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February 1994

Prepared for the U.S. Department of the Army
under a Related Services Agreement
with the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

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Pacific Northwest Laboratory
Richland, Washington 99352

(a) Deceased.

Summary

Pacific Northwest Laboratory (PNL), at the request of the U.S. Department of the Army, conducted a study on long-billed curlews (*Numenius americanus*) on the Yakima Training Center (YTC) in the spring and summer of 1992. The long-billed curlew is a federal candidate species and is listed by the Washington Department of Wildlife as a "species of special concern." Specific objectives of this study were to 1) locate nesting areas, 2) locate brood-rearing areas, 3) evaluate habitat requirements, 4) determine diet, 5) evaluate response to troop activities, 6) evaluate the impact of livestock grazing, 7) estimate the population size, and 8) estimate recruitment rates.

Six curlews (four females and two males) were captured and fitted with radio transmitters. These birds were relocated to obtain nesting, habitat use, and feeding information. Road surveys conducted over most of the YTC provided information on the birds' general distribution, habitat requirements, and nesting and brood-rearing areas.

Long-billed curlews arrived on the YTC from mid- to late-March. Courtship displays occurred from late-March to mid-April followed by nesting and brood rearing. Birds flocked for departure in mid- to late-June. Long-billed curlews were last sighted on the YTC on 28 June. The curlews' nesting areas were open annual or perennial grasslands. Sandberg's bluegrass (*Poa sandbergii*), cheatgrass brome (*Bromus tectorum*), and bluebunch wheatgrass (*Agropyron spicatum*) were the most common grasses. Their average heights were 24.3 cm, 15.9 cm, and 33.7 cm, respectively. Shrubs were scarce in the nesting areas, but were common in the non-nesting areas. The three shrub species were big sagebrush (*Artemisia tridentata*) and gray and green rabbitbrush (*Chrysothamnus nauseosus* and *viscidiflorus*).

Two nests were located; however, both were depredated. Total population size was estimated at 22 pairs by mapping known territories and using general distribution information. The livestock grazing that occurs on the YTC did not seem to detrimentally affect the curlews in 1992. Grazing may help maintain the short vegetation structure preferred by the birds. A threat of trampling exists, however, especially by sheep. The effect of troop training activities could not be determined. The extensive road system on the YTC has the potential to increase the chance of disturbance. Several small fires occurred, but did not appear to directly affect any curlews in the area.

The 1992 work provided important baseline data on the distribution of long-billed curlews on the YTC. However, a second year of study should be conducted to provide more specific information. Important areas to study further include vegetation requirements, behavioral responses to military training activities, the birds' use of grazed and ungrazed areas, population size, and recruitment rates.

Acknowledgments

This work was funded by the U.S. Department of the Army through a Related Service Agreement with the U.S. Department of Energy under contract DE-AC06-76RLO 1830 and was supported by the Northwest College and University Association for Science under the NORCUS Undergraduate Program. Jim Reddick, Range Officer, and Margaret Taaffe-Pounds, Natural Resources Biologist, provided assistance with the logistics of working on the YTC and provided information on curlew locations. Various Army personnel were supportive and provided information on curlew sightings. Valuable field assistance was given by Jason Klabon, Alan Leary, Colin Sveum, Matt LaCroix, and Tom Kollasch. Special help in plant identification and vegetation sampling was given by Bill Rickard and Janelle Downs.

This report is in memory of Les Eberhardt, who dedicated his life to wildlife and without whom this project would not have been started.

Contents

Figures

Tables

Introduction

This report summarizes and discusses the results obtained during 1992 from the study of long-billed curlews on the Yakima Training Center (YTC), which Pacific Northwest Laboratory(a) conducted for the U.S. Department of the Army. This study was initiated to provide basic ecological information on YTC long-billed curlews (*Numenius americanus*).

The long-billed curlew is a relatively common spring and summer resident on the YTC. However, other than casual observations, very little is known about the distribution, density, reproductive success, and habitat requirements for this species on the YTC. Until recently the long-billed curlew was a U.S. Fish and Wildlife Service candidate for listing as threatened or endangered; however, on November 21, 1991 it was down-listed to Class IIIc. The Washington Department of Wildlife lists the long-billed curlew as a "species of special concern."

Specific objectives of this study were to 1) locate nesting areas, 2) locate brood-rearing areas, 3) evaluate habitat requirements, 4) determine diet, 5) evaluate response to troop activities, 6) evaluate the impact of livestock grazing, 7) estimate the population size, and 8) estimate recruitment rates.

Six curlews (four females and two males) were captured and fitted with radio transmitters. These birds were relocated to obtain nesting, habitat use, and feeding information. Road surveys conducted over most of the YTC provided information on the birds' general distribution, habitat requirements, and nesting and brood-rearing areas.

Study Area

The study was conducted on the 1,058-km^2 YTC, located in south-central Washington in Yakima and Kittitas counties, approximately 11 km north of Yakima. The YTC is bordered by the Columbia River on the east, Interstate highway I-82 on the west, the Saddle Mountains on the north, and the Moxee Valley on the south (Figure 1). Umtanum Ridge, which bisects the YTC east to west, reaches elevations of 1,249 m. The lowest elevation on the YTC is 183 m.

The climate of the area is characterized by hot, dry summers and cold, dry winters. Annual precipitation is approximately 20 cm per year. Temperatures range from -4°C in January to 40°C in July.

The YTC supports one of the larger contiguous tracts of native shrub-steppe vegetation left in Washington. Stands of big sagebrush (*Artemisia tridentata*) occur throughout the area. On relatively undisturbed areas, bluebunch wheatgrass (*Agropyron spicatum*) is the dominant grass; however, cheatgrass brome (*Bromus tectorum*) and knapweed (*Centaurea* sp.) dominate heavily disturbed areas. Crested wheatgrass (*A. cristatum*) also occurs in certain sections, having been planted as a ground cover and forage plant.

(a) Pacific Northwest Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute.

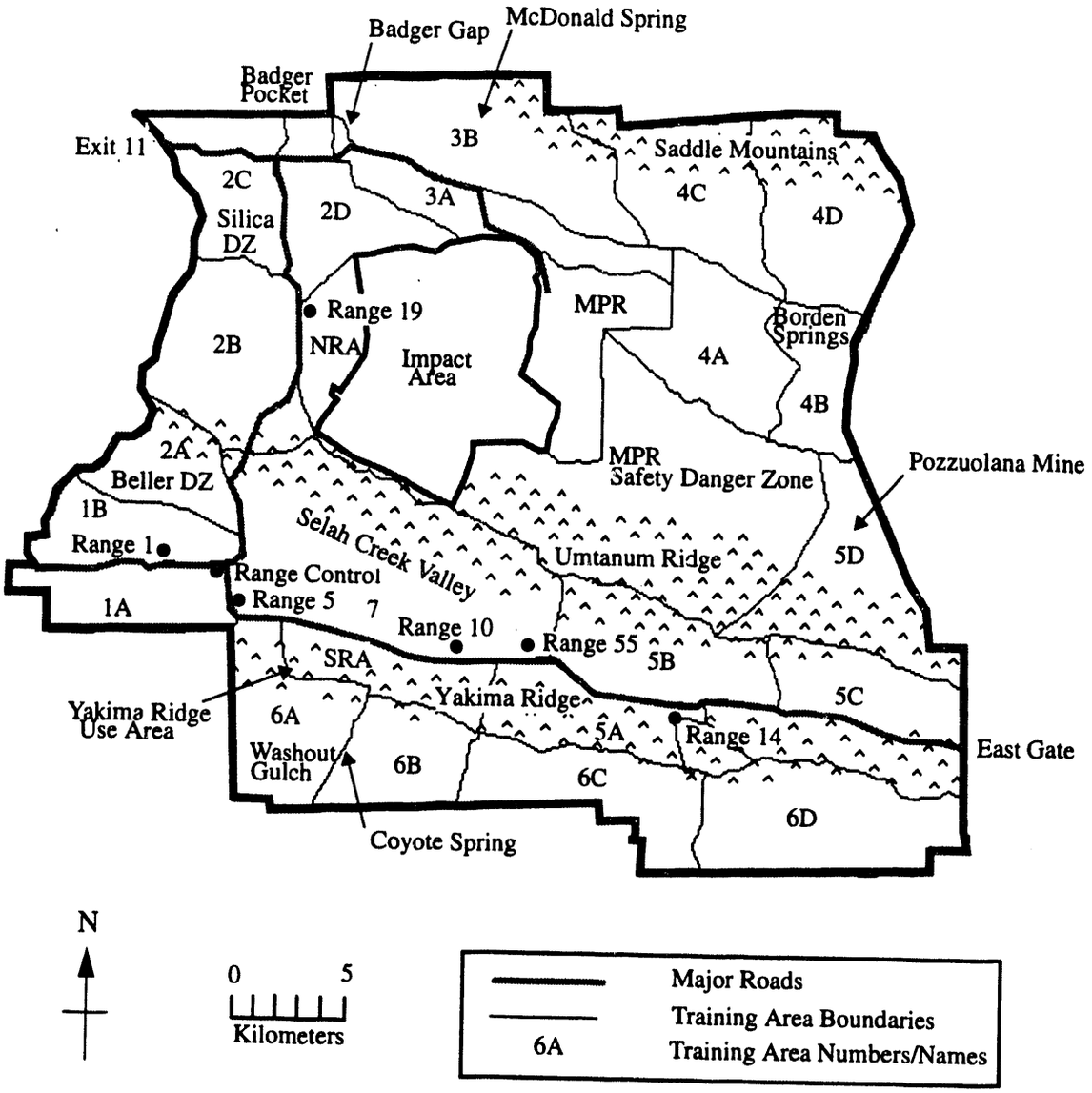

Figure 1. Yakima Training Center

The YTC is well-suited for training troops for desert warfare and is used by both active and reserve U.S. Army military components for troop maneuver exercises and weapons firing. In 1987 over 800,000 man-days of use (approximately 2,500 soldiers per day) occurred on the YTC (U.S. Department of the Army 1989).

This report includes descriptions of methods used to conduct curlew studies on the YTC, results, and additional data needs.

Methods

Population Surveys

The general distribution of long-billed curlews on the YTC was determined by driving as many roads as possible throughout the area during the nesting and brood-rearing seasons and recording all curlew sightings. Information recorded included date, time, location, number and sex of birds, and weather conditions. Location data were obtained with the Global Positioning System (GPS) and recorded in Universal Transverse Mercator (UTM) coordinates.

As the study progressed and we gained knowledge of the birds' general use areas, specific survey routes were established. Surveys over these routes were conducted in 1993, in addition to visual searches of habitats known or suspected to be used by curlews, to provide baseline knowledge of curlew abundance that can be compared with future counts.

Nesting Areas and Nest Searches

In addition to locating actual curlew nests, we identified general nesting areas by the birds' regular presence in an area and by their behavior while in the area. Allen (1980) states that "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." When disturbed on their nesting territories the birds become alert, give a strong "wheet wheet" call to warn other birds, and if necessary, perform threat displays toward the intruder. Courtship behavior also occurs on the nesting territories. Males exhibit display flights around the perimeter of their territories to attract females. After initial pair formation other precopulatory displays take place over several days leading up to copulation and nesting (Jenni et al. 1982; Redmond 1984).

We attempted to locate nests by observing pairs at their territory in the mornings and evenings during the nesting period. Allen (1980) reported that viewing the nest duty relief between males and females was the most successful method for locating nests. Radio-tracking was also used to locate nests. When first located, the incubating birds were flushed so the number of eggs could be counted. The nests were not approached closely again during the incubation period, nor were the birds flushed again from the nests.

Measurements (length, width, and depth) were taken of two nests after the adults had stopped incubating, in both cases a result of nest predation. The type of lining materials was also recorded.

Capturing and Marking

Ground-fired net launchers proved successful in capturing long-billed curlews. The net launchers were placed at various watering points used by the birds. Three capture sites were used: the Selah Creek ford on Badger Pocket Road (UTM 703906E 5174325N Zone 10), the Selah Creek ford adjacent to Range 15's tower (UTM 704686E 5175018N Zone 10), and a large puddle on Range 55 (UTM 715993E 5168381N Zone 10). Curlews tended to use shallow, still, or slow-moving water such as large puddles and stream fords. They came to specific areas regularly on warm afternoons. The net launcher used a 7.6-m x 7.6-m net by remote signal. When a curlew walked within

range of the net, the net was launched by an observer located approximately 75 m away. Because the birds are very quick, they needed to be near the back (trailing) edge of the net's range or facing toward the launcher for effective capture. Some birds became leery of approaching the watering areas when the observers and/or trucks were visible nearby. This problem was effectively solved by using a blind and parking vehicles approximately 200 m away or out of sight.

The use of a mist net and raven decoy near adult curlews with broods was also attempted.

Once captured, the birds were fitted with battery-powered radio transmitters and leg bands. The transmitters (weighing 5 to 7 g) were glued to the feathers of the back between the wings using an epoxy developed for use on shorebirds. Two colored and numbered plastic leg bands were placed on each bird, one on each leg, in unique color combinations. One U.S. Fish and Wildlife Service numbered aluminum band was also placed on each bird. The bands were placed around the tibiotarsus to be visible when the birds were standing. The sex of the birds was determined from bill length and shape and ages were estimated from bill length and general body size (Allen 1980). Three measurements were recorded: 1) tarsus (tarsometatarsus) length, measured from the point of the tibia/metatarsus joint to the point of the metatarsus/ middle toe joint, 2) exposed culmen length, measured from the point where the feathers on the forehead end straight to the tip of the maxilla, and 3) bill length from gape, measured from the corner of the mouth straight to the tip of the maxilla. These measurements were compared with those from the literature and used to confirm age and sex of the birds.

Monitoring Movements

Radio-equipped curlews were usually located from the ground. The general locale of the marked bird was determined using a vehicle equipped with an omni-directional antenna. The bird was then approached on foot using a hand-held H-element antenna, and the UTM coordinates were obtained with a single GPS unit. Additional data recorded included date, time, total number of birds and their sex, activity of the bird(s), and weather conditions (air temperature, wind speed, and percent cloud cover).

Permanent ground-tracking towers were used to obtain approximate locations for radio-equipped curlews in the Impact Area (Figure 1), because human access to this area was restricted. The permanent towers consisted of paired four-element yagi antennas mounted 6 m above the ground on a rotatable mast. Three of the tracking stations were located along Umtanum Ridge, which parallels, and lies above, the southern boundary of the Impact Area. A fourth station was located near the western border of the Impact Area.

A fixed-wing aircraft was used once to locate birds that had moved large distances and had been temporarily lost or were in inaccessible areas (e.g., the Impact Area or off-site). Aerial radio-tracking was accomplished using strut-mounted yagi antennas on a Cessna airplane. Aerial radio-tracking procedures used are described by Gilmore et al. (1981). GPS units were used to estimate the marked birds' Cartesian position (latitude/longitude). Average error in relocating marked sage grouse from the air in this area has been estimated to be 801 ± 223 m (1 SD) (Eberhardt and Hoffman 1991). A BASIC computer program was used to convert latitude/longitude coordinates into UTM coordinates (Dodge et al. 1986).

Attempts were made to locate radio-equipped curlews several times each week. On a few occasions relocating marked birds was not possible because of access restrictions resulting from military training.

Habitat and Vegetation Analysis

Vegetation plots were chosen from specific curlew use locations and randomly (within use areas) for both nesting and non-nesting (feeding, brood rearing, and flocking) activities. The random sites were determined by using a random number table to generate UTM coordinates. The nesting areas were distinct from other use areas and made up one category. There were not enough feeding, brood rearing, or flocking sites to list in separate categories, so they were combined into the non-nesting category. Measurements were also taken at the two known nest sites. The nest site measurements were taken on 9 and 10 June 1992. The random nesting area and all non-nesting area vegetation measurements were taken between 1 and 16 July 1992, after the nesting period.

