LIVESTOCK MANAGEMENT AND PRODUCTIVITY OF WILLOW FLYCATCHERS IN THE CENTRAL SIERRA NEVADA

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Abstract: The willow flycatcher (*Empidonax traillii*), a small passerine that nests in riparian deciduous shrub assemblages in the Sierra Nevada, is impacted by livestock grazing through alteration in shrub structure and upset of nests. From 1983 through 1986, four of 20 studied nests were destroyed by livestock prior to the young fledging. During 1987, no nests were upset by cattle. This may have been the result of a new livestock management program that reduced stocking levels by 40 percent and held 75 percent of the remaining livestock in a fenced pasture until 15 July. Attributes of nests that make them susceptible to cattle induced upset include their low height within the shrubs, the small diameter and therefore weakness of their supporting limbs, their proximity to water, the low branch density near the nests, and their proximity to shrub edges, including trails created by cows where they travel through shrubs. During 1987, nonviability was high as seven of 14 eggs failed to hatch. After the 1987 breeding season, a landowner in Dinkey Meadow bulldozed, as range improvement, an area where two of the three territories were held each year of our studies.

The willow flycatcher (*Empidonax traillii*) is a migratory passerine which breeds across much of North America north of Mexico. Its winter range is central America (AOU 1983). In California, it is restricted to riparian deciduous woodlands. Willows seem to be the preferred nesting substrate, but other shrub species have been reported as nest supports in California (Grinnell and Storer 1924).

In recent years, the Audubon Society has consistently included the willow flycatcher on the Blue List at the northeastern and southwestern borders of its breeding range. Remsen (1978) stated that the willow flycatcher "...face(s) immediate extirpation of (its)... California breeding population if current trends continue." He cites as reasons for the decline the destruction of willow-riparian woodland and, perhaps more importantly, parasitism by the brown-headed cowbird (*Molothrus ater*).

Acting on Remsen's listing, the California Department of Fish and Game contracted a survey of willow flycatchers in the Sierra Nevada. The results (Serena 1982) confirmed low populations. A total of 102 singing males (which were equated to breeding pairs, but see Stafford and Valentine 1985) were censused in the Sierra Nevada inclusive of the Kern River. An additional 19 were reported from elsewhere in the state.

The California Department of Fish and Game commissioned two additional studies in 1986. Harris et al. (1987) completed a second, expanded, state-wide survey and Flett and Sanders (1987) initiated an intensive two-year ecological study at two meadow systems on the Little Truckee River. Both studies recommended that the Department of Fish and Game designate the willow flycatcher as a threatened or endangered species. The listing has been initiated (R. Schlorff, pers. comm.).

On the Kings River Ranger District of the Sierra National Forest, Serena (1982) located six singing males at Dinkey Meadow, 2 at Lost Meadow and 1 at Long Meadow. Dinkey Meadow was scheduled for inundation by the Kings River Conservation District's (KRCD) Dinkey Creek Hydroelectric Project, and the other two meadows were designated as mitigation lands for the project. Recognizing that its project would impact a substantial portion of the known population (12 percent of Sierran birds and 7 percent statewide of Serena's (1982) estimates), KRCD began intensive ecological studies and geographical surveys of the immediate area (parts of the Kings River and Pine Ridge Ranger Districts) in 1983. The objectives were to identify habitat relationships and to document limiting factors. These data would enable us to prepare effective mitigation measures for the species. The studies yielded both empirical and subjective information with implications to forest management, especially livestock management.

Preliminary results were reported by Stafford and Valentine (1985). Valentine (1987) recommended a number of actions associated with willow flycatcher management, the strongest of which were related to cattle grazing. Subsequently, grazing was reduced during the 1987 grazing season.

The purposes of this report are to: (1)document the impacts of livestock grazing, (2) focus upon and reiterate those willow flycatcher management recommendations (Valentine 1987) that related to livestock, (3) describe a cattle management regime that potentially ameliorated some of the livestock conflict with willow flycatcher

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nesting efforts, (4) report observations of flycatcher egg nonviability, and (5) offer new management recommendations.

STUDY AREA

The study sites were Dinkey, Long, and Poison Meadows. All are within the Sierra National Forest in Fresno County, California. The grazing permits for the allotments encompassing the meadows allow a total of 800 AUMs to graze from 15 June through 15 September.

