BRUNEAU DUNES TIGER BEETLE STUDY

1994 and 1995

by
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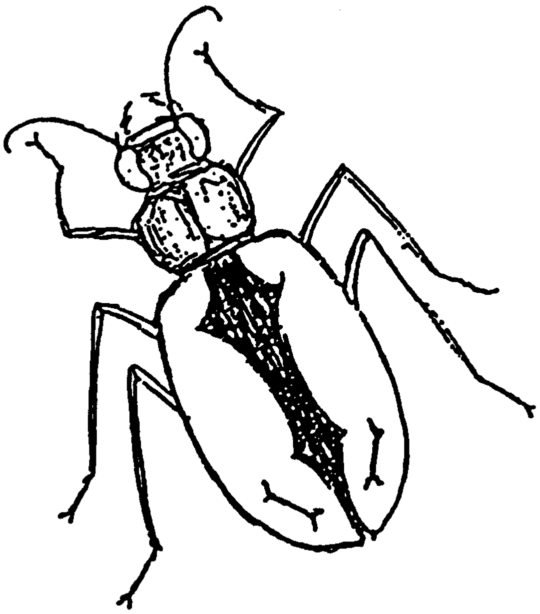

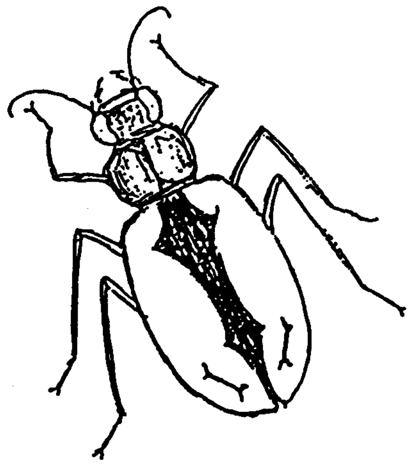

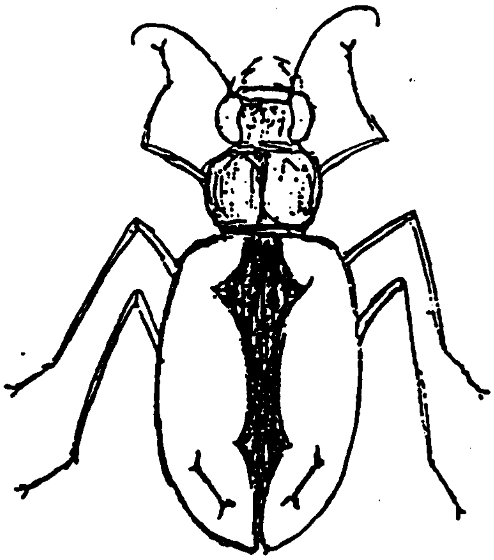

BRUNEAU DUNES

TIGER BEETLE STUDY - II

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Submitted to Boise District Office of Bureau of Land Management

August 15, 1996

BRUNEAU DUNES TIGER BEETLE STUDY - 1994 and 1995

FINAL REPORT

for

Challenge Cost Share Project:
D010-P40067
and
DO1O-P5-0140

Submitted to: Bureau of Land Management
Boise District Office
3948 Development Ave.
Boise, Idaho 83705

August 15, 1996

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INTRODUCTION

Sixteen species of tiger beetles are known to occur in Idaho but only Cicindela arenicola is an endemic (Shook 1984). Cicindela arenicola was described in 1967 from a series of specimens collected at two localities: St Anthony Sand Dunes and Sand Dune Lake (Rumpp 1967). This species is apparently restricted to dune systems located within the area generally known as the Snake River Plains of Idaho. The most western population occurs on the dune system at Bruneau Dunes State Park in Owyhee County. The most eastern population is located on the Mikesell Reservoir Dunes in Fremont County. The Mikesell Reservoir population was first discovered in 1995. This discovery extends the range of C. arenicola farther to the northeast (Logan 1995).

The attractive color pattern of Cicindela arenicola made it a favorite of collectors subsequent to its description by Rumpp in 1967. It became a species of concern during the early eighties when collectors reported greatly diminished numbers at some sites, and it was no longer found at a site where it was previously known to occur near Heyburn, Idaho. Because of these concerns the beetle was designated a category 2 species, and studies of its distribution and biology were initiated by the Bureau of Land Management (Anderson 1988). Subsequent studies have shown the species to have a greater range than formerly recorded (Baker et al. 1994, Logan 1995).

Initial bionomic studies of this species were done on the more eastern populations (Anderson 1988, 1989, and Bauer 1991). Subsequent to these studies concerns still remained for the more western populations of the beetle. The isolated nature and restricted size of the two most western populations argued that they be further studied. Adding impetus to this is the possibility that these two populations represent a very distinct subspecies.

Investigations on the biology and distribution of the beetles at the more isolated western sites were begun in the 1993 field season. The population at Bruneau Dunes State Park was found to be widely distributed within the park and not as restricted in occurrence as was previously thought. One new population was found in 1993 at a site 10 kilometers east of Bruneau Dunes State Park. This locality was named the Windmill Site (Baker et al. 1994).

Cicindela arenicola has been commonly referred to as "the dunes tiger beetle" (Anderson 1989 and Baker et al. 1994) or the "Idaho dunes tiger beetle" (Logan 1995). As used in this paper the designation Bruneau Dunes tiger beetle refers to specimens from both Bruneau Dunes State Park and the Windmill Site located 10 kilometers east of Bruneau Dunes State Park. Specimens at these two sites are quite removed geographically from other known sites but are relatively close to each other. Five separate studies involving the distribution and biology of these two western populations were done during 1994 and 1995. Those studies are reported in this paper.