Vegetation was measured with a modification of Canfield's (1941) line-intercept method, a 20 x 50 cm Daubenmire plot frame (Daubenmire 1959), and a Robel pole (Robel et al. 1970). Two 10-m transect lines, oriented perpendicular to each other, were measured. For nest site measurements, the center of the transect was located on the nest. The direction of the first line was randomly chosen. Ten Daubenmire plots were used at each site (five spaced 2 m apart along each line) to measure grasses and forbs. In addition, a 1-m^2 plot centered over each actual nest site was also measured for both herbs and shrubs. The following canopy coverage classes were used: 1) >0 to <1%, 2) 1 to 5%, 3) 6 to 25%, 4) 26 to 50%, 5) 51 to 75%, 6) 76 to 95%, and 7) 96 to 100%. Heights of grasses and shrubs were also recorded. Visual obstruction was measured at the center of each transect with a Robel pole (Robel et al. 1970). The pole was marked every 0.5 dm with the first 0.5 dm also graduated to 0.25 dm. The pole was placed vertically at the center of the transect. It was viewed from 4 m away from a height of 1 m. Four measurements were taken at each site from each of the four directions formed by the transect lines. The heights (to the nearest 0.5 dm) at which vegetation totally obstructed view of the pole were recorded. If the visual obstruction occurred below 0.5 dm, readings were taken to the nearest 0.25 dm. To measure shrubs along the two transect lines, the percent of each species intercepting the line and plant heights were recorded. The occurrence of fire and/or grazing in the area of the transect was also determined. In addition, distance to nearest shrub cover was determined by pacing each site.

Feeding Behavior and Diet

Direct observation of curlews while they fed is the basis for information on feeding behavior and diet. The prey species taken, feeding location, and presence or absence of regurgitated pellets were recorded when observable.

Results and Discussion

Six long-billed curlews (four females and two males) were captured and fitted with radio transmitters during 1992 (Table 1). All six birds were captured with the ground-fired net launchers. The mist net technique proved to be ineffective because the birds were able to move away during the setup period and did not engage in mobbing of the decoy. Bill and tarsus length were measured to aid in age and sex identification and are shown in Table 2. One male curlew's radio dropped off and was recovered five days after the bird's capture. Some birds traveled quite far from their capture sites at the watering areas (each bird's capture site is listed in Table 1). Three birds were relocated 11 to 12 km away from their watering areas; one female captured at the Taylor Pond site was later located off the YTC, approximately 12 kilometers to the southeast. Other radio-equipped birds nested or were otherwise observed 2.5 to 3.5 km away from their watering areas.

Breeding Chronology

The first curlew on the YTC was sighted on 19 March 1992. This date corresponds with arrival dates on the nearby Hanford Site (17 March 1976 and 21 March 1977) reported by Allen (1980). This first sighting was of a single bird. During the next week and a half, sightings of birds increased greatly (see Appendix A for times and locations of sightings). Sightings were generally of single or paired birds and occasionally groups of three. It appeared, from the increase and then leveling off of the number of sightings, that the majority of birds had returned to the YTC by the end of March (Figure 2).

Within a week of the first sighting, beginning on 25 March 1992, courtship display flights were evident. This behavior continued until approximately 22 April. On 20 April, a copulation sequence was observed. The process, from shaking behavior by the male through actual copulation, took approximately 5 minutes.

Egg laying was not observed, but according to Allen (1980) egg laying generally takes place during the first 2 weeks of April. Incubation begins at clutch completion and lasts 28 to 29 days. Hatching occurs in mid- to late-May (Allen 1980).

The intense mobbing displays of adults with chicks are obvious and can indicate the presence of the chicks, which themselves are difficult to locate because of their wide-ranging and independent movements (Allen 1980). Our observations of mobbing behavior indicate that the brood-rearing period took place from mid-May through the end of June and corresponds with a brood sighting near the Tri-Cities on 6 June and with Allen's (1980) findings on the Hanford Site.

Flocks of birds were seen on 23 and 24 June. These flocks were made up primarily of males with several chicks and a few females. Many females had apparently left the area already, as suggested by the disappearance of all the radio-equipped females. Similarly, Jenni et al. (1982) found that females abandoned their broods before their mates did and departed before the flocking period. The last sighting of a radio-equipped female occurred on 17 June. The last curlew sighting on the YTC in 1992 was of an adult male in a brood-rearing area on 28 June.

Table 1. Summary of Long-Billed Curlews Captured and Fitted with Radio Transmitters on the Yakima Training Center in 1992

Capture Date	Capture Site	UTM Coord. Zone 10	Age Class	Sex	Transmitter Frequency	Color Band		USFWS Band No.
						Left	Right	
5/7	Selah Cr. Crossing	703906E 5174325N	Adult	Female	149.281	Yellow#27	Yellow#26	795-39543
5/11	Selah Cr. Crossing	703906E 5174325N	Adult	Female	149.442	Green#26	Green#27	795-39544
5/19	Range 55 Waterhole	715993E 5168381N	Adult	Male	149.383	Blue#2	Blue#3	795-39545
5/19	Range 55 Waterhole	715993E 5168381N	Adult	Female	149.502	Red#2	Red#3	795-39546
5/21	Range 55 Waterhole	715993E 5168381N	Adult	Male	149.460[a]	Yellow#1	Green#28	795-39547
5/27	Range 55 Waterhole	715993E 5168381N	Adult	Female	149.543	Red#4	Yellow#2	795-39548

(a) Bird dropped radio. Radio was found 5/26/92, approximately 1 km north of capture site.

Table 2. Measurements (mm) of Long-Billed Curlews Captured on the Yakima Training Center in 1992

Bird Number	Age Class	Sex	Tarsus	Length of Bill	
				Exposed Culmen	From Gape
9.281	Adult	F	93	142	145
9.442	Adult	F	88	136	136
9.502	Adult	F	98	159	163
9.543	Adult	F	91	158	161
9.383	Adult	M	--	120	121
9.460	Adult	M	85	124	127

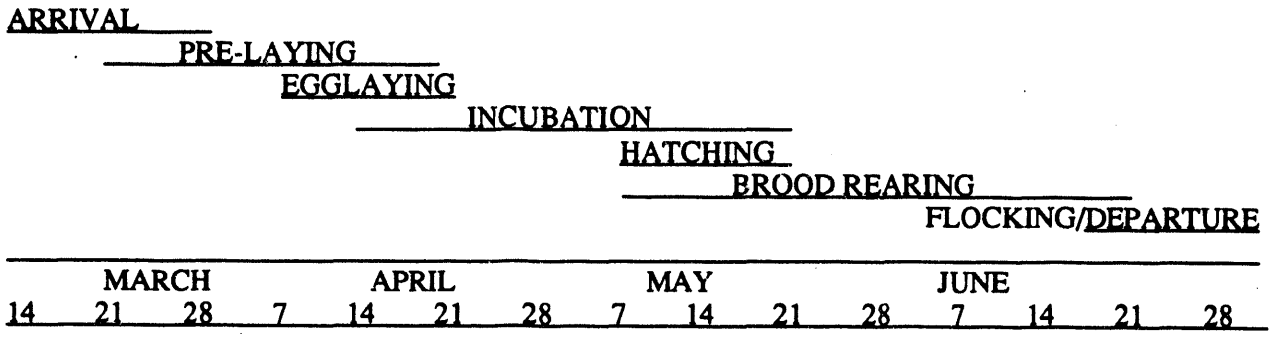

Figure 2. Breeding Chronology of the Long-Billed Curlew in 1992. Taken from observations on the YTC in 1992 and from Allen (1980).

Feeding Behavior and Diet

Curlews are known to regurgitate pellets of undigested food parts during certain times of the year. Hibbert-Ware and Ruttledge (1944) suggested that pellets are rare during the winter and spring because much of the birds' diet consists of soft-bodied prey during this time. We did not observe the regurgitation of pellets and did not find any pellets in the roosting or resting areas. The lack of pellets is somewhat puzzling because insects were being eaten.

An abundance of beetles and grasshoppers existed in areas where feeding was observed. Curlews are opportunistic feeders on their breeding grounds, eating grasshoppers, beetles, spiders, insect larvae, seeds, and occasional nestling passerines (Goater and Bush 1986; Hibbert-Ware and Ruttledge 1944; Jenni et al. 1982).

Curlews were observed feeding in open areas with relatively low vegetation. Several times birds were seen feeding off of their nesting territories. The top of Yakima Ridge near the western edge of the YTC (Yakima River Use Area in Figure 1) was used often by birds nesting in the Washout Gulch area. From our observations, curlews appeared to peck at prey items on the ground surface or among the vegetation. As Allen (1980) reported, the birds walked over a broad area while feeding.

Many birds tended to use specific watering areas. The Selah Creek ford on Badger Pocket Road and a large puddle north of Taylor Pond on Range 55 were the most heavily used sites. Birds came to watering sites generally in late afternoon and early evening, between 1330 and 1900 hours. There was a shorter morning watering period as well, between 0830 and 1030 hours.

Population Estimate

By mapping the territories of known pairs and using the highest single counts of curlews for each area the observed population was estimated at 22 pairs (Table 3). This is judged to be a conservative estimate, as there were probably some unobserved curlews (including unpaired birds) using portions of the YTC away from the areas of most concentrated use or in the Impact Area, which generally could not be directly observed.

Distribution

Long-billed curlews were observed over much of the YTC throughout the spring and summer of 1992. This very mobile bird was able to use various areas and cover types on the site. Several areas were heavily used. Figure 3 shows locations of all curlew sightings (both unmarked and radio-equipped) on the YTC and neighboring lands for 1992 overlaid onto a potential habitat map (discussed below). The map shows that several regions were highly used. Figures 4 through 9 show the sightings of each radio-equipped bird individually. Table 3 lists the highest single count of males and females and the corresponding best estimate of the number of curlew pairs for each use area.

We developed a map that illustrates potential long-billed curlew habitat on the YTC using the Geographical Resource and Analysis Support System (GRASS) software (U.S. Army Corps of

Table 3. Estimated Number of Curlew Pairs Based on the Highest Single Counts of Males and Females in Each Use Area

General Area	# Males	# Females	# Unknown	# Pairs
Borden Springs	1	1	0	1
Badger Gap	1	1	0	1
Silica DZ	1	1	0	1
Range 19	1	2	2	2
Beller DZ	3	1	2	3
Range 1	1	1	0	1
Range 5	2	1	3	2
SW of Range Control	1	1	1	1
Ranges 10 & 55	3	2	7	3
North of Range 14	2	1	0	2
Pozzuolana Mine	1	0	0	0
Washout Gulch	5	4	4	5
Coyote Spring	1	0	1	0
Total Pairs				22

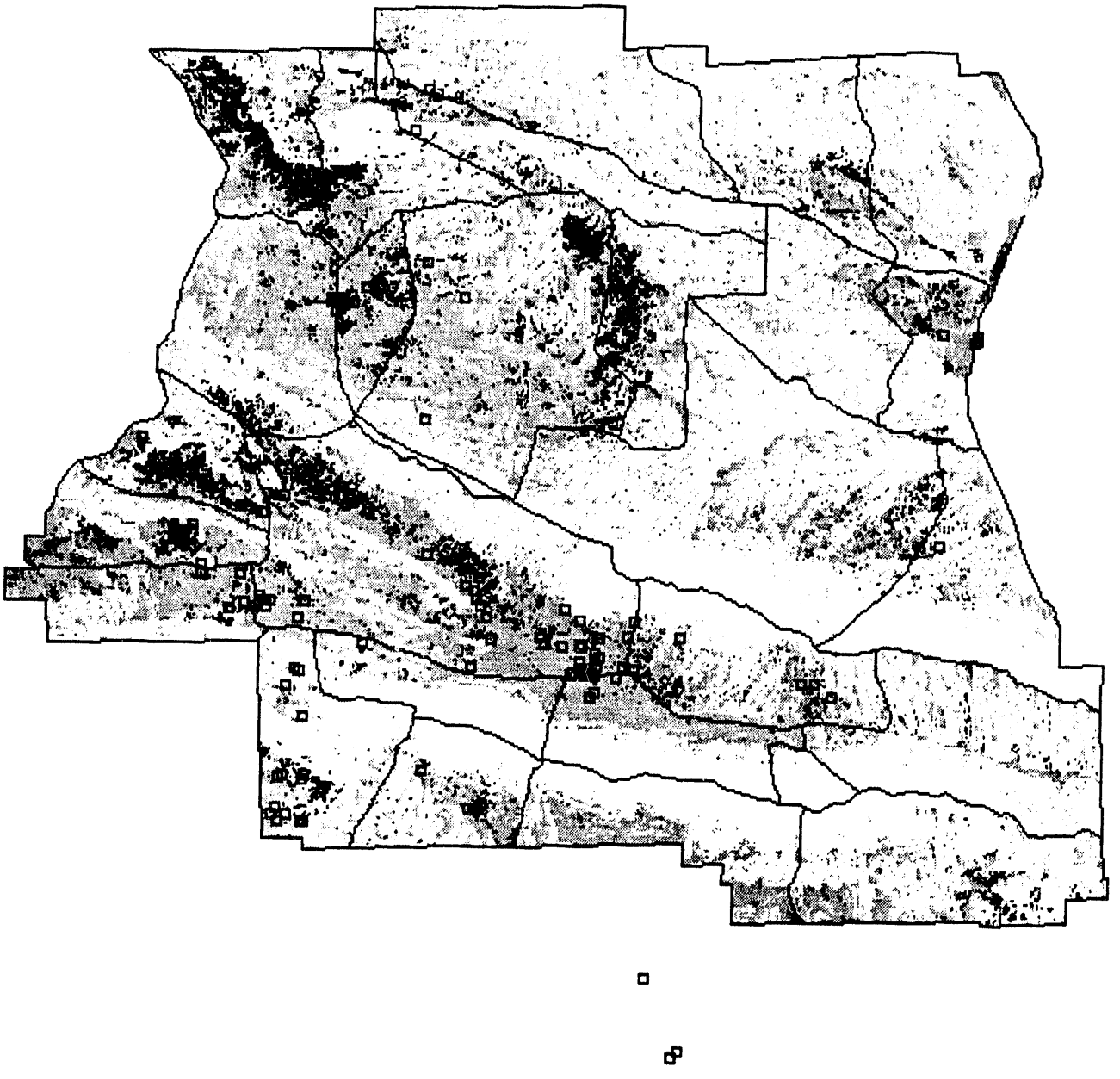

Figure 3. Locations of Long-Billed Curlews (Both Unmarked and Radio-Equipped Birds) on the Yakima Training Center and Neighboring Lands in 1992 and Potential Curlew Habitat (shown in grey and dark grey)