Dinkey Meadow is privately owned and is therefore not subject to Forest Service management. It is relatively wet and has willows densely clumped on its lower quarter. Two-thirds of that part with willows is grazed by two or three horses during the entire summer and is grazed intensively during about two weeks in the spring and again in the fall during cattle round-up. One third of the portion with willows is protected from all livestock grazing.

Long Meadow is a relatively dry meadow with willows scattered in clumps. The downstream one-fifth is private, fenced and grazed by 2-3 horses during the summer, and is used as a holding area and grazed by cattle in the spring and the fall. The remainder of the meadow is grazed under a U.S. Forest Service permit.

Poison Meadow is wet and narrow. It is subject to U.S. Forest Service administered grazing. Several species of willows and Creek dogwood (*Cornus stolonifera*) are abundant.

METHODS

Methods have been fully described in Stafford and Valentine (1985). As a brief review, willow flycatchers were mist-netted and banded with unique sequences of four colors that permitted subsequent field identification of individuals. Between 1983 and 1985, individual's territories were mapped, generally twice per week. Territories were not mapped in 1986 or 1987, but study sites were visited at least once per week. Nests were located as early in the season as possible and their progress chronicled. The evidence for attributing the fate of failed nests to a given cause was circumstantial. Losses of nests with evidence of livestock near them were attributed to that livestock. Losses of nests that were found still intact or destroyed but without any sign of recent livestock passage were attributed to predators or unknown causes.

After the flycatchers completed the nesting season, we characterized vegetative features of the general habitat, the territories, and the nest site. Nest sites were characterized by their location and the vegetation structure at the nest. Distance of nests from streams was determined by stretching a tape horizontally from the nests to the nearest stream channel that was active when nest sites were selected. Nest height above the ground and height of vegetation above the nest was measured with meter sticks affixed to a rigid pole. Stems supporting the nests were enumerated and measured with a micrometer caliper at their point of insertion into the base of the nest. Stem density at ground level was determined by counting the number of stems emerging from the ground within a 0.5 m radius of the nest. Stem density and their size distribution at nest height was calculated by enumerating and sorting into three size categories all stems bisected by an imaginary horizontal plane within a 0.25 m radius of the nests.

Under a temporary agreement between the cattle permittee and the permitting agencies (Sierra National Forest and Southern California Edison), overall cattle use in the area was decreased from 170 to 100 cow-calf units (AUMs) at all sites during the 1987 grazing season. Further, the at-large, season-long grazing (15 June to 15 September) was changed to a simple type of rest-rotation. Until 15 July, 75 to 100 head were confined within a fenced pasture. Only 25 head had season-long access to the range.

A temporary electric fence, using lightweight materials, was erected around two nests sites (approximately 1/4 acre each) where willow flycatchers were nesting. Our purpose was to experiment with the fences' efficacy in controlling livestock access. At one site, danger of nest upset was minimal due to nest placement and absence of livestock. The second nest was placed precariously over a cow trail; however, grazing intensity at the time was light.

RESULTS

Nest Success

1983.—Only Dinkey Meadow was intensively studied during 1983. Two pairs nested in the area used as a livestock holding area, a third pair nested in the area where livestock were excluded (Table 1). Two of the three nests failed after being disrupted by trespass cattle. The third nest fledged three young, then was destroyed by cattle 18 days later.

1984.—Long and Poison Meadows were added as study sites in 1984 (Table 1). One successful nest in Long Meadow was never located. In Poison Meadow, a successful nest fledged two young, then was destroyed by cattle three days later. Predators destroyed a nest in both Dinkey and Long meadows. A third nest was found in Long Meadow after the breeding season with two dead young in it. The cause of their death was not determined. Observations of the adults at this nest suggest that it did not fledge young.

1985.—No willow flycatchers nested in Dinkey Meadow in 1985 (Table 1). Despite the presence of three territorial males, no females elected to pair with them. A nest in Poison Meadow was destroyed by predators. Two

Table 1. Results of willow flycatcher nest attempts for all nests at all sites from 1983 through 1987. Post-fledging nest losses are the number of nests that successfuly fledged young and then were destroyed by livestock.

	Dinkey Meadow					Long Meadow				Poison Meadow				
Outcome	83	84	85	86	87	84	85	86	87	84	85	86	87	TOTAL
Failed Nests														
Predator	-	1	-	1	1	1	-	-	1	-	-	1	-	6
Livestock	2	-	-	-	-	1	1	-	-	-	-	-	-	4
Unknown	-	-	-	-	-	1	-	1	-	-	1	-	-	3
Total	2	1	-	1	1	2	1	2	1	-	1	1	-	13
Successful Nests														
Total	1	-	-	2	1	1	2	1	2	1	-	1	1	13
Post-fledging														
Nest Losses	1	-	-	-	-	-	-	1	-	1	-	1	-	4

nests in Long Meadow produced five young, while a third nest with nestlings was destroyed by cattle.

