmospheric mercury (Hg) comes from both natural sources (e.g., volcanoes, geothermal activity, and geological weathering) and anthropogenic sources such as the burning of fossil fuels, processing of mineral ores, and incineration of certain waste products (UNEP 2008). At a global scale, annual anthropogenic emissions of mercury equal approximately all natural marine and terrestrial emissions. Anthropogenic emissions in North America amounted to approximately 153 tonnes (168.7 tons) in 2005 (UNEP 2008). Exposure of humans and other mammals to mercury in utero can result in mental retardation, cerebral palsy, deafness, blindness, and dysarthria (speech disorder). Exposure as adults can lead to motor dysfunction and other neurological and mental impacts (U.S. EPA 2001). Terrestrial vertebrates are often exposed to mercury through the ingestion of food, water, and soil (Rattner and Ackerson 2006). Avian species' reproductive potential is negatively impacted by mercury. Measured trends in mercury deposition from west to east across North America can be observed in the common loon (*Gavia immer*), and throughout North America in mosquitoes (Evers et al. 1998, Hammerschmidt and Fitzgerald 2006). Mercury is also known to have a toxic effect on soil micro-flora (Meili et al. 2003). Although no ecological depositional threshold is currently established, the accumulation of mercury in organisms may affect key ecosystem processes (NPS 2013).

Data and methods

Data were obtained from the NADP Mercury Deposition Network (MDN) for Shenandoah National Park-Big Meadows VA28, which is about 250 km (155 mi) away from BOWA (http://nadp.sws.uiuc.edu/nadpdata/mdnsites.asp). Samples were collected continually in week-long intervals and analyzed for mercury concentration (measured in ng/L). Annual mean mercury concentrations were calculated and compared to the threshold. Current condition was assessed for the year 2013. Trend was assessed from 2002 to 2013.

Threshold

The indirect regulatory threshold of 2 ng/L in rainwater is a modeled estimate of mercury in rainfall that may result in a mercury concentration of 0.5 mg/kg wet weight in inland fish (Meili et al. 2003).This threshold was developed for low organic soils. It should be noted that highly humic soils in contrast are known to store large amounts of mercury that may later leach into inland waters, supplementing current atmospheric deposition (Meili et al. 2003). The threshold used for this assessment was 2 ng/L. Concentrations greater than this threshold were considered to be of significant concern and were assigned a score of 0% attainment. Concentrations less than 2 ng/L were considered to be in good condition and were assigned a score of 100% attainment.

Current condition and trend

The 2013 value of 5.33 ng/L represents a significant concern compared to the threshold for mercury concentration of 2 ng/L. This value represents a current condition of 0% attainment for the park. From 2002 to 2013, mercury concentrations increased slightly (Figure 4.8).

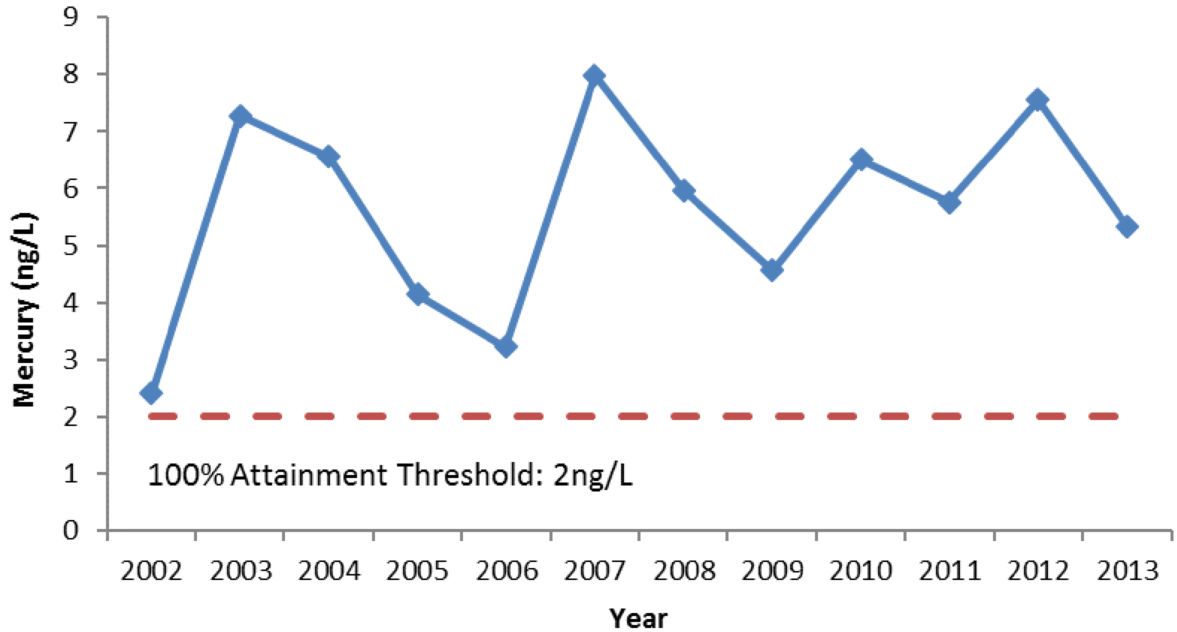


Figure 4.8. Mercury deposition in BOWA (NADP MDN 2014).

Data gaps and level of confidence

Data were collected from the NADP Mercury Deposition Network (MDN) monitoring station in Shenandoah National Park – Big Meadows, about 250 km (155 mi) away from BOWA. Confidence in the assessment is moderate because of the distance between the park and the collection station.

Source of expertise

Holly Salazer, NPS Northeast Region Air Resources Coordinator

4.2 Water Quality

4.2.1 Dissolved Oxygen

Relevance and context

Dissolved oxygen (DO) is a measure of the amount of oxygen contained in a body of water. Low DO concentrations can limit growth, species and population size, community richness, and ecosystem diversity (Breitburg 2002). The amount of oxygen in streams is inversely correlated with anthropogenic stresses such as fertilizer runoff and the dumping of sewage into waterways (Correll 1988, Prasad et al. 2011). As nutrient levels increase in aquatic systems due to these types of human activities, algae populations can proliferate leading to a depletion of oxygen in the water. The anoxic conditions that result affect nutrient cycling and stream biogeochemistry in potentially toxic ways (Brush 2009). Inputs from freshwater systems has led to significant eutrophication and prolonged anoxic conditions in large estuarine receiving bodies over the past 50 years (Cooper and Brush 1991, Murphy et al. 2011).

Data and methods

DO data were collected in accordance with the Mid-Atlantic Network's Vital Signs Monitoring Protocol using the YSI ProPlus Multiparameter Probe (Dammeyer and Weed 2017). Samples were collected by BOWA staff and their volunteers on a monthly basis. Five monitoring sites within BOWA were used for all water quality monitoring (Figure 4.9). Data used in the assessment cover the period from 2010-2013. Percent attainment was calculated for this metric as the percent of DO measurements that were above the regulatory threshold value.

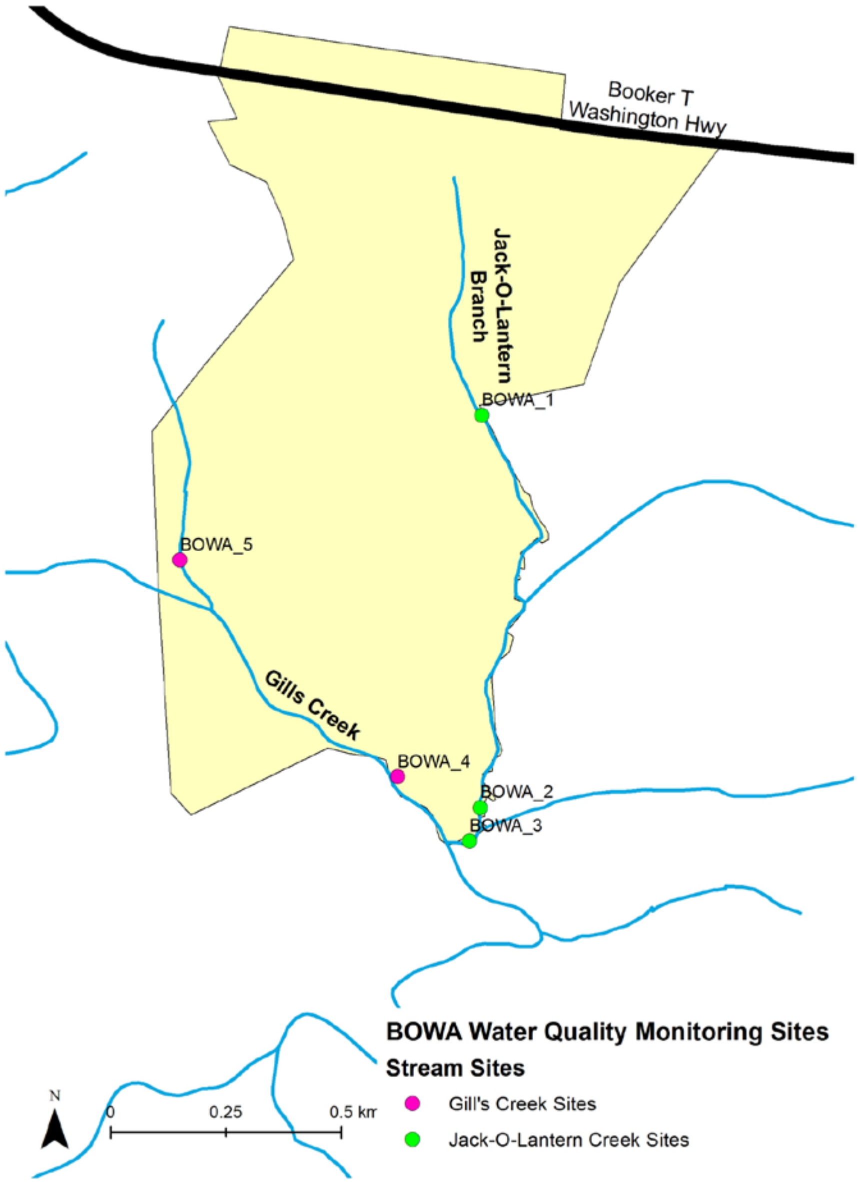


Figure 4.9. Map of water quality monitoring sites in BOWA (Dammeyer and Weed 2017).

Threshold

The Virginia Department of Environmental Quality sets regulatory threshold levels for DO with enforcement consequences when not met (VADEQ 2010). Within Class III non-tidal waters of the Coastal Plain and Piedmont, DO levels during the day should never drop below 4.0 mg/L and the average for a 24-hour period should not be less than 5.0 mg/L. Because the data collected in the park are not collected continuously throughout the day, the 5.0 mg/L value is used as the minimal threshold for the assessment.

Current condition and trend

Using data from 2013, the current condition for DO in the park is 100% attainment; all five sample locations were above the 5.0 mg/L value threshold for the entire year, with an average value of 10.8 mg/L. From 2010-2013, none of the five sample locations had a significant annual trend (Figure 4.10). There is a strong seasonal trend of peaks in the winter and troughs in the summer, as temperature and DO concentration are inversely related (Barbour et al. 1999).

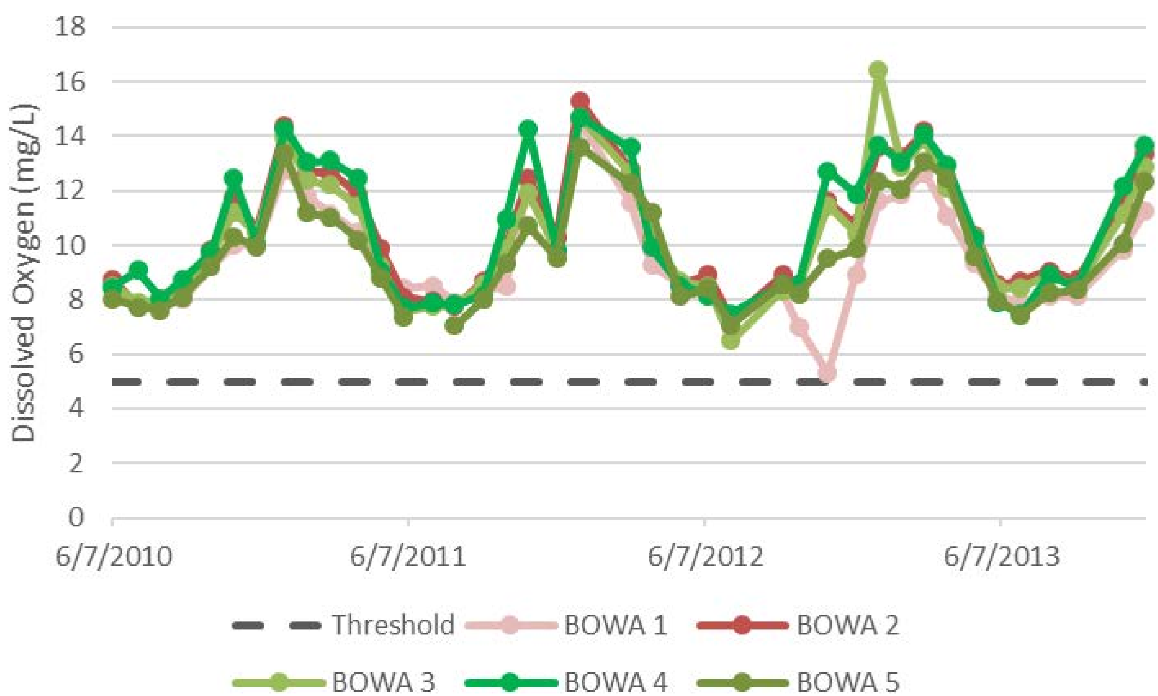


Figure 4.10. Monthly DO levels at sampling sites in BOWA (MIDN I&M Program).

Data gaps and level of confidence

Data span a relatively short period of time, especially for a comprehensive assessment of trends. Nevertheless, these data were collected using strict quality assurance/quality control measures and following standard NPS Protocols (Dammeyer and Weed 2017). The level of confidence therefore is moderate, and continued monitoring is recommended to track any potential trends.

Sources of expertise

Nathan Dammeyer, Hydrologist, MIDN, NPS

4.2.2 Water Temperature

Relevance and context

Water temperature strongly influences aquatic processes and biota. The mean temperature of Mid-Atlantic streams has increased significantly over the past 50 years (Isaac and Wijingaarden 2012). Changes in water temperature can be triggered by anthropogenic forces including climate change, urbanization, and deforestation (Klein 1979, Nelson and Palmer 2007, Okazi et al. 2008, Najjar et al. 2009). Stream temperatures in urban settings can be elevated by heating of runoff from paved surfaces and by the lack of canopy shading along stream riparian areas (LeBlanc et al. 1997, Herb et al. 2008). Some evidence suggests that stream temperatures are more affected by impervious surfaces in the Piedmont region than the Coastal Plain (Utz et al. 2011). If water temperatures change too rapidly or too drastically, fish and macroinvertebrate survival can be reduced (Morgan and Cushman 2005, Utz et al. 2009).

Data and methods

Water temperature data were collected in accordance with the Mid-Atlantic Network's Vital Signs Monitoring Protocol using the YSI ProPlus Multiparameter Probe (Dammeyer and Weed 2017). Samples were collected by BOWA staff and their volunteers on a monthly basis. Five monitoring sites within BOWA were used for all water quality monitoring (Figure 4.9). Data used in the assessment cover the period from 2010-2013. Percent attainment was calculated for this metric as the percent of temperature measurements that were above the regulatory threshold value.

Threshold

The state has discretion for setting criteria for maximum stream temperatures. The Virginia Department of Environmental Quality criteria for maximum stream temperature outside of the mixing zone is 31°C (89.6°F) for Class IV Mountainous Zones Waters (VADEQ 2010). Streams found to exceed this maximal value are classified to be "endangered" systems.

Current condition and trend

Using data from 2013, the current condition of temperature at all five sites sampled is below the threshold of 31°C, with an average temperature of 11.2°C. This value gives the park an attainment score of 100%. There is a strong seasonal pattern but no inter-annual trend discernable in the temperature values from 2010 to 2013 (Figure 4.11).

Data gaps and level of confidence

Data span a relatively short period of time, especially for a comprehensive assessment of trends. Nevertheless, these data were collected using strict quality assurance/quality control measures and following standard NPS Protocols (Dammeyer and Weed 2017). The level of confidence therefore is moderate, and continued monitoring is recommended.

Sources of expertise

Nathan Dammeyer, Hydrologist, MIDN, NPS

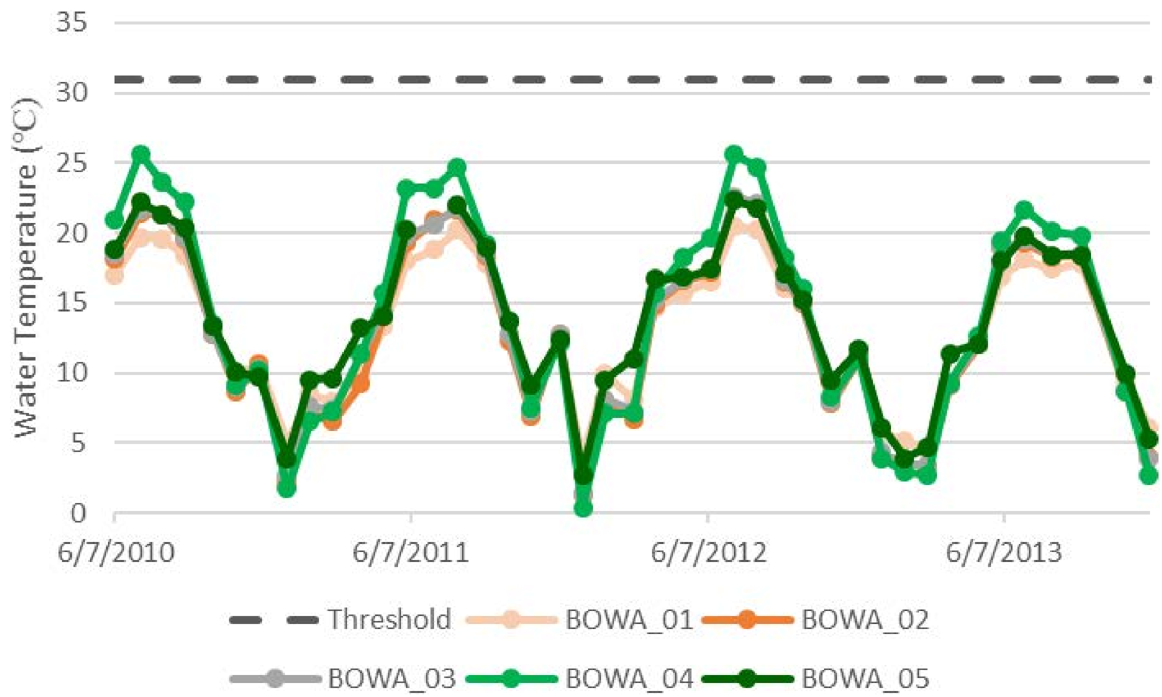


Figure 4.11. Monthly water temperature at sampling sites in BOWA (MIDN I&M Program).

4.2.3 Water pH

Relevance and context

Aquatic biota are sensitive to fluctuations in pH level. Water with either low pH (acidic) or high pH (basic) can be lethal by making toxic compounds more soluble (Sherman and Munster 2012, Driscoll et al. 2001). Acidic or basic environments also interfere with molecule structure and can render proteins and enzymes inactive (Driscoll et al. 2001). Aquatic system acidification is a concern in the region because of high levels of acid deposition, which is caused by sulfur and nitrogen emissions (Lovett et al. 2009).

Data and methods

Water pH data were collected in accordance with the Mid-Atlantic Network's Vital Signs Monitoring Protocol using the YSI ProPlus Multiparameter Probe (Dammeyer and Weed 2017). Samples were collected by BOWA staff and their volunteers on a monthly basis. Five monitoring sites within BOWA were used for all water quality monitoring (Figure 4.9). Data used in the assessment cover the period from 2010-2013. Percent attainment was calculated for this metric as the percent of pH measurements that were above the regulatory threshold value.