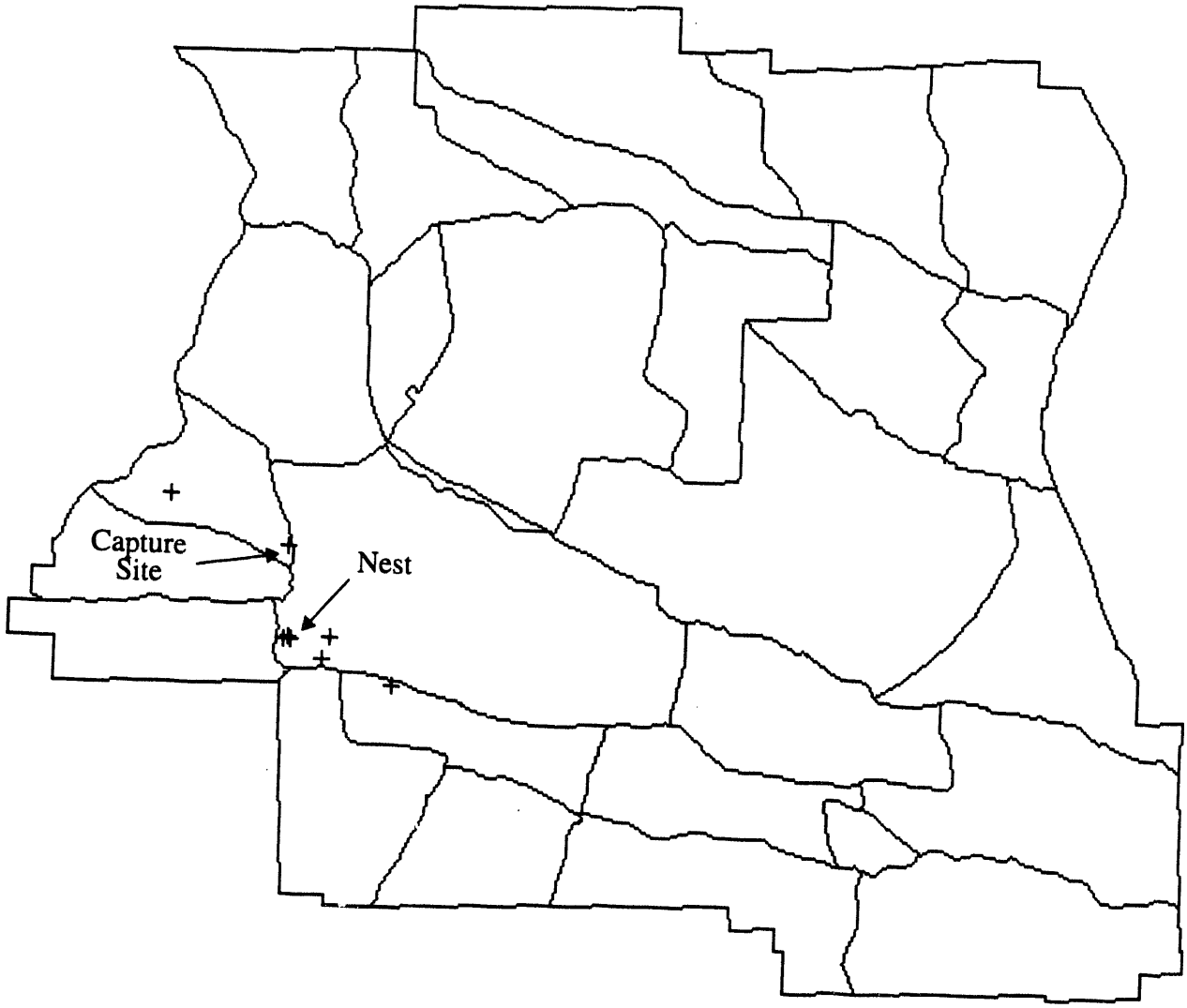

Figure 4. Locations of Curlew # 9.281

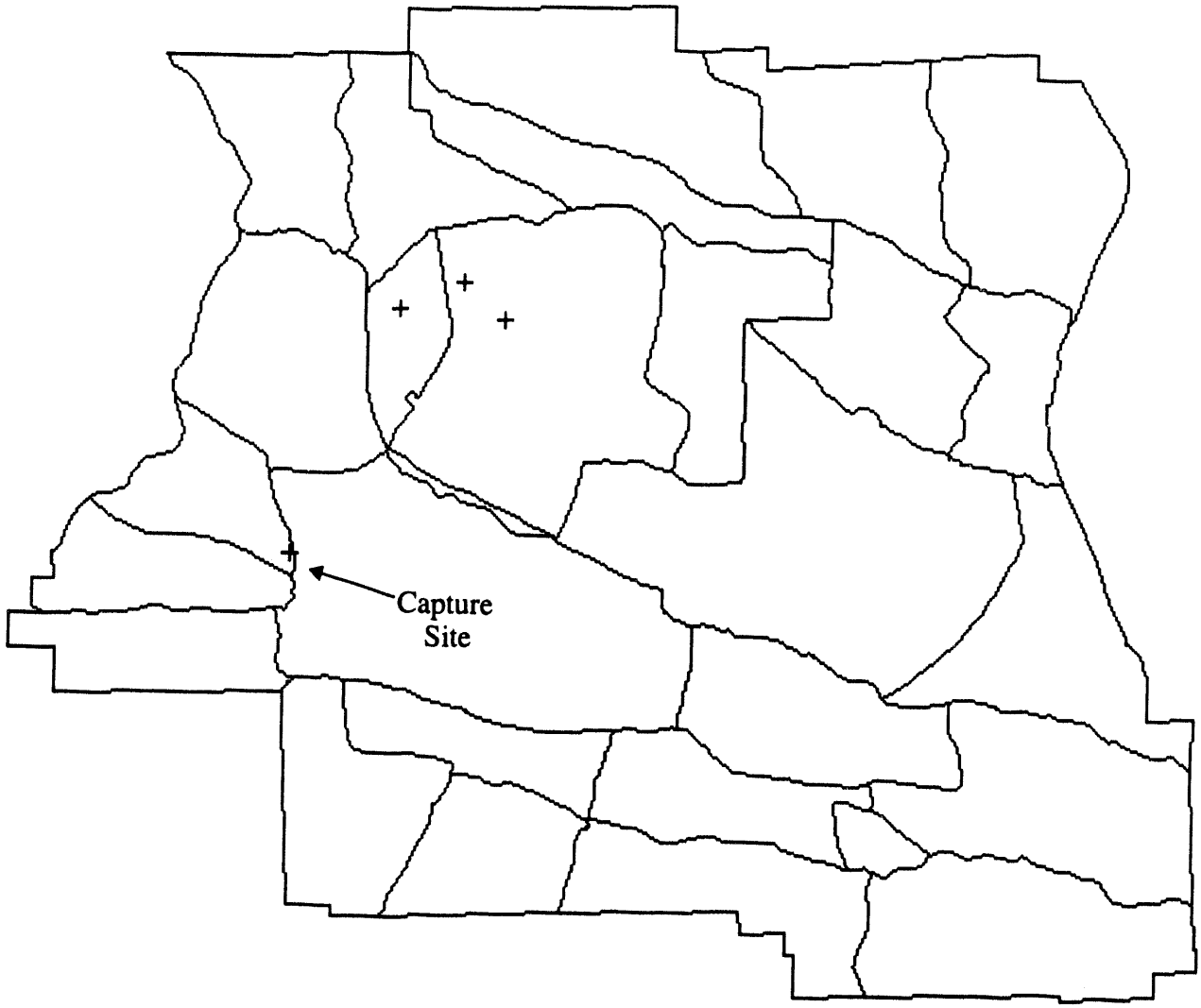

Figure 5. Locations of Curlew # 9.442

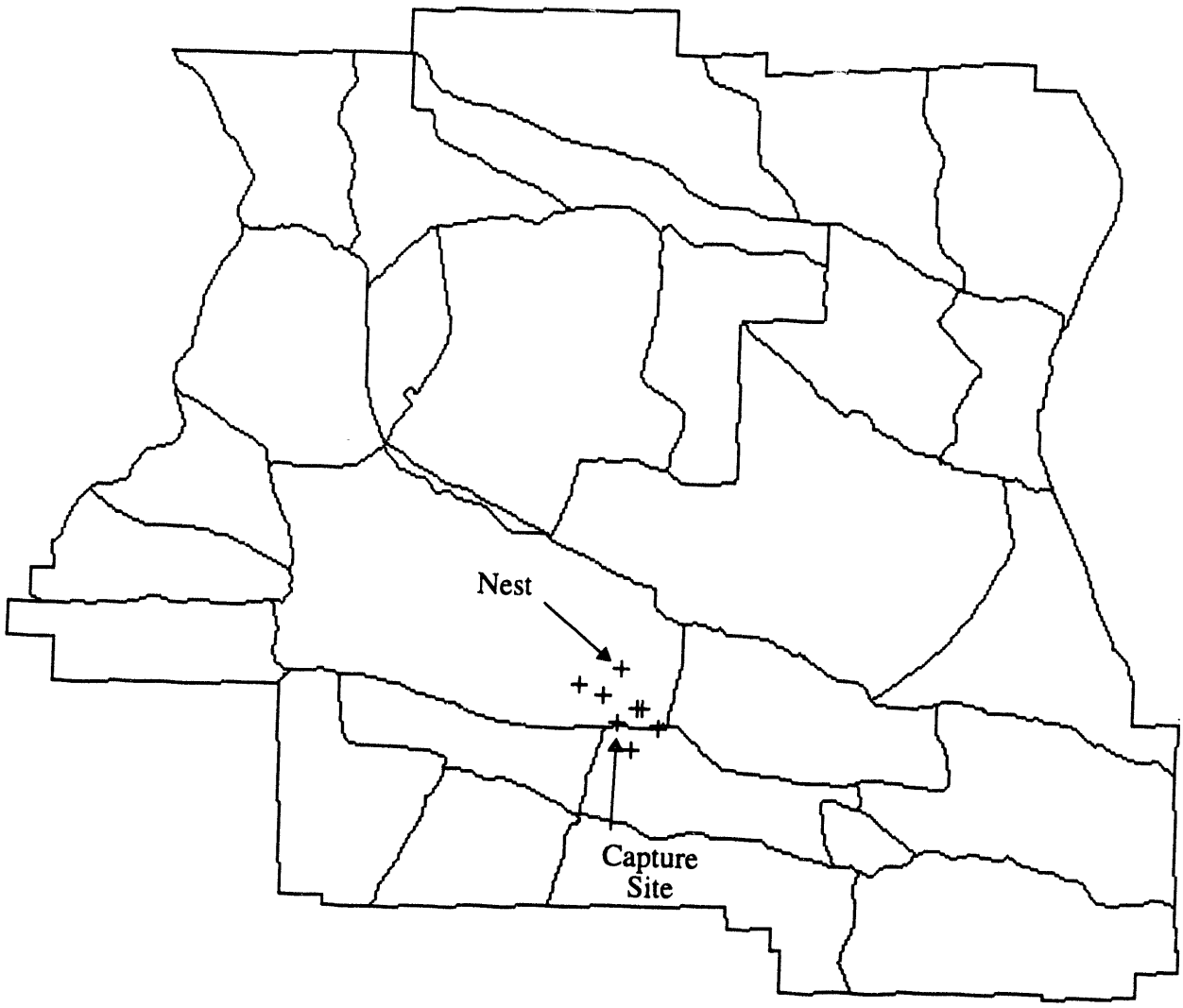

Figure 6. Locations of Curlew # 9.383

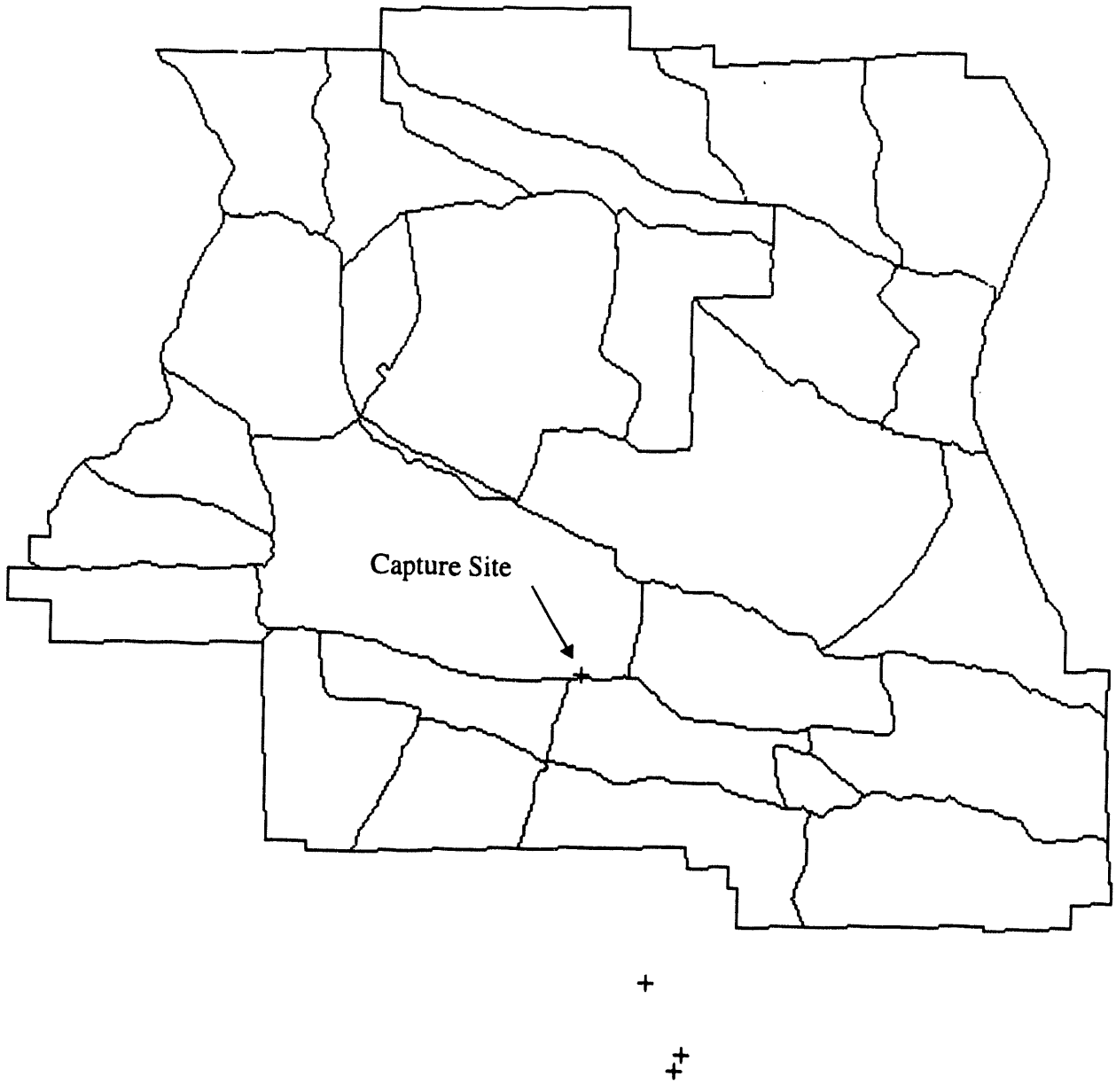

Figure 7. Locations of Curlew # 9.502

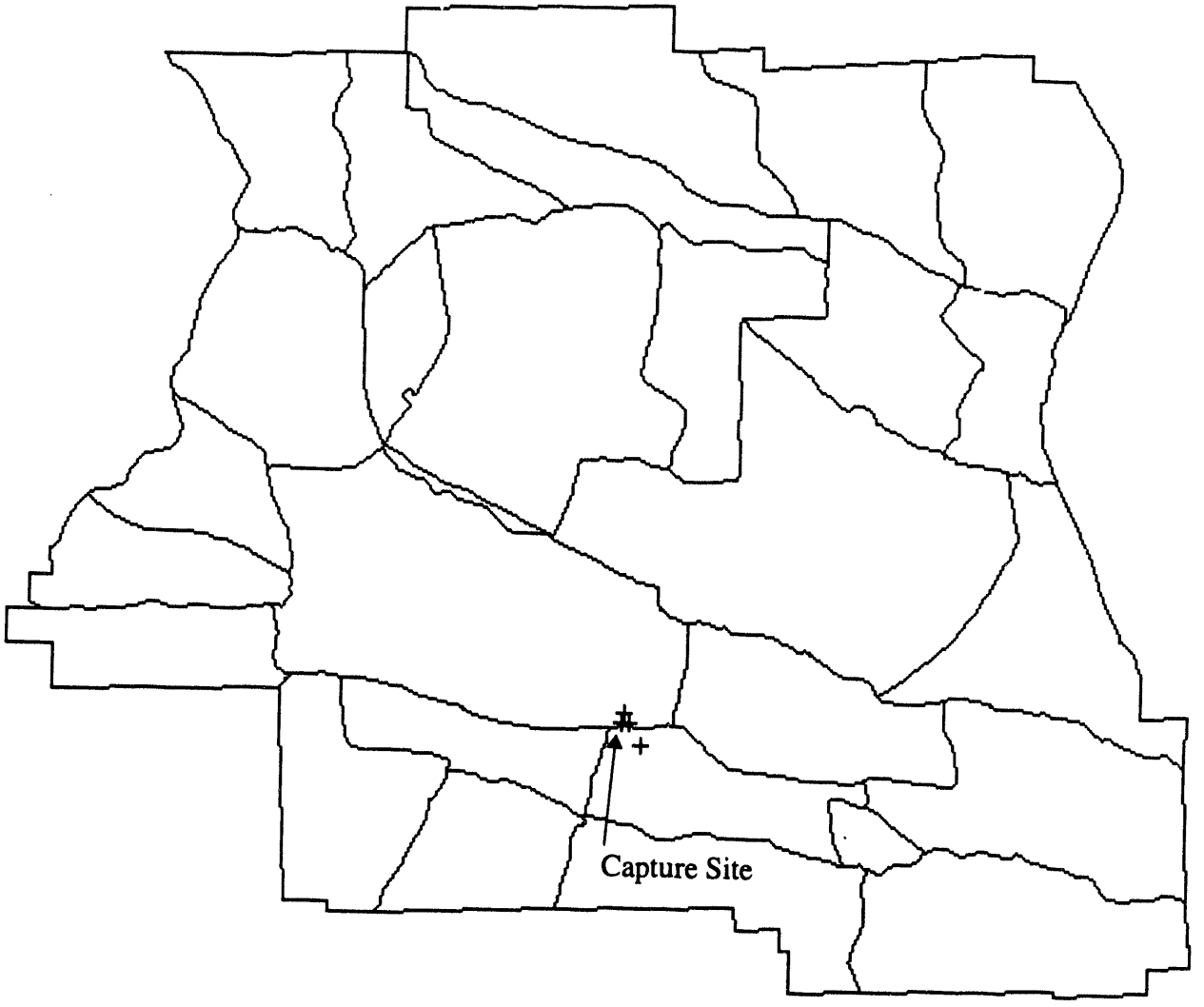

Figure 8. Locations of Curlew # 9.460

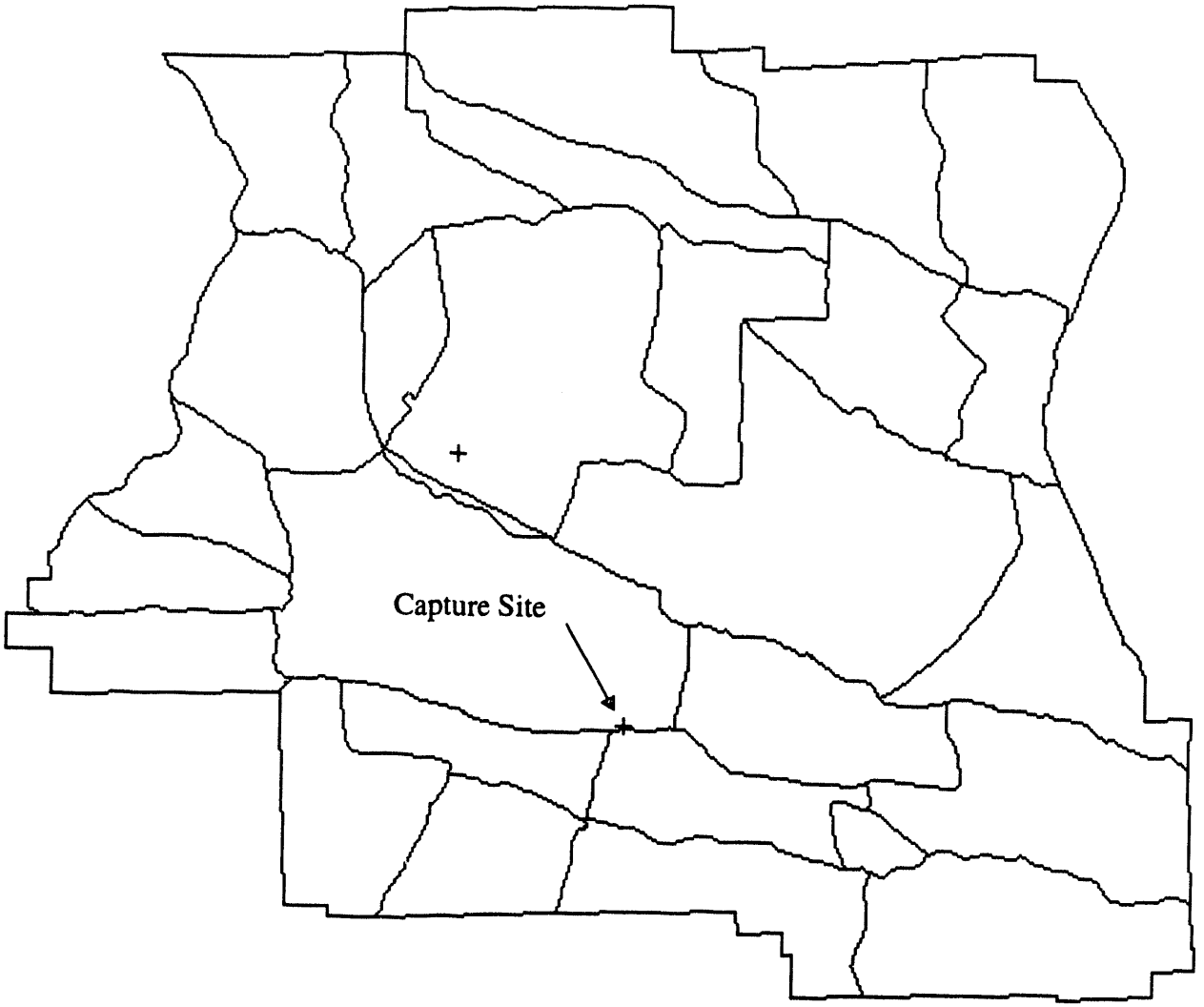

Figure 9. Locations of Curlew # 9.543

Engineers 1987) and information available in the literature on curlew habitat use (Figure 3). GRASS is a public-domain raster-based geographical information system software package developed by the U.S. Army Corps of Engineers' Construction Engineering Research Laboratory, Champaign, Illinois.

Three map layers (elevation, slope, and habitat degradation) were used in the construction of the potential habitat map. Digital elevation data obtained from the Defense Mapping Agency were used for the elevation map layer. Because curlews appear to be found primarily in locations <1,000 m in elevation (Allen 1980; Pampush 1980a; Jenni et al. 1982), GRASS software was used to reduce the elevation map layer to two categories <1,000 m and >1,000 m. Slope data were generated from the elevational map with GRASS. Curlews appear to favor relatively level terrain for nesting (Allen 1980), so the slope map layer was reduced to two categories $\leq 5°$ and $>5°$. The heavily disturbed habitat map layer was based on an analysis of SPOT panchromatic satellite scenes of the YTC. All areas with a reflectance of >27.5% were selected as representing highly degraded or disturbed habitat. Reflectance values of >27.5% have been shown to indicate areas where vegetative cover has been heavily disturbed (personal communication, L. G. McWethy, PNL). A cumulative degradation scene for the years 1987 through 1991 is included to indicate areas that have been recently disturbed to the extent that sparse recovering vegetation preferred by curlews (Allen 1980; Pampush 1980a; Jenni et al. 1982) was most likely to occur. The degraded areas do not necessarily provide suitable habitat for curlews at present, but show locations where invader species (including annual grasses and forbs) may colonize, thus creating suitable habitat. GRASS was used to combine the three map layers into a map showing potential habitat as those areas that are <1,000 m elevation and <5° slope (Figure 3).

Chi-square analyses showed curlews on the YTC preferred land areas having elevations below 1,000 m and slopes less than 5° ($x^2 = 107.06$, 1 df, $p < 0.005$). Within the preferred elevation and slope, YTC curlews also selected for degraded habitat ($x^2 = 40.89$, 1 df, $p < 0.005$). Figure 3 illustrates these preferences, showing that 1992 curlew locations are closely associated with areas identified as potential habitat.

Nesting Areas

In addition to the locations of two actual nests, several general nesting areas were found as indicated by the threat and courtship displays discussed. The southwest corner of the YTC in the vicinity of Washout Gulch, Ranges 10 and 55 along Cold Creek Road, and Beller DZ (Figure 1) had the highest bird use. Also used were Borden Springs, the Badger Gap area, Silica DZ, Range 19, the area just northwest of Range 1, the fields southwest of Range Control, Range 5, the fields on the north side of Cold Creek Road directly north from Range 14, and the area just west of the Pozzuolana Mine (Figure 1). The Impact Area could not be checked for curlew use because of entry restrictions. The Silica DZ and Borden Springs areas appeared, from their vegetation structure and size, to have potential for much higher bird use than sightings indicated.

Brood-Rearing Areas

Adults with broods were identified by their intense protective behavior. Adults with chicks readily mob both avian and ground intruders. The chicks proved impossible to locate until fledgling, because of their wide-ranging habits (attending parent birds remain near, but not with the young) and their ability to remain concealed. The presence of both the adult male and female together and their mobbing behavior were used as indicators of brood-rearing areas. The brood-rearing areas were

usually near or adjacent to the nesting areas. Ranges 10 and 55, Silica DZ, and the crest of Yakima Ridge north of Washout Gulch (Yakima River Use Area in Figure 1) were used by curlews with broods (Figure 1).

Vegetation

The YTC's vegetation ranges from riparian to grassland to shrubland. These three general types were sampled using techniques described in the Methods section. Table 4 lists the species encountered in the vegetation sampling.

The curlew nesting areas were open annual or perennial grasslands. Pampush (1980a,b) reported that curlews used annual grass-dominated habitats more than any other type. However, Pampush and others (Jenni et al. 1982) have stated that vegetation structure and height are more important than grass species. Sandberg's bluegrass (*Poa sandbergii*) was present in all nesting areas and had the highest combined canopy coverage (19.6%) as shown in Table 5. Cheatgrass brome (*Bromus tectorum*) was the second most common grass, with 14.2% canopy cover. Bluebunch wheatgrass (*Agropyron spicatum*) was also present in all of the nesting areas. It had a combined canopy coverage of 7.1%. Six-weeks fescue (*Festuca bromides*), Indian ricegrass (*Oryzopsis hymenoides*), and Thurber needlegrass (*Stipa thurberiana*) occurred in trace amounts in some of the areas. They are not included Table 5.

