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Prepared in cooperation with Maryland Department of Natural Resources, Michigan State University Extension, New Jersey Department of Environmental Protection, New York Natural Heritage Program, North Carolina Department of Natural and Cultural Resources, Ohio Department of Natural Resources, Western Pennsylvania Conservancy, U.S. Fish and Wildlife Service, Virginia Department of Conservation & Recreation, and West Virginia Division of Natural Resources

Range-Wide Relative Abundance of the Appalachian Grizzled Skipper (*Pyrgus centaureae wyandot*) in the Eastern United States

Open-File Report 2026–1017

U.S. Department of the Interior
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Contents

Figures

Tables

Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32) / 1.8.$$

Abbreviations

AGS	Appalachian grizzled skipper
FS	U.S. Forest Service
FWS	U.S. Fish and Wildlife Service
NYNHP	New York Natural Heritage Program
NYSDEC	New York State Department of Environmental Conservation
PNHP	Pennsylvania Natural Heritage Program

Range-Wide Relative Abundance of the Appalachian Grizzled Skipper (*Pyrgus centaureae wyandot*) in the Eastern United States

By Nimish B. Vyas,[1] Jennifer Selfridge,[2] David Cuthrell,[3] Robert Somes,[4] Erin White,[5] Judith Ratcliffe,[6] J. Merrill Lynch,[6] Laurie Hamon,[6] Eileen Wyza,[7] Betsy Leppo,[8] Peter Woods,[8] Anthony Tur,[9] Donovan Drummey,[9] Kathryn Nolan,[9] Ellison Orcutt,[10] Andrew Rapp,[10] Leah Card,[10] Jakob Goldner,[11] and Susan Olcott[11]

Abstract

The U.S. Fish and Wildlife Service has designated the *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) to be at-risk, based on its declining populations and the lack of information on its status. The objective of this study was to complete range-wide surveys to locate extant AGS colonies and to quantify the number of AGS observed at each location. From 2021 to 2024, 284 surveys were done in 25 unique (that is, distinct) counties in 8 states in the Eastern United States: Maryland, Michigan, New York, North Carolina, Ohio, Pennsylvania, Virginia, and West Virginia. We found AGS in only two counties: Alleghany County, Virginia, and Greenbrier County, West Virginia. AGS were observed 180 times in these 2 counties. Our results can inform U.S. Fish and Wildlife decisions about where and how future AGS conservation efforts can be implemented.

Introduction

Pyrgus centaureae wyandot (Appalachian grizzled skipper [AGS]; fig. 1) is a small (22–33-millimeter wingspan), dark brown-black butterfly with two irregular bands of white spots on the forewing (Allen, 1997). The U.S. Fish and Wildlife Service (FWS) considers the AGS to be at-risk (a declining species that is not currently protected under but may need the protections of the Endangered Species Act of 1973 [16 U.S.C. §§ 1531-1540]; FWS, 2018). The FWS is performing a discretionary review to fill knowledge gaps about the current status of AGS populations and assess whether the species should be listed as threatened or endangered (FWS, 2024). To inform these efforts, surveys were done to determine the range-wide relative abundance of AGS. Our findings can provide Federal and State natural resource managers with information so that effective strategies to protect the AGS can be developed and implemented.

Precise survey site locations are not provided here because the information has limited availability owing to restrictions (that is, for the protection of the colony locations and the privacy of the landowners). A general overview of AGS habitat is given in the following sections.

Range

Historically, the AGS's range encompassed nine states in the Eastern United States and the District of Columbia. Two populations are recognized: the Appalachian population (in Maryland, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Virginia, West Virginia, and the District of Columbia) and the Michigan population (in Michigan). The Appalachian population and the Michigan population differ in their larval plant, habitat preferences, number of larval development stages, and larval appearance (Allen, 1997; Parshall, 2002; Cuthrell, 2007; Schweitzer and others, 2011).

Within these landscapes, the AGS has been found in a variety of naturally disturbed and early successional habitats, including woodland openings associated with rocky outcrops in open barren sites with thin soil (in Ohio), summits of hills or mountains at middle elevations (914–1,067 meters [m] in North Carolina), shale barrens (in Pennsylvania, Virginia, Maryland, New York, and West Virginia), trap rock glades (in New Jersey and parts of New York), blueberry heath barrens,

[1] U.S. Geological Survey.

[2] Maryland Wildlife and Heritage Service.

[3] Michigan Natural Features Inventory.

[4] New Jersey Department of Environmental Protection.

[5] New York Natural Heritage Program.

[6] North Carolina Natural Heritage Program.

[7] Ohio Department of Natural Resources.

[8] Western Pennsylvania Conservancy.

[9] U.S. Fish and Wildlife Service.

[10] Virginia Natural Heritage Program.

[11] West Virginia Division of Natural Resources.

Figure 1. Photographs showing *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]). *A*, An AGS at a colony in Greenbrier County, West Virginia. Photograph by J. Goldner, West Virginia Division of Natural Resources, used with permission. *B*, Susan Olcott of the West Virginia Division of Natural Resources Section with an AGS during a survey at a colony in Greenbrier, West Virginia. Photograph by N. Vyas, U.S. Geological Survey. *C*, An AGS survey and training led by Susan Olcott (third from the right) at an active AGS colony in Greenbrier County, West Virginia. Photograph by J. Hajenga, West Virginia Division of Natural Resources, used with permission. *D* and *E*, AGS in North Carolina. Photographs by Ted Wilcox, reproduced here with permission from Ted Wilcox on September 12, 2025.

pine oak barrens, pine barrens (in New York), openings within sandy jack pines, pine-oak barrens or woodlands, limestone glades and barrens, coastal alvars and adjacent fields (in Michigan, New Jersey, and possibly in some parts of the Great Lakes ecoregion in New York and Ohio; Cuthrell, 2007; Schweitzer and others, 2011; New York State Department of Environmental Conservation [NYSDEC], 2014). The AGS has also been found in anthropogenically disturbed early successional areas including gas line and powerline corridors, fire lanes, forest roads, recently logged areas and clear cuts, open pastures, Christmas tree farms adjacent to open woods (in North Carolina), fallow hilltops, and trails and roadsides (fig. 2; Allen, 1997; Parshall, 2002; Schweitzer and others, 2011; NYSDEC, 2014; LeGrand and others, 2026).

Despite the diversity of habitats used by AGS, Schweitzer and others (2011) identified the habitat components that are necessary for the AGS:

1. Open or semi-open, sparsely vegetated areas that allow sufficient sunlight to support an abundance of AGS's larval host plants, such as *Potentilla canadensis* L. (dwarf cinquefoil) for the Appalachian population and *Fragaria virginiana* (Duchesne; wild strawberry) for the Michigan population.

2. An abundance of low-growing, flowering, nectaring plants for the adults, such as *Viola pedata* (birdfoot violet), *Phlox subulata* (moss phlox), *Claytonia virginica* (spring beauty), *Antennaria* spp. (pussytoes), *Vaccinium* spp. (blueberry), *Tussilago farfara* (coltsfoot), *Vicia sylvatica* (wood vetch), *Rubus chamaemorus* (cloudberry), and *Taraxacum officinale* (common dandelion) (fig. 3; apps. 3–12; Iftner and others, 1992; Parshall, 2002; Wurst, 2010; Schweitzer and others, 2011; New York Natual Heritage Program [NYNHP], 2025).

3. South or west-facing slopes or ridges with grassy patches and abundant unvegetated areas (in other words, bare rock, gravel, or soil). The AGS has an early flight season, and areas with bare rock, gravel, or soil (that rapidly heat up in the sun) serve as basking areas for thermoregulation (LeGrand and others, 2026). For example, during an April 12, 2023, AGS survey in Pennsylvania, the air temperature in the sun at midday was in the 20s degrees Celsius (°C), but the ground temperature registered in the upper 40s °C (apps. 3, 9; Betsy Leppo, Western Pennsylvania Conservancy, written commun., 2024).

4. *Quercus* spp. (oak), *Carya* spp. (hickory), and *Pinus* spp. (pine) woodlands within 30 m on at least two sides of the habitat patch. Trees provide AGS areas for roosting at night and an area to escape precipitation, wind, and predators.

5. A source of moisture (for example, temporary or permanent streamlets, damp soil, or muddy puddles) for the AGS and their host and nectaring plants (figs. 3*C*, 3*D*; moisture at base of slope for host and nectaring plants).

Biology

The Appalachian and Michigan AGS populations are univoltine (Allen, 1997). Mating and ovipositing take place in spring. The slow-growing larvae hatch in May and pupate in late summer, spending the winter in sealed leaf shelters close to the ground. The pupae eclose the following spring (Allen, 1997; Parshall, 2002). The AGS then disperses through corridors like ridges, gas pipeline and powerline corridors, dirt roads, and paths (for example, figures 2*I*, 2*J*; Pennsylvania Natural Heritage Program [PNHP], 2015).

The flight period of the AGS is short, about 5 weeks. In general, the Appalachian population's flight period ranges from late March until mid-May, depending on the latitude and elevation (Parshall, 2002). The Michigan population's flight period is from May to early June (table 1; Parshall, 2002; Cuthrell, 2007). The flight period, however, may shift by weeks depending on the weather conditions during the winter and spring (Leppo, 2019). For example, during a warm early spring in North Carolina, the flight period is from the end of March to about late April. In a cool spring in North Carolina, the flight period can range from mid-April to early May (LeGrand and others, 2026). During the flight period, adult AGS fly within a meter off the ground and spend the warm parts of the day perching, patrolling, feeding, puddling, basking, mating, and ovipositing (figs. 4*A*, 4*B*).

Although the basic biology of the AGS has been studied (Parshall, 2002; Chazal and others, 2004; Allen, 2009; Schweitzer and others, 2011), the FWS faces considerable knowledge gaps about the status of their populations (Donovan Drummy, FWS, written comm., 2026). The U.S. Geological Survey (USGS) did range-wide surveys for AGS to provide the FWS with information on their occurrence over their distribution range.

Objectives

The overall objective of this study was to complete range-wide surveys to locate extant AGS colonies and to quantify the number of AGS observed at each location.

Specific objectives included the following:

1. Selecting currently active and past active (that is, colonies that were previously active and historically active) AGS colony sites for survey;

2. Analyzing spatial habitat data to remotely select areas that could harbor undocumented AGS colonies;

Figure 2. Photographs showing examples of habitats searched to find *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]). *A*, A south-facing slope of a shale barren at an active AGS colony in Greenbrier County, West Virginia. White flowers are *Phlox subulata* L. (moss phlox). Photograph by N. Vyas, U.S. Geological Survey. *B*, A southwest-facing slope of a shale barren at an active AGS colony in Greenbrier County, West Virginia. White patches on and at the base of the slope are moss phlox. Photograph by N. Vyas, U.S. Geological Survey. *C*, The location of the last known AGS sighting (in 2012) in Huntingdon County, Pennsylvania. Photograph by Betsy Leppo, Western Pennsylvania Conservancy, used with permission. *D*, The location of an AGS colony (last active in 2008) at a Christmas tree farm in Ashe County, North Carolina. Photograph by J.M. Lynch, North Carolina Natural Heritage Program, Department of Natural and Cultural Resources, used with permission. *E*, The location of the last confirmed sighting of an AGS colony (in 2018) in the Bedrock glade habitat in Presque Isle County, Michigan. Photograph by D. Cuthrell, Michigan Natural Features Inventory, used with permission. *F*, The Alvar pavement barrens habitat in Jefferson County, New York. Photograph by G. Edinger, New York Natural Heritage Program, SUNY College of Environmental Science and Forestry, used with permission. *G*, The location of an active AGS colony in Alleghany County, Virginia. Photograph by J.M. Lynch, North Carolina Natural Heritage Program, Department of Natural and Cultural Resources, used with permission. *H*, A location in Rockbridge County, Virginia. Photograph by L. Card, Virginia Natural Heritage Program, Virginia Department of Conservation and Recreation, used with permission. *I*, A power line right of way in Orange County, New York. Photograph by E. White, New York Natural Heritage Program, SUNY College of Environmental Science and Forestry, used with permission. *J*, A gas line right of way in Alleghany County, Virginia. Photograph by L. Card, Virginia Natural Heritage Program, Virginia Department of Conservation and Recreation, used with permission.

Figure 3. Photographs showing the host and nectaring plants of the *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]). *A*, A host plant for the Appalachian population of the AGS, *Potentilla canadensis* (dwarf cinquefoil). Photograph by D. Cuthrell, Michigan Natural Features Inventory, used with permission. *B*, A host plant for the Michigan population of the AGS, *Fragaria virginiana* (wild strawberry). Photograph by D. Cuthrell, Michigan Natural Features Inventory, used with permission. *C–E*, Nectaring plants for the AGS along the road near an active colony in Greenbrier County, West Virginia. The white flowers are *Phlox subulata* (moss phlox), and the purple flowers are *Viola pedata* (birdfoot violets). Photographs by N. Vyas, U.S. Geological Survey

Table 1. General range-wide flight periods for *Pyrgus centaureae wyandot* (Appalachian grizzled skipper).

[Flight periods may shift by weeks depending on the severity of winter and spring weather.]

State	Flight Period	Source
Maryland	Mid-April–Early May	Maryland Butterflies, 2026
Michigan	Early May–Early June	Cuthrell, 2007
New Jersey	Mid-April–Early May	Wurst, 2010
New York	Late April–Mid-May	New York State Department of Environmental Conservation, 2014
North Carolina	Early April–Early May	LeGrand and others, 2026
Ohio	Mid-April–Early May	Iftner and others, 1992; Parshall, 2002
Pennsylvania	Mid-April–Mid-May	Betsy Leppo, Western Pennsylvania Conservancy, oral commun., 2025
Virginia	Mid-April–Early May	Virginia Department of Conservation and Recreation, 2021
West Virginia	Mid-April–Mid-May	Allen, 1997

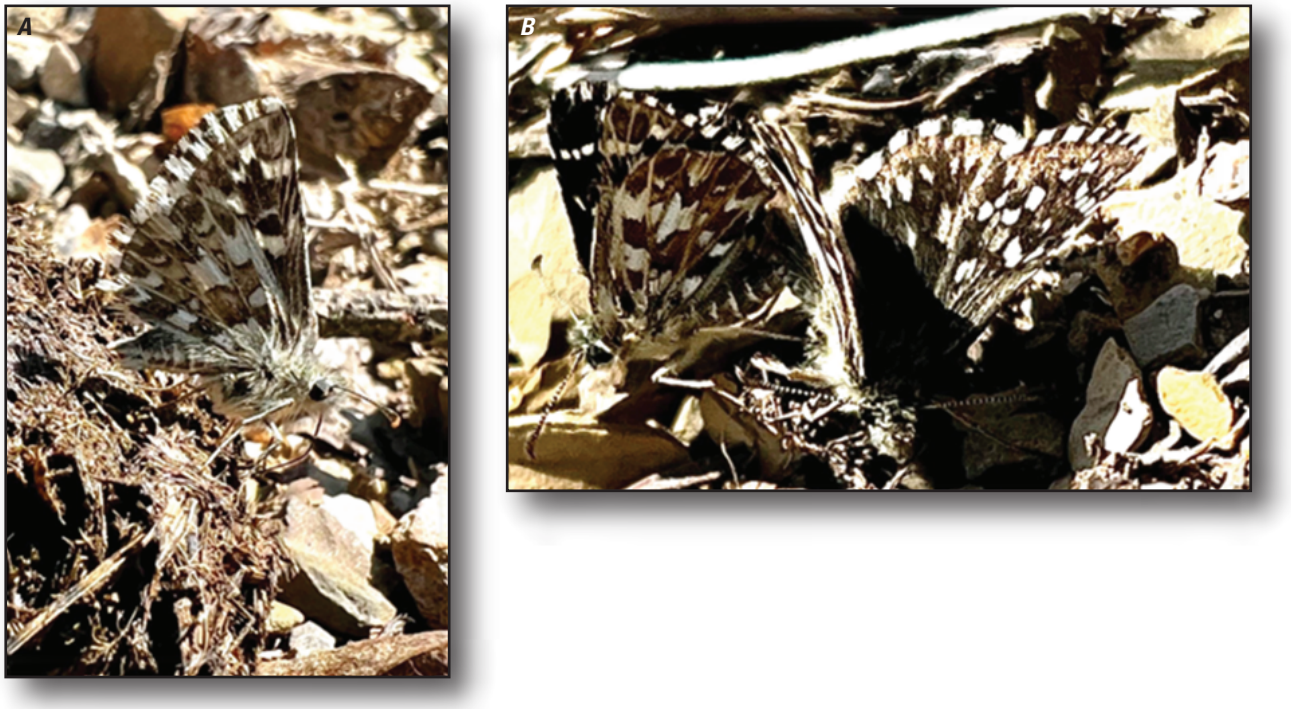


Figure 4. Photographs showing *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) in Alleghany County, Virginia. *A*, AGS during the flight period perched on leaf litter; *B*, a pair of AGSs copulating. Photographs by E. Orcutt, Virginia Natural Heritage Program, used with permission.