Threshold

The Environmental Protection agency (EPA) recommends an optimal range of 6.5-9.0 for in-situ measures of pH to be protective of aquatic life. The Virginia Department of Environmental Quality (DEQ) requires a slightly broader pH range from 6.0-9.0 for Class III non-tidal water of the Coastal Plain and Piedmont regions. This assessment uses the range of 6.0-9.0 as the state-specific criterion (NPS 1997; VADEQ 2010; EPA 2012).

Current condition and trend

Based on 2013 data, the current condition of stream water pH at sites in the park ranges between 6.7 and 7.4 at all five sites sampled, with an average pH of 7.3. The park therefore receives an attainment score of 100%. The BOWA_1 site consistently has the lowest pH. The trend in pH is assessed as stable based on the 2010 to 2013 data (Figure 4.12).

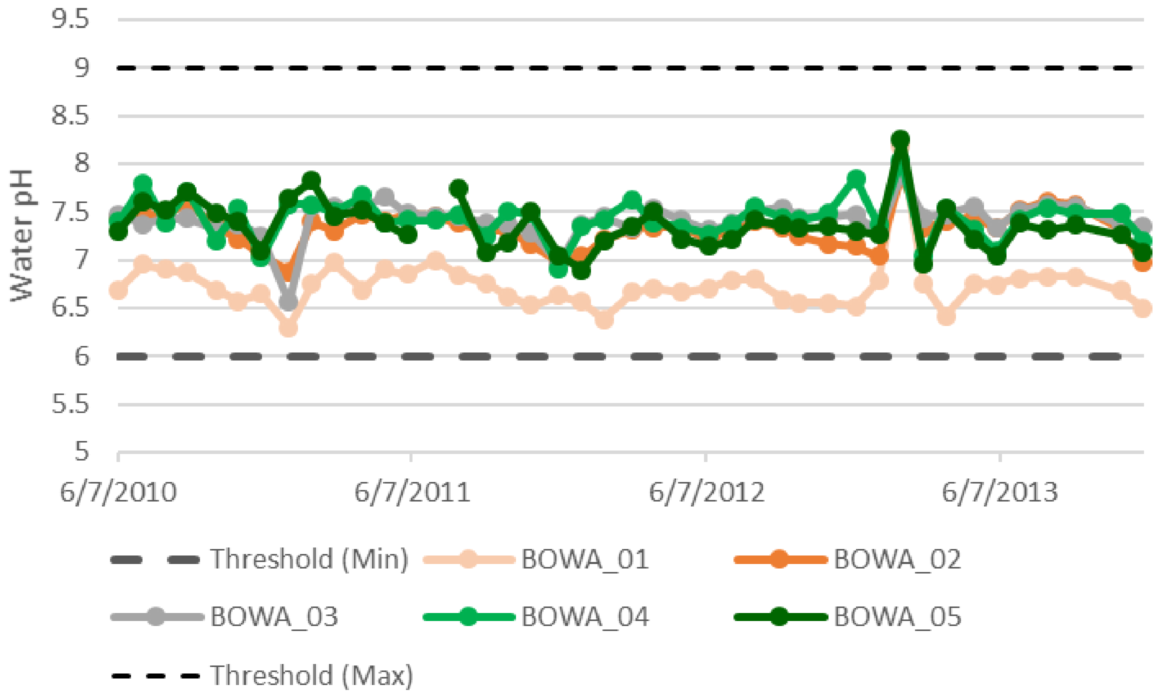


Figure 4.12. Monthly stream pH values at sample sites within BOWA (MIDN I&M Program).

Data gaps and level of confidence

Data span a relatively short period of time, especially for a comprehensive assessment of trends. Nevertheless, these data were collected using strict quality assurance/quality control measures and following standard NPS Protocols (Dammeyer and Weed 2017). The level of confidence therefore is moderate, and continued monitoring is recommended.

Sources of expertise

Nathan Dammeyer, Hydrologist, MIDN, NPS

4.2.4 Nitrate

Relevance and context

High levels of nitrogen, phosphorus, and sediments pose significant threats to surface water with potential effects ranging from harmful algal growth to decreased water clarity and dissolved oxygen (EPA 2010). The inorganic form of nitrogen - nitrate (NO_3) - is an important nutrient required for growth in most aquatic organisms. However, excessive amounts of nitrogen are harmful and even fatal to fish and invertebrates (Johnes 1996). Because nitrate is soluble in surface and ground water, agricultural operations and the use of fertilizers can cause significant additions of nitrogen to waterways, leading to eutrophication of aquatic ecosystems. These excess nutrients can lead to large algal-blooms, which can deplete oxygen levels in the water causing hypoxia (Hauer and Lamberti 2011), and can, in turn, lead to fish-kills (Dugdale and Wilkerson 1986).

Data and methods

Nitrate (NO_3) concentrations were measured in grab samples collected monthly from two sites within BOWA from 2010-2011 (BOWA_2 site and BOWA_4 site). Concentrations were determined using ion chromatography (Webb et al. 2009). Percent attainment (Figure 4.9) was calculated for this metric as the percent of nitrate measurements that were above the established threshold value.

Threshold

The Virginia Code for drinking water for nitrate as nitrogen (NO_3-N) is 10 mg/L (or 44 mg/L measured as NO_3, which is how BOWA samples were measured). Aquatic toxicity thresholds are typically lower: e.g., 8.8 mg NO_3/L (Camargo et al. 2005). In a report assessing the health of coastal Maryland waters in the Chesapeake Bay, the Maryland Department of Natural Resources set a threshold of 1 mg/L, measured as NO_3 (Wazniak et al. 2004). A threshold of 1 mg/L was used for this assessment. Samples found to exceeed this threshold were deemed in poor condition.

Current condition and trend

Four out of the 12 months in 2011 were below the 1 mg/L threshold for the sample station on Jack-O-Lantern Branch (BOWA_02), and three out of the 12 months were below the threshold for the station on Gills Creek (BOWA_04) for an overall current condition score of 29%. On average, the nitrate level at Gills Creek were higher than those observed at the Jack-O-Lantern Branch station. Concentrations were highest in the summer months. For the two years of data, there is a slight decrease in nitrate concentrations at both site (Figure 4.13), but given, the short sample period, trend is not quantified.

Data gaps and level of confidence

Data span a relatively short period of time, especially for a comprehensive assessment of trends. Nevertheless, these data were collected using strict quality assurance/quality control measures and following standard NPS Protocols. Our level of confidence therefore is moderate. Nutrient sampling was only conducted for a couple years, and nutrients are not measured regularly as part of the ongoing I&M sampling protocol. As nitrogen deposition decreases throughout the region (see section 4.1.2), the nitrogen levels in Mid-Atlantic streams have also been shown to decrease (Eshleman and Sabo 2016). However, the relationship between nitrogen levels in the air and nitrogen in water has not been explicitly demonstrated for the park.

Sources of expertise

Nathan Dammeyer, Hydrologist, MIDN, NPS

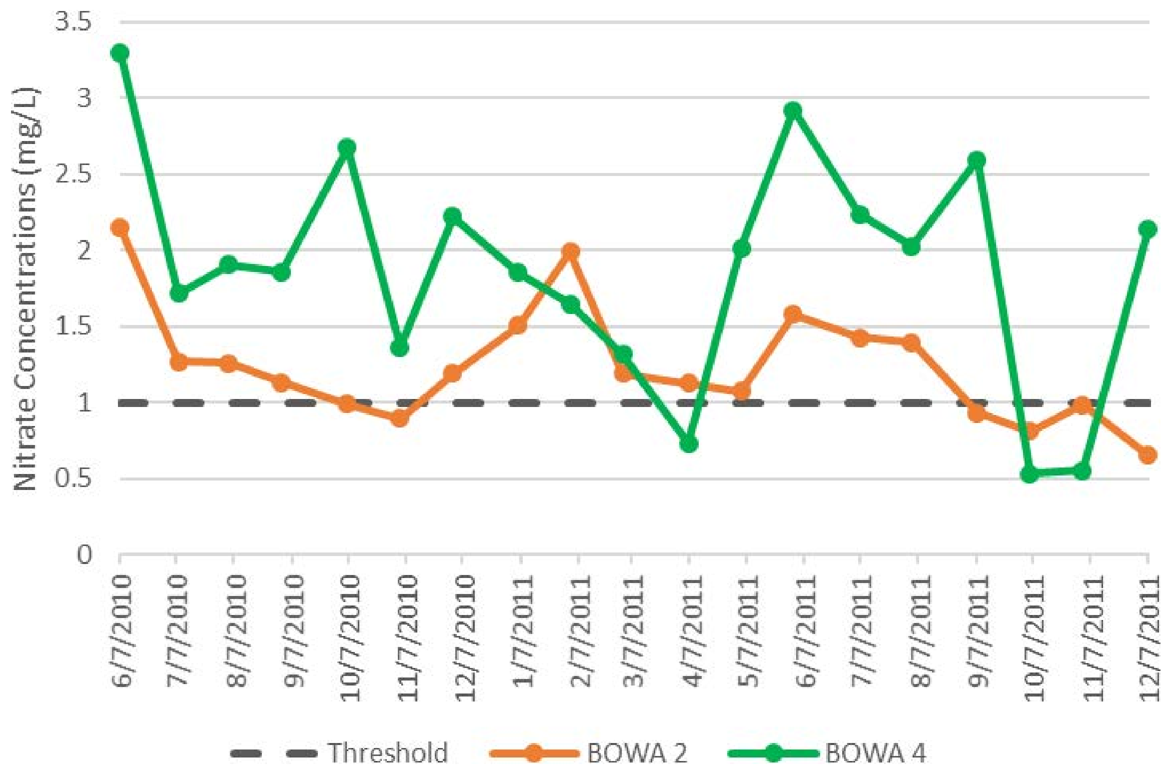


Figure 4.13. Monthly nitrate concentrations from sampling sites in BOWA (MIDN I&M Program).

4.2.5 Macroinvertebrates

<u>Relevance and context</u>

Aquatic macroinvertebrates are good indicators of aquatic ecosystem health due to their ubiquitous presence, short life cycles, relative ease with which they can be sampled, and their sensitivity to change in water chemistry and flow (Hauer and Lamberti 2011). Changes in macroinvertebrate species composition are relatively easy to detect and can be used to assess stream condition (Barbour et al. 1999). From a biomonitoring perspective, the presence of various orders and families of macroinvertebrates would indicate healthy stream conditions. These orders include: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies), otherwise known as EPT taxa in biological assessment literature (Burton and Gerritsen 2003). The presence of more pollution-tolerant orders and families is typically an indicator of impaired conditions and include certain species of midges, blackflies, worms, and snails (Burton and Gerristen 2003).

Barbour et al. (1999) developed Rapid Bioassessment Protocols for the Environmental Protection Agency with benthic macroinvertebrates as a component to evaluate the health of streams. As more regional metrics were needed, the State of Virginia modified some of Barbour's metrics and developed the Virginia Stream Condition Index (VSCI) to assess the health of its streams and relevant macroinvertebrate assemblages (Burton and Gerritsen 2003). For this assessment, metrics of the expected assemblages in streams in Virginia's Piedmont region were used.

In developing indices of biotic integrity for streams, much of the attention has been focused on benthic macroinvertebrates and fish (Barbour et al. 1999). However, there are several groups of non-insect macroinvertebrates, such as crayfish and snails, which have not been incorporated empirically into most multi-metric indices. This has mainly been attributed to the difficulty in sampling these types of macroinvertebrates (Burton and Gerritsen 2003). Crayfish present a problem because they are mobile but do not respond to electrical currents created by electrofishing (Stuecheli 1991). Snails are problematic because they are usually firmly attached to a substrate, and less research has been completed on their sensitivity to anthropogenic disturbance and pollution (Allan and Castillo 1995).

Data and methods

Aquatic invertebrate sampling has been conducted in BOWA since 2009, when the NPS initiated benthic macroinvertebrate monitoring in the MIDN (MIDN 2011). Twenty-three sites were chosen for monitoring throughout network, with two sites in BOWA: BOWA_02 and BOWA_04. At each site, a stream reach of 100 m was sampled using dip nets in a variety of microhabitats in (Figure 4.9) order to obtain a representative sample of the macroinvertebrate assemblage. All macroinvertebrates sampled were identified to the lowest taxonomic level feasible – in most cases, the genus - and counted. These sites are sampled yearly and a stream condition index score is calculated for each site according to the metrics outlined in the Virginia Stream Condition Assessment. Data from 2013 were used to assess the park's current condition. The final condition score for macroinvertebrates was assessed by comparing the benthic invertebrate index of biological integrity to established reference conditions.

To assess non-insect invertebrates, volunteers collected data from two sites within the park – one in Gills Creek and one in Jack-O-Lantern Branch - beginning in 2010. These data are recorded in Virginia's Save Our Streams databases and include the number of observations of a variety of insects, as well as crayfish and snails. These data were plotted primarily for context and not used in the quantitative assessment.

Threshold

The threshold for insect-macroinvertebrates was taken from the Virginia Stream Condition Index (VSCI), with a score above 60 indicating healthy and a score below 60 indicating impairment (Burton and Gerritsen 2003). This is an established metric by the Commonwealth of Virginia. Sites with a score of 60 or higher would indicate 100% attainment. Scores below 60 were scored as 0% attainment. Since no current empirical threshold exists for assessing crayfish and snail abundance, this metric was only considered as part of the assessment of trend.

Current condition and trend

In 2013, Jack-O-Lantern Branch had a VSCI score of 47. Gills Creek scored a 58 on the VSCI. Both of these scores represent 0% attainment relative to the threshold of > 60, indicating significant concern. The trend is relatively stable over the four-year sample period (Figure 4.14). It is worth noting that the current values of the VSCI are just below the threshold established. In 2009, 2011, and 2012, one of the streams was above the desired threshold level.

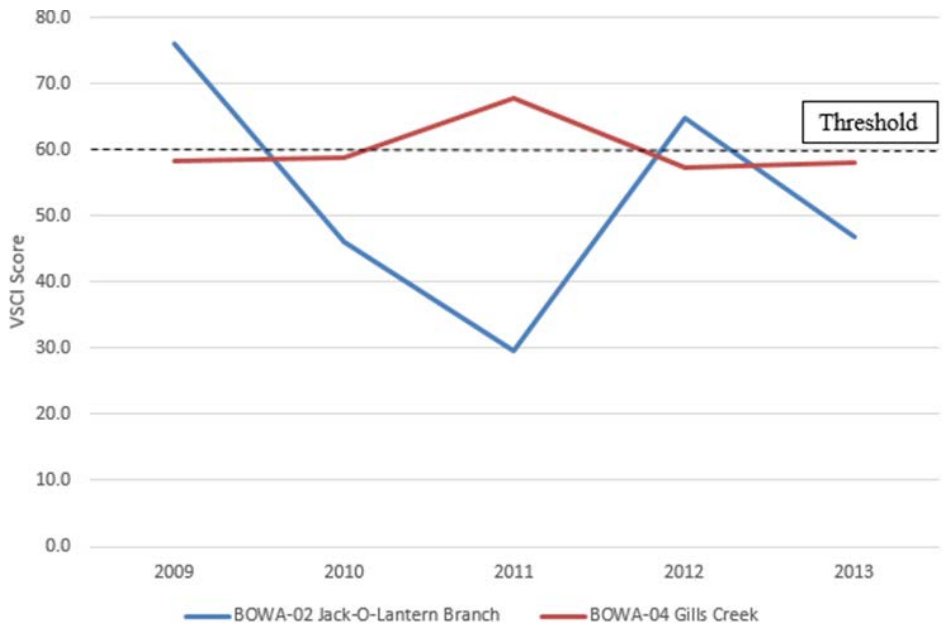


Figure 4.14. Virginia Stream Condition Index (VSCI) scores in BOWA (MIDN I&M Program).

Crayfish and snail abundances were highly variable over the time period sampled. For Jack-O-Lantern Branch, crayfish abundance was highest in 2009 and snail abundance highest in 2010 (Figure 4.15). For Gills Creek, crayfish abundance peaked in 2010 and snail abundance peaked in 2013 (Figure 4.16). Jack-O-Lantern Branch overall had generally higher abundances for both crayfish and snails.

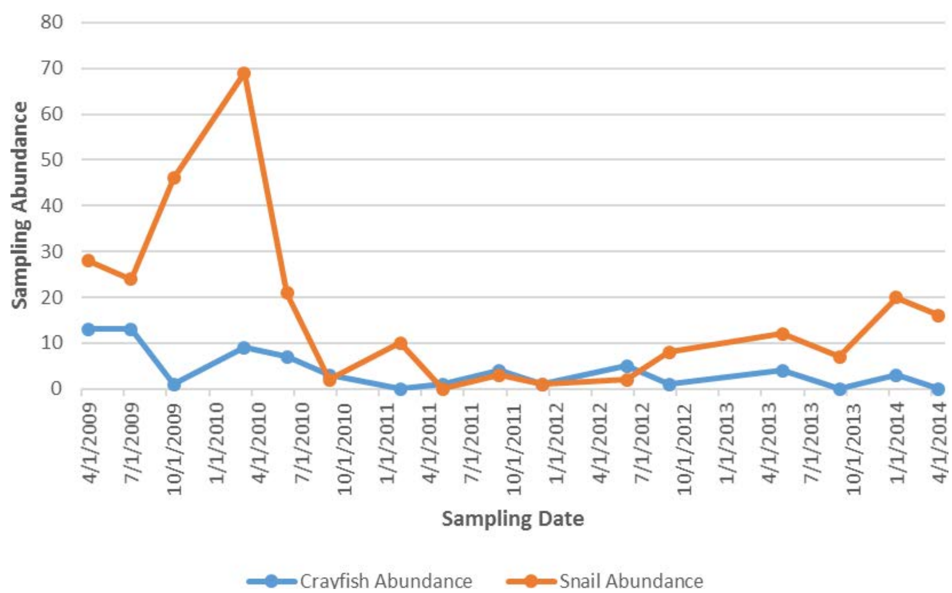


Figure 4.15. Non-insect benthic macroinvertebrates in Jack-O-Lantern Branch (Save our Streams Monitoring Program).

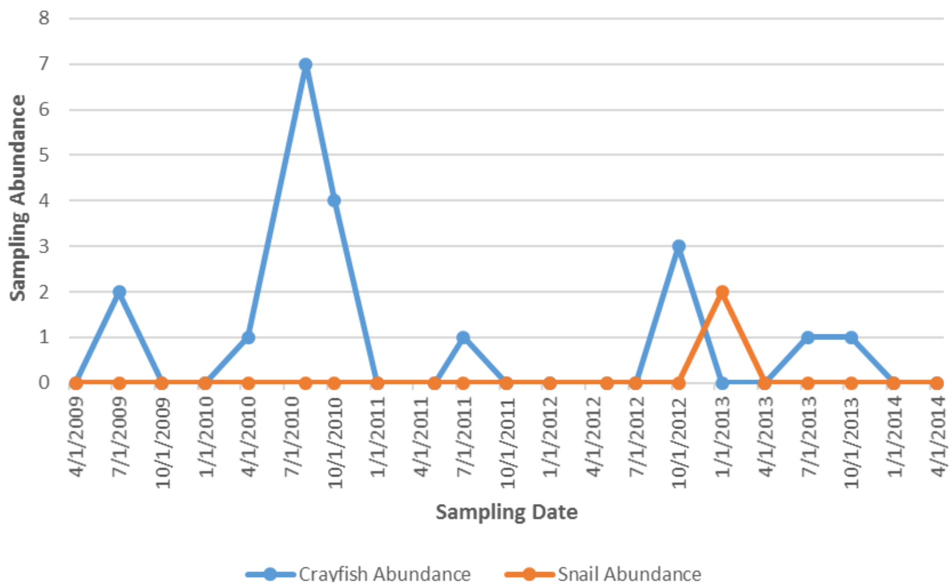


Figure 4.16. Non-insect benthic macroinvertebrates in Gills Creek (Save our Streams Monitoring Program).

Data gaps and level of confidence

Data collection for insect macroinvertebrates followed standard NPS protocols and was conducted as part of the MIDN I&M Program. However, the length of the data record is short for a comprehensive assessment of trends. Data collection for non-insect macroinvertebrates (crayfish and snails) were collected by volunteers, and no metrics have been established for these taxa. The data are presented at this point primarily for qualitative assessment and context. Our overall level of confidence therefore is moderate, and continued monitoring is recommended.