Washout Gulch, the nesting area with the highest curlew use [based on the number of birds in the area and their threat and courtship displays (Allen 1980)], was co-dominated by cheatgrass brome and Sandberg's bluegrass (Table 5). Both of these grasses in the Washout Gulch area were relatively tall with peak heights of 20.0 cm for cheatgrass and 29.5 cm for Sandberg's bluegrass (Table 6). The measurements in this area were taken on 1 July 1992. Allen (1980) found that nests on the Hanford Site were built in areas where the average height of cheatgrass was below 10 cm, and the average height of Sandberg's bluegrass was approximately 20 cm. Perhaps the Washout Gulch area is suitable because in early spring when the egg laying and incubation occur (April through May) the grasses have not yet reached their full height. The curlew broods have hatched and are able to move to more suitable areas by the time the grasses mature.

The areas used by curlews for non-nesting activities (feeding, brood rearing, and flocking) contained more diverse vegetation than did the nesting areas. Sandberg's bluegrass and cheatgrass brome were again the two most common grasses, with combined canopy cover of 13.0% and 10.3%, respectively (Table 7). Additional grasses, those not found in the nesting areas, included saltgrass (*Distichlis spicata*), Great Basin wildrye (*Elymus cinereus*), and an unidentified riparian grass. This reflects the use of wetter, more diverse areas for activities other than nesting. The heights of grasses present in both area types were similar when measured in early- to mid-July. Sandberg's bluegrass average height was 31.2 cm in non-nesting areas and 24.9 cm in nesting areas. Crested wheatgrass, bluebunch wheatgrass, and cheatgrass brome were just slightly shorter in feeding, brood rearing, and flocking areas (see Tables 6 and 8). Sedge (*Carex* spp.) and rush (*Juncus* spp.) occurred in trace amounts in the Borden Springs flocking area. They are not included in Tables 7 and 8.

Forbs commonly found in the nesting areas included yarrow (*Achillea millefolium*), milkvetch (*Astragalus* spp.), knapweed (*Centaurea* spp.), tansymustard (*Descurainea* spp.), willow-herb (*Epilobium* spp.), storksbill (*Erodium cicutarium*), clasping pepperweed (*Lepidium perfoliatum*), pink microsteris (*Microsteris gracilis*), phlox (*Phlox* spp.), hornseed buttercup (*Ranunculus testiculatus*), Russian thistle (*Salsola kali*), tumble mustard (*Sisymbrium altissimum*), and yellow salsify (*Tragopogon dubius*). Table 9 lists canopy cover of the most common forbs in the nesting areas.

Table 4. List of Vegetation Species Encountered on the Yakima Training Center During Vegetation Sampling of Long-Billed Curlew Use Areas (not a complete list)

Scientific Name	Common Name	Abbreviation
Graminoids		
Agropyron cristatum	Crested wheatgrass	Agcr
Agropyron spicatum	Bluebunch wheatgrass	Agsp
Bromus tectorum	Cheatgrass brome	Brte
Carex spp.	Sedge	Care
Distichlis spicata	Saltgrass	Disp
Elymus cinereus	Giant wildrye	Elci
Festuca bromides	Six-weeks fescue	Febr
Juncus spp.	Rush	Junc
Oryzopsis hymenoides	Indian ricegrass	Orhy
Poa cusickii	Cusick bluegrass	Pocu
Poa sandbergii	Sandberg's bluegrass	Posa
Sitanion hystrix	Squirrel tail	Sihy
Stipa comata	Needle and thread grass	Stco
Stipa thurberiana	Thurber needlegrass	Stth
Forbs		
Achillea millefolium	Yarrow	Acmi
Astragalus spp.	Milkvetch	Astr
Centaurea spp.	Knapweed	Cent
Descurainea pinnata	Tansymustard	Depi
Epilobium spp.	Willow-herb	Epil
Equisetum spp.	Horsetail	Equi
Erigeron spp.	Daisy	Erig
Eriogonum thymoides	Thyme-leaf eriogonum	Erth
Erodium cicutarium	Storksbill	Erci
Halogeton glomeratus	Halogeton	Hagl
Holosteum umbellatum	Jagged chickweed	Houm
Lepidium perfoliatum	Clasping pepperwort	Lepe
Lithospermum ruderale	Stoneseed gromwell	Liru
Lomatium triternatum	Nineleaf lomatium	Lotr
Lupinus spp.	Lupine	Lupi
Lythrum salicaria	Purple loosestrife	Lysa
Microsteris gracilis	Pink microsteris	Migr
Penstemon spp.	Beardtongue	Pens
Phlox spp.	Phlox	Phlo
Plantago lanceolata	Buckhorn plantain	Plla

Table 4. (contd)

Scientific Name	Common Name	Abbreviation
Forbs		
Ranunulus testiculatus	Hornseed buttercup	Rate
Salsola kali	Russian thistle	Saka
Sisymbrium altissimum	Tumblemustard	Sial
Tragopogon dubius	Yellow salsify	Trdu
Trifolium spp.	Clover	Trif
Shrubs		
Artemisia tridentata	Big sagebrush	Artr
Chrysothamnus nauseosus	Grey rabbitbrush	Chna
Chrysothamnus viscidiflorus	Green rabbitbrush	Chvi

Table 5. Mean Canopy Cover of Major Grasses[a] in General Curlew Nesting Areas on the Yakima Training Center (number of samples taken is shown in parentheses)

General Area	Mean Canopy Cover (%)[b]						
	Agcr	Agsp	Brte	Pocu	Posa	Sihy	Stco
Range 19 (3)	0	12.4	12.2	0.1	11.5	5.8	6.8
Beller DZ (4)	9.9	1.9	6.3	0	22.8	2.7	12.9
Range 1 (5)	6.3	5.2	9.7	0	17.9	4.4	3.6
Range 5 (3)	0	28.4	3.0	0.9	14.5	2.9	1.6
Washout Gulch (6)	2.6	0.6	33.2	0	24.8	0.2	0
Range 55 (1)	4.8	5.7	19.1	0	21.4	6.3	0
Range 14 (2)	16.7	3.0	1.7	2.4	20.7	0	0
Weighted Ave (24)	5.2	7.1	14.2	0.3	19.6	2.8	4.1

(a) Six-weeks fescue, Indian ricegrass, and Thurber needlegrass are not included.
(b) Agcr = crested wheatgrass, Agsp = bluebunch wheatgrass, Brte = cheatgrass, Pocu = Cusick bluegrass, Posa = Sandberg's bluegrass, Sihy = squirrel tail, and Stco = needle and thread grass.

