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Dorie S. Stolley  
Utah State University

John A. Bissonette  
Utah State University

John A. Kadlec  
Utah State University

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LIMITATIONS ON CANADA GOOSE PRODUCTION AT FISH SPRINGS NATIONAL WILDLIFE REFUGE

Dorie S. Stolley¹, John A. Bissonette², and John A. Kadlec³

ABSTRACT.—At Fish Springs National Wildlife Refuge, only 18 to 34 Canada Goose goslings were fledged per year from 1989 to 1993. In addition to the number of breeding pairs, a wide variety of variables can influence goose production, including clutch size, and nest, egg, and fledging success. We examined these variables at Fish Springs in 1996 and 1997 by finding and monitoring nests, and then following broods. We found that despite a limited number of breeding pairs on the refuge, production was further limited by poor ground nest success and low fledging success. Only 51.2% (n = 22) of ground nests produced hatchlings vs. 86.4% (n = 19) of platform nests. Of all eggs that hatched, 36.8% (n = 57) fledged successfully. Predation and human disturbance are discussed as major factors contributing to mortality.

Key words: Branta canadensis, Canada Geese, Fish Springs National Wildlife Refuge, fledging success, ground nest success, salinity, Utah.

Reproductive success in Canada Geese (Branta canadensis) is determined by a number of variables. Population size and age structure determine the number of potential breeders. Most female geese breed and pair in their 3rd or 4th year (Bellrose 1980). However, not all paired geese become territorial. Of those that do defend a territory, not all will initiate nesting. Ball et al. (1981) and Hanson and Eberhardt (1971) estimated that about 20% of territorial pairs do not nest. The number of potential territories can be a limiting factor in nesting; however, higher goose densities may result in increased abandonment of nests due to harassment of the nesting female (Ewaschuk and Boag 1973).

Once nesting is underway, important variables contributing to recruitment are clutch size, nest success, egg success, and survival of young birds to fledging. Younger and less experienced geese lay smaller clutches (Brakhage 1965, Finney and Cooke 1978, Lessells 1982, Rockwell et al. 1983) and raise fewer goslings to wing (Brakhage 1965, Finney and Cooke 1978, Raveling 1981). Adult body size appears to be loosely related to clutch size because nutrient reserves influence clutch size (Ankney and Macllmes 1978, Raveling 1979, Lessells 1982; but see Davies et al. 1985).

Nest success may depend upon location. Elevated platforms experience less predation than ground nests (Krohn and Bizeau 1980), and island ground nests are depredated less often than mainland ground nests when terrestrial predators are present (Klopman 1958, Vermeer 1970, Johnson and Shaffer 1990). A territory with poor forage may cause a female to spend more time off the nest feeding, leaving the nest vulnerable to predation. Conversely, Ankney and Macllmes (1978) found incubating female Snow Geese dead on the nest, apparently from starvation. Flooding can be a problem during the nesting season (Bellrose 1980). An estimated 85% of monitored nests were flooded in a section of marsh in northern Utah in 1997 due to snowmelt and extremely high water levels in the river feeding the marsh (D. Stolley personal observation). Nest success also is influenced by age and experience of the breeding pair (Raveling 1981). Older, more experienced females generally have more body reserves (Aldrich and Raveling 1983), due either to more efficient foraging or to the ability of the male to provide protection from conspecific harassment, allowing the female more feeding time (Raveling 1981). Heavier females are more attentive to their nests (Aldrich and Raveling 1983), leading to
less likelihood of predation. Experienced ganders are more successful at keeping other geese away from the incubating female. Abandonment may be caused by harassment of the nesting female by other geese (Ewaschuk and Boag 1979, Bellrose 1980, Raveling 1981), malnutrition (Harvey 1971, Anney and MacInnes 1978), or human disturbance (MacInnes and Misra 1972, Bellrose 1980).

Egg success is important in determining number of offspring. Often, eggs in a nest do not hatch and are either infertile or contain dead embryos. Occasionally, a female will lay eggs after full incubation has begun; thus, in the same nest normally developing eggs may not hatch synchronously. Females may incubate these eggs longer and successfully hatch them but often may abandon them as the earlier hatched goslings are led to the brood-rearing area. Contaminants can lower egg viability or produce deformed goslings that do not hatch or are incapable of surviving in the wild.

