

## A Review of the Status of the Regal Fritillary (*Speyeria idalia*) in Virginia

Anne C. Chazal, Steven M. Roble, and Christopher S. Hobson

Virginia Department of Conservation and Recreation  
Division of Natural Heritage  
217 Governor Street  
Richmond, Virginia 23219

### ABSTRACT

The Regal Fritillary (*Speyeria idalia*) has declined over much of its historic range in the past quarter century, including a near total loss of populations east of the Mississippi River. Only two extant populations of *S. idalia* are known in the eastern United States, including one each in Pennsylvania and Virginia. This paper presents a summary of known Regal Fritillary occurrences in Virginia based on literature accounts, museum collections, Internet resources, and 16 years of survey effort. Though once documented in 39 counties in Virginia, only six counties have yielded observations of *S. idalia* since 1995, and only one colony is known to persist. In light of the decline of *S. idalia*, conservation steps including legal listing, further surveys, and basic research to understand its life history are warranted.

*Key words:* Lepidoptera, Nymphalidae, *Speyeria idalia*, fritillary, status, Virginia.

### INTRODUCTION

The Regal Fritillary (Lepidoptera: Nymphalidae, *Speyeria idalia*) formerly ranged from the Maritime Provinces of Canada south to the Piedmont and Appalachian regions of North Carolina, and westward across the northern half of the United States to eastern Colorado and Montana (Opler & Krizek, 1984; Shuey et al., 1987). The habitats associated with the Regal Fritillary include prairies in the western portion of its range, to more human-impacted fields (hay fields, pasture, old fields, etc.), usually with some source of moisture, in the eastern portion of its range (NatureServe, 2008). This butterfly has declined over much of its historic range in the past quarter century, including a near total loss of populations east of the Mississippi River (Swengel, 1993; Opler, 1998; Williams, 1999). Explanations for this decline across its range include habitat fragmentation and conversion to human use, too much or too little fire, hurricane impact, spraying for gypsy moths, collecting, competition with other species of *Speyeria*, and the introduction of a parasitoid or pathogen (Schweitzer, 1991; Wagner et al., 1997).

In the United States, the Regal Fritillary does not have federal legal protection even though it is considered historical (i.e., not observed in 20 or more years) or extirpated in fifteen states (primarily in the eastern U.S.), and Washington, D.C. within its historical range of 31 states (NatureServe, 2008). Furthermore, seven states rank it as 'critically imperiled', including the remaining eastern states, and states along the southern and western periphery of its range (NatureServe, 2008). NatureServe (2008) ranks *S. idalia* as 'vulnerable' throughout its global and U.S. ranges and 'historical' in Canada.

Only two extant populations of *S. idalia* are known in the eastern United States, including one each in Pennsylvania and Virginia. Both of these populations occur on Department of Defense-owned lands. Currently, both bases support conservation measures and protection for the Regal Fritillary populations; however, as military needs change, there is no guarantee that these bases will be able to continue their conservation efforts for the butterfly. Despite extreme rarity and declining populations, the Regal Fritillary remains legally unprotected in Pennsylvania and Virginia (Terwilliger & Tate, 1995; The Nature

Conservancy, 2000).

Genetic and morphological studies suggest that eastern populations of *S. idalia* may be taxonomically distinct from Midwestern populations and thus eligible for listing by the U. S. Fish and Wildlife Service under the Endangered Species Act (Williams, 1999, 2001a, b); however, to date, these studies have not been completed for the Virginia population. Williams (2001b) formally described the western populations as a subspecies (*S. idalia occidentalis*) distinct from the eastern populations, assigning the nominate name (*S. idalia idalia*) to the latter.

The Virginia Department of Conservation and Recreation-Division of Natural Heritage (DCR-DNH) currently ranks *S. idalia* as G3 S1 recognizing its rarity at both the global and state levels (Roble, 2010). The G3 rank indicates that the species is ‘Vulnerable’ in its entire range and the S1 rank indicates it is ‘Critically Imperiled’ in the Commonwealth of Virginia.

This paper presents the results of 16 years of survey work on the Regal Fritillary in Virginia conducted by the staff of DCR-DNH. Information will be recounted on our survey efforts to relocate *S. idalia* populations at previously known sites and to document new occurrences.

## METHODS

### Literature and Museum Records

Literature sources, museum collections, and Internet (on-line) resources were searched for Virginia records of *S. idalia*. In addition, professional and amateur lepidopterists were contacted to determine if they had observed or collected *S. idalia* in Virginia.

### Roadside and Field Surveys

Based on literature reports, museum records, and personal observations, surveys were conducted to locate *S. idalia*. Roadside surveys were conducted by driving rural roads and visually inspecting any potential habitat that was encountered. Brief stops were made at sites where butterfly activity was detected and the most promising sites were searched on foot if landowner permission was granted. Field surveys were typically conducted by randomly walking through the habitat, with careful attention paid to nectar sources (e.g., thistle). Some field surveys consisted of more directed ‘transects’ through a habitat, to ensure complete coverage of an area.

## RESULTS

### Literature and Museum Records

Based on literature records, museum collections, and Internet resources, we determined that *S. idalia* historically occurred in 39 counties throughout the western and northern portions of Virginia (Fig. 1; Clark & Clark, 1951 [29 county records reported]; Schweitzer, 1991; Pavulaan, 1997; Opler et al., 2006). Most of these records are now considered ‘historical’ by DCR-DNH (i.e., >20 years old).

Entomological collections of the following ten museums were surveyed for Virginia specimens of *S. idalia*: American Museum of Natural History (AMNH; New York, New York), Carnegie Museum of Natural History (CMNH; Pittsburgh, Pennsylvania), Cornell University (Ithaca, New York), Lord Fairfax Community College (Middletown, Virginia), Museum of Comparative Zoology, Harvard University (MCZ; Cambridge, Massachusetts), National Museum of Natural History, Smithsonian Institution (NMNH; Washington, D.C.), University of Colorado Museum (Boulder, Colorado), Virginia Museum of Natural History (VMNH; Martinsville, Virginia), Virginia Polytechnic Institute and State University (VPI; Blacksburg, Virginia), and Peabody Museum, Yale University (YPM; New Haven, Connecticut). Dr. C. V. Covell, Jr. provided records from the McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, University of Florida (MC; Gainesville, FL) and from his personal field notes recorded from 1960-1963.

No Virginia specimens of *S. idalia* were found in the collections at the CMNH (J. Rawlins, pers. comm.) or MCZ. All specimens upon which the publication by Clark & Clark (1951) is based are believed to be housed at the NMNH (R.K. Robbins, pers. comm.), but we found considerably fewer specimens (16) of *S. idalia* in this collection than the number of counties (29) reported by these authors. Furthermore, only 11 of the 16 specimens were collected prior to 1951, and they represent only six counties. Apparently, Clark & Clark (1951) included many sight records or additional specimens were lost, destroyed, or are housed at other museums that were not surveyed by us. There are no known field notes from the Clarks in either the entomological library at NMNH (R.K. Robbins, pers. comm.) or in the Smithsonian Institution archives (D. Pawson, pers. comm.).