Table 6. Mean Height of Major Grasses[a] in Eight Curlew Nesting Areas on the Yakima Training Center (number of samples taken is shown in parentheses)

General Area	Mean Height (cm)[b]						
	Agcr	Agsp	Brte	Pocu	Posa	Sihy	Stco
Range 19 (3)	--	31.5	11.9	10.0	23.0	23.0	16.6
Beller DZ (4)	30.4	34.5	13.7	--	25.0	18.9	15.4
Range 1 (5)	25.0	40.7	16.0	--	23.5	20.4	16.4
Range 5 (3)	--	38.3	12.9	13.0	19.0	17.0	11.0
Washout Gulch (6)	17.4	27.0	20.0	--	29.5	8.0	--
Range 55 (1)	40.6	37.0	14.4	--	22.0	25.7	--
Range 14 (2)	38.0	27.0	19.5	10.5	28.3	--	--
Weighted Ave (24)	26.0	33.5	15.9	11.2	24.9	16.9	15.1

(a) Six-weeks fescue, Indian ricegrass, and Thurber needlegrass are not included.
(b) Agcr = crested wheatgrass, Agsp = bluebunch wheatgrass, Brte = cheatgrass, Pocu = Cusick bluegrass, Posa = Sandberg's bluegrass, Sihy = squirrel tail, and Stco = needle and thread grass.

Table 7. Mean Canopy Cover of Major Grasses[a] in Curlew Non-Nesting Areas on the Yakima Training Center (number of samples taken is shown in parentheses)

General Area	Mean Canopy Cover of Major Grass Species (%)[b]								
	Agcr	Agsp	Brte	Disp	Elci	Febr	Posa	Sihy	Unknown
Borden Springs (2)	0	0	1.9	25.0	0	0.1	0	0	19.8
Silica DZ (2)	2.4	2.2	13.6	0	0	0	8.1	15.2	0
Range 19 (1)	0	0.3	31.9	0	0	1.1	11.9	0	0
Range 5 (1)	0	5.7	4.2	0	0	1.7	10.8	2.2	0
Yakima Ridge (3)	0	7.9	0.8	0	0	0	24.7	1.5	0
Range 10Z (1)	0	0	5.0	0	0	1.2	7.4	0	0
Range 55 (4)	5.7	2.9	17.3	9.3	2.4	1.7	15.6	0.4	0
Weighted Ave (14)	2.0	3.3	10.3	6.2	0.7	0.8	13.0	2.8	2.8

(a) Sedge and rush are not included.
(b) Agcr = crested wheatgrass, Agsp = bluebunch wheatgrass, Brte = cheatgrass, Disp = saltgrass, Elci = giant wildrye, Febr = six-weeks fescue, Posa = Sandberg's bluegrass, and Sihy = squirrel tail.

Table 8. Mean Heights of Major Grasses[a] in Curlew Non-Nesting Areas on the Yakima Training Center (numbers of samples taken is shown in parentheses)

General Area	Mean Height (cm)[b]								
	Agcr	Agsp	Brte	Disp	Elci	Febr	Posa	Sihy	Unknown
Borden Springs (2)	--	--	12.0	12.0	--	13.0	--	--	11.6
Silica DZ (2)	29.4	39.5	12.8	--	--	--	29.0	21.0	--
Range 19 (1)	--	34.0	16.1	--	--	10.0	25.0	--	--
Range 5 (1)	--	43.8	14.0	--	--	10.1	21.0	19.7	--
Yakima Ridge (3)	--	17.5	9.8	--	--	--	29.7	7.7	--
Range 10Z (1)	--	--	14.2	--	--	7.5	36.0	--	--
Range 55 (4)	28.2	31.7	14.5	11.6	94.0	10.0	36.3	18.0	--
Weighted Ave (14)	28.6	30.6	12.9	11.7	94.0	10.4	31.2	15.7	11.6

(a) Sedge and rush are not included.
(b) Agcr = crested wheatgrass, Agsp = bluebunch wheatgrass, Brte = cheatgrass, Disp = saltgrass, Elci = giant wildrye, Febr = six-weeks fescue, Posa = Sandberg's bluegrass, and Sihy = squirrel tail.

Tumble mustard and tansymustard were found in all nesting areas, but were not abundant. Other forbs were found in up to half of the areas and had relatively low canopy cover. Willow-herb (*E.* spp.), daisy (*Erigeron* spp.), jagged chickweed (*Holosteum umbellatum*), stoneseed gromwell (*Lithospermum ruderale*), nineleaf lomatium (*Lomatium triternatum*), pink microsteris (*M. gracilis*), and yellow salsify (*Tragopogon dubius*) occurred in trace amounts in some of the areas. They are not included in Table 9.

Table 10 lists canopy cover of the most common forbs in the non-nesting areas. Many of the nesting area forbs were also present in these areas. Additional species found in the non-nesting areas included daisy (*Erigeron* spp.), buckwheat (*Eriogonum* spp.), halogeton (*Halogeton glomeratus*), and jagged chickweed (*H. umbellatum*). None of the forbs were present on every site. Yarrow, tansy-mustard, phlox, and hornseed buttercup were found in four of the seven areas. Willow-herb, horsetail (*Equisetum* spp.), stoneseed gromwell, clasping pepperwort, nineleaf lomatium, purple loosestrife (*Lythrum salicaria*), beardtongue (*Penstemon* spp.), buckhorn plantain (*Plantago lanceolata*), yellow salsify, and clover (*Trifolium* spp.) occurred in trace amounts in some of the areas. They are not included in Table 10.

Only scattered individual shrubs or small patches occurred in the nesting areas. Mean canopy cover and heights of the two shrub species that occurred [big sagebrush (*Artemisia tridentata*) and gray rabbitbrush (*Chrysothamnus nauseosus*)] are listed in Table 11. The average distance to the nearest shrub cover from randomly located points within identified curlew nesting areas was 51.6 m, and the individual distance ranged from 0 to 171 m. The distances to cover from the two actual nests were 70 m on Range 55 and 150 m on Range 5.

Shrubs were a common component of the brood-rearing areas. Visual observations during the brood-rearing period indicated that adult curlews move their broods into denser covertypes for brood rearing. This observation is supported by the sampling data. Three shrubs were encountered in

Table 9. Mean Canopy Cover of Major Forbs[a] in Curlew Nesting Areas on the Yakima Training Center (number of samples taken is shown in parentheses)

General Area	Mean Canopy Cover of Forb Species (%)[b]									
	Acmi	Astr	Cent	Depi	Erci	Lepe	Phlo	Rate	Saka	Sial
Range 19 (3)	0	0.8	0	0.9	0	6.2	3.6	0.8	0.1	4.7
Beller DZ (4)	0	0	0	0.1	0	7.9	0	0	6.1	3.0
Range 1 (5)	0	1.5	0.4	0.9	0	4.3	0	0.4	0.3	2.6
Range 5 (3)	2.3	2.3	0.1	0.1	0.1	0	6.7	0	0	0.1
Washout Gulch (6)	0	0	0	0.3	0.1	0	0	0	8.7	5.4
Range 55 (1)	0	0	10.3	0.1	0	0.6	0	0	0	4.6
Range 14 (2)	6.5	0	0	6.5	0	0.1	0	5.5	0	0.1
Weighted Ave (24)	0.8	0.7	0.5	0.9	0.04	3.0	1.3	0.6	3.3	3.2

(a) Willow-herb, stoneseed gromwell, nineleaf lomatium, lupine, pink microsteris, and yellow salsify are not included.

(b) Acmi = yarrow, Astr = milkvetch, Cent = knapweed, Depi = tansymustard, Erci = storksbill, Lepe = clasping pepperwort, Phlo = phlox, Rate = hornseed buttercup, Saka = Russian thistle, and Sial = tumble mustard.

Table 10. Mean Canopy Cover of Major Forbs[a] in Curlew Non-Nesting Areas on the Yakima Training Center (number of samples taken is shown in parentheses)

General Area	Mean Canopy Cover of Major Forbs (%)[b]										
	Acmi	Astr	Cent	Depi	Erig	Erth	Hagl	Houm	Phlo	Rate	Sial
Borden Springs (2)	0.1	0	0	0	0	0	8.7	0	0	0	0
Silica DZ (2)	0	0	0	0.1	0	0	0	0	0	0.1	0.7
Range 19 (1)	0	0	0	9.3	0	0	0	0	0.3	1.1	4.2
Range 5 (1)	1.7	12.9	0	0	0	0	0	0	0.3	0	0
Yakima Ridge (3)	0.1	0	0	0.1	6.5	5.3	0	0	6.3	0.1	0.1
Range 10Z (1)	0	0	7.4	0	0	0	0	0.1	0	0	0
Range 55 (4)	0.3	0	0	1.1	0	0	0	2.5	0.1	4.4	0
Weighted Ave (14)	0.2	0.9	0.5	1.0	1.4	1.1	1.9	0.7	1.4	1.4	0.4

(a) Willow-herb, horsetail, clasping pepperwort, stoneseed gromwell, nineleaf lomatium, purple loosestrife, beard tongue, buckhorn plantain, yellow salsify, and clover are not included.

(b) Acmi = yarrow, Astr = milkvetch, Cent = knapweed, Depi = tansymustard, Erig = daisy, Erth = thyme-leaf eriogonum, Hagl = halogeton, Houm = jagged chickweed, Phlo = phlox, Rate = hornseed buttercup, and Sial = tumble mustard.

Table 11. Mean Canopy Cover and Height of Shrubs in Curlew Nesting Areas on the Yakima Training Center (number of samples taken is shown in parentheses)

General Area	Big Sagebrush		Gray Rabbitbrush		Dead Standing	
	% Cover	Height	% Cover	Height	% Cover	Height
Range 19 (3)	1.4	21.0	0	--	0	--
Beller DZ (4)	0	--	0	--	0	--
Range 1 (5)	0.2	16.0	0.2	20.0	0.3	25.0
Range 5 (3)	0	--	0	--	0	--
Washout Gulch (6)	0	--	0	--	0	--
Range 55 (1)	0	--	0	--	0	--
Range 14 (2)	0	--	0	--	0	--
Weighted Ave (24)	0.2	17.9	0.04	20.0	0.06	25.0

brood-rearing areas: big sagebrush, gray rabbitbrush, and green rabbitbrush (*Chrysothamnus viscidiflorus*). Big sagebrush was the most abundant with a combined canopy cover of 2.7% (Table 12); the shrub occurred in five of the seven areas. The Borden Springs flocking area and the Yakima Ridge feeding area did not contain any shrubs (Table 12). Shrubs tend to be most important for chick hiding and thermal cover during brood rearing (Pampush 1980a).

Tables 13 and 14 list the mean cover (percent) of litter and bare ground for nesting areas and non-nesting areas, respectively. The percentages of bare ground in both area types were similar at 36.7 and 35.0%. These fairly high percentages reflect the curlews' preference for open areas. The percentages of litter between the two area types differed. The nesting areas contained only 9.6% litter because grasses do not provide much debris. The non-nesting areas contained about twice as much litter (18.9%). This appears to be due to the greater amount of shrubs in these other areas, which provide much more woody material.

The average obscurity values obtained for both nesting areas and non-nesting areas were generally low. The average value for random sites in the nesting areas was 0.19 dm (Table 15). The average values for the actual nest sites were 0.63 and 1.25 dm. The higher values for the actual nest sites most likely reflects microhabtitat selection by the birds; both nests were placed between clumps of grasses apparently to help conceal them. The average value for non-nesting areas was 0.19 dm (Table 16). These were random sites, however, and do not fully reflect microhabitat choices. For example, the Silica DZ brood-rearing area contained many sagebrush patches that were selectively used by chicks. The obscurity value of 0.19 dm from random plots does not reflect selective use of the tall, dense sagebrush by chicks in this area.

Table 17 compares total canopy cover of four vegetation types between the nesting and non-nesting areas. The most noticeable difference is the amount of shrubs in each area type. The nesting areas had little or no shrub coverage (0.2%) whereas the non-nesting areas contained more (6.7%). This reflects curlews' preference for open nesting habitats and their use of denser covertypes for non-nesting activities, especially brood rearing (Jenni et al. 1982). The nesting areas also contain somewhat more annual grass. This agrees with Pampush's (1980a,b) findings.

Table 12. Mean Canopy Cover and Height of Shrubs in Curlew Non-Nesting Areas on the Yakima Training Center (number of samples taken is shown in parentheses)

General Area	Big Sagebrush		Gray Rabbitbrush		Green Rabbitbrush		Dead Standing	
	% Cover	Height	% Cover	Height	% Cover	Height	% Cover	Height
Borden Springs (2)	0	--	0	--	0	--	0	--
Silica DZ (2)	4.2	30.1	0	--	0	--	0	--
Range 19 (1)	5.2	27.0	0	--	8.0	18.4	0	--
Range 5 (1)	15.2	52.2	0	--	0.5	25.0	0.8	32.0
Yakima Ridge (3)	0	--	0	--	0	--	0	--
Range 10Z (1)	2.7	31.0	0	--	7.0	21.4	0	--
Range 55 (4)	1.6	32.8	6.2	27.4	3.9	23.9	0	--
Weighted Ave (14)	2.7	33.5	1.8	27.4	2.2	22.9	0.06	32.0

Table 13. Mean Cover of Litter and Bare Ground in Curlew Nesting Areas on the Yakima Training Center (number of samples taken is shown in parentheses)

General Area	Litter (%)	Bare Ground (%)
Range 19 (3)	10.7	41.9
Beller DZ (4)	6.9	31.9
Range 1 (5)	12.7	44.7
Range 5 (3)	8.9	41.7
Washout Gulch (6)	10.8	26.3
Range 55 (1)	7.5	35.2
Range 14 (2)	4.7	43.8
Weighted Ave (24)	9.6	36.7

Table 14. Mean Cover of Litter and Bare Ground in Curlew Non-Nesting Areas on the Yakima Training Center (number of samples taken is shown in parentheses)

General Area	Litter (%)	Bare Ground (%)
Borden Springs (2)	42.4	13.2
Silica DZ (2)	10.7	56.9
Range 19 (1)	22.5	15.3
Range 5 (1)	39.8	28.0
Yakima Ridge (3)	10.4	44.7
Range 10Z (1)	18.2	74.4
Range 55 (4)	11.6	24.6
Weighted Ave (14)	18.9	35.0

Table 15. Mean Obscurity Values at Random Points in Curlew Nesting Areas on the Yakima Training Center (number of samples taken is shown in parentheses)

General Area	Obscurity (dm)
Range 19 (3)	0.15
Beller DZ (4)	0.20
Range 1 (5)	0.21
Range 5 (2)	0.31
Washout Gulch (6)	0.17
Range 55 (0)	--
Range 14 (2)	0.09
Weighted Ave (22)	0.19

Table 16. Mean Obscurity Values for Curlew Non-Nesting Areas on the Yakima Training Center (number of samples taken is shown in parentheses)

General Area	Obscurity (dm)
Borden Springs (2)	0.03
Silica DZ (2)	0.19
Range 19 (1)	0.06
Range 5 (1)	0.50
Yakima Ridge (3)	0.04
Range 10Z (1)	0.06
Range 55 (4)	0.36
Weighted Ave (14)	0.19

Table 17. Canopy Cover of Four Vegetation Types in Curlew Nesting and Non-Nesting Areas on the Yakima Training Center

Vegetation Type	Canopy Cover (%) Nesting Areas	Non-Nesting Areas
Perennial grass	40.0	31.7
Annual grass	14.5	8.8
Forb	15.2	12.7
Shrub	0.2	6.7
Total	69.9	59.9

Nest Construction and Clutch Size

Two nests were found by relocations of radio-equipped birds (one female, one male). Table 18 lists the UTM locations of the two nests. Locating nests by watching for nest duty relief was not successful. The rolling topography of many of the nesting areas made it difficult to keep the birds continuously in sight. One site in the Washout Gulch area thought to contain a nest (identified by a curlew pair's intense mobbing behavior and consistent presence) was searched on foot by traversing the area at approximately ten-meter intervals. This systematic search revealed only one unused scrape.