Similarly, many variables can affect fledging success in geese. Fledging success is measured as the percentage of hatched goslings that survive to reach flight stage, about 70 d (Yocom and Harris 1965, Eberhardt 1987).

Most Canada Goose gosling mortality occurs in the first 10–14 d after hatching (Geis 1956, Steel et al. 1957, Martin 1963, Dey 1964, Mickelson 1973, Krohn and Bizeau 1980, Ball et al. 1981, Eberhardt et al. 1989, Sargeant and Raveling 1992). Predation is an important cause of mortality in goslings (Geis 1956, Brakhage 1965, Sherwood 1966, Mickelson 1973, Wang 1982, Sedinger 1992). Likewise, disease can have catastrophic effects on a population. Sherwood (1966) documented gosling survival of only 16% after a 1964 outbreak of a Leucocytozoon blood parasite in Michigan. He also noted that when goslings were very young, human disturbance often resulted in abandonment of slower or separated goslings. Because nutrition is an important factor in growth and development of all young birds, inadequate nutrition can lead directly to mortality due to starvation or lack of essential minerals. It also can result in weak or small birds that more easily succumb to predation, exposure, or disease, or birds that are unable to keep up with their siblings. The quality of parental care affects fledging success in geese. Inexperienced or inattentive parents may not lead goslings to good grazing areas, guard well against possible predators, or react protectively against danger (Raveling 1981).

In the early 1960s Canada Geese were established at Fish Springs National Wildlife Refuge (NWR) in the west desert of Utah through release of captive birds and arrival of wild birds. From 1965 to 1969 Canada Goose numbers gradually increased, as did gosling production. The highest estimates of gosling production were made in the mid-1970s, but differences in census methods make these estimates suspect. From 1983 to 1987 the number of nesting pairs present on the refuge during the breeding season declined. From 1989 to 1993 nesting pair numbers ranged between 18 and 22. Gosling production during this same time was between 18 and 34 birds. We conducted field research March–July 1996 and 1997 to determine factors limiting gosling production at Fish Springs NWR. To do this, we quantified the number of territorial and breeding pairs and compared the numbers with historical data; we measured clutch size and documented nest and egg success; and we quantified fledging success.

**STUDY AREA**

Fish Springs NWR is located at the southwest edge of the Great Salt Lake Desert in Juab County, Utah. As ancient Lake Bonneville lake bottom, the refuge is very flat and the soil is saline and alkaline. Five major and several minor thermal springs arise from a fault line running parallel to the east side of the Fish Springs mountain range and feed the refuge’s 8900-acre marsh. Fish Springs NWR was established in 1959. Impoundments and other marshland development to provide habitat for waterfowl were completed in 1964. It is not known definitely whether Canada Geese nested in this area prior to establishment of the refuge (Annual Report, Fish Springs NWR, 1982; J. Banta, Fish Springs NWR, personal communication); however, they were not nesting in the refuge area in the late 1950s.

After the refuge was established, 9 large, shallow pools, impounded by dikes and fed from the springs through canals, were created, enlarging and modifying the natural marsh. Much of the more southern impoundment area, viz., Avocet, Mallard, Curlew, Egret, and Shoveler, was original slough and contains numerous islands and peninsulas, as well as
typical emergent marsh vegetation, e.g., Olney’s three-square bulrush (Scirpus americanus), cattail (Typha domingensis), hardstem bulrush (S. acutus), alkali bulrush (S. maritimus), wire rush (Juncus arcticus), and saltgrass (Distichlis spicata). Abundant mats of submergent vegetation, primarily wigeon grass (Ruppia maritima), musk grass (Chara spp.), spiny, or pond, naiad (Najas marina), and coontail (Ceratophyllum demersum) grow in the springs, canals, and pools. Additionally, the native Phragmites australis has expanded into much of the marsh. Northern impoundments, viz., Ibis, Pintail, Harrison, and Gadwall, were constructed on the northern edge of original wetlands and contain little of the original marsh structure. Most water feeding these pools comes from more southern pools. These impoundments become dry or reduced during summer because spring input volume cannot match evaporation rates. Vegetation bordering these impoundments is characterized by saltgrass (Distichlis spicata), pickleweed (Allenrolfea occidentalis), and annual sapphire (Salicornia europaea). The impoundments contain little emergent or submergent vegetation.