Additional literature records helpful in documenting the presence of *S. idalia* as well as targeting field surveys conducted by DCR-DNH include Wood & Gottschalk

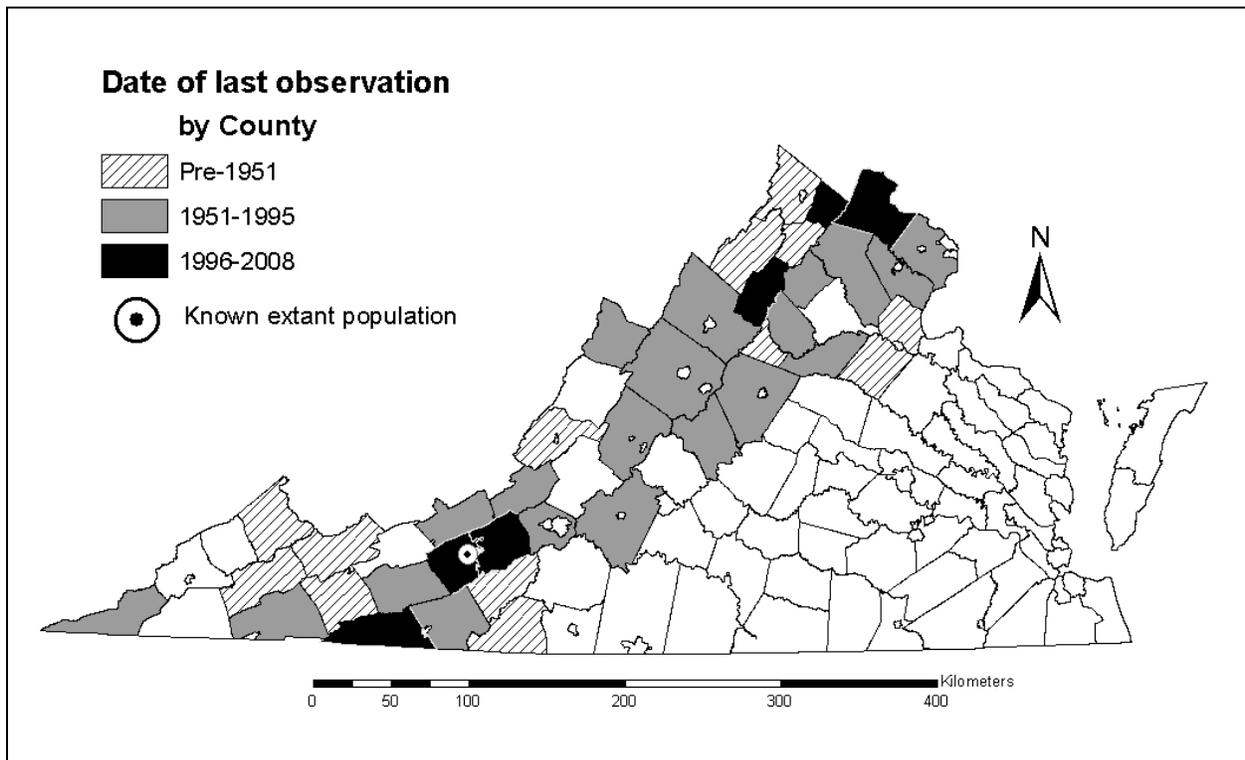


Fig. 1. Known county records for the Regal Fritillary (*Speyeria idalia*) in Virginia.

(1942), the season summary reports published in the *News of the Lepidopterists' Society* (years of *S. idalia* observation reported: 1977, 1979, 1983-1991), and the *Virginia Butterfly Bulletin* (McAvoy, 1996; Wyatt, 1999). The online database for season summaries of The Lepidopterists' Society was also checked (The Lepidopterists' Society, 2008) for *S. idalia* records in Virginia.

#### County Record Information

Each Virginia county from which *S. idalia* has been recorded (Figs. 1 & 2) is discussed below, with comments about known records and surveys by DCR-DNH. Following each county name is a list of references (CC = Clark & Clark, 1951; O1 = Opler, 1995; P = Pavulaan, 1995; O2 = Opler et al., 2006). It should be noted that more recent literature is most likely referring to older literature. In fact, the information cited in Pavulaan (1995) was based primarily on Opler (1995) and eventually was digitized to form the basis of the Opler et al. (2006) website. Harry Pavulaan provided us with more detailed information regarding the source of some of his and Opler's (1995) records, and these sources are mentioned below. Museum records or other observations are also listed in the text.

#### Albemarle County (CC, O1, P, O2)

There are no recent sightings of *S. idalia* in Albemarle County known to us. VPI has a male specimen with only county information, collected by C. V. Covell, Jr. on 15 June 1960. Covell (pers. comm.) clarifies this collection (5 total specimens) as being from about six miles (ca. 4 km) southwest of Charlottesville along U.S. Route 29. Nature Camp, a summer camp for teenagers in Vesuvius, Virginia, which focuses on natural history, has one specimen of *S. idalia* in its collection. Though label information is lacking, the collector, Lytton Wood, recalls capturing it near Earlysville during a population irruption in 1968 or 1969 (P. Coulling, pers. comm.). DCR-DNH surveys in Albemarle County have been primarily roadside surveys conducted in 1992.

#### Alleghany County (CC, O1, P, O2)

The VMNH has one specimen (formerly part of the University of Richmond collection), collected by C.C. Walton, from 'Clifton Forge' on 20 June 1937. It is unknown if this is the source of the Alleghany County record in Clark & Clark (1951), the last published report. There have been no surveys by DCR-DNH specifically for *S. idalia* in this county.

## Augusta County (CC, O1, P, O2)

No precise location information for the Clark & Clark (1951) record is known. Amos Showalter (pers. comm.) observed several males and females west of Waynesboro in June 1965. DCR-DNH conducted roadside surveys in Augusta County during 1992-1994, and 2001 without success. Surveys were also conducted at Cowbane Prairie Natural Area Preserve along the South River near Stuarts Draft. In 1992, DCR-DNH biologists reported a possible sighting of *S. idalia* at this preserve, but subsequent visits from 1992-2007 failed to verify this report.

## Bath County

There are no known records of *S. idalia* from Bath County; however, it has been documented in all adjacent Virginia counties and suitable habitat is present. DCR-DNH surveyed in Bath County during 1992-1994 and 2001. In 1993, there was an unverified sighting at Hidden Valley Recreation Area (George Washington National Forest). Subsequent surveys in 1994 could not verify this sighting.

## Bedford County (O1, P, O2)

Charles V. Covell, Jr. (pers. comm.) collected 5 males of *S. idalia* in a Bedford County field “between Lynchburg and Roanoke” on 15 June 1960. DCR-DNH surveyed in this county during 1992-1993 without success, and we are not aware of any recent records.

## Bland County

There are no known records of *S. idalia* from Bland County; however, it has been documented in all adjacent Virginia counties and suitable habitat is present. DCR-DNH surveyed in Bland County during 1993-1995 without success.

## Botetourt County

There are no known records of *S. idalia* from Botetourt County; however, it has been documented in all adjacent Virginia counties and suitable habitat is present. DCR-DNH surveyed in Botetourt County during 1993-1994, and 2001 without success.

## Buchanan County (CC, O1, P, O2)

No precise localities in Buchanan County are known. There have been no surveys by DCR-DNH specifically for *S. idalia* in this county.

## Carroll County (O1, P, O2)

There are no recent sightings of *S. idalia* in Carroll County known to us. Pavulaan (1995; pers. comm.) cites Leroy Koehn as the source for this county record with no further information available. The MC houses a male specimen collected by J. B. Sullivan, III on 26 June 1968 from along Co. Rt. 696. DCR-DNH conducted roadside surveys in this county in 1992, 1993, 1995, 1999, and 2001, including areas along the Blue Ridge Parkway, without success.

## Clarke County (O1, P, O2)

No precise localities for Clarke County are known. Pavulaan (1995; pers. comm.) reports this record is based upon a pre-1985 report from William Hartgroves. More recently, one adult *S. idalia* was observed on 27 July 1997 at an unspecified location east of Berryville, though it is uncertain if this observation was in Clarke County or adjacent Loudoun County. Pavulaan (pers. comm.) has conducted surveys in the Berryville area in an attempt to confirm this report, but without success. DCR-DNH surveys consisted of roadside surveys and foot surveys of a private farm in 2001 without success.