Both nests were in grass habitats and were similar in size (Table 8). The nests were lined with twigs, leaves, and grasses. One nest had several rabbit fecal pellets and pebbles in it. Both nests contained four eggs, which is reported as typical for the species (Allen 1980; Jenni et al. 1982; Pampush 1980a).

Table 18. Measurements of Long-Billed Curlew Nests on the Yakima Training Center

	UTM Coordinate			Diameter (mm)		
Nest Number	Easting	Northing	Zone	Long Axis	Short Axis	Depth
149.281	704122	5170957	10	188	180	42
149.383	716106	5170356	10	200	185	43

Reproductive Success

Both of the nests located were depredated before hatching. Because of the small sample size conclusions cannot be drawn concerning nest success or recruitment for the YTC population. Four juveniles in a group of 27 birds were seen at a flocking site in late June. Approximately six different adult pairs were observed exhibiting the intense mobbing behavior characteristic of adults with broods.

Nest and fledgling success rates reported by others vary between areas and years. Jenni et al. (1982) reported survival rates for the nesting period (egg laying and incubation) of 40.4, 37.0, and 34.0% for 1977, 1978, and 1979, respectively. Chick production was estimated at 1.74 chicks per nest. Pampush (1980a) reported higher rates of nest success for north-central Oregon, 69% in 1978 and 65% in 1979, though these figures may be elevated slightly because partial predation of clutches was not measured. Redmond (1984) estimated the number of young fledged per nest to be 0.96 in 1977 and 0.14 in 1978.

It is not known whether three of the other radio-equipped birds nested. The birds could not be monitored closely enough to check for nesting because they were in inaccessible areas (e.g., the Impact Area or off-site). Radio signals from two birds indicated they occupied the Impact Area during the nesting season. One bird's signal repeatedly came from a consistent direction, which suggests nesting; however, its activities cannot be confirmed. These birds left the area early in the season; their radio signals were last heard on 28 May 1992. The bird that went off-site was visually

located several times in mid-June. This bird was with a group of about 13 other adult birds and did not show any protective behavior. The remaining radio-equipped male was relocated only twice before losing his radio. This bird was not found on a nest and did not show any nesting or protective behavior.

The literature suggests that recruitment into the breeding population is generally low for long-billed curlews (Redmond 1984). These birds are potentially very long-lived (20 to 30 years) and have a conservative breeding strategy. Age at first breeding is thought to be 3 to 4 years at the minimum. Females lay only one clutch per year and have not been observed to renest following an unsuccessful attempt. Curlews rely more on longevity and low adult mortality for continued survival than on high annual recruitment rates (Jenni et al. 1982; Redmond 1984).

Other factors that can contribute to low recruitment into the population include habitat conditions, predation, and disturbance. Redmond (1984) reported that unusually heavy rainfall that resulted in higher than normal vegetation cover hindered curlew chick movements. This caused the chicks to use more open areas, which then made them vulnerable to predation by raptors. Disturbance during the nesting period can lead to the abandonment or destruction of nests and eggs (Jenni et al. 1982).

Impact of Livestock Grazing

Both cattle and sheep grazing occur on the YTC. Sheep grazed in the vicinity of Silica DZ during late fall and early winter 1991. Cattle were on or near the curlew use areas of Borden Springs, Silica DZ, Range 19, and Washout Gulch during the spring and summer (nesting season) 1992. No disturbances to nesting curlews by sheep or cattle were observed.

Cattle or sheep grazing is generally compatible with and can be beneficial to use by curlews. Grazing can produce the short vertical vegetation structure preferred by the birds. Sheep are more effective in creating short, open vegetation structure. Grazing systems such as fall and early spring grazing that result in reduced standing vegetation during March through May are most beneficial to nesting curlews (Jenni et al. 1982). Heavy grazing can be detrimental by enhancing the invasion of weeds (i.e., Jim Hill mustard, *Sisymbrium altissimum*). Curlews tend to avoid dense stands of weedy forbs (Pampush 1980b). Because of limited data, it was not practical to compare nesting on grazed versus non-grazed areas. Our general observations agree with Pampush's, in that there was little curlew use in several areas that had extremely dense stands of Jim Hill mustard and cheatgrass.

A potential threat exists to nests by trampling. Sheep move in large bands and pose more danger to curlew nests than cattle, which tend to move in smaller groups along established paths. Jenni et al. (1982) reported that cattle and sheep caused several broken eggs and five nest desertions during their study from 1978 through 1979 in western Idaho. They found that several factors influence whether desertion occurs, including the stage of incubation in which the disturbance occurs, amount of damage to eggs or nest, duration and frequency of disturbances, and association with humans. The risk of nest destruction or desertions is relatively low where grazing animals are dispersed in low densities throughout a large area.

Response to Disturbance

In addition to grazing, several other types of disturbances can affect curlews on the YTC, including fire, military training and maneuvers, and civilian vehicle and foot traffic.

Fires occur frequently on the YTC, mostly in the dry summer months when artillery training is being held. Several small fires occurred in the vicinity of Range 55 in summer 1992. These fires had little effect on the curlews since they occurred near the end of the nesting season. Most chicks had already hatched when the fires occurred and presumably could move away. Fires can produce suitable habitat depending on the time of the burn and the weather following the burn. Curlews often use recently burned areas for feeding. However, in the later stages of succession (especially during wet seasons) the suitability of burned areas for curlew use decreases because weedy forbs such as Jim Hill mustard tend to grow excessively tall and dense (Jenni et al. 1982).

Disturbances from military training and maneuvers or from civilian vehicle and foot traffic may detrimentally affect curlews. Prolonged human presence during the nesting season (especially the egg laying and early incubation stages) can cause nest abandonments. Also, curlews flushed off of nests may wait until the disturbance has ceased before returning. This may cause the eggs to overheat or become too cool, thereby killing the embryos (Jenni et al. 1982). During the first week of April, a pair of curlews was using the open area just northwest of Range 1 for feeding and courtship displays. Later in the month, a military squad was bivouacked in that same area. The curlew pair left the immediate area, though their precise movements could not be determined because they were not marked birds. Whether disturbance played a role in the birds' movements is not known.

The extensive road and trail system on the YTC provides easy access by military personnel and civilians to areas used by curlews. Easy road access may result in increased human disturbances. No direct detrimental encounters between humans and curlews were observed on the YTC; however, other researchers reported disturbance of curlews by humans at similarly accessible sites. Prolonged human presence can cause stress that interferes with brooding, feeding, and thermoregulatory activities that may then lead to the deaths of young chicks (Jenni et al. 1982).

Conclusions

Long-billed curlews are a species that can benefit from some habitat disturbance and from the military's use of the land because of their affinity for open habitats. Military activities create and maintain sparsely vegetated areas that may be used by curlews for nesting. Washout Gulch, Beller DZ, and Ranges 10 and 55 showed the highest curlew use in 1992 and are important for the success of the YTC curlew population. Borden Springs, Silica DZ, the area just west of Pozzuolana Mine, and the area north of Range 14 were also used and show potential for higher use in the future. Once chicks have hatched the birds move into heavier cover; therefore, habitats with shrub cover adjacent to the more open nesting areas are of benefit to the birds and should be protected as well.

The most critical time for curlews is during nesting and incubating periods when they are vulnerable to direct disturbance of nests and eggs. Any efforts to protect curlews should be directed toward limiting disturbance during the nesting season.

Curlews' use of nesting areas can vary from year to year as habitats change. Continued annual monitoring of the curlews' population size and distribution will be important to identify the areas of highest curlew use and to make any necessary changes in their protection.

Additional Data Needs

The 1992 work provided useful information on the general distribution of curlews on the YTC. However, at least one more year of study is recommended. The second year of study would yield more valuable and specific results than was possible during this first learning season. To better manage long-billed curlews on the YTC the following activities are recommended:

- Additional research on vegetation requirements of curlews should be conducted. Statistical analysis of use and non-use areas was not done this year.

- Behavioral responses of curlews to military training activities should be studied. We were not able to follow curlew movements intensively enough to determine effects caused by disturbance because of the small number of radio-equipped birds and the short duration in which they were monitored. Intensive monitoring of radio-equipped birds before, during, and after training activities would yield valuable information.

- Livestock grazing's impact should be evaluated by comparing vegetation structure in grazed and non-grazed areas and the curlews' use or non-use of those areas. Also, nests should be monitored for the occurrence of trampling.

- Better estimates of population size and density and information on changes in distribution could be facilitated by yearly surveys.

- Recruitment rates could be determined by locating and monitoring nests and broods. We were only able to locate two nests during the 1992 work, which was too small a sample size on which to base firm conclusions.

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Appendix A

Universal Transverse Mercator Coordinates of Curlew Sightings on the Yakima Training Center in 1992

Table A.1. Universal Transverse Mercator Coordinates of Long-Billed Curlew Sightings on the Yakima Training Center in 1992

Date	Time	Bird Number	UTM Coordinates			No. of Birds	Activity
			Easting	Northing	Zone		
920319	0929	--	719970	5169820	10	1	Unknown
920320	0645	--	717800	5168600	10	1	Feeding
920323	1255	--	706371	5182528	10	1	Flushed
920323	1045	--	699157	5177193	10	1	Unknown
920325	1015	--	725150	5168100	10	2	Feeding
920325	1255	--	706700	5182300	10	2	Unknown
920325	1500	--	709392	5189072	10	2	Flushed
920327	0715	--	270950	5173450	11	1	Flushed
920327	0740	--	709908	5190663	10	2	Unknown
920327	0840	--	700450	5176100	10	2	Flying
920327	1035	--	701850	5175250	10	1	Unknown
920330	1100	--	706500	5182100	10	2	Flying
920331	0740	--	706600	5182500	10	2	Flying
920401	0400	--	706900	5182400	10	1	Unknown
920401	0655	--	700800	5173500	10	2	Courtship display
920406	0730	--	707200	5182400	10	2	Unknown
920407	0430	--	706400	5182600	10	2	Unknown
920415	1000	--	702600	5170600	10	2	Unknown
920416	1635	--	699900	5175800	10	1	Flying
920416	1815	--	707100	5182700	10	2	Resting
920416	--	--	703000	5172000	10	1	Unknown
920417	0600	--	706600	5182500	10	2	Flushed
920417	0715	--	699600	5175600	10	3	Courtship display
920417	0855	--	700400	5176300	10	1	Feeding
920417	1015	--	724700	5168100	10	1	Feeding
920420	1112	--	716300	5168400	10	1	Flushed
920420	1544	--	711900	5168500	10	1	Unknown
920420	1815	--	701100	5173850	10	1	Unknown
920420	1820	--	700150	5173300	10	2	Courtship display
920420	1930	--	701500	5171950	10	1	Feeding
920420	1940	--	706600	5182600	10	2	Courtship display
920421	1000	--	712500	5170500	10	1	Flying
920421	1730	--	712200	5163100	10	2	Flying
920422	0630	--	725800	5167600	10	1	Courtship display
920422	0700	--	718200	5168500	10	1	Unknown
920422	1000	--	703140	5170859	10	2	Unknown
920422	--	--	710200	5172800	10	1	Unknown
920424	0840	--	703700	5171100	10	1	Flying
920428	0850	--	706700	5182300	10	2	Courtship display
920428	0955	--	705600	5164300	10	2	Flying
920428	1010	--	705500	5164100	10	1	Flushed
920428	1155	--	710100	5164500	10	1	Flying
920428	1245	--	715800	5168300	10	1	Hiding
920429	0700	--	716210	5169390	10	1	Courtship display
920429	0710	--	704600	5164200	10	1	Courtship display
920429	0745	--	704300	5162800	10	2	Hiding
920429	0745	--	716500	5168500	10	1	Feeding
920429	0850	--	704600	5162500	10	2	Flying
920429	0925	--	705500	5164100	10	1	Flushed

Table A.1. (contd)

Date	Time	Bird Number	UTM Coordinates Easting	Northing	Zone	No. of Birds	Activity
920429	1200	--	718000	5169800	10	2	Flying
920430	1745	--	699600	5175900	10	1	Resting
920430	1750	--	705200	5168400	10	5	Feeding
920501	0515	--	699700	5176000	10	1	Unknown
920501	0555	--	704900	5162800	10	2	Unknown
920501	0630	--	699700	5175900	10	1	Flying
920501	0740	--	705500	5162500	10	1	Unknown
920501	0910	--	704300	5162800	10	2	Feeding
920501	1035	--	705300	5168300	10	2	Feeding
920504	1815	--	712300	5170900	10	1	Flushed
920504	1830	--	716200	5168500	10	1	Unknown
920504	1845	--	716165	5169431	10	2	Flushed
920504	1900	--	705600	5162500	10	3	Courtship display
920505	0825	--	705500	5166500	10	2	Feeding
920505	0830	--	704800	5167700	10	2	Feeding
920505	1740	--	703906	5174325	10	3	Drinking, bathing
920505	1915	--	701500	5172300	10	1	Threat display
920507	0530	--	704500	5163000	10	1	Unknown
920507	0745	--	705500	5166500	10	4	Feeding
920507	1315	--	712087	5171094	10	1	Unknown
920507	1720	--	703906	5174325	10	2	Drinking, bathing
920507	1820	9.281	703906	5174325	10	1	Drinking, captured
920507	--	--	714800	5169500	10	1	Unknown
920508	1030	9.281	704122	5170957	10	1	Incubating, flushed
920510	1715	--	703906	5174325	10	2	Drinking, bathing
920510	1730	--	703906	5174325	10	1	Drinking, bathing
920510	1750	--	703906	5174325	10	2	Drinking, bathing
920510	1820	--	703906	5174325	10	1	Drinking, bathing
920511	0920	--	704000	5170700	10	1	Resting
920511	0920	9.281	704122	5170957	10	1	Incubating
920511	1315	9.281	704122	5170957	10	1	Incubating
920511	1615	9.442	703906	5174325	10	1	Drinking, captured
920511	1740	--	703906	5174325	10	1	Flying
920512	0800	9.281	707784	5169339	10	1	Feeding
920513	1145	9.281	704122	5170957	10	1	Incubating
920513	1730	--	703906	5174325	10	4	Flying
920513	1805	--	703906	5174325	10	1	Flying
920513	1825	--	703906	5174325	10	1	Drinking, bathing
920513	1910	--	703906	5174325	10	1	Flying
920514	0815	9.281	704122	5170957	10	1	Incubating
920514	0815	--	704000	5171000	10	4	Threat display
920514	1720	--	703906	5174325	10	1	Drinking, bathing
920514	1740	--	704686	5175018	10	1	Drinking, bathing
920514	1800	--	703906	5174325	10	1	Flying
920515	1745	--	705500	5166500	10	3	Threat display
920515	1810	--	703600	5170700	10	1	Flying
920515	--	--	271597	5181562	11	3	Threat display
920517	1400	--	715993	5168381	10	22	Resting, drinking
920518	1430	--	715993	5168381	10	4	Unknown