OBJECTIVE ONE: POPULATION SIZE ESTIMATION FOR THE SUBPOPULATION OF *CICINDELA ARENICOLA* AT SITE C IN BRUNEAU DUNES STATE PARK FOR THE YEARS 1993, 1994, AND 1995

Introduction

Early attempts to document the population size for Cincindela arenicola in the area of Bruneau Dunes State Park found very few adults. The very sparse numbers of the beetle seen at the Bruneau Dunes locality as compared to the very high numbers seen at the St. Anthony Dunes led Anderson to predict the extirpation of the beetle from the Bruneau site within five years (Anderson 1989). This prediction justified the initiation of a study to determine the population trend of this beetle for the Bruneau Dunes State Park area. Studies to track population trends for this beetle at Bruneau Dunes State Park were initiated in 1993 (Baker et al. 1994).

The population size of Cicindela arenicola at Site C in Bruneau Dunes State Park for 1993 was estimated using the number of 4 mm diameter larval burrows counted in transects totaling 1650 m^2 of area (Baker, et al. 1994). Subsequent field observations and laboratory studies indicated that both 3 mm and 4 mm diameter larval burrows should be used to derive a population estimate. The reasons for this are found in the discussion section. The data obtained for 1993 have been reassessed and are reported here along with the data for 1994 and 1995.

Materials and Methods

Larval habitat occurs in a rather narrow ecotone band of variable width situated between the open, drifting sand of the dunes and the established desert plant community. Within this ecotone band larval burrows are found in the sparsely vegetated flat areas that are interspersed amongst the sandy, more heavily vegetated hummocks. In 1993, eighteen west-to-east transects were established at various intervals over the entire north-south length (950 m) of this larval ecotone band (Baker, et al. 1994). The total area of the ecotone band surveyed by these transects is estimated to occupy 84,250 sq. meters.

Each transect starts in the sand at the edge of the dune just a few meters from where the dune stops. The transects traverse to the east across the ecotone band of larval habitat to terminate in the more established plant community that borders this area on the east. The area in which the transects end is beyond that normally used for larval development.

The length of the transect varies with the distance to which larval habitat extends out from the dune system. Three transects at the ends of the grid are only 50 m long. All others are 100 m long. Transects A through G are 80 m apart. Transects N9 through S1 are 40 m apart. The distance between transect G and transect N9 is 54 m, and the distance between transect S2 and S1 is 57 m (see Fig. 1).

Permanent markers (orange-painted digger bars pounded to within a few inches of the surface) were placed at the starting and ending points for each transect. Additional digger bars were placed at every 25 m along each transect. The starting point of each transect was flagged, as were the endpoints of most transects. Transects were established using a surveyor's Brunton compass and tripod on a sighting of N30W/S30E. A meter tape was affixed to the zero, 50 and 100m digger bars as a reference line for positioning of quadrats. Every other square meter of habitat along the north side of the transect was inventoried using a quadrat that was 1 m^2. A coin toss determined whether odd or even numbered quadrats on a given transect were inventoried.

All classes of larval burrows (2, 3, and 4 mm) were recorded, but only the 3 and 4 mm size classes were utilized for estimation of population size. There is a much higher survival rate for the second and third instar larvae (3 and 4 mm diameter burrows). Most first instar larvae

(2 mm size burrows) do not survive to the second instar (3 mm size burrows). The number of the 2 mm size burrows fluctuates greatly over the year. Counts at the time of hatching have shown as many as six 2 mm burrows per square meter but only about 15% of these survive to the second instar.

Results

The 3 and 4 mm larval burrows were counted for the years 1993, 1994 and 1995. The number of these burrows increased yearly. There were 16 burrows in 1993, 23 in 1994, and 25 in 1995. From these data we estimated both the burrow density and the total population for the 84,250 square meters of larval habitat at Site C at Bruneau Dunes State Park (Tables One and Two), and observed a general increase from year to year. In addition, the variation to mean ratio (a measure of dispersion of burrows) increased from year to year. In 1993 it was 0.982, indicating a more or less random distribution. In 1994, the variance to mean ratio had increased to 1.32, and in 1994 this ratio had further increased to 1.65. A greater than 1.0 variance to mean ratio indicates clumping of burrows.

Additional surveys in 1994 discovered several new areas where C. arenicola occurs within Bruneau Dunes State Park. It is now estimated that Site C represents about one-third of the area where C. arenicola occurs within Bruneau Dunes State Park. Beetle density in these various areas appears similar, therefore by extrapolation we estimate that there were approximately 7500 second and third instar larvae in the general area of Bruneau Dunes State Park in the spring of 1995.

Discussion

Counts of late instar larval burrows are deemed more reliable than counts of adult beetles for estimation of population size for the following reasons:

1. The 3 mm and 4 mm diameter burrows are regularly open and available for counting throughout the early spring activity period. Burrows generally remain open under cool, hot, windy, or cloudy conditions. Adult activity, by contrast, is relegated to a much narrower range of weather conditions. Cloudy, cool or excessively hot conditions will cause adults to take refuge beneath the surface where they are unavailable for survey purposes. It would be virtually impossible to obtain uniform weather conditions from year to year during which adult surveys could be conducted with any reasonable degree of reliability.