3. Carrying out surveys for AGS at currently occupied sites, previously occupied sites, and remotely selected sites that could support AGS based on habitat conditions; and

4. Describing AGS habitat characteristics at each survey location with respect to the weather during the survey, the habitat, occurrence of host and nectaring plants, and presence of other butterfly species.

Methods

Surveys were done in eight of the nine states that comprise the historical range of AGS: Maryland, Michigan, New York, North Carolina, Ohio, Pennsylvania, Virginia, and West Virginia. No survey results were reported by the New Jersey Department of Environmental Protection, and the District of Columbia was not surveyed because the most recent AGS record was from 1868 (Parshall, 2002). Therefore, New Jersey and the District of Columbia are not included in this report's "Results" section. Necessary permissions and permits were secured before entering private lands.

The specific methods used to achieve the study objectives are discussed in the following sections.

Objective 1. Select AGS Colony Sites for Survey

Each state's wildlife program has AGS records, gathered from many sources over many years, in a spatial database (for example, the NatureServe Biotics database [NatureServe, undated]). Each state used imagery or other coverages they had available and deemed appropriate for this task (for example, Pennsylvania used [1] World Imagery [Esri, Vantor, Earthstar Geographics, and GIS User Community, 2024], [2] Google Maps imagery [available at https://www.google.com], [3] the 2007–8 Color Orthophotos Cycle 2 for Pennsylvania [PAMAP Program and Pennsylvania Department of Conservation and Natural Resources, 2007], and [4] the 2006–8 LiDAR Breaklines, 2-foot lidar contours [PAMAP Program and Pennsylvania Department of Conservation and Natural Resources, 2008]).

State records on known (that is, confirmed as "Active") and past active (that is, "Previously Active," and "Historically Active") AGS colony sites were compiled for possible field survey. High-resolution aerial imagery was used to remotely locate the known and past active colony sites to confirm the location's current suitability for AGS. In general, locations of known colonies that were no longer suitable for AGS because of natural and anthropogenic habitat alterations (for example, vegetation succession and housing development) were excluded from surveys. However, the Western Pennsylvania Conservancy did in-person searches near historical colony sites even though the sites were not expected to be suitable for AGS based on remote assessment during this study. Their goal was to locate any overlooked remnants or new habitat patches that may be suitable for AGS within the historical colony landscape.

Objective 2. Analyze Spatial Habitat Data

Spatial habitat data were analyzed to remotely select areas that had not been surveyed previously but appeared suitable for AGS. The goal was to discover new, undocumented colonies and habitat patches. The document, "Guidance for Remotely Selecting Appalachian Grizzled Skipper (AGS) Colony Survey Locations" (fig. 1.1; app. 1) was prepared to harmonize the remote site selection methods across the eight states. The protocol for remote site selection was developed specifically for this project by the Western Pennsylvania Conservancy. The methods for remote site selection were as follows:

1. Known (currently active, previously active, and historically active) AGS colony sites were remotely located.

2. A 20-kilometer (km) circle was delineated around each colony using the tools available (for example, ArcGIS Pro). Each state then identified its own indicator species because the habitat specificity of plants varies across the AGS range. When data on indicator plant species and natural communities associated with AGS were available, the locations were further refined. However, even if no specific information on the locations of the past colonies and on indicator plant species was available, the Western Pennsylvania Conservancy searched for potentially suitable overlooked habitat throughout the former historical range in southeastern Pennsylvania to document the persistence of lingering colonies.

3. Within the 20 km circle, areas of interest (known AGS locations and locations with indicator plants) were buffered by a 3 km radius.

4. Within the 3 km radius circles, high-resolution aerial imagery (for example, World Imagery and Google Maps) was used to locate potential AGS habitats that met all three of the following criteria:

    a. Habitats that were on a southeast to southwest slope with a greater than 8 percent aspect.

    b. Open habitat.

        i. For the Appalachian AGS populations in Maryland, New York, North Carolina, Pennsylvania, Virginia, and West Virginia, the open habitat included clearcuts, unforested gas line and power line corridors, open roadsides, or woodland openings in shale habitat.

ii. For Appalachian AGS populations in New Jersey and parts of New York, the open habitat included woodland openings in trap rock habitat.

iii. For the Appalachian AGS population in Ohio, the open habitat included woodland openings in barren sites with disturbed thin soils that had sparse vegetation. Unlike the AGS populations in other states, AGS in Ohio have never been observed in shale barrens (Parshall, 2002).

iv. For the AGS populations in Michigan and in Jefferson County, New York, the open habitat included clearcuts, unforested gas line and power line corridors, open roadsides, limestone openings or glades, alvars, sandy habitat, trap rock, oak-pine barrens, and pine barrens.

c. Proximity of the habitat patch to at least some trees (within 50 m) for protection from weather and predators.

5. When reviewing the aerial imagery to determine the suitability of the habitat of known colony locations, areas with a full canopy of trees and shrubs, agriculture, mowed lawns, and development were excluded.

6. Areas with tree farms were not excluded.

7. The above winnowing steps resulted in areas with sparse vegetation and thin soils that could be locations of undocumented AGS colonies.

The remote site selection data were recorded on the "Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheet" (fig. 1.2).

Objective 3. Carry Out Surveys for AGS

The known colonies and the remotely selected locations that were to be surveyed were prioritized by type of site (known colonies first and then the remotely selected sites). Within the known colony sites, the colonies were sorted by the age of the last confirmed AGS record. Site categories and selection hierarchy for field surveys of AGS colonies were:

1. Active Colony—AGS observed since 2000.

2. Previously Active—AGS observed 1990–99.

3. Historically Active—AGS observed in 1989 or earlier.

4. Remote Selection—Sites without AGS records but may support AGS.

The "Guidance for Appalachian Grizzled Skipper (AGS) Field Survey Data Sheet" (fig. 1.3) harmonizes the methods for carrying out the field surveys. The AGS field survey methods (fig. 1.3) were drawn from the Frosted Elfin Habitat and Butterfly Survey Protocol (FWS Pilot Frosted Elfin habitat and butterfly survey protocols: FWS New York Field Office, Cortland, NY, unpub. data, written commun., 2021). Data from the surveys were entered on the "Appalachian Grizzled Skipper (AGS) Field Survey Data Sheet" (fig. 1.4). Surveys were generally done during the AGS flight period. Potential habitat suitability surveys by the Western Pennsylvania Conservancy were done during the AGS flight period and at any time throughout the growing season. The key fields that were included in the AGS field survey data sheet were selected by the investigators (they are also co-authors on this document). During an AGS survey, data were collected on:

1. Start time and end time of the walk-through.

2. GPS coordinates for the start and end locations of the walk-through.

3. Number of AGS observed during the walk-through.

4. GPS coordinates of AGS observed.

5. Confidence level of the identification (in other words, identified by sight without handling, identified by capture, or identified by photograph).

6. Behavior of each AGS observed (in other words, patrolling, perching, feeding, puddling, basking, mating, and egg laying).

Objective 4. Describe AGS Habitat at Each Survey Location

The "Guidance for Appalachian Grizzled Skipper (AGS) Field Survey Data Sheet" (fig. 1.3) also provided instructions for achieving Objective 4 and for completing the "Appalachian Grizzled Skipper (AGS) Field Survey Data Sheet" (fig. 1.4). The following data were collected on the data sheet:

1. Weather conditions during the survey—temperature; wind speed; percentage of cloud cover (visually estimated); the type, amount, and duration of precipitation; and any major changes in weather that could affect AGS activity.

2. General description of site (for example, clear cut, service road, natural clearing, powerline).

3. Host plant name, their density, and their distribution (qualitative).

4. Nectaring plant species names, their density, and their distribution (qualitative).

5. Host and nectaring plant species in bloom.

6. Map of survey path.

7. Other butterfly species observed during the survey.

8. Threats to the survey site.

9. Photographs of the survey site.

Data collected on the weather, host and larval plants and flowers, and other butterfly species during each survey site may explain the absence of AGS at the sites (apps. 2–12). For example, even if AGS were not sighted during a survey, data on the presence of AGS host and nectaring plants in bloom, the weather conditions, and the butterfly species in the AGS community (butterfly species that occupy the same area at the same time as AGS) can confirm if the survey was done at the appropriate time (Leppo, 2019).

In 2022 and 2023, the Western Pennsylvania Conservancy, in addition to doing surveys for AGS during the flight period, also did field site visits to determine AGS habitat suitability during and outside of the flight period. This allowed the Western Pennsylvania Conservancy to efficiently narrow down the number of locations that may be surveyed for AGS in the following year of the study.

In 2024, the West Virginia Division of Natural Resources expanded the scope of its AGS surveys by implementing a mark-recapture trial for estimating the AGS population size at the only known extant colony in West Virginia at the time. Another colony was later discovered about 1 km away from the core colony, 14 days after the mark-recapture trial had concluded there (apps. 3, 11, 12). Herein, we refer to the originally known colony as the core colony, whereas the other colony is called the second colony. The trial at the core colony involved 3 days of mark-recapture activities that included surveying the colony twice a day (a total of six surveys). This trial involved repeated sampling of uniquely marked AGS. During the first survey on the first day of the trial, all AGS observed were unmarked (in other words, new AGS). These AGS were netted, uniquely marked with a permanent marker on the ventral side of the wing (fig. 5), and released. On subsequent surveys, the uniquely marked AGS from the previous survey in the trial, when observed, were recorded as recaptured, and the unmarked AGS that were encountered were captured, marked, and released. Marking each individual AGS ensured that these individuals, when re-encountered during the subsequent sampling periods during the trial, were not counted as additional individuals in the colony. By analyzing the proportion of marked and unmarked AGS from the surveys of the trial, AGS population size at the core colony was estimated (Schnabel, 1938).

Figure 5. A marked *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) during the mark-recapture trial in Greenbrier County, West Virginia. Photograph by J. Goldner, West Virginia Division of Natural Resources, used with permission.

Results

Surveys

Two hundred eighty-four surveys were done in eight states (table 2). Of the 284 surveys, 124 surveys were done at the known colony sites (currently active, previously active, and historically active sites), whereas 146 surveys were done at remotely selected locations (table 2). The remaining 14 sites included either unplanned locations that were noticed on the way to other sites and opportunistically surveyed, or the method of colony selection was not reported. The numbers reported in table 2 represent the total number of surveys done, not the total number of unique sites surveyed, because many of the sites were surveyed more than once. The surveys were done in 25 unique counties (table 3), and 156 of the 284 surveys were done at unique sites (table 4).

Weather During Surveys

Eighty-nine percent of the surveys (*n*=247 surveys with data on the weather) were done when daytime high air temperatures ranged from 15.5 to 31.8 °C. The remaining surveys were done when air temperatures were from 7.2 to 15 °C or when weather data were not recorded. In general, wind speeds ranged from 0 to 16 kilometers per hour and cloud cover ranged from 0 to 100 percent.

AGS Relative Abundance

Despite 284 surveys in 8 states, AGS were only encountered in 32 surveys from 2 counties in 2 states: Alleghany County, Virginia, and Greenbrier County, West

Table 2. Number of surveys for *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) by site category.

[These numbers represent the number of surveys done in each survey category, not the number of unique sites surveyed. Many of the sites were surveyed multiple times. The site categories are as follows: 'active,' AGS observed since 2000; 'previously active,' AGS last observed 1990–99; 'historically active,' AGS last observed 1989 and earlier; 'remote selection,' spatial habitat data were used to remotely identify locations that appeared suitable for AGS but had not yet been surveyed; 'other,' a potentially suitable habitat patch found accidentally while in the field or unsure of status, and not reported, information not available. A zero (0) indicates that no location fit the site category, so no surveys were done in this site category.]

State	Site category						Total surveys by state
	Active	Previously active	Historically active	Remote selection	Other	Not reported	
Maryland	0	0	31	45	2	5	83
Michigan	4	6	0	6	0	0	16
New York	0	0	1	15	0	0	16
North Carolina	11	0	1	20	0	0	32
Ohio	0	0	1	0	0	0	1
Pennsylvania	0	1	9	16	0	0	26
Virginia	40	7	0	42	1	0	90
West Virginia	11	1	0	2	0	6	20
Total surveys by method of site selection	**66**	**15**	**43**	**146**	**3**	**11**	**284**

Table 3. Number of counties surveyed for *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) by year and state.

[Surveys in Pennsylvania fell into one of two categories: surveys for the presence of AGS and surveys for suitable habitat for AGS. The number of counties surveyed for suitable habitat is shown in parentheses. NS, no survey done]

State	Year				Total number of counties surveyed[1]	Number of unique counties[2] surveyed in each state
	2021	2022	2023	2024		
Maryland	NS	1	NS	1	2	1
Michigan	NS	1	2	2	5	3
New York	NS	2	2	2	6	4
North Carolina	NS	NS	2	3	5	3
Ohio	NS	1	NS	NS	1	1
Pennsylvania	NS	1 (5)	3 (2)	3 (0)	7 (7)	4 (7)
Virginia	3	NS	7	3	13	8
West Virginia	1	1	1	1	4	1
Total by year	**4**	**6 (5)**	**17 (2)**	**15 (0)**	**43 (7)**	**25 (7)**

[1]The total number of counties surveyed is greater than the number of unique counties surveyed because counties were often sampled more than once.

[2]In other words, distinct counties.

Table 4. Number of surveys done for *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) by year and state.

[Surveys in Pennsylvania fell into one of two categories: surveys for the presence of AGS and surveys for suitable habitat for AGS. The number of sites surveyed for suitable habitat is shown in parentheses. NS, no survey done]

State	Year				Total number of sites surveyed[1]	Number of unique sites[2] surveyed in each state
	2021	2022	2023	2024		
Maryland	NS	33	NS	50	83	34
Michigan	NS	2	6	8	16	12
New York	NS	6	5	5	16	11
North Carolina	NS	NS	20	12	32	13
Ohio	NS	1	NS	NS	1	1
Pennsylvania	NS	6 (39)	5 (6)	15 (0)	26 (45)	25 (43)
Virginia	20	NS	20	50	90	51
West Virginia	1	9	2	8	20	9
Total by year	**21**	**57 (39)**	**58 (6)**	**148 (0)**	**284 (45)**	**156 (43)**

[1]The total number of sites surveyed is greater than the number of unique sites surveyed because sites were often sampled more than once.

[2]In other words, distinct sites.