**METHODS**

Determination of the Number of Territorial and Breeding Pairs

To quantify number of territorial pairs, we conducted daily to weekly pair counts and daily to twice weekly observations of territorial and nesting behavior 22 March–5 May 1996, and 21 March–11 May 1997. We drove slowly along the dikes surrounding every impoundment and made observations from our vehicles using spotting scopes. Pairs, singles (assumed to be males with a mate on a nest), aggressive behavior, and nesting behavior were recorded and location of geese marked on a map. To determine if territorial pairs were breeding, we located nests. We observed artificial nesting platforms for signs of use and checked them several times during the season. We located ground nests with a variety of techniques. The vast majority were found from an airboat. Every impoundment was completely traversed by airboat at least once, and many twice, during the early part of nesting seasons. During our daily observations we scanned for signs of incubating females and small pieces of down in the vegetation, indicating a possible nest. We also looked for single ganders that might be guarding an incubating female, particularly in areas that previously had a pair evident. We found several nests and general nesting areas this way. We also traversed areas of the marsh by foot and inflatable kayak. We examined historical data on number of pairs by searching file archives at Fish Springs NWR headquarters for relevant information. We read study reports for 1983 and 1989–1994 as well as excerpts from all annual reports. We also examined archived pair count data. Unless noted otherwise, annual and goose study reports cited in the text are from Fish Springs NWR.

Pre-hatching

To quantify clutch size, nest success, and egg success, we observed nests from a distance, checking them by foot if we suspected that incubation was underway or that the nest had been abandoned. In 1996 we avoided checking either platforms or ground nests if we suspected the female was still laying. We did not check ground nests in 1997 when the female was laying. All eggs were counted, numbered, and candled to ascertain viability and approximate stage of development. We monitored status (i.e., incubating, pipping, abandoned, depredated) of all nests until broods had hatched and left the nest. We then returned to the nest to count and collect unhatched eggs for analysis. To determine number of infertile eggs and those with dead or decomposed embryos, we opened unhatched eggs.

Post-hatching

To quantify fledging success and determine whether mortality was related to location, we monitored gosling numbers and location by observing neck-banded, radio-collared, and unmarked adults. Many researchers use survival to a certain age (i.e., 4–6 wk, 8 wk, banding) as a surrogate for survival to fledging; we used survival to banding (=8 wk after hatching) to estimate fledging success.

In 1996 we trapped nesting females and collared them with yellow plastic neck bands inscribed with individual alpha-numeric codes. We collared additional adults and some goslings during the period when adults were flightless. In 1997 we took various measurements of each female, including body mass, and wing, culmen, tail, and total body lengths, and installed alpha-numeric color-coded collars.
equipped with radio transmitters. Our trapping activities were concentrated on nests where neither parent was collared. Because females are less likely to abandon their nests when eggs are pipping, we trapped at this time (Eberhardt et al. 1986). We approached the nest, flushed the female, and set up a bownet trap modified from a design by Sior (1990) to include a remote-control trigger. We returned after 2–4 h to spring the trap from a distance of 50–150 m. Three of 5 trapped females abandoned their nests in 1996. In 1997, to prevent nest abandonment, we utilized an injectable anesthesia, Propofol (Rapinovet; Mallinckrodt Veterinary, Inc.); only 1 of 8 females abandoned her nest.

After broods left the nest, we returned to ascertain the number hatched. Unhatched eggs were collected and examined. We attempted to locate all broods every day for the first 15 d following hatching, and then every other day. Broods were located by telemetry or observation, and location and number of goslings noted. Some broods moved from one pool to another. Some deaths occurred during an interval when a brood was not located; these were recorded as unknown deaths. We counted deaths occurring during an overland move of more than 200 m as deaths in transit. Overland moves of <200 m were not considered in transit.