2. Adult beetles are quite wary and often escape detection by survey workers. It is difficult to train observers to detect adults which run and fly in advance of an approaching person. By contrast, larvae retreat down the burrow when disturbed. Field workers can be trained easily to systematically conduct surveys for these open larval burrows. The chance of major measurement error is much greater in studies that count adults in comparison to studies that count the burrows of second and third instar larvae.

The number of burrows increased over the three year span of these surveys. The variance to mean ratio also showed a progressive increase, indicating that as the population density increased, so did the clumping of burrows. Thus, much of the density increase was accomplished by additional burrows in areas that already supported burrows. The clustering of burrows in certain reaches of the transects is readily apparent for the three years of this study (Figure 2).

The particular factor/factors driving this increase in numbers and increase in clumping is/are not known. However, we speculate that climatic factors during the two year life cycle of this species probably have the greatest impact on survival. The most critical period is likely March to June when mating, oviposition, hatching and first instar burrow formation occurs.

One important aspect of climate is timing of rain storms. The seasonal precipitation pattern could significantly impact larval survival. Our field and laboratory studies indicate that larvae hatch two to three weeks following oviposition. Embryological development rate is very likely influenced by temperature. Hatchling larvae are apparently unable to successfully burrow to the surface unless the sand is damp. Laboratory and field observations indicate that if the sand is dry, the newly emerged first instars remain in the oviposition chamber. A precipitation event that wets the sand to a depth of at least two to three centimeters will stimulate he first instar larvae to burrow to the surface through the damp sand. They cannot do so in dry sand since it caves in upon them. If there is a protracted drought during the time when larvae are hatching many larvae probably exhaust their food reserves and perish before they can establish a burrow and capture prey.

A second very important factor affecting beetle development and survival is prey availability. Weather patterns can significantly alter prey availability. Adults that emerge in the fall need to feed and find sheltering places to successfully over winter. Prey availability in the fall is probably critical to the effective survival of adults through the winter. Females of this species produce the largest eggs recorded for any species of tiger beetle in North America (2.7 by 1.4 mm). Prey availability in the spring would affect the ability of female beetles to produce these very large eggs. Highly successful foraging by females in the spring could significantly increase the number of eggs produced.

The progressive increase in numbers of larvae of this beetle from 1993 through 1995 is thought to have resulted from weather conditions that directly or indirectly permitted greater numbers of larvae to reach the second instar condition. In 1993 and 1995 spring precipitation was much greater. Although 1994 was a "drought" year, the sparse spring rains may have been optimally timed to the life cycle of the beetle. Counts in 1996 may well drop from the high seen this year due to the effects of the prolonged dry spell in the spring of 1995. The first new burrows for the 1995 season appeared immediately following the rain in late May. No new first instar larval burrows were seen through May 25 this year. After rains the next week, many new burrows were seen on June 3. It is very difficult at this time to clearly assess the impact of these variable weather patterns on the survival of newly hatched larvae of this species.

Factors which have been reported to decrease tiger beetle numbers include such things as: insect predators, insect parasitoids, bird and reptile predators, and impacts from human activities or their domestic animals. The current level of human activities at Site C are probably not having a significant impact on the population of C. arenicola. The new boundary fence constructed by the Bureau of Land Management in the fall of 1993 provides greater protection for Site C. The remote nature of Site C also appears to greatly reduce human activity in this area. Although some continued motor vehicle access has been noted, it is estimated to affect less than 3% of the general area.

Summary

Larval burrow counts for Cicindela arenicola have been done for three years at Site C in Bruneau Dunes State Park. The density of second and third instar larvae has increased each year during this period. On the basis of these counts it is estimated that the larval population at Site C has increased 56% from 1993 to 1995 . The total second and third instar larval population at Bruneau Dunes State Park for spring 1995 is estimated to have been 7500. This represents a three-fold increase over the 2500 specimen estimate made after the 1993 field season. Three factors contributed to this three-fold increase in the larval population estimate. First, new areas of larval habitat were found in 1994. Second, the density of larval burrows has increased since 1993. Third, the second instar larval burrows (3 mm diameter) have been added to the counts for purposes of population estimation.

OBJECTIVE TWO: WEED REMOVAL TO IMPROVE HABITAT FOR OVIPOSITION BY FEMALE CICINDELA ARENICOLA

Introduction

During the summer of 1993 there was a noticeable increase in weedy vegetation along the east side of the dune system at Site C. Some of the areas covered by these weeds were very similar in surface composition and topography to nearby open areas which supported larval burrows of Cicindela arenicola. It is assumed that areas overgrown with weeds are not used for larval development since female beetles do not enter vegetated areas and no larval burrows have been recorded in overgrown areas. The weeds were removed from one such overgrown area bordering an open area of active use in an attempt to provide additional habitat for oviposition by female C. arenicola.

Materials and Methods

An area overgrown with weeds was located adjacent to Transect G of the population study grid. Larval burrows of C. arenicola were present on three sides of the selected site. The fourth site bordered the edge of the dune system. A schematic diagram of this site is presented in Figure 3. The study area was quite flat with a surface that was a mixture of sand, gravel, pebbles and rocks. Previous study had shown that larval burrows were generally found where the surface was of this mixed nature (Baker et al.,1994).

