

A Camera-trap Survey Documents Widespread Distribution of Over-wintering Golden Eagles in Western North Carolina

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Abstract

We studied the incidence of Golden Eagles (*Aquila chrysaetos*) in western North Carolina over the course of three winters. We established camera trap stations consisting of deer carcasses staked in front of trail cameras in forest openings. We documented Golden Eagles visiting bait at 17 of 26 (65%) camera trap stations in 16 of the 20 (80%) counties surveyed. With respect to the winter season, these represent eight new county records. We then examined one camera station's (Unaka Mountain) data at a finer scale. Here, we noted eagles on 14, 54, and 15 calendar days in 2013, 2014, and 2015 respectively. Using plumage characteristics, we identified 5 individuals at Unaka in 2013, 14 in 2014, and 7 in 2015. Over the course of the study, half of the eagles at Unaka Mountain were adults, 42% were sub-adults, and 8% were juveniles. Finally, to assess the prevalence of incidental winter sightings, we examined peer-reviewed records of Golden Eagles spotted in western North Carolina during the winter months ($n = 29$). Over half of these incidental sightings hailed from the northern mountains. Our camera trap study demonstrates that wintering Golden Eagles are more widespread in the mountains than previously thought, but remain difficult to detect. Western North Carolina may be an important over-wintering area for Golden Eagles. *Keywords:* *Aquila chrysaetos*, camera trapping, Golden Eagle, Southern Appalachians, winter

Introduction

Eight decades after biologists noted an apparent migratory eastern population of Golden Eagles (*Aquila chrysaetos*) passing a hawk watch station in Pennsylvania, this population's winter ecology, distribution, and numbers in eastern North America are still poorly known. Recent research by the Eastern Golden Eagle Working Group is improving our understanding of this population in the East. Compared to its western counterpart, the eastern Golden Eagle population is smaller with an estimated size of $5,000 \pm 2,000$ individuals (Dennhardt et al. 2015, EGEWG 2015, Morneau et al. 2015). Between 1970 and 2004, Golden Eagle numbers at hawk watch stations increased, but this trend has ceased in recent years (Dennhardt et al. 2015). The primary threats to Golden Eagles are lead poisoning, accidental capture in foothold traps, electrocution, and collisions with structures such as wind turbines (Fitzgerald et al. 2015, Katzner et al. 2012).

Eastern Golden Eagles nest in Labrador, Quebec, and Ontario (Katzner et al. 2012, Morneau et al. 2015) and migrate through the Great Lakes and Appalachians to over-winter in the Appalachians (Katzner et al. 2012) and other regions of the eastern USA. The highest density of wintering Golden Eagles in the East occurs in the north-central Appalachians, particularly in Pennsylvania, West Virginia, and Virginia (Katzner et al. 2012). Southeastern states have only recently been systematically surveyed to assess the prevalence of overwintering Golden Eagles in the region (Katzner, Pers. Comm., Vukovich et al. 2015).

The status of the Golden Eagle in western North Carolina has been the topic of previous debate. Claims that the species historically nested in the North Carolina mountains were challenged by Lee and Spofford (1990) on the grounds that the evidence was anecdotal and inconclusive. Ganier (1933) described it as a "very rare resident in the mountains" and "very rare transient" in east Tennessee. It is considered a rare fall migrant and winter visitor to western North Carolina (LeGrand

et al. 2016) with a few sightings each winter and occasional records across the state, throughout the year.

Use of bait and trail cameras to document Golden Eagles greatly improved the understanding of the species' winter distribution in the central Appalachians (Jachowski et al. 2015). This technique exploits the species' readiness to scavenge. The success of the project prompted the Eastern Golden Eagle Working Group to extend the study southward. With 74% of tracking data points in the West Virginia mountains occurring in large blocks of forest (Katzner et al. 2012), the heavily forested mountains of western North Carolina were deemed a priority for investigation. The North Carolina Wildlife Resources Commission (the Commission) participated in a winter camera trapping study in 2013, 2014, and 2015 to assess and update the incidence of wintering Golden Eagles in the North Carolina mountains. Our objective was to determine the distribution of wintering Golden Eagles and assess the importance of western North Carolina to these birds by using a standardized camera trap protocol. Here we report updated distribution information obtained from camera trap stations in 20 counties. In addition, we report demographic information and behavioral observations from a station with high eagle visitation.