RESULTS

Numbers of Pairs

Prior to 1978 no pair counts were made at the refuge. From 1978 to 1987 pair counts during the breeding season ranged from 58 to 77. No distinction between total pairs and territorial or nesting pairs was made. During the 1988 breeding season, 25–40 pairs were present. From 1989 to 1993 numbers of nesting pairs ranged from 18 to 22. No pairs were done in 1994 or 1995. In 1996 we made 24 refuge-wide goose pair counts between 22 March and 5 May. Approximately 35 pairs became territorial; 26 (74%) of them nested. In 1997 we made 19 counts from 21 March to 11 May; our pair counts ranged from 31 to 52 and averaged 41. Observations and territory mapping yielded about 43 territorial pairs. Of these, approximately 34 (79%) nested, producing 39 known nests. Thus, 5 pairs (15%) of 34 were responsible for 2 nests apiece. Our observations suggested that all renests were the result of continued laying. No 1st or 2nd nests of the same pair contained more than 3 eggs or egg-shell fragments of more than 3 eggs.

Pre-hatching

CLUTCH SIZE.—We calculated clutch size for all complete nests after full incubation had started. In 1996 mean clutch size for artificial nesting platforms was 5.33 ± 0.71; for ground nests it was 4.42 ± 1.51 (range 2–6). When suspected renests were added to the first clutch, mean clutch size for ground nests was 5.30 ± 0.82. In 1997 mean clutch size for artificial nesting platforms (n = 10) was 5.70 ± 1.64. One nest contained 10 eggs, 5 of which were infertile; disregarding these, mean clutch size was 5.20 ± 0.63. Mean clutch size for ground nests (n = 19) was 4.65 ± 1.42. Including renests, mean clutch size for ground nests (n = 17) was 5.29 ± 0.77 (range 1–10). In 1996 and 1997 overall mean clutch size for successful nests (i.e., ≥1 eggs hatched) was 5.3 ± 5.3 ± , respectively.

NEST SUCCESS.—We located 28 nests in 1996. Geese nested on 10 (58%) of 17 available artificial nesting platforms. We found 18 ground nests, 2 of which were abandoned due to human disturbance at the nest during laying. Pairs in the disturbed nests renested; these were not used in calculating nest success. However, for this calculation we considered as successful those nests that contained pipping eggs but were subsequently abandoned due to our trapping efforts. Overall nest success (i.e., ≥1 eggs hatched) was 69%; 18 of 26 nests were successful. Nine (90%) of 10 platform nests were successful. Nine (50%) of 16 ground nests were successful. In 1997 we located 36 nests. Twelve (70.6%) of 17 artificial platforms were utilized, 10 of which (83.3%) were successful. Ten (41.6%) of 24 ground nests were successful. Three ground nests were assumed to exist because of the appearance of broods otherwise unaccounted for. Thus, ground nest success may have been as high as 48.1% (13 of 27 successful), and overall nest success 59.0% (23 of 39 successful). Over 2 yr goslings were produced in 64 nests. Even though ground nests produced more goslings (n = 22) than platform nests (n = 19), ground nests were less successful (51.2%, n = 43) than platform nests (56.4%, n = 22).

FATE OF UNSUCCESSFUL NESTS.—Of 28 nests found in 1996, 5 were found depredated. The
Table 1. Egg success from nests that hatched at least 1 Canada Goose egg at Fish Springs NWR, Juab County, Utah.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of nests</th>
<th>Total number of eggs</th>
<th>Average clutch size</th>
<th>Number of infertile eggs</th>
<th>Number of rotten eggs</th>
<th>Number of normal eggs</th>
<th>Number of eggs of total hatched (egg success)</th>
<th>Average hatch per nest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>14</td>
<td>75</td>
<td>5.4</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>70</td>
<td>5.0</td>
</tr>
<tr>
<td>1997</td>
<td>20</td>
<td>106</td>
<td>5.3</td>
<td>7</td>
<td>3</td>
<td>11</td>
<td>85</td>
<td>4.25</td>
</tr>
</tbody>
</table>

*We use "normal" to designate unhatched eggs with normal embryos that did not begin pipping.

1Pipping eggs from nests that were abandoned due to trapping efforts and subsequently did not hatch are counted as hatched for this calculation.

Five infertile eggs were from 1 nest that also contained 5 fertile eggs.

*Our activities at the nest may have caused broods to leave earlier than they would have normally; abandoning unhatched eggs; as many as 7 eggs may have been affected by this.