Sources of expertise

James Comiskey, Regional Program Manager, Northeast Region, NPS

4.3 Biological Integrity

4.3.1 Birds

Relevance and Context

Birds are one of the most studied taxa, and are often used as indicators of ecosystem health because of their relatively universal presence, their differing life-history traits, easy survey methods, the fact that they generally reflect the quality of the ecosystem, and the availability of long-term data sets (O'Connell et al. 1998). Forest interior dwelling birds are particularly sensitive to ecosystem disturbances and degradation (Canterbury et al. 2000). Fragmentation of forested land, for example, increases the amount of edge and creates smaller forest plots, which may lead to an increase in nest predation and parasitism (Brittingham and Temple 1983, Wilcove 1985), and increases in competition with edge species (Butcher et al. 1981), causing an overall decline of the forest interior species populations. In general, the density and richness of forest interior birds tends to decrease as the amount of forest decreases, and some species may not be present at all in small forests.

Additionally, the more isolated a tract of forest is from other tracts, the fewer forest interior species tend to be present (Askins et al. 1987).

The health of grasslands and shrublands can also be measured through the bird community. As a group sensitive to disturbances, the succession of land can greatly affect populations of grassland and shrubland birds (Canterbury et al. 2000). These birds have been declining dramatically for decades as grasslands and shrublands become later-successional stage habitats, are lost to development, or turned to modern agricultural fields (Brennan and Kuvlesky, Jr. 2005). Different species of grassland and shrubland birds require different successional stages of vegetation depending upon their foraging habits, nest placement, territorial behavior, and breeding habits (Peterjohn 2006a). In order for a grassland to be a functional habitat for a diverse bird community, it must be at least 50 hectares with some species requiring even larger habitat area (Vickery et al., 1994). As the tracts of land large enough to support such a community are decreasing, nontraditional sites such as the fields at airports and reclaimed surface mines have become increasingly important (Vickery et al. 1994, Brennan and Kuvlesky 2005). Additionally, encouraging farmers to wait to mow until after breeding activities have subsided has proven successful in providing habitat for grass and shrubland birds (Brennan and Kuvlesky 2005).

Bird populations are an indicator species for the health of the forest, grassland and shrubland ecosystems within BOWA (Photo by Timothy Sims).

<u>Data and Methods</u>

Bird communities in BOWA were surveyed in 2003 as part of the I&M Program (NPS 2009). Point count and area search methods were used in all seasons to capture breeding, migration, and over-wintering. Additionally, audio playback surveys were used to detect nightjars and owls - nocturnal species that are often difficult to detect otherwise. Before the survey was conducted, a list of potential species was compiled based on local records, surveys, and published literature. One-hundred and eighteen species were expected to occur in the park, 90 of which were expected to be present only during breeding season, 17 during winter, and 11 were expected to be present as migrants (Appendix B). A total of 10 sample sites covering each of the park's main habitats were surveyed: animal feedlot-paddock, forest-field edge, grassland, mature deciduous forest, mixed coniferous and deciduous forest, and riparian forest.

Of the 118 avian species expected to occur at BOWA, the 2003 inventory detected 90, or 76%. Two species that were not expected to occur at the park were also detected, bringing the total to 92. The breeding season surveys taken in 2003 suggested that 58 species were breeding in or in the near vicinity of the park. No federally-listed threatened or endangered species were detected in the park; however, 23 were of special concern or priority species listed by the United States Fish and Wildlife Service (USFWS), the Commonwealth of Virginia, or Partners in Flight (PIF) (Table 4.2) (NPS 2009). Many of these species have been detected again in subsequent surveys. Four additional species of conservation concern were also detected in later surveys (Table 4.2).

Table 4.2. Birds of conservation concern observed in BOWA (NPS 2009, Johnson 2014a,b).

Taxonomic Name	Common Name	Conservation Classification	Years Detected
Caprimulgus vociferus	whip-poor-will	USFWS species of special concern; PIF priority species	2003 (Migratory)
Chaetura pelagica	chimney swift	PIF watchlist	2003 (Breeding, Migratory), 2011-2013
Empidonax virescens	Acadian flycatcher	PIF stewardship species	2003 (Breeding, Migratory), 2009-2013
Certhia americana	brown creeper	Virginia species of special concern	2003 (Winter)
Troglodytes troglodytes	winter wren	Virginia species of special concern	2003 (Winter)
Regulus satrapa	golden-crowned kinglet	Virginia species of special concern	2003 (Winter, Migrant)
Hylocichla mustelina	wood thrush	USFWS species of special concern; PIF watchlist	2003 (Breeding, Migrant), 2009-2013
Catharus guttatus	hermit thrush	Virginia species of special concern	2003 (Winter, Migrant)
Dendroica magnolia	magnolia warbler	Virginia species of special concern	2003 (Migrant)
Seiurus motacilla	Louisiana waterthrush	PIF stewardship species	2003 (Breeding Migratory), 2009-2013
Piranga olivacea	scarlet tanager	PIF priority species	2003 (Breeding Migratory), 2009-2013

Table 4.2 (continued). Birds of conservation concern observed in BOWA (NPS 2009, Johnson 2014a,b).

Taxonomic Name	Common Name	Conservation Classification	Years Detected
Carpodacus purpureus	purple finch	Virginia species of special concern	2003 (Migratory)
Contopus virens	eastern wood-pewee	PIF watchlist	2003 (Breeding, Migratory), 2009-2013
Melanerpes carolinus	red-bellied woodpecker	PIF stewardship species	2003, 2009-2013
Poecile carolinensis	Carolina chickadee	PIF stewardship species	2003, 2009-2013
Dendroica pinus	pine warbler	PIF stewardship species	2003, 2009-2013
Picoides pubescens	downy woodpecker	PIF stewardship species	2003, 2009-2013
Dryocopus pileatus	pileated woodpecker	PIF stewardship species	2003, 2009-2013
Buteo lineatus	red-shouldered hawk	PIF stewardship species	2009-20132
Piranga rubra	summer tanager	PIF stewardship species	2009-2010, 2012-2013
Icterus galbula	Baltimore oriole	PIF watchlist	2010, 2012-2013
Tyrannus tyrannus	eastern kingbird	PIF watchlist	2003, 2010-2013
Colaptes auratus	northern flicker	PIF watchlist	2003, 2009-2010, 2012-2013
Parula americana	northern parula	PIF stewardship species	2003, 2009-2013
Icterus spurius	orchard oriole	PIF stewardship species	2003, 2010-2011, 2013
Helmitheros vermivorus	worm-eating warbler	PIF watchlist	2003, 2010, 2013
Buteo platypterus	broad-winged hawk	PIF watchlist	2013

In 2009, the I&M program began a breeding bird monitoring program to track trends in breeding bird communities (Johnson 2014a). Point count methods were used at 16 survey points - 4 in grassland habitat and 12 in forest habitat (Figure 4.17).

The assessment of birds was based on these monitoring data using the Bird Community Index (BCI), an index developed by O'Connell et al. (2003) to determine the biotic integrity of an environment for breeding bird communities. The BCI uses nine response guilds, or groups of bird species that occupy similar ecological niches, have similar life-history traits, and respond in similar manners to disturbances in habitat. These were grouped into three categories: structural guilds, functional guilds, and compositional guilds. Within each category, species were assigned to a guild and each guild was ranked (1-4) as follows based on the number of species observed for the guild and look-up tables provided in O'Connell et al. (2003) and Johnson (2014a):

1 = humanistic

2 = moderately disturbed

3 = largely intact

4 = naturalistic

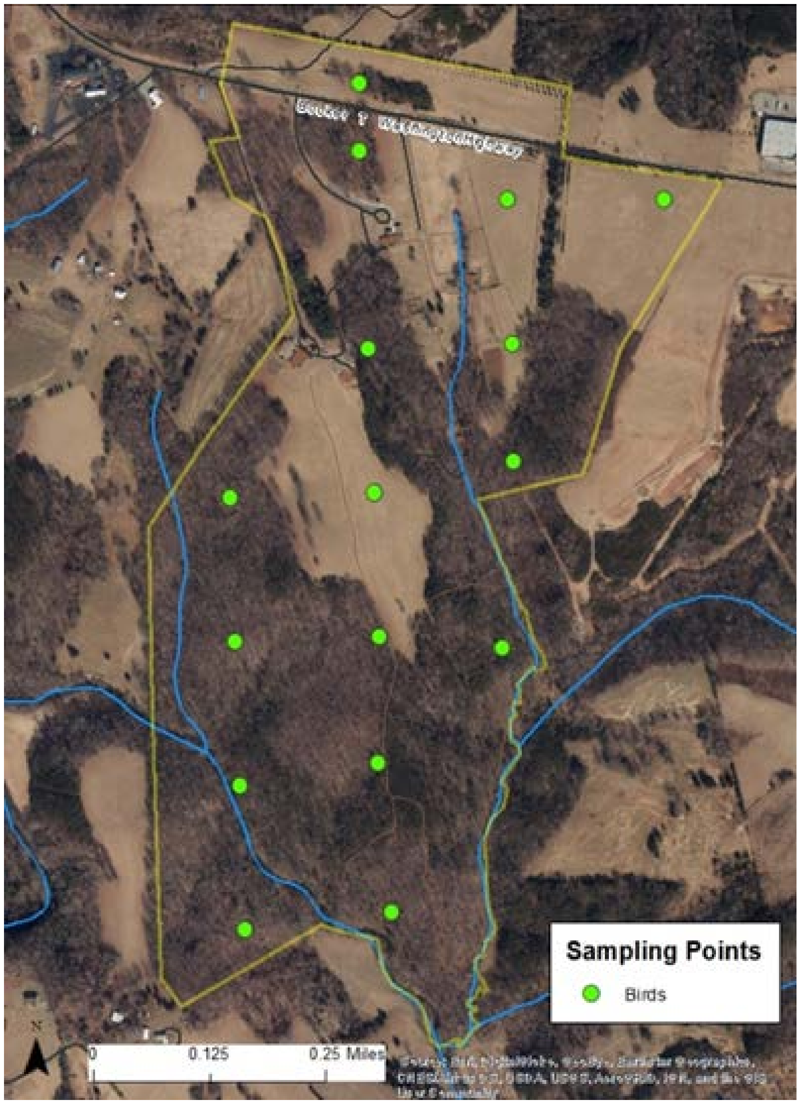


Figure 4.17. Bird survey points in BOWA (Johnson 2014a).

Threshold

The ranks of each guild were summed and divided by the theoretical maximum (for nine guilds, each with a maximum rank of 4, the theoretical maximum was 36) to provide the BCI, which was used as the percent attainment values for the bird community at BOWA. Communities with high BCI values have a greater proportion of guilds characterized as naturalistic, while those with low BCI value may be dominated by exotic species or habitat generalists. Data from 2013 were used to assess current condition, and monitoring results from 2009 to 2013 were used to assess trend.

Current Condition and Trends

BCI scores were calculated for each year from 2009 to 2013. In 2013, 656 birds representing 59 species were detected (Johnson 2014a). Among these were three species (common raven, belted kingfisher, and broad-winged hawk) not previously detected in the park (Johnson 2014a,b). Based on the species detected in 2013, the park was given a BCI score of 0.81 (equating to a percent attainment score of 81%). This BCI value is associated with the highest integrity category of naturalistic (O'Connell et al. 2003). Considering forest birds specifically, the forest interior guild also was ranked as naturalistic (Table 4.3). All guilds were ranked as naturalistic or largely intact, except the pine associated guild, which was ranked as moderately disturbed.

Data from the 2009-2013 monitoring surveys indicate a stable trend (Table 4.3). The exotic guild dropped one condition level from naturalistic to largely intact from 2012 to 2013, but there remains very few exotic birds relative to other guilds.

Data Gaps and Confidence

Based on the multiple surveys in multiple years, following I&M protocols (Johnson 2014a), confidence in the assessment is high. Sampling efforts vary slightly from year to year and not all 16 sample stations have been used each year. Each site has been sampled an average of 2.6 to 3.5 times per breeding season. Continued monitoring is recommended to increase the length of record.

Sources of Expertise

Mark Johnson, Ecologist/Data Manager, MIDN I&M Network, NPS

Table 4.3. BCI scores for BOWA (Johnson 2014a,b).

		2009		2010		2011		2012		2013	
Category	**Guild**	**%**	**Rank**	**%**	**Rank**	**%**	**Rank**	**%**	**Rank**	**%**	**Rank**
Structural	Forest Interior	34.9	Naturalistic	43.1	Naturalistic	37.5	Naturalistic	35.6	Naturalistic	33.7	Naturalistic
	Pine Associated	0.0	Humanistic	1.4	Moderately Disturbed	0.38	Moderately Disturbed	2.1	Largely Intact	1.9	Moderately Disturbed
	Urban/Suburban	43.6	Largely Intact	29.1	Largely Intact	33.6	Largely Intact	34.2	Largely Intact	39.7	Largely Intact
Functional	Bank Prober	16.7	Largely Intact	18.9	Largely Intact	19.4	Largely Intact	16.8	Largely Intact	17.2	Largely Intact
	Ground Forager	6.5	Largely Intact	6.8	Largely Intact	5.5	Largely Intact	6.6	Largely Intact	5.0	Largely Intact
	Upper Canopy Forager	17.3	Largely Intact	25.3	Naturalistic	23.8	Naturalistic	22.8	Naturalistic	20.4	Naturalistic
Compositional	Nest Predator/ Brood Parasite	18.3	Moderately Disturbed	11.9	Largely Intact	12.7	Largely Intact	12.7	Largely Intact	13.7	Largely Intact
	Single Brooded	45.8	Largely Intact	56.7	Naturalistic	52.8	Naturalistic	51.4	Naturalistic	48.5	Naturalistic
	Exotic	0.0	Naturalistic	0.0	Naturalistic	0.0	Naturalistic	0	Naturalistic	0.9	Largely Intact
Total BCI Score (max of 1.0)		**0.72**	**Largely Intact**	**0.83**	**Naturalistic**	**0.83**	**Naturalistic**	**0.86**	**Naturalistic**	**0.81**	**Naturalistic**

% = percent of all species observed assigned to that guild

4.3.2 Fish

Relevance and Context

Fisheries in the Southeast United States support more native fish species than any comparable area in North America north of Mexico (Warren et al. 2000). However, the Southeast U.S. fish communities face a number of threats (Warren et al. 2000). Located in the highly diverse Upper Roanoke River watershed, Gills Creek and Jack-O-Lantern Branch are home to a large variety of sucker fish, including the redhorse sucker (*Moxostoma* spp*)*, which completes its spring spawning run in Gills Creek (Atkinson 2008). The creeks also contain a large number of fish species endemic to the Roanoke River Basin including the Roanoke hogsucker (*Hypentelium roanokense*), white shiner (*Luxilus albeolus*), cresent shiner (*Luxilus cerasinus*), and riverweed darter (*Etheostoma posostemone*) (Atkinson 2008). Analyzing the health of these fish communities allows for a better understanding of the conservation actions that should be implemented to improve the health of aquatic ecosystems and water resources (Warren et al. 2000).

Park volunteers monitoring chub nesting in Gills Creek (Photo by Todd Lookingbill).

Indicator species can also be used to assess the biological integrity of aquatic ecosystems. Nest building fish, such as chub, construct mounds of pebbles to protect their eggs and young from predators. Within the guild of nest-builders, bluehead chub (*Nocomis leptocephalus*) and creek chub (*Semotilus atromaculatus*) standout as especially adept (Jenkins and Burkhead 1994). The presence of these two species is a good indicator of stream health because the nests they build are used by other fish species for spawning and to protect their eggs (Jenkins and Burkhead 1994). Creek chub are highly tolerant of polluted waters, whereas bluehead chub are more sensitive to pollution (Burton and Gerritsen 2003).

Redhorse sucker spawning at Gills Creek (Photo by Timothy Sims).

Data and Methods

Backpack electrofishing was used to assess fish communities in both Gills Creek and Jack-O-Lantern Branch in late summer of 2002 (Figure 4.18). Sampling was completed at one 400m transect along Gills Creek, and two transects of 100m and one of 80m along Jack-O-Lantern Branch. For this analysis, the results from all three sample transects in Jack-O-Lantern Branch were combined. In mid-May of 2004, Gills Creek was resurveyed due to the 2002 drought (Atkinson 2008).

Chub nest sampling is also conducted in the park on an ad hoc basis led by volunteers of the Virginia Master Naturalist - Blue Ridge Foothills and Lakes Chapter (Kelso 2014b). Chub nests were sampled in the early summer months of 2010, 2011, and 2014. Volunteers walked the banks of Gills Creek and Jack-O-Lantern Branch and recorded nest locations using GPS units and creek maps. In 2014, more detailed versions of creek maps were produced to allow for more precise GPS recordings. That same year, the sampling process on the creeks was slightly modified. Both creeks were broken into sampling segments and nest locations were numbered consecutively within each segment. Information on nest mounds and their levels of use were provided in the Visitor's Center to interested visitors.

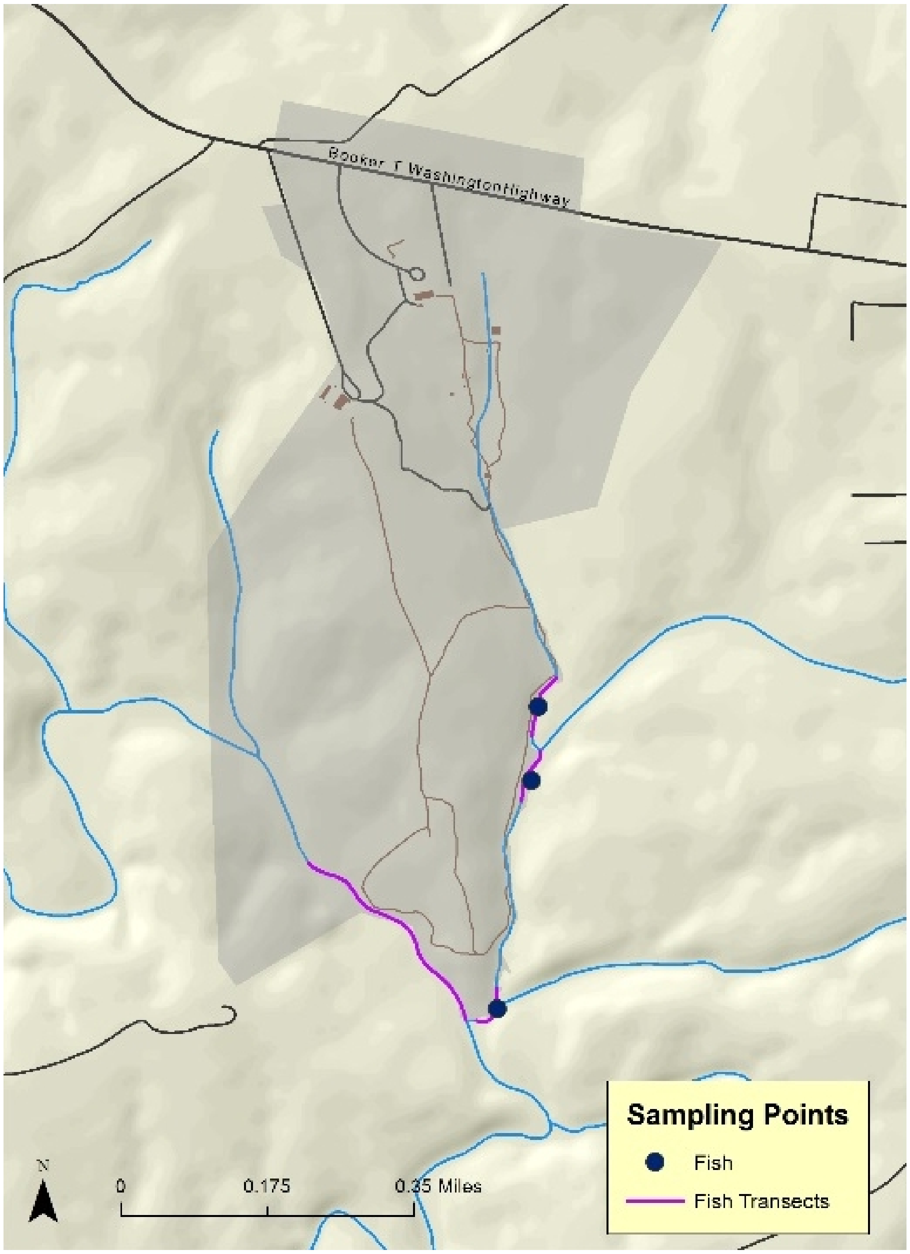


Figure 4.18. Chub sampling sites (points) and fish sampling transects (lines) in BOWA (Atkinson 2008).