Virginia (table 5). Ninety surveys were done in eight counties in Virginia, and AGS were found in 20 of the surveys. Twenty surveys were done at eight sites in Greenbrier County, West Virginia, and AGS were observed in 12 of the surveys (table 6). In the 32 surveys where AGS were detected, 66 AGS were recorded in Allegheny County, and 114 AGS were observed in Greenbrier County for a total of 180 AGS encounters (table 7; apps. 3, 10–12).

The number of AGS observed is a tally of the number of AGS encounters, regardless of whether the AGS is uniquely marked during the mark-recapture trial. The total number of AGS is not corrected for repeated counts of the same individual AGS because AGS were marked and uniquely identified in only 6 of the 110 surveys that were done in Virginia and West Virginia. The large AGS encounter rate from West Virginia (AGS were observed in 60 percent of the surveys) reflects the method of tallying AGS encounters, not unique individuals, and the use of repeated surveys (six mark-recapture surveys over 3 days) at a productive site. As a result, the range-wide AGS encounter rate (11 percent) is also expected to be inflated.

Table 5. Number of surveyed counties that had *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) by year and state.

[A zero (0) indicates that no AGS were found, but a survey was completed. NS, no survey done]

State	Year				Total counties with AGS
	2021	2022	2023	2024	
Maryland	NS	0	NS	0	0
Michigan	NS	0	0	0	0
New York	NS	0	0	0	0
North Carolina	NS	NS	0	0	0
Ohio	NS	0	NS	NS	0
Pennsylvania	NS	0	0	0	0
Virginia	1	NS	1	1	1
West Virginia	1	1	1	1	1

Mark-Recapture Trial

In West Virginia, 27 AGS were observed in total for 2021, 2022, and 2023, and 87 AGS were observed in 2024 (table 8; apps. 3, 11, 12). In 2024, 7 of the 87 AGS were counted at the core colony 10 days before the mark-recapture trial began, and 10 AGS were observed at the second colony 14 days after the mark-recapture trial ended at the core colony. The remaining 70 AGS were counted at the core colony during the mark-recapture study—57 were uniquely marked individuals, and 13 were recaptures (table 9). The West Virginia Division of Natural Resources estimated the core colony's AGS population to be 149 unique individuals (confidence limits=91–329; table 10; app. 12). Of interest is that one AGS marked at the core colony was encountered 14 days later, about 10 m from the location where it was marked.

Other Butterfly Species

Lists of other butterfly species that were observed during the surveys are provided in appendix 2.

Table 6. Number of surveys that located *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]).

State	Number of surveys	Number of surveys with AGS	Percent AGS encounter rate
All 8 states[1]	284	32	11
Virginia	90	20	22
West Virginia	20	12	60

[1]Sum of surveys done in Maryland, Michigan, New York, North Carolina, Ohio, Pennsylvania, Virginia, and West Virginia.

Table 7. Number of *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) observations by year and state.

[A zero (0) indicates that no AGS were found, but a survey was completed. NS, no survey done]

State	Year				Total number of AGS by state
	2021	2022	2023	2024	
Maryland	NS	0	NS	0	0
Michigan	NS	0	0	0	0
New York	NS	0	0	0	0
North Carolina	NS	NS	0	0	0
Ohio	NS	0	NS	NS	0
Pennsylvania	NS	0	0	0	0
Virginia	30	NS	18	18	66
West Virginia	4	5	18	87	114
Total AGS by year	**34**	**5**	**36**	**105**	**180**

Table 8. Summary of the *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) surveys done in Greenbrier County, West Virginia, in 2024.

[Data are from appendixes 3, 11, and 12. Dates given in month/day/year.]

Date	Number of AGS	Survey information
4/2/2024	7	At the core colony. This count was not part of the mark-recapture trial, and the AGS were not marked.
4/15/2024–4/17/2024	70	At the core colony, the total number of AGS sightings during the mark-recapture trial. Fifty-seven of these AGS sightings were uniquely marked during the trial, and 13 of the sightings were of previously marked (recaptured) AGS.
5/1/2024	10	At the second colony. This count was not part of the mark-recapture trial, and these AGS were not marked.
4/2/2024–5/1/2024	87	At the core and the second colonies. Total number of AGS encounters.

Table 9. Number of *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) observed during the 2024 mark-recapture trial per survey at the core colony, Greenbrier County, West Virginia.

[Data are from appendixes 3, 11, and 12. Date given in month/day/year.]

Date	Survey time during the day	Total AGS observed	AGS recaptured	Newly marked AGS (first time captured)
4/15/2024	Morning	18	0	18
	Afternoon	16	3	13
4/16/2024	Morning	15	4	11
	Afternoon	5	1	4
4/17/2024	Morning	8	1	7
	Afternoon	8	4	4

Table 10. An estimate of the *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) population size at the core colony, Greenbrier County, West Virginia, in 2024.

[Data are from appendixes 3, 11, and 12. The method of population estimation followed those reported in Schnabel (1938).]

AGS population estimate, 2024	AGS
Uniquely marked individual AGS observed during the mark-recapture trial. This value was used to estimate population size at the core colony in Greenbrier County during the 2024 flight period.	57
Estimated population size	149
Lower confidence limit	91
Upper confidence limit	329

State Summaries

Each state summary includes the following:

1. Information about the surveys.
2. A review of the general status of the species in the state.
3. A map showing the counties where AGS were found, counties that were searched but no AGS were found, and the counties with past observations but were not searched in this study.
4. A table supporting the map that lists the current and past counties with AGS, the last known date the AGS was observed in the county, and a citation of the information.

Maryland (fig. 6; table 11)

- Years surveyed: 2
- 2022 surveys done by the Maryland Wildlife and Heritage Service and the 2024 surveys done by the U.S. Fish and Wildlife Service.
- General status: All surveys in this study were done in Alleghany County, the location of the last confirmed AGS sighting in Maryland (Maryland Biodiversity Project, 2026). The AGS colonies in Maryland were nearly wiped out by pesticides in the early 1980s and again in the early 1990s (Parshall, 2002).
- Number of AGS found during these surveys: 0

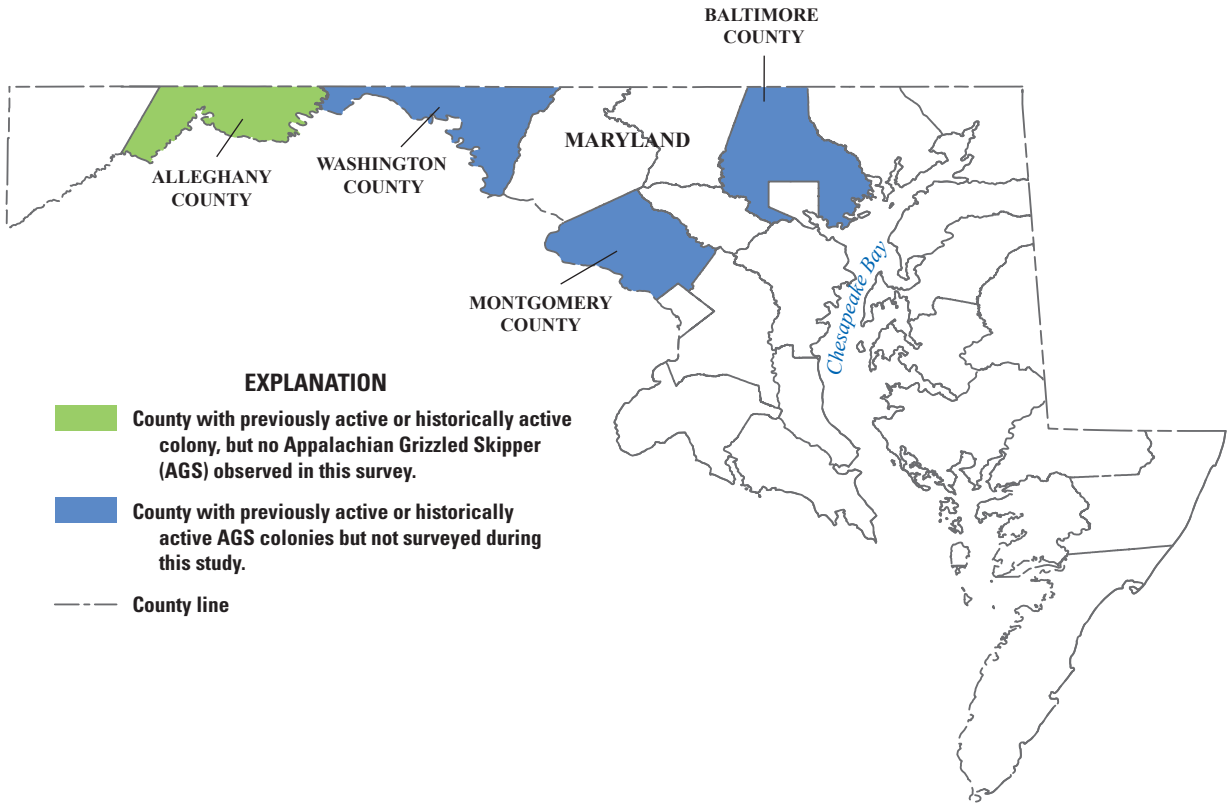


Figure 6. Map of Maryland showing the counties where searches were done for *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) during this study and in previous studies.

Table 11. Last confirmed observations of *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) by county in Maryland (2022 and 2024).

County	Last known observation	Citation
Alleghany	1998	Survey results in appendixes 3 and 4; Maryland Biodiversity Project, 2026
Baltimore	No date reported	
Montgomery		
Washington		

Michigan (fig. 7; table 12)

- Years surveyed: 3
- 2022–24 surveys done by the Michigan Natural Features Inventory.
- General status: Historically, AGS were in 12 counties. The three counties surveyed for this study were selected based on the dates of the recent sightings and the presence of suitable habitat. The last confirmed sighting in Michigan was in Presque Isle County in 2018 (apps. 3, 5). The first AGS survey in Alpena County was conducted during this study.
- Number of AGS found during these surveys: 0.

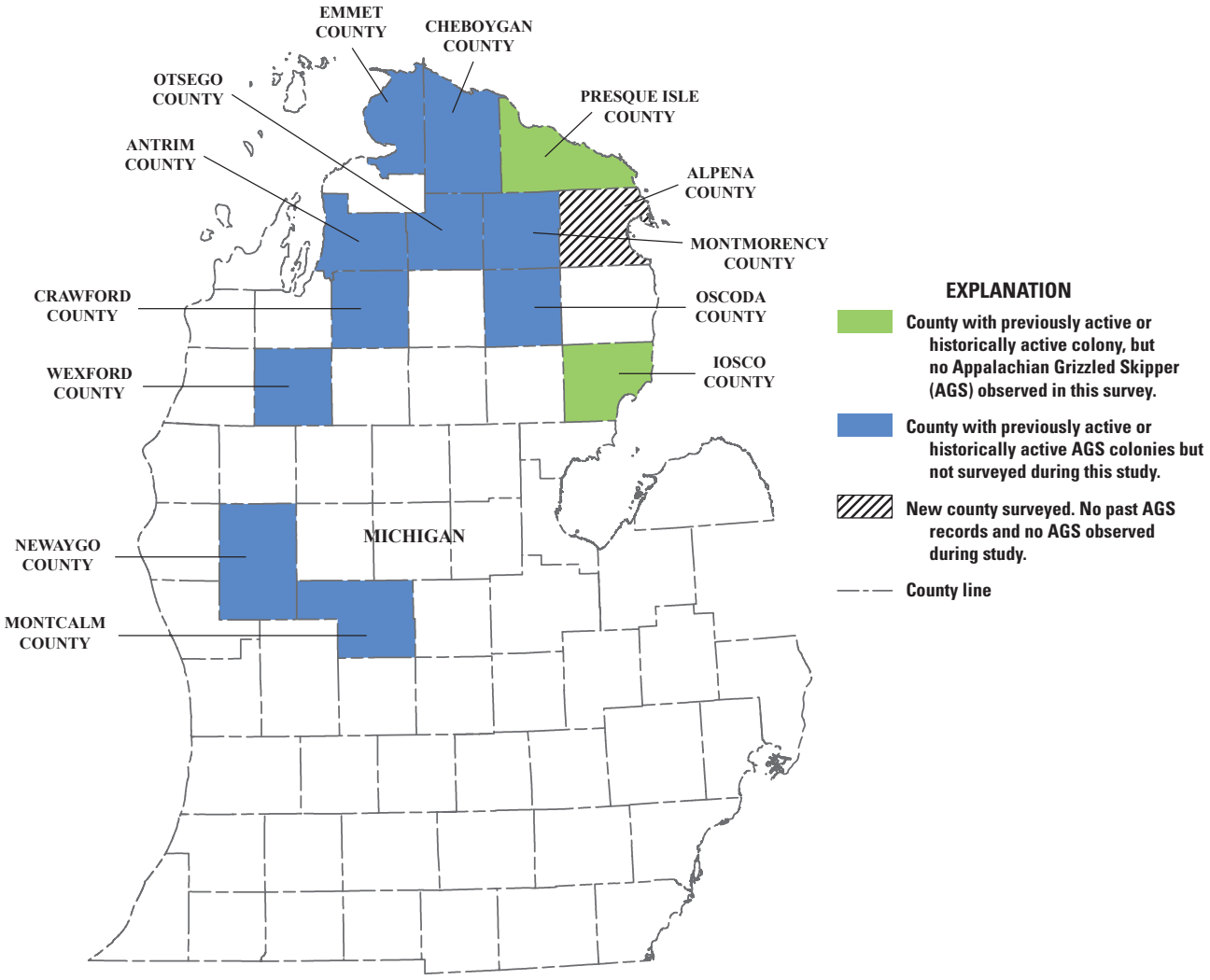


Figure 7. Map of Michigan showing the counties where searches were done for *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) during this study and previous studies.

Table 12. Last confirmed observations of *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) by county in the lower peninsula of Michigan.

County	Last known observation	Citation
Presque Isle	2018	Survey results in appendixes 3 and 5
Iosco	2012	
Antrim	1985	Michigan Natural Features Inventory, undated
Cheboygan	1935	
Crawford	1965	
Emmet	1932	
Montcalm	1987	
Montmorency	1941	
Newaygo	1986	
Oscoda	1953	
Otsego	1988	
Wexford	1957	
Alpena	No prior survey[1]	Survey results in appendixes 3 and 5

[1]No known surveys for AGS in this county until this study.

New York (fig. 8; table 13)

- Years surveyed: 3
- 2022–24 surveys done by the NYNHP.
- General status: The last confirmed AGS observations were from Tompkins and Tioga counties in 1970. In this study, after not encountering AGS in the previously known and remotely selected areas in 2022 and 2023, the NYNHP expanded its searches into Jefferson County in 2024. The first AGS survey in Jefferson County was conducted during this study. Jefferson County has no confirmed records of AGS, but this site was selected because it is geologically like historical AGS locations in Michigan. Jefferson County borders Lake Ontario and contains alvar pavement grassland habitat underlain with Chaumont limestone (Galoo-Rock outcrop complex; NYNHP, 2026). Although pavement barrens are also present in other counties in New York, Jefferson County was selected for survey because the Michigan colony locations are in the Great Lakes Ecoregion (app. 12; Edinger and others, 2014). The pavement barrens community type includes barrens habitat with grasses growing over thin soils on limestone bedrock (app. 12; Edinger and others, 2014). If AGS were found in the alvar habitat in Jefferson County, it would have been interesting to learn if the butterflies were from the Appalachian or Michigan populations and to learn their preferred host plant (dwarf cinquefoil or wild strawberry).
- Number of AGS found during these surveys: 0.