## Craig County (O1, P, O2)

No precise localities in Craig County are known. Paul C. Hammond (pers. comm.) reported observing several male *S. idalia* visiting milkweed (*Asclepias*) flowers in the company of *Speyeria diana*, *S. cybele*, and *S. aphrodite* along Craig Creek in both Montgomery and Craig counties on 30 June 1978. DCR-DNH has conducted roadside surveys in 1993, 1994, and 2003 without success. Jason Weintraub (pers. comm.) surveyed roadsides in the Sinking Creek watershed during July 2004 without success.

## Culpeper County

There are no known records of *S. idalia* in Culpeper County; however, it has been documented in all adjacent Virginia counties and suitable habitat is present. DCR-DNH conducted roadside surveys in this county in 1992 and 1993.

## Fairfax County (CC, O1, P, O2)

There are two NMNH specimens including a male collected by E. Shoemaker on 22 June 1911 at an unspecified location in Fairfax County. Clark (1932) reports “Ernest Shoemaker has specimens from Black

Pond, Fairfax County, VA". It is not clear if this is the same or an additional record for Fairfax County. There are two 'Black Ponds' in Fairfax County labeled on USGS topographic maps. Both are small ponds adjacent to the Potomac River, upstream of Washington D. C. It is unlikely that any appropriate habitat remains in this highly developed area.

The second NMNH specimen of *S. idalia* is also a male, collected at Difficult Run on 14 June 1936 (collector unknown, but likely Austin and Leila Clark). The mouth of Difficult Run is near one of the Black Pond locations mentioned above. DCR-DNH surveyed the Difficult Run area in 1993 and reported little to no available habitat persisting. Pavulaan (pers. comm.) also has surveyed for butterflies along Difficult Run numerous times in the past decade without observing *S. idalia*. Few other DCR-DNH surveys have been conducted in this area because appropriate habitat is scarce and fragmented.

G.C. Pitts collected one male *S. idalia* "on thistle" from Fairfax (city) on 6 July 1940. The specimen is now housed at the VMNH (formerly part of the University of Richmond collection). The MC has a female specimen collected by Gary N. Ross on 13 August 1959 from Vienna. William D. Hartgroves (pers. comm.) reported sighting a single male *S. idalia* near Annandale in June 1968 but did not see it during subsequent visits.

#### Fauquier County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is not known. YPM has a series of specimens (19 males and 2 females) collected by Ward P. Watt between 27 June and 3 July 1960 west of Middleburg. Dr. Watt (pers. comm.) recalled a breeding population along Rt. 50 with hundreds of individuals. We also have accounts of observations near Cresthill as recently as 1978 (G. Krizek, pers. comm., 1998). In addition, in the course of conducting roadside surveys, DCR-DNH had an unconfirmed sighting in 1993 about 8 km north of Warrenton; however, subsequent surveys in that area in 1994 were unsuccessful in confirming the presence of *S. idalia*. Additional roadside surveys were conducted in 2001 without success.

#### Floyd County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is unknown. The Blue Ridge Parkway was surveyed by DCR-DNH during 1992-1995 and 1999 without success. Also, many general butterfly surveys by Clyde Kessler and Bruce Grimes (pers. comm.)

along the Blue Ridge Parkway have not yielded any observations of the Regal Fritillary. While DCR-DNH conducted roadside surveys for another butterfly species in Floyd County during 1999-2008, no Regal Fritillaries were found. However, the Regal Fritillary was not the primary target of these surveys and thus appropriate habitat may have been overlooked, although, because the flight seasons of the two species overlap, it is appropriate to consider this effort.

#### Franklin County

There are no known previous records of *S. idalia* in Franklin County; however, it has been documented in adjacent Virginia counties to the north and west, and suitable habitat is present. DCR-DNH surveys consisted of roadside surveys along the Blue Ridge Parkway and foot surveys of Smart View Recreational Area in 1993. Clyde Kessler (pers. comm.) frequently conducts butterfly surveys in this county but has not reported this species.

#### Frederick County (CC, O1, P, O2)

NMNH has a female specimen of *S. idalia* collected by Austin H. Clark on 10 July 1938 at 'Gainesboro'. DCR-DNH conducted surveys in the Winchester area in 1996 without success.

#### Giles County (O1, P, O2)

There are several reports of *S. idalia* in Giles County. In 1993, two observers (unnamed) reportedly observed *S. idalia* near Clover Hollow. Several attempts to verify a population in the area were unsuccessful. The original observers did provide verification of *S. diana*, but failed to document *S. idalia* again in the area. This is not considered a valid sighting, and is likely a case of mistaken identification.

Another report consists of an observation of a lone *S. idalia* on top of Butt Mountain about 1974 (D. West, pers. comm.). We know of three other reports (all pers. comm.) from the 1970s. John A. Hyatt observed *S. idalia* at Little Meadows, Leroy Koehn reports that he observed them in Green Valley, and Stephen P. Hall recalled seeing them near Mountain Lake. Gerald Straley reported *S. idalia* from Eggleston (presumably Green Valley area) between 30 June and 9 July 1981. Roadside surveys in Giles County by DCR-DNH during 1993-1995 were unsuccessful. C. Kessler (pers. comm.) and other butterfly enthusiasts frequently conduct surveys in this county but have not reported this species.

## Grayson County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is unknown. DCR-DNH surveyed meadows along the Blue Ridge Parkway in 1992-1993 and 2006, and high elevation wetland areas of Mt. Rogers in 1992-1993. In 1998, a single *S. idalia* was reported about 0.4 km NW of Spring Valley (Wyatt, 1999). Efforts by DCR-DNH to confirm this record in this area and in other parts of the county were unsuccessful in 2001. Jason Weintraub and Ronald Gattelle (pers. comm.) checked the Spring Valley area independently in 2004 without success. Good habitat is present in this area.

## Greene County (CC, O1, P, O2)

The AMNH has three specimens labeled 'Skyline Drive' collected on 16 July 1940 (collector unknown). We are not aware of any more recent sightings. DCR-DNH has not specifically surveyed in Greene County for *S. idalia*.

## Highland County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is unknown. D. A. Young (pers. comm.) reported observing two *S. idalia* near Monterey Mountain in June 1989. Subsequent surveys by DCR-DNH during 1992-1995 were unsuccessful in locating a population in this area.

## Lee County (O1, P, O2)

John Hyatt (pers. comm.) reported that a colony of *S. idalia* inhabited a family farm west of Jonesville in the early 1960s. Later that decade, this population had disappeared from the area. We are not aware of any additional records from Lee County. DCR-DNH conducted some road surveys in 1995 without success.

## Loudoun County (CC, O1, P, O2)

William D. Hartgroves (pers. comm.) reported observing one adult in Sterling during July 1968. To our knowledge, no subsequent surveys were conducted.

The NMNH has one male *S. idalia* collected '7 mi SE Leesburg' on 25 June 1979 by J. M. Burns and R. G. Robbins. This area was surveyed in 1993 by DCR-DNH and determined that it was too developed and fragmented to continue to support a population of *S. idalia*. More recently, an adult *S. idalia* was observed on 27 July 1997 at an unspecified location east of Berryville, but it is uncertain if this observation was in Loudoun County

or adjacent Clarke County. Harry Pavulaan (pers. comm.) has conducted surveys in the Berryville area in an attempt to confirm this report, but without success. DCR-DNH also conducted roadside surveys in 2001 without success. The Smithsonian Naturalist Center, a satellite program of the NMNH in Leesburg, VA, has one male *S. idalia* in its collection. It was collected by William Grooms near Round Hill, Loudoun County, VA on 14 July 2006. The collector reports that it was found in a marshy, sedge meadow with thistle and milkweed (H. Lisy, pers. comm.). This site may be near or the same as the "Berryville area" record noted above.