Threshold

Southerland et al. (2007) established a set of density thresholds for cold-water highland streams with less than 0.88 fish/m^2 or below signifying significant concern, and greater than 2.24 fish/m^2 signifying ideal conditions. For the purpose of this assessment, a density of 2.24 fish/m^2 was assigned a score of 100% and 0.88 fish/m^2 was assigned an attainment score of 0%. Scores assigned to abundance levels between these thresholds were scaled linearly from 0 to 100%.

Data are not available to assess trends in this indicator.

Currently there is no established threshold for the monitoring of chub nests, and these data are provided primarily for context.

Current Conditions and Trend

In 2002, a total of 28 fish species were detected in Gills Creek with an abundance of 10.57 fish/m^2. Eight of these species were also detected in Jack-O-Lantern Branch. Jack-O-Lantern Branch had a density of 1.30 fish/m^2. Using the total area and total number of fish, the overall density of fish in the park was 3.95 fish/m^2, making the overall attainment score 100%. The most abundant species in Gills Creek included the bluehead chub, the redbreast sunfish (*Lepomis auritus*), the crescent shiner (*Luxilus cerasinus*), and the satinfin shiner (*Cyprinella analostana*); while the most abundant fish in Jack-O-Lantern Branch were the rosyside dace (*Clinostomus funduloides*) and the mountain redbelly dace (*Phoxinus oreas*).

The 2004 resampling of Gills Creek yielded slightly different community results. Six species that were not detected during the 2002 survey were detected in 2004, bringing the total detected species for the two samples to 34 (Appendix C). Among the species not detected in the 2002 survey was the bigeye jumprock (*Scartomyzoa ariommus*), a globally rare species listed on Virginia's Natural Heritage Vertebrate Watch List (Roble 2003, Atkinson 2008). It is noteworthy that the samples were completed at different times of year. The 2002 sample was completed in late summer, while the 2004 sample was completed in mid-May. Differences in habitat use, spawning activity, and water flows may impact the samples at the different times of year (Atkinson 2008).

A large number of the bluehead chub, a sensitive species, were observed in Gills Creek as part of the BOWA NPS fish inventory in 2002 and 2004 (Table 4.4). Though the interpretation of nest surveys is complicated by challenges in locating and marking nests, nest construction has occurred regularly in recent years on both Jack-O-Lantern Branch and Gills Creek (Figure 4.19).

Table 4.4. Abundance of bluehead and creek chub in BOWA from NPS fish inventory (Atkinson 2008).

	2002		**2004**	
Species	**Gills Creek**	**Jack-O-Lantern Branch**	**Gills Creek**	**Jack-O-Lantern Branch**
Bluehead chub	874	27	258	N/A (not sampled)
Creek chub	5	61	0	N/A (not sampled)
% of total taxa	**38%**	**24%**	**30%**	**0%**

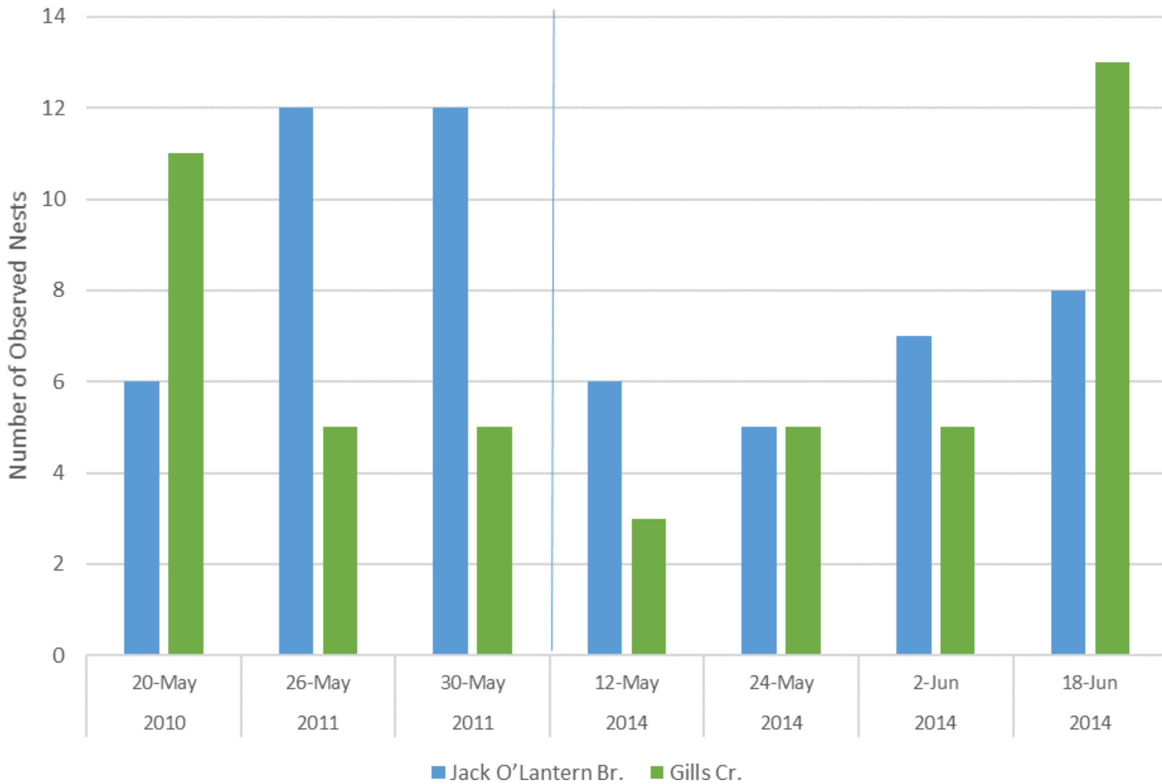


Figure 4.19. Chub nest observations in BOWA from volunteer nest monitoring (Kelso 2014b).

Data Gaps and Level of Confidence

Due to the lack of more recent data and variation in sampling conditions, the confidence in this information is moderate. When the fish sampling took place in 2002 there were low flow conditions, while in 2004 there was moderate to high flow conditions in Gills Creek. Additionally, the sampling was done in late summer in 2002 and mid-May in 2004, which influences water temperature, spawning activity, habitat condition, and fish abundance. Additional data would be required to assess any trend. It is possible to have high total fish abundance but low diversity due to degraded stream condition. Additional measures of the fish community such as richness and/or diversity would be useful in future analyses. For example, chub would be a useful indicator species because of nest sensitivity to water quality; this indicator could be developed for future assessments.

Sources of expertise

James B. Atkinson, Natural Resources Branch, Shenandoah National Park
Donald Kelso, Associate Professor Emeritus, George Mason University

4.3.3 Mammals and Herpetiles

Relevance and context

As a result of human land use and overexploitation, many large mammal species including elk (1855; *Cervus elephus*), mountain lion (1882; *Puma concolor*), and gray wolf (1910; *Canis lupus*) faced severe decline or were extirpated in Virginia in the early 20th century (Handley 1992). Due to the small size of the park and nearby encroaching development, few large mammals make their permanent residence in BOWA (Pagels et al. 2005). However, it may still provide a valuable ecosystem service as a corridor connecting other larger patches of habitat (Lidicker Jr. 1999). Small mammal populations that are resource generalist often do well in disturbed habitats, such as those found in BOWA (Bowman et al. 2001).

Amphibian and reptiles (herpetofauna) are ubiquitous but under-studied, especially in the Piedmont region of the Southeast United States, an area rich in vertebrate species (Kapfre and Munoz 2012). Globally, herpetofauna are in general decline, with habitat loss as the leading cause (Stuart et al. 2004). As forested areas are developed, the amount of impervious surface greatly increases, altering the hydrology of streams, particularly spate frequency and magnitude. This change in flooding regime alters the habitat for species such as water dwelling salamanders (Barrett et al. 2010). Woodland salamanders and hylids can also be affected as many exhibit a biphasic lifestyle and breed in streams (Barrett and Guyer 2008). Reptiles may also be impacted but are slightly better able to withstand these changes due to their larger size, thicker skin, amniotic eggs, and higher tolerance to changes in water quality (Barrett and Guyer 2008). Both amphibians and reptiles can be used as indicators of ecosystem health. For example, the box turtle is often used as an indicator due to its sensitivity to pesticides such as organochlorines, which may cause abnormal development (Mitchell 2006).

The northern red salamander (Photo by Timothy Sims).

Data and methods

Mammal communities at BOWA were surveyed from June 2003-August 2004 as part of the I&M Program (Pagels et al. 2005). Prior to the inventory, a list of 39 expected species was compiled based on literature, museum records, and the personal experience of mammalogist John F. Pagels (Virginia Commonwealth University). Species were then inventoried using traps, night-camera photography, and observations. Three sample sites were chosen from each of the following four main habitat types: field-forest edge, mixed pine hardwood, hardwood, and bottomland hardwood, for a total of 12 sample sites (Figure 4.20). All collection methods were used at each site.

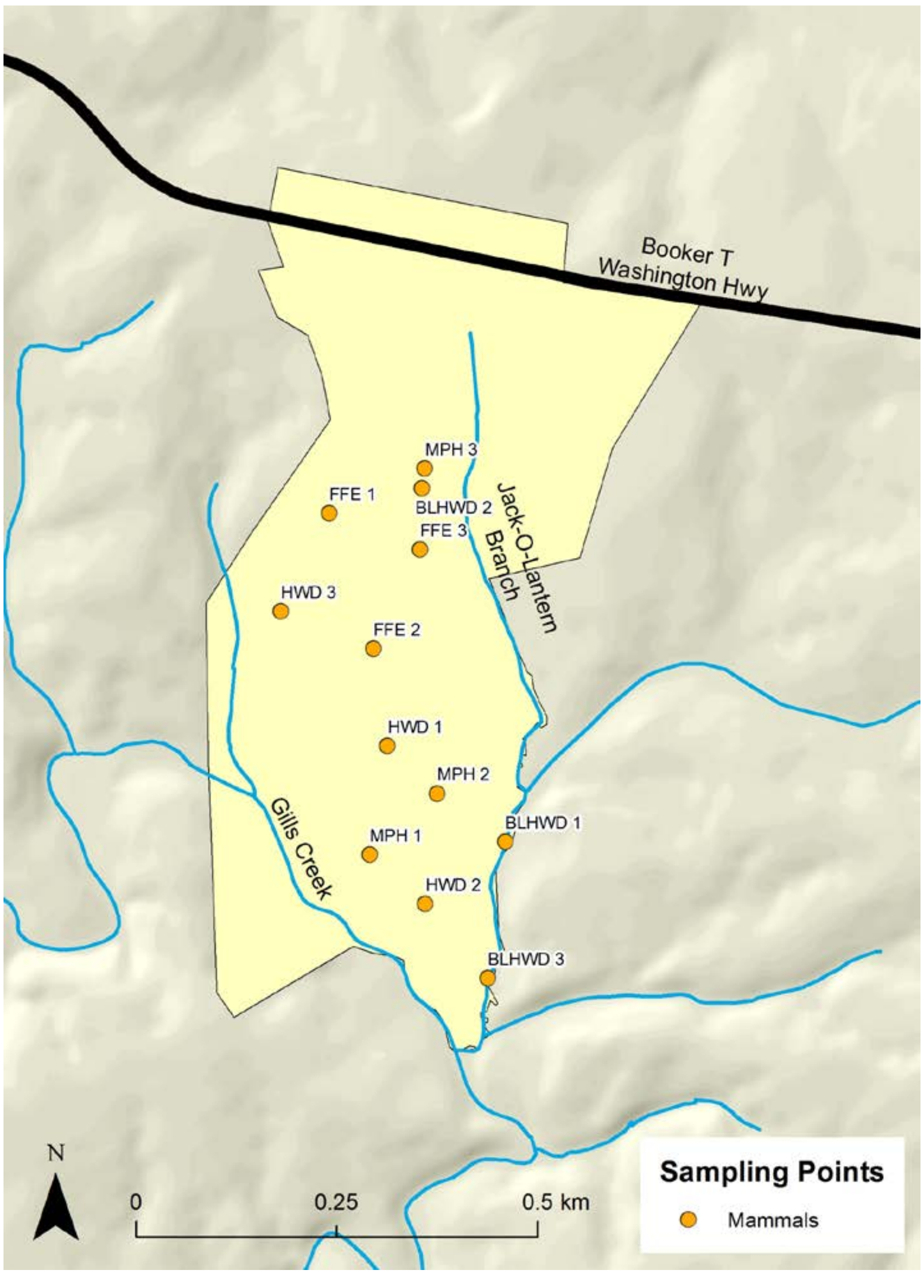


Figure 4.20. Mammal sampling locations in BOWA (Pagels et al. 2005).

Based on information from Mitchell (1994), Conant and Collins (1998), and Mitchell and Reay (1999), 22 species of amphibians and 24 species of reptiles are expected to occur at BOWA. Herptofauna were sampled by the I&M Program on May 29, 2002; from March 20 to September 27, 2003; and on May 29, 2004 (Mitchell 2006). Data were collected using audio survey, dipnet survey, visual encounter survey, and minnow and turtle trap methods. Survey points were located in habitat types including: grasslands, mixed hardwoods and pine, mixed hardwoods, mixed pine, impoundment ponds, floodplain pools, and streams (Mitchell 2006) (Figure 4.21).

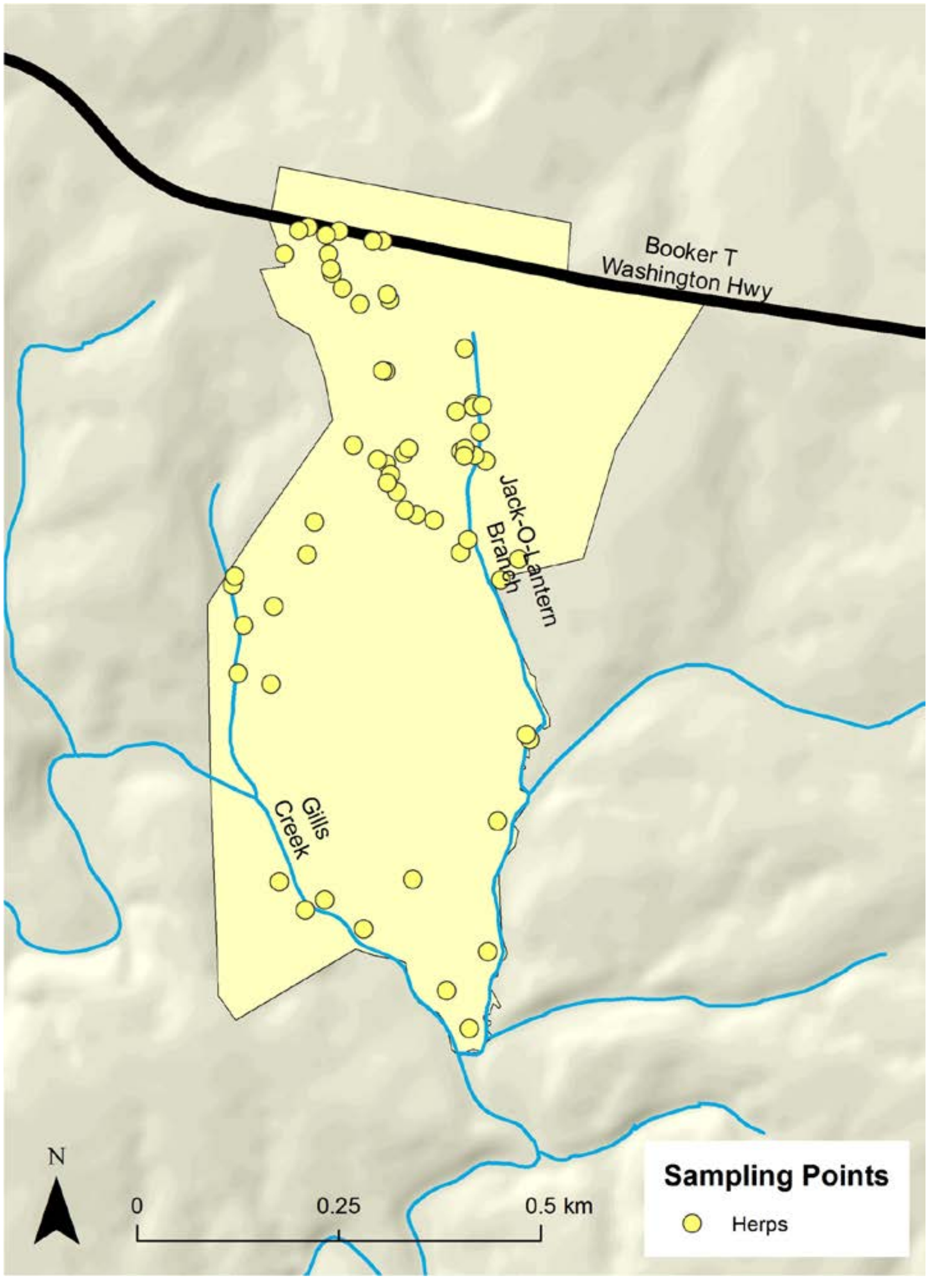


Figure 4.21. Amphibian and reptile sampling locations in BOWA (Mitchell 2006).

Threshold

The condition of mammals and herpetofauna was based on the number of "expected" mammal, amphibian, and reptile species that were detected in the I&M inventories. The proportion of expected species observed was recorded as the percent attainment. Data were not available to assess trend for this indicator.

Current conditions and trend

Of the 39 expected mammal species, 26 (or 67%) were found to be present at BOWA during the 2003-2004 inventory (Appendix D). The most common species recorded were the white-footed mouse (*Peromyscus leucopus)* and northern short-tailed shrew (*Blarina brevicauda*), which accounted for 53% and 17%, respectively, of all mammals captured (Pagels et al. 2005). Among habitat types, species richness ranged from six to 11 species with the bottomland hardwood habitat having the greatest number of species. No threatened or endangered species were found. Based on the available data, no trend assessment can be made.

Of the 46 amphibian and reptile species expected to be observed at BOWA, only 18 were observed during inventory sampling, yielding an attainment score of 39% (Appendix E). Nine (five frog species and four salamander species) of the 22 expected amphibians were found to be present, and nine (two turtle, five snake, and two lizard species) of the 24 expected reptiles were detected. Of the salamanders, none of the expected fully terrestrial species were present. This is potentially a sign that the hardwood forests had not yet reached a mature enough age to provide the proper habitat for them (Mitchell 2006). Due to the lack of monitoring data, no trend can be determined.

Averaging together the condition scores for mammals and herpetofauna yields an overall attainment score of 53%, a condition of moderate concern (Table 4.5). No trend can be determined.

Table 4.5. Mammal and herpetofauna attainment scores and condition summary.

Category	Percent attainment	Condition
Mammals	67%	Good
Herpetofauna	39%	Moderate Concern
Total	**53%**	**Moderate Concern**

Data gaps and level of confidence

This simple comparison of the number of species detected versus the number of species expected to reside in the park is not a robust indicator of all facets of mammal and herpetofauna health. For example, it provides no information on population or demographic characteristics. The data also represent a single point in time (over a decade ago). During the sample period, the mammalian population may have been affected by the unusually high levels of rain in 2003 that followed a three-year drought. Short-term amphibian and reptile surveys are known to be especially sensitive to climate, temperature, and precipitation condition at the time of sampling (Mitchell 2006). Confidence in the condition assessment is, therefore, low. Additional survey data would be useful in future assessments and would be needed to determine any overall trends in species richness.