On March 30, 1994, rakes and pitchforks were used to clear an area 20 meters by 15 meters. Most of the weeds were Russian thistle (Salsola kali). Other plants included tumble mustard (Sisymbrium altissimum), cheat grass (Bromus tectorum), and sandbur (Franseria acanthicarpa). The area was staked with digger bars at the four corners; it measured 15 meters along the transect and 20 meters out from it (Figure 2). After removal of the emergent weeds an attempt was made to rake the smaller organic particles from the surface of the soil.

However, it was discovered that the upper soil profile had much organic matter on it and embedded within it. The removal of this embedded organic material would have required significant alteration of the soil surface, so it was left as it was. The vegetation that had established in this area had significantly changed the nature of the underlying soil surface. Surveys to check for the presence of larval burrows were done two days after clearing (April 2) and during the time of peak emergence of new larvae (May 25) for the 1994 field season. Surveys were also done at the beginning and end of the 1995 field season.

Results

No tiger beetle larval burrows were seen in the cleared area during 1994 and 1995. This area was not used by female beetles for oviposition, but areas only 14 meters away were used: a new first instar burrow (2 mm diameter) was found 15 meters south of meter 7 of Transect G and a second new first instar burrow was found 14 meters south of meter 22 of Transect G. No new burrows were seen closer to the cleared area. Older burrows (4 mm diameter) were seen along the transect in the area between meter 33 and meter 40; 11 meters beyond the cleared area (Figure 3). These larger burrows resulted from ovipositon activity in a previous year, probably from both 1993 and 1994.

Discussion

It was not apparent at the outset that the soil beneath the weeds had accumulated a considerable amount of organic material. Also, the nature of the soil here was probably different initially from nearby open areas since weeds were able to establish on it but were not able to invade the small open flats about 15 meters south of the cleared area. The accumulated organic matter in the surface soil probably permits weedy species to persist in these areas since the soil retains more water. The small open flats bordering the weedy areas continue to be used by the female beetles as oviposition sites.

On the basis of general tiger beetle biology and our knowledge of C. arenicola behavior in particular, it appears doubtful that weed removal projects of this nature provide an easy way to increase the habitat acceptable to C. arenicola females for oviposition activity for the following reasons:

First, the literature indicates that the female cicindelids are very selective in choosing the oviposition site. They have been observed to take bites of the soil to check for acceptability (Pearson 1988). The female may assess salinity, moisture, and particle size as well as other factors in this manner. I observed soil biting by captive females of C. arenicola on several occasions. The abundance of small twigs, leaves and other organic particles would probably deter female beetles accustomed to laying eggs in clean sand from using such areas for egg laying. Increased organic content would indicate soils that are better suited to support plants because of the better water retention capability of these soils. It is thought that the increased humus could serve as a deterrent to oviposition since it is an indicator of potentially greater vegetation cover later in the year. Larvae are not believed to survive as well under these conditions. It is thought that C. arenicola has evolved an oviposition behavior that avoids such soils.

Second, observations made during the 1995 field season indicate that not all available larval habitat is utilized by this species in each year. Several areas that evidenced high usage in the 1993 season were not used at all in 1994 and 1995. Some areas were utilized as oviposition sites in each of the three field seasons. The more highly preferred sites were very open and had very little or no accumulated organic debris on the surface. Accordingly, it is not likely that females will use sites such as this when existing, more optimal areas are not being fully utilized. This site will be monitored for the next two years.

Summary

A 15 by 20 meter area was cleared of weeds so female C. arenicola could use it for oviposition. Considerable organic debris was found to have accumulated on and in the surface soil beneath the weeds. This organic material is viewed as having significantly diminished the acceptability of the area for oviposition activity by the beetle. No oviposition activity was observed in the area from which the weeds were removed for the 1994 and 1995 field seasons.

OBJECTIVE THREE: IDENTIFICATION OF ADDITIONAL AREAS OF LARVAL HABITAT FOR *CICINDELA ARENICOLA* WITHIN BRUNEAU DUNES STATE PARK

Introduction

Concern for the survival of the Bruneau Dunes tiger beetle at Bruneau Dunes State Park dictated that surveys be conducted to determine the status of this species. An initial survey indicated that the beetle had a very limited distribution at the park (Anderson 1988). More recent surveys indicate that the beetle has a more extensive distribution at Bruneau Dunes State Park (Baker et al. 1994). Surveys conducted in 1993 found the beetle to be more widely distributed than in 1988, but resource and time constraints did not allow all prospective areas to be surveyed in 1993. The southeast portion of the park was not done in a complete manner that year. In 1994 a more extensive survey was made to delineate the areas that support larvae of Cicindela arenicola in that portion of the park situated to the east and south of the main dune system. The results of this 1994 survey are presented here.

Materials and Methods

The 1994 survey was conducted on May 8 under optimal weather conditions for activity by adults or larvae. The day was sunny with a very slight breeze. Air temperature was 70 degrees Fahrenheit by 1000 hours and sand surface temperatures reached 120 degrees Fahrenheit by 1300 hours. The survey was done on foot at a slow pace by two observers (Charles Baker and Conrad Colby). The survey began at 1015 hours and ended at 1630 hours. New burrows of the first instar larval cohort for 1994 were not yet present at this time of the year. The line of march for the survey was very similar to that done by George Stephens in 1993.

Results

Many areas were found to support larval burrows in this portion of the park. The burrows occurred in areas that were flat and usually covered with a mixture of sand, pebbles, and gravel. Most of the areas of preferred habitat had fewer than 50 larval burrows each. It is very difficult to locate the boundaries of these different areas precisely on a map. A general map (Map 1) is marked with 10 general sites where larval burrows were found. Four of these sites were noted by George Stephens in 1993 to have either larvae or adults of C. arenicola present.