Methods

Field Site Description. Western North Carolina falls within Bird Conservation Region 28-Appalachian Mountains (U.S. NABCI Committee 2000). The heavily forested Appalachian Mountains are dominated by oak-hickory and other hardwood and mixed forests with spruce-fir at the highest elevations. Approximately 30% of BCR 28 in North Carolina consists of public lands (e.g., national and state forests and parks, and state game lands), land trust holdings, and conservation easements. We assigned camera trap locations to five geographic sub-region categories: southwestern mountains ($n = 6$), central mountains ($n = 8$), northern mountains ($n = 8$), foothills ($n = 3$), or piedmont ($n = 1$).

For survey sites, we selected fields, wildlife openings, or edges of balds in a forested landscape at elevations ranging from ~579 to 1,676 m and where human disturbance was minimal. These openings ranged from less than 0.4 Ha to 4.8 Ha in size and the majority (75%) were less than 2.0 Ha. Annual survey effort varied with respect to availability of staff and volunteers. We conducted surveys November 2012 to March 2013 and January to March in 2014 and 2015. Initially we operated camera trap stations where staff was available in 2013 ($n = 9$ stations). We subsequently expanded the effort more broadly across western North Carolina in 2014 ($n = 13$ stations) and 2015 ($n = 15$ stations). Three of the survey stations straddled county lines; thus, a detection at these stations was noted as a record for both counties. We surveyed five stations all three years, allowing us to examine annual observed occupancy.

Camera Traps. We baited camera trap stations with road kill White-tailed Deer (*Odocoileus virginianus*) staked to the ground near the edge of an opening and within 2 m of the camera. To reduce risk of exposure to lead shot, we collected deer after the close of gun season. In a few instances, a road kill Elk (*Cervus canadensis*) and beavers (*Castor canadensis*) served as bait. Great Smoky Mountains National Park staff baited their station with feral hogs (*Sus scrofa*) taken with non-lead shot. We used Bushnell Trophy, Bushnell Trophy HD, and Reconyx PC900 Hyperfire Pro IR cameras. All cameras ran 24 hours per day and took a picture when motion triggered, and then paused for 60 seconds before the motion sensor could be triggered again. To minimize disturbance to eagles, we refreshed bait, memory cards, and batteries only as often as needed, usually every ~5 to 10 days. We reviewed images and noted the presence of Golden Eagles at each station and the time lag from initial deployment of bait to first detection.

We then examined one camera station's (Unaka Mountain, Mitchell County) data in finer detail. Here we noted time of day when an eagle visited the station based on each image's time stamp, age class based on plumage (Bloom and Clark 2001,

Ellis 2004, Liguori 2004), and identity of individuals based on distinguishing plumage characteristics. Age class nomenclature followed Liguori (2004) with juveniles having all juvenal flight feathers, sub-adults having a mix of juvenal and adult flight feathers, and adults (>4 years old) having replaced all juvenal flight feathers. We calculated average length of stay (\pm standard deviation). Three independent reviewers scrutinized images to identify individual eagles.

Finally, to assess the prevalence of incidental winter sightings by birders, we examined records of Golden Eagles spotted in western North Carolina during the winter months. We compiled peer-reviewed records published in *The Chat, Briefs for the Files* between 1974 and 2015. Records from the Great Balsams in the 1980s were considered but with the caveat of the potential confounding effect of an effort at that time to establish a breeding Golden Eagle population from eagles released in the North Carolina mountains. Due to the potential to confuse juvenile bald eagles (*Haliaeetus leucocephalus*) and adult Golden Eagles, we elected not to compile sightings that had not undergone peer-review, such as those reported on birding listservs. With few exceptions, records in eBird.org also appear in *Briefs for the Files*.

Results

All Camera Stations. One purpose of our study was to better understand the winter distribution of eagles. We documented Golden Eagles at 17 of 26 (65%) stations in 16 of 20 (80%) counties surveyed (Figure 1, Table 1). With respect to the winter season, eight of these represented new county records (Buncombe, Caldwell, Cherokee, Clay, Graham, Surry, Swain, and Yancey). We documented eagles at camera stations in all sub-regions: southwestern mountains, central mountains, northern mountains, foothills, and piedmont. The highest elevation camera trap station with Golden Eagles was at 1,660 m; the lowest was at 603 m. In winter 2013, we detected eagles at five of nine (56%) camera trap stations. In 2014, we detected

eagles at eight of 13 (62%) camera trap stations. In 2015, we detected eagles at nine of 15 (60%) camera trap stations.

