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THE ECOLOGY AND BEHAVIOR OF THE ^{LONG} ~~LOG~~-BILLED CURLEW
(NUMENIUS AMERICANUS) IN SOUTHEASTERN WASHINGTON

Julia N. Fitzner

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THE ECOLOGY AND BEHAVIOR OF THE LONG-BILLED CURLEW
(NUMENIUS AMERICANUS) IN SOUTHEASTERN WASHINGTON

ABSTRACT

by Julia Natalia Fitzner, Ph.D.
Washington State University, 1978

Chairman: Don E. Miller

The behavior and ecology of a population of Long-billed Curlews (Numenius americanus) were studied in 1976 and 1977. The investigation was carried out on the Department of Energy's Hanford Site in Southeastern Washington. Direct observations of courtship, mating, nesting, incubation, hatching, chick-rearing, and flocking behavior were made.

The breeding territories are well defined and are subsequently occupied from year to year. The birds arrive on their territories either as pairs or as single males soliciting for a female. Agonistic displays and postures involved with territorial defense are described, as are displays and postures involved with sexual behavior. Most displays are performed by the male. On the Hanford Site, pre-hatching territory size varies from six to 20 hectares depending upon the habitat available. After hatching, only the area in the vicinity of the chicks is defended.

Following the initial arrival period, the birds are usually only in the nest fields during the early morning, late afternoon, and night-time hours. The rest of the day is spent either elsewhere within the territory, along the Columbia River, or feeding in irrigated fields. Courtship displays and mating begin almost immediately after arrival and continue through egg laying. Maintenance behavior (comfort movements, resting, feeding) is described.

The choice of nest site appears to be based on features of the environment. Once the nest site is selected, four eggs are laid at 48-hour intervals. Magpies (Pica pica) and Coyotes (Canis latrans) in particular contribute to egg losses. If the nest is destroyed, the birds do not attempt to re-nest, but abandon their territory.

The female incubates during the day and the male at night. The day-time incubation posture is a head-up, relaxed but alert position except when disturbed. Coyote predation was considered the primary cause of nest losses during this phase.

Adult defense behavior against predators becomes particularly intense at hatching and through the first weeks of the chicks' lives. Starring of the eggs occurred three to four days prior to hatching. Hatching was synchronous within nests and also within each nesting area. Chick mortality is very high and though most of the causes are uncertain, predation, weather, and disturbances at hatching time are no doubt partly responsible. Both parents care for the chicks for the first two to three weeks, after which the female usually departs and is no longer seen.

Up to 250 Long-billed Curlews congregate on Island 3 in the Columbia River daily for one to two weeks during the flocking phase. Small groups of 30 individuals or less migrate from this staging area in the late afternoon and presumably head south.

Long-billed Curlews are very sensitive to disturbances during the nesting period. Though they may become habituated to certain human routines, the eggs and chicks are stressed by exposure. If flushed from the nest once, the incubating adult will subsequently flush readily at the first sign of danger.

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INTRODUCTION

The Long-billed Curlew (Numenius americanus) is the largest of our shorebirds, and yet it is one of North America's lesser known bird species. Its life history, ecology, and behavior have until recently received little attention. The paucity of knowledge about the Long-billed Curlew relates to its isolated and heretofore remote ranges and to its status as a non-game species; non-game wildlife have only recently begun to receive management consideration from governmental agencies. The breeding range is restricted to scattered locations in the Western United States, and parts of Eastern Washington still provide suitable nesting habitat, though in ever-diminishing amounts.

There is little published information on the distribution and ecology of Long-billed Curlews; until recently almost all of its known biology was based on purely observational and rather subjective works written around the turn of the century (e.g., Bailey, 1904; Bent, 1907; Cameron, 1907; Dice, 1918; Dawson, 1909; Ferry, 1910; Grinnell and Hunt, 1929; Oberholser, 1918; Shufeldt, 1913; Silloway, 1902, 1909; and Wickersham, 1902). Recently, Long-billed Curlew studies have become more numerous (e.g., Campbell, 1972; Forsythe, 1967, 1970, 1971, 1972, 1973; Graul, 1971; McCallum, Graul, and Zaccagnini, 1977; Sadler and Maher, 1976; and Timken, 1969), but as was noted by Palmer in 1967 and Pettingill in 1968, there is still today little information on their breeding behavior.

Objective

The primary objective of this study was to examine in depth the nesting ecology and behavior of the Long-billed Curlew on a breeding area relatively free of disruptive human activity. Two summers of field work were devoted to that end; a post-breeding season survey in 1976 of the major National Wildlife Refuges in Washington, Southern Idaho, Utah, Nevada California, and Oregon enlarged the scope by including unpublished records of Long-billed Curlews in these areas. I hope this information will be useful to agencies or individuals responsible for the preservation of the Long-billed Curlew and its habitat.

Status of the Long-billed Curlew

At one time the Long-billed Curlew occurred in large numbers over most of the prairie regions of the United States and Southern Canada. By the early 1900's the species had already declined markedly. This reduction was a direct result of (1) overzealous sport hunters, who took advantage of the curlew's nature of returning to circle over wounded comrades, (2) market hunting (curlew wings brought 74¢ apiece in 1900; Stone, 1901), and (3) the "reclamation" of vast areas of their former breeding range for farming and ranching (Wolf, 1931 and Sugden, 1933). Habitat destruction and livestock (sheep in particular) have restricted the curlews to scattered populations in the West. Today they are rarely encountered east of the Mississippi River, whereas formerly they were a common transient along the Atlantic Coast. The numbers noticeable on marshes, flats, and fields today represent a concentration in a restricted range rather than an increase in the number of birds (Sugden, 1933). Changing conditions in land use south of the United States where some curlews winter have also contributed to their reduced numbers.

Long-billed Curlews now nest from Southern British Columbia, Alberta, Saskatchewan, and Manitoba southward to Utah, New Mexico, and Texas. They no longer nest in Michigan, Minnesota, Wisconsin, Illinois, Iowa, Eastern Nebraska, and Kansas (A.O.U., 1957 and Oberholser, 1918). They winter from California, Western Nevada, Texas, and Louisiana southward to Baja California, Oaxaca Mexico, and Guatemala, and also from South Carolina to Florida (A.O.U., 1957).

Other members of the genus Numenius found in North America are the Whimbrel, the Eskimo Curlew, and the Bristle-thighed Curlew. On rare occasions Eurasian Curlews may be sited on the Atlantic coast, but these are displaced migrants and not native to the United States. In comparing the relative abundance of the Whimbrel, Eskimo, and Long-billed Curlews today with their status 100 years ago, a striking example of differential adaptation among species is seen. At that time the Whimbrel was the rarest of the three; today it is the most common. The Eskimo Curlew is virtually extinct; the last confirmed sighting having been in 1972 (Iversen, 1976). Possibly the Long-billed Curlew can hold its own, but only if measures taken to preserve it are soon forthcoming.

Although the curlew now is protected by law from hunting throughout North America, the process of habitat destruction continues at an ever increasing rate. In both Southeastern Washington and Northeastern Oregon an estimated 30,000 acres per year of former curlew habitat are lost to cultivation (John Kurtz, personal communication). In view of this, public lands such as National Wildlife Refuges and the DOE Hanford Site where curlews occur are bound to become arid islands of refugia in a sea of irrigated farmland. For the foreseeable future, lack of habitat protection threatens the survival of the Long-billed Curlew. Apparently in response to this situation, the United

States Department of the Interior (1973) has categorized the Long-billed Curlew as "status - undetermined," which means that it has been suggested as possibly threatened with extinction but sufficient information is not available to determine its status. More information is needed.

TAXONOMY OF THE LONG-BILLED CURLEW

The Long-billed Curlew (family Scolopacidae, order Charadriiformes) is closely related to the snipe, sandpipers, and yellowlegs. In the early 1900's, considerable debate was going on concerning the status of the two supposed races of the Long-billed Curlew and over correct names to be used (Bishop, 1910; Grinnell, 1921; Oberholser, 1918; and Ridgeway, 1919). Evidence presented points toward a smaller northern race versus a larger southern race, but there is notable size overlap between the two. The American Ornithologists Union (1957) distinguishes between the two in their checklist, accepting the names Numenius americanus americanus and N.a. parvus. The bird which I studied in Southeastern Washington belongs to the smaller race (N.a. parvus).

DESCRIPTION OF STUDY AREA

General Description

The United States Department of Energy (DOE) Hanford Site comprises 1,476.3 km² or 147,715.5 hectares of shrub-steppe vegetation at the southern end of the lower Columbia Basin in Southeastern Washington (Figure 1). Formerly in private land holdings, the Atomic Energy Commission (AEC) acquired the land in 1943 as a national security area which was closed to agriculture, grazing, and unofficial travel. Basically, all of the original residential and commercial buildings have been removed and only remnant trees and concrete weir boxes stand as testimony to the irrigation that once serviced the area. Today there are 12 controlled or limited access areas on the Hanford Site which are identified by area numbers (e.g., 300 Area, 200-E Area, 100-H Area, etc.). Each of these areas is totally enclosed by a high antipersonnel fence.

Physical Features

The most striking topographic feature of the Hanford Site is Rattlesnake Mountain which bounds the Site on the southwest. For 5 km, the crest of this mountain is 1,100 m high. The north slope drops steeply to 650 m elevation and then eases down to Cold Creek Valley at 150 m. North of Cold Creek Valley the land surface again rises to a plateau at about 225 m near the center of the Hanford Site. From here the terrain slopes downward toward the Columbia River through a series of benches or terraces. The Gable Mountain, Gable Butte complex consists of two large basaltic rock outcroppings rising to a height of 338.94 and 224.94 m, respectively, between the central plateau

Figure 1. Map of Washington State Showing Columbia Basin and the United States Department of Energy Hanford Site.

Fig. 1

and the northern reaches of the River. The northern shoreline of the Columbia River is marked by the steep-walled "White Bluffs" rising 70-100 m above the bank for about 11 km; the eastern border of the River is also lined with steep banks. Two sets of dunes cross the Hanford Site. About 3,000 hectares of active sand dunes near the Columbia River form a belt 6.4 km wide immediately south of Hanford townsite to a point opposite Ringold on the east bank of the River. The second group of dunes focuses on the area between the Yakima Horn and North Richland, with the dune belt dying out to the northwest and southeast. The dunes trend northeastward and cross due west of the 300 Area.

The Columbia River is the largest body of water in the region and flows within the Hanford Site for a distance of 83 km. Twenty islands ranging in size from 2.7 hectares to 135.0 hectares lie within this stretch of the Columbia. The River is approximately 800 m across and flow is manipulated at a series of hydroelectric dams upstream. Other bodies of water include four small ponds on or near the centrally located plateau, Rattlesnake Spring at the base of Rattlesnake Mountain, and several flowing wells located in the northeast corner of the Site.

Vegetation

Three major vegetation types (Figure 2) occur on the Hanford Site west of the Columbia River (Cline, Uresk, and Rickard, 1975). (1) The Sagebrush-Bitterbrush/Sandberg's Bluegrass-Cheatgrass type covers the low elevations in the eastern and southeastern parts of the Site and occupies the sandiest soil short of dunes. (2) The Sagebrush/Bluebunch Wheatgrass-Sandberg's Bluegrass vegetation type is confined to the Rattlesnake Hills at elevations above 274 m. (3) The vegetation type which occurs as a broad zone between the two above-listed types is the Sagebrush/Cheatgrass-Sandberg's

Figure 2. Boundaries of the Three Major Vegetation Types on the Hanford Site.

Fig. 2

Bluegrass vegetation type. A general paucity of herbaceous cover tends to favor invasion by Russian Thistle.

Although much of the Hanford Site was undeveloped at the time of its inception, there were several farming communities which were displaced. The fields were left fallow and were soon invaded by Cheatgrass. Notably enough, these abandoned fields surrounded like islands by stands of native vegetation and isolated overtime from human intrusion provide the suitable nesting habitat for the Long-billed Curlew on the Hanford Site.

Weather

The climate of the Hanford area is greatly influenced by the Cascade Mountain Range to the west. Annual precipitation at the Hanford Meteorology Station (located at 223 m elevation near the center of the Site) averages 16.5 cm but has ranged from about 7-30 cm during the past 30 years. On the average, 60% of this precipitation falls between October and February. Precipitation decreases after the three wettest months of November, December, and January but increases again to a secondary maximum in June. June is also the month of the highest average wind speed and only once in seven years will it have even one day with a peak gust under 21 kph. December, on the other hand, is the month of lowest average wind speed and has an average of 10 such days. The climate of the Hanford region can thus be described as having windy springs, hot and dry summers, and moderately cold winters. July is the hottest and driest month, whereas January is the wettest and coldest month.

Temperatures during 1976 averaged 0.6°C cooler than usual. Total precipitation for the year was 46% of normal, making 1976 the driest year on record in the Hanford area. The spring and summer of 1976 were also windier and cloudier than normal. Even so, the spring growth of plants was for the

most part unaffected and the weather in general did not appear to be detrimental to successful curlew nesting.

The weather during 1977 was bizarre, with many months being substantially warmer or cooler than normal and with precipitation falling during usually dry months. Coupled with the shortage of precipitation in 1976, drought conditions persisted until August when sudden rains finally initiated the "spring growing season" for many plants. Consequently, when the curlews arrived in March many plants had not germinated or bloomed, including the Cheatgrass. The only nesting cover in the fields was the dead vegetation from the previous year.

Specific Study Sites

Although the entire Hanford Site west of the Columbia River was surveyed for curlews, only three study sites were selected for concentrated behavioral observations. Because of its relative inaccessibility, the Hanford Site north of the Columbia River was not included in this study. However, groups of birds from the Wahluke Slope area north of the Columbia River are included under the topic of Staging and Departure. The three concentrated study sites were as follows (Figure 3).

The 300 Area study site was the primary study area. Located due west of the 300 Area and approximately 0.8 km from the Columbia River, this site encompassed approximately 10.36 km² of Sagebrush-Bitterbrush/Sandberg's Bluegrass-Cheatgrass vegetation and former homesteads with a few remnant trees. Sandy, shrub-covered ridges and small dunes are present and separate the relatively flat nesting fields (Figure 4). The topography is gently undulating and broken and lacks well defined surface drainage channels. In the spring, the ridges and dunes display a burst of flowers: Long-leafed

Figure 3. Map of the Hanford Site with Dots Showing Location of Concentrated Study Areas.

Fig. 3

Figure 4. Habitat at the 300 Area Study Site. a. South Field, b. Mosaic of Shrub and Field Areas.

a.

b.

Fig. 4

Phlox, Prickley-pear Cactus, Pale Evening Primrose, Balsamroot, Desert Parsley, Lupine, Yarrow, Fleabane, Antelope Bitterbrush; Brodiaea, Wall-flower, and Tarweed Fiddleneck. Later in the summer, Russian Thistle germinates in the fields and becomes more prominent.

The fields themselves are Cheatgrass mixed with Sandberg's Bluegrass with occasional patches of Jim Hill Mustard. Variations of this include two fields with Bluebunch Wheatgrass, sparsely distributed, and one field with Gray Rabbitbrush and Big Sagebrush sparsely distributed. The main vehicle entrance to the site is via a test well access road.

The second concentrated study area was the 100-H/100-D study site located between the 100-H and 100-D Areas directly adjoining the Columbia River. This location is markedly different from the 300 Area study site in physical appearance (Figure 5). It is larger (approximately 15.48 km^2), more open, and lacks the lushness of vegetation that is present at the 300 Area site. The major vegetation type is Sagebrush/Cheatgrass-Sandberg's Bluegrass. It is comprised almost exclusively of abandoned fields and orchards with only scattered areas of sparsely distributed shrubs (Big Sagebrush, Spiny Hopsage, Gray Rabbitbrush, and Buckwheat). Most of the fields are Cheatgrass-Sandberg's Bluegrass; Jim Hill Mustard is extensive in some areas and Munro Globe-mallow is common, blooming profusely in the spring. There are two groves of trees along the River, several old fruit orchards, and numerous trees planted at old homesites. The entire site is criss-crossed with old roadways, most of which were originally abandoned by the AEC. The surface is relatively flat and declines toward the River. The shoreline drops off abruptly near the 100-H Area, but it descends more gradually towards the 100-D Area where a large cobble beach of riverwash extends out along the water.

Figure 5. Habitat at the 100-H/100-D Study Site. a. Adjacent to Columbia River Showing White Bluffs, b. Vicinity of "Study-Plot-Road" Territory.

a.

b.

Fig. 5

The third study site of approximately 5.18 km² lies southeast of the 100-F Area along the Columbia River. Though not as frequently visited as the first two areas, it was used most consistently for observations during the brood period. There is one large main field of very dense Cheatgrass, and a test well access road runs north and south through the site dividing this field. Along the north edge is an old burn which is now covered with blackened Big Sagebrush stumps, Russian Thistle, and grasses. Sagebrush/Cheatgrass-Sandberg's Bluegrass vegetation surrounds several smaller Cheatgrass fields. Sand Dropseed is very prominent in one field and an old asparagus patch continues to come up each year. Jim Hill Mustard occurs over much of the site and several trees grow along the River bluff. The topography is gently undulating with sandy ridges except for the fields which were leveled when originally farmed.

PROCEDURES AND METHODS

Summary of Records

In addition to the data collected in the field, I compiled all the available records for the Long-billed Curlew on the major National Wildlife Refuges in Washington, Southern Idaho, Utah, Nevada, California, and Oregon. Census information was taken from the Refuge Quarterly Reports for 1960 and 1970 to June of 1976. I also drew upon communications with Battelle personnel, U. S. Fish and Wildlife Service personnel, and reports of private individuals.

Study Areas

The 300 Area study site was selected because it supports the highest density of nesting Long-billed Curlews on the Hanford Site. It also contains the major habitat types used by Long-billed Curlews in other Southeastern Washington breeding areas.

Field work started 15 March 1976 and covered the breeding seasons of 1976 and 1977. I visited the 300 Area study site daily from early March until mid-July when all the curlews were gone. I spent time at the secondary study sites on a rotating basis; the time of day, duration, and frequency of these visits depending upon the phase of the breeding cycle. Other areas of the Hanford Site were censused weekly or biweekly.

Descriptive details of the Hanford Site were developed from my field notes, U. S. Geological Survey maps, and Battelle Northwest documents (Cline, et al., 1975 and Stone, Jenne, and Thorp, 1972).

Habitat Analysis

Replicated 50 m transects were laid out in each of the major curlew utilization areas. The transect lines were chosen so as to characterize the nesting fields and the feeding habitats of each area. Canopy coverage provided by herbaceous taxa was measured by reading fifty, 2 x 5 dm, plot frames systematically spaced at 1 m intervals on each line transect. From 100 to 300 plots were read in each area, depending on the variability and utilization. Canopy coverage for each taxon was ocularly estimated using a method developed by Daubenmire (1959). A modification of the method was to separate species into litter and live categories and to treat the two categories as separate "taxa" for analysis. Total live canopy coverage and total litter canopy coverage were also estimated. As classification numbers are often modified by individual investigators using this method, they are given here: 1 = 0-5%, 2 = 5-25%, 3 = 25-50%, 4 = 50-75%, 5 = 75-95%, and 6 = 95-100%. Frequency of occurrence was calculated as percentage of the total number of examined plots in which a particular taxon was present. All field data on habitat analysis were obtained between June 6 and 13 of 1977. Summaries of field data are presented in Appendix B.

Weather Data

Summarizations of the climatological data from the Hanford Meteorology Station located at 223 m elevation near the center of the Hanford Site have been used.

Observations on Curlew Behavior

Observations, aided by 7 x 50 power binoculars and a 15-60 variable power spotting scope, were made in two ways. The first, and most productive prior to hatching, was from six stationary blinds placed in strategic locations

overlooking eight territory nest fields on the 300 Area study site. The blinds were constructed of brown burlap and measured 1.2 x 1.2 x 1.5 m with a window on each side which could be pinned open or closed. At the 300 Area study site my truck was always parked in one location, and set pathways to the blinds were used. This routine was intended to reduce impact on the vegetation and to habituate the birds to my presence as much as possible.

The second means of observation was from a pickup truck parked along a roadway. This method was used during the entire 1976 breeding season. During 1977, it was used on all curlew areas other than the 300 Area study site and for all brood period observations. The majority of the behavioral observations was made in the open fields where the birds could be readily seen, and descriptions of displays are based on what was considered typical for the species.

Nest Study

After the Long-billed Curlews had started incubating at the 300 Area study site in 1976, the fields were systematically searched for nests. One method was to drag the fields using a piece of conduit approximately 6 m long with strips of cloth tied to it. A bell was pinned to the free end of each strip of cloth to create noise. However, sitting and watching the birds proved less destructive to the grass cover and far more productive in locating nests. A nest location was first approximated using the surrounding features during nest relief, then approached and marked with a small white flag placed about 5 m away.

The eggs in each nest were weighed in a plastic bag using a 300 g spring scale and individually marked with a colored dot on the tip of the small end. The eggs were subsequently weighed weekly until hatching. By the

identifying dots I was able to study the fate of each egg, the hatching sequence within the nest, and the duration of hatching. After each examination, the area around the nest and along the approach route was sprinkled with paradichlorobenzine granules to mask my scent which might otherwise lead Coyotes or other mammalian predators to the nest site. After hatching, the broken shells were collected from each nest. Eggs failing to hatch were also collected.

During the 1977 breeding season, active nests were not approached and the nest fields were not traversed. I was advised that certain behavioral patterns which I observed and thought to be normal in 1976 were actually abnormal and a result of my disturbance at the nest site (Tremaine, personal communication). Also, walking through the fields left scars for the remainder of the season. At the end of the breeding season scrapes were measured, photographed, and described.

Capturing and Banding

Standard U. S. Fish and Wildlife Service bands (size 5) were placed on all captured Long-billed Curlew chicks. Numbered, colored, plastic leg bands (National Band and Tag Co., Newport, Kentucky) were used to identify individual birds and also year and place of origin. Most chicks were weighed, measured, and banded as soon as they hatched. Others were caught by hand at a later age. I withheld marking the birds in any way which might adversely affect their natural camouflage and make them more susceptible to predation. Notes requesting band returns were sent to North American Bird Bander, National Audubon Society, The Murrelet, The Auk, The Wilson Bulletin, The Wildlife Society, and The Condor for publication. Flyers were also sent to Mexico and to all the National Wildlife Refuges in Washington, Oregon, Idaho,

California, Arizona, Nevada, Utah, New Mexico, and Texas requesting information on band sightings.