Following year 13 of 36 nests were depredated, 8 by avian predators including ravens (Corvus corax). At 2 nests we also found owl pellets. Three nests appeared depredated by coyote (Canis latrans), and 3 others were destroyed by an unknown predator. Of 13 depredated nests we do not know if abandonment came before or after predation. However, one may have been abandoned due to harassment at the nest, first by a Golden Eagle (Aquila chrysaetos) and later by our checking the nest. Another nest appeared to have been abandoned due to harassment by conspecifics; we observed aggressive interactions between geese in the nest vicinity both before and after the egg loss. In 1997, 2 nests were abandoned, apparently due to our visiting the nest.

Egg Success.—Eighteen nests were successful in 1996. We used 14 nests with complete histories to compute egg success (Table 1). Seventy-five eggs were used in the calculations. Overall, 5 (6.7%) did not hatch, for an egg success rate of 93.3%; 2 (2.7%) were infertile, 1 (1.3%) had decomposed, and 2 (2.7%) contained normal embryos that had not hatched. We calculated egg success for 20 of 23 successful nests in 1997 (Table 1). Of 106 eggs laid, 21 (19.8%) did not hatch: 7 (6.6%) of the 106 were infertile, 3 (2.8%) were decomposed, and 11 (10.4%) contained developed embryos that had not pipped. Over the 2-year study, 26 (14.4%) did not hatch. In both years we examined all eggs that did not hatch and found no evidence of physical deformities. One egg contained twins; they were normal but several days behind their nestmates in development. Mean egg success for the 2 yr was 85.6% (n = 155).

Fledging Success

In 1996, 70 eggs hatched and 14 goslings (20%) survived to fledging. In 1997, 85 eggs hatched from 20 nests; 43 goslings (50.6%) survived to fledging. Three nests containing a total of 13 eggs were counted as "successful" for nesting success estimation; however, they were abandoned as pipping eggs or hatchlings due to trapping efforts, and so cannot be used in fledging success estimation. Another 3 goslings from successful nests died immediately after hatching due to trapping efforts; they were not included in the count of 85 hatched eggs. In 1997, 37 goslings hatched in platform nests; 18 (48.6%) fledged. Forty-six goslings hatched in ground nests; 25 (54.4%) fledged. Platform and ground nest fledging success was not significantly different ($\chi^2 = 0.20, P = 0.66$).

Effect of Location.—We examined number of gosling deaths per use-day (DPUD) on all brood-rearing impoundments for 17 broods (Table 2). Seven broods were with radio-collared females, 5 were with 1 or both parents that wore neck bands, and in 5 broods neither adult was collared. We identified these broods by age of goslings and location. The 17 broods hatched 75 goslings. We counted hatching day as day 0. By the end of day 1, all broods had left the nest. By day 15 following hatching, 42 goslings (56%) were still alive; 33 (44%) had died. The mean number of DPUDs during this period was 0.0435. Four locations had below-average DPUDs: Harrison, Ibis/S. Gadwall, Pintail, and Shoveler. Two locations, Maldard and Green Pond, had DPUD numbers that ranged from 0 to above average. Three locations (Egret, Curlew, and N. Gadwall) and birds "in transit" had above-average DPUDs.

Breeding Experience.—We collared 5 females in 1996, all of which incubated their clutches to pipping, returned to the same general nesting vicinities with mates in 1997, and became territorial. At least 4 of them nested,
and 1 successfully hatched a brood and raised 2 goslings to fledging. Another 5 pairs may have been returning pairs; they nested early and utilized artificial nesting platforms that were used the previous year. We suspect another 7–8 pairs had prior breeding experience at Fish Springs due to a combination of clues, including nest placement and behavior. One collared male and a mate were present on the refuge in 1996 but did not breed; in 1997 they successfully fledged 3 goslings.