Sources of expertise
John Pagels, Mammologist, Virginia Commonwealth University
John Mitchell, Biologist, University of Richmond

4.3.4 Forest Regeneration

Relevance and context
Forests comprise approximately 65% of the land cover in the Mid-Atlantic region and 66% of the land cover in BOWA itself (McKenney-Easterling et al. 2000, Patterson 2008). They provide esthetic, recreational, and wildlife habitat. They also provide an important linkage to the history of the site. Changes in forest condition have been linked to changes in biodiversity, carbon sequestration, and riparian zone health (McKenney-Easterling et al. 2000). Indicators of forest health include regeneration, canopy health, and the level of deer-browsing.

This assessment uses forest regeneration to quantify condition, but provides additional information on canopy condition and deer browsing for context. Forest regeneration, i.e., the act of restoring forest tree cover through the establishment and growth of new trees, allows ecosystems to maintain natural processes and protects against erosion (Boring et al. 1981). However, regeneration in U.S. southern hardwood forests can be hindered by fungi, exotic species competition, and browsing mammals (Romagosa and Robison 2003).

Canopy health indicates the general condition of trees within a forest, particularly leaves and branches. The canopy acts as a regulator for sunlight, heat, and rain within the forest (Hutchison et al. 1986). Changes occur in canopy structure throughout the year, allowing for the forest to adapt to the seasonal conditions (Hutchison et al. 1986). In the Eastern U.S., canopies can be decimated by invasive species and diseases such as the hemlock woolly adelgid (Orwig and Foster 1998). Other invasive species, such as beech bark disease and the emerald ash borer, can also have destructive effects on the health and condition of forest canopies. Holes in the canopy can result in long-term loss of canopy connectivity (Beckage et al. 2000).

Deer browsing can stunt or destroy new vegetation growth, significantly affecting the structure of a forest environment (Rossel et al. 2005). Saplings and seedlings of preferred species can be decimated, leaving fewer species to eventually replace the canopy (Kribel et al. 2011). This can result in trophic cascades and habitat modification, which then indirectly affect populations at higher levels in the food web (Rooney and Waller 2003).

Data and methods
Data were derived from the MIDN I&M forest vegetation monitoring (Comiskey et al. 2009). Plots were randomly located through a generalized random-tessellation stratified (GRTS) approach and sampled by I&M teams from 2007 to 2014. A total of eight 20 m x 20 m plots were sampled, each containing 12 1m^2 quadrats (Figure 4.22). To measure forest regeneration, tree seedlings were measured in the quadrats, and a weighted score based on height class was applied. To measure canopy health, the percentage of trees within the forest vegetation monitoring plots that showed signs or occurrences of foliar damage, pests, or diseases – including key indicator diseases, like hemlock

woolly adelgid or beech bark - were measured. The level of deer browsing was determined by the percentage of seedlings that showed signs of browsing within a plot.

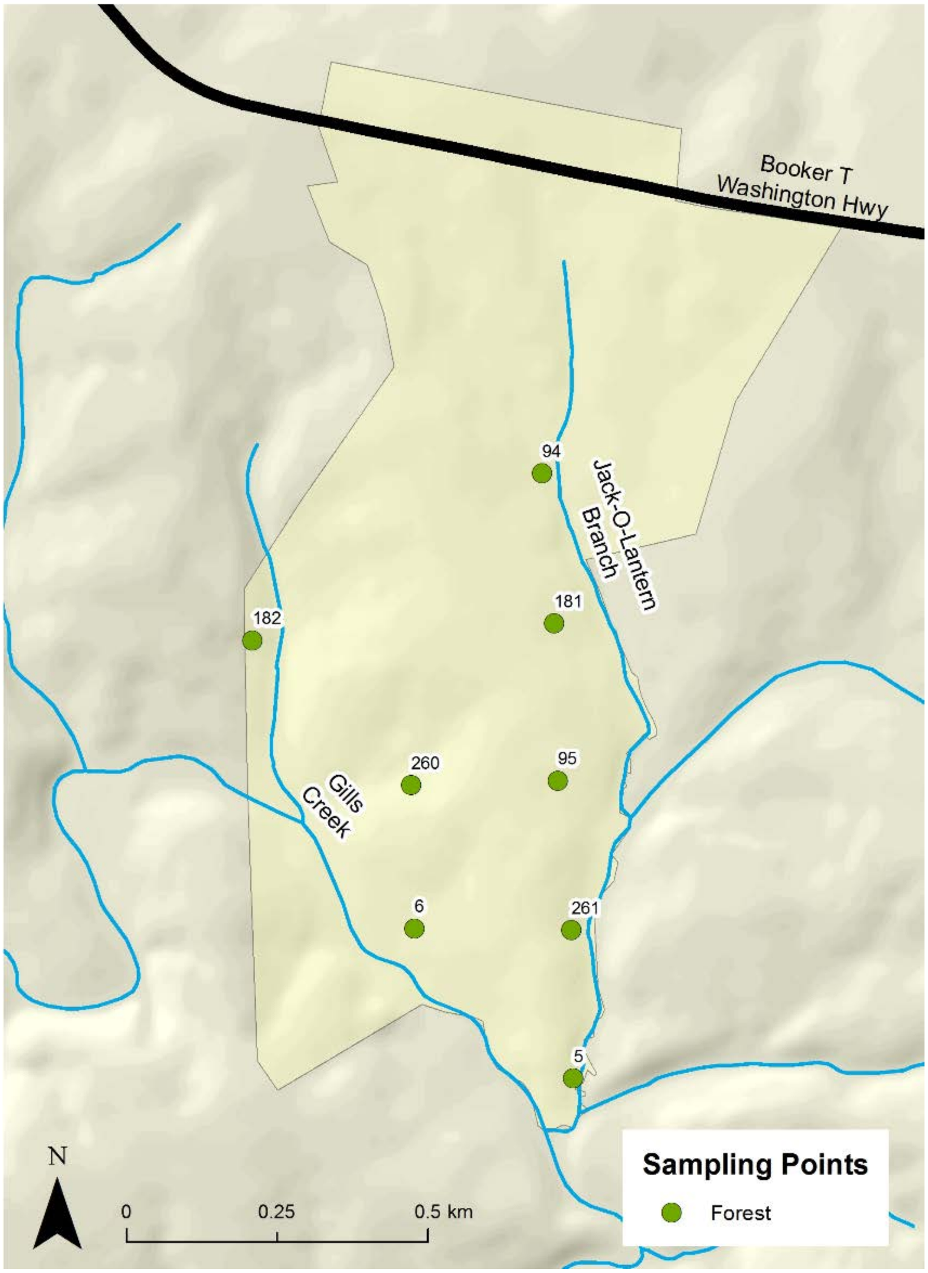


Figure 4.22. I&M forest vegetation monitoring plots in BOWA (Comiskey et al. 2009).

Current condition was assessed using the complete sample of all eight plots conducted from 2011-2014. Data from the 2007-2010 sampling rotation was additionally used to assess trend.

Threshold

Seedling stocking densities of 35,000 seedlings per hectare or greater, depending on the amount of deer browsing, have been recommended to ensure regeneration success in Mid-Atlantic forests

(Marquis 1981, Marquis and Bjorkbom 1982, Côté et al. 2004). Instead of using raw seedling counts, the MIDN I&M forest vegetation monitoring protocol uses a weighted approach to assess seedling densities (Comiskey and Wakamiya 2011). The weighted scoring system considers a seedling taller than 1.5 m in height equal to 50 seedlings within the 0.15-0.3 m height size class (McWilliams et al. 2005) (Table 4.6).

Table 4.6. Seedling height class categories and associated weighted score to estimate stocking index (McWilliams et al. 2005).

Seedling Height Class	Weighted Score
0.15-0.3m	1
0.3-1m	2
1-1.5m	20
>1.5m	50

Condition is then assessed as follows:

- ≥8 seedlings/m^2 = good condition,
- 2 to 8 seedlings/m^2 = caution, and
- ≤2 seedlings/m^2 = significant concern.

Plots deemed good or caution are considered to have adequate regeneration (Comiskey and Wakamiya 2011); therefore, 2 seedlings/m^2 was used as the threshold for this assessment. Current condition was evaluated as the percent of plots with weighted densities above this threshold value for the 2011-2014 sample. Trend was assessed by comparing these density values to those calculated for the 2007-2010 sample.

<u>Current condition and trend</u>

Out of the 8 plots surveyed in BOWA between 2011 and 2014, 6 had adequate regeneration for a score of 75% attainment. The pine community had higher recruitment than other locations in the MIDN, but high Virginia pine mortality was also observed, typical of early succession patches that are maturing (Comiskey 2013). The trend from the 2007-2010 initial survey to the 2011-2014 resample is stable (Figure 4.23). Six of the plots increased in density, but none of the changes were substantial.

A total of 224 trees were sampled on the eight plots from 2011 to 2014. Of these individual trees, 101 (or 45%) had foliar damage (Figure 4.24). No instances of beech bark disease or hemlock woolly adelgid were observed. A total of 78 (or 19%) of the 407 seedlings sampled on the eight plots had evidence of deer browse. At the plot scale, the percent of seedlings browsed ranged from 0% to 40% (Figure 4.25).

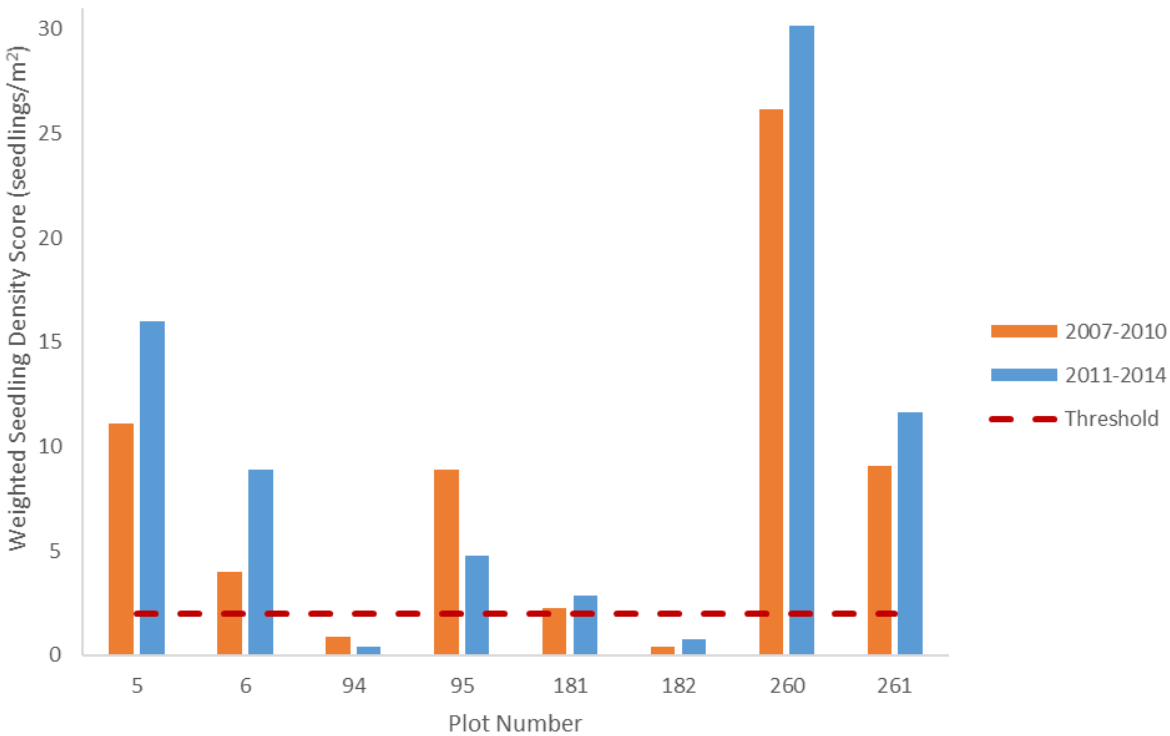


Figure 4.23. Weighted seedling density for BOWA forest monitoring plots (MIDN I&M Program).

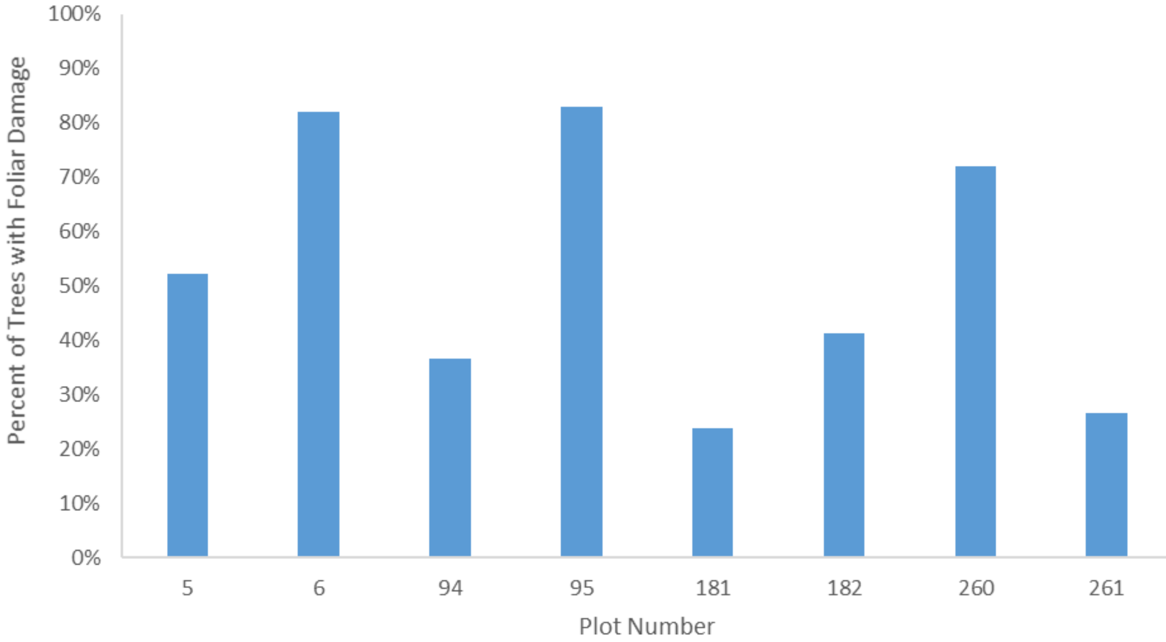


Figure 4.24. Foliar damage percentages for BOWA forest monitoring plots (MIDN I&M Program).

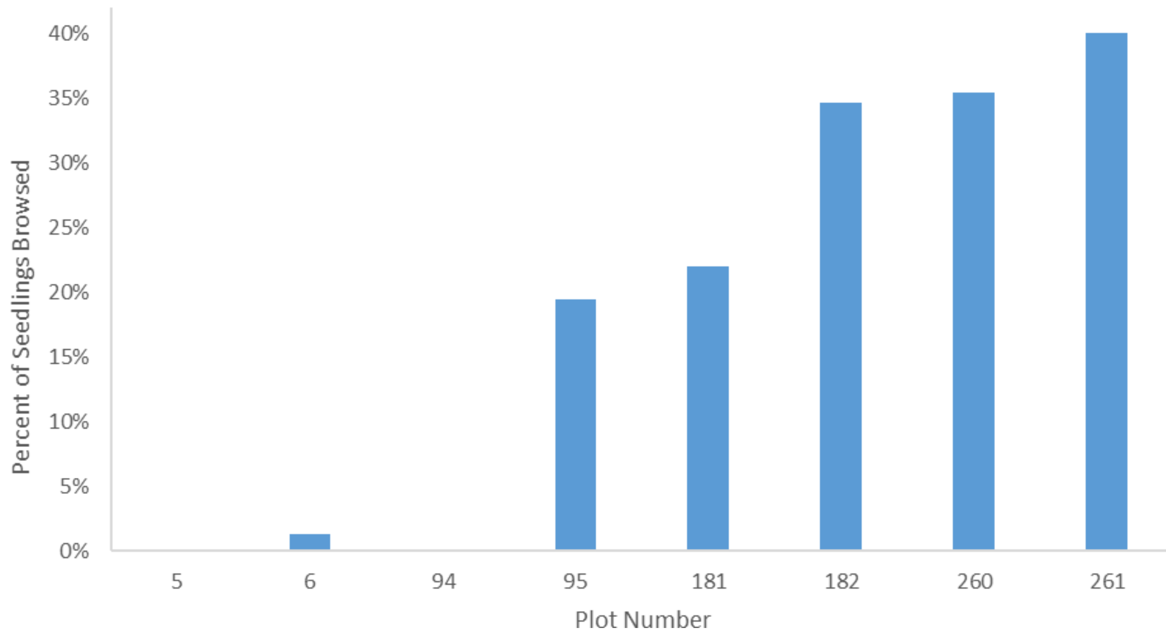


Figure 4.25. Deer browse percentages for BOWA forest monitoring plots (MIDN I&M Program).

<u>Data gaps and level of confidence</u>
The level of confidence in this indicator is moderate. Seedling data are highly variable. However, the data are collected following rigorous forest vegetation sampling protocols (Comiskey et al. 2009). Relative to other parks in the region, deer browse is relatively low an-d seedling regeneration is relatively high (Comiskey 2013). The length of record is short though, with only 2 sample rotations completed, and the sample effort is restricted to only eight plots in the park. Continued sampling is recommended.

<u>Source of expertise</u>
James Comiskey, Regional Program Manager, Northeast Region, NPS

4.3.5 Invasive Plant Species

<u>Relevance and Context</u>
Ecosystems in the NPS are consistently under threat from exotic plant invasions (Allen et al. 2008). As these species encroach on NPS lands, they can replace native plant species and reduce the natural integrity of the landscape. One study documented a 64% reduction in native species biomass attributable to exotic invasive species (Flory and Clay 2010). Once established, invasive plants can have adverse ecological effects that ripple up the food chain including altering insect (Bezemer et al. 2014) and bird communities (Skórka et al. 2010). Exotic invasive plants are often transported across borders accidently, and growing global trade is exacerbating the problem (Robinet et al. 2012).

<u>Data and Methods</u>
Nine exotic invasive plant species were catalogued in the U.S. Invasive Plant Atlas as occurring within BOWA (Swearingen 2007). Data for the assessment of exotic invasive species were collected as part of the MIDN I&M vegetation monitoring protocol (Comiskey et al. 2009). Plots were

selected using a GRTS approach and assessed by field crews from 2007-2010. A second survey of these plots was completed from 2011-2014. A total of eight 20 x 20 meter plots were established (see Figure 4.22 in Forest Regeneration section). The presence or absence of 29 exotic indicator species was recorded within each of 12 quadrats of each plot (each quadrat = 1 meter^2 in area), and cover estimates of each exotic indicator species were documented (Comiskey et al. 2009).

Threshold

A threshold of <2 indicator species per plot was set based on NPS guidance criteria of less than 0.5 to 3.5 species per plot (Tierney et al. 2016). Current condition was calculated as the percent of the eight plots sampled from 2011 to 2014 that contained <2 indicator species. Trend was assessed based on comparison to the first sample rotation from 2007-2010.

Current Condition and Trends

Four exotic indicator species were observed in the 2011-2014 sample: Japanese honeysuckle (*Lonicera japonica)*, multiflora rose (*Multiflora rosa*), Japanese stiltgrass (*Microstegium vimineum*), and Oriental lady's thumb (*Persicaria posumbu*). In the initial sample rotation, Indian strawberry (*Duchesnea indica*) was also observed on one of the plots in 2007.

Japanese Stiltgrass (*Microstegium vimineum*) is a common invasive species in the park (Photo by Todd Lookingbill).

Five of the eight sample plots (62.5%, moderate concern) had fewer than two exotic indicator species in the 2011-2014 sample (Table 4.7). Japanese honeysuckle was the species most frequently detected and was recorded on six of the plots. It was recorded on seven of the plots in the 2007-2010 sample. Trend was assessed as stable; one plot had one fewer species, and one plot had one additional species detected in the later sample. Percent cover was less than 25% for all samples. In general, BOWA has fewer invasive exotic plant species and lower total cover than other parks sampled as part of the MIDN I&M forest monitoring network (Comiskey 2013).

Table 4.7. Number of exotic invasive indicator plant species observed in BOWA forest monitoring plots (MIDN I&M Program).