Attempts to capture adult Long-billed Curlews were futile. Mist-netting, night-lighting, and hand-netting of incubating adults were employed in this endeavor, but all were unsuccessful. Stevanovic and Ham (1970) reported success in catching curlews with vertical nets. Their attempt, however, was during September when the birds roost in large flocks.

Censusing

Censusing of Long-billed Curlews on the Hanford Site was done throughout the breeding season by making weekly road counts that consisted of stopping every quarter mile, walking a short ways off the road, imitating a curlew call, and recording the number and sex of the curlews which responded. Birds were also counted at loafing and staging areas on a daily basis toward the end of the 1977 season. Also in 1977, one Columbia River census was made in which the islands and shorelines between Vernita Bridge and Richland were searched.

Weights and Measurements

Any time a chick was captured for banding, it was also weighed and measured. Small chicks were weighed in a plastic bag with a 300 g hand-held spring scale. Larger juveniles were weighed with their wings secured with velcro straps on a 1,610 g platform balance. Measurements were taken on all birds using vernier calipers or a millimeter straightedge. These are described here as some of them do not follow conventional methods. (1) Length of tarsus (tarso-metatarsus) as measured diagonally from the point of the tibia/metatarsus joint behind, to the point of the metatarsus/middle toe

joint (Figure 6a). (2) Length of exposed culmen from the point where the feathers of the forehead end straight to the tip of the culmen (Figure 6b). (3) Length of bill from gape as measured by the chord, straight from the tip of the maxilla to the corner of the mouth (Figure 6c). (4) Length of middle toe as measured on the dorsal surface with the foot bent back from the point of the joint with the tarsus to the tip of the toe exclusive of the claw (Figure 6d). (5) Length of hallux as measured along the ventral surface between the point of juncture with the tarsus and the tip exclusive of the claw (Figure 6e). On older juveniles, wing chord and tail measurements were also taken. (6) Length of closed wing (wing chord) as measured from the farthest anterior point to the tip of the longest primary, without attempting to straighten the curve of the feather (Figure 6f). (7) Length of tail as measured from the insertion point of the two middle rectrices to the tip of the longest tail feather when the tail is closed (Figure 6g).

Three chicks were recaptured at a later date and were again measured and weighed.

Four adult Long-billed Curlews were collected, weighed, and also measured as above. In addition, the extent of wings with feathers was measured as the distance between the tips of the out-stretched wings from the farthest primary tip on one side to the farthest primary tip on the other by laying the bird flat on its back and grasping each wing at the carpal joint to spread the wings out along a ruler as far as possible without injuring the bird or flattening the wing quills (Figure 6h).

Study skins were prepared for future reference and are in the Museum of Natural History, University of Puget Sound, Tacoma, Washington.

Figure 6. Methods of Measuring Curlews. a. Length of Tarsus, b. Length of Exposed Culmen, c. Length of Bill from Gape, d. Length of Middle Toe, e. Length of Hallux, f. Length of Closed Wing, g. Length of Tail, h. Extent of Wings with Feathers.

Fig. 6

Fig. 6--cont.

Predation Study

Time-lapse cameras were set up in several of the blinds overlooking nests at the 300 Area study site to record predation. The cameras were mounted in rainproof boxes lined with foam, then mounted on wooden stakes inside the blinds. The cameras were set to take one frame every 60 seconds. Where the predator at a nest site was not seen or filmed, the remaining evidence was examined for possible identification of the predator.

Sex and Age Determination

I judged sex of adult Long-billed Curlews by configuration and length of the bill in proportion to the head. In profile, the bill of the female is more than three times the length of the head; in the male the bill is three times or less than the length of the head (Figure 7). In addition, the bill of a male has a more perfectly symmetrical curve whereas the female bill is rather flat on top with a more pronounced curve towards the tip. This method of distinguishing sex was devised by Tremaine (personal communication) for curlews in Nebraska and is accurate and easy to use after a little experience. Also, the female of a pair is often larger (up to one-third larger) than the male, but this is a difficult criterion to use by itself unless both members of the pair are present for comparison. Juveniles (birds of the year) can be separated from adults by their noticeably shorter bill length.

Data Analysis

Program COVER written by R. H. Sauer (Battelle Northwest Laboratories, Richland, Washington) specifically to handle habitat analysis data obtained with Daubenmire's (1959) method was used to combine the habitat data. This program provides the following: percentage coverage by species, relative coverage and species diversity, and frequency of occurrence. Weights and measurements were compared with t-Tests.

Two large cameras were set up in several of the plots overlooking
the 100 Area study site to record predation. The cameras were
mounted in rainproof boxes fixed with foam, then mounted on wooden stands
beside the plots. The cameras were set to take one frame every 30 seconds
where the operator at a post site was not seen or filmed. The film
evidence was examined for possible identification of the predator.

Sex and Age Determination

I judged sex of adult long-billed larvae by configuration and length
of the bill in proportion to the head. In general, the bill of the female
is more than twice the length of the head, in the male the bill is twice
as long as the head (Figure 7). In addition, the bill of
a male head more perfectly symmetrical curve whereas the female bill is

Figure 7. Comparison of Bill Length between Male and Female.

Female in Foreground.

Fig. 7

PLUMAGE, MORPHOLOGY, AND SEXUAL MATURITY

Plumage

Adults

The plumage of adult Long-billed Curlews is well described by many authors (Bailey, 1904; Bent, 1962; Brooks, 1920; Dawson, 1909; Grinnell and Hunt, 1929; Griscom, 1939; Palmer, 1967; Ridgeway, 1919; Suckley, 1860; and Wilson and Bonapart, 1831). Palmer (1967) and Ridgeway (1919) made a distinction between nuptial and winter plumages, and both noted that in the winter plumage the under parts are darker or deeper pinkish in color. Bent (1962) reported the juvenile plumage to be somewhat more tawny than the winter adult plumage, especially below, and the streaks on the neck and the breast to be fewer and narrow. Suckley (1860) thought the overall rufous shade of the adult plumage to be more distinct in the young. On the basis of the four adult skins in nuptial plumage which I have and four juveniles which were examined during the postnatal molt, I found the following:

- (1) the streaks on the neck to be fewer and less pronounced (narrow and smaller) in the juvenile plumage than in the nuptial plumage (per Bent),
- (2) except for a few lateral feathers, the breast of the juveniles to be completely unstriped, unlike the adults which are conspicuously striped, and
- (3) the juvenile plumage to be more rufous or with a deeper pinkish-cinnamon cast than the nuptial plumage (per Suckley). If the adult winter plumage is a deeper pinkish or rufous than the adult nuptial plumage, then the juvenile plumage may be more tawny when compared at that time (per Bent).

Grinnell and Hunt (1929) reported that the female Long-billed Curlew has a much pinker flush over the body and wings than does the male, and that as a rule the male shows more white on the wing coverts. I cannot pick out either characteristic in the four skins which I have (one female and three male), and the sexes appear indistinguishable on the basis of plumage. In addition, my field observations did not reveal any sexual dimorphism in plumage. Individual birds could be identified by feather aberrations and/or variations in the feather patterns, but these could not be used as a key to the sex of the bird.

Chicks

The downy young were described briefly by Allen and Kyllingstad (1949), Bent (1962), Ridgeway (1919), and Palmer (1967) as basically buffy colored with irregular dark brown markings. According to Bent (1962), the buffy color varies from "warm buff" on the breast and flanks to "cream buff" on the face, upper parts, and belly, and to "cream color" on the throat with the crown even paler.

After banding several chicks at the 300 Area study site, I noticed what at first appeared to be two color phases in the newly hatched chicks. Of six broods, three chicks were entirely "cream colored" on the breast and belly and 10 were "warm buff" to varying degrees on the breast and belly. The three "cream colored" chicks were from separate nests. I thought this might indicate a difference in sex, but all 12 chicks from five broods banded at the 100-H/100-D study site were cream colored, and the probability is remote that all the chicks would be the same sex. If a large number of chicks were examined, one would probably find a gradation of colors from one extreme to the other.

Weights and Measurements

The weight and measurements of 22 Long-billed Curlews at hatching are given in Table 1. Table 2 gives those measurements at hatching published by two other authors, but neither of them describe their measurement procedures. I believe weight and exposed culmen measurements are comparable between us, but not the tarsus length because the wide variation suggests different measuring techniques. A Bonferroni t-Test (Miller, 1966) indicates that the weights from these three studies are significantly different from one another ($\alpha = 0.05$); the Long-billed Curlew chicks from Washington were significantly lighter at hatching than those from Utah or Colorado. On the other hand, an analysis of variance on the length of the exposed culmen does not show significant variation among the three groups ($\alpha = 0.05$).

Table 3 gives the weight and measurements of juveniles and adults. Forsythe (1973) reported the growth in length of the exposed culmen, tarsus, and middle toe of chicks to be linear but not at equal rates. I do not have enough data points to comment on this.

In the same format as presented by Grinnell (1921), Figure 8 compares the adult measurements found by me, Grinnell (1921), Oberholser (1918), and Ridgeway (1919). The latter two authors classified their specimens into two distinct subspecies on the basis of size, but as Grinnell pointed out, there is a significant degree of overlap between the two and most of the measurements are for migrants. The specimens from Washington tend to align more closely with the N.a. parvus specimens of Ridgeway and Oberholser than with their N.a. americanus specimens. This is particularly apparent for exposed culmen. The shortness of the bill in parvus as compared with americanus is the characteristic which has been emphasized most; however, my small sample size (four birds) precludes definitive conclusions.

TABLE 1
Weight and Measurements of Long-billed Curlews at Hatching

Chick No.	Hatching Date	Weight (gm)	Tarsus (mm)	Culmen (mm)		Middle Toe (mm)
				From Gape	Exposed	
1	5-11-76	52	47.1	27.0	20.3	33.8
2	5-11-76	51	45.3	27.0	20.2	34.4
3	5-11-76	50	43.3	25.3	20.7	33.8
4	5-11-76	56	44.3	26.0	19.6	33.5
5	5-11-76	51	45.2	25.2	18.5	33.5
6	5-12-76	50	43.6	25.3	20.6	35.8
7	5-12-76	44	45.1	23.9	21.5	37.7
8	5-13-76	56	45.2	26.5	21.3	35.4
9	5-13-76	52	46.5	27.8	20.3	35.1
10	5-13-76	53	42.8	24.8	19.0	34.8
11	5-14-76	47	44.2	24.5	19.5	38.0
12	5-14-76	50	42.5	24.7	20.2	35.9
13	5-14-76	49	44.7	26.2	21.5	36.9
14	5-25-76	48	46.7	25.8	21.1	36.0
15	5-25-76	50	43.8	25.2	22.0	35.7
16	5-25-76	50	45.5	26.5	22.3	35.5
17	5-29-76	45	39.7	23.2	18.5	30.6
18	5-29-76	47	42.5	26.5	20.8	35.0
19	5-29-76	46	40.4	28.5	22.1	34.2
20	5-29-76	47	41.6	25.6	21.9	32.4
23	6-3-76	53	48.5	28.5	24.5	37.0
24	6-3-76	46	46.5	30.0	25.0	37.1
mean ± standard error		49.7 ± 0.69	44.3 ± 0.47	26.1 ± 0.34	21.0 ± 0.35	35.1 ± 0.38

TABLE 2

Published Weight and Measurements of Long-billed Curlews at Hatching

Chick No.	Hatching Date	Weight (gm)	Tarsus (mm)	Exposed Culmen (mm)	Author
1	5-24-66	56.6	35	22	Forsythe (1973)
2	5-24-66	55.6	31	21	Forsythe (1973)
3	5-24-66	57.6	41	21	Forsythe (1973)
1	6-3-69	66.0	46.0	22.0	Graul (1971)
2	6-3-69	62.0	47.0	22.0	Graul (1971)
3	6-3-69	62.0	47.5	22.0	Graul (1971)

TABLE 3

Weight and Measurements of Juvenile and Adult Long-billed Curlews

Bird No.	Date	Sex	Age ¹	Weight (gm)	Wing Chord (mm)	Tarsus (mm)	Culmen (mm)		Tail (mm)	Middle Toe (mm)	Hallux (mm)	Wing Span (mm)
							From Gape	Exposed				
21	6-3-76	Unk.	Juv.	164	--	72.5	45.2	38.5	--	43.0	10	--
22	6-3-76	Unk.	Juv.	187	--	73.0	47.2	39.7	--	43.4	10	--
25	6-7-76	Unk.	Juv.	129	--	63.5	43.7	38.7	--	42.0	10	--
5 ²	5-19-76	Unk.	8 days	55	--	49.6	30.7	22.8	--	37.7	11	--
21 ³	6-10-76	Unk.	Juv.	250	--	81.9	53.4	48.4	--	44.4	10	--
13 ²	6-14-76	Unk.	31 days	383	182	89.2	62.8	56.0	--	47.1	12	--
26	6-9-77	♀	Ad.	533.9	269	88.4	129	131	108	45.8	10	944
27	6-9-77	♂	Ad.	494.4	255	88.2	124	120	99	44.8	11	887
28	6-9-77	♂	Ad.	502.2	269	87.9	116	113	109	43.4	11	909
29	6-15-77	♂	Ad.	541.4	272	86.8	120	120	108	46.2	10	918
30	6-13-77	Unk.	Juv.	308.3	163	89.4	59	54	62	43.0	11	--

¹Ad = Adult, Juv. = Juvenile chick of unknown age.²Recaptured after banded as chick, see Table 1.³Recaptured after banded as juvenile.

TABLE 3
Height and Measurements of Juvenile and Adult Long-billed Curlews

Sex	Age	Wing Chord (mm)	Exposed Culmen (mm)	Tail (mm)	Wing (mm)	Height (mm)
♂	Juvenile	100	30.5	100	100	100
♂	Adult	100	30.5	100	100	100
♀	Juvenile	100	30.5	100	100	100
♀	Adult	100	30.5	100	100	100

Figure 8. Presentation of Measurements of Adult Long-billed Curlews. a. Wing Chord (mm), b. Exposed Culmen (mm), c. Tail (mm). Values are Maximum, Minimum, and Mean.

Sex	Age	Wing Chord (mm)	Exposed Culmen (mm)	Tail (mm)	Wing (mm)	Height (mm)
♂	Juvenile	100	30.5	100	100	100
♂	Adult	100	30.5	100	100	100
♀	Juvenile	100	30.5	100	100	100
♀	Adult	100	30.5	100	100	100

WING ♂

WING ♀

a.

Fig. 8

EXPOSED CULMEN ♂

EXPOSED CULMEN ♀

b.

Fig. 8--cont.

TAIL ♂

FITZNER (N. americanus)	(3 SPEC.)	99	105.3	109
GRINNELL (1921, N. americanus)	(7 SPEC.)	95.2	103.6	108.5
OBERHOLSER (1918, N.a. americanus)	(3 SPEC.)	109	121	128
RIDGEWAY (1919, N.a. americanus)	(10 SPEC.)	105.5	114.2	128.3
OBERHOLSER (1918, N.a. parvus)	(7 SPEC.)	105	112	117
RIDGEWAY (1919, N.a. parvus)	(10+ SPEC.)	96	108.6	123.7

TAIL ♀

FITZNER (N. americanus)	(1 SPEC.)	108		
GRINNELL (N. americanus)	(7 SPEC.)	99.6	105.4	108.6
OBERHOLSER (1918, N.a. americanus)	(3 SPEC.)	121	126	136
RIDGEWAY (1919, N.a. americanus)	(11 SPEC.)	104	118.4	135.6
OBERHOLSER (1918, N.a. parvus)	(3 SPEC.)	104.5	111	116
RIDGEWAY (1919, N.a. parvus)	(11+ SPEC.)	104	110.2	116

c.

Fig. 8--cont.

Comparing the measurements of the three males from Washington with the seven males measured in California by Grinnell (1921), those for body weight and length of exposed culmen differed significantly (t -Test, $\alpha = 0.05$). Wing chord and tail measurements, however, showed no significant difference at the 0.05 level. Table 4 summarizes his data and mine.

Age at First Breeding

I observed small flocks of birds which would pass through the nesting areas after nesting was well underway. These small groups would frequent the areas adjacent to the territories for up to a week at a time where they would be seen walking-and-feeding leisurely as a group. They showed no migratory restlessness. Occasionally such a group would alight in one of the nest fields to feed, but they were rarely driven out by the territory holders. In addition to this group behavior which is distinctive from that of migrants, the group members all appeared to have a shorter, male-length bill. Taverner (1934) stated that the bills of curlews continue to grow for some time after apparent maturity. Possibly the birds I observed were one year old subadults who would not reach sexual maturity until the following year and whose bills were, therefore, not yet fully developed.

TABLE 4

Comparison of Adult Measurements Obtained in this Study with those of Grinnell (1921)

Specimens	Weight (gm) $\bar{x} \pm \text{S.E.}$	Culmen (mm) $\bar{x} \pm \text{S.E.}$	Wing Chord (mm) $\bar{x} \pm \text{S.E.}$	Tail (mm) $\bar{x} \pm \text{S.E.}$
Males				
Grinnell (7 spec.)	693.0 $\pm$ 21.85	132.91 $\pm$ 3.59	261.0 $\pm$ 2.94	103.62 $\pm$ 1.72
Fitzner (3 spec.)	512.67 $\pm$ 14.54	117.67 $\pm$ 2.33	265.33 $\pm$ 5.24	105.33 $\pm$ 3.18
Females				
Grinnell (8 spec.)	815.64 $\pm$ 36.34	175.81 $\pm$ 6.11	282.63 $\pm$ 2.67	105.84 $\pm$ 1.09 ¹
Fitzner (1 spec.)	533.9	131	269	108

¹Only 7 specimens

DISTRIBUTION

The present distribution of the Long-billed Curlew has not been adequately described; although common in parts of its range, its distribution, and abundance throughout its range are poorly understood. Included in this section is information from National Wildlife Refuge (NWR) records, which is tenuous at best but does map the distribution of Long-billed Curlews in the areas where it was collected.

Breeding Range

Western United States

National Wildlife Refuge records which I have summarized show curlews during the breeding season on or near the following refuges (see Figure 9): Columbia, Saddle Mountain, McNary, Toppenish, Cold Springs, Umatilla, Deer Flat (Sand Hollow area between Ontario and Caldwell), Minidoka, Malheur, Clear Lake, Upper Klamath, Lower Klamath, Tulelake, Modoc, Sacramento, Colusa Delevan, Salton Sea, Imperial, Havasu, Stillwater, Ruby Lake, and Bear River. Of these, nesting populations are thought not to occur at Imperial or Havasu; the birds present being uncommon migrants. Although curlews are year-round residents in the Sacramento Valley (where Sacramento, Colusa, and Delevan NWR's are located), they are not known to nest (Manolis and Tangren, 1975). Long-billed Curlews are also present throughout the year in varying numbers in the Imperial Valley (Salton Sea NWR), but again are not known to nest (McCaskie, 1970). As my search was restricted to the NWR system, the possibility remains that curlews may occur in other locations during the breeding season.

Fig. 9

Washington

Within the State of Washington most of the curlew population is restricted to the Columbia Basin. Figure 10 shows the areas within and adjacent to the State where known breeding populations exist. Additional populations undoubtedly exist elsewhere in the State as well. The distribution of curlews on the Hanford Site is shown in Figure 11.

Winter Range

Long-billed Curlews do not winter in Washington, Oregon, Idaho, Utah, or Nevada. As previously noted, curlews are year-round residents in the Sacramento and Imperial Valleys of California. Spring migrants apparently move northward up the west coast of Mexico and concentrate in the Gulf of California. The Salton Sea, situated just north of the head of the Gulf of California, is the last large body of water these birds find before they encounter the desert areas of Eastern California. Spring and fall concentrations of Long-billed Curlews at the Salton Sea suggest that they are wintering in Mexico or farther south.

A recent feeding behavior and diet study (Stenzel, Huber, and Page, 1976) also identified a wintering population on Bolinas Lagoon northwest of San Francisco, California on the Pacific Coast. Forsythe (1970) observed wintering curlews in Texas at Aransas NWR, Aransas County, and at Kingsville and Padre Island National Seashore Monument, Kleberg County.

Bystrak (1974) mapped the wintering areas of bird species summarized from Audobon Christmas Bird Counts nationwide (a 1971-72 average in the case of the Long-billed Curlew). In addition to the Sacramento and Imperial Valleys in California, he shows curlews in the San Joaquin Valley, the

Figure 10. Map of Washington Showing Areas where Curlews were Recorded for 1976-1977.

Fig. 10

Figure 11. Map of the Hanford Site Showing Location of Areas, Diagonally Lined, Utilized by Long-billed Curlews.

Fig. 11

San Francisco Bay area, and along much of the coast. In Texas, the birds concentrate inland around Midland (Midland County), around San Angelo (Tom Green County), and in the area between these two cities. The Texas and Louisiana Gulf Coast regions are shown to be very popular. The only other sightings shown are in Florida: Monroe County, the Tampa Bay area, the Merritt Island area, and around Jacksonville.

BREEDING POPULATION NUMBERS

The fact that no total census of Long-billed Curlews exists reflects formidable logistics of surveying a range characterized by widely scattered pockets of suitable habitat within forbidding terrain remote from centers of human habitation. Moreover, the pairs disperse widely during the breeding season and their characteristic shyness makes them difficult to locate. None of these factors has encouraged an effort to make a complete count.

For reference, McCallum, et al. (1977) reported 73 sightings involving 226 individual curlews in 13 counties for two breeding seasons in Colorado. Whether that figure is the breeding population of the State or the sum of birds counted in two years is not clear. Either way, the numbers are few. The number of Long-billed Curlews on Bolinas Lagoon (a wintering area) consistently averaged 40 during the study conducted by Stenzel, et al. (1976).

The Hanford Site and adjoining Wahluke Slope together support a Long-billed Curlew population of approximately 300 birds during the breeding season. The Hanford Site west of the Columbia River has a resident population of approximately 100 birds. Of these approximately 60 are paired, 20 are unpaired but territorial males, and 20 are unemployed individuals.