1986.—Two nests of a polygynous male in Dinkey Meadow fledged five young (Table 1). A third nest was destroyed by a predator just prior to fledging. One nest in Long Meadow fledged three young but was destroyed by cows less than one week later. A second nest with nestlings was destroyed by a horse. A third nest with nestlings was destroyed by a predator. At Poison Meadow, one nest was predated near the hatch date. A second nest fledged three young, then was destroyed by cows three days later.

1987.—Livestock grazing intensity and duration was reduced during the summer of 1987. Two willow flycatcher territories were held in Dinkey Meadow during 1987, one in the area from which livestock were restricted (Table 1). Two nests were monitored. A possible third nest may have been the product of a polygynous mating. We did not find this nest, but we observed three unbanded, fledged juveniles and one adult *Empidonax* spp. in August. At the same time, the adult was interacting with the banded adults in the vicinity. Of the two nests monitored, one fledged two young and contained one nonviable egg, while the second with three eggs was destroyed by a predator.

At Long Meadow, one nest fledged two young and contained one nonviable egg. A second nest fledged one young, lost one egg to a predator before its viability was determined, and contained two nonviable eggs. A third nest with three eggs was destroyed by a predator. However, at least two of its eggs were nonviable. The third egg may have been nonviable because its incubation exceeded the average required for hatching (King 1955). A nest in Poison Meadow fledged two young, and a third egg was nonviable.

All Years.—Between 1983 and 1986, nine of 20 nests fledged 19 to 26 young (Table 1). Failure of the other 11 were attributed to predators (n = 4), unknown causes (n = 3), and to livestock (n = 4). In 1987, four of six nests fledged at least one young, none were upset by livestock, and two failed due to predators. Nonviability of eggs was high (Table 2). Seven of 14 eggs inspected were nonviable. The nonviable eggs came from five nests. All were from initial (and only) clutches for the season. Predators destroyed five eggs before their viability was determined.

Nest Site Characteristics

Height of nests in the Dinkey Creek area averaged 149.4 cm (n = 22, range 77-218 cm, SE = 7.82, Fig. 1) above the ground. Nests averaged 119 cm (n = 18, range 51-185 cm, SE = 8.6) below the top of the willow branches on which they are constructed.

Few stems arose from the ground below the nests (Fig. 2); 16 per m^2 was the greatest. Fifty percent of the nests had four or fewer stems per m^2 below the nests. Sparseness of the branches in the nests vicinity is further illustrated by the few number of stems at nest height (Fig. 3). While the density was greater at nest height than at the ground, the size distribution was skewed towards small diameter stems. The meager stem count near willow flycatcher nests reflected the bird's preference for nesting near the edges of clumps and near streams (Fig. 4). Greater than 25 percent of nests were directly above a

Table 2. Fate of willow flycatcher eggs in 1987 in the Dinkey Creek area.

Nest ID	Eggs Laid	Viability			Lost to Predators	Successfully Hatched
		No	Yes	Undetermined		
87-01	3	1	2	—	—	2
87-02	4	2	1	1	1	1
87-03	3	—	—	3	3	—
87-04	3	2	—	1	3	—
87-06	3	1	2	—	—	2
87-07	3	1	2	—	—	2
Total	19	7	7	5	7	7

stream channel. Over 50 percent of the nests were placed within 3 m of streams. The sample size is too small to determine if the distribution of nests relative to streams was associated with failure. However two-thirds of the nests over streams failed.

The limbs supporting the nests were small (Fig. 5) and at several nests some were independent of each other to the ground. Sixty-eight percent of supporting branches were less than 5 mm in diameter and 96 percent were less than 10 mm.