Discussion

Although not all areas in Bruneau Dunes State Park have been extensively surveyed for C. arenicola it is apparent that this species is quite widely distributed within the park, covering a much greater area than that previously indicated by Anderson (1988). There are many factors which could account for this, chief among which are the following: First, more recent surveys have been conducted earlier in the year and in a different manner; Second, more favorable weather has allowed the population to increase over the last three years; Third, reduced pressures (parasitoid, predator, disturbance, etc.) on the beetle has allowed enhanced reproduction.

Cicindela arenicola is quite widely distributed within Bruneau Dunes State Park. Current park policies and activity levels by recreationists using the park do not appear to be negatively impacting this species. Accordingly C. arenicola does not appear to be in imminent danger, barring a major catastrophic event, of being eradicated from this area.

Summary

An extensive survey was done for C. arenicola in the southeast portion of Bruneau Dunes State Park on May 8, 1994. The survey disclosed several new sites where C. arenicola larvae occur. The new areas include enough additional habitat to allow the population estimation for the species to be raised by about 30%.

OBJECTIVE FOUR: ADDITIONAL SURVEYS TO BETTER DETERMINE THE POPULATION SIZE AND THE RANGE OF *CICINDELA ARENICOLA* AT THE WINDMILL SITE

Introduction

In 1993 a new population of C. arenicola was found at a site 13 kilometers east of Bruneau Dunes State Park. This new location was named the Windmill Site (Baker et al. 1994). Visits during 1993 indicated that the range of this population was quite limited with adults and larvae closely associated with the open dune system and the contiguous grassy flats. The limits of the range of the beetle at this site were not determined in 1993 nor was any population survey work done. The results of population and range surveys done at the Windmill Site in the spring of 1994 and the fall of 1995 are presented here.

Materials and Methods

March 13, 1994

A walking survey of the Windmill Site was conducted on March 13, 1994 by Luana McCauley, Steve Staufer, and Charles Baker. Weather conditions were very good for adult beetle activity on that day. There was bright sun, light breeze, air temperature of 68 degrees Fahrenheit, and a sand surface temperature that varied from 90 to 98 degrees Fahrenheit. The one-hour survey for adults started at 1335 hours and ended at 1435 hours.

The walking survey on March 13 started at the northeast extremity of the dune system. At this point the open dune adjoins a line of large shrubs. The shrub line continues eastward as an irregular border along the northeastern margin of the grassy swale. The three observers walked in a line with a distance of about 8 to 10 meters between them. An observer cannot effectively see beetles at distances beyond 10 meters. The line of march stayed generally on the higher, open sandy areas. A diagrammatic sketch of the line of march and salient topographic features including the lone elm tree cluster is given in Map 2.

Beetles at this time of year are found principally on the open sand dunes where they search for food and mates. When beetles are disturbed they run or fly to escape the perceived threat. Beetles were counted only when they ran or flew back behind the line of march. Such beetles were not likely to be seen or counted again during that day's survey. The counts were of a conservative nature in that some beetles probably flew so far forward and off to the side that they were not included in the final total.

The survey for larval burrows started at 1435 hours and ended at 1700 hours. Surveys for burrows can be conducted anytime during the day since active burrows remain open day and night. Most of the area east of the dunes all the way to the top of the main ridge was surveyed. Burrows were found in the flat areas near the dunes and eastward up the open sandy areas beyond the lone tree, ash pit, and transverse dune (Map 2).

Observers walked very slowly and stopped frequently when surveying for larval burrows. The burrow is virtually undetectable if the larva is up and has its head blocking the opening. The slow walk-and-stop approach gives the larva time to drop from the entrance when disturbed. The open hole is now more easily seen by the observer. If the larva has recently enlarged or cleaned out the burrow the throwout pile of sand balls helps the observer locate the burrow.

October 14, 1995

On October 14, 1995, Kevin Cornwall and Charles Baker measured the length and width of the main larval habitat area at the Windmill Site. Observations were made for both larvae and adults with respect to numbers and distribution. There was a heavy frost at dawn, but by mid-afternoon the air temperature was 76 degrees Fahrenheit. The day was clear with a light breeze from the southeast. These conditions were very good for adult beetle activity. Selected collecting of adults was done to assess the sex ratio and to get voucher specimens.

Results

March 13, 1994

The one-hour adult beetle survey yielded a count of 29 confirmed individuals. There were 36 sightings, but only 29 of these were clearly observed to pass behind the line of observers. The adults were very active and widely scattered in the open areas. Later, while surveying for larval burrows on the hillside beyond the tree cluster, an additional eight adults were seen. Thus, at least 37 adult beetles were seen on March 13, 1994.

The larval burrows were widely scattered throughout the sandy flats bordering the east side of the main dune system. Numerous burrows were also found in the open sand areas east of the tree cluster. This sandy area continues uphill all the way to the top of the main ridge that overlooks this dune system on the east side. Burrows were found only in the lower half of this reach where the more open sandy areas evidently provide adult beetles with habitat for feeding and mating. The upper half of this sandy strip is heavily vegetated with weedy species and is probably not viable habitat for C. arenicola.