**DISCUSSION**

**Nesting Success**

Our results show that low recruitment rates of geese at Fish Springs National Wildlife Refuge are in part a result of low nesting success, particularly of ground nests. Although ground nests fledged more goslings, nests on platforms had greater nesting success. There are several possible explanations for this. First, female geese leave the nest periodically and are usually accompanied by the gander (Bellrose 1980), leaving the nest vulnerable to predation. Avian and mammalian predators are common on the refuge, especially Common Ravens and coyotes, which are ubiquitous. The elevated platform nest is more visible at a distance to the gander than a ground nest and predation attempts more easily detected. Second, it appears that experienced pairs are using platforms. Successful platform nests are initiated earlier than ground nests. We noted that birds we marked in 1996 returned earlier to the refuge in 1997 than most unmarked birds. More experienced, older breeders often begin incubation with more body reserves and spend less time off the nest feeding. First-time breeders develop and strengthen their pair bond on wintering grounds, thus often arriving later on breeding grounds. Once on the breeding ground, naive birds often find the best territories occupied. Additionally, Aldrich and Raveling (1983) showed that 1st-time breeders lay smaller clutches than experienced breeders. However, our analysis of clutch size, if renesting is taken into account, shows remarkably similar clutch sizes for platform and ground nests in both 1996 and 1997. In addition to being vulnerable to avian predators, ground nests are at risk from mammalian predators. The most common mammalian predator at the refuge is the coyote; however, red foxes (Vulpes fulva) and striped skunks (Mephitis mephitis) are also present.

Females on ground nests appear to react more strongly to disturbance, often leading to nest abandonment. In 1996 and 1997 we unintentionally flushed laying females from their ground nests of 1–2 eggs while conducting nest searches. In all cases (2 each year), females abandoned the nests. In 1996 we checked 4 platform nests before the clutch was completed. In no case did we flush the female from the nest, although in at least 2 cases the pair was in the vicinity. In 1997 we checked 4 platform nests with incomplete clutches, flushing females from 3 of these nests. There were 3 eggs as well as down feathers in each nest,
indicating initiation of incubation (Cooper 1978). No females abandoned platform nests during laying because of observer visitation.

The general wariness of nesting females at Fish Springs compared with other populations may have significance. In 1996, 4 of 6 collared females abandoned their nests because of activities related to our capture attempts. Four females did not return to the nest until the trap was removed. Other researchers who have trapped nesting female geese found this unusual (J. Sedinger, University of Alaska, personal communication; T. Aldrich, Utah State Division of Wildlife Resources, personal communication). Eberhardt (1987) trapped 41 nesting females for radio-tagging. Of these, only 7 (17%) abandoned. Abandonment late in incubation, or while eggs are hatching, suggests that female geese on the nest may be responding to proximate conditions (i.e., low body reserves). Fish Springs NWR nesting females did weigh less than Cutler marsh nesting females.

Low Fledging Success

We found that fledging success at Fish Springs was uncharacteristically low for this species and that most mortalities occurred in the first 15 d following hatching. Geis (1956) found significant mortality during the first few days following hatch as broods trekked overland from nesting areas to brood-rearing areas. She attributed most mortalities to predation. This appears to be what happened to the goslings disappearing in transit at Fish Springs. We surmised by the timid behavior of nesting geese that defense against mammalian predators was either nonexistent or ineffectual. We observed that smaller goslings were often unable to keep up with the rest of the brood during trips through dense saltgrass or harsh upland desert. Wary parents often appeared to abandon slower young in favor of getting the others to safety as quickly as possible, suggesting that predation remains a significant selection pressure. During both 1996 and 1997, when we approached slowly in the truck, adults and young often would run into the upland desert away from the safety of water. We examined the area and found coyote tracks interspersed with goose tracks, as well as a coyote path, along a low (4-m-high) ridge that paralleled the dike and grazing area. In 1989 high gosling loss was reported in this area, attributed to easy access by coyotes (J. Engler, Goose Production, Fish Springs NWR, 1989). Additionally, in 1997 water levels were low enough to allow easy access by mammals to the islands and peninsulas within the pool. In 1996 a juvenile coyote with a dead adult goose in its mouth was observed on Pintail impoundment (K. Jenkins, Fish Springs NWR, personal communication). We also saw coyotes with pups apparently stalking goslings.

Even though ground nests produced a few more goslings (22 vs. 19) than platform nests, ground nests were only about half as successful (51.2% vs. 86.4%). Additionally, broods reared on northern impoundments fared better than those on more southern areas. If localized numbers are below carrying capacity, it would seem that increasing the number of platforms available for nesting in northern impoundments may improve gosling production and fledging success.

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