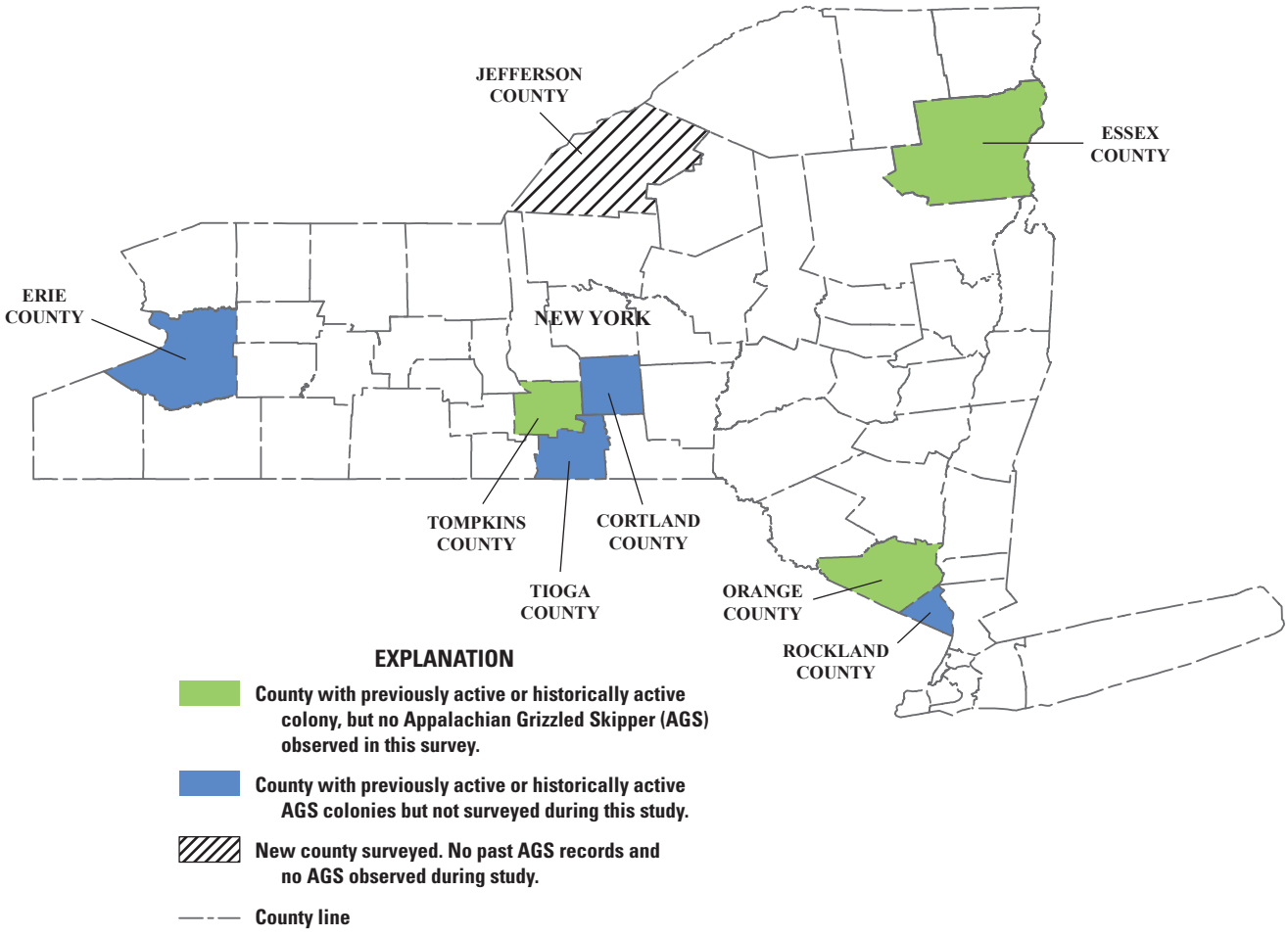


Figure 8. Map of New York showing the counties where searches were done for *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) during this study and previous studies.

Table 13. Last confirmed observations of *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) by county in New York.

County	Last known observation	Citation
Tompkins	1970	NYSDEC, 2014; Butterflies and Moths of North America, 2025
Tioga		
Rockland	No date reported	
Erie		
Cortland		
Long Island (no county name provided)	1968	New York State Department of Environmental Conservation, 2014
Orange	1942	Survey results in appendixes 3, 6, and 12
Essex	No date reported	
Jefferson	No prior survey[1]	

[1]No known surveys for AGS in this county until this study.

North Carolina (fig. 9; table 14)

- Years surveyed: 2
- 2023–24 surveys were done by the North Carolina Natural Heritage Program.
- General status: Historically, AGS have been documented in three counties. The most recent AGS confirmations are from Ashe and Alleghany Counties in 2008 and 2005, respectively. The last AGS observation date in Polk County was in 1938. The first AGS survey in Wilkes County was conducted during this study. Wilkes County has no past AGS records, but it was selected for survey based on habitat and elevation (app. 12; Parshall, 2002; LeGrand and others, 2026). Since 1990, AGS have been found along the margins of Christmas tree plantations and in disturbed clearings; none have been found in natural openings, such as around rocky margins or natural glades (Harry LeGrand, former zoologist with the North Carolina Natural Heritage Program, and current author/editor of a number of websites for the North Carolina Biodiversity Project, Raleigh, North Carolina, written commun., 2025).
- Number of AGS found during these surveys: 0.

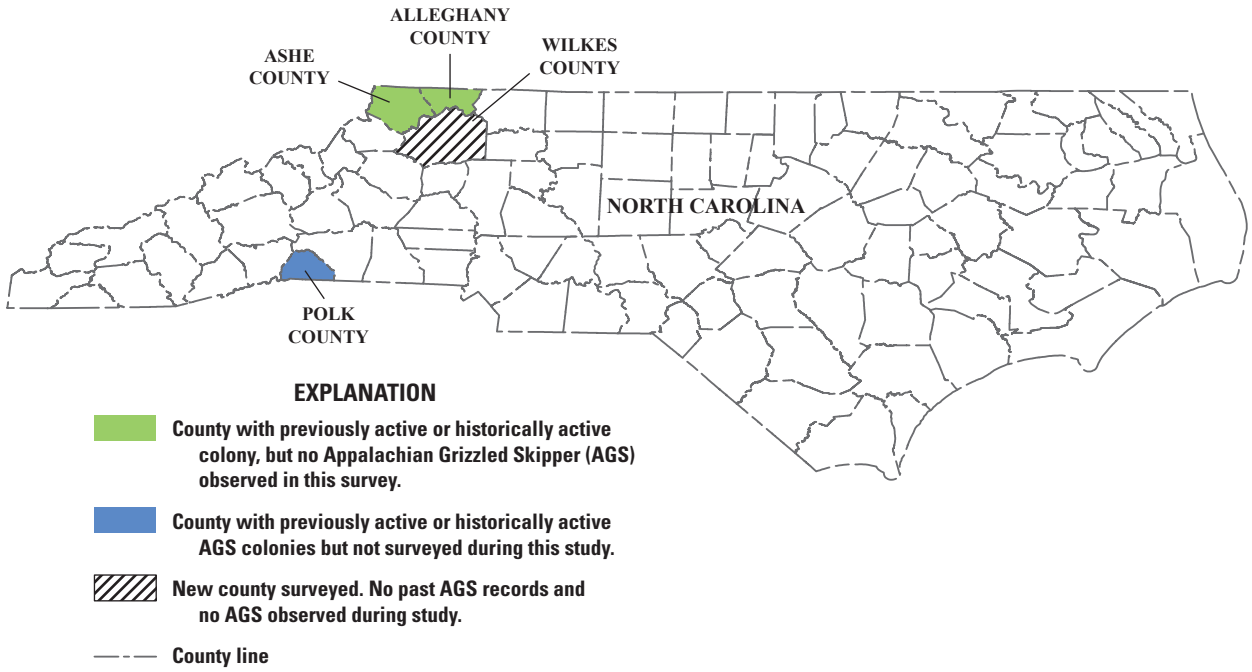


Figure 9. Map of North Carolina showing the counties where searches were done for *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) during this study and previous studies.

Table 14. Last confirmed observations of *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) by county in North Carolina.

County	Last known observation	Citation
Ashe	2008	Survey results in appendixes 3, 7, and 12
Alleghany	2005	
Wilkes	No prior survey[1]	
Polk	1938	Parshall, 2002; LeGrand and others, 2026

[1]No known surveys for AGS in this county until this study

Ohio (fig. 10; table 15)

- Years surveyed: 1
- 2022 survey done by the Ohio Department of Natural Resources.
- General status: AGS were observed in five counties in Ohio, and the last known observation in the state was from the early 2000s in Hocking County, Ohio (apps. 3, 8, 12; Iftner and others, 1992; Parshall, 2002).
- Number of AGS found during these surveys: 0.

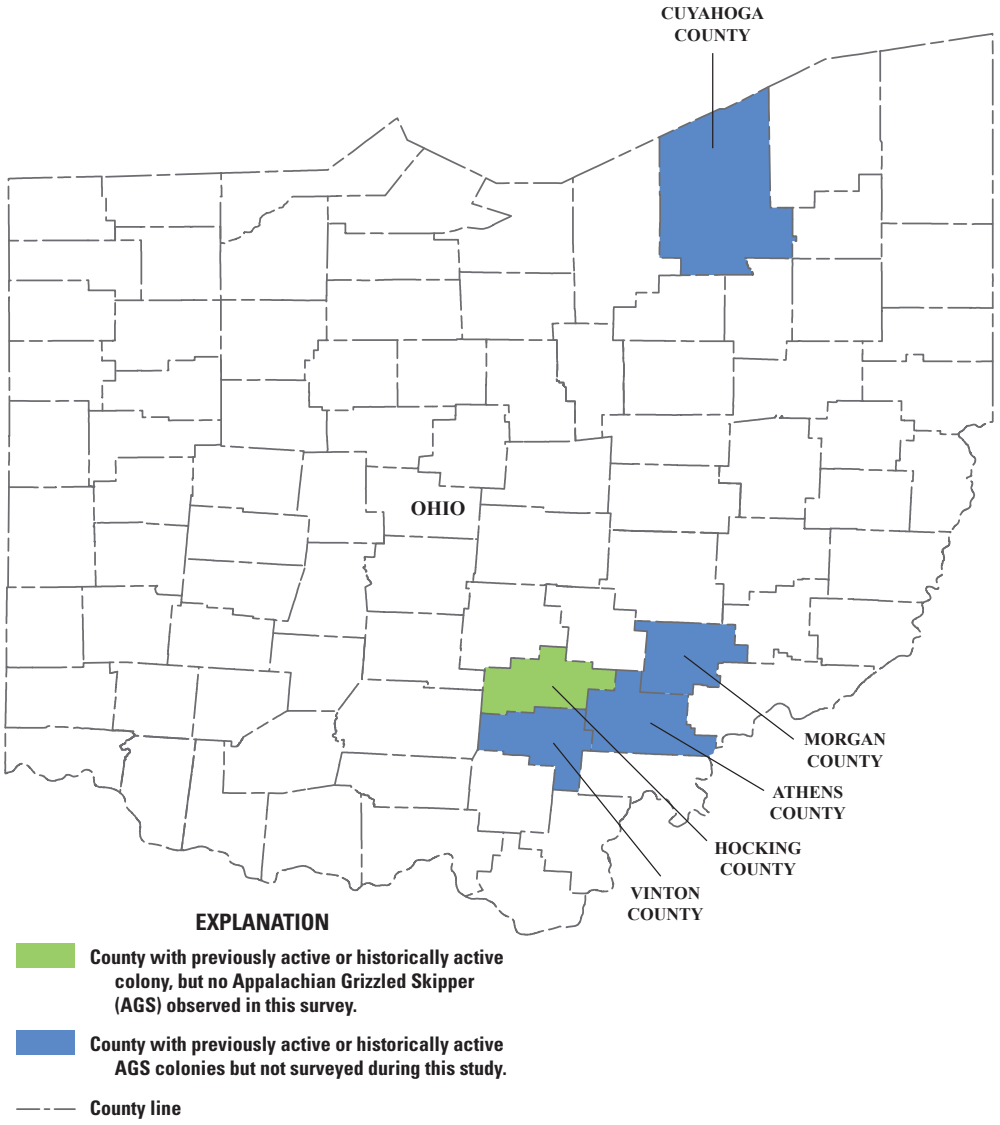


Figure 10. Map of Ohio showing the counties where searches were done for *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) during this study and previous studies.

Table 15. Last confirmed observations of *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) by county in Ohio.

County	Last known observation	Citation
Hocking	Early 2000s	Survey results in appendixes 3, 8, and 12; Parshall, 2002
Vinton	1983	Iftner and others, 1992; Parshall, 2002
Athens	1988	
Cuyahoga	1916	
Morgan	No date reported	

Pennsylvania (fig. 11; table 16)

- Years surveyed: 3
- 2022–24 surveys done by the Western Pennsylvania Conservancy.
- General status: The shale barrens in Pennsylvania were part of the core region for the Appalachian AGS populations. By the 1950s, the AGS had extended its range into the non-shale regions of southeastern Pennsylvania (Parshall, 2002; Schweitzer and others, 2011), but these colonies have now been extirpated. In the shale region, a colony in Huntingdon County, discovered in 2000, was reliably seen until 2012. This was the last known AGS colony in Pennsylvania. No extant colonies were found in Pennsylvania during this study.
- Number of AGS found during these surveys: 0

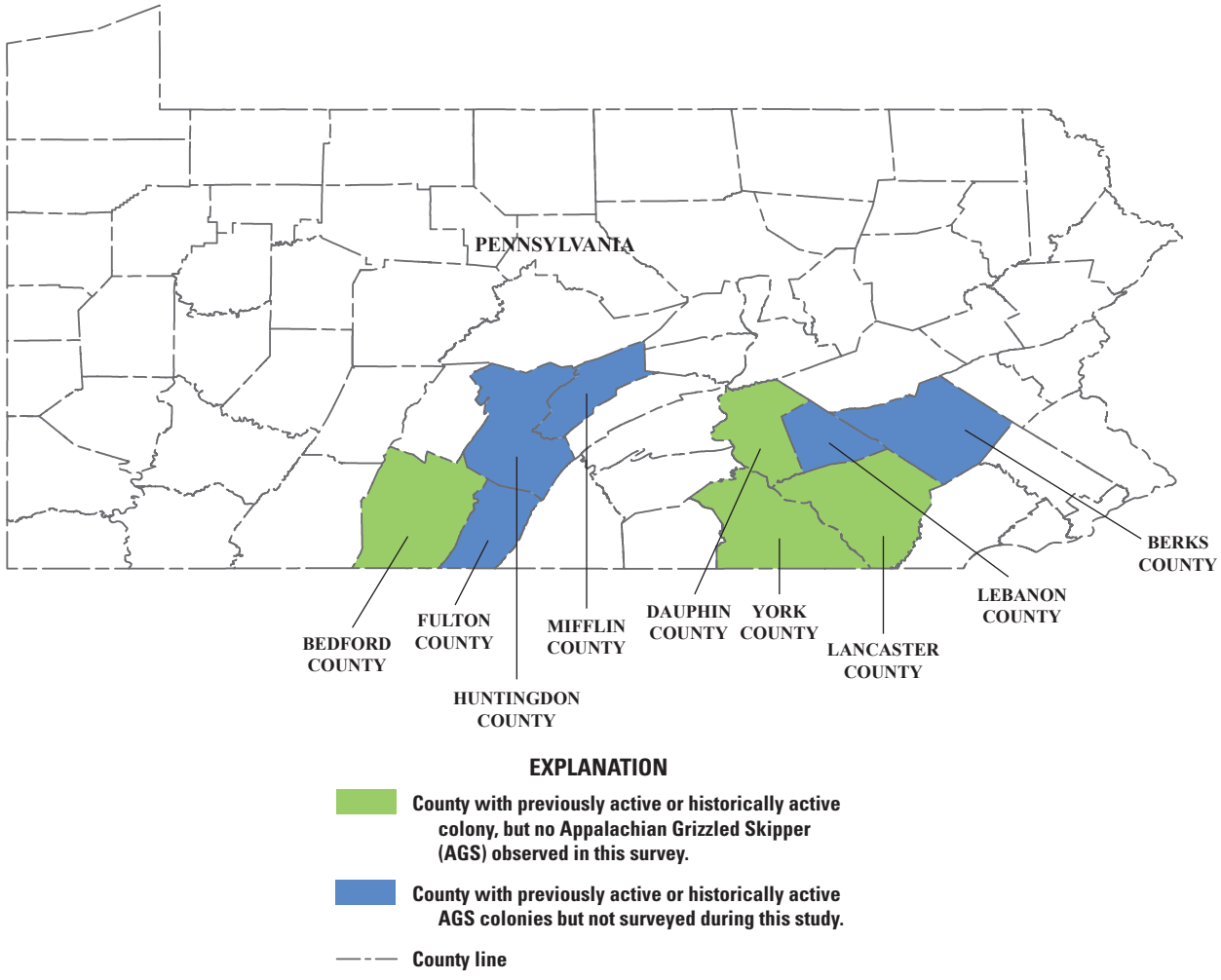


Figure 11. Map of Pennsylvania showing the counties where searches were done for *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) during this study and previous studies.