## Madison County (CC, O1, P, O2)

The University of Colorado Museum has a voucher of *S. idalia* from 'Woodbury Forest' (no county information) collected in 1937 (C. A. Pague, pers. comm.). We were unable to locate a town of that name; however, we did find a 'Woodberry Forest School' in Madison County. This is a private boarding school open since the late 1800s located on 1,000 acres (404 ha) of open field and forest formerly owned by William Madison, brother of James Madison. We could not resolve the discrepancy in spelling.

The AMNH has 11 specimens of *S. idalia* collected in 1978 by J. Zeligs in the vicinity of Banco, Virginia. W. Hartgroves (pers. comm.) reported *S. idalia* to be 'local but common' during the first week of July in 1978, 1979, and 1980. The localities that he specified ('Madison County', 'Aylor', 'Syria' and 'Etlan') and his road directions (Hwy. 211 and Rt. 671) do not agree. Hartgroves notes that the population near Aylor had disappeared a year or two after he found it, but does not give the exact dates for that location. It should be noted that the Aylor, Banco, Etlan, and Syria observations are in close proximity to each other and may have been one large metapopulation. Hartgroves also reports that other lepidopterists (R. Smith and G. Krizek) attempted to locate *S. idalia* in this area using this information, but were not successful. DCR-DNH has conducted roadside surveys in Madison County; however, these specific areas have not been checked.

## Montgomery County (CC, O1, P, O2)

There are numerous records of *S. idalia* from Montgomery County. There are several NMNH specimens with only county information dating from 19 August 1926 (three females), and one male with no date (collectors unknown for all). The AMNH also has a specimen with only county information, collected by 'J.H.S.' on 19 August 1926. It is possible the NMNH and AMNH collections from this date are from the

same collector.

The NMNH also houses specimens, collected by C. V. Covell, Jr., at 'Blacksburg' on 23 June 1960 (two males), and 'Near Blacksburg, Pepper Station' on 1 July 1961 (one male). Covell (pers. comm.) has many records for the Pepper Station area from 1960 (23-25, 27 June), 1961 (28 June, 1, 4-5 July, 4 August), 1962 (15 June) and 1963 (24 June) totaling 33 specimens. In addition to the three specimens at the NMNH, four of these specimens are housed in the MC.

Numerous records exist for the Poverty Hollow area north of Blacksburg. Covell (pers. comm.) reports observations from Poverty Hollow in 1960 (9 July, 21-23 July, and 1 August) and 1961 (5 September). The season summary reports of The Lepidopterists' Society (1977-1993) include the following records: 8 July 1988 (observed by A. F. Beck); 13 July 1980 (one worn individual observed by F. Bower); 1 July 1978 (observed by C. Watson); 2 June 1978 (observed by L. Koehn); August 1977 (observed by J. Weintraub); July 1977 (observed by J. Hyatt); and 2 July 1977 (female observed at swamp milkweed by F. Fee; specimen housed at MC). The Poverty Hollow area was surveyed by DCR-DNH during 1993-1995 and 2001 without success.

Leroy Koehn (pers. comm.) reported observing *S. idalia* in Craig Creek Hollow sometime between the late 1970s to early 1980s. Paul C. Hammond (pers. comm.) reported finding this species along Craig Creek in both Montgomery and Craig counties. At one site (county not specified), several males of *S. idalia* were observed on 30 June 1978 nectaring on milkweed with *S. cybele*, *S. aphrodite*, and *S. diana*. DCR surveyed this road in 1993, 1994, and 2003 but could not relocate this population.

Covell (pers. comm.) reported collecting an adult *S. idalia* from 'Slusser Church Road near Brush Mountain west of Blacksburg' on 6 July 1964. A Slussers Chapel is located on Rt. 624 (Mt. Tabor Road) north of Blacksburg and does run along Brush Mountain. Covell's directions could not be reconciled with current topographic maps and road names.

Paul C. Hammond (pers. comm.) also reported a small colony in hay fields about 3-4 miles south of Blacksburg, where he found fresh teneral males on 12, 18, and 20 June 1978, and a freshly eclosed female on 24 June 1978. He estimated the colony size at 20-25 adults.

Wood & Gottschalk (1942) reported *S. idalia* from Whitethorne Meadows (now called Kentland Farms – Virginia Polytechnic Institute and State University, near Whitethorne, VA) on 19 August 1926. This may refer to the specimens in the NMNH and AMNH collections mentioned above from the same date. Covell (pers.

comm.) observed *S. idalia* in the early 1960s near Longshop, Virginia (1 adult collected on 19 September 1960; Covell, pers. comm.), which is close to Whitethorne. During 1993-1995, McAvoy (1996) observed several adults here and collected a female on 1 September 1993 at Whitethorne on musk thistle (*Carduus nutans*) now in the VPI collection (McAvoy, pers. comm.). DCR-DNH also observed the species there in 1994. Return visits by T. McAvoy in 1996, 1997, and 1998 found no evidence of the *S. idalia*. In 1998, DCR-DNH was also unable to locate *S. idalia* at this site and we presume this population is now extirpated based on habitat alterations.

Kenneth Cooper (fide B. Grimes, pers. comm.) reported the most recent observation on 20 May 2000 at the Brown Farm Park in Blacksburg. DCR-DNH surveyed the area in 2001 but was unable to locate a population here. Given the early date of this observation, this is not considered a confirmed sighting.

Nelson County (CC, O1, P, O2)

The source of the Nelson County record in Clark & Clark (1951) is unknown. Eight adults were collected south of Afton by C. V. Covell, Jr. on 30 July 1961. There have been no surveys by DCR-DNH specifically for *S. idalia* in this county.

Orange County (CC, O1, P, O2)

The NMNH has two Orange County specimens collected by G. W. Rawson (male on 5 July 1921 and female on 29 June 1922). Neither has specific locality information. David Liebman (pers. comm.) published photographs of *S. idalia* (Stolzenburg, 1992) that he found near Lahore about 1988. This general area and other areas in Orange County were surveyed by DCR-DNH in 1992 and 1993 without success.

Page County (O1, P, O2)

The NMNH has a male specimen collected by Paul A. Opler on 20 June 1978 at Bealer's Ferry. Subsequent surveys in 1991 (by John Coffman) and 1992 (by DCR-DNH) were not successful and the habitat was described as overgrown.

In 2001, Jane Hulse (pers. comm.) reported seeing a single individual near Luray, but she has not observed the species in subsequent visits. A housing development was proposed for the area, which was previously farmland. DCR-DNH has not surveyed this area to determine if a population is present.

DCR-DNH and other lepidopterists have surveyed the Big Meadows area of Shenandoah National Park

without success.

#### Patrick County (CC, O1, P, O2)

No precise localities in Patrick County are known. DCR-DNH conducted roadside surveys in 1992, 1993, 1995, and 1999, primarily along the Blue Ridge Parkway and the Meadows of Dan area.

#### Prince William County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is unknown. Eric Quinter (pers. comm.) observed this species near Haymarket or Gainesville in the 1970s, but no specific details were recorded and no collections were made. DCR-DNH conducted roadside surveys in 1993. Site surveys were conducted in native grasslands at Manassas National Battlefield Park in 1993 and 1999 but no *S. idalia* were recorded.