DISCUSSION

A problem in working with uncommon species is that of small sample sizes. In addition, multiple year

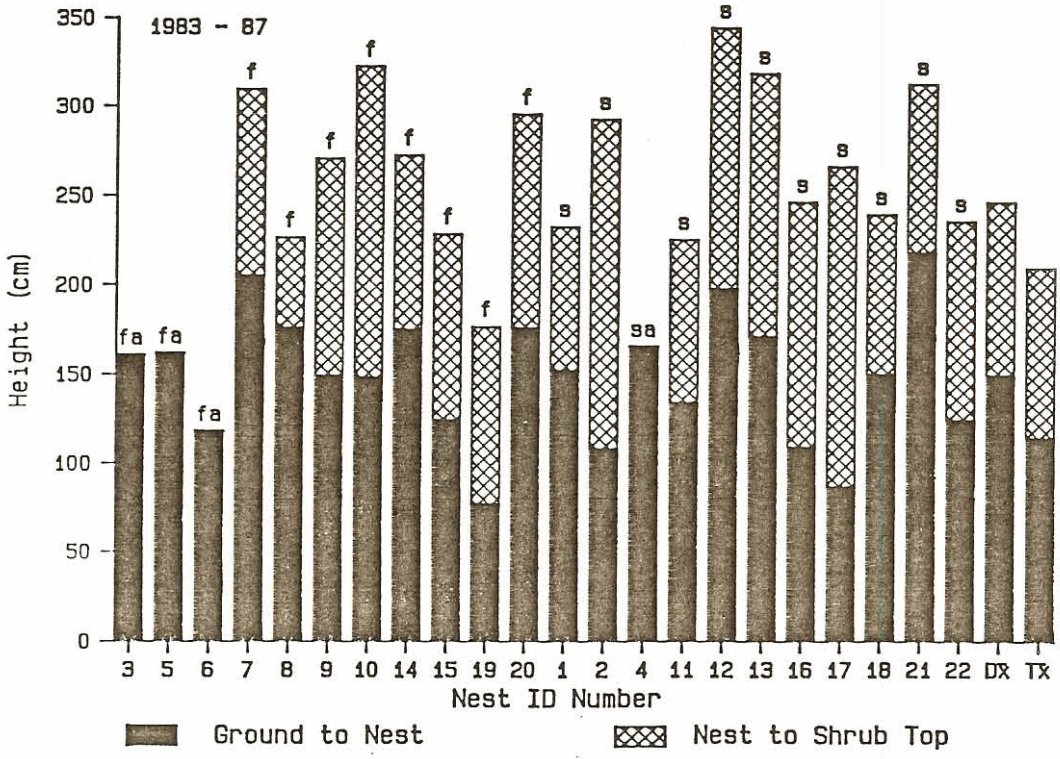

Fig. 1. Nest height relationships of willow flycatcher nests from 1983 through 1987. The final column ($T\bar{x}$) represents the average information reported by Sanders and Flett (1988). The column labeled $D\bar{x}$ is the average for the present study. Column labels: s = successful nests, f = failed nests, a = distance from nest to shrub top not recorded.

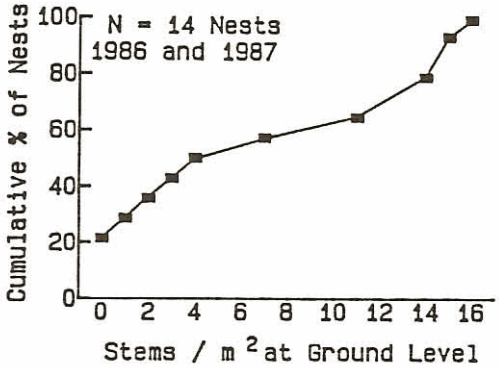

Fig. 2. Cumulative percent of nests which have less than or equal number of stems per square meter directly below the nest.

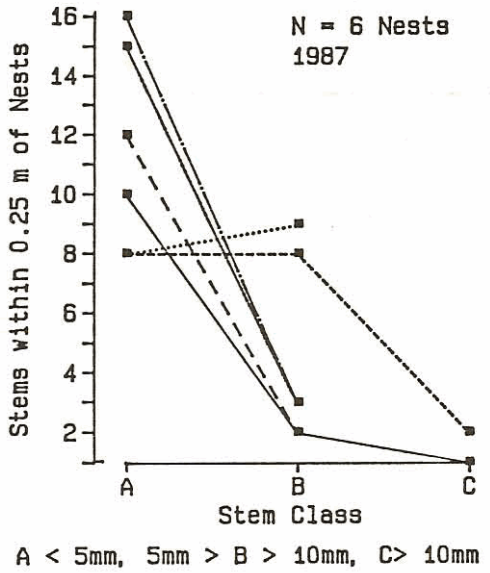

Fig. 3. The number of stems within a 0.25 m radius of the nest at nest height by diameter class. Each nest is identified by a single, continuous line from right to left.