Table 16. Last confirmed observations of *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) by county in Pennsylvania.

County	Last known observation	Citation
Bedford	1994	Survey results in appendixes 3 and 9
Dauphin	1950s	Schweitzer and others, 2011; Parshall, 2002; Butterflies and Moths of North America, 2025
Lancaster	1950s	
York	No date reported	
Lebanon	No date reported	Butterflies and Moths of North America, 2025
Mifflin		
Berks	No date reported	Parshall, 2002
Fulton	1980	
Huntingdon	2012	Betsy Leppo, Western Pennsylvania Conservancy, oral commun., 2025

Virginia (fig. 12; table 17)

- Years surveyed: 3
- 2021, 2023, and 2024 surveys done by the Virginia Natural Heritage Program.
- General status: Historically, AGS were in 20 counties in Virginia (Chazal and others, 2004; Virginia Department of Conservation and Recreation, 2021). Between 1992 and 2002, Chazal and others (2004) did AGS surveys at 75 sites in 12 Virginia counties, but AGS were found at only 6 sites and in only 2 counties (Alleghany and Rockbridge). In this study, eight counties in Virginia were searched, but extant AGS colonies were found only in Alleghany County. The sites in Alleghany County have been active since at least 2000.
- Number of AGS found during these surveys: 66

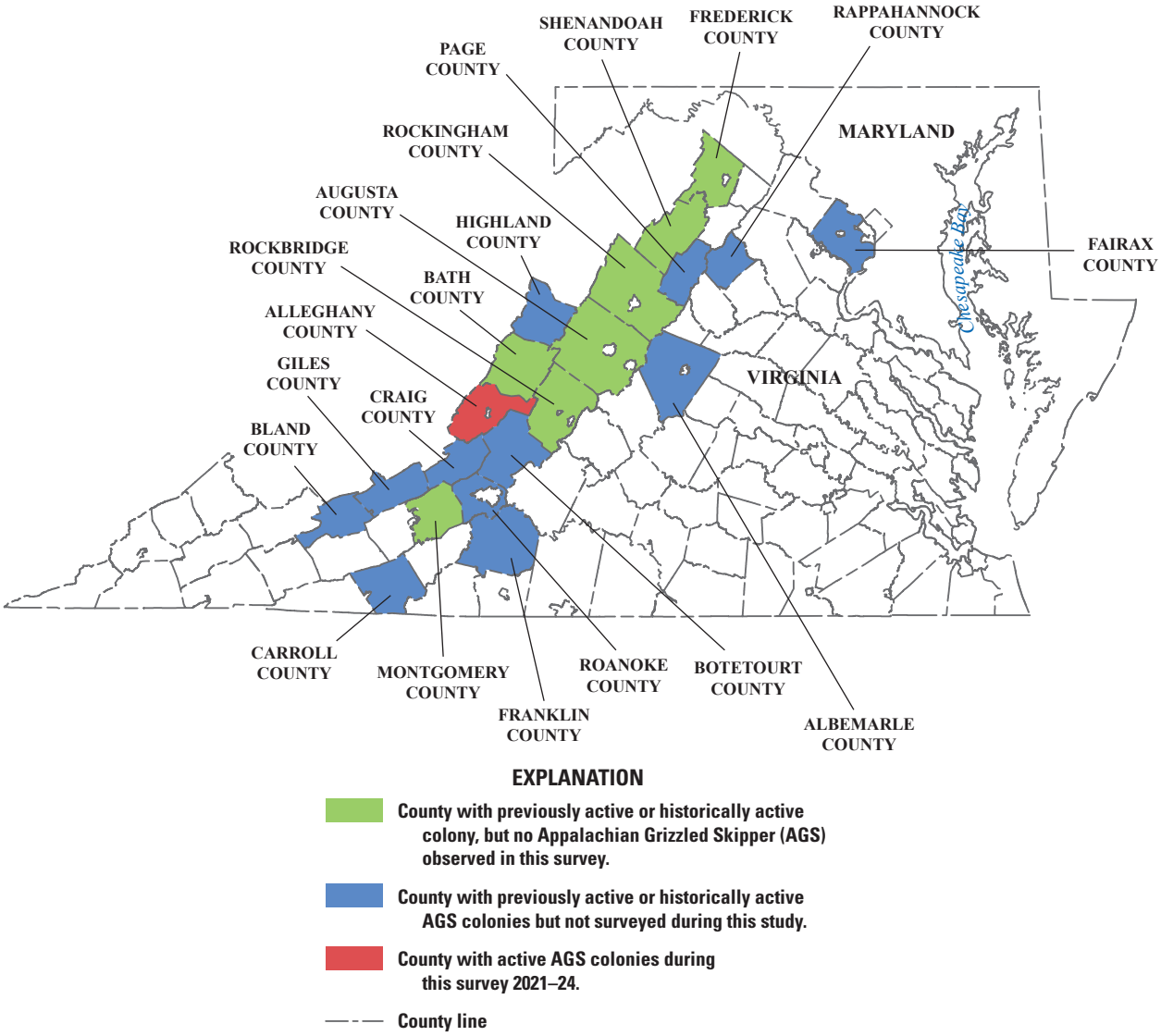


Figure 12. Map of Virginia showing the counties where searches were done for *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) during this study and previous studies.

Table 17. Last confirmed observations of *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) by county in Virginia.

County	Last known observation	Citation
Counties surveyed in current (2021–24) study		
Alleghany	Currently active	Survey results in appendixes 3, 10, and 12; Chazal and others, 2004
Rockbridge	1999	
Frederick	2008	Chazal and others, 2004; David Boyd, Virginia Natural Heritage Program, written commun., 2023
Augusta	1980	
Montgomery	1975	
Bath	Before 1950	
Shenandoah	No date reported	
Rockingham	No date reported	
Counties surveyed before 2021 by others		
Fairfax	1937	Chazal and others, 2004; David Boyd, Virginia Natural Heritage Program, written commun., 2023
Rappahannock	1985	
Page	Before 1950	
Highland	No date reported	
Albemarle	1948	
Botetourt	Before 1950	
Craig	No date reported	
Roanoke	1939	
Franklin	Before 1950	
Bland	Before 1950	
Pulaski	No date reported	
Carrol	No date reported	

West Virginia (fig. 13; table 18)

- Years surveyed: 4
- 2021–24 surveys done by the West Virginia Division of Natural Resources.
- General status: Historically, AGS colonies were found in five counties, but they are believed to have been extirpated before 1992, primarily from forest insecticide applications (Allen, 1997; Parshall, 2002, Schweitzer and others, 2011). In 2009, a colony in Greenbrier County was discovered, and it is currently active (U.S. Forest Service [FS], 2009a). Greenbrier County is the last known county with AGS in West Virginia (Sue Olcott, West Virginia Division of Natural Resources, oral commun., 2021).
- Number of AGS found during these surveys: 114.

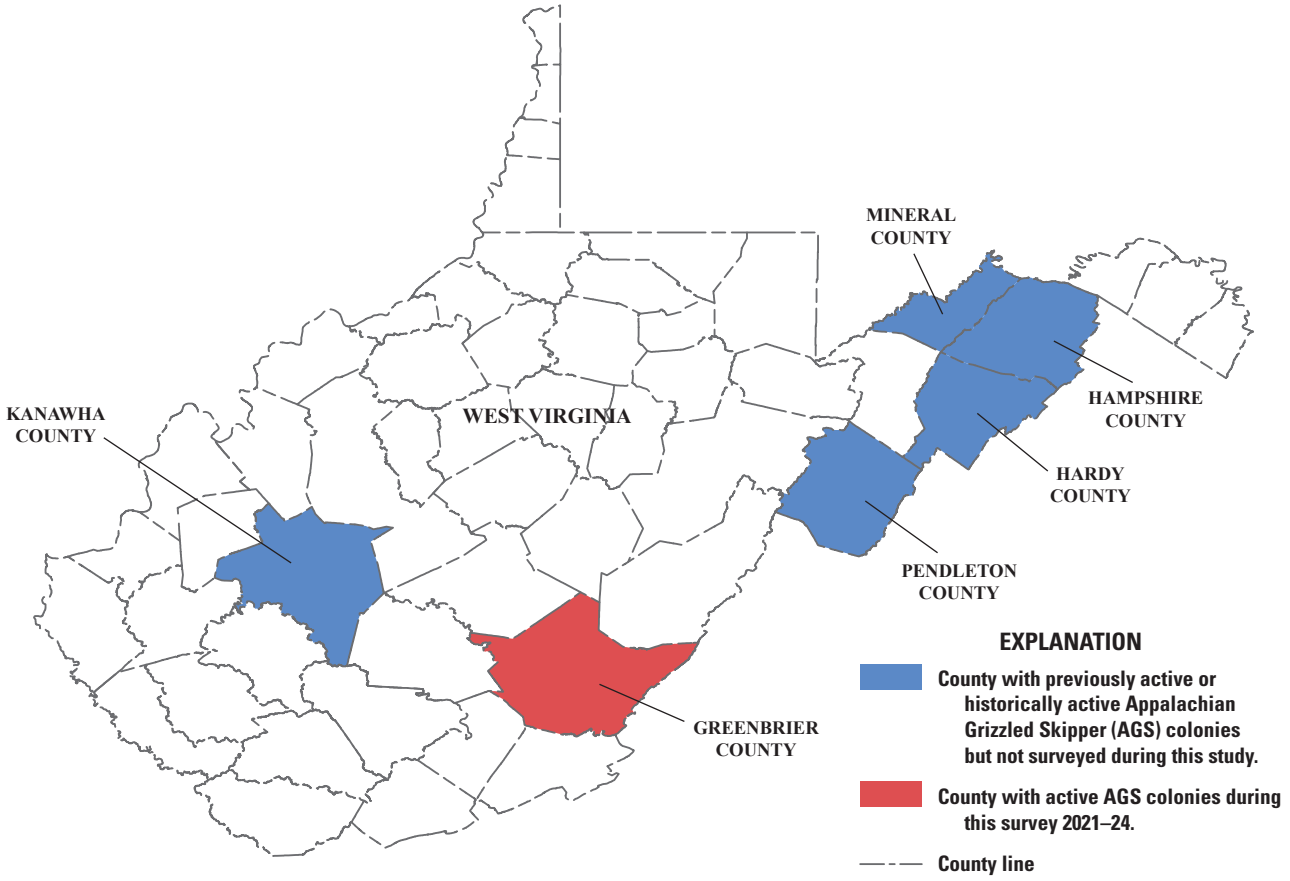


Figure 13. Map of West Virginia showing the counties where searches were done for *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) during this study and previous studies.

Table 18. Last confirmed observations of *Pyrgus centaureae wyandot* (Appalachian grizzled skipper [AGS]) by county in West Virginia.

County	Last known observation	Citation
Greenbrier	Sites discovered in 2009 and currently active.	Survey results in appendixes 3, 11, and 12; Parshall, 2002; FS, 2009a
Hampshire	Before 1992	Allen, 1997
Hardy		
Kanawha		
Mineral		
Pendleton		

Discussion

Historically, the core of the AGS's range was the shale region from Huntingdon County, Pennsylvania, into western Maryland, western Virginia, and eastern West Virginia. A few isolated AGS colonies occurred in New York. Colonies or individual AGS have also been recorded in non-shale habitats in North Carolina, New York, southern Ohio, southeastern Pennsylvania, northwestern New Jersey, northern Virginia, and Washington, D.C. The AGS colonies of the Michigan population were found in various habitats, including exposed limestone bedrock communities that are structurally like Appalachian shale habitats (Schweitzer and others, 2011).

Historical AGS data show that they have occupied suitable habitats in at least 77 unique counties (sum of the red, blue, and green counties in figures 6–13). Of the 77 counties, the 25 unique counties (green counties in figures 6–13) surveyed in this study were selected based on the most reliable information on known colonies and habitat characteristics of remotely selected sites. Of note is that despite the distant last reported observation dates (tables 11–18), in many of the 77 counties, periodic surveys and observations by entomologists and butterfly enthusiasts have continued over the years. For example, the last known AGS observation in Pennsylvania happened in Huntingdon County in 2012. However, the Western Pennsylvania Conservancy and its volunteers and partners have visited the site more than 47 times between 2014 and 2019. These surveys did not locate AGS.

In this study, AGS were observed in only 2 (2.6 percent) of the 77 known historical counties (a 97.4 percent decline in the number of counties where AGS were found). The long-term, range-wide population trend for AGS has declined by 80–90 percent, and the AGS conservation status ranks for the nine states include "Possibly Extirpated" and "Critically Imperiled" (NatureServe Explorer, 2025). The precipitous decline in the number of AGS populations is a concern for the survival of the species.

The AGS is a monophagous species. The larvae feed exclusively on Dwarf Cinquefoil or Wild Strawberry (Allen, 1997). Although these plants are commonly found in a variety of habitats (for example, barrens, fields, alvars, lawns, forest clearings), most habitat patches with the host plants remain unoccupied by AGS. A habitat patch must contain larval host and adult nectaring plants to harbor an AGS colony, but the presence of these plants does not guarantee that the patch will attract or hold an established AGS colony. There are at least three possible reasons as to why suitable habitat patches remain unoccupied by AGS:

1. Studies on other butterfly species show that in a heterogeneous landscape, the habitat and butterfly metapopulation dynamics may generate a highly localized distribution, despite widespread availability of the host plant (Gutiérrez and others, 1999).
2. Patch occupancy may be governed by landscape, patch, macrohabitat, and microhabitat scales (for example, the size and shape of the habitat patch and its proximity to other patches, the diversity, distribution, and abundance of nectaring plants and the host plants, and moisture and temperature conditions for the egg, larvae, and overwintering pupal stages (Nowicki and others, 2007; Curtis and others, 2015; Kalarus and Nowicki, 2015; Ghidotti and others, 2018; Betsy Leppo, Invertebrate Zoologist, Western Pennsylvania Conservancy, oral commun., 2025). Schweitzer and others (2011) identified some habitat variables that are necessary for patch occupancy by AGS, but the other habitat variables listed above have not u studied. Therefore, some of the unoccupied habitat patches that appear overtly suitable for AGS to humans, may not satisfy the habitat requirements for AGS (Parshall, 2002; Ghidotti and others, 2018). Additional research on habitat requirements could provide information on AGS's patch preference criteria. Nevertheless, the abundance of unoccupied suitable habitat across the AGS's range suggests that size of the AGS population is not limited by the availability of the host and nectaring plants.
3. Patch occupancy may also be determined by the size and distribution of the AGS population. Historically, AGS colonies were localized and contained a small number of individuals (Schweitzer and others, 2011). The large range-wide AGS population decline over the years has resulted in only a small number of extant colonies. Therefore, the majority of the suitable habitats would be expected to remain unpopulated by AGS.