#### Pulaski County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is unknown. Covell (pers. comm.) reported collecting a pair from east of Dublin along Hwy. 11 on 5 July 1961. In 1994, Thomas McAvoy (pers. comm.) reported one *S. idalia* sighting in a pasture near Belspring. DCR-DNH was unable to find more adults during surveys in 1995 and 2001. Additional road surveys in the county were also negative.

In 1997, several adult *S. idalia* were observed by Shay Garriock at the Radford Army Ammunition Plant (RAAP) – Radford Facility (Reynolds, 1999). DCR-DNH captured twenty adults as part of a mark-recapture study in 1998. In mid-July 1998, the field where *S. idalia* was located was mowed, effectively eliminating adult nectar sources in the immediate area and possibly displacing adults inhabiting the site. Similar efforts in 1999 led to only one capture and 4-5 total observations. Continued efforts by DCR-DNH to find this population between 2000 and 2003 and again in 2005 were unsuccessful, and we believe it is now extirpated.

Also in 1997, Garriock (in Reynolds, 1999) rediscovered *S. idalia* on the RAAP – Dublin facility. Decades earlier (about 1960), C. V. Covell, Jr. (pers. comm.) had observed and filmed Regal Fritillaries from outside the facility's perimeter fence. Between 1998 and 2006, DCR-DNH monitored this population using mark-recapture techniques (1998-2000) and transect counts (2001-2006). In 2007, RAAP staff took over monitoring efforts with volunteer help. Population counts during DCR-DNH mark-recapture efforts ranged between 10 (surveys began late in the flight season) to 109 in 2000. In general, counts of observations from

transect surveys (which may recount individuals) declined between 2001 and 2006 from a high of 256 observations in 2004 to a low of 28 in 2006. Data from the RAAP surveys in 2007 and 2008 support this downward trend with only 10 observations in 2007 and one individual in 2008 (L. DiIoia, pers. comm.). When accounting for differences in survey effort (observations per hour of survey) the data trend is the same. To date, the RAAP population represents the only extant population in Virginia to our knowledge; however its continued viability may be in jeopardy for undetermined reasons. RAAP continues to maintain the (native) grassland habitat and monitor the population, yet the population seems to have declined. Violets, the larval foodplants, are uncommon in the breeding habitat (DCR-DNH observations). Preliminary genetic analysis suggests that this population has very low genetic diversity (J. Weintraub, pers. comm.). Specific data for this population will be presented in a subsequent paper.

#### Rappahannock County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is unknown. There are two specimens housed at Lord Fairfax Community College (Robert Simpson, pers. comm.). One was collected at the confluence of the Thornton and Rush rivers on 24 June 1975. The other record (25 June 1978) was obtained near the junction of 'Rt. 636 and Rt. 533'. Rt. 533 could not be located; however Rt. 636 does intersect with Hwy. 522 and is the likely correct location. Both sites supported colonies of *S. idalia* (R. Simpson, pers. comm.). Simpson (pers. comm.) also observed this species at two other sites in this county in the 1970s, but does not recall specific dates or locations. One site is believed to have been near Sperryville, and the other possibly along the Rappahannock River. Both sites were open meadows and inhabited by numerous *S. idalia*. Some areas of Rappahannock County had roadside surveys conducted by DCR-DNH in 1993 and 2001.

#### Roanoke County (including the City of Salem) (CC, O1, P, O2)

The record in Clark & Clark (1951) may refer to the reports of Wood & Gottschalk (1942), who found *S. idalia* in three areas in Roanoke County: Katz Hill and Fort Lewis (both 1938), and Salem (1926). The AMNH has one specimen with label information simply listed as 'Salem', collected 26 June 1940. The University of Colorado Museum also has a specimen from 'nr. Salem' taken 16 July 1940. These are presumably from Salem in Roanoke County, but there are small villages of the same name in both Culpeper and Page counties.

The MC has a female specimen from 'Roanoke' collected on 18 August 1968 by H. Flaschka. DCR-DNH has conducted roadside surveys in 1993 and 1994 without success. Many general butterfly surveys by Mike Donahue (pers. comm.) along the Blue Ridge Parkway near Roanoke have not yielded any observations of the Regal Fritillary. To our knowledge there have been no recent observations in Roanoke County.

#### Rockbridge County (CC, O1, P, O2)

The report in Clark & Clark (1951) is possibly based on Smyth's (1938) record for this county. Charles Watson (pers. comm.) reported observing one *S. idalia* near 'Liberty Hall ruins' off of Rt. 60 outside of Lexington in about 1974. DCR-DNH has conducted surveys in 1992, 1994, and 2001.

#### Rockingham County (O1, P, O2)

Clark & Clark (1951) did not list this as a county in which *S. idalia* occurs though they did record it from four of five adjacent counties. Pavulaan (1995; pers. comm.) credits John Coffman with the county record, but our efforts to obtain more information from Mr. Coffman regarding his observations and collections were unsuccessful. DCR-DNH has not conducted surveys for *S. idalia* in Rockingham County.

#### Russell County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is unknown. We are not aware of any other observations in Russell County. DCR-DNH conducted surveys in 1993 and 1995.

#### Scott County

No records of *S. idalia* are known from this county; however, DCR-DNH conducted some surveys here in 1995 in the Rye Cove area.

#### Shenandoah County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is unknown. We are not aware of any other observations in Shenandoah County. DCR-DNH has not conducted surveys in this county.

#### Smyth County (CC, P, O2)

The precise location for the Clark & Clark (1951)

record is unknown. The MC has two specimens (collection dates: 26 June 1932 and 23 June 1938) from an unknown collector(s), both from Seven Mile Ford. It is unknown if this collection was known to the Clarks. Opler (1995) did not include a record of *S. idalia* for Smyth County, but Pavulaan (1995) did, referring to Clark & Clark (1951) as the source. Opler et al. (2006) also included this county. DCR-DNH conducted surveys in 1992, 1993, and 1995.

#### Spotsylvania County (CC, O1, P, O2)

The Clark & Clark (1951) record is probably based on a male specimen (NMNH) collected on 17 June 1922 at Spotsylvania by G.W. Rawson. To our knowledge, there have been no recent observations of *S. idalia* in this area. DCR-DNH conducted roadside surveys in 1993.

#### Stafford County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is unknown. We are not aware of any other observations in Stafford County. DCR-DNH conducted surveys in 1992, 1993, and 1995. The grassland-dominated artillery impact areas and other portions of the Quantico Marine Corps Base were surveyed by DCR-DNH on several occasions (1993, 1998) without success.

#### Tazewell County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is unknown. We are not aware of any other observations in Tazewell County. DCR-DNH conducted surveys in 1993 and 1995.

#### Warren County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is unknown. We are not aware of any other observations in Warren County. DCR-DNH conducted surveys in 1993 and 2001.

#### Washington County (CC, O1, P, O2)

The Clark & Clark (1951) record is probably based on a NMNH voucher specimen (male) collected at Konnarock in 1936. Cornell University has a male specimen collected by Eric Quinter on 7 July 1971 from north of Bristol. DCR-DNH has spent time surveying Washington County in 1993 and 1995, including the Konnarock area, without success.

Wythe County (CC, O1, P, O2)

The precise location for the Clark & Clark (1951) record is unknown. One specimen housed at VPI was collected in 1972 by Walter Knausenberger from along Reed Creek (W. Knausenberger, pers. comm.). Leroy Koehn (pers. comm.) reported observing *S. idalia* along the New River at Rt. 100 and at Shot Tower Historical State Park sometime in the late 1970s to early 1980s. Although DCR-DNH has driven some roads in Wythe County (1995, 2001), neither of these areas was searched.