MAINTENANCE BEHAVIOR

Comfort Movements

Comfort movements are those maintenance activities which aid in the care of the body and which are not concerned with feeding, locomotion, or resting. Some of these movements differ in form from group to group and have been used in classification. For example, Simmons (1957), by using the method of head scratching as a character, placed the recurvirostrids near the charadriids rather than near the scolopacids.

Two-wing Flap

The Two-wing Flap is a movement whereby the head and neck are stretched upwards and the angle of the back is increased slightly. Simultaneously, the wings are extended vertically into the air over the head to their full extent and fluttered briefly. The wings are then held extended in a pause (Figure 12a). The bird rises on its toes and commonly an individual will lift off the ground several centimeters while performing the fluttering phase of the movement. The Two-wing Flap was regularly observed in flocks of birds at loafing sites where it appeared to be preparatory for flight. It also appeared to signal impending flight to neighboring birds and thus was an aid in coordinating departure. The Two-wing Flap was also observed in birds on their territories, and in these cases it presumably functioned in stretching cramped muscles.

Figure 12. Comfort Movements. Typical Postures Illustrated. a. Two-wing Flap, b. Two-wing Stretch, c. Direct Head Scratch, d. Bathing, e. Feather Shaking.

Fig. 12

Two-wing Stretch

The Two-wing Stretch (Figure 12b) is a movement whereby the body is brought to a near horizontal position with the head and neck extended anteriorly. Simultaneously, the wings are extended vertically into the air over the back and to their full extent. The bird stands squarely on both feet. The Two-wing Stretch is performed slowly and deliberately and lasts for several seconds. It does not appear to have any social significance and was most commonly observed following resting.

Wing and Leg Stretch

Another form of stretch is the Wing and Leg Stretch. In this movement a leg is stretched backward, extended, and held as the wing on the same side is partially extended and stretched downward and backward next to it. This stretch also does not appear to have any social significance as only one bird was observed to give the Wing and Leg Stretch at a time. Those birds in which it was observed were walking-and-feeding and merely paused briefly to stretch.

Scratching

In the suborder Charadrii, two methods of head scratching are found. The scolopacids scratch directly (i.e., the foot is brought directly to the head) and the charadriids scratch indirectly (i.e., the bird lowers a wing and brings the corresponding leg over the shoulder) (Simmons, 1961). Long-billed Curlews scratch the head directly with the foot (Figure 12c) and were never observed to use the indirect method. Scratching presumably functions to alleviate some irritating stimulus, and as such a stimulus is likely to be present at any time, another activity is usually interrupted for scratching purposes. The foot is used for scratching all parts of the head and those

areas of the breast and neck where the bird can reach. Other areas of the body are "scratched" with the bill, the tip of which is directed to the location of the stimulus and the mandibles rapidly move back and forth at the site. Some individuals showed a much greater tendency to scratch than others, which was possibly a reflection of the presence, absence, or abundance of ectoparasites which the individual harbored.

Bathing

A bathing bird (Figure 12d) lowers itself into knee-deep water by bending the legs until the breast is at water level. The bird then wets itself by repeatedly rocking forward rapidly and submerging the head in a dipping motion. Simultaneously, the wings are quivered slightly. Once wet, the bird briefly beats the water with its folded wings. This is done in a head-up position. Afterward the bird stands, shakes off the excess water, moves to shallow water or to shore, and preens. Frequently during preening, the bird will extend and flap its wings several times. The form of bathing by Long-billed Curlews did not differ noticeably from what I have observed in domestic geese. Bathing was frequently observed to be performed simultaneously by two or more birds at the same location. As bathing was a relatively uncommon activity, the sight of one bathing bird likely stimulated others to bathe. Solitary bathers, however, were also observed.

Preening

Preening consists of manipulating and arranging the feathers with the bill. Oil is obtained from the uropygial gland with the bill and is manipulated into the feathers. While preening, birds will frequently rub the top of the head over the back and sides. This helps to spread the oil over the feathers and probably serves to preen the top of the head which cannot be

reached with the bill. Preening birds usually stand on both feet with their feathers ruffled up. A pair will stand within a meter of each other, facing the same direction, and preen. If it is windy or hot, the birds seek the shelter of a large shrub for protection and shade. Complete preening of the body lasts a minimum of five minutes, but many times throughout the day the birds stop and preen one particular area briefly before proceeding with another activity. Preening was most commonly observed interspersed with feeding or preceded by feeding and followed by resting. Many curlews in flocks loafing along the River are often observed preening simultaneously, demonstrating the social nature of the activity. In this situation birds were sometimes observed preening while standing on one leg, and occasionally a bird would lose its balance resulting in a "hop-and-flap" sequence as the bird would attempt to recover equilibrium without putting the other foot down. (A hop-and-flap consisted of a bird hopping a short distance to the side on one leg while simultaneously extending and flapping its wings several times.)

Feather Shaking

Feather Shaking is a generalized ruffling of the feathers brought about by a shaking of the body while standing on both feet with the head and neck extended out in front (Figure 12e). As a comfort movement, Feather Shaking was closely associated with preening and resting, and both of these activities were commonly preceded and followed by it. During cold or rainy weather the birds would stop and shake frequently, presumably to enhance heat retention. Feather Shaking was also observed in the morning after the birds stood up from roosting for the night and after bathing as previously noted.

Other Comfort Movements

Bill shaking (not to be confused with Shaking behavior discussed under Sexual Displays and Postures) consists of a violent shake of the head, usually only once. Birds were observed to stop momentarily, shake the head, and often scratch the head before proceeding. Therefore, possibly it is a movement in response to some irritating stimulus. Additionally, a male would sometimes shake his bill following a prolonged and unsuccessful mating attempt.

Foot shaking consists of rapidly shaking a foot and was observed in two types of situations. First, this movement was performed as a leg was being raised into the one-leg resting position and was presumably to remove debris. Second, shaking of the trailing foot was occasionally seen while a bird was walking-and-feeding. Here the movement appeared to rid the foot of debris or entanglement in the vegetation.

Feather-arranging movements, such as the shaking of the tail or lowering of the tail, are often observed especially after bathing or when a bird is preening. Shaking of the tail was also sometimes performed by one or both members of a pair following a courtship/mating sequence and by participants at the conclusion of an agonistic interaction. In addition, it was common to see a bird shake its tail while walking-and-feeding.

While resting or walking-and-feeding, birds were occasionally observed to raise their feathers which produced the same visual effect as Feather Shaking. However, the plumage would often be held in the raised position for a minute or so before the bird would resume its usual profile.

Resting

The basic characteristic of resting is a lack of or a minimizing of activity which probably results in minimal expenditures of energy. The most common behavior that can be included in resting is sleeping, but unfortunately

it is not always possible to tell if a bird is, in fact, sleeping. Consequently, no attempt was made to differentiate sleeping from resting. I considered as resting (1) all birds in one of three resting postures and (2) birds that were stationary and preening at very low intensities. Birds preening at low intensities were considered as resting because preening frequently immediately precedes and follows resting, and the transition from one to the other is difficult to differentiate. Also, when birds were mildly disturbed while resting they frequently preened before resuming their rest.

Curlews rest facing into the wind so that in any given area, all resting individuals are found facing the same direction. On their territories they will seek wind protection and/or shade from whatever shrubs are available, even though such a position appears to block their view in at least one direction.

Resting Long-billed Curlews assume several distinct postures. In terms of energy expenditure, the different postures are probably roughly equivalent and I was unable to associate the different postures with particular situations or time intervals except that during inclement weather only the hunch-down posture was observed.

In the bill-back position the bill is placed under the scapulars; the legs may be in either of two positions. In one method the bird stands on both legs, whereas in the other the bird stands on one leg with the other tucked under the breast (Figure 13a). In the one-leg method, the leg is brought up into position sometimes before and sometimes after the bill is placed on the back. When the head is turned around, the wing on the opposite side is lifted slightly to allow the bill to slip under the scapulars, but there was no correlation between the direction the head was turned and the leg that was raised. When resting in this position is terminated, the head is turned forward before the leg is lowered.

Figure 13. Resting Postures. a. Bill-Back, b. Hunch-Down, c. Sitting.

Fig. 13

In the hunch-down posture (Figure 13b), the bird stands on both feet facing forward with the head and neck retracted into the shoulders. The feathers are often fluffed up, particularly during inclement weather. Often too, the tail is dropped below the level of the primaries.

Long-billed Curlews often employ another method of resting in which they sit on the ground with both legs tucked under their breasts. While sitting (Figure 13c), the bird usually faces forward with the neck semi-retracted. Less frequently the bill is turned back and placed under the scapulars. Curlews are likely to rest sitting if it is a hot day, and migrants most commonly rest in this position.

Feeding

Long-billed Curlews, like other waders, are opportunists, feeding on whatever foods are available. Consequently, one expects considerable differences in the diets of birds at different localities or at different times of the year.

On their breeding grounds the Long-billed Curlews appear to feed entirely by day. They feed within and throughout their territories as well as elsewhere on the Hanford Site and in the irrigated fields nearby. Prior to incubation, a pair will feed together with one following the other or both wandering in separate directions and eventually rejoining. Commonly I saw them 50 m or more apart when out in the open field. Usually visual contact is maintained, but vocal communication also plays an important role especially in the shrub areas. A soft "Curlee Curlee" or "Wheet Wheet" call is used for this. When too great a distance is reached, one bird, usually the male, will fly over to the other and land nearby, then continue feeding. Once incubation has begun, the unattending individual feeds alone when on the territory.

Detailed analysis of the different habitat areas used for feeding can be found in Appendix B. Nest fields were also used for feeding prior to incubation but have been tabulated separately for discussion under Nesting. At the 300 Area study site the partially exposed dune areas and ridge areas (groups J and K, respectively in Appendix B) had the greatest variety of plant species and were also the most preferred for feeding.

In an attempt to be consistent with other authors, I have assigned the feeding movements of curlews to two categories: (1) pecks, in which only the bill tip touches the substrate, and (2) probes, in which the bill is partially or fully inserted into the substrate.

Pecks form a large proportion of the feeding movements, but their significance is not always easy to assess. They are used to obtain prey on the substrate surface; however, most pecks do not result in any obvious capture. Curlews "walking-and-feeding" in a territory are in constant motion as they zigzag across an area with bill pointed diagonally downward, pecking here and there, and heads bobbing. Occasionally they may be seen to walk with head held high and to run rapidly, sometimes for several meters, ending with a peck (or a probe) for prey that has presumably been seen. Hunting by sight has also been reported by Burton (1974), Stenzel, et al. (1976), and Hibbert-Ware and Ruttledge (1944).

Probes commence directly in front or diagonally to one side. As the bill is inserted into a burrow or hole during a probe, a great deal of movement involving the head and neck and the legs and feet may be seen as the bird maneuvers to locate the prey. Vigorous side-to-side, forward and back, and up and down movements of the head are used in these endeavors, and oftentimes a bird will appear to stand on its head with tail tipped skyward in its effort to succeed. Turns of up to 180° with the bill full-length in the ground are

common. Subterranean prey items are extracted before being swallowed, and they emerge gripped by the bill tip. Curlews which are walking-and-feeding in a field probe into existing holes or crevices as they come upon them and at the base of grass clumps. They give particular attention to thick patches of vegetation, often probing in them repeatedly. Where the soil is sandy and the substrate is soft, they walk along pecking and probing in the loose substrate, sometimes violently stabbing into holes and other times calmly exploring depressions in the sand which may indicate a submerged beetle or a rodent cache. Most searches are concentrated around the bases of small forbs and shrubs, and each bird makes many exploratory probes for each successful catch.

Stenzel, et al. (1976) describes a "pause probe" method used by Long-billed Curlews to obtain prey in submerged areas. On two occasions I observed a similar "pause probe" technique which was used to capture prey from burrows in the fields. The bird walked along, then stopped suddenly and posed with the tip of its bill at the opening of a burrow or with its bill inserted into the burrow. It froze in this position for several moments, presumably until detecting some movement below, then made a quick thrust into the burrow. Most attempts were fruitless and others were aborted as presumably no prey was detected. After each one, the bird moved on to another burrow and repeated the sequence.

Another technique for obtaining prey is climbing up into the bases of shrubs and poking among the branches with the bill. Where Munro Globe-mallow occurs, the birds pay particular attention to it. An individual may circle a plant several times poking among the branches, presumably gleaning insects from the foliage.

After capture, the passage of small prey items up the bill is effected by rapid, small opening and closing movements of the mandibles, accompanied by backward jerks of the head as it is gradually raised. Larger items are conveyed to the mouth and swallowed by fewer and more violent movements with the bill near the horizontal.

Long-billed Curlews were never observed to drink water, and I suspect that they obtain almost all of their water from their diet.

Prey Species

Long-billed Curlews were observed to eat large black beetles and also other smaller insects that could not be identified from a distance. Superficial examination of excreta samples revealed an abundance of adult tenebrionid and carabid beetle exoskeletons. Other insect parts were also present but could not be so easily identified. Subterranean insect larvae also constitute an important fraction of the diet judging from the amount of time spent probing in loose substrate.

Timken (1969) and Sadler and Maher (1976) reported Long-billed Curlew predation on altricial nestlings of Lark Bunting and Horned Lark, respectively. Horned Larks are very common on the Hanford Site but I never observed a curlew preying on a nest.

Regurgitated Pellets

Many waders produce regurgitated pellets containing the undigested hard parts of their prey. These can be useful in studying the diet and several authors have done so with curlews (Goss-Custard and Jones, 1976; Hibbert-Ware and Ruttledge, 1944; and Stenzel, et al., 1976). According to Hibbert-Ware and Ruttledge, the number and size of the pellets are cyclic, varying with the time of year and with changes in diet. Their field observations showed that when food changed from the insectivorous and grain types to

that of earthworms and other soft foods utilized during the winter and spring months, the pellets diminished in number and size to a marked degree. Their data suggest that pellets are rare or absent during the breeding season.

On the Hanford Site, Long-billed Curlews were never observed to regurgitate pellets and no such pellets were ever found in roosting or loafing areas even though their diet is highly insectivorous throughout the breeding season.

LOCOMOTION

In normal flight the neck is held slightly folded in a manner somewhat analogous to that of herons, but not as extreme (Figure 14). Hamilton (1975), in comparing the American Avocet and the Black-necked Stilt, reported distinctive neck positions for each species. The Long-billed Curlew holds its neck in a manner similar to the Stilt but with a more pronounced fold.

When taking off curlews customarily use their legs to obtain the necessary spring. The legs are brought up to the flight position soon after take-off and are lowered just before landing. When landing the birds swing upwards with the wings momentarily fluttering high overhead before touching down. This puts them into a stall and allows them to drop gracefully to the ground. Or they may run a meter or so with the wings raised before coming to a halt. In both forms the tail fans out as the birds touch down. If alighting in shallow water, curlews hover with their legs dangling and lower themselves gingerly. Other types of specialized curlew flights are discussed in subsequent sections.

I never observed Long-billed Curlews to swim, and wading was not common except when bathing. Most of the locomotion occurs on the ground where the birds walk or run. Running was normally observed during agonistic interactions. The exact postures used during walking, running, or wading are determined by the other activities which are simultaneously being performed.

LOCOMOTION

In normal flight the neck is held slightly folded in a manner some-

what analogous to that of horses, but not as extreme (Figure 14). Hamilton

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distinctive neck postures for each species. The long-necked Curlew holds its

neck in a manner similar to the Stilt but with a more pronounced fold.

When taking off curlews customarily use their legs to maintain the

necessarily springy. The legs are brought up to the flight position soon after

take-off and are lowered just before landing. When landing the bird swings

upward with the wings extended in a fluttering high overstep before reaching

down. This was then done in a way that allowed the bird to drop gradually to the

Figure 14. Normal Flight Posture.

ground. Or they may take a leap or so with the wings raised before coming to

a rest. In both forms the tail fans out as the bird touches down. It is not

long before the wings are lowered and the legs are lowered and the bird is

ready to take flight. Other types of specialized curlew flight are discussed in

subsequent sections.

I never observed long-billed curlews in water, and wading was not

common except when passing. Most of the observation occurs on the ground where

the birds walk or run. Running was normally observed during agonistic inter-

actions. The most constant sound during walking or running was the

rustling of the outer webbing which are a distinctive sound.

Fig. 14

AGONISTIC DISPLAYS AND POSTURES

I have categorized agonistic intraspecific interactions as mild (in which no physical contact occurs between individuals) and violent (in which physical contact between individuals does occur). Although agonistic interactions are common during the prenesting season, they become infrequent once nesting has begun and do not erupt again until the brood season. Throughout this paper such terms as aggression, aggressive, and aggressor refer to offensive behavior.

The Upright posture which is used during these interactions is characterized by the birds standing immobile with the angle of their backs above the horizontal and with their necks extended and their heads raised high (Figure 15a). It is often held for several minutes before other postures are assumed. Frequently, when two birds are interacting both will assume an Upright posture, or as one bird approaches another the other will assume an Upright posture.

During intraspecific interactions, the orientation of the bodies of the interacting birds is very important to them. If the birds face each other, this indicates aggression or a tendency to attack. Facing away (or looking away) indicates appeasement. Interacting birds frequently stand parallel to each other with their heads either facing the same direction or opposite directions. The bodies' parallel relationship between combatants is probably advantageous since this position would enable either interacting individual to strike with its wings or feet. Attack or retreat are equally possible from the bodies' parallel position.

Figure 15. Postures used in Aggressive Interactions. a. Upright,
b. Crouch-Run, c. Wing-Raising.

Fig. 15

Mild Interactions

Mild interactions most commonly occur while a bird is stationary or while it is running or walking on land. But they also occur in flight. Frequently one bird will pursue another which is also in flight. Aerial-pursuit is generally and for the most part one bird chasing another, but often intricate patterns of dives, swoops, turns, and twists are performed as two birds fly around a territory. Flying sequences are commonly initiated following other agonistic interactions, and the birds may make numerous short flights from place to place before the sequence is terminated. In general, aerial-pursuit continues until the individual being chased is driven away.

Hovering

Hovering is a form of aerial behavior used by an aggressive male and may function in locating an opponent which is hiding on the ground. The male flutters overhead on rapidly beating wings in a way resembling the hovering of an American Kestrel or a Belted Kingfisher. The hovering is of short duration (20 seconds or less) and concludes with the aggressor landing near the opponent.

Crouch-Run

A display often used during mild interactions is the Crouch-Run. In this display the head is lowered, the back is held at an angle below the horizontal, the body feathers are raised and fanned, and the bill is directed out in front (Figure 15b). The bird crouches down with the wings slightly raised from the body. This display is directed at another bird and it is accompanied by movement toward the other bird, either by walking or (more frequently) by running. It is used by an aggressive bird and is a running-threat which serves to lessen the distance between the aggressor and its

opponent. The Crouch-Run was observed to be used when the opponent was within about 10 m of the aggressor. The display shows an attack tendency and was usually continuous with an attempt to peck (or stab) the opponent, followed by a return to an Upright posture.

A stationary form of the Crouch-Run is often performed when the opponent is at close range, e.g., when a territorial bird is joined by an outsider. In such cases the aggressor assumes the Crouch-Run posture, aiming its bill at its opponent, but without the accompanying movement toward the opponent.

The opponent's response to the Crouch-Run varies. Departure of the intruder usually results from a stationary Crouch-Run or from a walking approach. A running approach concludes with (1) flight of the intruder, (2) flight of the intruder and subsequent pursuit by the aggressor, (3) the intruder running or fluttering out of immediate striking range in which case the threat would be repeated, (4) the intruder assuming an appeasement posture thereby delaying or aborting a peck by the aggressor, or (5) violent interaction of some kind.

Upright-Run

The Upright-Run is a running threat commonly used by an aggressive bird to pursue an opponent or to lessen the distance between it and its opponent. It replaces the Crouch-Run at distances of more than about 10 m. The Upright-Run is essentially an Upright posture put in motion and may terminate in any of the other mild or violent displays described herein, depending upon the situation and the response of the opponent.

Concealment

Concealment is a display in which the aggressor approaches its opponent, then suddenly flops down in the grass and disappears from view. The bird assumes a position with the head and neck low, the bill resting on the ground, and the body flattened. The opponent often appears unable to locate the concealed individual and will walk back and forth across the area as if searching for him. When the opponent approaches the concealed bird, the concealed individual suddenly springs up at it in a Crouch-Run posture, then instantly drops back into the grass out of sight. The opponent stands and watches as the aggressor repeats the display, and the aggressor moves closer to the opponent with each performance. Eventually either the concealing bird will spring up and proceed with the Crouch-Run or the opponent will depart. However, the sequence is often prolonged and sometimes results in violent interaction.

Supplanting

Supplanting is another form of mild interaction in which an aggressive bird flies or runs to the position of another bird. If the non-aggressor fails to defend its position and flies or runs away, supplanting has been effected and the relinquished position will be assumed by the supplanter. If, however, the non-aggressor does not respond and remains in the immediate area, ground-pursuit by the aggressive bird or violent interaction may result.

Wing-Raising

In Wing-Raising (Figure 15c), the bird essentially maintains an Upright posture but with the wings raised over the back. It is a standing-threat display performed by an aggressive bird and directed at another bird in close range. Wing-Raising is commonly associated with supplanting and

the Upright-Run and also functions as a means of establishing individual distance between flock members at loafing sites. Abbreviated Wing-Raising, in which the wings are only partially raised, is more common than the full display and often precedes the full display. The intruder's response to Wing-Raising is usually to depart or to move further away.

Feather-Raising

Feather-Raising is a generalized raising of the body feathers which results in a visual effect similar to that of Feather Shaking. The pose is held for several moments at a time, and the tail is often fanned simultaneously. Feather-Raising is usually terminated with Feather Shaking after which the usual profile is resumed. Feather-Raising was observed in a few instances among males. Under the circumstances involved, two males were competing for a female and each time all three birds came together the males would perform Feather-Raising.