The steep range-wide historical extirpation of AGS appears to have been driven by the interaction between various stressors and the life history of the species. These stressors also continue to interfere with establishment of new AGS colonies. The AGS's vulnerability to various stressors arises from the direct and indirect intersections of the stressors with AGS's life history (behavior, phenology, physiology, and dependence on metapopulation networks). In areas that are occupied by AGS, the stressors that adversely affect the abundance and distribution of the host and nectaring plants can indirectly translate to negative effects on AGS populations. The AGS are also vulnerable to the direct adverse effects of stressors. Some interactions between the life history traits and stressors that may be indirectly or directly contributing to the decline in populations of AGS include:

1. Ecological succession can outcompete and shade out the low-growing host and nectaring plants, thus reducing the quantity and quality of habitat patches for AGS (Chazal and others, 2004; Cuthrell, 2007; Allen, 2009; Schweitzer and others, 2011; NYSDEC, 2014; Leppo, 2019).

2. Changes in weather and climate may create temperature and moisture extremes (highs or lows, protracted wet or dry periods) that may exceed thermal and (or) moisture tolerances of AGS (Williams and others, 2014; Schuurman and others, 2023). This may lead to heat and (or) cold shock, desiccation and loss of lipid reserves in pupae (Schuurman and others, 2023), create asynchrony between the phenologies of AGS and host and nectaring plants (Patterson and others, 2020; Guralnick and others, 2023; Qiu and others, 2024), and facilitate the spread of pests, pathogens, and invasive species against AGS and their plants (Short and others, 2017; Invasive Species Advisory Committee, 2023; Bradley and others, 2024). Changes in climate can also create deficits in rainfall, resulting in droughts (Patterson and others, 2020; Gebrechorkos and others, 2025). Droughts may reduce the abundance of the host and nectaring plants (Schweitzer and others, 2011; NYSDEC, 2014; PNHP, 2015), and droughts may also trigger wildfires that can extirpate local AGS populations (Schweitzer and others, 2011; PNHP, 2015). Furthermore, it has been suggested that climate change may be responsible for the contraction of AGS's southern breeding range (Rogan and others, 2023; Rubenstein and others, 2023; Harry LeGrand, former zoologist with the North Carolina Natural Heritage Program, and current author/editor of a number of websites for the North Carolina Biodiversity Project, Raleigh, North Carolina, written commun., 2025).

3. Pesticides may have negative impacts on AGS and its host and nectaring plants. Herbicide use can eliminate host and nectaring plants (Schweitzer and others, 2011; NYSDEC, 2014). Aerial insecticide applications on forests to control *Lymantria dispar* (spongy moth, previously known as gypsy moth) are well acknowledged as the primary cause for the extirpations of AGS populations (Shuey and others, 1987; Allen, 1997; Parshall, 2002; Schweitzer and others, 2011). The insecticide products used in the past and currently used for spongy moth control indiscriminately kill all Lepidopteran larvae (FS, 2022). However, there are two additional insecticides that kill only spongy moths, but they are used sparingly (FS, 2009a, b; Ohio Department of Agriculture, 2022; FS, 2022). The risks of poisoning for AGS arise from the overlap of the timing of insecticide applications with the early larvae of AGS (Schweitzer and others, 2011). The larvae are exposed to the insecticides because they occupy woodland openings that may lack a protective leaf canopy cover, especially before the leaf flush in spring (Shuey and others, 1987; Schweitzer and others, 2011; PNHP, 2015). The establishment of no-spray zones may not provide adequate protection for AGS because it is not always possible to exclude a small habitat patch during aerial applications (Parshall, 2002; PNHP, 2015).

4. Human activity can not only reduce the abundance of the host and nectaring plants but can also directly destroy the AGS's sedentary life stages (pupae, eggs, and larvae; app. 12; Parshall, 2002; Cuthrell, 2007; Allen, 2009; PNHP, 2015; Leppo, 2019; NYNHP, 2025). The destruction of known and undocumented habitat patches and colonies may eventually unravel the metapopulation networks of AGS by fragmenting and reducing the habitat. Fragmentation and reduction of habitat increases isolation among colonies and thereby may weaken the metapopulation network (Parshall, 2002; Cuthrell, 2007; NYNHP, 2025).

5. The AGS is a metapopulation-dependent species. That is, the species' survival requires a network of interconnected local colonies and dispersal among them (Saccheri and others, 1998). Historically, the colonies of AGS have occurred in disjunct and localized clusters and the individual colonies have often consisted of a small number of individuals (Schweitzer and others, 2011). These colony clusters were able to survive by sustaining their metapopulation dynamics via maintaining their genetic variation and by easily colonizing new or vacant habitat patches within a metapopulation. A few isolated colonies have periodically existed but only temporarily because they lacked metapopulation network support. Over a relatively brief time, these colonies were extirpated by environmental and demographic stochasticity (Schweitzer and others, 2011; Wilson and Primack, 2019).

Over the decades, as the threats have increased, the number of colonies that have been extirpated from their metapopulations has increased, and the remaining active colonies in those clusters have become increasingly isolated, with consequent ramifications for the longevity of these colonies. Throughout their range, the metapopulation networks of AGS have been deconstructed mainly by ecological succession, widespread insecticide applications, and other human activities. For example, statewide AGS extirpations have occurred in New Jersey (New Jersey Department of Fish and Wildlife, 2015) and New York, and regional AGS extirpation has occurred in southeastern Pennsylvania (NYSDEC, 2014, 2015; Betsy Leppo, Western Pennsylvania Conservancy, oral commun., 2025). In a healthy metapopulation, some of the colonies may be extirpated by stressors, but the metapopulation can continue to survive as long as dispersal and colonization among the remaining colonies continue (Saccheri and others, 1998). If, however, enough colonies in a metapopulation become extirpated, the protections afforded to the surviving colonies by their metapopulation structure can be lost. Therefore, it is reasonable to assume that in declining metapopulations, although anthropogenic and natural stressors may be responsible for the initial losses of colonies in metapopulations, the subsequent losses of the surviving colonies may result from isolation. This in turn may further

erode the remnant metapopulations and may eventually result in species extinction (Hill and others, 1996; Thomas, 2000; Higgins and Lynch, 2001).

In the following sections, two examples will illustrate the erosion of a metapopulation and colony resilience. Please note that the explanations provided on AGS metapopulation extirpations in southern Ohio and the resilience of AGS colonies in Virginia and West Virginia are based on assumptions drawn from survey data, metapopulation theory (Hill and others, 1996; Gutiérrez and others, 1999), and AGS life history.

Example 1.—*Erosion of a metapopulation (fig. 14).—* The AGS colonies have been recorded in six locations in southern Ohio. The stressors responsible for colony extirpations are known for only two of the six colonies. Insecticides are not attributed to the extirpation of any of the southern Ohio colonies because, at the time of extirpation, spongy moth had not spread to this region (Shuey and others, 1987).

Parshall (2002) discussed the history of AGS in southern Ohio. In 1971, an AGS colony was found in southern Ohio's Vinton County. This colony remained active until 1983. Repeated surveys to find AGS in Ohio over the next 20 years did not produce any additional sightings. Another colony was reported in the early 1980s in neighboring Athens County, but little is known about it. In 1986, a large colony was located in Hocking County, but it was destroyed in the early 1990s when its habitat patch was replaced by a parking lot. A second colony in Athens County was found in 1988, and it lasted until 1989. A single AGS was seen in Morgan County around 1988, but no further information is available about this colony. A second colony in Hocking County was discovered in 1993. This colony was eliminated by 1996 because of the loss of AGS host and nectaring plants from ecological succession. Lastly, a third Hocking County colony was found in 1999 but was lost by the early 2000s (fig. 14; app. 12; Parshall, 2002). Parshall (2002) noted that at this site, there was an abundance of host plants, yet AGS have not been observed there since the early 2000s. This was the last known sighting of AGS in Ohio (app. 12).

Possible explanations for why no new AGS colonies have been located since the early 2000s may be that fewer surveys are being done now than before 2000, or the AGS metapopulation in southern Ohio may have finally become dysfunctional in the early 2000s because too many of its colonies were extirpated. That is, the eroded metapopulation network could no longer sustain its remnant isolated colonies.

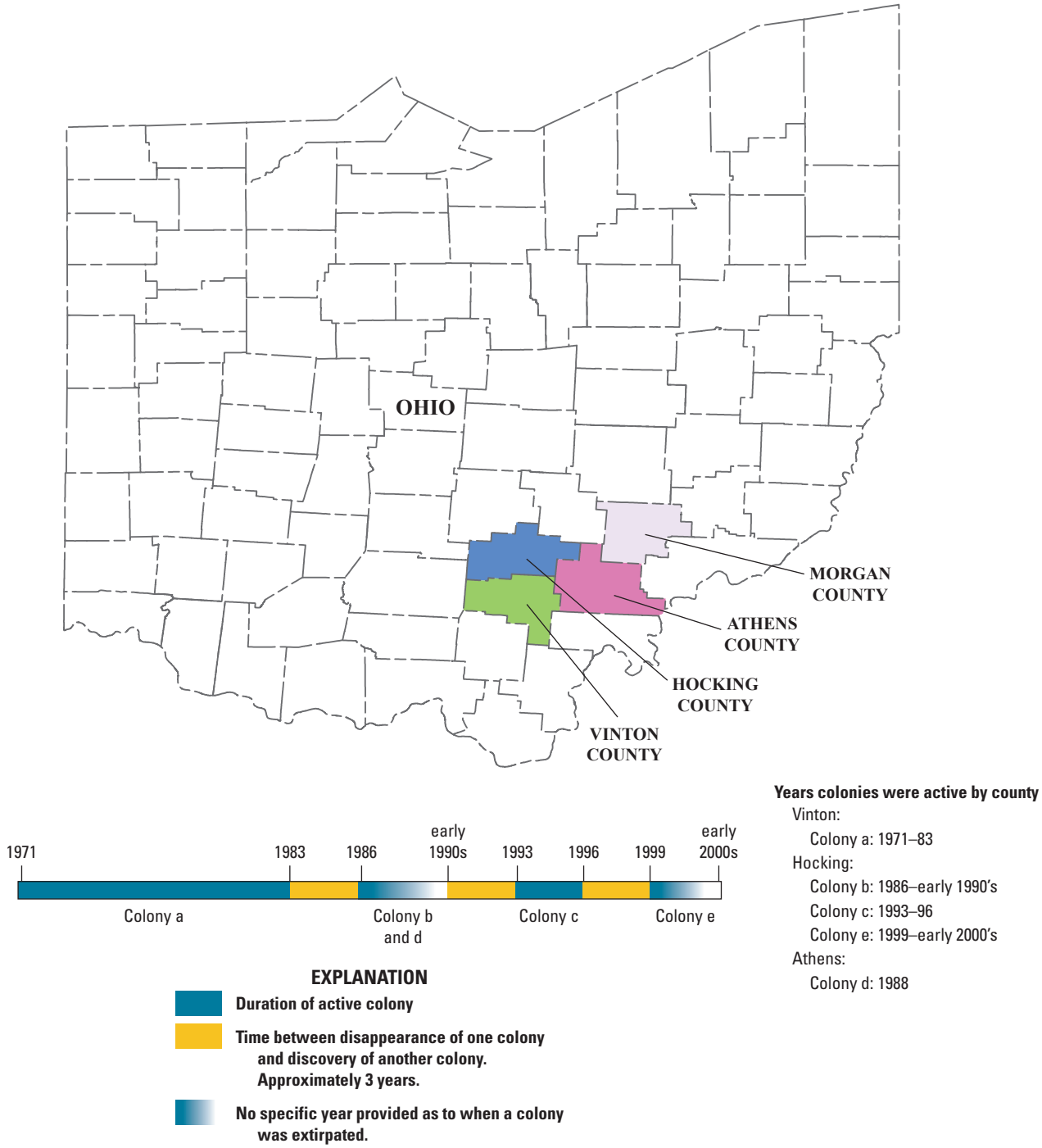
A healthy metapopulation network maintains its resilience to intrinsic (for example, inbreeding because of isolation) and extrinsic (for example, mortalities from insecticide applications) stressors. Fox and others (2017) have suggested that a metapopulation would become extinct when all its colonies are simultaneously extirpated. Almost simultaneous collapse of all AGS colonies in a metapopulation is a reasonable scenario after range-wide, large-scale forest insecticide applications. The insecticides would have initially reduced the number of active colonies and any surviving colonies would have subsequently gone extinct due to isolation. These two phenomena (insecticide applications and the subsequent destruction of the surviving colonies because of isolation) may explain the AGS extirpations that followed the progression of the U.S. Department of Agriculture's spongy moth control program's application path in the Eastern United States (Parshall, 2002).

Example 2.—*Colony resilience.*—In our study, AGS were observed in only two counties in two states: Alleghany County, Virginia, and Greenbrier County, West Virginia. Before the use of insecticides for spongy moths, AGS were documented in 21 Virginia counties and were considered a common "generally distributed" skipper in "all suitable localities" in the mountains of Virginia (refer to Schweitzer and others, 2011). Widespread insecticide applications for spongy moths in Virginia began in the 1980s, and by 1992, AGS were documented in only four counties. A 10-year survey (1992–2002) by the Virginia Department of Conservation and Recreation, Division of Natural Heritage, reported AGS in only two counties, Alleghany and Rockbridge Counties (Chazal and others, 2004). In 2000, several small AGS colonies were discovered in Alleghany County, Virginia. Our survey (2021–24) of eight Virginia counties (including Rockbridge County) found AGS colonies only in Alleghany County (fig. 12).

West Virginia had a similar situation to Virginia. Before the widespread, heavy use of insecticides for spongy moths had started in the late 1980s (Parshall, 2002; NatureServe Explorer, 2025), AGS were not considered to be "rare" in West Virginia (Parshall, 2002) and were documented from five West Virginia counties (fig. 13). The colonies in these counties are believed to have been extirpated by insecticides (Allen, 1997; Schweitzer and others, 2011). However, in 2009, a colony (the core colony) was discovered in Greenbrier County, West Virginia (FS, 2009a). The Greenbrier County colony was active during our survey (2021–24; fig. 13).

Although the other known AGS colonies and their metapopulations in Virginia and West Virginia are considered to have been extirpated (Susan Olcott, West Virginia Division of Natural Resources, oral commun., 2021; Chazal and others, 2004), the colonies in Alleghany County have been active for at least 24 years and the core colony in Greenbrier County has been active for at least 15 years. We suggest that the resilience of these colonies may be attributed to three factors.

First, Alleghany County, Virginia and Greenbrier County, West Virginia are juxtaposed (fig. 15). The linear distances between the colonies in these counties range from only 9 to 15 km (Steven Roble, Virginia Natural Heritage Program, written commun., 2017). The persistence of these colonies may stem from their proximity to each other (clustering of colonies). That is, the colonies may be close enough to maintain their genetic diversity through dispersal and interbreeding (that is, sustaining the metapopulation dynamics). Genetic testing could elucidate the relationships among these extant colonies.



Note: The following are not included in the timeline

- A second Appalachian Grizzled Skipper (AGS) colony in Athens County that is not well documented.
- The sighting of a single AGS in Morgan County.
- The AGS from Cuyahoga County that was observed in 1916 in Northern Ohio.

Figure 14. Map and timeline showing the possible fate of a *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) metapopulation in southern Ohio.