Roadside Survey Results

Since 1992, DCR-DNH has driven more than 2,000 miles (3,200 km) searching for *S. idalia* throughout western and northern Virginia (Fig. 2). This includes surveys in 39 counties. Counties from which *S. idalia* is known (based on Opler et al., 2006) but DCR-DNH has not yet surveyed are: Alleghany, Buchanan, Greene, Nelson, Rockingham, and Shenandoah. Surveys were conducted in six counties and one city with no previous

records of *S. idalia*: Bath, Bland, Botetourt, Culpeper, Franklin, and Scott counties, and the City of Roanoke. For this effort, DCR-DNH has only a handful of unverified possible sightings, and no reconfirmations of reported sightings or locations. The presence of *S. idalia* at RAAP was brought to our attention by researchers conducting studies there.

Of the 39 Virginia counties from which *S. idalia* has been documented, 13 lack verified records since 1951. Eight of these are no more than county records reported in Clark & Clark (1951). Nine of these 13 counties had some survey work conducted by DCR-DNH. The records for all 13 counties are considered ‘Historical’, i.e., the species has not been seen in 20 or more years. Ranks presented here are based on DCR-DNH Element Occurrence (EO) Ranks, which attempt to provide a qualitative measure of a population’s estimated viability, i.e. the likelihood that it will persist in the future (Table 1). It is difficult to assess if these counties have been surveyed adequately or if a sufficient amount of appropriate habitat remains that would warrant changing the ranks of these records from ‘Historical’ to ‘Extirpated’ (i.e., H and X, respectively).

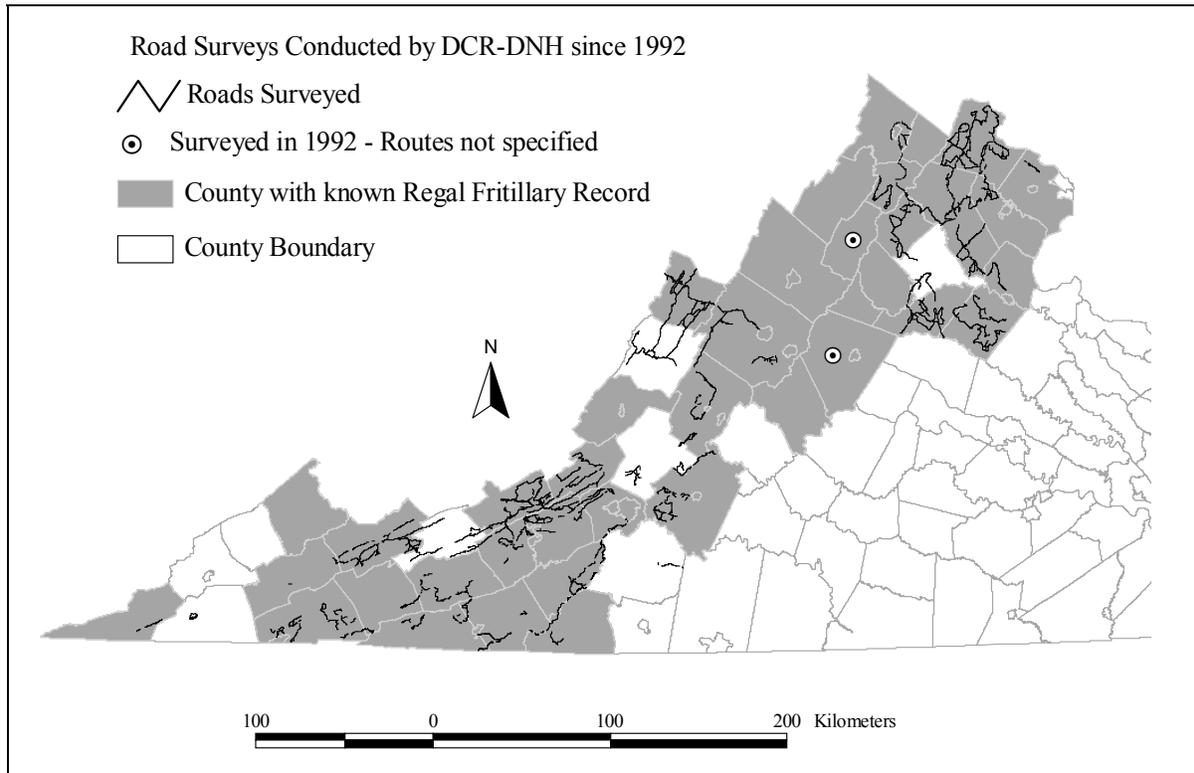


Fig. 2. Road surveys conducted by DCR-DNH for *Speyeria idalia* in Virginia. Most surveys were conducted between 1992 and 2001. Note that the survey route information in 1992 was recorded only as general locations and thus is not depicted as surveyed roads. Also note, extensive road surveys for another butterfly species in Floyd County, concurrent with the flight period of *S. idalia*, are not given here.

Table 1. The element occurrence (EO) ranks and the numbers observed during the last observation at known localities for Regal Fritillaries in Virginia are shown. Counties are listed within the time period of the last observation for that county, even though specific records from that county may fall within a different time period. EO ranks are taken from the DCR-DNH Biotics database. Locations with the same superscripted number indicate records in close proximity which may have functioned as metapopulations. # = possibly the same record; \* = a colony was present based on numerous previous sightings; + = The 'Whitethorne Area' includes the Montgomery County areas of Whitethorne Meadows, Pepper Station, Longshop, and the Brown Farm, and the Pulaski County areas of Belspring and RAAP-Radford.

Time Period	Known Locality Records Locality: Year of Last Observation	EO Rank <sup>a</sup>	Numbers Observed
Pre-1951	Alleghany: Clifton Forge: 1937	H	1 collected
<u>County only (all H)</u> Buchanan	Frederick: Gainesboro: 1938	H	1 collected
Floyd	Greene: Skyline Drive: 1940	H	3 collected
Patrick	Spotsylvania: Spotsylvania: 1922	H	1 collected
Russell	Smyth: Seven Mile Ford: 1938	H	1 collected
Shenandoah			
Stafford			
Tazewell			
Warren			
1951-1995	Albemarle: Near Earlysville: 1968 or 1969 6 mi SW Charlottesville: 1960	H H	1 collected 5 collected
<u>County only (all H)</u> Rockingham	Augusta: W of Waynesboro: 1965	H	"several"
	Bedford: "Between Lynchburg and Roanoke": 1960	H	5 collected
	Carroll: Rt. 696: 1968	H	1 collected
	Craig: Craig Creek <sup>1</sup> : 1978	H	"several"
	Fairfax: Black Pond <sup>#</sup> : No date	X	No data
	County only <sup>#</sup> : 1911	X	1 collected
	Difficult Run: 1936	X	1 collected
	Fairfax: 1940	X	1 collected
	Vienna: 1959	X	1 collected
	Annandale: 1968	X	1
	Fauquier: W of Middleburg: 1960	H	Colony (100s)
	Cresthill: 1978	H	Colony
	Giles: Little Meadows: 1970s	H	1
	Mountain Lake: 1970s	H	No data
	Butt Mountain: 1974	H	1
	Green Valley: 1981	H	No data
	Highland: Near Monterey Mountain: 1989	H	2
	Lee: W of Jonesville: 1960s	X	Colony
	Madison: Woodbury Forest: 1937	H	1 collected
	Banco <sup>2</sup> : 1978	H	Colony
	Aylor/Etlan/Syria <sup>2</sup> : 1980	H	Colony

Table 1 (continued).