We determined how quickly eagles located deer carcasses by examining date stamps on each image. Average time elapsed from deployment of cameras and deer carcasses to first detection of a Golden Eagle was 13 days in 2013, 19.7 days in 2014, and 10.6 days in 2015. However, eagles were documented within two hours of initial baiting at Mitchell River Game Land and Nolton Ridge (Graham County) and within two days at Catpen (Madison County).

Of the five sites surveyed for >1 year, we detected eagles all three years at Unaka Mountain and Thurmond Chatham Game Land (Wilkes County). We detected eagles at Mitchell River Game Land (Surry County) in 2014 and 2015 but only in 2014 at Buffalo Cove Game Land (Caldwell County). We never detected eagles on Joanna Road (Transylvania County).

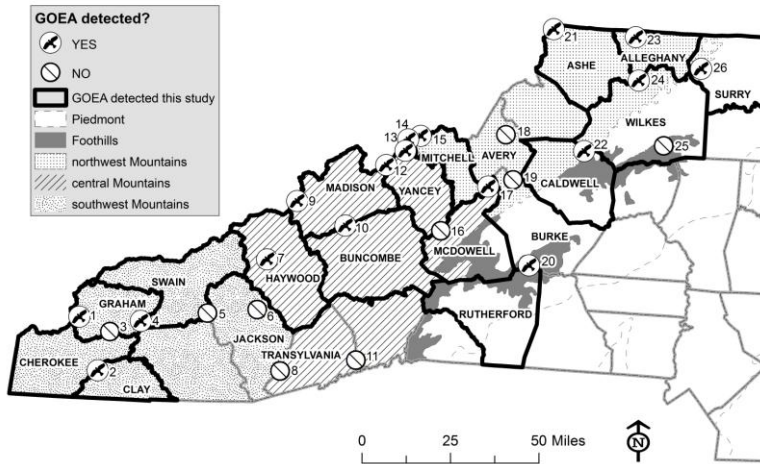


Figure 1. Locations of 26 camera trap stations surveyed for at least one winter season (2013, 2014, and/or 2015) and summary of Golden Eagle detections in western North Carolina.

Unaka Mountain Camera Trap Station. Another purpose of our study was to estimate numbers, summarize age classes, and determine length of stay of eagles visiting Unaka Mountain. The first winter we detected eagles on 14 of 48 (29%) calendar days surveyed between December 28, 2012 and February 13, 2013. We identified five individuals consisting of three adults and two sub-adults and we noted unknown individuals on two days. Two adult eagles pictured at Unaka Mountain also visited the Flat Top camera trap station located 9.7 km away. The second winter we detected eagles on 54 of 80 (68%) calendar days surveyed between December 23, 2013 and March 23, 2014. We identified 14 individuals consisting of five adults, seven sub-adults, and two juveniles (Figure 2) and we noted unknown individuals on seven days. The two juveniles arrived on February 21 and 23, 2014. The third winter we detected eagles on 15 of 29 (52%) calendar days surveyed between

January 8 and February 13, 2015. We identified seven individuals consisting of five adults and two sub-adults. We also trapped eagles at this camera station for a related GPS telemetry study. Thus, we knew that at least two individuals were returning birds: An adult male captured in 2013 again visited Unaka Mountain in 2015. In one image, he fed simultaneously with an adult female that was captured on February 11, 2015 and previously observed with this male in 2013. Disturbance associated with trapping may have affected visitation in the days following trapping. Despite this, eagle visitation remained high overall at Unaka Mountain.



Figure 2. Adult Golden Eagle pictured at Unaka Mountain on February 22, 2014.



Figure 3. Juvenile Golden Eagle pictured at Unaka Mountain on February 22, 2014.



Figure 4. Sub-adult Golden Eagle pictured at Unaka Mountain on February 22, 2014.

Over the course of the three winters at Unaka Mountain we captured 1,157 images of Golden Eagles and documented them on a total of 83 calendar days. We noted a single eagle on 46 calendar days and >1 individual on 37 calendar days (Figure 3).