Plot Number	Rotation 1 (2007-2010)	Rotation 2 (2011-2014)
005	3	3
006	2	1
095	1	1
094	1	1
182	1	2
181	2	2
261	1	0
260	0	0

Data Gaps and Level of Confidence

A recent, comprehensive, and park-wide assessment of invasive species has not occurred. The only available data is from the I&M forest vegetation monitoring plots. Due to the generally variable and dynamic nature of invasive plant species, the confidence in this assessment is low.

Sources of Expertise

Karen D. Patterson, Virginia Department of Conservation and Recreation, Division of Natural Heritage

4.4 Landscape Dynamics

4.4.1 Forest Landcover

Relevance and Context

Both habitat loss and fragmentation are leading causes of extinction, with the effects of habitat loss likely outweighing those of fragmentation (Fahrig 1997, Fahrig 2013). Though the primary focus of BOWA is on cultural resources, which include maintaining several agricultural fields, the park maintains a significant proportion of its land as forested. Regionally, forests cover approximately 65% of the Mid-Atlantic United States (McKenney-Easterling et al. 2000). Land conversion from forest can occur for a variety of purposes including agriculture, timber harvesting, and mining (Dale et al. 2000). From 1973 to 2000, total forest has decreased by 4.3% nationally (Sleeter et al. 2013) and 4.0% in the Eastern U.S. (Drummond and Loveland 2010) due primarily to increasing urban, suburban, and exurban development. Deforestation can lead to exotic species invasions (Vitousek et al. 1997), degraded and diminished water flows (Meyer and Turner 1992), and the spread of new diseases (Langlois et al. 2001).

Data and Methods

Maps of forest landcover for 2001, 2006, and 2011 were extracted from the National Land Cover Dataset (NLCD) (Jin et al. 2013). Percent forest cover in the park was used to assess current condition (Budde et al. 2009). Any discernable changes from 2001 to 2011 were used to assess trend.

Threshold

Simulation studies of forest loss suggest a critical threshold value of at least 59% of the total landscape area be maintained in forest to maintain many ecological functions and services (Gardner et al. 1987, Turner et al. 2001). Landscapes with lower forest amount tend to lose the characteristic qualities of intact forest required of organisms such as forest interior birds and forest dwelling mammals. Small losses in forest within landscapes near this critical threshold result in large changes in average patch size, the amount of interior forest, the amount of edge habitat, and related metrics of fragmentation (Fahrig 2003). These same studies identified a second potential threshold value of 30% (Turner et al. 2001, Fahrig 2003). Landscapes with less than 30% forest suffer from more serious concerns related to overall habitat loss rather than issues of forest fragmentation per se (i.e., the breaking apart of intact habitat into a larger number of smaller pieces). For this assessment, forest land cover percentages above 59% were assigned an attainment score of 100%; forest percentages below 30% were assigned an attainment score of 0%; and forest percentages between 30–59% were scaled linearly from 0–100% attainment.

Current Condition and Trend

Using NLCD data, the park had a total forest cover of 64.9% for 2011, which represents 100% attainment (Figure 4.26). There was no observable trend from 2001 to 2011 for the park (Figure 4.27). Much of the land surrounding the park is currently changing slowly from agricultural and forested land to urban land (Figure 4.28).

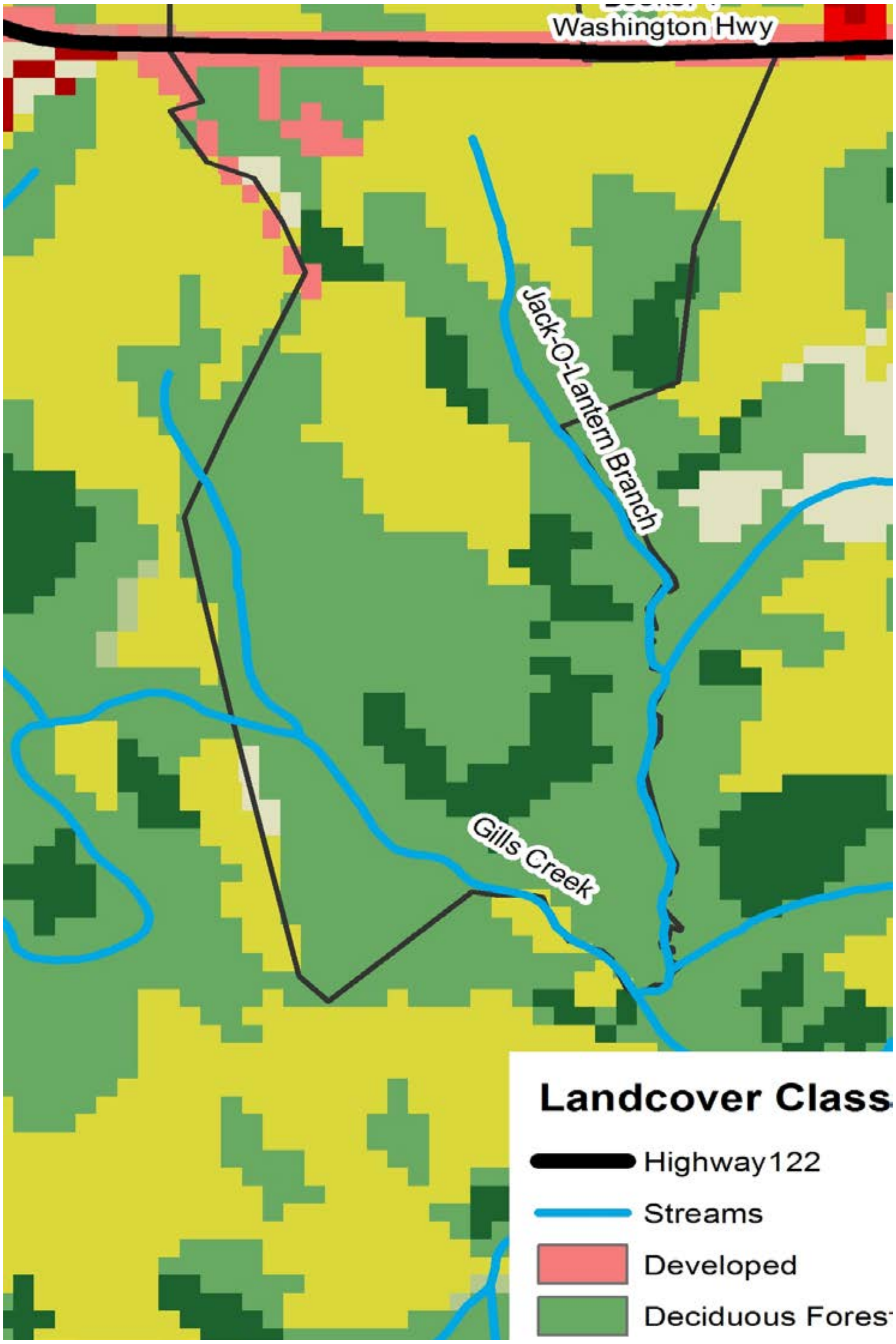


Figure 4.26. Land cover for BOWA (NLCD 2011).

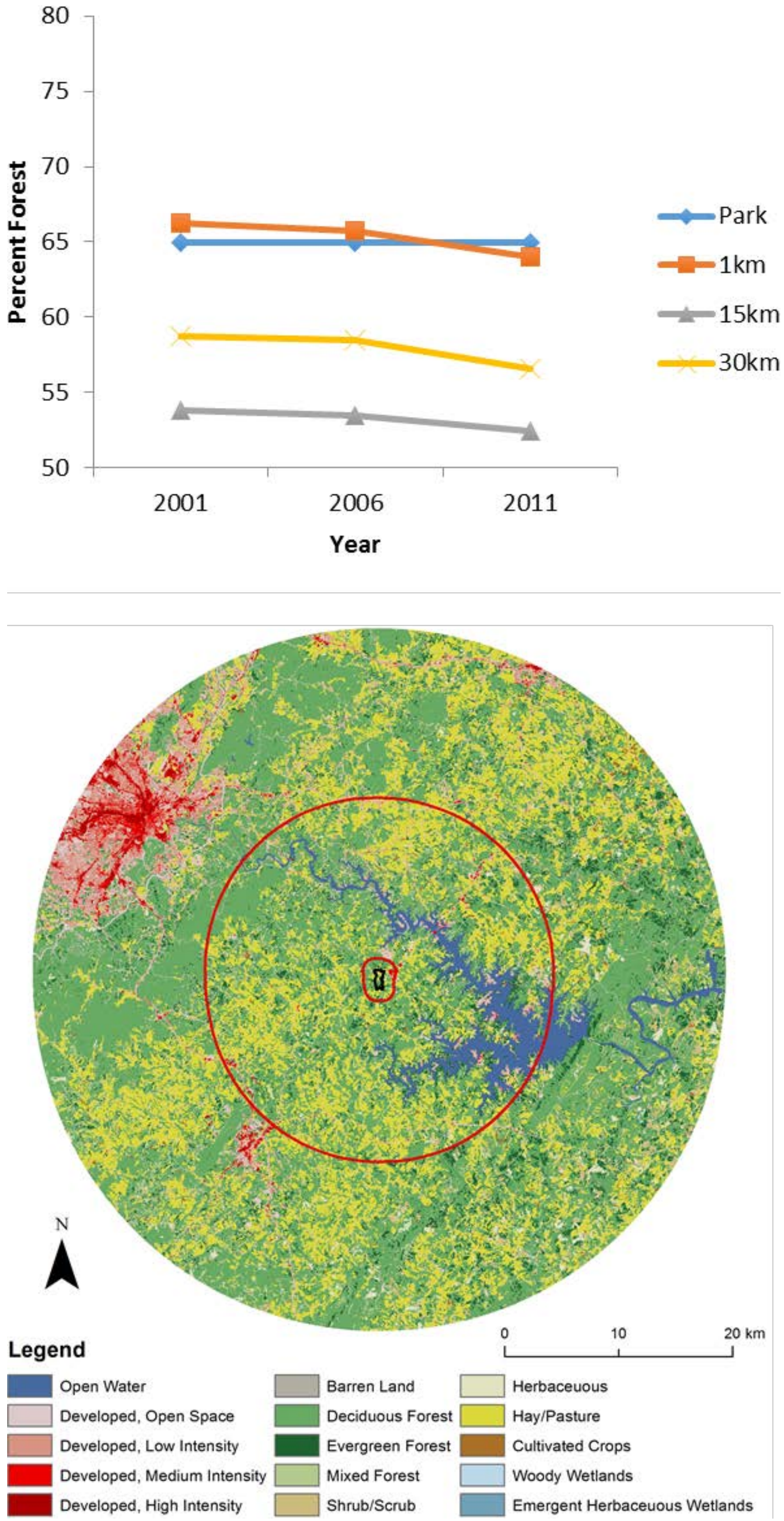


Figure 4.27. Trends in forest landcover for BOWA and surrounding region: 1-km buffer, 15-km buffer, and 30-km buffer (NLCD 2001, 2006, 2011).

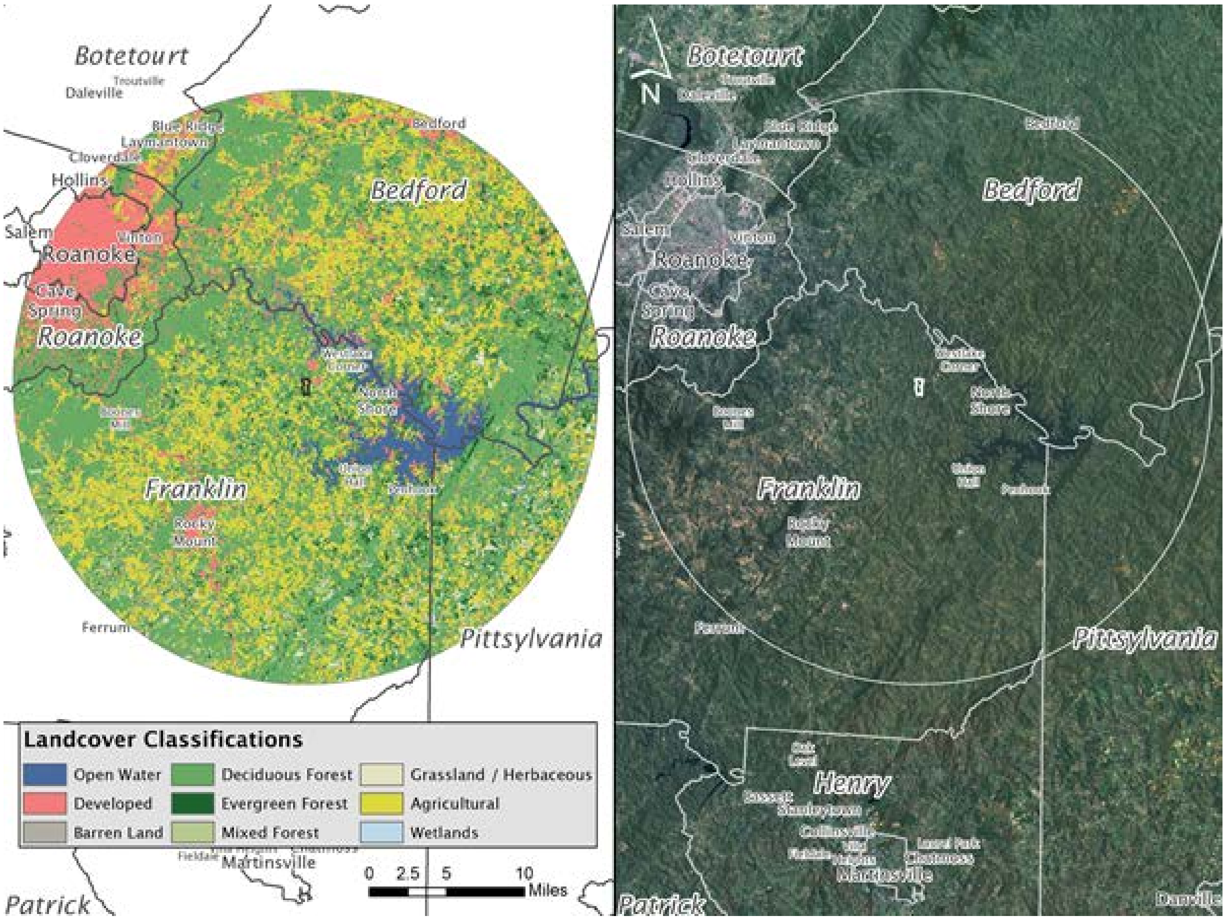


Figure 4.28. Land cover for 30-km buffer surrounding BOWA (NLCD 2011).

Data Gaps and Level of Confidence

This assessment of forest cover treats all types of forest as equivalent. Differences in forest composition and quality are not considered. Similarly, the assessment treats all non-forest cover types equivalently. Different types of non-forest land could have drastically different effects on forest fragmentation. The assessment also makes use of a national-scale data product (NLCD) to do a local scale analysis. A higher resolution, site-specific land cover classification would increase confidence in the results. However, the results are consistent with a one-time assessment for the park that estimated 66% of BOWA was covered by forest (Patterson 2008). The overall level of confidence in this metric is moderate.

Sources of Expertise

Mike Story, Remote Sensing Specialist, National I&M Program, NPS

4.4.2 Riparian Buffer

Relevance and Context

Forested riparian buffers enhance biodiversity and improve water quality. They enhance terrestrial biodiversity by providing foraging, nesting, breeding, and escape cover; protecting sensitive habitats; and maintaining landscape connectivity (Hodges and Krementz 1996, Wanger 1999, Bentrup 2008).

They also provide valuable benefits to aquatic habitat, for example, by shading streams to maintain favorable temperature (Moore et al. 2005). Forested riparian buffers protect water quality by reducing the amount of sediment, nutrients, and other pollutants that enter streams, lakes, and other surface waters (Phillips 1989). They attenuate nutrients such as nitrogen through plant uptake, microbial immobilization and denitrification, soil storage, and groundwater mixing (Lowrance et al. 1997).

Despite strong evidence that forested riparian buffers are an important best management practice, many factors affect the ability of the riparian forest to function effectively including pollutant load, field slope, type and density of vegetation, soil structure, subsurface drainage patterns, and the frequency and force of storm events (Osborne and Kovacic 1993). The scientific basis for determining a specific width for the best management practice depends on the overall rational for the buffer, with 100 m recommended as an appropriate width for riparian buffers intended to provide both water quality benefits and benefits to terrestrial species that use forested riparian areas as movement corridors and amphibians, turtles, and other aquatic species that use the land for at least part of their life cycles (Bentrup 2008).

Trees along the bank of Gills creek provide important ecosystem functions, improving water quality and enhancing biodiversity (Photo by Todd Lookingbill).

Data and methods

Land cover data from the NLCD were used to generate a map of forested area within the park (Jin et al. 2013). The percentage of the 100-m riparian zone that was forested was then calculated for all streams inside the park. The 2011 NLCD data product was used to assess current condition. The 2001, 2006, and 2011 NLCD data were used to assess trend.

Because Gills Creek and Jack-O-Lantern Branch form boundaries to the park at some locations, portions of their riparian zones lie outside the park. The percent forest within these boundary zones that lie just outside the park was also calculated for reference purposes, but these values were not used in the final scoring of condition.

Threshold

The Chesapeake Bay Program has a long-term goal of 70% forest coverage in riparian areas of the Bay watershed (Sprague et al. 2006). Using this desired condition as a threshold value, forest cover of greater than 70% in the riparian zone was deemed as 100% attainment for the purpose of this assessment. For a riparian zone with percent forest cover between 0 and 70%, the condition score would be scaled linearly from 0 to 100% attainment between these two reference points.

Current condition and trend

Using 2011 NLCD data, 82% of the riparian area within BOWA is forested, representing 100% attainment relative to the threshold of 70% (Figure 4.29, top panel). Additionally, NLCD data from 2001 and 2006 were used to assess temporal trends in land cover and showed an increasing amount of forest within the riparian zone over the past decade (Figure 4.30).

For the streams of BOWA, a significant amount of their riparian zones lie outside park boundaries (Figure 4.29, bottom panel). These riparian areas were slightly less forested (72%) than the riparian areas inside the park.

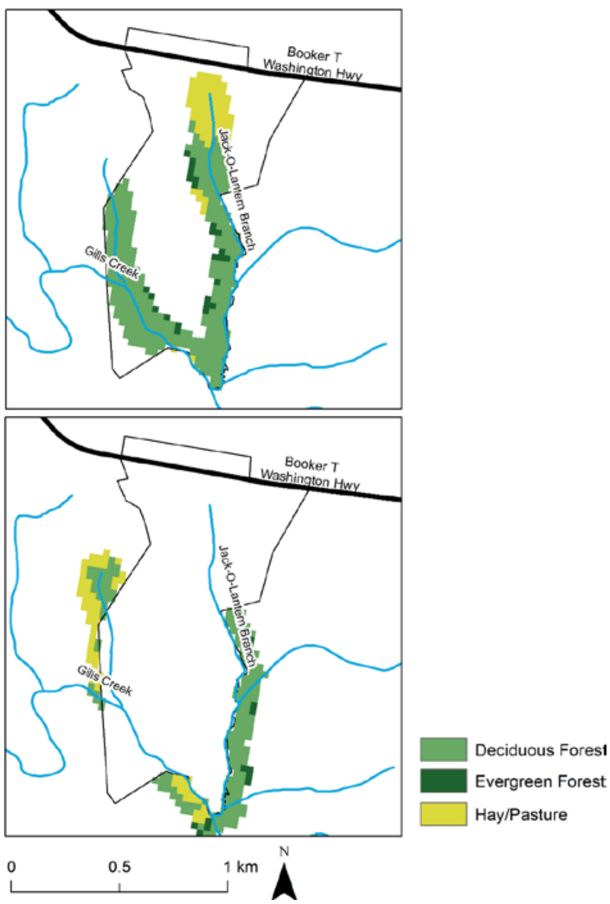


Figure 4.29. Forested and non-forested riparian areas around streams of BOWA (NLCD 2011).