Table A.1. (contd)

Date	Time	Bird Number	UTM Coordinates Easting	Northing	Zone	No. of Birds	Activity
920518	1435	--	715993	5168381	10	1	Drinking, bathing
920518	1550	--	715993	5168381	10	1	Drinking, bathing
920518	1640	--	715993	5168381	10	2	Drinking, bathing
920518	1725	--	715993	5168381	10	2	Drinking, bathing
920518	1545	9.442	707678	5183033	10	3	Flushed
920519	0815	9.281	699600	5176000	10	1	Unknown
920519	1315	--	715993	5168381	10	3	Flying
920519	1500	--	715993	5168381	10	3	Drinking, bathing
920519	1555	9.383	715993	5168381	10	1	Drinking, captured
920519	1715	9.502	715993	5168381	10	1	Drinking, captured
920519	1830	--	715993	5168381	10	1	Drinking, bathing
920519	1900	--	715993	5168381	10	1	Drinking, bathing
920520	0730	9.383	716106	5170356	10	1	Incubating
920520	0805	--	718200	5170400	10	2	Threat display
920520	1205	9.442	710000	5184000	10	1	Unknown
920521	1640	9.460	715993	5168381	10	6	Drinking, captured
920522	0720	--	712207	5171967	10	1	Flying
920522	1045	9.383	716106	5170356	10	1	Incubating
920522	1050	--	716700	5168300	10	2	Threat display
920522	1115	9.460	716700	5167600	10	7	Flushed
920522	1815	--	705500	5166500	10	3	Threat display
920522	1905	--	711900	5163100	10	1	Flying
920523	0715	9.383	716106	5170356	10	1	Incubating
920523	0720	9.460	716300	5168400	10	1	Unknown
920523	0900	9.281	705500	5171000	10	1	Unknown
920526	1130	--	716106	5170356	10	1	Incubating, flushed
--	--	9.460	716129	5168756	10	--	Unknown
920526	1345	9.383	714603	5169753	10	3	Flushed
920526	1500	9.281	703816	5170953	10	2	Flushed
920527	1200	9.442	711432	5182687	10	1	Unknown
920527	1230	9.502	718782	5156732	10	1	Unknown
920527	1500	--	715993	5168381	10	3	Resting
920527	1715	--	715993	5168381	10	1	Drinking, bathing
920527	1720	9.543	715993	5168381	10	1	Drinking, captured
920528	0720	9.383	716106	5170356	10	1	Incubating
920528	0730	--	716500	5168400	10	1	Flying
920528	0945	9.281	705205	5170271	10	2	Hiding
920528	1030	9.442	711432	5182687	10	1	Unknown
920528	1030	9.543	710000	5178000	10	1	Unknown
920528	1350	--	716300	5168300	10	3	Threat display
920528	1610	--	715993	5168381	10	1	Drinking, bathing
920528	1625	--	715993	5168400	10	1	Preening
920528	1725	--	715993	5168381	10	3	Flying
920602	1110	9.383	716554	5167461	10	3	Flushed
920602	1935	9.383	715478	5169351	10	1	Hiding
920603	0930	9.383	717563	5168184	10	2	Flushed
920609	1715	--	716661	5168411	10	4	Threat display
920609	1730	9.383	716923	5168939	10	1	Flushed
920609	1800	--	716805	5168657	10	1	Hiding

Table A.1. (contd)

Date	Time	Bird Number	UTM Coordinates Easting	Northing	Zone	No. of Birds	Activity
920610	0549	--	716800	5168650	10	1	Flushed
920610	0556	--	716750	5169100	10	2	Threat display
920610	0601	--	716750	5169100	10	2	Flying
920610	0615	--	704750	5164300	10	2	Threat display
920610	1110	1.111	705791	5186310	10	2	Threat display
920610	1127	--	711672	5171674	10	2	Threat display
920611	1230	--	716700	5168900	10	2	Threat display
920611	1230	9.383	716700	5168900	10	8	Flushed
920611	1400	--	712005	5171438	10	2	Threat display
920611	1530	1.111	705516	5187283	10	2	Threat display
920612	0640	--	699525	5175546	10	3	Flushed
920612	0945	1.111	705294	5186701	10	2	Threat display
920612	1200	9.502	720189	5153964	10	14	Threat display
920616	0945	9.502	719902	5153731	10	3	Hiding
920616	0950	--	719902	5153731	10	6	Flying
920616	1100	--	715500	5170800	10	1	Threat display
920616	1330	1.111	705816	5186701	10	2	Threat display
920616	--	--	716900	5169700	10	2	Unknown
920617	1200	9.502	719900	5153700	10	--	Unknown
920623	1207	--	715950	5168400	10	1	Threat display
920623	1515	--	272893	5181351	11	1	Threat display
920623	1520	--	272849	5181186	11	27	Resting
920624	0850	--	272797	5181170	11	14	Resting
920626	1524	--	712700	5169600	10	1	Threat display
920628	1400	--	715900	5168400	10	1	Threat display