At least 120 larval burrows were counted during the larval survey. The burrows were more concentrated in the sandy areas on the hillside above the tree than they were in the sandy flats along the dune line. At one place on the hillside there were 14 burrows within a circular area of approximately two meters diameter. The burrows at this place were of all three size classes (2, 3, and 4 mm.). The number of burrows seen uphill from the tree cluster was 56. At least 65 burrows were seen between the tree cluster and the first dune (Map 2). Some of the burrows on the hillside were found in the wheel tracks left by a motorbike. These burrows had been reopened after being run over by the tires of the motorbike.

On this day two people operating a four wheel all-terrain vehicle were observed to knock down a fence so as to access the open dune areas for recreational purposes. They did extensive driving on the main open dune areas. They left upon our approach, long before any identifications were possible.

October 14, 1995

The width of the area supporting larval burrows was 158 m along the east base of the main dune cluster. The larval habitat proceeds from the base of this dune cluster in an eastward direction along the ends of the larger open dune areas (Map 2). The tree cluster is about 478 m from where the larval habitat starts. The area of larval habitat continues beyond the tree cluster uphill for about another 382 m. It is thought that 90% of the larval habitat at the Windmill Site occurs within an area measuring 158 m x 860 m.

One small area with larval burrows was found about 150 m beyond the principal larval habitat area. There may be other such areas scattered throughout the large area of sandy soils which occur to the south of the windmill. Cursory surveys of these smaller dune areas in 1993 and 1994 did not disclose any larval burrows or adults of C. arenicola.

As the day warmed the adults became very active. It is estimated that between 100 and 200 adult beetles were seen. Six males were captured as voucher specimens. No females were taken from this site. The sex ratio appeared to be about 1:1. The larger female beetles flew more slowly and were easier to capture.

Discussion

More adult beetles were seen during the March 13, 1994 survey than during any survey done in 1993 at the Windmill Site. Surveys done in 1993 never detected more than 12 adult beetles on a given day. However, it is known that adult beetle activity varies greatly with weather conditions and seasonal progression. It is quite possible that conditions were optimum for adult beetle activity on March 13, 1994.

Previous surveys for larval burrows had not identified the area of burrows located east of the tree up on the hillside. This discovery essentially doubles the area of viable larval habitat for the Windmill Site population of C. arenicola. Although this hillside area is smaller in size than the total area of sandy flats bordering the dunes, it has a greater density of burrows. The smaller area of open sandy dunes probably concentrates female beetles in this area at the time of mating. This would then logically lead to a higher density of female beetles that would oviposit in the adjoining areas of available larval habitat. The bigger open dunes would not tend to concentrate mated females in such a manner. Accordingly, a greater density of larval burrows would be seen in this hillside area as compared to the density of larval burrows seen in the flats adjoining the very extensive main dune system.

Summary

A extensive survey for adults and for areas of larval habitat at the Windmill Site was conducted on March 13, 1994 by three observers. At least 37 adults and over 120 larval burrows were counted. These numbers were higher than any obtained from surveys done in 1993. Motorized vehicles do access these dunes for recreational purposes, and the larval habitat on the hillside does sustain some disturbance from offroad vehicular activity. A survey on October 14, 1995, the first fall survey at this site, found many more adult beetles than seen at the Windmill Site during any previous spring survey.

OBJECTIVE FIVE: REARING OF ALL LIFE STAGES OF *CICINDELA ARENICOLA* IN THE LABORATORY

Introduction

Laboratory colonization and rearing of an insect provides important insights into the biology of that species. Significant relationships relating to tiger beetle larvae have been discovered recently, through such studies (Pearson and Knisley, 1985 and Knisley, 1987). The laboratory rearing of Cicindela arenicola Rumpp was undertaken during the spring of 1994. No previous attempt has been made to rear this species from adult to adult under laboratory conditions.

Materials and Methods

Two pairs of adult Cicindela arenicola were collected from Site C at Bruneau Dunes State Park during March of 1994. The first pair was collected March 2, and the second pair was collected March 26. The males and females of both pairs were housed in separate containers in the laboratory and provided with a diversity of prey items: mealworm larvae, pomace flies and anthomyiid flies. Each jar contained screened sand to a depth of seven to eight inches. A mesh cloth cover kept the beetles from flying out. Periodically enough water was added to keep the lower five to six inches of sand damp. The surface of the sand was allowed to dry out between waterings. The adults were not individually marked, because marking procedures were thought to be too risky: they could adversely alter the behavior of the beetles, resulting in the failure of the rearing experiment.

During the first week of April each pair of beetles was placed together in a gallon jar. After mating was observed the beetles were separated. Regular feeding and watering was continued while a special observation chamber was constructed. This plexiglass observation chamber (POC) was built to facilitate viewing of female beetle behavior. The POC was built similar to an "ant farm" with a 1 cm wide chamber sandwiched between plexiglass sides 30 cm across x 32 cm down. This chamber was filled with damp sand to a depth of 30 cm leaving a 2 cm space at the top in which the beetle could move about. A loose-fitting plexiglass lid prevented escape. Watering was done from above or from below through a side tube that opened into the bottom sand.

A mated female was put into the POC on April 18. This female appeared to be quite disturbed by the confining quarters of the POC. It ran to and fro in a quite rapid manner, but did eat and dig in the sand. Digging was done mostly at each end rather than in the middle area. Examination of the jar from which this female was taken disclosed the presence of a egg. The female beetle had laid the egg against the glass at a depth of about two and a half inches during the period of April 7 to April 18. This egg was noticeably smaller by April 25 and covered with mold by April 26 at which time it was no longer viable.