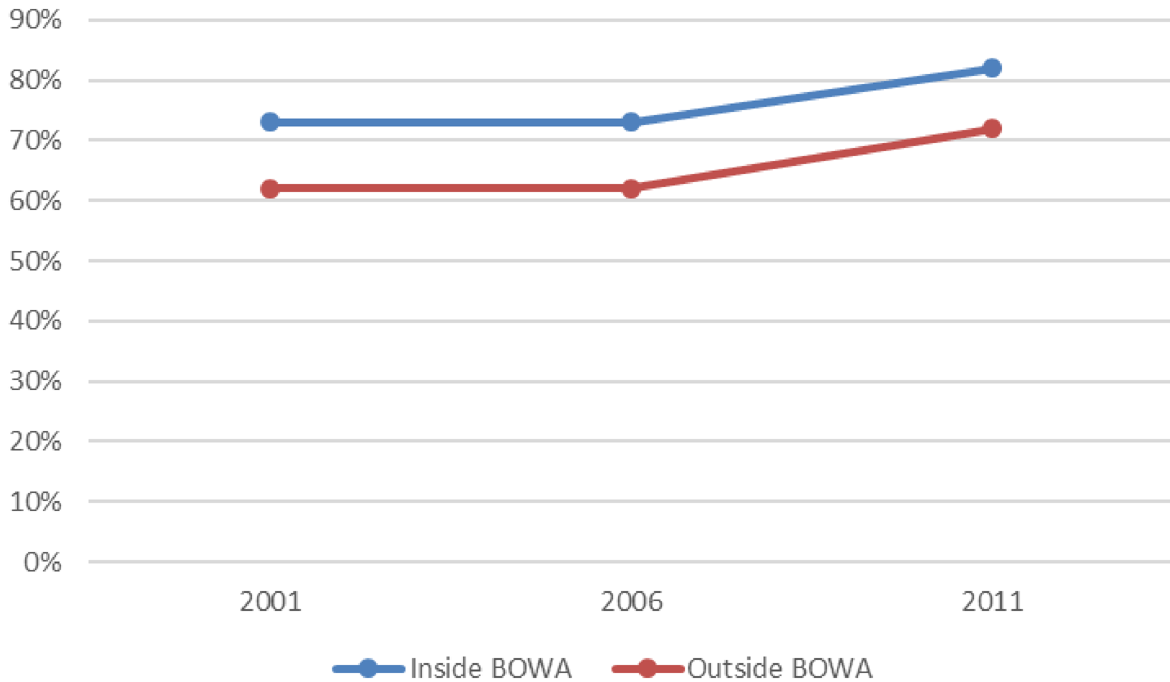


Figure 4.30. Percent of riparian zone that was forested (NLCD 2001, 2006, 2011).

<u>Data gaps and level of confidence</u>

The analysis relies on the NLCD, a national-level land cover classification that is not specifically intended for local-level analyses. Errors associated with the NLCD data set are well documented in Hollister et al. (2004) and Thogmartin et al. (2004). The confidence in this indicator is moderate.

<u>Sources of expertise</u>

Albert Todd, Watershed Program Leader, USDA Forest Service

4.4.3 Impervious Surface

<u>Relevance and Context</u>

Impervious surfaces are materials that prevent water from infiltrating the soil such as roads, rooftops, and compacted soils. The amount of impervious surface cover on a landscape is directly correlated with urbanization and is frequently used as an indicator of the impacts of human modifications of the landscape on environmental conditions, specifically, changes in water quality and flow (Arnold and Gibbons 2007). By preventing water from seeping into the ground, impervious surfaces alter hydrology leading to increased erosion and pollution (Arnold and Gibbons 2007). Increased impervious cover along with decreased evapotranspiration in urbanized watersheds can lead to increased peak flow rates and annual discharge volumes (Boggs and Sun 2011). As part of a characteristic set of effects referred to collectively as the “urban stream syndrome,” impervious surface cover has been found to have a greater effect on sensitive macroinvertebrates than even the disruption of riparian buffers (Walsh et al. 2005, Walsh et al. 2007). Percent impervious surface, therefore, can provide a good approximation of watershed and aquatic habitat degradation, even within areas of little development (Gergel et al. 2002).

Data and methods

Impervious surface data were taken from the 2011 NLCD in which all 30-m raster pixels were classified into 101 possible values (0–100% impervious surface cover) (Homer et al. 2007). Using the park boundary layer, the total area of impervious surface within the park was calculated. The percentage of the park covered by impervious surface for the 2011 data was compared to a threshold value to assess current condition. Trend was assessed using the 2001, 2006, and 2011 estimates of impervious surface from the NLCD.

For context, these calculations also were conducted for the 10-digit (Figure 4.31) and 12-digit Hydrologic Unit Code (HUC) watersheds surrounding the park (Faber-Langendoen 2009).

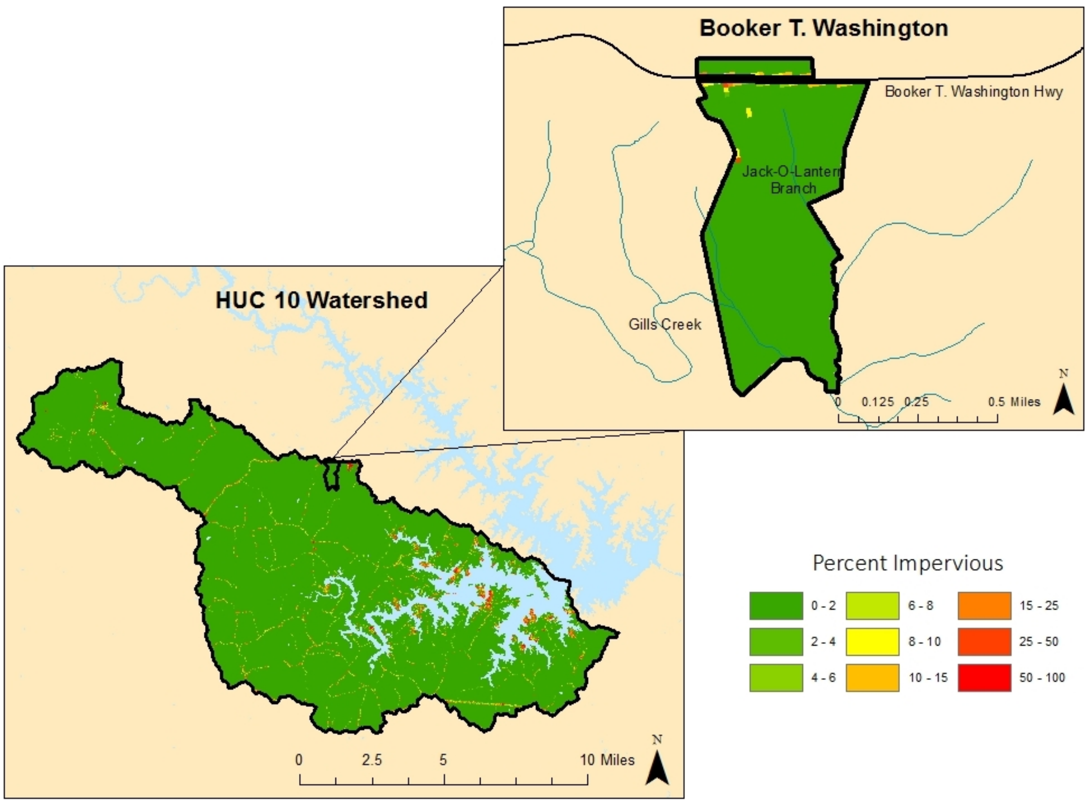


Figure 4.31. Impervious surface cover for the park and surrounding HUC10 watershed (NLCD 2011).

Threshold

Many studies have documented threshold type effects on different ecosystem resources at relatively low impervious surface cover. A study in Georgia showed significant increases in nutrients, including nitrate, in watersheds with greater than 5% impervious surface cover (Schoonover and Lockaby 2006). In a Maryland study, impervious surface cover as low as 0.5–2% resulted in the decline of the majority (80%) of the stream taxa, while 2–25% cover showed a decline in 100% of the taxa (King et al. 2011). Watersheds with 3–5% cover have shown significant changes in stream flow, and Piedmont watersheds with 2.5-15% cover have shown a loss of sensitive aquatic invertebrate taxa (Utz et al. 2009, Yang et al. 2010). This assessment used a threshold value based on the idea that impervious surface totaling less than 2% of the total park area represented an attainment score of 100% and impervious surface totaling greater than 10% represented an attainment score of 0%. Percent impervious surface between 2% and 10% were scored linearly from 0-100% (Arnold and Gibbons 1996, Lussier et al. 2008).

<u>Current condition and trend</u>

Using the 2011 NLCD data, the park was covered by 0.4% (0.9 acres) impervious surfaces for a current condition attainment score of 100%. For the same time period, the amount of impervious surface in the HUC10 and HUC12 watersheds containing the park was also less than 1%. The amount of impervious surface in the 30km buffer surrounding the park in 2011 was 1.7%.

The amount of impervious surface coverage increased by 0.1% (27 acres) for both the HUC10 and HUC12 watersheds over the past decade, but remained stable within the park boundaries (Figure 4.32). Although 4.9% of the park is classified as NLCD class 21 (Developed, Open Space), this land cover class indicates the presence of minimal development, and is comprised of mostly vegetation with impervious surface accounting for a small portion of the total cover. Only 0.1% of the park was classified as class 22 (Developed, Low Intensity). This category indicates slightly higher levels of development with impervious surface accounting for 20% to 49% of total cover.

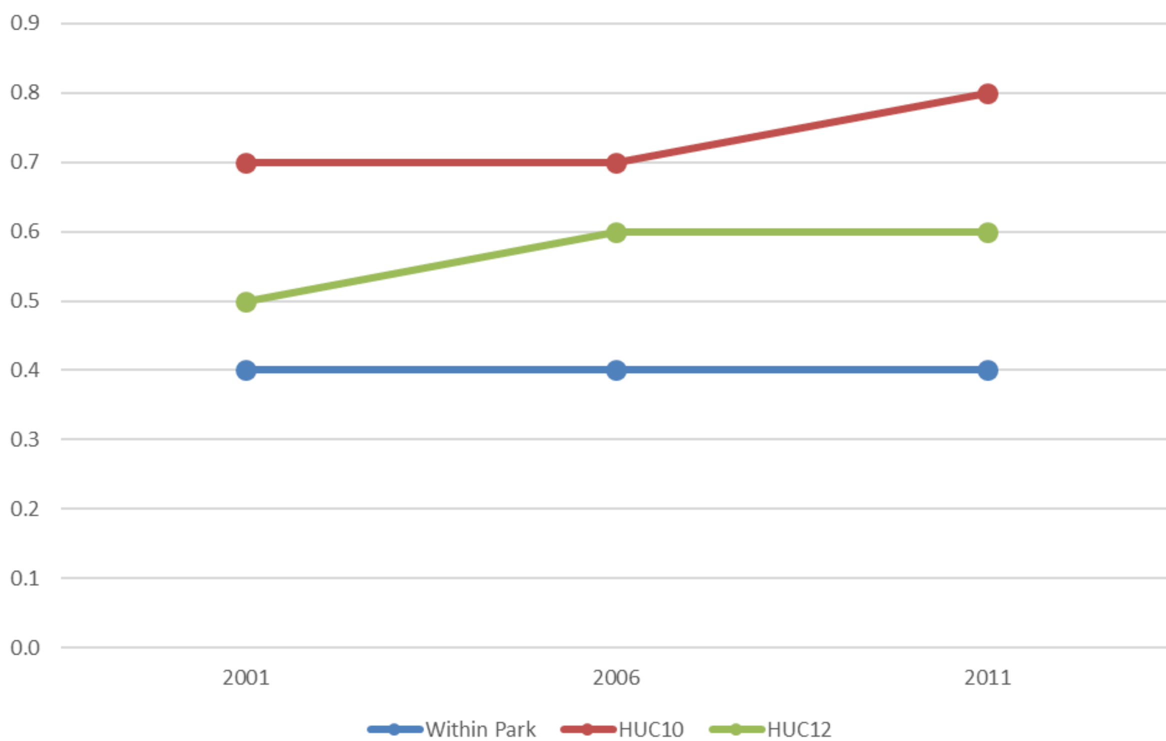


Figure 4.32. Impervious surface coverage trends for BOWA, HUC10, and HUC12 watersheds (NLCD 2001, 2006, 2011).

<u>Data gaps and level of confidence</u>

The analysis relies on the NLCD, a national-level land cover classification that is not specifically intended for local-level analyses. Errors associated with the NLCD data set are well documented in

Hollister et al. (2004) and Thogmartin et al. (2004). Future projections of development and impervious surface would be beneficial in anticipating environmental impacts. Confidence in this assessment is moderate.

Sources of expertise

Matt Baker, Associate Professor of Geography, University of Maryland Baltimore County

4.4.4 Grassland Patches

Relevance and Context

The decline of grassland birds in the Mid-Atlantic is attributed to a combination of factors. One of the most important causes is the fragmentation of open space in the region (Watts 2000, Peterjohn et al. 2007). The combination of increasing urban development and forest secondary succession on abandoned agricultural land has generally resulted in fewer and smaller grassland patches. In Virginia, the amount of open grassland has been reduced by 55% since 1945 and currently comprises less than 2% of the landscape (Watts 2000). Up to 95% of remaining grassland patches are < 10 ha (25ac) in size (Watts 2000). Most grassland bird species are highly sensitive to patch size. As a consequence, grassland birds are experiencing one of the highest rates of decline of any group of birds in North America (Peterjohn and Sauer 1999). Historical and cultural parks may be critical refuges for grassland birds in the Northeast. In a recent inventory of four, relatively small, battlefield parks in the region (Antietam, Monocacy, Manassas, and Gettysburg), compositions of grassland bird communities were highly variable among sites; however, there was a consistent finding that breeding grassland birds avoided fields < 10 ha (25 ac) in size (Peterjohn et al. 2007).

Data and methods

Land cover data from the 2011 NLCD were used to generate a map of contiguous grassland within the park (Jin et al. 2013). All fields were then characterized by size. The largest single contiguous patch of grassland was compared to a minimum threshold deemed desirable to support grassland birds. Trend was assessed using the 2001, 2006, and 2011 estimates of grassland cover from the NLCD.

Threshold

Watts (2000) provides a minimum patch size requirement of 10 ha (25 ac) to support grassland bird communities. In his assessment of grassland bird area requirements, Peterjohn (2006) used similar reference values. According to his recommendations, contiguous grassland areas <4.9 ha (12 ac) in size are generally avoided by grassland birds. Areas need to be greater than 10 ha (25 ac) to be consistently occupied. Even 10-ha patches are not large enough to serve as high-quality habitat for many grassland birds. Peterjohn (2006) recommends contiguous grassland area >40 ha (100 ac) to support healthy grassland bird communities in the region.

This assessment used a graduated set of thresholds: all patches <5 ha = 0% attainment; at least one patch >5 ha = 30% attainment; at least one patch >10 ha = 70% attainment; at least one patch >40 ha = 100% attainment.

Fields and traditional wooden fences in BOWA (Photo by Todd Lookingbill).

Current condition and trend

The park met the ecological threshold of having at least one patch ≥ 10 ha in size for an attainment score of 70%. The largest patch was 15.8 ha (39.1 acres). The next largest patch size was 9.2 ha (22.7 acres). All other patch sizes were > 2 ha (Figure 4.33). No changes in patch size were detected when comparing the 2011 data to the 2001 and 2006 data sets.

Data gaps and level of confidence

Confidence in this metric is assessed as moderate. The size of grassland patches can be quantified with a high level of accuracy using relatively simple mapping techniques. The level of confidence would be increased by additional research to refine the threshold. For example, the influence of patch quality on minimum patch size could be incorporated or species-specific minimum area requirements could be researched. Thresholds applicable to species other than grassland birds would also be relevant. Finally, a better measure of patch size would incorporate adjacent property along the park boundary.

Sources of expertise

Brian Watts, Director, Center for Conservation Biology, College of William & Mary

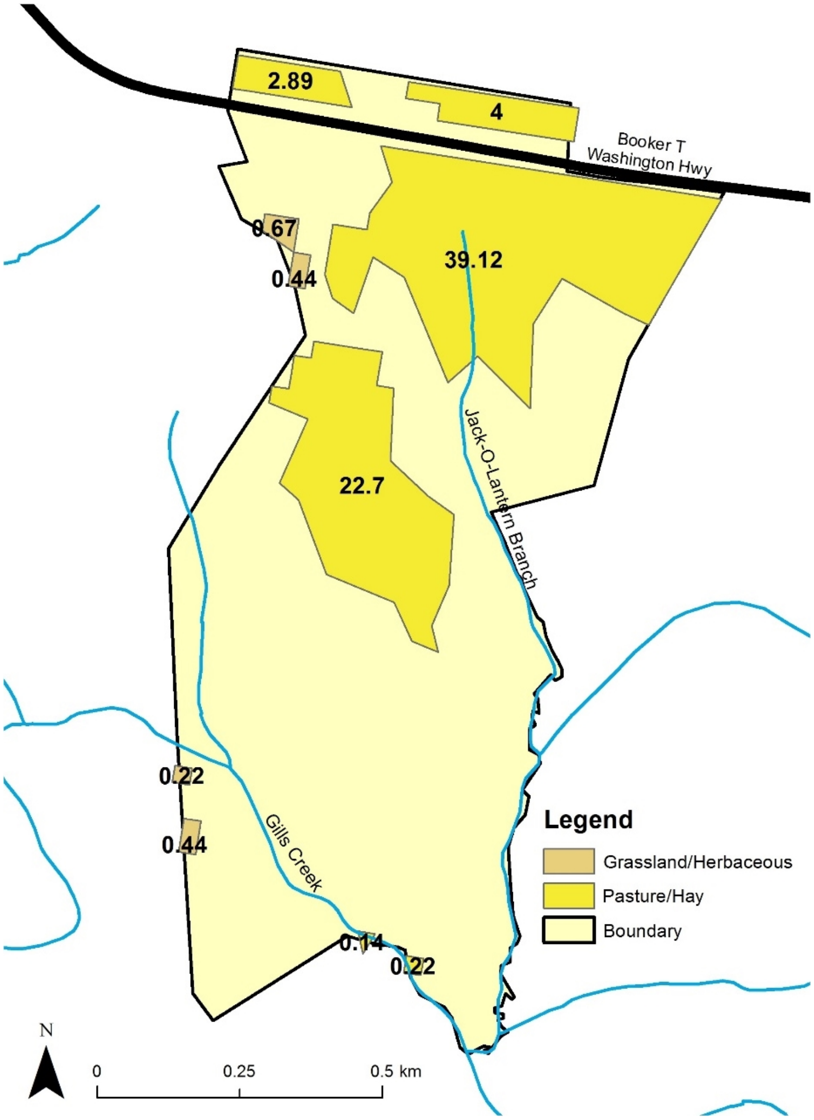


Figure 4.33. Large patches of grassland located in BOWA with area of patch provided in acres (NLCD 2011).

Chapter 5. Discussion

5.1 Booker T. Washington National Monument Context for Assessment

The resources of BOWA possess historic, esthetic, cultural, economic, and scientific values. The condition of natural resources in the park must be considered in the context of its geography, legislative mission, and history. The park's founding documents require park management to protect certain historical conditions, including the preservation of historical landmarks.

The natural condition of these resources has been assessed systematically through: describing the park resource setting, consulting with relevant stakeholders on the assessment approach, compiling available data for resources and stressors, identifying suitable metric indicators of resource condition, using available literature and expert opinion to develop thresholds for these metrics, and deriving a percentage score for the park as a whole. Based on this information, this final chapter summarizes the key conditions, stressors, and threats to resources within the park. It provides brief recommendations for better understanding these resources and maintaining or improving their future condition.

5.2 Park Natural Resource Condition

Different park objectives and management practices are associated with each of the four Vital Sign categories within BOWA: Air Quality, Water Quality, Biological Integrity, and Landscape Dynamics. The natural condition of the park has been assessed based on 19 indicators representing these categories as outlined in Chapter 3. The detailed methods used to assess each indicator and the final assessment of their condition and trend were provided in Chapter 4. In this chapter, the key findings for each indicator are summarized. Recommendations were compiled in collaboration with park natural resource personnel.