Appendix B

Survey Routes on the Yakima Training Center in 1992

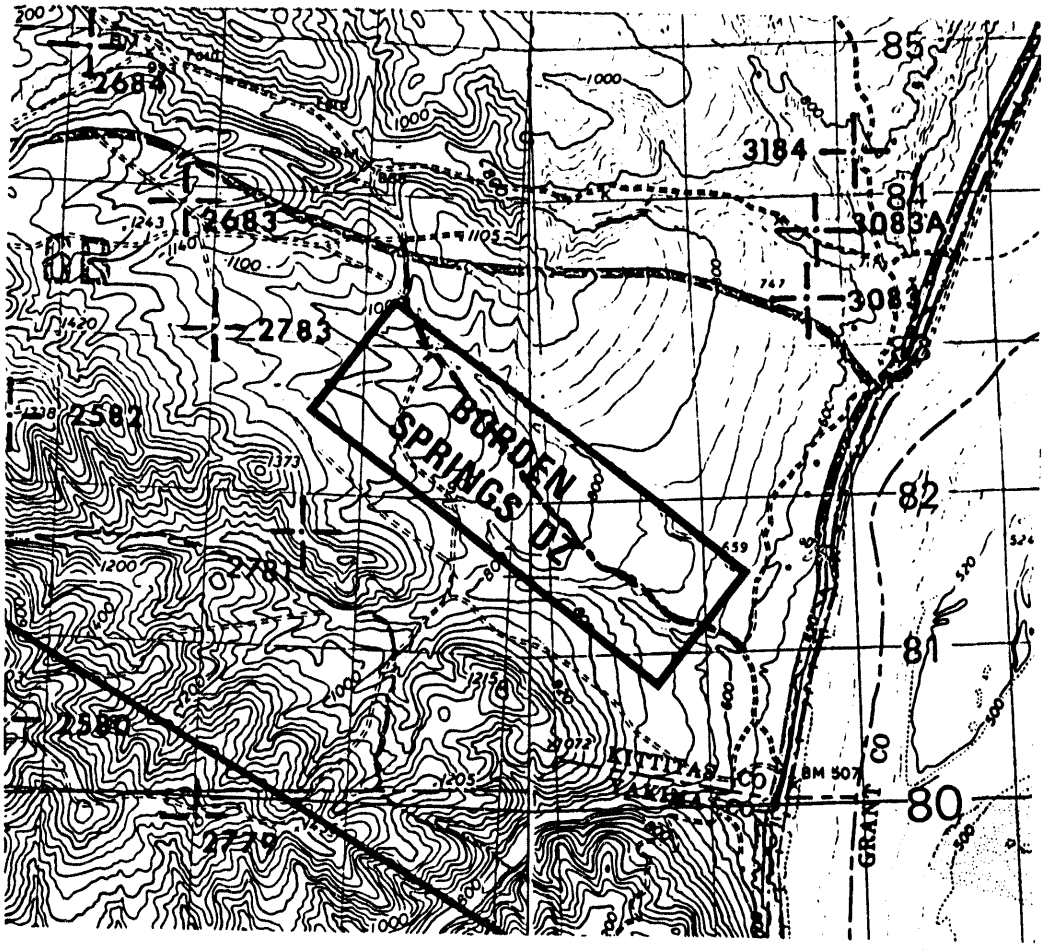

Figure B.1. Borden Springs (———) Curlew Survey Route

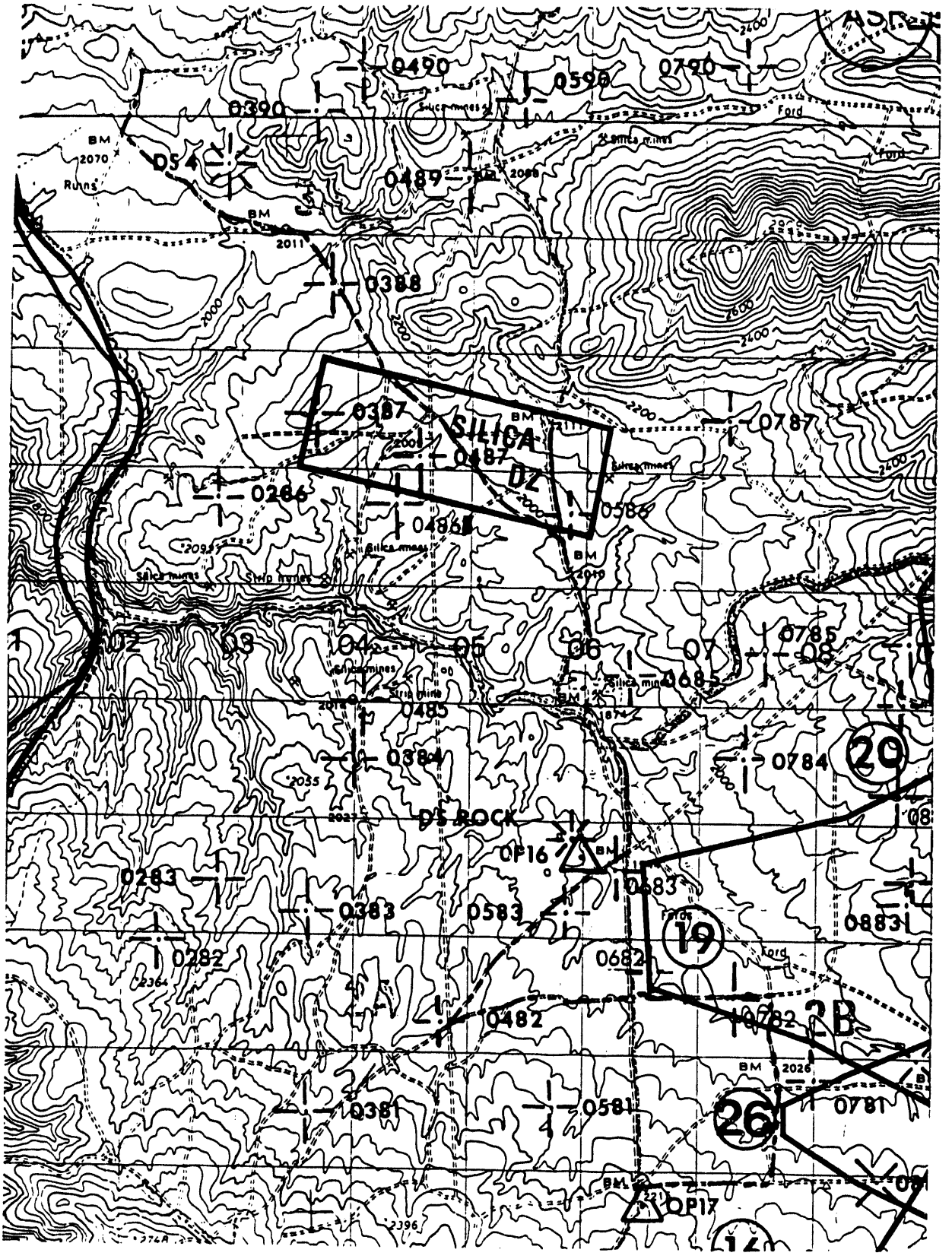

Figure B.2. Silica DZ (— - — - —) and Range 19 (— - - - —) Curlew Survey Routes

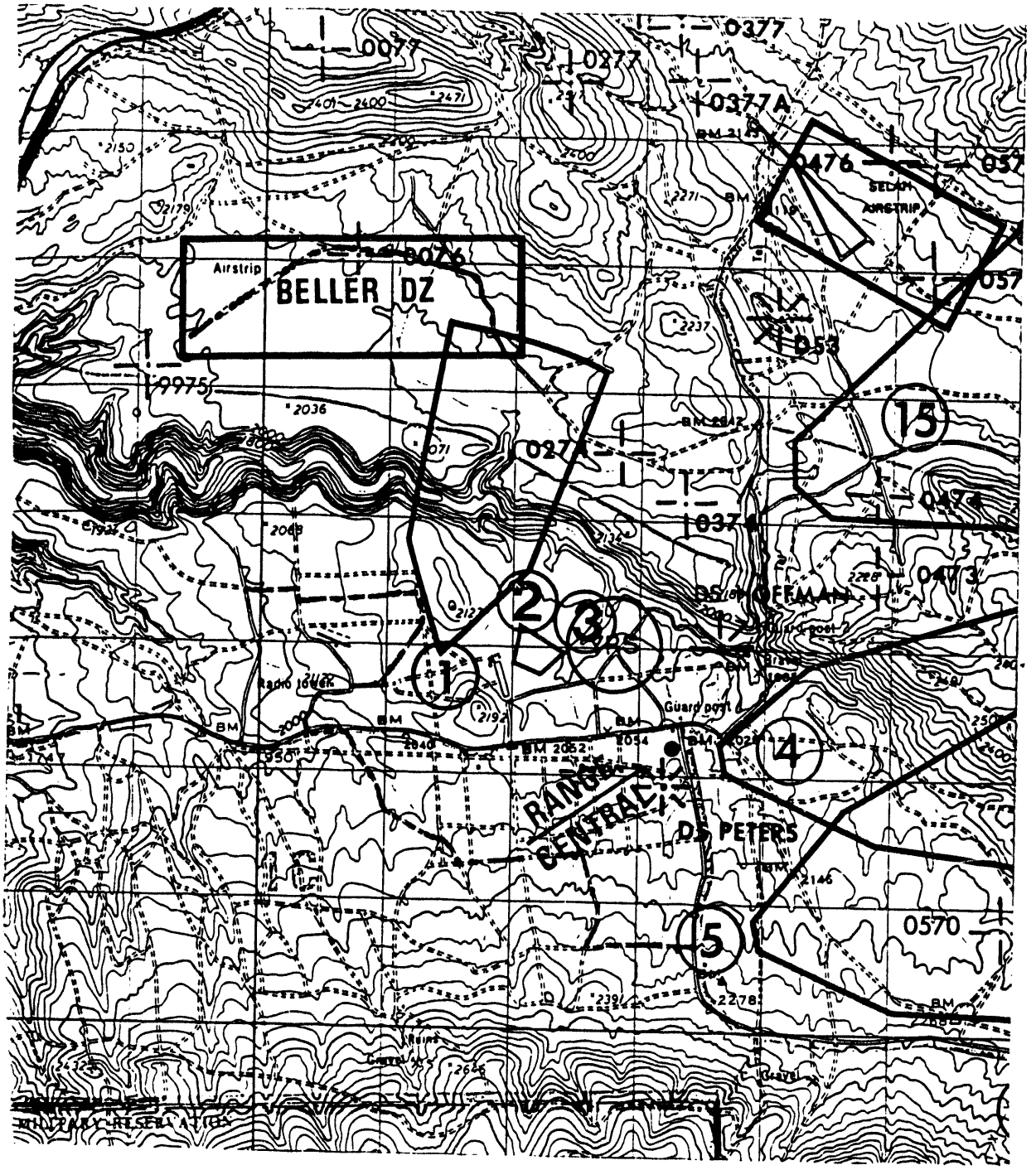

Figure B.3. Beller DZ (— — —) and Range 1 (— — — —) Curlew Survey Routes

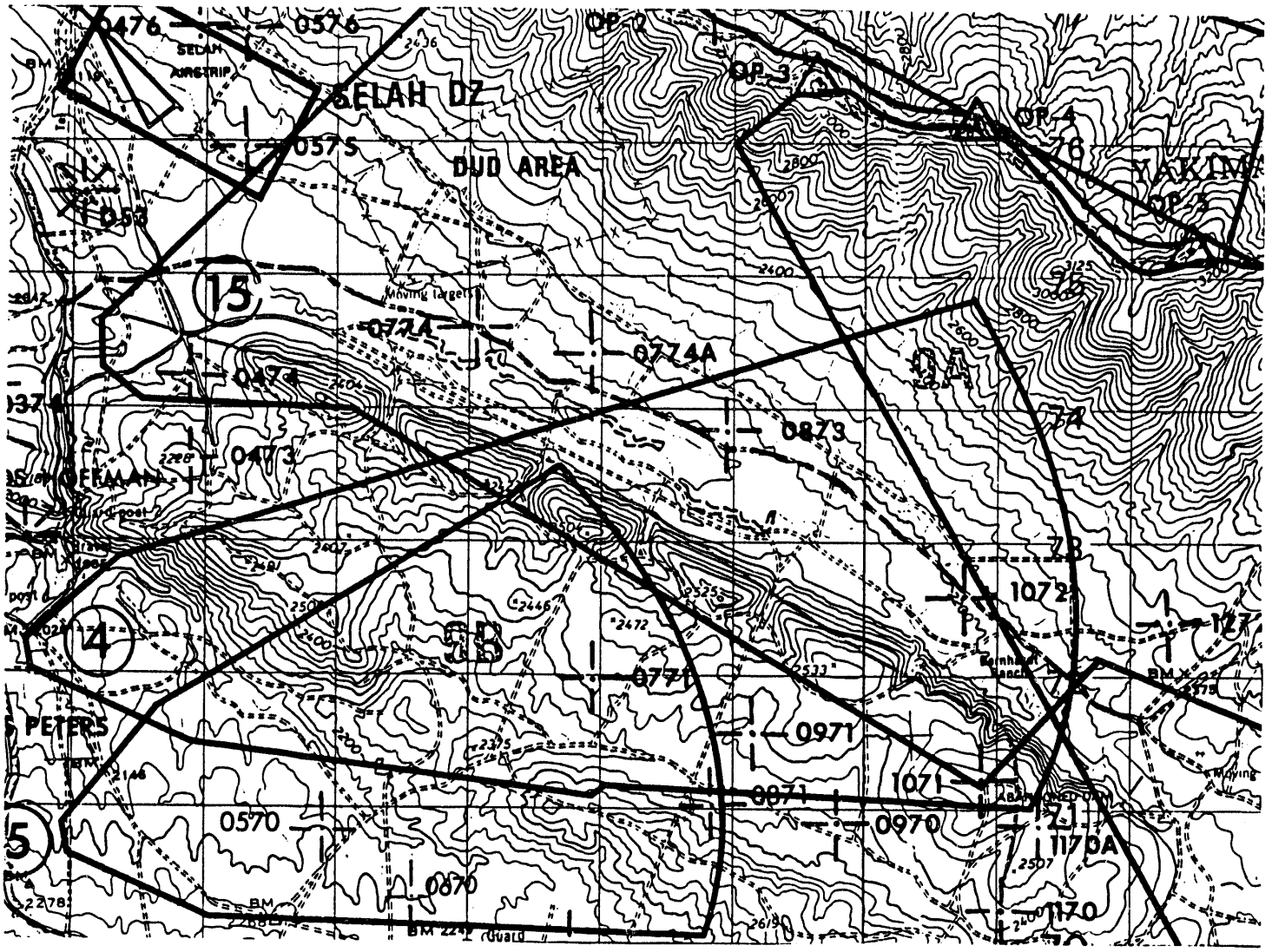

Figure B.4. Selah Creek (— - — -) Curlew Survey Route

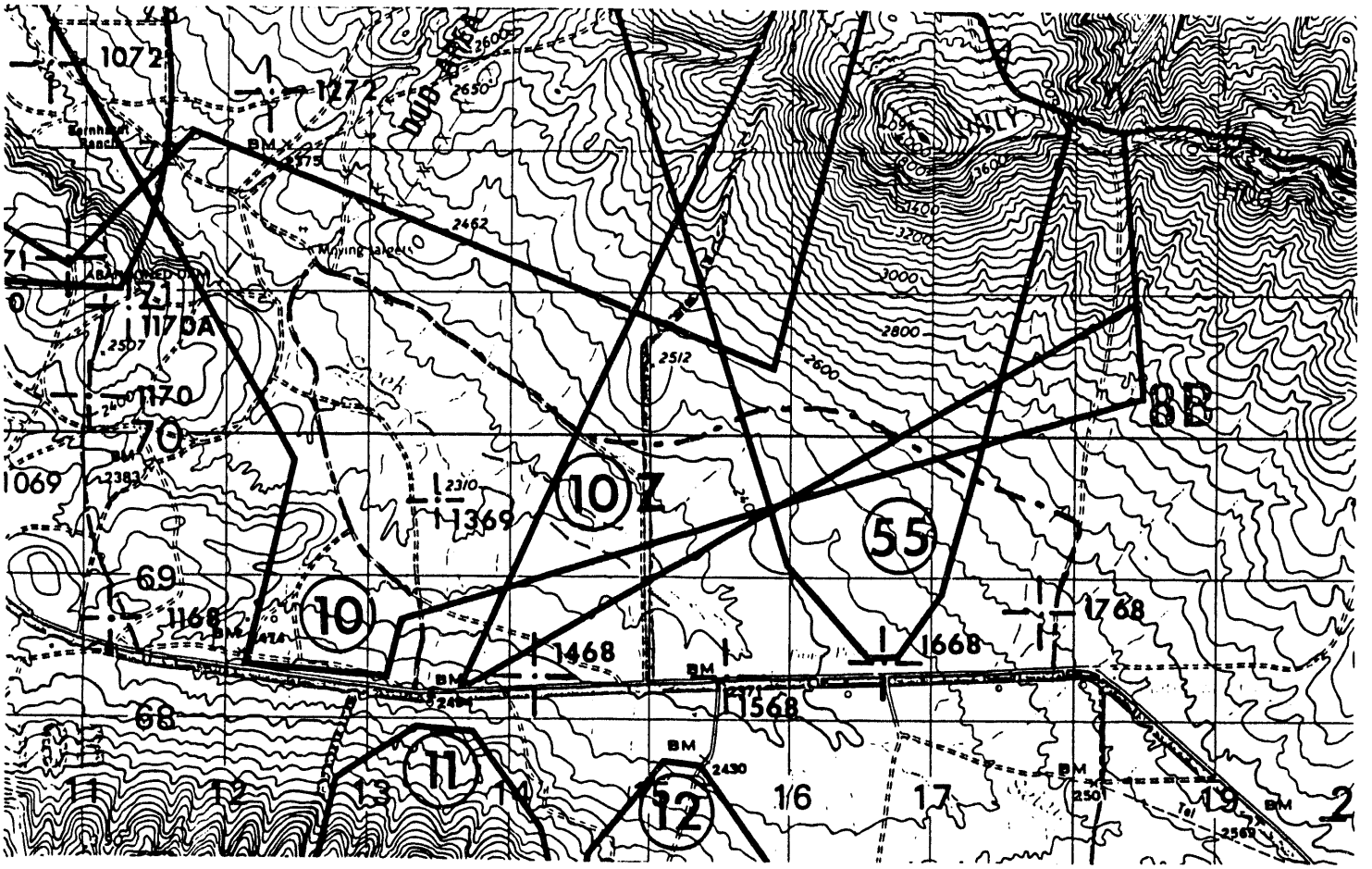

Figure B.5. Range 10-55 (— - — - —) Curlew Survey Route

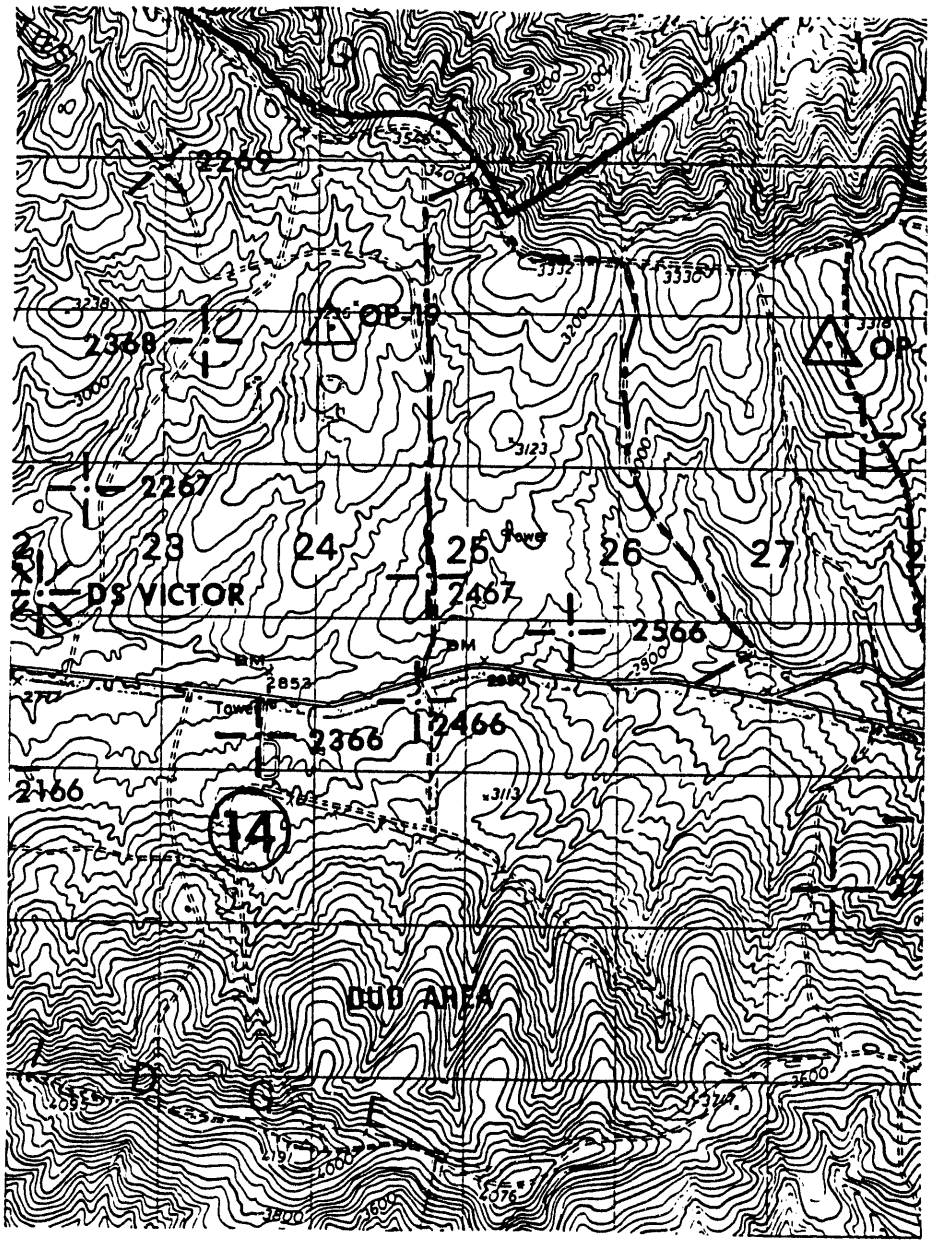

Figure B.6. Range 14 (— - — -) Curlew Survey Route

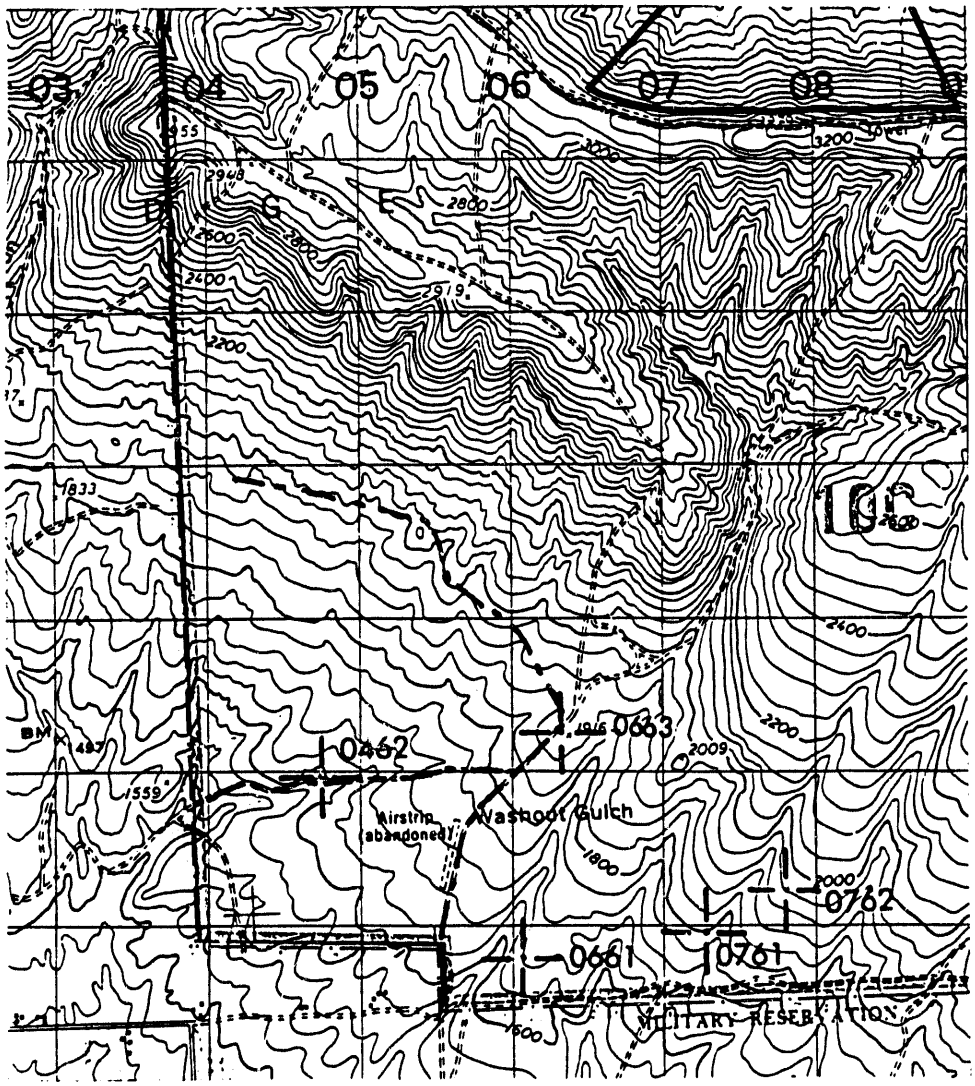

Figure B.7. Washout Gulch (——— Curlew Survey Route

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