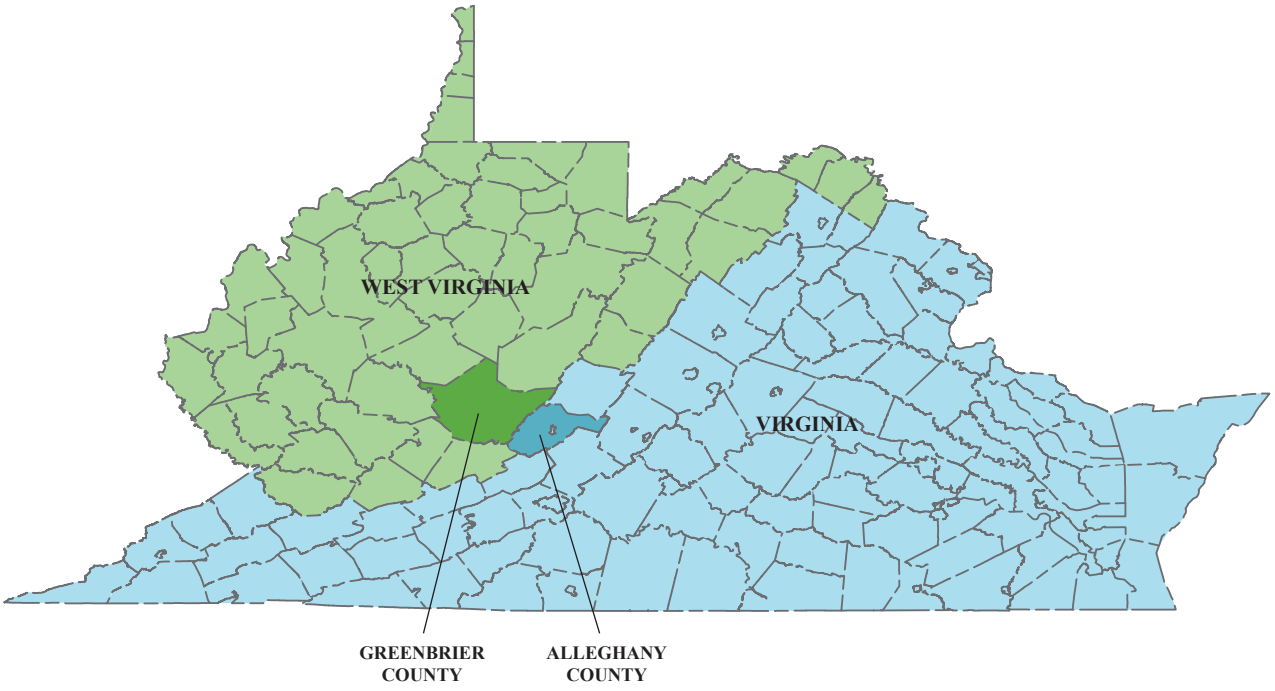


Figure 15. Map showing counties with extant *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) colonies, in Virginia and West Virginia.

Second, the Appalachian County and Greenbrier County colonies, in addition to being in two different states, may have survived because they may have experienced different habitat management practices. For example, the known extant colonies in Alleghany County are on private lands and in the FS's George Washington and Jefferson National Forests, and the known extant colonies in Greenbrier County are nestled in the FS's Monongahela National Forest (FS, 2009a). Therefore, the metapopulation network composed of the Alleghany County and Greenbrier County colonies may have survived extirpation because the colonies may not have received simultaneous insecticide applications or even the same insecticide products. The possible asynchrony in application timing and the possible differences in pesticide active ingredients and formulations may be providing the Virginia and West Virginia colonies windows for dispersal to maintain genetic diversity

Third, it is possible that these colonies have not been challenged with the threats (for example, insecticides) that have extirpated the other colonies.

To our knowledge, these colonies form the only known extant, functioning metapopulation network for AGS. To sustain this network over the years, safe corridors for genetic exchange among the colonies are needed (Jangjoo and others, 2016). The inter-patch dispersal distances of genus *Pyrgus* are not well studied and may depend on a specific species in the genus and their habitat (average distance less than 300 m [Widhalm and others, 2020], but flight distance for some species may exceed 1.5 km [Brereton and others, 1998]). Because the distances between the Greenbrier County and Alleghany County colonies are greater than the average dispersal flight distance, there may be suitable habitat patches and additional colonies along the dispersal route that maintain the connections between colonies across state lines. Additional searches in the vicinity of these colonies could provide knowledge of undocumented colonies and suitable habitat locations.

Uncertainties associated with AGS counts include the following:

1. ***Overcount.***—The average lifespan of *Pyrgus centaureae* (grizzled skipper) is 4 to 6 weeks (Bohman, 2014). Because our AGS were not individually marked and due to how we combined the total number of butterflies observed at a site across multiple visits, the estimated number of AGS at a colony may be inflated if any individuals were counted again in subsequent visits during the AGS's life span. For example, the small mark-recapture study at the core colony in West Virginia showed that without marking, the core colony's population size would have been overestimated by at least 23 percent over a 3-day period.

2. ***Undercount.***—Several factors may have contributed to an undercount of the number of AGS colonies and the number of AGS in those colonies in the surveys.

a. Our limited capacity to conduct the surveys.

b. Daily AGS flight activity is affected by temperature, cloud cover, precipitation, and wind speed (Wikström and others, 2009). Despite meticulous planning for extended travel to the survey locations, because of the unpredictability of local weather, some site visits did not coincide with ideal conditions for AGS activity or with the bloom time of host and nectaring plants (app. 12).

c. Incomplete records on the locations of some past colonies excluded these colonies from being surveyed in this study (Chazal and others, 2004).

d. Small, scattered, undocumented AGS colonies (especially in unexpected locations; Parshall, 2002; Chazal and others, 2004) could have been missed.

e. Not all possible colony sites could be surveyed because permissions were not secured to access some private lands (apps. 3, 4).

f. AGS's flight behavior, threat avoidance behavior, and cryptic morphology make them difficult to detect in the field (fig. 4*A*; Shuey and others, 1987; Iftner and others, 1992; Schweitzer and others, 2011).

Conclusion

Without intervention, the AGS may be at high risk of extinction because (Schweitzer and others, 2011; Wilson and Primack, 2019):

1. Their colonies are localized, and their extant range is limited;

2. They face a variety of local and range-wide threats that can degrade or destroy their habitats and harm AGS (such as ecological succession, pesticide use, and other human activities); and

3. Their low population densities make them susceptible to environmental or demographic stochasticity.

The results of this study provide the FWS and state fish and wildlife agencies with an updated range-wide status assessment for AGS, demonstrating that the distribution has contracted, with extant populations in only a small percentage of its historical range. These surveys also demonstrated that unoccupied, suitable sites exist in several states, suggesting that habitat degradation was not solely responsible for these declines. Future efforts to stabilize and strengthen the remaining populations could ensure suitable habitat remains available and is distributed in ways to support connected networks of populations by building redundancy and resiliency within metapopulations. Coordinated efforts among stakeholders that focus on identifying the management techniques that support necessary habitat conditions with minimal impacts to the remaining individuals, and work towards developing capacity for captive breeding programs for reintroducing the species to suitable areas near the existing populations, may be crucial to stabilizing the AGS populations.

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Appendix 1. Guidelines and Data Sheets

Guidelines and data sheets associated with *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) surveys. These documents are provided for context and have not been modified or brought to U.S. Geological Survey standards during the review of this publication. They can be downloaded as a separate file at https://doi.org/10.3133/ofr20261017.

Guidance for remotely selecting Appalachian Grizzled Skipper (AGS) colony survey locations

The purpose of this document is to harmonize methods for remotely selecting AGS colony survey locations among the 12 federal and state partner agencies. This document provides guidance for completing the Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheet

- Please use new Data Sheet for each site.
- On top of each page, please fill in basic information on date and site in the following order Date/State/County/Site #.

1. Site selector information: contact information of individual(s) selecting sites.

2. Site considered because: Site categories:
   a. Active colony - AGS observed since 2000.
   b. Previously Active - AGS last observed 1990-1999.
   c. Historically Active - AGS last observed 1989 and earlier.

   For colonies with known locations.

   d. Remote - No known AGS observations but habitat appears suitable for AGS.

   For remotely selected locations based on criteria presented here.

Methods:

a. Remotely locate Active, Past Active and Historically Active AGS colony locations.
b. Delineate a 20 km radius circle around each colony.
c. If data is available, use indicator plant species and natural communities associated with AGS to refine locations for potential habitat.
d. Within the 20 km circle, buffer the areas of interest (known AGS locations and locations with indicator plants) by 3 km radius.
e. Using recent, high resolution aerial imagery, search for potential AGS habitat within the 3 km radius circles that meet all three of the following criteria:
    a. Southeast to southwest aspect
    b. Open habitat.
        i. For the AGS Appalachian population, this includes clearcuts, unforested right of ways, open roadsides, or shale woodlands.
        ii. For the AGS Michigan population, this includes clearcuts, unforested right of ways, open roadsides, limestone openings or glades, alvars, sandy habitat (trap rock), oak-pine barrens, and pine barrens.

Figure 1.1. Copy of the "Guidance for Remotely Selecting Appalachian Grizzled Skipper (AGS) Colony Survey Locations."

c. Proximity to al least some trees (within 50 meters) for shade, resting sites, and protection.

f. Do not include areas that (1) have a full canopy of trees or shrubs, (2) are in agriculture (row crops, hayfield, or pasture), although tree farms may be included, (3) are mowed or developed. If aerial photography allows, exclude areas with denser vegetation.

g. Above process will leave areas with sparse vegetation and thin soils, i.e. possible locations of AGS colonies.

3. Tools used during remote selection: Please add details of tools used.

4. Site information: Provide site identification. This information should be the same as that entered on top of page.

5. Notes on site information: Provide additional notes on the methods used for site selected.

Figure 1.1.—Continued

Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheet

Date/State/County/ Site #_____

-Please use new form for each site.
-For assistance with this form, refer to the Guidance for remotely selecting Appalachian Grizzled Skipper (AGS) colony locations.

1. Site selector(s) information:
   Selector Name and Affiliation:_____
   Email:_____ Phone: _____
   Names and contact information of others involved in selection process: _____
   _____
   _____
2. Site considered because: Active Previously Active Historically Active Other
   For the Active, Previously Active and Historically Active, enter date of last observation record: _____
   Confidence in observation record: _____
3. Tools used during remote selection and source:
   a. Aerial imagery: _____
   b. Topographical maps: _____
   c. Soil maps: _____
   d. Historical records of AGS: _____
   e. Information on management actions (e.g., clear cuts, pesticide applications):
   _____
4. Selected site information:
   Site ID: _____ State: ____ County:_____
   Town:_____
   GPS coordinates: _____
5. Notes on site selection method:

Figure 1.2. Copy of the "Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheet."

Guidance for Appalachian Grizzled Skipper (AGS) Field Survey Data Sheet.

The purpose of this document is to harmonize methods for AGS surveys among 12 federal and state partner agencies. This document provides guidance for completing the Appalachian Grizzled Skipper (AGS) Field Survey Data Sheet.

- Please use new Data Sheet for each survey by site and date.
- On top of each page, please fill in basic information on date and site in the following order Date/State/County/Site #.
- Please take photos on smart phone with GPS points to map the site, characterize the habitat and to describe the host and nectar plant presence and distribution.

1. Observer information: contact information.

2. Location information: Site location.

3. Site selected because: Why this site was selected for survey
    a. Active colony - AGS observed since 2000.
    b. Previously Active - AGS last observed 1990-1999.
    c. Historically Active - AGS last observed 1989 and earlier.
    d. Remote selection - No known observations but habitat is suitable for AGS.

4. Survey conditions: Weather
    a. Temperature: Please specify Fahrenheit or Celsius. In comments section, add changes in temperature, wind speed and direction, cloud cover during the survey
    b. Wind: Velocity and direction.
    c. Cloud cover: Visually estimate percent cloud cover.
    d. Comments: Please include significant changes in weather during the survey.

5. AGS Survey: Scan the area to determine where the walk-through survey path will be placed. The recorder is not constrained by transects. Recorder should establish the survey path such that the entire site can be searched. The path should pass close to all areas with host and nectar plants. Do not record the same AGS individuals when doubling back on the path. Do not step on host and nectar plants.
    Note: The data sheet requests GPS point numbers. For each GPS point taken, you will assign it a unique identifier. For simplicity, record the unique GPS point identifier instead of entering the GPS coordinates.
    a. Walk-through survey: Once the path is determined, begin walk-through and enter the start time and start GPS point number.
    b. Continue recording GPS point numbers during the walk-through to delineate the survey path. A linear path (e.g., along a road) may require fewer GPS points than a winding path (e.g., through a meadow).

Figure 1.3. Copy of the "Guidance for Appalachian Grizzled Skipper (AGS) Field Survey Data Sheet."

c. Are AGS present? Circle Yes or No.
d. GPS point numbers for AGS and confidence level:
   i. Take GPS locations for the spot on the path that is closest to where the AGS was found.
   ii. Enter the GPS point numbers in table.
   iii. Enter level of identification confidence (Confident or Uncertain) in table.
   iv. If confident, specify method used to establish confidence:
      1. Sight: diagnostic features were observed by sight without handling.
      2. Net: diagnostic features were observed on captured individuals.
      3. Photo: diagnostic features were observed by photograph
   v. Uncertain: none of the above methods provided a confident identification.
e. AGS behavior: Circle the behaviors observed. If more than one AGS, circle more than one behavior.
f. Enter walk-through survey end time: and enter the GPS point number at end of survey path.
g. AGS count: Total number of AGS found during this survey.

6. Other butterfly species present: List other species observed at site.

7. Site habitat: Every site is different therefore, the best way to characterize the habitat at each site is through description. Examples of possible responses are included below:
   a. General description of site (ex. clear cut, service road, natural clearing, powerline, etc.).
   b. Host plant name and description of its distribution (ex. cinquefoil [Genus species] occurring in sunnier areas throughout the path but patchy distribution. Host plant flowering. No large or dense flowering mats. See photos…).
   c. Nectar plant species in bloom and description of their distribution. (ex. AGS seen on or near Bird's foot violet [Genus species] and phlox [Genus species]. Other possible nectar plants in bloom: dandelion [Genus species], vetch [Genus species], pussytoes [Genus species], flowering dogwood [Genus species], sassafras [Genus species]. Nectar plants found throughout the path but patchy distribution. Large clumps and dense of phlox and violets in some areas. See photos…).
   d. Map of survey path. (ex. AGS habitat within 20 feet along forestry road. Map provided. See photos…).
   e. Threats to area:
      i. Vehicular: vehicular activity is not contained to roads or tracks and is impacting the habitat patch.
      ii. Human: human activity is not constrained to trails, campsites, or other designated areas and is impacting the habitat patch.
      iii. Chemical: chemicals, including herbicides and/or pesticides, are evident nearby.
      iv. Succession: vegetation is encroaching on host plants and/or shading the patch.
      v. Invasive Species: invasive species are present on the site and the patch is susceptible to colonization.
      Development: roads, parking lots, buildings or other development is impacting the patch.

Figure 1.3.—Continued

vi. Browse: deer and/or other herbivores are targeting host plants in the patch.
vii. Mowing: the patch has been mowed during the flight period of the frosted elfin or during the growing season of the host plant.
viii. Forestry: forestry equipment, logs, and or slash are present in the patch during the flight period of the frosted elfin or during the growing season of the host plant.
ix. Burning: fire has been present in the patch during the flight period of the frosted elfin or during the growing season of the host plant.
x. Grazing: cattle or other grazers are impacting the patch by trampling or incidentally eating the host plant.
xi. Other.
(ex. Vehicular - plants and AGS along edge of road may be squashed under truck tires. Succession - pine saplings encroaching and shading habitat. Invasive Species - multiflora rose encroaching and shading habitat. Forestry - surrounding area logged for wildlife management. Other- Dust from large trucks settling on flowers and AGS may interfere with foraging.)

f. Other comments: (ex. Possible reasons for why count for lower than expected. Not many flowering host plants and not many AGS so don't know if the survey was too early or too late in the flight period. Unseasonably cold weather during the previous week could have also affected AGS numbers).