Territorial Boundary Display

Territorial Boundary Displays involve two neighboring territory holders near the territorial line. Both birds assume an Upright posture and make a series of short dashes directly towards or parallel to each other. Each dash, or charge, is followed by an abrupt halt, and violent grass pulling or displacement-pecking in which chunks of duff and litter are snatched up in the bill, "chewed" into little pieces, then dropped (Figure 16). Sometimes rather large pieces of sagebrush or dead flowering stalks of Jim Hill Mustard are picked up in the bill and carried for short distances. Each time a bird halts and strikes the ground with its bill, its tail simultaneously fans out. In addition, the tips of the wings are often dropped below the level of the tail. Some birds carry their wings in this manner throughout an entire

Figure 16. Territorial Boundary Display Showing Displacement Pecking in
Bodies Perpendicular Position.

Fig. 16

encounter while others drop them only when making a charge. Still others never seem to drop them. The position varies with the individual and with the intensity of the encounter.

Neither bird crosses the territorial boundary line nor comes within 1 m of its opponent in most cases. During these interactions the birds almost always walk with their heads turned at an angle towards one another; looking away by one individual triggers a charge on the part of its opponent. When one bird initiates a charge, the other stands upright and watches. When a charge is directly towards an individual which is within close range, that individual takes a stance facing the aggressor. The sudden halt at the end of these direct charges is sometimes accompanied by a swinging to the side instead of displacement-pecking, so that the birds wind up standing perpendicular to each other. Occasionally both birds run at one another simultaneously and either halt and snatch up debris, or turn to the bodies' perpendicular position upon reaching the boundary line.

Occasionally a Territorial Boundary Display erupts into violent fights, usually from the bodies' parallel position in which one bird sidles up to the other, raises its wings, and flips up to attack the opponent with its feet. Often, however, the opponent moves away sideways rather than fights.

As a display progresses, the opponents move along the boundary line. Eventually their paths begin to diverge and they begin displacement-feeding. One individual may turn and surge back to the line in an Upright-Run after the other has moved some distance away, but then will again turn and also wander away. The display ends when the paths of both individuals have diverged to a point where neither shows further aggression.

Appeasement

Appeasement by a bird may be indicated by a general crouched posture in which the bill is pointed diagonally downward, the neck is retracted, and the bird turns at an angle sideways and away from its opponent (Figure 17). In response to a running threat an appeaser will often remain stationary in this posture, but then "duck" down suddenly when the aggressor approaches as if in a reflex-like response to an expected blow. Other times an Appeasement-Run will result in which the same basic posture is maintained, but the bird runs away. Invariably the aggressor pursues in either the Crouch-Run or the Upright Run posture, and such chases are often protracted as those being pursued are usually unwilling to leave. An Appeasement-Run was never observed to terminate in violent interaction, probably because of the nature of the display, but in all cases intruders were eventually driven away.

Appeasement is also indicated by sitting or lying down. This behavior was observed in females as a response to male aggression. The female would sit down with the body flattened in a posture similar to that assumed for incubation. Her head would either be low, with the tip of the bill resting on the ground, or hunched down but still in the upright position. The male's response was either to stand and watch or to walk back and forth in front of her. The female usually remained sitting for less than a minute, and immediately upon rising remained crouched. Feather Shaking was usually performed by the female before proceeding with another activity.

The Bill-Down display probably serves an appeasement function, presumably minimizing the threatening potential of the bill. The body is held with the long axis parallel to the ground. The neck is retracted and the head is in line with the body. The bill chatters and is directed downward, perpendicular to the ground. In this position some birds stand still, but others

Figure 17. Appeasement Posture. Appeaser on Left, Opponent on Right.

Fig. 17

make little jerking movements forward and back with the bill, while still others make very slow rhythmic movements forward and back with the bill. I made many observations of the display involving pairs, but only one between non-paired birds. In the latter case, a female ceased a running threat toward an intruding male when he demonstrated the display. Since all observations of Bill-Down displays involved birds close together in pairs, perhaps the display serves to reduce aggressive tendencies in the mate which permits the two birds to remain close to each other.

Violent Interactions

Violent interactions involve actual physical contact with an opponent. The wings, the bill, and the feet are all used as weapons by fighting birds. But although these interactions are sometimes prolonged, an injury was never observed to result. Violent interactions are similar in many respects to mild interactions, but neither participant in a violent interaction initially shows any indications of appeasement; rather, both birds demonstrate a definite tendency to attack.

The most common position for fighting is facing front-to-front (Figure 18). The birds attack each other stabbing with their bills, clawing with their feet, and striking with their upraised wings, often flapping 0.5 m or more off the ground as they clash in a noisy ruckus. Violent fighting may also be side-to-side. In this position the feet are the primary weapons though the wings are upraised and the bills may also be engaged. Sideways encounters last only a few seconds as one bird either moves away or both birds turn to the front-to-front position to continue the fight.

Another attack maneuver is jumping, with wings raised, on the back of the opponent and delivering violent kicks with the feet while pecking with the

make little jerking movements forward and back with the bill while still
contact with the other's bill. In many observations of the display, only one between
non-paired birds. In the latter case, a female ceased a run or chase toward
an intruding male when he demonstrated the display. Since all observations of
anti-down displays involved birds close together in pairs, perhaps the display
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to remain close to each other.

Violent Interactions

Violent interactions involve actual physical contact with an opponent.
The wings, the bill, and the feet are all used as weapons by fighting birds.
But although these interactions are sometimes prolonged, an injury was never

Figure 13. Fighting Front-to-Front.

observed as a result. Violent interactions in many respects are
interactions, but not all violent interactions are necessarily
any indication of a permanent relationship. Rather, they demonstrate a definite con-
tact in attack.
The basic combat position for fighting is facing front-to-front
(Figure 13). The birds attack each other, strike with their bills, clashing
with their feet, and strike with their winged wings. In fighting, birds
on both sides spread their wings in a noisy fashion. Violent fighting may
also be side-to-side. In this position the feet and the primary weapons
through the wings are against the bill's weapon. In engaged, sideways
encounters, each bird's feet extend as one bird strikes away from both birds
toward the other's head to continue the fight.
Further, birds attempt to touch the other's wings raised on the back of
the opponent and deliver a violent blow with the feet while holding with the

Fig. 18

bill. Oftentimes a back-attack is preceded by running towards the opponent with wings raised over the back. Such attacks usually, but not always, result in a reciprocal back-attack by the opponent and/or front-to-front fighting.

Pecking or attempting to peck is commonly performed by aggressive birds following a running threat. Avoidance or departure is the usual response of the opponent.

INTERSPECIFIC INTERACTIONS

Escape is the most usual reaction to disturbances outside the breeding season or away from the nesting territories. On the territories during the breeding season, reactions to man or predators are different. At either time, the Alert-Attitude (Figure 19), in which the alarmed bird stretches up to its full height with elongated neck, is the first response. This attitude is often accompanied with a strong "Wheet Wheet" call which alerts other curlews in the area who then also assume the Alert-Attitude. The Alert-Attitude is held for a time and, if necessary, escape by flight or a threat or distraction display follows. Otherwise, previous activity is resumed as soon as the disturbance has passed.

Flying threats toward avian predators are often very elaborate. One or a few of the breeding birds fly to the level of the predator and fly at it with raucous cries of "Wheet Wheet" attempting to strike it on the back with their feet. The predator must usually twist and stoop to dodge the attacks which continue until the predator has departed.

The Chirping call signifies an intense response to a disturbance. I believe it to be the same vocalization as "cackling" and the long, rattling "que-he-he-he-he-he" call mentioned by other authors (e.g., Bent, 1962). The Chirping call is also believed to be the same as the "ki-keck" call described by Forsythe (1970). This call is an alarm call given in response to ground predators and often attracts conspecifics.

Figure 19. The Alert-Attitude.

Fig. 19

Injury-feigning to distract a predator involves movement away from a nest site with the toes just touching the ground, the wings flapping against the grass, the neck outstretched, and the head turned sideways watching the intruder behind.

A behavior known as Demonstration in waders is essentially an aerial and vocal form of reaction akin to the "mobbing" behavior of other groups. Demonstrating Long-billed Curlews circle an intruder, making short flights from place to place giving repeated "Wheet Wheet," "Curlee Curlee," and Chirping calls.

In the Arc display, so named by Forsythe (1970), the bird (usually the male) rapidly flies straight at the intruder (Figure 20). When within several meters of the intruder, the bird angles straight upward and thus avoids hitting the predator. The bird then circles back to repeat the performance. The "Guaah Kiee" call is given during this display. The "guaah" is a harsh guttural sound which has qualities similar to the caw of a Raven. It is uttered, most commonly twice, when the bird is approaching. The "kiee" sound begins harshly but then becomes more of a whistle, and it is uttered as the bird reaches the peak of its climb and is followed by the Chirping call as the bird heads away. The Arc display is a maximum intensity attack response and appears to serve to intimidate a predator and also to attract conspecifics to the site. Similar displays are performed by other large shorebirds (e.g., American Avocet, Hamilton, 1975; Oyster Catcher, Black-tailed Godwit, European Curlew, and Whimbrel, Simmons, 1955).

The Enticement-Run is used to lure a ground predator away from the nest or young. The performing bird lands about 10 m in front of the intruder then runs along through the grass with head turned sideways enticing the intruder to follow. If the intruder gets too close to the bird, the bird flies

A faint, light-colored diagram is visible in the background of the page. It appears to be a technical drawing of an arc display, showing a central point with several curved lines radiating outwards, possibly representing different arcs or paths. The diagram is centered horizontally and vertically on the page.

Figure 20. Arc Display.

Fig. 20

further ahead, lands, and runs through the grass again. During this display, the body is horizontal and the head is held close to the body (Figure 21).

Figure 21. Enticement-Run.

Fig. 21

SEXUAL DISPLAYS AND POSTURES

Bounding-SKK Flight

In the Bounding-SKK Flight display the bird rapidly flutters upward, rising almost perpendicularly, then sets its wings in a downward curved arch resembling an umbrella (Figure 22). In this position it slowly glides back down, pinions motionless on the breeze, sometimes coming to within 0.3 m of the ground before rising again. The Soft "Kerr Kerr" call consists of a high-pitched and very melodious "kerr" note that tapers off at the end and is repeated in a series. Each time the call is repeated the bird opens its bill only slightly and the sound is like that of wind blowing through a pipe. The Soft "Kerr Kerr" call begins as the bird reaches the peak of the flight and continues until it reaches the bottom. Sometimes a bird performing bounding flight gives the "Hee-Who" call intermingled with the Soft "Kerr Kerr." The "Hee-Who" call is another melodious call and consists of two drawnout notes, the second lower pitched than the first. The Bounding-SKK Flight display is a means of solicitation used by a male to advertise his unpaired status.

Although no other curlews have been reported to have this exact display with its accompanying call, some species do have aerial displays with similar elements. For example, the Eurasian Curlew has a similar rising and falling flight with a high-pitched and flute-like call which is uttered on the descent (Bent, 1962 and Watson, 1972). The Whimbrel gives a call described as a very long-drawn "Kewiu" which is uttered with scarcely opened bill and heard throughout the day (Bent, 1962). Possibly the call is similar to the Long-billed Curlew's "Kerr Kerr" call.

Figure 22. Bounding-SKK Flight Display.

Fig. 22

Ground-Calling

In Ground-Calling the bird assumes an appeasement posture and utters a high-pitched and very melodious (yet mournful sounding) call which has several variations. The basic note is a long drawnout "whee" that fades in, rises in the middle, and then fades out. It is uttered with the bill only slightly opened and is repeated in a series. The following are variations on the basic "Whee" call: "whee," "whee-a-ee-a-ee," "wheer," "whee-a-ee-a-eeer," "ee-a-ee-a-ee," and "eee." The "Hee-Who" call is sometimes intermixed with the "Whee" call. Ground-Calling is performed by a male to attract a female for breeding. Occasionally it is performed by a member of a well-established pair, but its function in these instances is unclear.

Scraping

In Scraping (Figure 23), the performing bird drops down onto its breast, wings slightly away from the body, with tail and wing tips pointed upwards. The bill is directed forward and diagonally downward as the feet are rapidly kicked backward alternately, pushing dirt up and out of the shallow depression (or "scrape") that is formed. The bird may rise and change position in the scrape frequently, each change usually involving a rotation of about 90 or 180°. Between scraping movements the bird will commonly inspect the scrape with its bill and poke around in the bottom. Scraping produces nest bowls and many of these become scattered throughout a territory. Some of these sites are used repeatedly during courtship. Scraping is common among shorebird species that nest on the ground.

Ground-Calling

Ground-Calling the bird assumes an aggressive posture and utters a high-pitched and very persistent (yet somewhat subdued) call which has several variations. The basic note is a long drawn-out "wee" that rises in pitch in the middle, and then falls out. It is uttered with the bill only slightly open and is repeated in a series. The following are variations on the basic "wee" call: "wee-wee-wee", "wee-wee-wee", "wee-wee-wee", "wee-wee-wee", and "wee". The "wee-wee-wee" call is sometimes interrupted with the "wee" call. Ground-Calling is performed by a male to attract a female for breeding. Occasionally it is performed by a member of a well-established pair, but its function in these instances is unclear.

Scraping

In scrapes (Figure 23), the performing bird drops down onto the ground, wings slightly raised, and the body held stiff and wing tips pointed upwards. The bird is then held in this position for a moment as the feet are rapidly kicked backward alternately, pushing dirt up and out of the feet. The bird then rises and the feet are held in the air for a moment. The bird may rise and change position in the scrape frequently, each change usually involving a rotation of about 90 or 180 degrees. Between scraping movements the bird will commonly rest on the ground with its bill and feet tucked in the ground. Scraping movements are performed by many of these species scattered throughout a territory. Some of these species are also frequently heard during courtship displays. Scraping is common among species that nest on the ground.

Figure 23. Scraping.

Fig. 23

Tossing

Tossing is a nest-building movement which appears to be essentially the same as the Sideways Throwing Display described for other shorebirds and gulls (Graul, 1973). During Tossing the bird either stands with its back to the scrape and throws nest material along one side of the body or alternately on each side, or it stands sideways to the scrape and throws nest material off to one side. The nest material is picked up in the bill then tossed into the scrape in repeated, quick movements. The act may also be performed while the bird is standing in the scrape.

Courtship-Run

The Courtship-Run (Figure 24) is a pre-copulatory running approach posture performed by the male. The neck is retracted unlike in the Upright-Run and the back is not at an angle below the horizontal as in the Crouch-Run. The head is held upright with the bill parallel to the ground and the body feathers are in their usual position. As the male approaches the female, the wings may be raised partially with the primaries "flagging" in preparation for Shaking (see below) which immediately follows.

Shaking

Shaking is a pre-copulatory display performed by the male. During Shaking (Figure 25) the male takes up a position behind the female with the wings raised out to the side and the primaries "flagging." The tail of the male is cocked upward, the neck is outstretched, and the angle of the back approaches the horizontal. The footwork of the male is elaborate as he moves back and forth behind the female on either side of her tail, violently shaking his head and bill out in front. As he shakes, the bill of the male ruffles the shoulder feathers of the female. His head bobs up and down such that his

Figure 24. Courtship-Run.

Fig. 24

Figure 25. Shaking Behavior. Male behind Female.

Fig. 25

bill traces a U pattern, moving first down one side of her shoulders and then down the other. The female stands erect, looking around. Occasionally the female will move a few steps ahead, but for the most part she stands still.

As Shaking progresses, the male becomes more frenzied in his movements. The wings are gradually raised until they are bent in a position above the back where they are fluttered in a jerky fashion. The male moves in closer to the female straddling her tail, and climbing movements are made with the feet. The bill at this point ruffles the neck feathers of the female alternately on each side, and the female has assumed a more horizontal body posture, though with head and neck still upright and looking around.

The Shaking call is given by the male throughout the Shaking display. It is difficult to describe but sounds like an evening chorus of Pacific Treefrogs around a pond. It also has a squeaky characteristic. When a bird is giving the call, the mandibles are not visibly separated but rather vibrate against one another. Forsythe (1970) briefly mentioned a "Sou Call" which he thought might be associated with copulation attempts. His description of the behavior of the birds at the time the call was heard corresponds closely with the Shaking behavior I observed, but his phonetic "sou sou sou" rendition does not.

Mounting

At the height of his Shaking frenzy, the male mounts the female by fluttering onto her back. At this point he flexes his legs until he is resting on his tarsi with each foot cupped over a shoulder of the female (Figure 26a). While on the female, the male makes very rapid "marking time" movements with his tarsi and feet such that his body vibrates or oscillates from side to side. Simultaneously he holds his wings above his back and moves them in a way which helps to maintain his balance. The male's tail

Figure 26. Mounting Prior to Copulation. a. Side View, b. Front View.

Fig. 26

is cocked upwards and the head and neck are upright with the bill pointed diagonally downward.

The female stands with both feet squarely underneath. Her head and neck are also upright, but her bill is parallel to the ground and her back is horizontal. From the front her trunk appears somewhat dorso-ventrally flattened, giving her an elliptical silhouette (Figure 26b). As the foot shuffling of the male continues, he gradually pushes the female's wings apart with his tarsi such that her wing tips drop below the level of her tail and one tarsus slips slightly underneath each wing. Mount time prior to copulation is about 60 seconds.

The male continues to call after mounting and a rapidly repeated "wee" note is discernible. I believe the vocalizations heard during Shaking to be the same as those during mounting, the only difference being a certain amount of distortion caused by the action of the head during Shaking.

Copulation

The male's tail does not pass around the side of the female's until just before dismounting occurs. His tail drops under one of her wings as she tips slightly forward (Figure 27). Copulation is brief (about 2 seconds); the male falls backwards as his tail is pressed down, fanned, and his wings are fluttered. Simultaneously the female "falls forward" a few steps moving out from under the male.

If a copulatory attempt fails, the male regains his position on the female's back with feet shuffling, and he tries to copulate again 5-10 seconds later. Rarely, three or four attempts are made before coition occurs. Oftentimes, however, once an unsuccessful attempt has been made by the male, the female will no longer stand and moves out from under him before he can continue.

Figure 27. Copulation.

Fig. 27

Post-copulatory Behavior

There are no post-copulatory displays as such. The female Whistles as soon as the male dismounts, shakes her plumage, and begins walking-and-feeding, occasionally pausing and Feather Shaking a second time. The male dismounts, stands briefly, preens, and then also begins walking-and-feeding or less commonly, flies to another part of the field.

MIGRATION AND BREEDING CHRONOLOGY

The spring migration is a general northward movement, but actual routes have not been identified. My use of color bands was to provide information on migratory pathways, but no returns have been reported.

Small flocks and single birds sporadically pass through on their way to other areas after the Long-billed Curlews have started breeding on the Hanford Site, and as the season progresses migrants and residents can easily be confused. These transients rest or feed in or near areas where the residents are established. When flying through a nesting area, migrants commonly give a characteristic "Whort-Whort" call which is repeated continually by one bird at two-second intervals. This call appears to have the effect of advertising their migratory status and therefore dispells any agonistic displays by the territorial residents. Migrants not using the "Whort-Whort" call give the "Wheet-Wheet" call as they cross the territories. (Local pairs or individuals often fly over one nesting area on their way to and from their own. These birds fly along established routes which do not cross directly over the nest fields.)

When migrants land in a territory during the day, they alight in the open field first. They walk-and-feed very rapidly and often cock their heads skyward. Their behavior conveys a certain restlessness or nervousness which is particularly apparent in those which are paired. Members of a pair move in unison remaining within 1 m of each other and occasionally one bird gives the "Whort-Whort" call as they feed. Migrants usually linger in an area only briefly, commonly less than an hour during the day, but sometimes they stay to

roost most of the night. Those that spend the night Whistle back and forth for about one-half an hour before departure at dawn.

Figure 28 summarizes the breeding chronology of the Long-billed Curlew on the Hanford Site.

Arrival dates were 17 March 1976 and 21 March 1977 for the Hanford area. At the Umatilla NWR which is approximately 40 km southward, arrival dates were as follows: 21 March 1968, 14 March 1969, 24 March 1970, 13 March 1971, 20 March 1975, 15 March 1976, and 21 March 1977 for an average date of 20 March. For the years 1956-1971, Littlefield (1973) found the earliest and latest arrival dates at Malheur NWR in Southeastern Oregon to be 22 March 1970 and 17 April 1967, respectively. The average arrival date at Malheur is 28 March for that period. Malheur is approximately 335 km south of Hanford and one would expect curlews to arrive there first. Possibly the two populations of birds follow different migratory routes.

The first eggs were laid on about 8 April in 1976 and on about 2 April in 1977. A few adults may have still been incubating in June, but most eggs hatched by the end of May. Chicks began appearing on 11 May during both years and most fledged by late June.

The fall migration of Long-billed Curlews commences before the onset of the driest and hottest months. Those pairs whose eggs have been destroyed head southward early. I had one pair stay eight days on the territory after losing their nest, and Tremaine (personal communication) found departure within 10 days for lost nests. The overall movement of the birds south is, therefore, more extended than the move north, and in fact the early migrants also appear to be more leisurely in their behavior. Small flocks or pairs frequent Cheat-grass fields and may be seen resting or loafing in them for several hours at

Figure 28. Breeding Chronology of the Long-billed Curlew on the Hanford Site.

Fig. 28

a time. The birds generally just sit, but occasionally one will stand and preen or wander nearby feeding. Now and again, one will cock its head and look skyward.

In 1976 no curlews were seen on the Hanford Site after 1 July. A late record was one bird in Richland, Washington on 24 October 1976. Three curlews (two at Leadbetter Point and one at Ocean Shores) were also reported for the Washington coast in the fall of 1976, but Long-billed Curlews are considered rare migrants west of the Cascade Mountains. In 1977 a large concentration of Long-billed Curlews left the Hanford Site from 15-23 June, and the last bird was seen on 22 July. Late records for the year were of birds feeding in alfalfa fields east of Red Mountain (Sections 7 and 8 T9N, R28E) the week of 20 August and two curlews on the McNary NWR on 24 August.

ARRIVAL AND TERRITORIALITY

First observations were single birds (males), but within a week numerous individuals had arrived and adult females continued to trickle in through the first week of April. In Utah, Forsythe (1970) reported a period after arrival when small flocks would frequent plowed fields and pastures. This period would last for several weeks before agonistic behavior would increase, leading to flock breakup and the dispersal of pairs to their territories to breed. On the Hanford Site, however, flocks of adult birds were not observed to remain intact after arrival but rather the birds were first seen dispersed on their territories. Only on one occasion was agonistic behavior observed among members of a group resulting in group breakup.