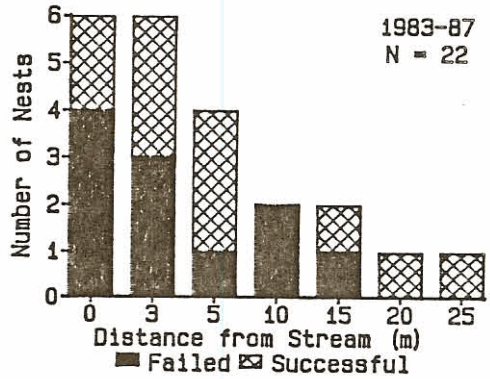

Fig. 4. Distribution of nests from streams.

studies with some of the individuals returning between years and within the same meadows results in pseudoreplication (Hurlbert 1984). Both these characteristics of our data limit: (1) the applicability of our results to willow flycatchers across the Sierra Nevada, (2) an analysis of flycatcher habitat preference relative to different grazing regimes on our study sites, and (3) the statistical validity of any comments about amelioration deriving from the grazing intensity adjustments.

Concern about the continued existence of the willow flycatcher as a breeding bird in California, and across much of the west is growing. Region 1 of the U.S. Fish and Wildlife Service (Idaho, Washington, Oregon, Nevada, and California) and Region 5 (California) of the U.S. Forest Service have identified the willow flycatcher as a Sensitive Species (Sharp 1987, Anonymous 1984). Robbins et al. (1986) graphically display and remark about "a rather strong decline" of populations west of the Rocky Mountains. A petition to list the willow flycatcher as endangered is currently being prepared by the California Department of Fish and Game (R. Schlorff, pers. comm.).

All of the parameters that we evaluated relative to nest site selection show that the nests are sensitive to physical disturbance, either by weather or livestock. Nests tended to be near relatively open portions of riparian deciduous clumps on the perimeter), near cow trails, in ow density portions of large clumps, and/or near water. The placement of nests in these locations accounts for the low stem density we recorded. For cattle, willows provide attractive foraging and loafing areas as the summer progresses. The value to livestock of herbaceous plants growing beneath willows increases as forage is exhausted elsewhere (Loft et al. 1987). The presence of forage and drinking water invites cattle passage which is in conflict with flycatcher nesting. Nests placed deeper in riparian deciduous clumps would be less sensitive; however, willow flycatchers have rarely been observed to nest there. King (1955) and Flett and Sanders (1987) and Sanders and Flett (1988) also noted the frequent placement of willow flycatcher nests near the periphery of riparian deciduous clumps or other edges within them. Sanders and Flett (1988) reported that the 20 nests on their Truckee river study sites averaged 2.3 m (SD = 1.7, range 0.6-7.5 m) from the edge of the willows and 1.71 m (SD=0.74, range 0.6-3.5 m) from livestock trails. Krueger and Anderson (1985) noted that *Empidonax* spp. preferred to nest in low-density willow stands in Wyoming. Thin willow stands do not discourage cattle movements.

On Flett and Sanders' (1987) Little Truckee River study sites, willow flycatcher nests averaged 114 cm high

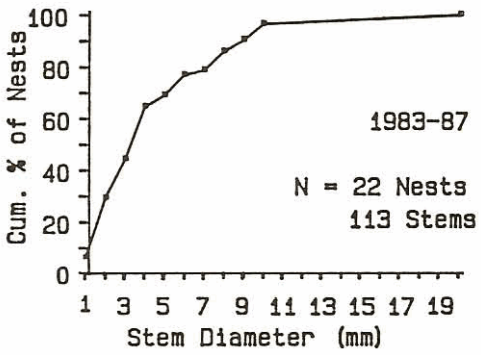

Fig. 5. Cumulative percent of stems supporting nests by stem diameter.

(n = 20, range 0.7-1.75 m, SD = 29 cm). Nest height on their study site differed significantly from that on our site ($t = 3.45$, $df = 40$, $P < 0.01$). The height to which livestock can affect nests is not known. However, Loft et al. (1987) showed that heavy grazing can reduce the cover afforded by willows up to at least 1.5 m. On two study sites in Wyoming, tunnels resulting from livestock use averaged 0.75 and 0.95 m high and ranged up to 1.8 m (Krueger and Anderson 1985). Undoubtedly, livestock activities that result in cover reduction and tunnel creation up to these heights will disturb and move branches at higher levels.