The highest number of individual eagles visiting the site in a single day was five on February 23, 2014. Despite the presence of multiple individuals per day, Golden Eagles fed together on just three occasions: two adults on February 7, 2013, an adult and sub-adult on January 31, 2014, and two adults on February 6, 2015. In all other visits an individual fed alone. However, additional video footage and observations from a blind documented more instances of two eagles feeding together than the still cameras documented. Length of stay of adult eagles ($n = 13$) averaged 4.7 days (± 4.4 days). The longest lengths of stay for three adults were 12, 11, and 10 days. Length of stay of sub-adult eagles ($n = 11$) averaged 3.5 days (± 1.9 days) and the longest length of stay was six days for two individuals. One juvenile was documented on 20 days and a second juvenile on nine days. Eagles visited bait throughout the day, but never between sunset and sunrise.

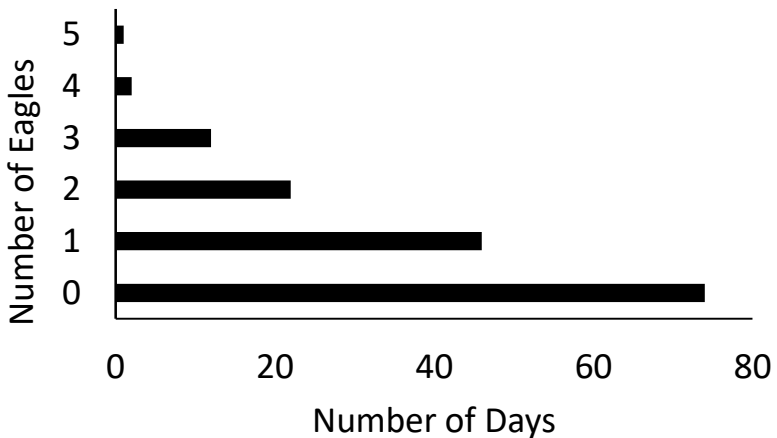


Figure 5. Number of Golden Eagles detected per day over the course of three winters (2013, 2014, and 2015) at Unaka Mountain camera station.

Records from *The Chat*. We found 114 reports of Golden Eagles in western North Carolina published in *The Chat Briefs for the Files* between 1974 and 2015 with records spanning

every month of the year. Of these we examined 29 reports falling between early January and late March to coincide with the timeframe of the bulk of our camera trapping effort. Seventeen records (58%) originated from the northern mountains. The remaining twelve records originated from the piedmont (1), foothills (2), central mountains (8), and southwestern mountains (1) and in total represent 13 counties. Ninety percent of winter records reported a single bird and only three reported multiple individuals. Adult eagles represented 48% of these sightings, immatures 32%, and 19% were of undetermined age. For most records of immatures, it was unclear if the bird was a juvenile or sub-adult. Published winter records outside of the January to March timeframe of our study included 15 for the month of December. For the southwestern mountains, we found published accounts of Golden Eagles limited to two summer records (Graham County), one autumn record (Swain County), and no winter or spring records. We found two other sources of winter Golden Eagle records. a U.S. Forest Service file noted 12 observations of Golden Eagles in the Shining Rock area (Haywood County) of the Pisgah Ranger District during surveys conducted by staff in winter 1974 and 1975 (Sanders 1976). The Commission's peregrine falcon monitoring data noted Golden Eagles invading falcon territories in Macon (February 2014) and Madison Counties (March 2004).

Table 1. Annual survey effort and detections of Golden Eagles at camera trap stations ($n = 26$) in western North Carolina in winters 2013, 2014, and 2015.