Forsythe (1970) and Wolf (1931) both reported that the birds seem to be paired on arrival, and Wolf (1931) also believed them to be mated on arrival as he never observed mating. Territories at Hanford were first occupied either by pairs or, and equally as commonly, by unpaired males. In addition, courtship behavior, call-advertising, and territorial behavior were observed as soon as the birds arrived.

Figure 29 is a map showing the locations of the central territory nest fields on the 300 Area study site. Territories were identified and named according to their relative position or to a prominent feature within them. The map also shows the location of areas and structures mentioned in the text.

Initial territory size varies with topography and habitat on the Hanford Site. They are the smallest at the 300 Area study site where topography and habitat are the most varied. Here each territory consists roughly of a nest

Figure 29. Map of 300 Area Study Site Showing Locations of the Central Territory Nest Fields.

Fig. 29

field with an adjoining shrub area. Most of these nest fields are about 2 hectares in area, with the smallest about 0.4 hectares. Total territory size is only about 6-8 hectares. Nesting territories are largest at the 100-H/100-D study site where the features are more uniform. Here, and at the other nesting areas as well, "nest fields" as such do not exist because the habitat is so open. Instead, certain "nest areas" within the territories can be defined. In these relatively flat and open habitats, the territories are about 20 hectares in area.

The same territories were used in 1976 and 1977 and I believe them to be historical in nature with previously defined boundaries. As such I have taken the liberty of referring to them as territories even though the boundaries are not always defended against conspecifics. An increase in the number of birds present in 1977 over 1976 did not result in a reduction of territory size but rather in an increased utilization of marginal areas, and some birds seemed to not nest at all. Conceivably, territory size had already been reduced to a minimum. In 1976, all the territorial males at the 300 Area study site acquired a mate for the breeding season. But in 1977, a shortage of females left almost half of them unpaired and therefore unsuccessful. In addition, many males holding marginal territories in 1977 were unpaired for the season.

Apparently, at least some birds may return to the same territories in subsequent years. This is based on identifiable plumage characteristics and on behavioral idiosyncracies of the birds which were seen from one year to the next. Head markings in particular were recorded for members of each pair, and in at least three cases birds with the same markings returned the following year. However, I do not know how common these head patterns are in the general population.

Agonistic encounters between early arrivals were common. The few birds present would range over large overlapping areas covering parts of several territories though each bird or pair could be associated with one territory in particular. Boundaries were not necessarily defended, especially not by unpaired males against neighboring paired females, until more birds had arrived. Once all the territories were occupied, paired birds would often tolerate the association of other birds in areas outside the actual nest field, but unpaired males were more defensive of their entire territory and give aerial-pursuit to any male intruders not accompanied by a female.

Territorial defense was usually performed by the male. Supplanting was the most commonly effectual means of evicting trespassers from territories but the Crouch-Run followed by aerial-pursuit was also observed frequently in this endeavor. Following a flying chase, the territorial bird would return to the field with a loud Whistle and sometimes briefly perform Bounding-SKK Flight before alighting. Additionally, the Upright-Run, Wing-Raising, and Concealment were used to drive away trespassers, and violent interactions would occasionally erupt.

Variations occurred in the initial reaction of territorial birds to trespassers and depended in part on the stage of the breeding cycle and on whether the territorial individual was present when the trespasser first arrived. Paired males were more tolerant of outsiders in their territories for longer periods of time after mating had occurred. If a territorial male or pair returned to the territory to find an intruder present, the male would usually fly directly to the site of the intruder and proceed with agonistic displays. If a territorial male or pair was already present when an interloper arrived, an Upright posture was assumed by all individuals and was held for several moments before another posture (e.g., Crouch-Run) was assumed or previous activity (e.g., feeding by the female) was resumed.

Defense of territorial boundaries for the most part involved Territorial Boundary displays between neighbors, though violent encounters were not uncommon. Territorial Boundary displays were consistently observed to occur only along those stretches of the boundary line which separated one nest field from another, and in these "zones" the line corresponded to a physical marker of some kind (e.g., a dead furrow, a road, a Coyote path, a fence line, a ditch). Elsewhere, a certain amount of flexibility existed in the territorial lines. Those neighbors whose nest fields did not adjoin were never observed to engage in Territorial Boundary displays with one another.

A Territorial Boundary display was initiated when one neighbor provoked an encounter by entering the display zone and walking along the line. The other neighbor then flew or ran over to the zone and took up a position opposite his opponent, oftentimes sidling towards him and sometimes with the far wing raised overhead. Encounters most commonly involved just the males, but prior to the onset of incubation both members of a pair were often present though usually only one member of each pair was directly involved in the interaction. Encounters were usually either male-to-male or, more rarely, female-to-female. Only one male-to-female interaction was observed. When two paired males were interacting, the females either stood and watched or more commonly, continued to walk-and-feed. When two females were interacting, however, the males assumed an appeasement posture and performed displacement-feeding while slowly but continually walking around about a 1 m^2 area. They displayed this behavior until the Territorial Boundary display between the females ended. With the passing of time on the territories, the intensity of the interactions between neighbors gradually lessened to the point where full displays were rarely observed. Entering the zone by one neighbor still provoked an encounter, but the birds often remained farther apart and engaged only in displacement-feeding.

DAILY ROUTINE

Each day begins approximately one-half hour before dawn with repeated volleys of Whistling as individual birds call out one after another from their roosting sites. "Curlee Curlee" and "Wheet Wheet" calls may also be heard but Whistling is the most common. Periods of quiet are interspersed with these rounds of Whistles, but the vocalizations continue until the birds begin their other daily activities.

During about the first two weeks following arrival, the birds are very active on their territories. There is rarely a peaceful moment during the day as calls ring incessantly across the fields, birds fly back and forth across their territories, solicitation and courtship begin with a frenzy, and agonistic encounters occur frequently. Unpaired males are particularly vocal and the majority of their time is spent maintaining a visible profile. Paired and up-paired birds alike frequently move in and out of their nest fields all day long.

Courtship displays are most frequent during the early morning hours from dawn to about mid-morning, but commonly continue through the morning and into early afternoon during this initial period. Courtship activities by one pair appear to stimulate courtship activities in neighboring pairs (social facilitation) as frequently three or four pairs will be courting within sight of one another. Solicitation for a female by unpaired males also begins in the early morning, but then continues throughout the day. All reproductive activity is, however, stifled during inclement weather as the birds tend to stay in the shrub areas where there is more protection.

After about the first two weeks, but still prior to incubation, daily activities become more routine. Territorial pairs are usually in their nest fields only during the late afternoon, evening, night, and early morning hours. During the day they feed quietly in the shrub areas within their territories, occasionally coming out into the open for maintenance activities or to pursue an intruder, or they are gone from their territories entirely, having moved to other areas to feed. Courtship displays in pairs are now performed almost entirely during the first few hours of light. Paired birds have developed patterns for feeding, courtship, and mating which they now routinely follow. The unpaired males continue to maintain a high profile as before, though perhaps with a little less vigilance, and tend to be much less routine in their activities. As the season progresses and a mate is still not obtained, solicitation becomes more intense with each passing female.

All birds usually leave their territories once a day for several hours (less for unpaired males) during the heat of the day to feed in irrigated fields or in other areas of the Hanford Site, and/or to loaf on islands in the Columbia River. The daily departure of a pair from their territory is often preceded by "Wheet," "Curlee," and "Curlee Wheet" calls for up to 10 minutes while the birds walk-and-feed. Actual departure is initiated by the female, who takes off quietly or calling "Wheet Wheet." The male assumes an Alert-Attitude, then follows calling "Curlee Curlee" and catches up with the female in flight. Commonly when a territory is unattended, neighboring birds will trespass flagrantly.

Curlews return to their territories in late afternoon and frequent the fields until they roost for the night. Occasionally courtship behavior was observed during this afternoon/evening period, but this was not common.

At dusk the birds become very quiet on their territories as they walk-and-feed through the fields, and eventually none are heard. As twilight nears they stop and assume an Alert-Attitude often listening and watching for several minutes. Then just at dark, they quietly fly to their roosting area (up to 200 m away) and disappear from sight. The same part of the field is used for roosting each night and members of a pair roost 10-50 m apart. Whereas territorial birds roost in their fields, migrants stopping over often use the areas of transitional vegetation bordering the fields.

By searching roosting areas which were covered with unusually thick stands of Cheatgrass, I was able to find oval-shaped depressions in the grass with curlew excreta at one end. The narrowness of the ovals indicated that the birds do not flatten-out on the ground when roosting as they do when concealing. I had no way of ascertaining the head position during roosting.

SOLICITATION AND INITIAL PAIR FORMATION

Solicitation or call-advertising by unpaired males is seen in the form of Bounding-SKK Flights and Ground-Calling. These displays serve to attract a female and are important in initial pair formation along with the Scrape Ceremony.

A male exhibits Bounding-SKK Flight most commonly flying in a path around the perimeter of his territory or in a figure-8 pattern over the nest field, but at times no particular pattern can be discerned. If a female is in his territory, a male will usually orient his display around her. Bounding-SKK Flights may last up to one-half hour, but usually sequences are shorter. Frequently though, the birds will remain on the ground only a minute or two between sequences. When a male completes a series of flights, he Whistles as he lands.

Bounding-SKK Flights become particularly intense whenever a female passes through a nesting area. At such times all the unpaired males rise up and perform the display over their respective territories. If the female is unpaired, she usually alights in the nest field of one of the soliciting males but often does not stay there. Instead she wanders from territory to territory walking-and-feeding. Once she leaves a male's territory, he becomes less intense in his solicitation, landing frequently and spending more time on the ground. For reasons which were not apparent to me, a female would eventually remain in one territory and tolerate the association of that male for up to a day, then move to a neighboring territory and male. She might switch back and forth more than once before presumably a pair bond was formed and she remained

with one of the males. A male persists with Bounding-SKK Flights throughout the first day of his association with a female, and some were observed to continue the displays for up to three days. With each succeeding day, however, the displays became shorter and fewer and were usually performed only when transients passed through the area or in association with other pair formation behavior.

As a form of call-advertising, Ground-Calling is performed by an unpaired male within sight of a female who is either associated with another male, or who has recently arrived but is in a neighboring territory. Ground-Calling is usually interspersed with bouts of Bounding-SKK Flight. The soliciting male slowly walks through his field in an appeasement posture giving the "Whee" call. If the female is close by or has previously been in the male's territory, the aspiring male commonly performs Scraping behavior as he gives the "Whee" call. Ground-Calling is an integral part of the Scrape Ceremony.

The Scrape Ceremony is performed many times during pair formation and involves ritualized Scraping. Initially the Scrape Ceremony is preceded by Bounding-SKK Flight, after which the male takes up a position across the field from an unpaired female in his territory and performs Scraping behavior while Ground-Calling. Between Scraping movements he stands in the scrape and repeatedly calls. The female walks directly toward the male, often moving rapidly. When she is within about 10 m her pace slows, and the male assumes the Bill-Down posture and continues Ground-Calling softly. The female then approaches the scrape and steps into it as the male moves out sideways still maintaining the Bill-Down posture. The female commonly Whistles as she enters the scrape. The male takes up a position with his body oriented perpendicular to, and almost always behind the female (Figure 30). Once out of the scrape

Figure 30. Scrape Ceremony Showing Bill-Down Posture and Orientation of the Male.

Fig. 30

cavity the male usually ceases to call. During initial Scrape Ceremonies, the female often displays a certain amount of aggressiveness towards the male and directs pecking "intention-movements" at him. The Bill-Down posture of the male appears to dissipate these aggressive tendencies, though the male may be observed to flinch in response to them.

While standing in the scrape the female may change her direction many times, and each time the male will re-position himself accordingly to maintain the original orientation. Also while standing in the scrape, the female may inspect it with the tip of her bill, making Tossing movements, or perform Scraping herself. Sometimes the female Whistles during the course of these activities. However, she remains in the cavity only briefly before stepping out, though she usually stands for a time close by before walking away. Once the female has vacated the scrape, the male slowly raises his bill and then his head as if testing the female for aggressiveness before assuming another posture.

Scrape Ceremonies may be repeated by the male numerous times throughout the first day of association with a female such that it seems all of her time is spent walking back and forth across the field in response to his calls. Some males stop only briefly during the day to rest or feed or drive out an intruder.

At this stage following the ceremonies, the male usually performs Bounding-SKK Flight and the female begins walking-and-feeding. Gradually this leads into the next phase in which pre-copulatory displays follow each Scrape Ceremony, and the pair-bond becomes well established. Birds which arrive already paired begin their courtship activities at this stage.

COURTSHIP, MATING, AND PRELIMINARY NESTING

Throughout this paper terms such as "courtship" and "courting" refer to events leading to copulation. After initial pair formation, the Scrape Ceremony becomes a pre-copulatory display. Scraping behavior eventually becomes disassociated with mating and appears to be the mechanism for designating the most favorable potential nest locations.

The basic Scrape Ceremony is described in the preceding section in its context with pair formation. The Scrape Ceremony is the same when performed as a pre-copulatory display with one addition: The male demonstrates Tossing behavior while calling the female over to the nest. Tossing behavior is widespread among shorebirds but its role in courtship is uncertain.

Following the Scrape Ceremony when the male raises his bill and head, he also slowly raises his wings out to the side, "flagging" the primaries. In this position he "cautiously" moves around behind the female and begins Shaking.

Initially the female is unreceptive to the advances of the male. She does not tolerate Shaking behavior, and either turns in a Crouch-Run posture and pecks at the male or runs away. The male often pursues, chasing along behind, or circling one way and then another in an effort to take up a position behind her tail without being struck or grabbed. Once the female is receptive to Shaking, Shaking lasts for about 30-45 seconds before the male attempts to mount. More time is required, however, before the female becomes tolerant of Mounting behavior.

Eventually the female permits Shaking and Mounting, but runs out from under the male before copulation occurs. She then turns in a Crouch-Run posture

and threatens the male. The male usually does not persist with courtship at the time, but instead tries again later. At this stage some Scrape Ceremonies are followed by Tossing by the male (instead of further courtship). The Tossing often begins while the female is still standing in the scrape and continues until after she has walked away. In addition, mating attempts are sometimes made without the preceding Scrape Ceremony. Instead, the Courtship-Run is displayed by the male followed by Shaking. The point at which the Scrape Ceremony (with Tossing behavior) changes from a pre-copulatory behavior to a nest site selection behavior is vague. A gradual process which is closely associated with the courtship/mating sequence is involved.

The final phase occurs when the female will tolerate the entire sequence of behavior from pre-copulatory displays through coition. Once this phase is reached, the Scrape Ceremony becomes isolated from courtship displays which are then preceded by the Courtship-Run. (The Scrape Ceremony will be discussed further under Nest Site Selection). A male may still be unsuccessful at his first mating attempt each day, and therefore repeated courtship displays still occur. Additionally, I did not observe more than one copulation in a pair on any given day, though some males would attempt two or more.

NESTING

Nest Site Selection

Scraping activities result in several scrapes, usually in one general area of each field with two or three occasionally being found within 8 m of the nest. Most of these scrapes are used repeatedly during Scrape Ceremonies and one of them becomes the nest, but the means by which the actual site is selected is not clear.

Once Scraping behavior has become distinct from courtship behavior, each Scrape Ceremony is followed by the male Tossing while the female wanders away. Once the nest site is selected, Scrape Ceremonies cease but Tossing continues as the method for lining the nest cup.

Commonly during the process of nest site selection a bird was seen Tossing and missing the scrape altogether as a result of either misorientation or standing too far away from the site. Presumably in the latter case, the material tossed towards the scrape might be picked up later and tossed into it. Even with repeated use and Tossing by the male, however, the scrapes were never substantially built and were usually devoid of nesting material when they were abandoned. Subsequent Scraping behavior undoubtedly removed material previously placed in the bowl.

During nest site selection the female often performs Scraping and Tossing during the Scrape Ceremony, and I suspect that her behavior ultimately determines which site will be used. During this period, females were observed to start scrapes and perform Scraping behavior without the accompaniment of the male. A male was never observed to respond to Scraping initiated by a female,

but rather continued with his present activity. On the other hand, neither did the female call to the male or otherwise appear to be trying to attract his attention.

Nest Construction and Materials

The nest is initially formed as a scrape during a Scrape Ceremony. The bowl is made deeper with subsequent Scraping and with repeated bill poking. Improvement in the form of added nest material by Tossing is made throughout the laying period.

The nest cup is lined with whatever material is available in the immediate vicinity. Cheatgrass leaves and culms are the most common and are used along with rabbit pellets, small stems and twigs, seeds, Canada Goose excreta, and miscellaneous litter. Occasionally a small stone was found in a nest along with the eggs. Considerable differences were noted in the amount of care taken to construct the nest. Some nests contained sparse amounts of insulating material and bare soil could be seen in the nest bottom. Other nests had thick bottoms and walls that afforded more protection to the clutch. Generally too, nests were more substantial where nesting material was locally abundant than where nesting material was scarce.

Incubating birds often pick up nearby material and place it in the perimeter of the nest using the same nest-building movements as in Tossing, except that the bird is in a sitting position. This activity is essentially the same as the "Side-ways Building Display" mentioned by Graul (1973). Incubating individuals also reach out and pick up material, then drop it directly in front of the breast in a forward and back movement. As a result of these nest-building activities, the brim of the nest becomes slightly elevated above the surroundings. Eventually the area surrounding some nests becomes completely denuded of vegetation and litter.

Scrape Size

Fifty-nine scrapes were measured for depth and diameter (major and perpendicular axes). Depth in millimeters (58 scrapes) was $\bar{x} = 46.04 \pm 10.67$ S.E. with a minimum of 23 mm and a maximum of 66 mm. Diameter in millimeters (118 measurements) was $\bar{x} = 201.16 \pm 37.04$ S.E. with the smallest measuring 130 x 130 mm and the largest 275 x 245 mm. These measurements are similar to those reported by Graul (1971) for one nest (diameter 190 mm and depth 45 mm) and by Silloway (1902) for one nest (major axis about 220 mm, minor axis about 153 mm, and depth about 51 mm). The variation in scrape diameter is probably a reflection of the size of the bird which made the scrape. Depth probably varies with the extensiveness to which the scrape was frequented.

Nest Site Characteristics

Evidence is accumulating that birds base their choice of habitat on features of the environment such as slope of the ground and structure of the vegetation rather than on the plant species present (Wiens, 1969).

Vegetation Type

All nest fields were of a general Cheatgrass community of one of two types. The first type was a Cheatgrass/Sandberg's Bluegrass association and the second type was Cheatgrass with no accompanying Bluegrass. Table 5 summarizes total percentage coverage and percentage frequency of occurrence of Cheatgrass and Sandberg's Bluegrass for these two types. Various forbs and/or shrubs in very minor quantities were associated with both these types, and Appendix B shows their relationship in each transect analyzed. Other Cheatgrass communities (e.g., those which include a preponderance of Jim Hill Mustard) and other grass communities (e.g., Bluebunch Wheatgrass stands) were not utilized by curlews for nesting.

TABLE 5

Total Percentage Coverage and Percentage Frequency of Occurrence
of Bromus and Poa in Two Types of Nest Fields

Taxa	<u>Bromus/Poa Association</u>		<u>Bromus</u>	
	Total Percentage Coverage	Percentage Frequency of Occurrence	Total Percentage Coverage	Percentage Frequency of Occurrence
<u>Bromus tectorum</u>	6.7 $\pm$ 2.2	72.7 $\pm$ 15.7	13.6 $\pm$ 1.6	93.5 $\pm$ 5.8
Old <u>Bromus tectorum</u>	65.4 $\pm$ 10.9	100 $\pm$ 0	92.2 $\pm$ 2.8	99.5 $\pm$ 0.5
<u>Poa sandbergii</u>	16.6 $\pm$ 4.2	81 $\pm$ 7.9	---	---
Old <u>Poa sandbergii</u>	4.6 $\pm$ 2	56.3 $\pm$ 18.5	---	---

NOTE: Values are $\bar{x} \pm$ S.E.

Of 21 nest fields (or areas) identified, six, or 29%, were Cheatgrass and 15, or 71%, were Cheatgrass/Sandberg's Bluegrass. On the Hanford Site, all areas with Cheatgrass/Sandberg's Bluegrass fields in them were utilized by curlews, whereas many areas of just Cheatgrass were never used.

In the nest fields the average height of Cheatgrass is <100mm. The culms are robust, leafy, and spreading (as opposed to erect) and the panicle is dense and drooping. Cheatgrass covers the ground much more effectively than does Sandberg's Bluegrass (see Table 5). Sandberg's Bluegrass has very slender erect culms rising from a tuft of very fine short basal foliage. It averages about 200 mm in height in the nest fields, which is noticeably taller than the Cheatgrass, but because of its fineness probably does not present a visual barrier to the birds. In addition, where Cheatgrass and Sandberg's Bluegrass are associated, the grass clumps are more widely spaced with mosses and lichens in between, and the Cheatgrass does not reach the density that is found in areas of pure stands (see Table 5).

The effects of grazing on breeding bird density and diversity in a prairie community were evaluated by Cole and Sharpe (1976). They found that both species diversity and total density were increased for their grazed study site in part because Long-billed Curlews were absent from their ungrazed study site. Work done by Tremaine in Nebraska (personal communication) supports these observations that Long-billed Curlews may be restricted to such grazing areas. Wolf (1931) confirms a preference for short grass.

In summary, Long-billed Curlews probably select shortness of the vegetation and also spacing of the grass clumps. Because they rely on camouflage for protection of the eggs and themselves during incubation, the short grass presumably allows for better visibility of approaching danger and the irregular pattern of the grass clumps complements their cryptic coloration.