Limbs supporting nests were small at and near the nests. At several nests, branches supporting nests were independent from each other, a factor which magnifies the detrimental effect of branch movements. The diameters are such that a little force (whether by cattle, wind, or predators) can result in substantial movement leading to a nest upset.

Prior to reduction of grazing intensity in 1987, livestock accounted for 36 percent of the failed nests, or 20 percent of all nesting attempts. In addition, livestock destroyed four successful nests shortly after the young had fledged. This demonstrates the vulnerability of nests. Potentially, livestock may have destroyed eight nests (53 percent of the losses or 40 percent of the results of all nest attempts).

Livestock upset active nests between July 11 and August 15, despite the presence of completed nests as early as 10 June, of nests with eggs as early as 16 June, and of nests with nestlings as early as 21 June (Fig. 6). This

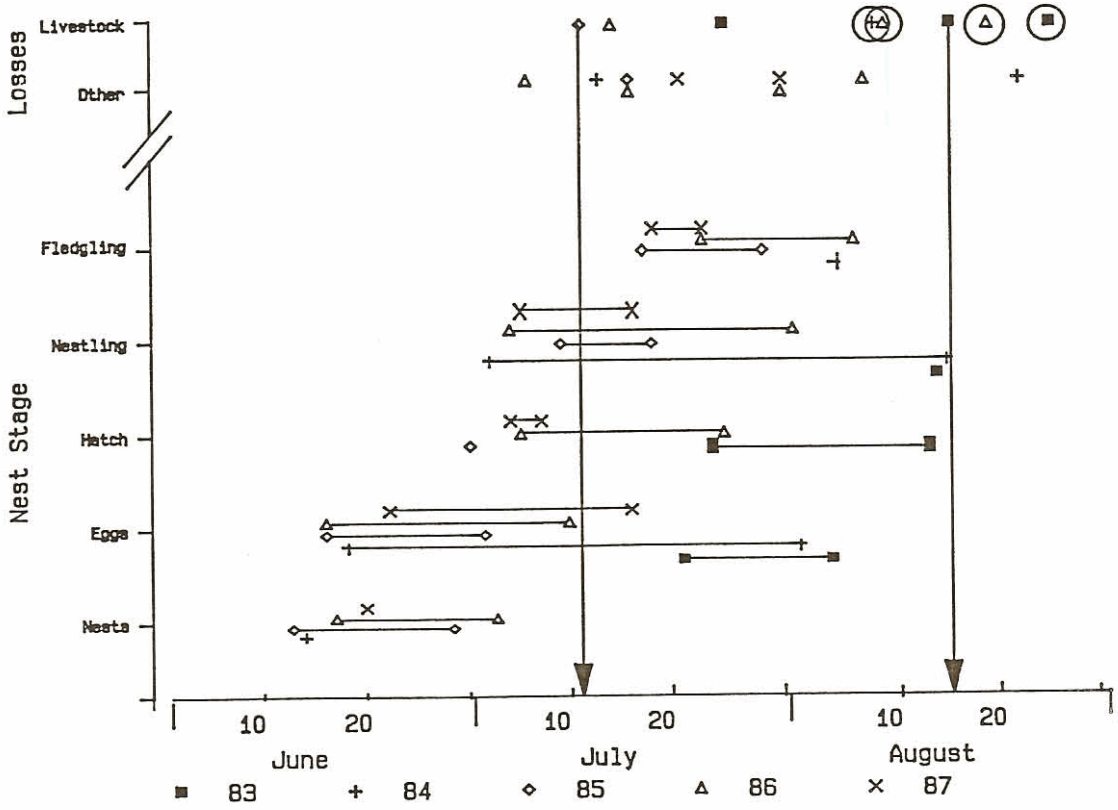

Fig. 6. Chronology and outcome of nesting attempts for all nests from 1983 through 1987. Horizontal bars encompass the period of known nest stage for each year. Failure events are noted for each year; circled events were nest upsets after the young had fledged. Vertical arrows encompass the period when livestock upset active nests.

led to the recommendation (Valentine 1987) that cattle be excluded from flycatcher nesting areas between July 11 and August 15. That recommendation was strengthened by advancing the exclusion date to July 1, which provided for a margin of error. Earlier exclusion is probably unnecessary in the Dinkey Creek area because those features that attract cattle to willowed meadows late in the grazing season (drinking water, succulent forage, mild climate) are abundant elsewhere in the allotment during the willow flycatchers' initial nesting activities. Additionally, prior to the first of July, the wetness of the meadows deters substantial cattle movement. Consistent with our findings, Loft et al. (1987) found that as the season progressed, cattle increasingly moved into willow stands. They attributed cattle invasion of willow stands to the depletion elsewhere of other, more accessible forage. Graphically, their results correspond to the period of nest destruction we found. The earliest marked decline of willow cover caused by cattle grazing was after 10 July.