Time Period	Known Locality Records Locality: Year of Last Observation	EO Rank <sup>a</sup>	Numbers Observed	
1951-1995 (continued)	Nelson: South of Afton: 1961	H	8 collected	
	Orange: County only: 1922 Lahore: 1988	H H	1 collected >5	
	Prince William: Haymarket/Gainesville: 1970s	H	No Data	
	Rappahannock: Thornton/Rush River: 1975 Rt. 636: 1978	H H	Colony Colony	
	Roanoke: Katz Hill <sup>3</sup> : 1938 Fort Lewis <sup>3</sup> : 1938 Salem <sup>3</sup> : 1940 Roanoke: 1968	H H H H	No data No data No data 1 collected	
	Rockbridge: County only: 1938 Liberty Hall: 1974	H H	No data 1	
	Washington: Konnarock: 1936 N of Bristol: 1971	H H	1 collected 1 collected	
	Wythe: Reed Creek: 1972 New River: ca. 1980 Shot Tower: ca. 1980	H H H	1 collected No data No data	
	1995-2008	Clarke: Near Berryville: 1997	D?	1
		Grayson: NW of Spring Valley: 1998	D?	1
		Loudoun: Sterling: 1968 SE of Leesburg: 1979 Round Hill: 2006	X X D?	1 1 collected 1 collected
		Montgomery: County only: 1926 Blacksburg: 1960 Near Brush Mountain: 1964 3-4 mi S Blacksburg: 1978 Craig Creek <sup>1</sup> : 1978 Poverty Hollow: 1988 Whitethorne Area <sup>+</sup> : 1999	H H H H H H X	4 collected 2 collected 1 collected Colony (20-25) "several" ≥1 in 1988* 4-5 in 1999*
		Page: Bealer's Ferry: 1978 Luray: 2001	H D?	>1 1
Pulaski: Hwy 11, east of Dublin: 1961 RAAP-Dublin: 2008		H CD	Pair collected Colony	

<sup>a</sup> EO Ranks reflect the current condition of a population and are defined as follows:  
 A = excellent estimated viability; B = good estimated viability; C = fair estimated viability; D = poor estimated viability; E = verified as extant, still existing but often not enough information is available to rank otherwise;  
 H = historical; X = extirpated; ? = need more information to refine the rank

## DISCUSSION

## Summary of Status

Twenty Virginia counties have last observations of *S. idalia* reported between 1951 and 1995. One of these (Rockingham Co.) lacks specific dates but was first recorded in the literature by Opler (1995). Most of these records are now considered 'Historical', but all of the locations known from Fairfax County are considered 'Extirpated' (X rank) due to residential and commercial development. Also ranked 'X', the Lee County colony was visited frequently by the original observers in the early 1960s, but had disappeared later that decade and has not been seen subsequently. The 'H' ranked colony from Madison County near Banco probably includes the surrounding areas of Aylor, Etlan, and Syria. This area has not been specifically targeted by DCR-DNH surveys in the past but warrants a high priority for future work.

Only six counties have yielded observations of *S. idalia* since 1995; however, few of these observations have enough individuals to rank them meaningfully. Clarke, Grayson, Loudoun, and Page counties have observations of one individual each on one date and subsequent surveys have not been able to relocate either the individuals or any source population. These have been given the rank of 'D?' to indicate that population viability is low and that it is questionable if a population even exists in that exact location. *Speyeria idalia* is a strong flyer, thus the observations of single individuals may have their source populations up to several miles away. These records should not be discounted either, as they may help us to find viable colonies.

Montgomery County has several known locations for *S. idalia*, including Blacksburg, Brush Mountain, Craig Creek, Poverty Hollow, and the Whitethorne area. The Blacksburg, Brush Mountain, Craig Creek, and Poverty Hollow occurrences are considered 'Historical', and with habitat being developed for residential and agricultural uses, they may soon warrant 'Extirpated' status.

The Whitethorne area has a long history - first mentioned by Wood & Gottschalk (1942) based on a 1926 record at Whitethorne Meadows and last observed in 1999 at the Radford Army Ammunition Plant (RAAP)-Radford facility. The Whitethorne area is actually comprised of multiple locations that are close enough in proximity to each other that they may have acted as a single metapopulation. These sites include Whitethorne Meadows, Pepper Station, Longshop, RAAP-Radford, Belspring, and the Brown Farm (near Blacksburg). *Speyeria idalia* has not been observed at

Whitethorne Meadows since 1995. A poorly-timed mowing event at RAAP-Radford in 1998 appears to have effectively eliminated the *S. idalia* population documented there. A few adults were seen the following year, but none since. An unconfirmed sighting at the Brown Farm in May 2000 is the last report for this metapopulation. Efforts to verify this record in 2001 were not successful.

The Pulaski County population of *S. idalia* that inhabits the RAAP-Dublin facility is the last known extant colony in Virginia, but it appears to be rapidly declining. It is currently ranked 'CD' indicating poor to fair viability. Further monitoring of this population should be a high conservation priority. It is unknown if this population can exist without a metapopulation in place.

Of the 69 total known localities (ranging from specified locations to county level records) for *S. idalia* in Virginia, 54 are considered 'Historical' and 10 are considered 'Extirpated'. Of the remaining five localities with recent records, four have very little associated data and are given provisional ranks of 'D?'. Only one population of *S. idalia* in Virginia warrants a higher ranking, and its estimated population viability is believed to be poor to fair. To date, there is no published genetic information available for the *S. idalia* population in Virginia; however, whether based on taxonomy, or on range and distribution, conservation actions, including possible federal (and state) listing under the Endangered Species Act, are warranted for populations in Virginia, and perhaps for the entire eastern region.

Additional conservation actions that might be implemented prior to legal listing include gathering basic life history information, identifying important habitats within the known range, and searching for more populations. DCR-DNH has been collecting some of this information as limited funding allows; however, a larger scale effort should be attempted to hasten results and subsequent management recommendations.

With regards to searching for new populations, DCR-DNH has been conducting surveys for many years, but, given the scarcity of *S. idalia*, roadside surveys may not be the most efficient means of surveying areas. Predictive habitat modeling using aerial imagery may be of some use; however, the images do not reflect real-time habitat conditions and must be ground-truthed by visiting the location. Attaining access to private properties can also be problematic. Enlisting the help of amateur lepidopterists to specifically search areas during the flight period may be beneficial in locating or relocating populations.

The reasons for the decline of *S. idalia* in Virginia and most of eastern North America remain unknown. Habitat loss and fragmentation may be a major part of the answer,

because there is some evidence that colonies relocate to new sites periodically, thus requiring large tracts of open, prairie-like habitat on a regional basis (Cech & Tudor, 2005). However, Powell et al. (2007) found the species at numerous, small (mean = 7.1 ha) remnant prairies in eastern Kansas. Potentially suitable habitat for *S. idalia* seems to be common to abundant in some parts of Virginia, particularly the western counties. However, we hypothesize that the conversion of many pastures from native, warm season grasses to exotic, cool season grasses (mostly fescue) in the middle part of the 20<sup>th</sup> century may have reduced the suitability of thousands of acres of open field habitats for this species and contributed to its decline in Virginia. Although the Regal Fritillary formerly occupied a variety of habitat types in the state, occurring “in pastures with boggy or marshy areas, in damp open grasslands, in extensive grassy bogs, and, at high altitudes [= elevations], dry pastures” (Clark & Clark, 1951), some recent authors consider it to be a native grassland specialist (e.g., Swengel & Swengel, 2001; Cech & Tudor, 2005), with eastern populations essentially being disjunct from the core of the range in the Midwest and Great Plains. Currently, populations of *S. idalia* appear to be faring best in Midwestern and Great Plains native prairie habitats (typically remnants of formerly large areas), some of which are protected as nature preserves or parks (e.g., Nagel et al., 1991; Powell, 2007).