Slope of the Ground

Long-billed Curlews generally select relatively flat areas for nest sites, but some nests were found in locations where the ground is uneven; e.g., on top of a dead furrow (three nests) or on a roadside furrow (one nest). Wolf (1931) stated that the ideal location is on a slight rise of ground, and Graul (1971) found the nest he observed at the edge of a large valley adjacent to a gently sloping hill. I found three nests on a slight rise of ground, but most nests were located toward the southern edge of the field regardless of slope. In fields with an east-west major axis, the nest was additionally located in either the east quarter or the west quarter. On the 100-H/100-D study site, the overall slope of the ground is downward to the Columbia River to the north, and so a southerly nest site gives the bird a sweeping view down the field. But on the 300 Area study site, the direction of slope in each field is variable and the advantages of a southerly location are not readily apparent.

Proximity to Conspicuous Objects

Distances from scrapes to the nearest conspicuous object were measured. The most common objects were old Big Sagebrush limbs, rocks, bare dirt mounds, and dead furrows. Other items were a steel cable, a horse manure pile, a rusty 5-gallon can, an old tumbleweed, and a large bunchgrass. Twenty-two nests (37%) were within 1 m of an object, 18 nests (31%) were within 30 cm of an object, and 16 nests (27%) were against an object.

Individual birds were not consistent in selecting scrape sites in relation to conspicuous objects (Table 6). However, I was unable to make comparisons between the nest sites chosen by the same bird in different years, and individuals may be more consistent in their final choice. Of 59 scrapes, 14 were used as nests and 9 of these 14 nests were near a conspicuous object. In

TABLE 6

A Comparison of the Distance in Centimeters to the
Nearest Conspicuous Object between Different
Scrapes of the Same Bird

	Scrape 1	Scrape 2	Scrape 3	Scrape 4	Scrape 5	Scrape 6
1	against	NA	NA	NA	NA	NA
2	against	against	against	5.5	300	NA
3	NA	NA	NA	NA	NA	NA
4	against	41	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
6	against	against	28.5	--	--	--
7	136	120	71	246	--	--

NOTE: NA = no objects were available in the vicinity of the scrape.

general, though, conspicuous objects are in short supply in the Cheatgrass fields on the Hanford Site. Surface rocks and sage stumps were removed when the land was farmed, and there are no grazing livestock to provide manure piles. Those objects present are widely scattered and some nest fields appear to be without any at all. Therefore, the tendency to select a nest site close to a conspicuous object is probably limited by the availability of those objects.

Presence of Other Curlews

The presence of Long-billed Curlews in an area undoubtedly serves to attract conspecifics to the site which increases the probability of obtaining a mate in addition to the survival value afforded in a group situation. Territorial behavior spaces the birds over a given area, but even though definite boundary lines are established, nests in neighboring fields were never adjacent. The nearest neighbor nesting distance was 250 m at the 300 Area study site. However, in particularly favorable habitat, there is a tendency for pairs to nest within sight of one another. Nests in other areas were 500 m or more apart which concurs with Forsythe (1970) who found nests about 462 m apart.

Nest Density

Sadler and Maher (1976) estimated approximately one pair of breeding curlews per 6 to 7 km² of suitable habitat in Saskatchewan. Nesting density is much higher on the Hanford Site. Fifteen territories were identified at the 300 Area study site which encompasses only 10.36 km². The 5.13 km² 100-F Area study site supports at least three territories, and the 100-H/100-D Area site (15.48 km²) supports at least 10.

Differences in nest density can be attributed to differences in habitat and territoriality. Each territory must have suitable areas for nesting and chick rearing that include adequate food, cover, and shelter. The 300 Area study site supports the highest nesting density of curlews because the habitat there is prime. Such is not the case at the other study sites and consequently the nesting densities are lower. The ranges of Saskatchewan where curlews occur are vast open prairies unlike what exists at Hanford, and therefore too one expects to find differences in breeding density.

EGG LAYING

Laying Behavior

The behavior of three females was observed during egg laying and was similar in each case: The female approaches the nest to within a meter, stands alert momentarily, then steps into the bowl. She first inspects the nest, looking and poking around with her bill, and sometimes tosses or pulls additional material inside. Once this is completed, the female settles into the bowl and sits quietly. After the egg is laid, the female rises from the nest and begins Tossing while still standing in the bowl. Eventually she steps out of the nest but continues Tossing behind or to the side for 5-10 minutes. Time spent on the nest in the three cases observed was 13, 25, and 87 minutes. The final egg in the clutch was laid during the 87-minute observation and so the onset of incubation probably influenced the extended time spent on the nest.

Once laying has started both birds become very attentive, returning to the nest numerous times throughout the day. During these visits the bird usually steps into the nest bowl and stands over the eggs, sits down, or alternately stands and sits. When standing over the eggs the female usually assumes a body posture which is essentially the same as that described for appeasement. On two occasions a female was observed to be calling softly while standing in this position. The Bill-Down display is performed by the female when and if the male approaches her while she is standing in the nest bowl, and terminates as soon as he moves away. Males were never observed to stand over a nest for any length of time, but females would often do so for up to 30 minutes. Either bird might sit on the eggs for 1-2 hours during a visit.

Tossing behavior is closely associated with nest attentiveness, occurring along with repeated visual and tactile inspection of the bowl and its contents while the bird is in or around the nest. Tossing is also performed just before a bird steps out of the nest and again before it moves away from the site.

Courtship continues during egg laying, but mating attempts were observed to be successful only on those mornings when an egg was not laid. The laying of the last egg in a clutch was observed in one pair, and in this case the last copulation was seen the day before.

Clutch Initiation and Laying Intervals

Dates for the laying of first eggs were calculated by back-dating at hatching, allowing 28 days for incubation (Graul, 1971) and six days for laying. Most clutches were initiated within two and a half weeks of when the first clutch was started. In 1977 one clutch was initiated unusually late on 23 May.

Eggs were laid in the early morning hours (within two hours of dawn) on alternate days. I was able to record the interval between the laying of two eggs (the first and second) in only one case, and it was 47 hours and 25 minutes. Graul (1971) reported a case of three eggs being laid over four days and a minimum laying period of five days. Forsythe (1970) observed egg laying at two-day intervals.

Clutch Size and Egg Description

All the nests in which incubation was initiated contained four eggs (Figure 31). This is the number reported as the usual clutch size for Long-billed Curlews (e.g., Bent, 1962; Sugden, 1933; and Wolf, 1931).

a.

b.

Fig. 31

The eggs are well described in the literature from the early 1900's when oology was popular (e.g., Bent, 1962 and Shufeldt, 1913). These descriptions indicate a considerable variation in shape, prevailing ground color, and spotting. I also found this to be true, though most of the eggs had either a light beige or a pale bluish-green ground color with chocolate colored markings. The dark markings can be bold, large blotches or fine, small specks, or mixtures of the two (Figure 32). However, unlike what Bent (1962) reported, there was a tendency for the markings to be heavier and more numerous at the big end of the egg. I have no evidence that individual females tend to lay eggs with a distinctive pattern, and single clutches contained eggs representing both ground colors.

Two eggs weighed soon after laying were found to be 73 and 71 g. Table 7 summarizes the egg weights from four clutches and groups them by week. Figure 33 graphically shows the general weight loss which occurred as the embryos developed.

Egg Losses and Renesting Attempts

Coyotes and Magpies are the major predators and are particularly adept at locating nests, especially if the nests have previously been approached by a human intruder. Ravens and Pacific Gopher Snakes are probably next in importance; Badgers may also be effectual.

If the nest is located by a ground predator the birds' initial response is Demonstration, followed by displacement-feeding some distance away while calling a rapid "Whee-whee-wheet." They do not attempt to drive the predator away from the nest. Flying threats are directed toward avian predators entering the territory, and a curlew will not hesitate to drive a Magpie or a Raven away from the nest should it be located. If a Magpie pecks one of the eggs in the

Figure 32. Examples of Eggs Showing Variation in Shape and Markings.

Fig. 32

TABLE 7
Egg Weights in Grams at Various Stages in Incubation¹

Eggs	First Week	Second ² Week	Third Week	Pipping
Clutch A				
1	68	64, 65	63	
2	66	62, 64	63	
3	66	64, 63	64	
4	68	64, 64	64	
Clutch B				
1		74, 71	67	66
2		70, 68	64	64
3		70, 68	63	63
4		73, 71	67	67
Clutch C				
1		63	59	58
2		65	61	60
3		65	61	61
4		64	62	59
Clutch D				
1			67	61
2			60	58
3			62	58
4			65	62
$\bar{x} \pm \text{S.E.}$	67.0 ± 0.58	66.6 ± 0.82	63.3 ± 0.61	61.4 ± 0.89

¹Weights are grouped by week of incubation calculated by back-dating.

²Clutches A and B were weighed twice during the second week.

Figure 33. Weights of Eggs and Newly Hatched Young in Relation to Hatching Date. Circles Represent Weights of Eggs; Triangles, Weights of Young.

Fig. 33

nest, the curlews abandon the entire clutch (four observations), but as a Raven may fly away from the nest site with an egg (two observations), possibly the curlews continue to attend any that are left behind. Pacific Gopher Snakes are common on the Hanford Site, and in the sandhills region of Nebraska Bull-snakes are a major predator, raiding nests for the eggs of birds like the American Avocet and the Long-billed Curlew (Tremaine, 1975). Consequently, though I have never actually observed such, I suspect Pacific Gopher Snakes are predators on the curlew nests at Hanford. Their impact, however, is difficult to ascertain.

If egg shells remain in the nest after it has been destroyed, as is usually the case following predation by a Magpie, the female of the pair will often remove them in the same manner as shells are removed following hatching (see Hatching). An aberrant form of shell removal is also often displayed in which the female picks up and crushes the shells between her mandibles, dropping the fragments in and around the nest.

In 1977, five nests which had been located during the egg laying period were destroyed prior to the onset of incubation. Three of these losses were attributed to Coyotes and two to Magpies. Only two nests were found during this period in 1976 and both were destroyed by Magpies.

Long-billed Curlews do not appear to renest once their first attempt has been thwarted. However, I did observe one female lay one egg in a second nest following the destruction of the first by a Magpie. The first nest contained only one egg, which was presumably the first one laid. The egg in the second nest was also pecked by a Magpie and no further nesting attempts were observed.

INCUBATION

The incubation period for the Long-billed Curlew has been reported once by Graul (1971) as 27 days and 14 hours (± 9 hours) between the laying and hatching of the last egg. As the start of incubation was unknown for all the successful nests which I observed, I was unable to verify these data.

Observations at two nests indicate that the male initiates incubation on the morning following the laying of the last egg. Both male and female Long-billed Curlews share in incubation duties, but it takes a day or two for them to establish a routine of nest relief where the female sits during the day and the male sits at night. Prior to that time they may exchange places several times during the day, and the male may actually incubate more than the female. On one occasion during this early adjustment period, a female was observed to supplant the male from the nest by performing Wing-Raising. Also during these first few days the birds tend to fly off the nest at the slightest disturbance. Once the incubation phase is underway in an area, the fields are much quieter and only the unpaired males and transient individuals participate in exchanging Whistles at dawn. The birds remain relatively quiet unless disturbed.

Behavior

The normal daytime incubation posture is an alert, head-up position (Figure 34). During inclement weather, however, the incubating bird modifies this posture and sits with its head low, often below the level of the grass. Birds using this low posture frequently raise their heads up, look around, then

INCUBATION

The incubation period for the long-billed Curlew has been reported as 25 to 30 days (1911) as 21 days and 14 hours (1912) between the laying and hatching of the first egg. At the start of incubation was unknown for all the successful nests which I observed. I was unable to verify these data.

Observations of two nests indicate that the male initiates incubation on the morning following the laying of the first egg. Both male and female long-billed Curlews share in incubation duties, but it takes a day or two for them to establish a routine. It was noted that the female sits during the day and the male sits at night. From to that time they may exchange places.

Figure 34. Normal Incubation Posture.

On one occasion during this early incubation period, a male was observed to approach the nest from the east by performing Wing-Raising. Also during these first few days the birds seem to fly off the nest at the slightest disturbance. Once the incubation routine is underway in an area, the birds are much quieter and no longer approach the nest and retreat to the nest at the slightest disturbance. The disturbance is usually caused by the male's relative position.

Incubation

The normal incubation posture is an alert, head-up position. The male and female incubate together. However, the incubation posture is not maintained with the head up. It is often below the level of the breast. This posture is for comfort. It is not a posture of alertness. The birds are not alert. They are relaxed. They are comfortable. They are at ease. They are at home. They are at rest. They are at peace. They are at love. They are at life. They are at death. They are at everything.

Fig. 34

sink back down. In the evening, just before dusk, the male ducks his head presumably in this same low position. I was unable to observe the birds at night but assume the male remained low on the nest throughout. Shortly after dawn the male may slowly raise his head and assume the normal head-up position used during the day, or he may remain low on the nest until relieved by the female, popping his head up in response to her calls. In hot weather the attending bird sits with head held high and pants.

During the day the incubating adult adds nest material to the rim of the bowl in an idle manner, though such activity is sometimes more pronounced at nest-relief time. The incubating bird also frequently re-positions itself to face a different direction on the nest. Sometimes the bird accomplishes this by scootching around while remaining seated on the nest. More commonly the bird rises, pokes in the bowl with its bill (presumably to rearrange or rotate the eggs), and then turns to face a different direction. The breast feathers are occasionally preened at this time. Sitting down again, however, is usually protracted as the bird repeatedly attempts to settle over the eggs. The incubating bird is usually quiet, though Whistling from the nest is common at nest-relief time (see below). Whistles are also occasionally exchanged between neighbors, and a sitting bird will Whistle at a trespassing curlew if its mate is not present to defend the territory.

To rise from the eggs, the incubating bird tips forward onto its breast bringing its legs up behind, then pushes itself up and back with the tip of the bill until the feet are regained. When settling onto the eggs, the bird first lowers itself onto the breast with the wings slightly away from the body. The rear is then lowered as the bird simultaneously squirms into position adjusting the wings individually.

During the day when the female is incubating, the male may or may not be present on the territory. Some males leave for only 1-2 hours, spending most of the day feeding within the territory, while others are gone until nest-relief time and leave the female to fend for herself. When the female is relieved in the afternoon or evening, she usually leaves immediately for the River or another feeding area and does not return until dusk. She departs again in the morning before returning to incubate for the rest of the day.

Nest Relief

Nest relief occurs about the same time each day for any given pair unless the birds are disturbed. For example, nest relief by one pair was delayed two hours one morning because a Swainson's Hawk was perched in a tree near their nest. The female curlew wandered up and down the field displacement-feeding and watching until the hawk left. The morning exchange period was either between 0500 and 0630 or between 0900 and 1015. Evening exchange periods were not as clearly defined but were observed between 1700 and 1930, although on one very hot day a male was observed to relieve the female at 1343. (The female immediately flew to a shady spot between two Big Sagebrushes and rested there for 20 minutes before departing.)

Typically, at changeover time the incoming bird flies into the nest field and Whistles as it alights. The incubating bird answers the call with a Whistle from the nest. The incoming bird then walks or flies to within about 15 m of the nest. The incubating individual flies directly off the nest as its mate approaches, and lands elsewhere in the field. Departure from the nest is generally in the same direction each time, and on one occasion a male was observed to rotate 180° on the nest before flying off. The incoming bird approaches the nest along a particular route and settles over the eggs. The

eggs are usually left exposed for less than 60 seconds. However, a disturbance at this time will cause the relieving bird to delay its approach and in hot weather this could kill the embryos. The bird which has been relieved preens its breast feathers and stretches its wings with a Two-wing Stretch or a Two-wing Flap before beginning another activity. On one occasion a male preened, then flew very rapidly low to the ground around a small area, swooping up and down while tipping from side as if chasing butterflies. I could not resist the thought that the male's extraordinary behavior was a result of pure delight at being freed from the nest even though he was probably only stretching cramped muscles.

Responses to Disturbances

Responses to Human Intruders

Responses to human intruders are described separately from other disturbances because I did not observe other ground predators approach nest sites, though I presume the responses are similar.

If a human enters a nest field when the non-incubating bird is nearby, the non-incubating bird assumes an Alert-Attitude and generally gives the Chirping and/or "Wheet Wheet Wheet" call. If the intruder does not leave immediately, Demonstration interspersed with displacement-feeding and the Alert-Attitude ensues, and sometimes the Enticement-Run is performed. As the intruder approaches within 10-15 meters of the nest, the non-incubating bird ceases with these displays and stands or displacement-feeds calling a soft, rapid "Whee-whee-wheet" or "Curlee Curlee."

The bird on the nest maintains normal incubation posture even when its mate or neighboring birds are Chirping. It assumes a concealing posture, lying motionless as tight to the ground as possible with the bill resting on the

ground (Figure 35) only after the intruder comes within sight, or if its mate flies up nearby calling "Curlee Curlee." As long as the intruder is a potential threat to the nest, the incubating bird maintains this posture and the non-incubating partner continues calling. When no further calls are heard from the non-incubating partner or it whistles an "all clear," the sitting bird slowly raises its head and looks around. If the non-incubating mate is not present when an intruder appears, the bird on the nest may remain low for half an hour or more after the intruder has gone before slowly rising up. I commonly observed such delays following my approach to a blind though eventually some birds habituated to my routine and would pop their heads up within minutes after my disappearance into the blind.

Incubating females do not usually flush when approached unless the intruder comes within about 2 m. The males, however, sometimes vacate the nest before an intruder is close enough to locate it. Several authors (e.g., Graul, 1971; Sugden, 1933; and Wolf, 1931) have touted their ability to approach an incubating bird and stroke it on the back or lift it off the nest, particularly near the end of the incubation period. I was never able to do this and believe the reason was because I originally located the nests by searching the fields and flushing the incubating birds. Once a curlew is flushed from the nest by a human intruder, a sensitivity threshold seems to be broken and the bird subsequently flushes at the first sign of approaching danger. This behavior may attract a predator to the site which might otherwise have gone unnoticed.

When flushed from the nest at close range, the incubating bird bursts forth with a loud squawk, then feigns injury for 10-20 m before performing the Enticement-Run and calling "Wheet Wheet." The bird eventually takes flight

Figure 35. Incubating Long-billed Curlew Concealing on Nest.

Fig. 35

and, joined by its mate, Demonstration interspersed with the Enticement-Run and displacement-feeding is performed. Neighboring birds which are not incubating gather nearby and add their voices to the ruckus.

Once the intruder has departed, the attending bird often takes up to an hour to settle back on the nest. During this time the bird preens or feeds and may return to the nest several times to inspect the contents. The bird may settle over the eggs, then fly off again a few minutes later only to wander back and resettle. This period is crucial for the eggs during hot weather. The male often returns to the nest first even when it is not his turn to incubate, and if the disturbance occurred in the middle or late afternoon he usually remains on the nest through the night. If the disturbance occurred in the morning, the female usually relieves the male within several hours.

Responses to Other Species

An incubating bird responds to the presence of a potential avian predator (Swainson's Hawk, Red-tailed Hawk, Marsh Hawk, Ferruginous Hawk, Great Horned Owl, Raven) by crouching low on the nest as described previously. The non-incubating bird responds with flying threats (Marsh Hawks excepted; see below) or performs the Arc display if the avian predator is perched near the nest.

Cameron (1907) reported seeing nesting curlews make flying attacks on Marsh Hawks. At the 300 Area study site a pair of Marsh Hawks commonly hunted over the dune area and parts of the nearby fields, but the curlews usually ignored them. Magpies are a persistent threat to nesting Long-billed Curlews, but a pair can usually keep them from the eggs if not otherwise distracted. An incubating curlew does not conceal in response to a Magpie, but the non-incubating bird will pursue a Magpie on the ground with the

Crouch-Run or in flight. Though gulls routinely fly over the 300 Area study site, they are ignored by the curlews and themselves show no interest in the nesting shorebirds unless a disturbance at a nest site creates a ruckus which then attracts them.

One or two Coyotes commonly cross through the nesting fields daily, sometimes passing within a few meters of a nest. The incubating bird conceals as the non-incubating bird flies to a vantage point Chirping. The non-incubating bird then displacement-preens or displacement-feeds while calling "Curlee Curlee" off and on until the Coyote departs. Neighboring birds may also fly to vantage points to watch the Coyote, calling "Curlee Curlee." When a Coyote is passing through an area, its movements are easy to follow merely by listening to the chain of curlew Chirping calls which results as it moves from one territory to another. A Townsend's Ground Squirrel was observed once in the vicinity of a Long-billed Curlew nest but the incubating female showed no aggression even though the squirrel came within 4 m of her.

Responses to Other Disturbances

Airplanes elicit the same response in incubating Long-billed Curlews as do avian predators, but non-incubating birds assume the Alert-Attitude and cock their heads skyward to watch. If a plane is between 15 and 30 m off the ground, all of the non-attending birds in the area begin calling a loud and shrill "Wheet Wheet," then fly up in alarm. Once the airplane has passed, they return to their fields Whistling as they land, and those on the nests pop their heads up again. Unusual sounds also cause an incubating bird to duck down on the nest, and the whistle of a nearby train invariably elicited this response.

Nesting Success

Nesting success was good in 1976 (no losses were observed) and poor in 1977. All the nests which I had located prior to hatching were destroyed by predators, including all the nests but two at the 300 Area study site. The success of the predators in 1977 is attributed to insufficient nesting cover resulting from the dry winter of 1976. Additionally, Coyotes were thought to be more abundant in 1977 than in 1976, but this is purely subjective.

Time-lapse film from one nest shows a Coyote approaching and eating the eggs. The Coyote was originally passing by about 5 m away, but then spotted the concealing curlew and turned to investigate. In a year of normal grass growth, a Coyote would be unable to spot a concealing curlew at 5 m.

During the incubation period Coyotes appear to be the major predator, but other potential predators include Badger, Pacific Gopher Snake, and Magpie. At one nest trampling by feral horses appeared to be the cause of destruction, but such damage may be offset by the benefits gained from grazing during years of overabundant plant growth. No losses by adverse weather were noted.

Behavior Following Nest Loss

Curlews abandon the nest once the eggs are damaged or destroyed. Once a nest is abandoned by a pair, they gradually become less and less responsive to predators and disturbances. The territory is still defended against conspecifics for a week to 10 days following the destruction of the nest, but the birds spend more and more time each day away from it. Finally they depart and presumably migrate south.