Cattle grazing in the Dinkey Creek area is governed by two grazing permits: one administered by the Southern California Edison Company and the other by the Sierra National Forest. On both allotments, there were indications unrelated to our willow flycatcher research, although little actual data, that livestock use levels were too high for good forage management. Thus, the grazing adjustments described in the methods section were effected.

During 1987, the potential for cattle to upset willow flycatcher nests appeared to be greatly diminished from previous years. The meadows exhibited no evidence of current season livestock grazing during most of the flycatchers' breeding season. Only during the last two weeks were cattle observed near or on the meadows. Even then, the grazing pressure was very light. Despite the fact that cattle were provided open range two weeks earlier than recommended (Valentine 1987), the combination of reduced cow numbers and the retarded turn-out date for the majority of cows seemed to provide ample forage elsewhere on the range and thus protect the meadows until after most of the flycatchers had completed nesting.

Continued monitoring of flycatcher nesting success would be necessary to determine if the livestock management scheme described above eliminates or diminishes livestock-flycatcher conflicts. Despite possible reductions in direct nest upsets, response of willow structure to any livestock management regime should be monitored to prevent the more insidious deterioration of habitat quality through high-lining (removal of the lower, lateral branches) of willows.

When using our data to estimate the potential for livestock disruption of willow flycatcher nesting under the prior grazing regime, the rates of loss should be considered low estimates. Nests which failed due to factors other than livestock (predators, weather, disease, undetermined) were no longer exposed to disruption by livestock. Had they not been otherwise destroyed, some of these may have been upset by livestock. While we attempted to ensure that our activities would not attract predators, we can not be certain that the loss to predation was not elevated due to our activities. Had we been absent, the number of nests escaping predation and therefore exposed to cattle disruption could have been greater. We know of no reason that our presence could have elevated losses of nests to livestock disruption. Conversely, on occasion, we drove trespass cattle out of fenced areas and repaired fences. Had we not been on-site, exposure to livestock upset would have been greater.

Flett and Sanders (1987) recorded four of 11 (36 percent) nests failed during the 1986 field season at Perazzo Meadows and Lacey Valley on the Little Truckee River. During 1987, eight of ten nests were lost, primarily as the result of severe weather (Sanders and Flett 1988). None were lost to livestock disruption, although both studies noted that most of the nests were vulnerable to livestock disruption.

Evidence that livestock are adversely impacting willow flycatchers is increasing. Taylor and Littlefield (1984) and Taylor (1986) found willow flycatcher numbers increased about seven-fold when livestock use was reduced 75 percent over ten years in Oregon. The amount of grazing was inversely correlated with shrub volume and height. R. Schlorff (pers. comm.) noted the reappearance of willow flycatchers in Modoc County after the area was rested from grazing for just a few years. Knopf et al. (1988) assigned the willow flycatcher in Colorado to the stenotopic response guild relative to historical patterns of seasonal grazing. This guild was present in winter grazed pastures but was absent from the summer grazed pastures. Decadent willows typified the summer grazed pastures.

The decline of the willow flycatcher can not be explained solely by the direct disruption of willow flycatcher breeding by cattle. Despite no recent grazing in Yosemite National Park, willow flycatchers are now extirpated from the valley floor (Gaines 1977). Undoubtedly, the amount of habitat in the Central Valley has dwindled and is responsible for some of the decline. However, apparently suitable habitat still exists but is devoid of willow flycatchers. Brown-headed cowbird parasitism is perhaps the most reasonable explanation of the decline in number of willow flycatchers. Harris (1988) found that 13 of 19 nests at the Nature Conservancy's Kern River Preserve were parasitized by brown-headed cowbirds during 1987. The egg-to-fledgling rate was at most 24 percent. Sedgwick and Knopf (1988)

found that brown-headed cowbirds parasitized 11 of 27 nests built by 15 pairs of willow flycatchers in Colorado during 1985 and 1986. On the Santa Margarita River in southern California, willow flycatchers have increased from five to 17 territorial males coincident with a cowbird removal program during 1981 to 1986 (Unitt 1987).