#### ACKNOWLEDGMENTS

Funding to DCR-DNH was provided by the U. S. Fish and Wildlife Service, Virginia Department of Agriculture and Consumer Services, U. S. Geological Survey, and U.S. Department of Defense (Radford Army Ammunition Plant). Shay Garriock first reported the modern sighting at RAAP and assisted us with surveys for several years. Charles Chase and Len DiIoiia from RAAP coordinated our visits, provided funding for surveys, and kept the best interest of the butterfly in mind during resource management projects on the base. Numerous individuals assisted with surveys over the years, including Kurt Buhlmann, Kim Cousins, Kathy Derge, Mike Donahue, Angela Hutto, Janice Jones, Gina Pisoni, and Sherri White. Phil Coulling, Charles Covell, Jr., Bruce Grimes, William Grooms, Steve Hall, Paul Hammond, William Hartgroves, Jane Hulse, John Hyatt, Clyde Kessler, Leroy Koehn, George Krizek, David Liebman, Helene Lisy, Tom McAvoy, Paul Opler, Chris Pague, Harry Pavulaan, Eric Quinter, Amos Showalter, Rob Simpson, Charles Watson, Jason Weintraub, David West, Lyt Wood, Ward Wyatt, and David Young all contributed personal observations or collection information. John Rawlins provided information regarding the *S. idalia* holdings at CMNH.

Charles Covell, Jr. provided information regarding the *S. idalia* holdings at MC. Robert Robbins and David Pawson provided helpful information about the Clark records. We would also like to thank all of the museum curators for making their collections available to us.

#### LITERATURE CITED

- Cech, R., & G. Tudor. 2005. Butterflies of the East Coast. Princeton University Press, Princeton, NJ. 345 pp.
- Clark, A.H. 1932. The butterflies of the District of Columbia and vicinity. U. S. National Museum Bulletin No. 157. 337 pp.
- Clark, A.H., & L.F. Clark. 1951. The butterflies of Virginia. Smithsonian Miscellaneous Collections No. 116. 239 pp.
- McAvoy, T. 1996. Field Reports: western and southwestern Virginia. Virginia Butterfly Bulletin 4(1): 9.
- Nagel, H.G., T. Nightengale, & N. Dankert. 1991. Regal fritillary butterfly population estimation and natural history on Rowe Sanctuary, Nebraska. Prairie Naturalist 23: 145-152.
- NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, VA. <http://www.natureserve.org/explorer> (accessed 15 October 2008).
- News of the Lepidopterists' Society. 1977-1993. Annual Season Summary Reports. Various pages.
- Opler, P.A. 1995. Lepidoptera of North America 2. Distribution of the Butterflies (Papilionoidea and Hesperioidea) of the Eastern United States. Contributions of the C. P. Gillette Museum of Insect Biodiversity, Department of Entomology, Colorado State University, Fort Collins, CO.
- Opler, P.A. 1998. A Field Guide to Eastern Butterflies. Houghton Mifflin Company, Boston. 486 pp.
- Opler, P.A., & G.O. Krizek. 1984. Butterflies East of the Great Plains. The Johns Hopkins University Press, Baltimore. 294 pp.
- Opler, P.A., H. Pavulaan, R.E. Stanford, and M. Pogue (coordinators). 2006. Butterflies and Moths of North America. Bozeman, MT: NBII Mountain Prairie Information Node. <http://www.butterfliesandmoths.org/>

(Version 10152008).

Pavulaan, H. 1995. Checklist of Virginia butterflies. Privately printed, Herndon, VA. 39 pp.

Pavulaan, H. 1997. Checklist of Virginia butterflies (1996 revised draft edition). Privately printed, Herndon, VA. 39 pp.

Powell, A.F.L.A., W.H. Busby, & K. Kindscher. 2007. Status of the Regal Fritillary (*Speyeria idalia*) and effects of fire management on its abundance in northeastern Kansas, USA. *Journal of Insect Conservation* 11: 299-308.

Reynolds, R.J. 1999. Biological survey of the Radford Army Ammunition Plant; including threatened, endangered, and species of concern. Virginia Department of Game and Inland Fisheries. Unpublished report submitted to Alliant Techsystems, Inc., Radford Army Ammunition Plant. 86 pp. plus appendices.

Roble, S.M. 2010. Natural heritage resources of Virginia: Rare animal species. Natural Heritage Technical Report 10-12. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA. 45 pp.

Schweitzer, D.F. 1991. Regal Fritillary. Pp. 243-245 *In* K. Terwilliger (coord.), *Virginia's Endangered Species*. McDonald and Woodward Publishing Company, Blacksburg, VA.

Shuey, J.A., E.H. Metzler, D.C. Iftner, J.V. Calhoun, J.W. Peacock, R.A. Watkins, J.D. Hooper, & W.F. Babcock. 1987. Status and habitats of potentially endangered Lepidoptera in Ohio. *Journal of the Lepidopterists' Society* 41: 1-12.

Smyth, E.A., Jr. 1938. A preliminary list of the butterflies of Rockbridge County, Virginia. *The Raven* 9: 56-58.

Stolzenburg, W. 1992. Nature's silent sirens. *Nature Conservancy* 42(3):8-13.

Swengel, A.B. 1993. Regal Fritillary: prairie royalty. *American Butterflies* 1(1): 4-9.

Swengel, A.B., & S.R. Swengel. 2001. A ten-year study of the status and trend of the Regal Fritillary (*Speyeria idalia*) (Lepidoptera: Nymphalidae) in Wisconsin,

U.S.A. *Great Lakes Entomologist* 34: 111-128.

Terwilliger, K., & J.R. Tate. 1995. *A Guide to Endangered and Threatened Species in Virginia*. McDonald and Woodward Publishing Company, Blacksburg, VA. 220 pp.

The Lepidopterists' Society. 2008. Online Season Summary Database. <http://www.flmnh.ufl.edu/butterflies/research/lepsoc/default.asp> (accessed 20 October 2008).

The Nature Conservancy. 2000. Population monitoring and life history studies of the Regal Fritillary (*Speyeria idalia*) at Fort Indiantown Gap Military Reservation, Annville, Pennsylvania: Activity summary and report of findings (January-December 2000). The Nature Conservancy, Ft. Indiantown Gap Office, PA. Unpublished draft report to the Pennsylvania Department of Military and Veterans Affairs.

Wagner, D.L., M.S. Wallace, G.H. Boettner, & J.S. Elkinton. 1997. Status update and life history studies on the Regal Fritillary (Lepidoptera: Nymphalidae). Pp. 261-275 *In* P.D. Vickery, P. Dunwiddie, & C. Griffin (eds.), *The Ecology and Conservation of Grasslands and Heathlands in Northeastern North America*. Massachusetts Audubon Society, Lincoln, MA.

Williams, B. 1999. Regal fritillaries in a tailspin: a story of east and west, DNA, and the urgent need for conservation of a flagship species. *American Butterflies* 7(4): 16-25.

Williams, B.L. 2001a. Patterns of morphological variation in *Speyeria idalia* (Lepidoptera: Nymphalidae) with implications for taxonomy and conservation. *Annals of the Entomological Society of America* 94: 239-243.

Williams, B.L. 2001b. Recognition of western populations of *Speyeria idalia* (Nymphalidae) as a new subspecies. *Journal of the Lepidopterists' Society* 55: 144-149.

Wood, C.E., Jr., & C.W. Gottschalk. 1942. The butterflies of Roanoke and Montgomery Counties, Virginia (Lepidoptera: Rhopalocera) [part 2]. *Entomological News* 53: 159-164.

Wyatt, H. 1999. Grayson and Patrick counties. *Virginia Butterfly Bulletin*. Winter 1999. p 7.