Site #	Site	County	Region ¹	Golden Eagle detected?		
				2013	2014	2015
1	Oak Knob	Graham	SW	-	-	Yes
2	Leatherwood	Clay/Cherokee	SW	-	Yes	-
3	Walker Fields	Graham	SW	-	No	-

4	Nolton Ridge	Swain/Graham	SW	-	-	Yes
5	Pigpen Flats	Swain	SW	-	No	-
6	Balsam Mountain Preserve	Jackson	SW	No	-	-
7	Purchase Knob	Haywood	C	-	-	Yes
8	Toxaway Mountain	Transylvania	C	-	No	-
9	Catpen	Madison	C	-	-	Yes
10	Sandy Mush Game Land	Madison/Buncombe	C	-	Yes	-
11	Joanna Road	Transylvania	C	No	No	No
12	Big Bald	Yancey	C	Yes	-	-
13	Flat Top	Yancey	C	Yes	-	-
14	Shinbone	Mitchell	N	-	-	Yes
15	Unaka Mountain	Mitchell	N	Yes	Yes	Yes
16	Curtis Creek	McDowell	C	-	-	No
17	Humpback Mountain	McDowell	N	-	Yes	-
18	Sugar/Bald Mountain	Avery	N	-	No	-
19	Ripshin	Burke	N	-	-	No
20	South Mountains Game Land	Rutherford	F	-	Yes	No
21	Pond Mountain Game Land	Ashe	N	-	-	Yes
22	Buffalo Cove Game Land	Caldwell	F	No	Yes	No
23	Turkey Knob	Alleghany	N	Yes	-	-
24	Thurmond-Chatham Game Land	Wilkes	N	Yes	Yes	Yes
25	Brushy Mountains	Wilkes	F	-	-	No
26	Mitchell River Game Land	Surry	P	No	Yes	Yes

¹ C = central mountains. F = foothills. N = northern mountains. P = piedmont. SW = southwestern mountains. A dash (-) indicates no survey conducted.

Discussion

Our camera trapping survey resulted in new county records for the winter season, thus increasing distribution knowledge of

Golden Eagles. Our data are especially important in light of a recent change in trends of Golden Eagles at hawk watch stations that indicates the increasing population trend stabilized in 2004 (Dennhardt et al. 2015). Concurrently, eagle biologists are concerned about rapid wind energy development in the Central Appalachians and unresolved threats posed by lead poisoning and accidental capture in foothold traps.

Perhaps the most significant new records were those that filled in distribution gaps in the southwestern mountains. We have first county records for the Cheoah, Unicoi, and Valley River Mountains in that corner of the state. Prior to our study, sightings from the southwestern mountains were scant and most sightings were from the High Country of northwestern North Carolina. Furthermore, we documented wintering Golden Eagles broadly across the region- in North Carolina's southwestern, central, and northern mountains and in the foothills and western piedmont.

The number of golden eagles visiting the Unaka Mountain camera trap station was remarkably high, with as many as 14 individuals in the 2014 season. In comparison, the highest number reported on the coastal plain in the Carolinas was eight individuals identified from seven camera trap stations (Vukovich et al. 2015). The presence of more than one individual per day was not unusual at our Unaka Mountain camera trap, occurring on 37 days of surveys. Our data of eagles scavenging at a deer carcass diverge from most North Carolina winter records from birders, which typically note a single eagle in flight that is often not relocated. A notable exception in the published records were reports of three adults and one "immature" eagle at Bakers Mountain Park (Catawba County) in December 2003 (Davis 2004, D. Martin, Pers. Comm.). This observation bears greater similarity to our camera trap observations than other winter reports. Furthermore, these December sightings at Bakers Mountain followed three other sightings of adult and immature eagles at Bakers Mountain in May, June, and October, 2003.

In addition to being numerous, Golden Eagles visited Unaka Mountain fairly frequently, on 52% of total survey days. Not surprisingly given the presence of bait, sixty-two percent ($n = 26$) of identifiable individuals visited on multiple dates. The longest number of days we detected individuals at the Unaka Mountain station was lower than the 30 and 31 days reported for two adult Golden Eagles in South Carolina (Vukovich et al. 2015). However, the results of that study represent a compilation of data from seven camera trap stations spread across the Savannah River Site, whereas ours represented a single camera trap station. Movement of one of our transmittered birds between Unaka Mountain and Flat Top was similar to the short-distance movements documented in South Carolina. Thus, we suspect that the number of days individuals were detected would have been higher had we included data from our additional camera trap stations situated in the vicinity of Unaka Mountain at distances comparable to the spacing of stations across the South Carolina study area.