Figure 1.3.—Continued

Appalachian Grizzled Skipper (AGS) Field Survey Data Sheet

Date/State/County/ Site #_____

-Please use new form for each survey site and date.

-Please take photos on smart phone with GPS points to map the site, characterize the habitat and to describe the host and nectar plant presence and distribution.

-For assistance with this form, refer to the Appalachian Grizzled Skipper (AGS) Field Survey Guidance.

6. Observer(s) information:
   Observer Name and Affiliation: _____
   Email: _____ Phone: _____
   Names and contact information of others present: _____
   _____
7. Location information:
   Site: _____ State: ____
   County:_____ Town:_____ Site owner's name:
   _____
8. Site selected because: Active Previously Active Historically Active Remote selection
9. Survey Conditions: Weather:
   Temperature:_____ Wind:_____ Cloud cover:_____
   Comments:
   _____
10. AGS Survey:
    a. Walk-through survey: Start time: _____. Start GPS point number: _____.
    b. GPS point numbers along path:
       _____
    c. AGS present: Yes No.
    d. GPS point numbers for AGS and confidence level: Confident or Uncertain.

GPS number	Confidence and method	GPS number	Confidence and method	GPS number	Confidence and method	GPS number	Confidence and method

    e. AGS behavior: Patrolling/Perching, Feeding, Puddling, Basking, Mating, Ovipositing, Other_____
    f. Walk-through survey: End time: _____. End GPS point number: _____.
    g. AGS count: _____.
11. Other butterfly species present:
    _____
    _____
    _____

Figure 1.4. Copy of the "Appalachian Grizzled Skipper (AGS) Field Survey Data Sheet."

12. Site habitat: In your description on next page, please consider:
    a. General description of site.
    b. Host plant name and description of its distribution.
    c. Nectar plant species in bloom and description of their distribution.
    d. Map of survey path.
    e. Threats to area.
    f. Other comments.

    Site habitat description and additional notes. Continue on back if needed.

Figure 1.4.—Continued

Appendix 2. Other Butterfly Species Observed During Surveys, by State

Table 2.1. Other butterfly species observed during *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) surveys in Maryland.

[Surveys were done by the Maryland Wildlife and Heritage Service and by the U.S. Fish and Wildlife Service in 2022 and 2024, respectively.]

Scientific name	Common name
Anthocharis midea	Falcate orangetip
Battus philenor	Pipevine swallowtail
Callophrys gryneus	Juniper hairstreak
Calycopis cecrops	Red-banded hairstreak
Celastrina spp.	Azures
Colias philodice	Clouded sulphur
Cupido comyntas	Eastern tailed-blue
Epargyreus clarus	Silver-spotted skipper
Erynnis brizo	Sleepy duskywing
Erynnis juvenalis	Juvenal's duskywing
Eurytides marcellus	Zebra swallowtail
Glaucopsyche lygdamus	Silvery blue
Hesperia metea	Cobweb skipper
Hylephila phyleus	Fiery skipper
Family Lycaenidae	Blues
Lon hobomok	Hobomok skipper
Lon zabulon	Zabulon skipper
Family Lycaenidae	Hairstreaks
Nymphalis antiopa	Mourning cloak
Papilio glaucus	Eastern tiger swallowtail
Papilio troilus	Spicebush swallowtail
Family Pieridae	Whites, sulphurs
Phyciodes tharos	Pearl crescent
Speyeria cybele	Great spangled fritillary
Vanessa atalanta	Red admiral
Vanessa cardui	Painted lady
Vanessa virginiensis	American lady

Table 2.2. Other butterfly species observed during *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) surveys in Michigan.

[Surveys were done in 2022–24 by the Michigan Natural Features Inventory.]

Scientific name	Common name
Amblyscirtes vialis	Common roadside-skipper
Atrytonopsis hianna	Dusted skipper
Boloria bellona	Meadow fritillary
Callophrys augustinus	Brown elfin
Callophrys polios	Hoary elfin
Celastrina ladon	Spring azure
Colias interior	Pink-edged sulphur
Cupido comyntas	Eastern tailed-blue
Danaus plexippus	Monarch
Erynnis icelus	Dreamy duskywing
Erynnis juvenalis	Juvenal's duskywing
Erynnis lucilius	Columbine duskywing
Erynnis spp.	Duskywings
Euchloe olympia	Olympia marble
Glaucopsyche lygdamus	Silvery blue
Lon hobomok	Hobomok skipper
Nymphalis antiopa	Mourning cloak
Papilio canadensis	Canadian tiger swallowtail
Family Pieridae	Sulphurs

Table 2.3. Other butterfly species observed during *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) surveys in New York.

[Surveys were done in 2022–24 by the New York Natural Heritage Program.]

Scientific name	Common name
Celastrina ladon	Spring azure
Erynnis horatius	Horace's duskywing
Erynnis juvenalis	Juvenal's duskywing
Family Lycaenidae	Blues
Family Pieridae	Sulphurs
Papilio spp.	Appalachian or eastern tiger swallowtail
Pholisora catullus	Common sootywing[1]
Phyciodes tharos	Pearl crescent
Pieris rapae	Cabbage white
Thorybes spp.	Cloudywings
Vanessa Atalanta	Red admiral
Vanessa virginiensis	American lady

[1]Identification uncertain.

Table 2.4. Other butterfly species observed during *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) surveys in North Carolina.

[Surveys were done in 2023–24 by North Carolina Natural Heritage Program.]

Scientific name	Common name
Anthocharis midea	Falcate orangetip
Boloria bellona	Meadow fritillary
Callophrys augustinus	Brown elfin
Celastrina neglecta	Summer azure
Colias philodice	Clouded sulphur
Cupido comyntas	Eastern tailed-blue
Danaus Plexippus	Monarch
Epargyreus clarus	Silver-spotted skipper
Erynnis juvenalis	Juvenal's duskywing
Erynnis spp.	Duskywings
Family Hesperiidae	Skippers
Junonia coenia	Common buckeye
Limenitis arthemis	Red-spotted admiral
Lycaena phlaeas	American copper
Nymphalis antiopa	Mourning cloak
Family Nymphalidae	Satyr
Papilio polyxenes	Black swallowtail
Papilio spp.	Appalachian or eastern tiger swallowtail
Papilio Troilus	Spicebush swallowtail
Family Pieridae	Sulphurs
Phyciodes tharos	Pearl crescent
Pieris rapae	Cabbage white
Polygonia interrogationis	Question mark
Vanessa virginiensis	American lady

Table 2.5. Other butterfly species observed during *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) surveys in Ohio.

[Surveys were done in 2022 by the Ohio Department of Natural Resources.]

Scientific name	Common name
Celastrina landon neglecta	Summer azure
Erynnis icelus	Dreamy duskywing

Table 2.6. Other butterfly species observed during *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) surveys in Pennsylvania.

[Surveys were done in 2022–24 by the Western Pennsylvania Conservancy.]

Scientific name	Common name
Callophrys augustinus	Brown elfin
Calycopis cecrops	Red-banded hairstreak
Celastrina landon neglecta	Summer azure
Celastrina spp.	Azures
Cupido comyntas	Eastern tailed-blue
Erynnis juvenalis	Juvenal's duskywing
Erynnis spp.	Duskywings
Euptoieta claudia	Variegated fritillary
Eurytides marcellus	Zebra swallowtail
Glaucopsyche lygdamus	Silvery blue
Lycaena Hyllus	Bronze copper
Phyciodes tharos	Pearl crescent
Pieris rapae	Cabbage white
Vanessa virginiensis	American lady

Table 2.7. Other butterfly species observed during *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) surveys in Virginia.

[Surveys were done in 2021, 2023, and 2024 by the Virginia Natural Heritage Program.]

Scientific name	Common name
Amblyscirtes hegon	Pepper and salt skipper
Amblyscirtes vialis	Common roadside-skipper
Anthocharis midea	Falcate orangetip
Battus philenor	Pipevine swallowtail
Boloria bellona	Meadow fritillary
Callophrys augustinus	Brown elfin
Callophrys gryneus	Juniper hairstreak
Callophrys henrici	Henry's elfin
Callophrys irus	Frosted elfin
Callophrys niphon	Eastern pine elfin
Callophrys spp.	Elfins
Calycopis cecrops	Red-banded hairstreak
Celastrina ladon	Spring azure
Celastrina neglectamajor	Appalachian azure
Celastrina spp.	Azures
Colias eurytheme	Orange sulphur
Colias philodice	Clouded sulphur
Cupido comyntas	Eastern tailed-blue
Cyllopsis gemma	Gemmed satyr
Epargyreus clarus	Silver-spotted skipper
Erynnis baptisiae	Wild indigo duskywing
Erynnis brizo	Sleepy duskywing
Erynnis icelus	Dreamy duskywing
Erynnis juvenalis	Juvenal's duskywing
Erynnis spp.	Duskywing
Eurytides marcellus	Zebra swallowtail
Family Hesperiidae	Skippers
Feniseca tarquinius	Harvester
Glaucopsyche lygdamus	Silvery blue
Hesperia metea	Cobweb skipper
Hesperia sassacus	Indian skipper
Lon hobomok	Hobomok skipper
Megisto cymela	Little wood-satyr
Nymphalis antiopa	Mourning cloak
Papilio polyxenes	Black swallowtail
Papilio spp.	Appalachian or eastern tiger swallowtail
Papilio troilus	Spicebush swallowtail
Family Pieridae	White
Parrhasius m-album	White M hairstreak
Phoebis sennae	Cloudless sulphur

Table 2.7. Other butterfly species observed during *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) surveys in Virginia. —Continued

[Surveys were done in 2021, 2023, and 2024 by the Virginia Natural Heritage Program.]

Scientific name	Common name
Phyciodes tharos	Pearl crescent
Pieris rapae	Cabbage white
Polygonia comma	Eastern comma
Speyeria cybele	Great spangled fritillary
Strymon melinus	Gray hairstreak
Thorybes pylades	Northern cloudywing
Vaness atalanta	Red admiral
Vanessa virginiensis	American lady

Table 2.8. Other butterfly species observed during *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) surveys in West Virginia.

[Surveys were done for other butterfly species by the West Virginia Division of Natural Resources only in 2022, but not during field work in 2021, 2023, and 2024.]

Scientific name	Common name
Cupido comyntas	Eastern tailed-blue
Erynnis juvenalis	Juvenal's duskywing
Erynnis icelus	Dreamy duskywing
Erynnis brizo	Sleepy duskywing
Glaucopsyche lygdamus	Silvery blue

Appendix 3. Master Data Spreadsheet (Redacted)

The redacted spreadsheet in this appendix, which can be accessed at https://doi.org/10.3133/ofr20261017, contains *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) survey data collected for each of the following states: Maryland, Michigan, New York, North Carolina, Ohio, Pennsylvania, Virginia, and West Virginia. New Jersey data was not included in this spreadsheet.

Appendix 4. Maryland Data (Redacted)

Raw “Appalachian Grizzled Skipper (AGS) Field Survey Data Sheets” completed in April 2022, April 2024, and May 2024. These sheets are available in a separate file at https://doi.org/10.3133/ofr20261017.

No “Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheets” are available for this state because the remote sites were selected in the previous year or because only known sites were visited in a year.

Appendix 5. Michigan Data (Redacted)

Raw “Appalachian Grizzled Skipper (AGS) Field Survey Data Sheets” completed in 2022, May 2023, and May 2024. These sheets are available in a separate file at https://doi.org/10.3133/ofr20261017.

No “Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheets” are available for this state because the remote sites were selected in the previous year or because only known sites were visited in a year.

Appendix 6. New York Data (Redacted)

Raw “Appalachian Grizzled Skipper (AGS) Field Survey Data Sheets” completed in May 2022, April–May 2023, and in May 2024. These sheets and associated Appalachian “Grizzled Skipper (AGS) Remote Site Selection Data Sheets” are available in a separate file at https://doi.org/10.3133/ofr20261017.

Appendix 7. North Carolina Data (Redacted)

Raw "Appalachian Grizzled Skipper (AGS) Field Survey Data Sheets" completed in March–May 2023 and April–May 2024. These sheets and the associated 2023 Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheet are available in a separate file at https://doi.org/10.3133/ofr20261017.

No "Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheets" are available for this state in 2024 because the remote sites were selected in the previous year or because only known sites were visited in a year.

Appendix 8. Ohio Data (Redacted)

Raw “Appalachian Grizzled Skipper (AGS) Field Survey Data Sheet” completed in May 2022. This sheet is available in a separate file at https://doi.org/10.3133/ofr20261017.

No “Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheet” is available for this state because the remote sites were selected in the previous year or because only known sites were visited in a year.

Appendix 9. Pennsylvania Data (Redacted)

Spreadsheet containing *Pyrgus centaureae wyandot* (Appalachian grizzled skipper) survey data from 2022 through 2024. This spreadsheet is available in a separate file at https://doi.org/10.3133/ofr20261017.

No "Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheets" are available for this state because the remote sites were selected in the previous year or because only known sites were visited in a year.

Appendix 10. Virginia Data (Redacted)

Raw "Appalachian Grizzled Skipper (AGS) Field Survey Data Sheets" completed in April–May 2021 and April–May 2024 and a data spreadsheet from April 2023. These sheets and associated 2023 Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheet are available in a separate file at https://doi.org/10.3133/ofr20261017.

No "Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheet" is available for this state in 2021 and 2024 because the remote sites were selected in the previous year or because only known sites were visited in a year.

Appendix 11. West Virginia Data (Redacted)

Raw “Appalachian Grizzled Skipper (AGS) Field Survey Data Sheets” completed in April 2022, April 2023, and April–May 2024. These sheets are available in a separate file at https://doi.org/10.3133/ofr20261017.

No “Appalachian Grizzled Skipper (AGS) Remote Site Selection Data Sheet” is available for this state because the remote sites were selected in the previous year or because only known sites were visited in a year.

Appendix 12. Presentations and Reports Submitted by States (Redacted)

These redacted presentations and reports, which are available in a separate file at https://doi.org/10.3133/ofr20261017, were submitted to the U.S. Geological Survey during internal annual Appalachian grizzled skipper team meetings in 2021-2024. They were prepared, presented, and submitted to the U.S. Geological Survey by the coauthors of this study and are presented herein with the coauthors' permission. Titles and authorship information are given below in the order they appear in the separate appendix file:

"AGS Surveys in New York 2022–2024," a presentation by Erin White

"Appalachian Grizzled Skipper (AGS) Surveys in New York 2022–2024," a report by Erin White

"Appalachian Grizzled Skipper (*Pyrus centaureae wyndot*)—Results of the North Carolina Survey, 2023–2024," a report by J. Merrill Lynch

"Ohio AGS Survey 2022 Report," a report by Eileen Wyza

"Virginia DCR 2023 Appalachian Grizzled Skipper Surveys," a presentation by Leah R. Card and Ellison C. Orcutt

"Appalachian Grizzled Skipper Notes from 2023-2024 USGS Surveys" (in Virginia), a report by Andrew J. Rapp, Ellison C. Orcutt, and Leah R. Card

"West Virginia 2023 Rare Butterfly Monitoring—Appalachian Grizzled Skipper 2023 Survey Report," a presentation by Jakob Goldner

"Rare Butterfly Monitoring—Appalachian Grizzled Skipper 2024 Survey Report," a presentation by Jakob Goldner

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