Immediately after the predator leaves the nest the curlews approach, and if any egg shells remain in the nest they are removed. The birds at this point are hypersensitive to any disturbance and direct intensive flying attacks

toward potential predators. Demonstration and displacement-feeding are performed. Within several hours the birds begin walking-and-feeding or rest in the field near the nest. In time the male begins Ground-Calling and then Scraping and Shaking, all intermixed. Incomplete Scrape Ceremonies and Tossing behavior are also performed; the Bill-Down posture, however, was never observed. The female is not receptive to this renewed courting by the male but she does perform Scraping at several different sites of her own. This behavior lasts for up to two hours, interspersed with brief periods of maintenance activity and standing around. Eight hours after one nest was destroyed, the pair finally left the nest field and flew toward the River.

HATCHING

Starring of an egg commonly appeared three to four days prior to hatching, and a hole usually developed one to two days before the chick emerged. "Clicking" noises from inside the egg were heard in pipped eggs up to 53 hours prior to hatching.

Forsythe (1967) described the hatching method of the Long-billed Curlew. He observed that the pip hole was started approximately one-third the distance from the large end of the egg, then was progressively enlarged until the chick pushed out the large end and emerged by splitting the remaining shell into three roughly triangular pieces. I did not observe the complete hatching process but did find the pip hole to be started as he described (Figure 36). I also collected several shells as soon as the chicks were free. In each, about half of the large end and one side were missing whereas the rest of the shell was intact, indicating a slightly different method from that which Forsythe found.

Presumably the eggs were rotated throughout incubation as a result of poking and shuffling by the adult bird, but during hatching they maintained a relatively stable position, usually with the pipped area upward. This would seem advantageous, making it easier for the chicks to switch to air breathing.

Hatching was usually synchronous within a nest, all the chicks being hatched within five hours, and seemed to occur at any hour of the day or during the night. Hatching was also synchronous within an area, unlike what Forsythe (1970) observed in Utah. In 1976, hatching on the 300 Area study site was 11-14 May (five nests); at the 100-H/100-D Area it was 25 May to 2 June (four nests).

Figure 36. Hatching. a. Pipping, b. Downy Chick.

a.

b.

Fig. 36

Behavior

Long-billed Curlews, like many other birds, become especially attentive at hatching time and both members of the pair remain present once the eggs are starred. Once hatching had actually begun, the female appeared to assume all the incubation duties as she was invariably on the nest when checks were made, even at dawn when previously the male was in attendance. During hatching, however, it was not unusual to find both adults off the nest for short periods of time for reasons I was unable to ascertain.

Responses to Intruders

Hatching of the young seems to elicit a protective response in the adults that is not seen previous to this time. Arc displays are directed at human intruders as are Demonstration and Enticement-Run displays, and therefore presumably at other ground predators as well. Avian predators which fly over or perch within the territory are confronted with the same flying threats, and Marsh Hawks are attacked at this stage for the first time. Conspecifics which are attracted to the site join the ruckus though do not perform the Enticement-Run or the Arc display. If the nest has not been disturbed on previous occasions, the female remains concealed over the eggs during the male's displays unless discovered; then she too demonstrates and performs the Enticement-Run. As soon as the intruder retreats, she or the male immediately returns to the nest.

Egg Shell Removal

Adults remove egg shells as soon after hatching as possibly by grasping them in the bill and flying several hundred meters before alighting and dropping them. Each shell is dropped in a different spot and not always

in the same direction from the nest. Graul (1971) observed the male (short-billed individual) performing this function. At two nests where I observed this behavior, the females removed the shells.

Chick Behavior

Chicks generally dry out completely within three hours of hatching but even before they are dry they begin to toddle out of the nest alone, resting in the grass and returning to be brooded for short periods. They are at first shaky on their feet but manipulate their wobbly legs surprisingly well. Within a few hours coordination of the young has improved substantially, and those that hatch first often wander too far from the nest before the others are ready and are lost. At two sites I was unable to find the first-hatched chick within a 10 m radius of the nest. Newly hatched chicks do not follow or respond well to the calls of the adults, and once mobile may run from the nest when there is a disturbance instead of concealing. Upon approaching a nest soon after hatching I would usually find the chicks resting in or just outside the bowl. When handled, the chicks would often cry in distress, giving the "Squee" call which would throw the adults into a frenzy of displays at close quarters. One chick called "Peep Peep" and "Hee-Who" while resting in the nest prior to being banded. During the first 24 hours the chicks slowly peck at the ground and at various objects and appear to start feeding by the second day.

BROOD PERIOD

Nest Departure

If the last chick hatches in the morning or very early afternoon and the weather is favorable, the entire brood is likely to leave the nest that afternoon. If the last chick hatches later in the afternoon or evening, the brood usually stays at the nest until the following day, leaving about mid-morning when the temperature has risen sufficiently for the chicks not to require brooding. In rainy or cool weather, the brood may stay in the nest for up to 24 hours (one observation). If the site is disturbed during hatching, the chicks are moved away from the nest prematurely, often before the youngest are fully mobile.

At the time of departure, the male stands watch some distance away in the direction they intend to move as the female gives a low call while standing near the nest. At the 300 Area study site the chicks were moved directly to the south-ridge area, and the male took up a position on top of the first ridge overlooking the field and the rest of the ridge area. Normally the chicks return and are brooded at the nest site at night for several days following hatching, and the site is defended during this time (Tremaine, personal communication).

Brooding

Brooding is accomplished by the same posture used in incubation or by the adult standing with the wings dropped down with the young standing beneath (Figure 37). Young are regularly brooded at different times during

Figure 37. Brooding Posture.

Fig. 37

their first few days by both sexes, particularly during the cool early morning hours. I do not know the age of the young when brooding is terminated, but I never observed chicks being brooded after they were about two weeks old.

Behavior

Shading

The chicks spend most of their time walking-and-feeding even during the heat of the day, though when small they frequently rest for short periods in the shade of a shrub or a large forb. Sometimes the chicks crawl up into these plants, presumably gaining the additional advantage of the cooling effect of the wind. I never observed adults shading their chicks, but on the Hanford Site the chick-rearing areas all include plant species large enough to provide shade so adult shading is not necessary. The adults also seek shade during the heat of the day, but one bird always maintains a lookout.

One observation illustrates the seriousness of extended exposure of the chicks to the sun. On this occasion, the chicks were confined with the temperature above 24°C while I searched for them in a Big Sagebrush/Antelope Bitterbrush area. After 10 minutes, one chick stood up in a thin Cheatgrass patch between the shrubs and began calling "Peep Peep." The chick was bubbling from the mouth and panting; it still had its egg tooth. I moved the chick into the shade where I measured and banded it, and it appeared to have recovered when I left. I am convinced that any further delay in seeking shade would have been fatal for the chick.

Brood Movements

Long-billed Curlew family units do not keep together the way some other shorebirds do, e.g., Killdeer. The chicks wander independently and often become widely separated. The older they get, the more independent the chicks

become and the farther apart they wander. One juvenile of about three weeks of age was found approximately 563 m from its parents and a sibling. On another occasion the two chicks in that same brood were separated by approximately 805 m. One parent was with each chick and neither could see the other. The adults can determine the general direction of travel by the male flying 50-100 m ahead and standing, while the chicks and the female wander towards him walking-and-feeding. If the chicks are wandering in the preferred direction on their own, the adults may merely follow along behind them. If the adults remain in one localized area, the chicks will center their activities there but may range 100 m out and back.

The adults maintain a close watch, usually 50-100 m apart with the chicks somewhere in between. Daily brood movements were of two patterns, presumably a function of the habitat available. At the 300 Area study site the chicks were moved from the fields into the south-ridge area, where at first they were found in different locations each day. Then sometime within the first two weeks, chick-rearing areas were selected and each brood could be found daily in one specific area. Detailed observations were not made on broods in the south-ridge area because the topography and vegetation inhibited sightings. At the 100-H/100-D and 100-F study sites the broods followed a daily routine of moving toward the River from their nest area in the early morning, feeding in the fields along the bluffs during the day, and then heading back toward their nest area in the late afternoon and evening. The chicks and adults would then roost for the night in or near their nest area.

Perching

Long-billed Curlews commonly alight in Big Sagebrush, Antelope Bitterbrush, trees, or on top of dried tumbleweeds, dirt mounds, rocks, stumps, fence posts, utility poles, rails, etc. (Figure 38). Though this behavior may

Figure 38. Male Perching in Shrub.

Fig. 38

be seen at any time during the breeding season, it is particularly advantageous during the brood period when the adults are protecting their flightless young. At the 300 Area study site where the chicks are reared in shrub vegetation that averages about 1.2 m high, the adults cannot possibly spot intruders at a distance while standing on the ground. Hence, at least one adult perches in the top of a suitably tall shrub. Occasionally a bird was observed to assume a bill-back resting posture while perched in a shrub, but this may have been a displacement activity. In chick-rearing areas where shrubs are not predominant, the adults perch on whatever is available. Those areas along the Columbia River have scattered trees and I have seen curlews land in them as high as 20 m off the ground when disturbed by an intruder. From these vantage points, the parent curlews keep close watch over the fields until they are assured all danger has passed.

The birds touch down gracefully when alighting above ground and the wings are fluttered overhead until balance is obtained. Sometimes this is a rather lengthy process if the branches of a particular bush are flimsy and the weight of the bird is too much for them. Some birds are often persistent and keep trying for several minutes, breaking numerous branches before selecting another perching site.

Roosting

The chicks are still downy when they are no longer brooded at night. They continue walking-and-feeding after sundown until the female calls them with the "Wheet" call toward the roosting area. Soon after sundown, the male flies from the field but I was never able to follow where he went. At twilight each chick disappears into the grass while the female stands alert. At dark she flies low across the field and also disappears. I made one observation of chick behavior on the first night following their abandonment by the

female (see below). The chicks were alone with the male and 15 minutes after sundown began to follow after him. The male responded by flying from place to place around the field as the chicks ran first one way and then another in an attempt to keep up, but the male always landed too far away. Finally it got so dark I could no longer see the chicks and presumably they sat down in the grass.

Feeding

The chicks walk-and-feed in a manner similar to the adults except that they more frequently run after insects and probing was not observed. They pay particular attention to Munro Globe-mallow plants when they are available, poking among the foliage and tugging at the leaves.

Flapping-Jump

The downy young were frequently observed to perform a movement which I have termed the Flapping-Jump, in which they would make short dashes, simultaneously flapping their wings and jumping up and down as if attempting to fly. The behavior occurred when the chicks were crossing an open area such as a road, and each chick in turn would Flapping-Jump for a few seconds before going on. I have observed strikingly similar behavior in Canada Geese goslings.

Fledging

The females usually abandon their broods when the chicks are 2-3 weeks old, though it is not unusual for one to remain up until fledging. After the females depart, only the males care for the chicks. Two young broods were found in which only the female was caring for the chicks, and in these cases the male had presumably been killed.

About 31 days after hatching, the juveniles and attending adult(s) change their daily routine and begin moving cross-country away from their nesting area. The feather development of chicks of known ages captured prior to this wandering period appeared to be within 10 to 14 days of completion. On this basis, Long-billed Curlews fledge at 41-45 days. Watson (1972) reported that Eurasian Curlews fledge in 35-42 days.

Once the birds start moving they may travel over 2 km a day, and tracking them through the shrubby areas to make observations was not feasible since the adults at this stage no longer fly up at the first sign of disturbance. As a result I have no data for this period and was not able to watch the process of "learning" to fly. However, on 21 July, I watched one juvenile flying from the Columbia River after loafing for several hours on an island. A strong breeze was blowing and the bird had considerable difficulty making headway, but eventually it was able to land on top of the bluffs above the River. After resting for seven minutes, the bird again took off and with great difficulty disappeared over the horizon headed northeast. Adult birds could easily negotiate the climb over the bluffs in even strong winds.

Territoriality

Pairs with young spend a considerable amount of time evicting other Long-billed Curlews from the vicinity of the chicks. The area defended by the parents, however, is a minimum distance from the chicks themselves rather than the entire "territory" as was the case prior to hatching. Therefore as the chicks move so does the area defended. The interactions with conspecifics are usually mild but violent encounters are also common.

The interlopers become increasingly problematic through the month of June. Their numbers increase as do the size of the groups as those birds without chicks are flocking, and migrants from other areas are starting to

arrive. In the late afternoon and evening they move into the fields to feed and roost for the night. They appear to be attracted by the presence of other curlews and usually try to land with the parent birds and their young. Commonly these intruders are very persistent and hesitate to leave, resulting in prolonged Appeasement-Run behavior. If a group flies in and lands near the chicks, the male or female threatens or pecks each bird one at a time and often repeatedly before the entire group departs. The chicks appear not to be bothered by the adult interactions and ignore the intruders.

Responses to Disturbances

At the first sign of approaching danger, adults with a newly hatched brood give a mixed series of Chirping, "Curlee Curlee," and "Wheet Wheet" calls. Demonstration is then performed by the female while the male remains with the chicks, though flying to a vantage point. If the intruder continues to approach, then the male too demonstrates and sometimes the Enticement-Run is performed. The Arc display is performed if the intruder is very close to the young; e.g., when a human is searching for the chicks.

When an avian predator flies over the chick-rearing area, the adults pursue it intensely. Occasionally a raptor will perch near the chicks or will be perched in an area where the adults are trying to take the chicks. In these situations the adult curlews repeatedly perform the Arc display. On two occasions I observed parent curlews flying at a perched Red-tailed Hawk for over 35 minutes. Perching raptors, however, rarely appear to be annoyed by the aerial displays of Long-billed Curlews, and ultimately the curlews resort to chick-removal as a solution.

The chicks usually do not conceal promptly in response to the adult alarm calls, but they do conceal if both adults leave the immediate area. Their cryptic coloration serves them well as they crouch flat and motionless

on the ground (Figure 39), making them difficult to locate. The adults call them up with a soft "Wheet" call when the danger has passed.

As the chicks get older, they wait to conceal until they actually see the intruder approaching. Also, these older more experienced chicks tend to hide when possible with the head at least under a shrub or forb, this often involving a run to a suitable point. As they run, they turn their heads to watch the intruder and hold their wings out to the side (Figure 40). I located one chick which had crawled into a small depression, covered with grass and broken Jim Hill Mustard stems. Another was located 13 cm off the ground in a Big Sagebrush. Corresponding roughly with this change in chick behavior, Long-billed Curlew adults gradually stop performing threat displays and give only alarm calls in response to disturbances.

The older the chicks get, the more they run before concealing, and often I could approach within 10 m before losing sight of them. Chicks within 1-2 weeks of fledging would conceal, then just as I was reaching for them they would jump up and take off running. Once in hand, the chick would give a call similar to the adult "Guaah" call, and one even bit my finger.

When a chick is first captured by a human, the adults Demonstrate and perform the Arc display. After the chick has been in hand for several minutes, it usually ceases to give its alarm note and the adults displacement-feed or assume the Alert-Attitude nearby. As soon as the chick is released the adults begin again with their demonstrations. The chick runs away: Younger ones usually conceal in the nearest shrub if one is available; older ones run until they are out of sight of the intruder. The adults assume a vantage point and keep watch until the intruder has departed.

Figure 39. Chick Concealing.

Fig. 39

Figure 40. Chick Running Away from Human Intruder.

Fig. 40

Accidents, Injuries, and Mortality

Two fledging juveniles were involved in collisions with man-made structures. One was found dead, presumably having flown into a utility wire. The other was found stunned after an apparent collision with a car; it recovered and was released.

Three chicks were captured that were suffering from some kind of injury. The first was about a week old and had a fractured tibiotarsus bone. The chick was found in an emaciated condition and died within two hours. The second was 2-3 weeks old and had two Cheatgrass florets lodged in one eye. The eye was completely closed, but after I removed the florets the bird was able to partially open it. The eye appeared normal when the same chick was recaptured one week later. The third case involved a 4-5 week old chick. It had an unidentified grass floret embedded in the feather shaft of one primary, and that primary had not emerged as fully as the others. I removed the floret before releasing the bird.

Mortality is highest in chicks under one week of age and seems to level off after that. A very unusual situation is to see a pair of adults with more than two young in their care and most adults have none. The chicks are lost most frequently at night when observations are made with difficulty.

Many of the causes of chick mortality are uncertain, but predation is no doubt partly responsible. R. E. Fitzner found the remains of one downy chick at a Swainson's Hawk nest, feathers from three juvenile or adult birds in Ferruginous Hawk castings, and feathers from one juvenile or adult bird in a Great Horned Owl casting. I saw a Magpie carry off one chick that was less than 24 hours old. I suspect Coyotes are of primary concern, though I never actually saw one take a chick.

Some chicks may perish early by wandering too far from the nest too soon or by not being able to keep up with the adults and other brood members. A disturbance at hatching time resulting in chick-removal most certainly increases chick losses in this way. One chick less than two days old was found dead in a nest field, presumably of exposure. Exposure during the heat of the day or at night may cause mortality, and an example of such was described above under Behavior.

Adverse weather conditions are undoubtedly stressful for the chicks. The nights are still cool when the chicks are downy and June is wet and windy. I have watched chicks walking-and-feeding for hours at a time in a high wind while it rained continuously. Cold, wet, windy nights must certainly take their toll. The wind also poses a problem for the adults when a predator approaches because they cannot effectively fly at it.

Many broods are still on the ground after the flocking phase is well underway. Those chicks that hatch late in May will still be downy after the bulk of the adults has departed, and this absence of conspecifics which would otherwise provide additional eyes and ears to guard against predators may also contribute to chick mortality.

In 1976 no estimate of fledging success was made. In 1977 nine juveniles remained at the staging area after the main congregation of Long-billed Curlews from the Hanford Site and the Wahluke Slope had departed. I was unable to estimate age or ascertain sex of the birds at the staging area because the staging island was too distant from the mainland.

STAGING AND DEPARTURE

Staging and departure was not observed in 1976. In 1977 the first small flocks were observed in the fields in early June.

Flocks spend the heat of the day resting in fields or loafing on the upstream tips of islands in the Columbia River. A spit on the south side of Island 3 ("Big Dune Island") between 100-H and 100-D Areas serves as the primary loafing and staging area for curlews from the Hanford Site and the Wahluke Slope.

Birds usually arrive at Big Dune Island in the morning between 1000 and noon. They arrive singly or in groups, some of which include up to 100 birds by mid-June. Time on the Island is spent resting, preening, and occasionally bathing. The majority of the birds remains at the site until late afternoon or evening, usually leaving between 1600 and 1800; all are gone by 2000.

As the daily departure time grows near, "Wheet Wheet Wheet" calls and bouts of Two-wing Flap movements ripple through the flock. The birds become more restless, shifting about calling "Wheet Wheet Wheet," and groups begin to leave for the fields where they roost for the night.

Each group leaves in a flurry of Two-wing Flap behavior. A few birds lift off first, calling "Wheet Wheet Wheet," and are immediately joined by others. Their flight is erratic as they are buffeted by the wind, but eventually they rise up and fly away in strong, even flight though in no particular formation. Often shortly after taking off, individuals were observed to dive straight down, twisting back and forth, then to swoop up just before hitting the water as if they were playing in the wind.

The curlews can apparently identify the other birds that roost in their area because each group lifts off together and heads in a particular direction. When several groups leave simultaneously there doesn't seem to be any confusion among group members about which way to go or with whom. However, when a group initiates its departure, other birds may also fly up to join them but then "realize their mistake" and return to the flock.

As the flocking phase progresses, the birds arrive earlier and leave later each day; the flocks also become larger. A peak population of approximately 250 birds was present on 17 June, following which their numbers decreased to merely a few stragglers by the end of the month. In the month of July, only a small group of juveniles was present.

During this period of flock reduction, groups of up to 30 birds were observed to leave the Big Dune Island at the usual daily departure time, but instead of heading out in one particular direction they began milling around over a nearby field, calling "Wheet Wheet Wheet" continuously as they spiraled upwards. I watched these groups through binoculars until they went up so high that I could no longer see them. Presumably these birds migrated from the Hanford Site and Southeastern Washington.

A CURLEW'S FAREWELL

I tried but I can try no more

I cried but I can cry no more

I failed to bring a young chick's cry

Into this world.

Time now bids me say farewell

The sun is setting and I must go

But I will come again next year...

and try

Until I die.

--Anon.

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PLANTS

Scientific Name

Common Name

Bromus cecurum
Bromus cecurum
Bromus cecurum
Bromus cecurum
Bromus cecurum

Chenopodium
Sambucus
Sambucus
Sambucus
Sambucus

POLYMONACEAE - Buckwheat Family

Eriogonum

Buckwheat

CHEMOPODIACEAE - Goosefoot Family

Salix
Salix
Salix
Salix
Salix

Russian Thistle
Spiraea

APPENDIX A

SYSTEMATIC LIST OF COMMON AND SCIENTIFIC NAMES

OF PLANTS AND ANIMALS MENTIONED IN THE TEXT

Salix
Salix
Salix
Salix
Salix

LEGUMINOSAE - Pea Family

Lupinus

Lupine

POLEMONIACEAE - Phlox Family

Phlox

Long-leaf Phlox

SORASTIACEAE - Sorus Family

Amorpha

Twisted Field Pea

CHABACEAE - Evening Primrose Family

Oenothera

White Evening Primrose

Plant identification and names follow Hitchcock and Maguire (1947)

PLANTS¹

<u>Common Name</u>	<u>Scientific Name</u>
GRAMINEAE - Grass Family	
Cheatgrass	<u>Bromus tectorum</u>
Sandberg's Bluegrass	<u>Poa sandbergii</u>
Bluebunch Wheatgrass	<u>Agropyron spicatum</u>
Sand Dropseed	<u>Sporobolus cryptandrus</u>
POLYGONACEAE - Buckwheat Family	
Buckwheat	<u>Eriogonum sp.</u>
CHENOPODICEAE - Goosefoot Family	
Russian Thistle	<u>Salsola kali</u>
Spiny Hopsage	<u>Atriplex spinosa</u>
CRUCIFERAE - Mustard Family	
Jim Hill Mustard	<u>Sisymbrium altissimum</u>
Wallflower	<u>Erysimum asperum</u>
LEGUMINOSAE - Pea Family	
Lupine	<u>Lupinus sp.</u>
POLEMONIACEAE - Phlox Family	
Long-leaf Phlox	<u>Phlox longifolia</u>
BORAGINACEAE - Borage Family	
Tarweed Fiddleneck	<u>Amsinckia lycopsoides</u>
ONAGRACEAE - Evening Primrose Family	
Pale Evening Primrose	<u>Oenothera pallida</u>

¹Plant identification and names follow Hitchcock and Cronquist (1973).