The high rate of nonviability is cause for concern. Future studies should attempt to determine the cause and ubiquity of this finding. Shell thickness of eggs collected prior to 1986 have been measured and no thinning has been detected (KRCD 1988). Nonviable eggs should be collected and analyzed to determine stage and cause: infertility, abnormal embryonic development, and possible pesticide contamination. High rates of nonviability might cause elimination of willow flycatchers from suitable habitat such as Yosemite Valley.

The willows over a portion of Dinkey Meadow were uprooted and piled by a bulldozer after completion of the 1987 willow flycatcher breeding season. The landowner feared that the willows would take over the meadow if left uncontrolled, thus reducing cattle forage. This event was important for three reasons. First, on a local scale, the area converted from willowed meadow to open meadow sustained two of three nests each year that flycatchers nested there. Nests in the area not converted have failed each year since the inception of our studies. Secondly, it illustrates that range management as well as livestock management can eradicate willow flycatcher habitat. Finally, Dinkey meadow was an important component of the Dinkey-Shaver population area, the third most populous willow flycatcher habitat in the Sierra Nevada (Harris et al. 1987). The importance of this population center to willow flycatchers in the Sierra is evident when considering the low production that occurred during 1987 at the two larger population centers. On the Kern River Preserve, cowbird parasitism limited fledging to only five of 19 nests (Harris 1988). On the Little Truckee study sites, a mid-summer snow storm was responsible for the loss of eight of ten nests and restricted production to only six fledglings (Sanders and Flett 1988).

MANAGEMENT IMPLICATIONS

Livestock Management

Livestock appear to be an important limiting factor to willow flycatcher populations. Livestock destroy nests and can reduce the suitability of nesting habitat by altering shrub structure. The brown-headed cowbird, a nest parasite strongly associated with livestock, can effectively negate willow flycatcher nesting efforts. Since livestock grazing is the most manageable factor limiting willow flycatcher productivity, livestock management options seem central to enhanced flycatcher productivity.

Grazing Season Adjustment.—In the montane meadow systems we studied, livestock destroyed active nests between 11 July and 15 August. Cattle should be restricted from meadow riparian zones where willow flycatchers nest from 1 July through 20 August. In other regions, the timing of livestock invasions of willow stands should be determined to formulate effective time restrictions.

Where conflicts are expected, electric fencing might provide an economic, effective, and convenient protection measure for nests in areas that are sensitive to livestock grazing. The electric fences we erected were light-weight and easy to install. One person could carry the materials to enclose approximately 1/4 acre and could erect the fence in about one hour. We observed the flycatchers to forage frequently from perches on the fences. However, we experienced difficulty with the power packs maintaining their charge and occasional inspections were necessary. Cows were observed within fenced areas during the early period of attempted exclosure. We were not confident of protection until late in the season, after the flycatchers had completed their breeding activities. Then the exclosures retained their charge for up to about 20 days on six C-cell batteries. Solar panels may alleviate this problem.

Adjust Grazing Intensity.— As indicated by the results of the 1987 grazing season, reduced grazing intensity may interact with the factors that determine when cattle invade willow stands. Willow flycatchers are dependent on the structure as well as the presence of riparian deciduous shrubs. High-lined shrubs do not provide the required nest site characteristics. The intensity of livestock grazing that degrades the structure of willows to a degree that precludes willow flycatcher nesting has not been identified. Grazing intensity should be managed to ensure that riparian deciduous shrubs are not high-lined.

The response of willows to different management actions including different grazing regimes needs study. There may be grazing regimes that enhance the structure of willows for nesting substrate. Krueger and Anderson (1985) attributed the sparse condition of willows preferred by the flycatchers to livestock grazing. However, grazing would have to be carefully controlled to avoid development of low suitability, high-lined willows.

The livestock management program exercised on the south zone of the Sierra National Forest during the summer of 1987 appeared to minimize conflicts between nesting flycatchers and cattle. It is worthy of being instituted and evaluated elsewhere. In summary, this program reduced stocking levels by 40 percent, and kept 75 percent of the remaining livestock contained in a fenced pasture for the first month of the grazing season (15 June to 15 July).

Nonviability Investigations.—The population dynamics of willow flycatchers are poorly understood. A 50 percent nonviability rate suggests that the populations may not be replacing themselves. Livestock induced nesting failures may be accelerating an existing decline. Research should determine if the rate of infertility observed during 1987 is simply a temporary extreme in its normal range of variation, or is the effect of some environmental factor. If egg nonviability is important, its causes and solutions need to be researched.

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