On April 19 two eggs were seen against the wall of the POC at one end. Excavation of this area revealed the presence of four eggs all about a half inch below the surface. Three of the eggs were preserved and one was left in place. The egg that was not removed retained a healthy appearance until June 3 when it began to discolor. It gradually deteriorated over the next several weeks. No further work was done with the POC since it appeared to significantly alter the behavior of beetles placed within it. The two females generally oviposited at depths greater than two inches when maintained in less confining quarters.

One of the two males died during the week of April 13 to 20, probably because the sand had been allowed to become too dry. On April 20 the remaining male and the second female were placed in a large terrarium in which the sand varied in depth from two to four inches. This presented an uneven and therefore more natural surface over which the beetles could move. Abundant food was provided: mealworm larvae, pomace flies, and anthomyiid flies. A screen cover prevented escape. The sand was sprinkled about every second day but allowed to remain dry for at least one day between waterings. Watering was sufficient to keep the lower portion of the sand in a damp, but not wet, condition. The pair was observed in amplexus on April 21. The male was removed from this terrarium on May 6 and placed in the gallon jar with the first female. This male and female were separated after one week, but the female did not lay additional eggs.

First instar larvae were fed two food items: larvae of the red flour beetle, Tribolium castaneum, and adults of a pomace fly, Drosophila virilis. Many approaches for feeding these prey to the tiger beetle larvae were tried. As a result of these trials the following method was derived. Early first instar tiger beetle larvae that had just opened their burrows were fed head-crushed intermediate-size flour beetle larvae. Two to three days later the tiger beetle larvae were given head-crushed large-size flour beetle larvae. The flour beetle larvae were inserted into the burrow openings head first. The food items generally lodged in the upper part of the burrow or dropped down out of sight. On occasion the tiger beetle larvae would actively grab the food item and pull it quickly down the burrow. On other occasions the tiger beetle larvae would reject the food item, tossing it out of the burrow opening. These food items were often accepted when presented again.

Larger first instar tiger beetle larvae were fed adult pomace flies. The head and thorax of the flies were crushed using jewelers forceps. This inactivated the flies so that they could be easily manipulated. The flies were inserted head first into the burrow opening to a depth such that the tip of the fly's abdomen was at or just below the entrance level of the burrow. The tiger beetle larvae generally took the flies within 15 minutes. On occasion the tiger beetle larvae would grab the fly while it was being placed in the burrow and pull it quickly down the burrow. On other occasions the tiger beetle larvae would push the food items up to the burrow entrance and eject them in the same manner used to throw out sand balls during digging activities. Reinsertion of the food item often brought acceptance and feeding by the tiger beetle larvae.

Second and third instar tiger beetle larvae were fed in the same manner, but the food items used were generally larger. Second instar larvae were fed adults of Drosophila virilis, adult Musca domestica, or field-collected adult flies. Third instar larvae were fed larger flies and some head-crushed mealworm larvae. The field-collected flies used as food items were mainly anthomyiids, dolichopodids, muscids, and sarcophagids.

Results

The first female is known to have produced at least seven eggs of which three were preserved. Two failed to develop and larvae hatched from two. One of these was preserved as a first instar larva and the other was preserved in the prepupal stage. The second female produced 13 larvae which opened burrows in the terrarium. Five of these larvae died during rearing. One second instar larva was fixed when it was observed to have an abdominal discoloration. The other seven larvae reached the pupal or the adult stage.

One male beetle died within two months of collection. A second male and one female beetle died during their fourth month of captivity. The second female lived through the summer and winter and was last seen alive above ground on April 2, 1995. This beetle had been collected on March 26, 1994. Although it lived into a second reproductive season and did mate with newly collected males it laid no eggs in the second spring of captivity.

There were fifteen larvae that clearly established burrows. Six of these died during the study. Four (2 larvae, 1 prepupa, 1 pupa) were fixed for later descriptive use. Five larvae survived to the adult stage. The first adult emerged on May 18, 1995, and the last emerged October 14, 1995. Representatives of all life stages (eggs; first, second, and third instar larvae; pupae; and adults) were preserved. The average length and width of the three eggs was 2.73 mm by 1.4 mm. The specimens reared and preserved in this study and field-collected stages will be used later for description of the life stages of this beetle.

Twelve first instar larvae were reared to the second instar stage. The length of time that the first instar larvae maintained an active open burrow varied from 7 to 15 days (x = 13). These larvae had a closed burrow for 6 to 14 days (x = 9.75) during which they molted to the second instar larval stage.

Nine second instar larvae were reared to the third instar. The length of time that the second instar larvae maintained an active open burrow varied from 9 to 16 days (x = 12.1). The length of the closed burrow period during which transformation to the third instar occurred also varied from 9 to 16 days (x = 12.2).

All nine third instar larvae closed their burrows by early August. The third instar larvae showed greater variation in the duration of this stage when compared to the duration of the first and second instars. However, precise duration times could not be determined since transformation to the pupal stage occurred beneath the surface and out of view.

The third instar larvae also showed greater variation in the opening and closing of their burrows during the first season of activity when compared to the opening and closing activities of the first and second instars. One larva opened and closed its burrow four times in 26 days, but another never closed its burrow for 23 days. Successful prey capture often led to a brief closure of the burrow during which the tiger beetle larva probably finished feeding on the captured prey item. Prior to burrow closure by all larvae in early August, the nine third instar larvae closed their burrows one to four times (x = 1.1). The burrows of these nine larvae were open for 11 to 24 days (x = 17.4). The number of days they were closed ranged from zero to 20 days (x = 3.5). In general there is a much longer time requirement for the third instar larva, during which it acquires the necessary energy reserves to support the process of pupation. All third instar larvae that reached adulthood reopened their burrows and fed again in the fall and spring of the year following the spring of their emergence.