Golden Eagles in our study exhibited winter site-fidelity, much like Golden Eagles in the West (Kochert et al. 2002). At Unaka Mountain we observed apparent site-fidelity to the wintering grounds across years in at least five adult eagles (three females, two males) identified and tracked with cameras and/or telemetry, even when bait was not supplied in winter 2016 (C. Kelly, unpublished data). In other studies, eagles exhibited winter site fidelity in Alabama and South Carolina (Soehren, Pers. Comm., Vukovich et al. 2015). Quick return to mid-season replacement of bait, a phenomenon observed in our study and in South Carolina, suggests that eagles had remained in the area. Frequent and/or repeat visitation to baited camera traps may be higher where topography favors development of updrafts, which may in turn facilitate detection of carcasses (Jachowski et al. 2015). Or the site may be situated closer to roost sites or hunting/scavenging grounds or further from human disturbance. Further analysis of winter home range, habitats, and distribution of GPS-tracked Golden Eagles in

North Carolina is needed and currently in progress to better understand wintering behavior.

The Eastern Golden Eagle Working Group's approach of using baited camera traps allowed us to rapidly gather distribution information for Golden Eagles wintering in North Carolina. Golden Eagles arrived quickly at some camera trap sites at the start of the survey season, suggesting their presence in the area prior to baiting, a phenomenon observed in South Carolina as well (Vukovich et al. 2015). Using a baited camera station could potentially introduce bias to the distribution of Golden Eagles by luring them to a site (Jachowski et al. 2015). However, we contend that this bias is minimal, in light of the distances between camera stations, concurrent presence of eagles at these sites, and apparent site fidelity even in the absence of bait.

Wintering Golden Eagles are likely much more widespread than previously thought but remain generally undetected due to low birder visitation to remote, often inaccessible forest tracts in winter. In fact, the remoteness of the North Carolina mountains suits the Golden Eagle's apparent aversion to human disturbance. Researchers in South Carolina attribute high detections of Golden Eagles at their study site to the fact that visitor access to the Savannah River Site is tightly restricted (Vukovich et al.2015).

Management Implications

Our findings should inform management of Golden Eagles, especially with respect to threats posed by foothold traps, lead ammunition used in feral hog eradication and game hunting, and wind energy development. To reduce accidental capture of eagles in foothold traps, biologists in Quebec recommend bait be buried in containers and positioned at least 30 m from a trap in case it becomes uncovered (Fitzgerald et al. 2015). In West Virginia, bait must be concealed if it is within 15 m of a trap (WVDNR 2016). Even with restrictions on bait placement, it is possible that Golden Eagles and other raptors may still be accidentally captured in foothold traps due to their ability to

walk long distances searching for the bait. Implementing and enforcing requirements on solidly anchoring traps and daily trap attendance, as well as trapper education on how they should respond if they capture a raptor, will decrease injuries and mortalities (Olfenbuttel, pers. comm.). Golden Eagles in our study scavenged deer and feral hog carcasses. Vukovich et al (2015) recommended that managers of feral hog control programs should incorporate measures to minimize exposure of Golden Eagles to lead ammunition. These recommendations are especially relevant for Mitchell County, an area with both abundant eagles and abundant feral hogs as well as an active hog eradication program (M. Crockett, Pers. Comm.). Although the North Carolina Administrative Code (15A NCAC 10B .0106) specifies that the non-edible portions of a deer carcass should be buried or disposed of in a safe and sanitary manner, the potential for eagles to ingest lead when scavenging carcasses of deer taken with lead shot remains a concern (NCWRC 2016). Lastly, distributional records for wintering Golden Eagles are increasingly needed due to interests in wind energy development in the mountains (Raichle and Carson 2009, Graeter et al. 2015).

Our results contribute to information needed by the Commission, by the Eastern Golden Eagle Working Group, and by birders. Midway through our study, the Golden Eagle was listed as a species with a significant knowledge gap in the North Carolina Wildlife Action Plan (NCWRC 2015). Likewise, as a result of this regional camera trapping effort, 12 eastern states now list the Golden Eagle in their State Wildlife Action Plans, up from just five states in 2012 (Katzner et al. 2012). Despite declines at fall migration hawk watch stations, winter sightings of Golden Eagles are on the rise. This is a direct consequence of this increased survey effort and awareness (EGEWG 2015). Birders wishing to check the Golden Eagle off their list should investigate small openings situated in large forest blocks at prominent topographic positions, especially places with expansive views of the valleys below, and search for soaring birds riding the thermals.

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