5.2.1 Air Quality

The condition of air quality in BOWA was assessed as being of "significant concern" based on an attainment score of 24% (Table 5.1). Confidence in this assessment is moderate based on the high quality of the data but collection sites not being within the park boundaries. The length and temporal resolution of the air quality data allows clear assessment of trends. The spatial resolution, however, is poor as the information is spatially interpolated from monitoring stations sometimes located far from the park. Though current air quality conditions at BOWA, as well as the region as a whole, are degraded, trends for the past decade indicate that conditions are improving for all metrics but mercury deposition.

Air quality degradation is not an issue specific to BOWA. Park management efforts to directly improve regional air quality are likely to have minimal impact. However, the park can play a leading role in regional education of the causes and effects of air pollution. These impacts include human health issues, plant defoliation, water acidification, and altered nutrient cycling (Table 5.2).

Table 5.1. Summary of air quality indicators and threshold attainment for BOWA.

Indicators	Reference Condition Attainment	Current Condition	Trend in Condition
Ozone	75%	Good	Improving
Wet Nitrogen Deposition	0%	Significant Concern	Improving
Wet Sulfur Deposition	45%	Moderate Concern	Improving
Visibility	0%	Significant Concern	Improving
Mercury Deposition	0%	Significant Concern	Declining
Air Quality	**24%**		

Table 5.2. Key findings and recommendations for air quality in BOWA.

Key Findings	Recommendations
• Regional degradation of air quality • Improving conditions for many indicators	• Spread awareness throughout the region • Educate the public on the causes and effects of air pollution

5.2.2 Water Quality

The condition of water quality for the park was assessed as being in "moderate" condition based on an average attainment of 66% for all metrics (Table 5.3). The trends do not indicate any significant declines in water quality, though the length of the data record is relatively short at this time. Confidence in the assessment of this Vital Sign category is considered moderate based on the monthly sampling being conducted by the NPS I&M Program within the park. While the trend for sensitive macroinvertebrate populations is considered stable, the indicator value was right below the threshold value set for the index of biological integrity. Small amounts of annual variability have resulted in this indicator fluctuating above and below threshold levels in recent years. More monitoring data would be useful to track these trends and to try to better understand what is causing the degradation of this resource (Table 5.4).

Table 5.3. Summary of water quality indicators including threshold attainment for BOWA.

Indicators	Reference Condition Attainment	Current Condition	Trend in Condition
Dissolved Oxygen	100%	Good	Stable
Water temperature	100%	Good	Stable
Water pH	100%	Good	Stable
Nitrate	29%	Significant Concern	Not Assessed
Macroinvertebrates	0%	Significant Concern	Stable
Water Quality	**66%**		

Table 5.4. Key findings and recommendations for water quality in BOWA.

Key Findings	Recommendations
• Water temperature, pH and DO in generally good condition	• Take steps to decrease the potential for eutrophication
• High nitrate (NO_3) concentrations	• Prevent cows from entering Jack-O-Lantern Branch
• Macroinvertebrate indicator values are near desired threshold levels	• Continue and increase monitoring of macroinvertebrates as an integrative measure of stream quality with special attention on species that have not yet been documented in the park

As nitrogen deposition continues to decrease throughout the region, airborne pollution of streams are likely to decrease in the park. Future studies could quantify these relationships within the park. Increased collaboration with state agencies such as Department of Environmental Quality could assist with the collection of data. The leveraging of volunteer efforts continues to provide useful data. Regional collaboration and partnerships with neighbors is important to maintaining good water quality in the park.

5.2.3 Biological Integrity

Biological integrity was assessed as being in "good" condition based on attaining 71% of the threshold scores (Table 5.5). Confidence in the assessment for this Vital Sign is moderate. While the assessment of bird and vegetation resources in the park was based on ongoing monitoring, the assessment of many of the other indicators was based on single inventory reports.

Table 5.5. Summary of biological integrity indicators including threshold attainment for BOWA.

Indicator	Reference Condition Attainment	Current Condition	Trend in Condition
Birds	81%	Good	Stable
Fish	100%	Good	Not Assessed
Mammal	67%	Good	Not Assessed
Herpetofauna	39%	Moderate Concern	Not Assessed
Forest Regeneration	75%	Good	Stable
Invasive Plants	62.5%	Moderate Concern	Stable
Biological Integrity	**71%**	n/a	n/a

Because the same stressors degrade the condition of several indicators, the conditions of many of the indicators are interconnected. For example, fish communities and herpetile communities are both influenced by water quality. More basic data collection is needed on biotic resources such as mammals and terrestrial invertebrates. Additional data on invasive plant species distributions would also be useful to management (Table 5.6). Although invasive species pose a potential threat to biotic resources, fewer invasive plants have been detected in BOWA than other parks in the region. Monitoring for new invasives and forest pests such as hemlock woolly adelgid is recommended. Deer densities, and associated deer browsing, also are lower in BOWA than many other parks in the Mid-Atlantic but should be tracked.

Table 5.6. Key findings and recommendations for biological integrity in BOWA.

Key findings	Recommendations
• Presence of invasive plant species, but at lower densities than some of the other parks in the region • Minimal data to assess mammals, herpetofauna, and fish • Minimal data on vegetation pests • Relatively healthy fish population includes several species endemic to the Roanoke River Basin	• Continue and increase treatment of known invasive species problems such as Japanese stiltgrass; increase monitoring of treatment effectiveness • Increase monitoring and survey efforts for herpetofauna • Monitor white-tailed deer densities, which are a regional problem • Coordinate with other parks to prepare for hemlock woolly adelgid and emerald ash borer

5.2.4 Landscape Dynamics

The condition of landscape dynamics were assessed as being **good** based on an average attainment of 92% for all metrics (Table 5.7). Confidence in the assessment was moderate, and would be increased by developing a higher resolution land cover classification specific to the park. The trends for all indicators are either stable or improving. However, there are a number of areas that would benefit from further data collection such as the collection of information on light and noise pollution, issues of increasing NPS concern nationally and locally important in recreating the historic context of this landscape (Table 5.8).

Table 5.7. Summary of landscape dynamic indicators including threshold attainment for BOWA.

Indicators	Reference Condition Attainment	Current Condition	Trend in Condition
Forest Landcover	100%	Good	Stable
Riparian Buffer Width	100%	Good	Improving
Impervious Surface	100%	Good	Stable
Contiguous Grassland Area	70%	Good	Stable
Landscape Dynamics	**92%**	n/a	n/a

As a small park, the condition of the BOWA landscape is inextricably linked to activities on lands surrounding the park. Partnerships and regional collaboration will be important to maintaining this historic landscape in good condition. The park itself maintains enough land in forested land cover to be a valuable source of forest habitat for the region and potentially provide a movement corridor for forest- and grassland-dependent species. However, the park is near a critical threshold in the amount of forest that it maintains and any decrease in the amount of forest in the park could reduce its capacity to provide valuable ecosystem services. It is unlikely that the park could create a grassland patch large enough to meet the requirement (40 ha) to increase the score for that indicator to 100%. Some landscape resources, such as riparian forest buffers, are in better condition inside the park than along its boundaries.

Table 5.8. Key findings and recommendations for landscape dynamics in BOWA.

Key Findings	Recommendations
• Large grassland patches are supportive of grassland bird community • As a small park, external development has the potential to impact park natural resources • While impervious surfaces, riparian buffers, and forest cover within the park are stable and in good condition, these indicators are near thresholds of concern and the park's immediate surrounding areas show a trend toward increased urban development • Park likely suffers from light and sound pollution but currently no data are available to assess	• Consider connectivity of forest resources when conducting any management activities that would result in the loss of forest cover in the park • Work with neighbors to minimize impacts of future development outside of park's borders • Preserve healthy riparian forest buffers inside park and along its boundary • Continue to practice mowing techniques that will protect the integrity of large grassland patches • Gather data on night skies and soundscapes

5.3 Overall Park Condition

The overall condition of BOWA was assessed as being of "moderate concern" based on an average attainment of 64% for the four Vital Sign categories assessed (Table 5.9).

Table 5.9. Summary of park vital signs including attainment average of indicators for BOWA.

Vital Sign	Reference Condition Attainment	Current Condition	Confidence in Assessment
Air Quality	24%	Significant Concern	Moderate
Water Quality	66%	Moderate Concern	Moderate
Biological Integrity	73%	Good	Moderate
Landscape Dynamics	92%	Good	Moderate
Booker T. Washington National Monument	**64%**	n/a	n/a

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Appendix A: List of butterfly species found at BOWA

Appendix A Table 1. List of butterflies found at BOWA (Clyde Kessler, personal communication, 2014; Timothy Sims, personal communication, 2014).

Scientific Name	Common Name
Battus philenor	Pipevine Swallowtail
Eurytides marcellus	Zebra Swallowtail
Papilio polyxenes	Black Swallowtail
Papilio glaucus	Eastern Tiger Swallowtail
Papilio troilus	Spicebrush Swallowtail
Pieris rapae	Cabbage White
Colias philodice	Clouded Sulphur
Colias eurytheme	Orange Sulphur
Eurema nicippe	Sleepy Orange
Strymon melinus	Gray Hairstreak
Calycopis cecrops	Banded Hairstreak
Calycopis cecrops	Red-banded Hairstreak
Celastrina neglecta	Summer Azure
Cupido comyntas	Eastern Tailed-Blue
Euptoieta claudia	Variegated Fritillary
Speyeria cybele	Great Spangled Fritillary
Chlosyne nycteis	Silvery Checkerspot
Phyciodes tharos	Pearl Crescent
Polygonia comma	Eastern Comma
Polygonia interrogationis	Question Mark
Nymphalis antiopa	Mourning Cloak
Vanessa atalanta	Red Admiral
Vanessa virginiensis	American Lady
Junonia coenia	Common Buckeye
Limenitis arthemis	Red-spotted Purple
Danaus plexippus	Monarch
Cercyonis pegala	Common Wood-Nymph
Enodia anthedon	Northern Pearly-Eye
Megisto cymela	Little Wood Satyr
Hermeuptychia sosybius	Carolina Satyr
Cyllopsis gemma	Gemmed Satyr
Epargyreus clarus	Silver-spotted Skipper
Thorybes bathyllus	Southern Cloudywing
Pyrgus communis	Common Checkered Skipper

Scientific Name	Common Name
Erynnis juvenalis	Juvenal's Duskywing
Erynnis brizo	Sleepy Duskywing
Erynnis icelus	Dreamy Duskywing
Erynnis baptisiae	Wild Indigo Duskywing
Ancyloxypha numitor	Least Skipper
Atalopedes campestris	Sachem
Polites origenes	Cross-line Skipper
Polites peckius	Peck's Skipper
Pompeius verna	Little Glassywing
Poanes zabulon	Zabulon Skipper
Euphyes vestris	Dun Skipper
Libytheana carinenta	American Snout
Asterocampa celtis	Hackberry Emperor
Achalarus lyciades	Hoary Edge

Appendix B: List of bird species found at BOWA

Appendix B Table 1. List of bird species found at BOWA during I&M surveys (NPS 2009, Johnson 2014a,b, raw data).

Scientific Name	Common Name
Empidonax virescens	Acadian Flycatcher
Corvus brachyrhynchos	American Crow
Carduelis tristis	American Goldfinch
Setophaga ruticilla	American Redstart
Turdus migratorius	American Robin
Icterus galbula	Baltimore Oriole
Hirundo rustica	Barn Swallow
Dendroica castanea	Bay-Breasted Warbler
Ceryle alcyon	Belted Kingfisher
Coragyps atratus	Black Vulture
Mniotilta varia	Black-And-White Warbler
Dendroica striata	Black-Poll Warbler
Dendroica caerulescens	Black-Throated Blue Warbler
Dendroica virens	Black-Throated Green Warbler
Guiraca caerula	Blue Grosbeak
Cyanocitta cristata	Blue Jay
Plioptila caerulea	Blue-Gray Gnatcatcher
Buteo playpterus	Broad-Winged Hawk
Toxostomat rufum	Brown Thrasher
Molothrus ater	Brown-Headed Cowbird
Sitta pusilla	Brown-Headed Nuthatch
Dendroica tigrina	Cape May Warbler
Poecile carolinsis	Carolina Chickadee
Thryothorus ludovicianus	Carolina Wren
Bobycilla cedrorum	Cedar Waxwing
Chaetura pelagica	Chimney Swift
Spizella passerina	Chipping Sparrow
Quiscalus quiscula	Common Grackle
Chordeiles minor	Common Nighthawk
Corvus corax	Common Raven
Geothlypis trichas	Common Yellowthroat
Junco hymalis	Dark-Eyed Junco
Picoides pubescens	Downy Woodpecker
Sialia sialis	Eastern Bluebird

Scientific Name	Common Name
Tyrannus tyrannus	Eastern Kingbird
Sturnella magna	Eastern Meadowlark
Sayornis phoebe	Eastern Phoebe
Pipo erythrophthalmus	Eastern Towhee
Contopus virens	Eastern Wood-Pewee
Sturnus vulgaris	European Starling
Spizella pusilla	Field Sparrow
Passerella iliaca	Fox Sparrow
Ammodramus savannarum	Grasshopper Sparrow
Dumetella carolinensis	Gray Catbird
Ardea herodias	Great Blue Heron
Myiarchus crinitus	Great Crested Flycatcher
Picoides villosus	Hairy Woodpecker
Carpodacus mexicanus	House Finch
Passer domesticus	House Sparrow
Passerina cyanea	Indigo Bunting
Charadrius vociferus	Killdeer
Seiurus motacilla	Louisiana Waterthrush
Dendroica magnolia	Magnolia Warbler
Zenaida macroura	Mourning Dove
Colinus virginianus	Northern Bobwhite
Cardinalis cardinalis	Northern Cardinal
Colaptes auratus	Northern Flicker
Mimus polyglottos	Northern Mockingbird
Parula americana	Northern Parula
Seiurus noveboracensis	Northern Waterthrush
Icterus spurious	Orchard Oriole
Pandion haliaetus	Osprey
Seiurus aurocapillus	Ovenbird
Dendroica palmarum	Palm Warbler
Dryocopus pileatus	Pileated Woodpecker
Dendroica pinus	Pine Warbler
Dendroica discolor	Prairie Warbler
Carpodacus purpureus	Purple Finch
Melanerpes carolinus	Red-Bellied Woodpecker
Vireo olivaceus	Red-Eyed Vireo
Beuto lineatus	Red-Shouldered Hawk
Buteo jamaicensis	Red-Tailed Hawk

Scientific Name	Common Name
Agelaius phoeniceus	Red-Winged Blackbird
Archilochus colubris	Ruby-Throated Hummingbird
Piranga olivacea	Scarlet Tanager
Melospiza melodia	Song Sparrow
Piranga rubra	Summer Tanager
Melospiza georgiana	Swamp Sparrow
Baeolophus bicolor	Tufted Titmouse
Cathartes aura	Turkey Vulture
Caprimulgus vociferus	Whip-Poor-Will
Sitta carolinensis	White-Breasted Nuthatch
Zonotrichia leucophrys	White-Crowned Sparrow
Zonotrichia albicollis	White-Throated Sparrow
Meleagris gallopavo	Wild Turkey
Hylocichla mustelina	Wood Thrush
Sphyrapicus varius	Yellow-Bellied Sapsucker
Coccyzus americanus	Yellow-Billed Cuckoo
Icteria virens	Yellow-Breasted Chat
Dendroica coronata	Yellow-Rumped Warbler

Appendix C: List of fish species found at BOWA

Appendix C Table 1. List of fish species found in Gills Creek and Jack-O-Lantern Branch (Atkinson 2008).

Family	Scientific Name	Common Name
Catostomidae	*Carpiodes cyprinus*	Quillback
Catostomidae	*Catostomus commersonii*	White Sucker
Catostomidae	*Hypentelium nigricans*	Northern Hogsucker
Catostomidae	*Hypentelium roanokense*	Roanoke Hogsucker
Catostomidae	*Moxostoma anisurum*	Silver Redhorse
Catostomidae	*Moxostoma erythrurum*	Golden Redhorse
Catostomidae	*Moxostoma pappillosum*	V-Lip Redhorse
Catostomidae	*Scartomyzon ariommus*	Bigeye Jumprock
Catostomidae	*Scartomyzon cervinus*	Black Jumprock
Centrarchidae	*Lepomis auritus*	Redbreast Sunsfish
Centrarchidae	*Lepomis cyanellus*	Green Sunfish
Centrarchidae	*Lepomis gibbosus*	Pumpkinseed
Centrarchidae	*Lepomis macrochirus*	Bluegill
Centrarchidae	*Micropterus salmoides*	Largemouth Bass
Cyprinidae	*Campostoma anomalum*	Central Stoneroller
Cyprinidae	*Clinostomus funduloides*	Rosyside Dace
Cyprinidae	*Cyprinella analostana*	Satinfin Shiner
Cyprinidae	*Cyprinus carpio*	Common Carp
Cyprinidae	*Luxilus albeolus*	White Shiner
Cyprinidae	*Luxilus cerasinus*	Rosefin Shiner
Cyprinidae	*Nocomis leptocephalus*	Bluehead Chub
Cyprinidae	*Notropis hudsonius*	Spottail Shiner
Cyprinidae	*Notopis procne*	Swallowtail Shiner
Cyprinidae	*Phoxinus oreas*	Mountain Redbelly Dace
Cyprinidae	*Pimephales notatus*	Bluntnose Minnow
Cyprinidae	*Semotilus atromaculatus*	Creek Chub
Ictaluridae	*Noturus insignis*	Margained Madtom
Moronidae	*Monroe americana*	White Perch
Percidae	*Etheostoma flabellare*	Fantail Darter
Percidae	*Etheostoma nigrum*	Jonny Darter
Percidae	*Etheostoma podostemone*	Riverweed Darter
Percidae	*Perca flavescens*	Yellow Perch

Appendix D: List of mammal species found at BOWA

Appendix D Table 1. List of mammal species found at BOWA from 2003-2004 inventory (Pagels et al. 2005).

Scientific Name	Common Name
Castor canadensis	American Beaver
Neovison vison	American Mink
Ursus americanus	Black Bear
Urocyon cinereoargenteus	Common Gray Fox
Procyon lotor	Common Raccoon
Canix latrans	Coyote
Tamias striatus	Eastern Chipmunk
Sylvilagus floridanus	Eastern Cottontail
Sciurus carolinensis	Eastern Gray Squirrel
Scalopus aquaticus	Eastern Mole
Sciurus niger	Fox Squirrel
Mus musculus	House Mouse
Cryptotis parva	Least Shrew
Mustela frenata	Long-Tailed Weasel
Zapus hudsonius	Meadow Jumping Mouse
Blarina brevicauda	Northern Short-Tail Shrew
Sorex minutus	Pygmy Shrew
Vulpes vulpes	Red Fox
Sorex longirostris	Southeastern Shrew
Glaucomys volans	Southern Flying Squirrel
Mephitis mephitis	Striped Skunk
Didelphis virginiana	Virginia Opossum
Peromyscus leucopus	White-Footed Mouse
Odocoileus virginianus	White-Tailed Deer
Marmota monax	Woodchuck
Microtus pinetorum	Woodland Vole

Appendix E: List of herpetile species found at BOWA

Appendix E Table 1. List of herpetile species found at BOWA from 2002-2004 inventory (Mitchell 2006).

Category	Scientific Name	Common Name
Toads and Frogs	*Bufo americanus*	American Toad
	Hyla chrysoscelis	Cope's Gray Tree Frog
	Pseudacris crucifer	Northern Spring Peeper
	Rana catesbeiana	American Bullfrog
	Rana Clamitans	Green Frog
Salamanders	*Desmognathus fuscus*	Dusky Salamander
	Eurycea cirrigera	Southern Two-Lined Salamander
	Gyrinophilus porphyriticus	Spring Salamander
	Pseudotriton ruber	Northern Red Salamander
Turtles	*Chelydra serpentina*	Common Snapping Turtle
	Terrapene carolina	Eastern Box Turtle
Snakes	*Carphophis amoenus*	Eastern Worm Snake
	Diadophis punctatus	Northern Ring-Necked Snake
	Elaphe obsoleta	Eastern Ratsnake
	Nerodia sipedon	Northern Watersnake
	Storeria occipitomaculata	Red-Bellied Snake

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