<u>Common Name</u>	<u>Scientific Name</u>
MALVACEAE - Mallow Family	
Munro Globe-mallow	<u>Sphaeralcea munroana</u>
LILIACEAE - Lily Family	
Asparagus	<u>Asparagus officinalis</u>
Brodiaea	<u>Brodiaea douglasii</u>
UMBELLIFERAE - Parsley Family	
Desert Parsley	<u>Cymopterus terebinthinus</u>
CACTACEAE - Cactus Family	
Plains Prickly-pear Cactus	<u>Opuntia polycantha</u>
ROSACEAE - Rose Family	
Antelope Bitterbrush	<u>Pursia tridentata</u>
COMPOSITAE - Aster Family	
Big Sagebrush	<u>Artemisia tridentata</u>
Gray Rabbit Brush	<u>Chrysothamnus nauseosus</u>
Green Rabbit Brush	<u>Chrysothamnus viscidiflorus</u>
Fleabane	<u>Erigeron sp.</u>
Balsamroot	<u>Balsamorhiza careyana</u>
Yarrow	<u>Achillea lanulosa</u>

ANIMALS²

<u>Common Name</u>	<u>Scientific Name</u>
BIRDS	
Order Anseriformes	
Canada Goose	<u>Branta canadensis</u>
Order Falconiformes	
Ferruginous Hawk	<u>Buteo regalis</u>
Swainson's Hawk	<u>Buteo swainsoni</u>
Red-tailed Hawk	<u>Buteo jamaicensis</u>
Marsh Hawk	<u>Circus cyaneus</u>
American Kestrel	<u>Falco sparverius</u>
Order Galliformes	
Ring-necked Pheasant	<u>Phasianus colchicus</u>
Order Charadriiformes	
Oyster Catcher	<u>Haematopus ostralegus</u>
American Avocet	<u>Recurvirostra americana</u>
Black-necked Stilt	<u>Himantopus himantopus</u>
Killdeer	<u>Charadrius vociferus</u>
Whimbrel	<u>Numenius phaeopus</u>
Eskimo Curlew	<u>Numenius borealis</u>
Bristle-thighed Curlew	<u>Numenius tahitiensis</u>
European Curlew	<u>Numenius arquata</u>
Black-tailed Godwit	<u>Limosa limosa</u>
Willet	<u>Catotrophorus semipalmatus</u>
Gull	<u>Larus sp.</u>

²Common and scientific names of birds follow the American Ornithologists' Union Checklist of North American Birds (1957); mammal names follow Hall and Kelson (1959); reptile and amphibian names follow Stebbins (1966).

<u>Common Name</u>	<u>Scientific Name</u>
Order Strigiformes	
Great Horned Owl	<u>Bubo virginianus</u>
Order Coraciiformes	
Belted Kingfisher	<u>Megaceryle alcyon</u>
Order Passeriformes	
Raven	<u>Corvus corax</u>
Black-bellied Magpie	<u>Pica pica</u>
Horned Lark	<u>Eremophila alpestris</u>
Lark Bunting	<u>Calamospiza melanocorys</u>

MAMMALS

Coyote	<u>Canis latrans</u>
Badger	<u>Taxidea taxus</u>
Townsend's Ground Squirrel	<u>Citellus townsendii</u>

REPTILES

Pacific Gopher Snake	<u>Pituophis melanoleucus catenifer</u>
Bullsnake	<u>Pituophis melanoleucus sayi</u>

AMPHIBIANS

Pacific Treefrog	<u>Hyla regilla</u>
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APPENDIX B

HABITAT ANALYSIS DATA

1991 Biological Corridor for the Pacific Northwest

TABLE

TABLE 8

Total Percentage Coverage for Feeding Areas

Taxa	Group B		Ave. B	Group E	Ave. E		Group J			Ave. J	Group K		Ave. K	Group L		Ave. L
	T ₁	T ₂	X ± S.E.		T ₁	T ₂	X ± S.E.	T ₁	T ₂	T ₃	X ± S.E.	T ₁	T ₂	X ± S.E.	T ₁	T ₂
Annual Grasses																
Bromus tectorum	3.5	5.8	4.6 ± 1.2	22.4	15.4	18.9 ± 3.5	1.2	0.8	11.4	4.5 ± 3.5	6.5	7.8	7.2 ± 0.7	5.9	8.9	7.4 ± 1.5
Old Bromus tectorum	97.5	96.5	97 ± 0.5	94.6	95	94.8 ± 0.2	5.2	3.8	35.8	14.9 ± 10.4	24.2	24.5	24.3 ± 0.2	49.2	46.2	47.7 ± 1.5
Perennial Grasses																
Poa sandbergii	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0 ± 0	4.4	0.6	2.5 ± 1.9	0	1.4	0.7 ± 0.7
Old Poa sandbergii	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0 ± 0	0.6	0	0.3 ± 0.3	0	0	0 ± 0
Stipa comata	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0 ± 0	0	1.3	0.6 ± 0.6	0	0	0 ± 0
Annual Forbs																
Ambrosia acanthicarpa	0	0	0 ± 0	0	0	0 ± 0	14.8	6.4	0	7.1 ± 4.3	0	0.05	0.02 ± 0.02	0	0	0 ± 0
Old Ambrosia acanthicarpa	0	0	0 ± 0	0	0	0 ± 0	0	2.6	0	0.9 ± 0.9	0	0.05	0.02 ± 0.02	0	0	0 ± 0
Austrobaileya laevis	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0 ± 0	0	0.05	0.02 ± 0.02	0	0	0 ± 0
Cryptantha circumscissa	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0 ± 0	0.05	0.1	0.1 ± 0.02	0	0	0 ± 0
Cryptantha pterocarya	0	0	0 ± 0	0	0	0 ± 0	0	0	0.2	0.05 ± 0.05	0.05	0	0.02 ± 0.02	0	0.4	0.2 ± 0.2
Descurainia pinnata	0	0.05	0.02 ± 0.02	0	0	0 ± 0	0	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0
Lactuca scariola	0	0	0 ± 0	0	0	0 ± 0	0	0	0.05	0.02 ± 0.02	0	0	0 ± 0	0	0	0 ± 0
Plantago purshii	0	0	0 ± 0	0	0	0 ± 0	0	0	0.2	0.1 ± 0.1	0	0	0 ± 0	0	0	0 ± 0
Salsola kali	2.4	1.9	2.1 ± 0.2	0	0	0 ± 0	0	0	0	0 ± 0	0.05	0	0.02 ± 0.02	0	0	0 ± 0
Sisymbrium altissimum	0	0.05	0.02 ± 0.02	0.3	0	0.2 ± 0.2	0	0	0	0 ± 0	0	0	0 ± 0	0.05	0	0.02 ± 0.02
Old Sisymbrium altissimum	0	0	0 ± 0	0	0	0 ± 0	0.3	0.1	0.05	0.2 ± 0.1	0	0	0 ± 0	0.1	0	0.05 ± 0.05
Perennial forbs																
Asparagus officinalis	0	0	0 ± 0	0	1.6	0.8 ± 0.8	0	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0
Eriogonum niveum	0	0	0 ± 0	0	0	0 ± 0	0	0	8.4	2.8 ± 2.8	2.6	3	2.8 ± 0.2	1.9	2.4	2.2 ± 0.2
Old Eriogonum niveum	0	0	0 ± 0	0	0	0 ± 0	0	0	17.2	5.8 ± 5.8	2.9	6.8	4.8 ± 2	8	7.4	7.7 ± 0.3
Eriogonum spp.	0	0	0 ± 0	0	0	0 ± 0	0	0	0.05	0.02 ± 0.02	0	0	0 ± 0	0	0	0 ± 0
Ionatum triternatum	0	0	0 ± 0	0	0	0 ± 0	0	0	0.05	0.02 ± 0.02	0.8	0	0.4 ± 0.4	0	0	0 ± 0
Oenothera pallida	0	0	0 ± 0	0	0	0 ± 0	6.9	8.1	1	5.3 ± 2.2	0	0.8	0.4 ± 0.4	0	0.2	0.1 ± 0.1
Old Oenothera pallida	0	0	0 ± 0	0	0	0 ± 0	1.3	0	0.1	0.5 ± 0.4	0	0	0 ± 0	0	0	0 ± 0
Opuntia polycantha	0	0	0 ± 0	0	0	0 ± 0	0	0	0.8	0.2 ± 0.2	3	2.6	2.8 ± 0.2	0	0	0 ± 0
Psoralea lanceolata	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0 ± 0	0.3	0.4	0.3 ± 0.02	0.4	0.05	0.2 ± 0.2
Sphaeralcea munroana	1.6	0	0.8 ± 0.8	0	0	0 ± 0	0	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0
Shrub																
Artemisia tridentata	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0 ± 0	0	0	0 ± 0	0	9	4.5 ± 4.5
Old Artemisia tridentata	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0 ± 0	0	0	0 ± 0	0	3.7	1.8 ± 1.8
Chrysothamnus nauseosus	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0 ± 0	2	1.4	1.6 ± 0.3	10.2	6.2	8.2 ± 2
Old Chrysothamnus nauseosus	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0
Chrysothamnus viscidiflorus	0	0	0 ± 0	0	0	0 ± 0	0	0	0.05	0.02 ± 0.02	0	0.8	0.4 ± 0.4	0	0.3	0.2 ± 0.2
Old Chrysothamnus viscidiflorus	0	0	0 ± 0	0	0	0 ± 0	0	0	1.2	0.4 ± 0.4	0	0	0 ± 0	0	0.8	0.4 ± 0.4
Purshia tridentata	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0 ± 0	2.7	0	1.4 ± 1.4	2	1.6	1.8 ± 0.2
Total Live	5.6	7	6.3 ± 0.6	22.4	14.8	18.6 ± 3.8	20	15.1	19.3	10.1 ± 1.5	22.6	16.6	19.6 ± 3	20	26	23 ± 3
Litter Total	97.6	96.5	97 ± 0.5	94.6	97	95.8 ± 1.2	21	20.4	51.4	30.9 ± 10.2	28.2	33.8	31 ± 2.9	60.4	53.1	56.8 ± 3.6

TABLE 9

Percentage Frequency of Occurrence for Feeding Areas

TAXA	Group B				Ave. B				Group E				Ave. E				Group J				Ave. J				Group K				Ave. K				Group L				Ave. L			
	T ₁	T ₂	X	S.E.	T ₁	T ₂	X	S.E.	T ₁	T ₂	T ₃	X	S.E.	T ₁	T ₂	X	S.E.	T ₁	T ₂	X	S.E.	T ₁	T ₂	X	S.E.	T ₁	T ₂	X	S.E.											
Annual Grasses																																								
Bromus tectorum	80	92	86	6.0	100	98	99	2	28	24	100	50.7	24.694	94	100	97	3	100	94	97	3																			
Old Bromus tectorum	100	100	100	0	100	98	99	1	50	46	100	65.3	17.372	94	98	96	2	98	96	97	1																			
Perennial Grasses																																								
Poa sandbergii	0	0	0	0	0	0	0	0	0	0	0	0	0	42	14	28	14	0	24	12	12																			
Old Poa sandbergii	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	6	6	0	0	0	0																			
Stipa comata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	2	0	0	0	0																			
Annual Forbs																																								
Ambrosia acanthicarpa	0	0	0	0	0	0	0	0	92	90	0	60.667	30.339	0	2	1	1	0	0	0	0																			
Old Ambrosia acanthicarpa	0	0	0	0	0	0	0	0	0	18	0	6	6	0	2	1	1	0	0	0	0																			
Amsinckia lycopsoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0																			
Cryptantha circumscissa	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	3	1	0	0	0	0																			
Cryptantha pterocarya	0	0	0	0	0	0	0	0	0	0	6	2	2	2	0	1	1	0	14	7	7																			
Descurainia pinnata	0	2	1	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																			
Lactuca serriola	0	0	0	0	0	0	0	0	0	0	2	0.667	0.667	0	0	0	0	0	0	0	0																			
Plantago purshii	0	0	0	0	0	0	0	0	0	0	10	3.333	3.333	0	0	0	0	0	0	0	0																			
Salsola kali	8	26	17	9.0	0	0	0	0	0	0	0	0	0	2	0	1	1	0	0	0	0																			
Sisymbrium altissimum	0	2	1	1.0	2	0	1	1	0	0	0	0	0	0	0	0	0	2	0	1	1																			
Old Sisymbrium altissimum	0	0	0	0	0	0	0	0	2	4	6	2.667	2.667	0	0	0	0	4	0	2	2																			
Perennial Forbs																																								
Asparagus officinalis	0	0	0	0	0	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0																			
Eriogonum niveum	0	0	0	0	0	0	0	0	0	0	48	16	16	18	16	17	1	18	20	19	1																			
Old Eriogonum niveum	0	0	0	0	0	0	0	0	0	0	58	19.333	19.333	22	16	19	3	24	18	21	3																			
Eriogonum spp.	0	0	0	0	0	0	0	0	0	0	2	0.667	0.667	0	0	0	0	0	0	0	0																			
Leonium triternatum	0	0	0	0	0	0	0	0	0	0	2	0.667	0.667	2	0	1	1	0	0	0	0																			
Oenothera pallida	0	0	0	0	0	0	0	0	34	54	12	33.333	12.129	0	20	10	10	0	10	5	5																			
Old Oenothera pallida	0	0	0	0	0	0	0	0	12	0	4	5.333	3.528	0	0	0	0	0	0	0	0																			
Opuntia polycantha	0	0	0	0	0	0	0	0	0	0	2	0.667	0.667	8	12	10	2.0	0	0	0	0																			
Psoralea lanceolata	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	3	1	16	2	9	7																			
Sphaeralcea munroana	4	0	2	2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																			
Shrubs																																								
Artemisia tridentata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	6	6																			
Old Artemisia tridentata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	3	3																			
Chrysothamnus nauseosus	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	4	2	26	10	18	8																			
Old Chrysothamnus nauseosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																			
Chrysothamnus viscidiflorus	0	0	0	0	0	0	0	0	0	0	2	0.667	0.667	0	2	1	1	0	2	1	1																			
Old Chrysothamnus viscidiflorus	0	0	0	0	0	0	0	0	0	0	2	0.667	0.667	0	0	0	0	0	2	1	1																			
Purshia tridentata	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	2	2	2	4	3	1																			
Total Live	80	98	89	9.0	100	96	98	2	96	94	100	96.667	1.764	100	100	100	0	100	100	100	0																			
litter total	100	100	100	0	100	100	100	0	98	84	100	94	5.033	98	100	99	1	100	100	100	0																			

TABLE 10

Total Percentage Coverage for Nest Fields

TAXA	Group A			Group C			Group G			Group H			Group I			
	T ₁	T ₂	X ± S.E.	T ₁	T ₂	X ± S.E.	T ₁	T ₂	X ± S.E.	T ₁	T ₂	X ± S.E.	T ₁	T ₂	T ₃	T ₄
Annual Grasses																
<i>Bromus tectorum</i>	10.4	12.8	11.6 ± 1.2	0.6	0.6	0.6 ± 0.02	16.9	15.6	16.2 ± 0.7	3.5	8.2	5.8 ± 2.4	7.8	15	7.4	8.7
Old <i>Bromus tectorum</i>	86.9	79	82.9 ± 4	83.3	81	82.2 ± 1.1	97.5	96.8	97.1 ± 0.4	75.5	90.9	83.2 ± 7.7	94.2	69	30.5	34.3
Perennial Grasses																
<i>Agropyron spicatum</i>	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0.3
Old <i>Agropyron spicatum</i>	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0.05
<i>Poa sandbergii</i>	0	0.05	0.02 ± 0.02	4.4	11.7	8.1 ± 3.6	0	0	0 ± 0	10.8	0	5.4 ± 5.4	12.8	13.6	32.8	24.6
Old <i>Poa sandbergii</i>	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	2.6	0	1.3 ± 1.3	2.8	3.5	11.1	10.2
Annual Forbs																
<i>Chenopodium leptophyllum</i>	0	0	0 ± 0	0.3	0	0.2 ± 0.2	0	0	0 ± 0	0	0	0 ± 0	0	0.05	0	0
<i>Descurainia pinnata</i>	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0
<i>Salsola kali</i>	21.2	20	20.6 ± 0.6	0.3	1	0.7 ± 0.4	1.2	6.9	4 ± 2.9	2.6	6.8	4.7 ± 2.1	0	0	0.3	0
<i>Sisymbrium altissimum</i>	17.2	4.2	10.7 ± 6.5	0	0	0 ± 0	0	0	0 ± 0	1.4	0.2	0.8 ± 0.6	0	0	0	0.4
Old <i>Sisymbrium altissimum</i>	0.6	0	0.3 ± 0.3	0	0	0 ± 0	0	0	0 ± 0	5.7	9.4	7.5 ± 1.8	0	0	0	2
<i>Tragopogon dubius</i>	0	0	0 ± 0	0	0	0 ± 0	0.05	0	0.02 ± 0.02	0	0	0 ± 0	0	0	0	0
Perennial Forbs																
<i>Lomatium macrocarpum</i>	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0.05
<i>Oenothera pallida</i>	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0.3	0	0.2 ± 0.2	0	0	0	0
<i>Phlox longifolia</i>	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0.4	0	0.2 ± 0.2	0	0	0	0
<i>Rumex</i> spp.	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0	1.5	0.8 ± 0.8	0	0	0	0
<i>Sphaeralcea munroana</i>	0	0	0 ± 0	1.6	0	0.8 ± 0.8	0	0	0 ± 0	0	0	0 ± 0	0	0	0	0
Shrubs																
<i>Artemisia tridentata</i>	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	3	0	0	0
<i>Chrysothamnus nauseosus</i>	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	3	0	0	0
Old <i>Chrysothamnus nauseosus</i>	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	3	0	0	0
<i>Chrysothamnus viscidiflorus</i>	0	0	0 ± 0	0	0	0 ± 0	0	0	0 ± 0	0.8	0	0.4 ± 0.4	0	0	0	0
Total live	40	28	34 ± 6	6.2	13.2	9.7 ± 3.5	17.0	19.9	10.8 ± 1	17.3	15	16.2 ± 1.2	22.8	22.2	32.8	25.4
Total total	91.2	85.8	88.5 ± 2.7	83.3	81	82.2 ± 1.1	97.5	96.8	97.1 ± 0.4	78.8	90.9	84.8 ± 6	95	71.9	53	50.4

TABLE 11

Percentage Frequency of Occurrence for Nest Fields

TAXA	Group A		Ave. A		Group C		Ave. C		Group G		Ave. G		Group H		Ave. H		Group I				Ave. I	
	T ₁	T ₂	X	S.E.	T ₁	T ₂	X	S.E.	T ₁	T ₂	X	S.E.	T ₁	T ₂	X	S.E.	T ₁	T ₂	T ₃	T ₄	X	S.E.
Annual Grasses																						
<i>Bromus tectorum</i>	76	92	84	± 8	22	24	23	± 1	98	100	99	± 1	50	98	74	± 24	94	100	98	98	97	± 1.258
Old <i>Bromus tectorum</i>	98	100	99	± 1	100	100	100	± 0	100	100	100	± 0	100	100	100	± 0	100	100	100	100	100	± 0
Perennial Grasses																						
<i>Agropyron spicatum</i>	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	0	0	0	2	0.5	± 0.5
Old <i>Agropyron spicatum</i>	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	0	0	0	2	0.5	± 0.5
<i>Poa sandbergii</i>	0	2	1	± 1	48	90	69	± 21	0	0	0	± 0	70	0	35	± 35	74	76	100	98	87	± 7
Old <i>Poa sandbergii</i>	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	34	0	17	± 17	72	70	100	96	84	± 7.8
Annual Forbs																						
<i>Chenopodium leptophyllum</i>	0	0	0	± 0	2	0	1	± 1	0	0	0	± 0	0	0	0	± 0	0	2	0	0	0.5	± 0.5
<i>Descurainia pinnata</i>	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	0	0	0	0	0	± 0
<i>Salsola kali</i>	78	84	81	± 3	2	4	3	± 1	16	40	28	± 12	16	38	27	± 11	0	0	2	0	0.5	± 0.5
<i>Sisymbrium altissimum</i>	58	24	41	± 17	0	0	0	± 0	0	0	0	± 0	16	6	11	± 5	0	0	0	4	1	± 1
Old <i>Sisymbrium altissimum</i>	4	0	2	± 2	0	0	0	± 0	0	0	0	± 0	24	46	35	± 11	0	0	0	10	2.5	± 2.5
<i>Tragopogon dubius</i>	0	0	0	± 0	0	0	0	± 0	2	0	1	± 1.0	0	0	0	± 0	0	0	0	0	0	± 0
Perennial Forbs																						
<i>Tomatum macrocarpum</i>	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	0	0	0	2	0.5	± 0.5
<i>Oenothera pallida</i>	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	2	0	1	± 1	0	0	0	0	0	± 0
<i>Phlox longifolia</i>	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	6	0	3	± 3	0	0	0	0	0	± 0
<i>Rumex</i> spp.	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	0	10	5	± 5	0	0	0	0	0	± 0
<i>Sphaeralcea munroana</i>	0	0	0	± 0	4	0	2	± 2	0	0	0	± 0	0	0	0	± 0	0	0	0	0	0	± 0
Shrubs																						
<i>Artemisia tridentata</i>	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	6	0	0	0	1.5	± 1.5
<i>Chrysothamnus nauseosus</i>	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	4	0	0	0	1	± 1
Old <i>Chrysothamnus nauseosus</i>	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	4	0	0	0	1	± 1
<i>Chrysothamnus viscidiflorus</i>	0	0	0	± 0	0	0	0	± 0	0	0	0	± 0	2	0	1	± 1	0	0	0	0		
Total live	98	100	99	± 1	62	94	78	± 16	98	100	99	± 1	96	98	97	± 1	98	100	100	100	99.5	± 0.5
Total	100	100	100	± 0	100	100	100	± 0	100	100	100	± 0	100	100	100	± 0	100	100	100	100	100	± 0

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