Discussion

Bauer (1991) reported that Cicindela arenicola requires two years to complete a life cycle. Our laboratory results support this finding. Larvae that hatch in the spring feed and molt to the second instar within three weeks. If prey are abundant the second instar needs a minimum of about three weeks to get to the third instar. The duration of the third instar is much longer, requiring about one year. Also, the third instar shows much more variation in the opening and closing of the burrow entrance. If adequate food is available third instar larvae reach the pupal stage by the summer of the year following hatching. Adult beetles would normally emerge about 18 months after larval hatching. It is yet to be determined if low prey availability would require an extension of the time to complete the life cycle to three or more years.

Summary

All stages for the life cycle of C. arenicola, with the exception of the adult female, were reared in the laboratory from adult beetles collected at Bruneau Dunes State Park in the spring of 1994. Representatives of these stages were preserved for use in the description of the life stages of this beetle. Laboratory data obtained in this study supports a two-year life cycle for this species.

The Life Cycle for *Cicindela arenicola* at Bruneau Dunes State Park

The general life cycle presented here for the Bruneau Dunes tiger beetle (Cicindela arenicola Rumpp) is based on three seasons of field observations and two years of work in the laboratory during which all stages of the beetle were reared from field-collected adults.

Egg Stage:

The egg of this species is larger than the egg of other species of Cicindela. The average length and width of three eggs was 2.73 by 1.4 mm. The egg of C. japonicum measures 2.2 by 1.5 mm (Hori 1982). The maximum length recorded by Willis for eight species of Cicindela was 2.21 mm (Willis 1967). The eggs of the Bruneau Dunes Tiger Beetle are about 24% longer and would accordingly contain about 20% more food reserves to sustain the early development of this species. The eggs of this species are even longer than those of the larger, more robust tiger beetles of the genus Omus , 2.4 by 1.6 mm, (Leffler 1979). Oviposition usually occurs from March to June, and probably peaks in late April.

First Instar Larva:

Hatching of this stage probably starts in April and peaks in May with some hatching as late as June. We were able to time embryogenesis of only one egg in the laboratory. The first instar larva hatched from this egg on day seventeen and burrowed to the surface four days later. Newly opened first instar burrows (2 mm diameter) are seen in May and June after a precipitation event wets the sand down to at least a depth approaching one inch.

In the laboratory it was observed that first instar larvae delayed the construction of burrows and the opening of these burrows until the surface sand was wet. It is assumed that the first instar larva cannot effectively construct a vertical burrow in dry sand. Dry sand would tend to cave in about the larva as it attempted to construct a burrow to the surface. Larvae attempting burrow construction in dry sand would probably deplete their energy reserves and die in the attempt. The first instar larva digs readily in damp sand. The collar of the borrow opening is apparently cemented with salivary secretions since the sand grains are tightly bound together at the surface of the burrow. In larger burrows this collar of "cemented" sand extends to a depth of about 10 mm. The "cementing" of the sand at the burrow entrance helps to maintain the integrity of the burrow opening even during times when the surrounding sand is very dry.

Field observations support the laboratory finding that first instar larvae do not burrow to the surface immediately after hatching. The apparently await warm, damp conditions conducive to effective burrow construction. In 1995 there was an extended dry period from late April to late May. In 1993 and 1994 numerous new first instar burrows were seen in the first week of May. In 1995 no new burrows were seen until after our field trip of May 25. There was at least one significant precipitation event in the week preceding the June 3 field trip at which time new first instar burrows were seen in most areas of preferred habitat. The greatest density of new burrows was a group of 69 seen in one small pavement area (5 x 7 m) near an open dune.

It is not known how long newly hatched first instar larvae can wait for conditions proper for burrow establishment before they deplete their energy reserves. It is assumed that the very large eggs of this species have evolved to provided nutrients sufficient to get the first instar larvae through this period of burrow establishment and first prey capture.

Feeding probably occurs whenever prey items of proper size are available. Many first instar larvae probably die from starvation before catching prey. Those that capture sufficient prey may molt to the second instar during the spring of their emergence, but it is more likely that they pass the summer underground in an inactive state and molt to the second instar stage during early fall when they are again active.

Second Instar Larva:

This stage can occur in the spring of hatching, but more often is first seen in the fall or spring following hatching. The second instar is often the one that opens the burrow in February or March of the year following hatching. It is the most common larval stage seen during February and March, although some first and third instar larvae are also found during this period. If food is abundant at this time, the second instar larva feeds and molts to the third instar larva during March and April in the spring of the second year.

Third Instar Larva:

This stage is quite common in April and May of the second year. When sufficient food has been obtained this stage closes the burrow preparatory to pupating. Such closings can occur throughout the spring period but are more commonly seen in late May and June. If food is scarce this stage may enter a summer diapause or quiescence and become active again next fall. Such individuals would emerge in year three of their life cycle rather than in year two. It is probably these forms that appear as the newly emerging adults, augmenting population numbers during late spring.

Pupal Stage:

The pupal stage normally occurs during the summer of the second year. Initial laboratory observations indicate that the prepupal stage is quite variable in length. Pupation could occur in the field any time during the period of May to September. There is even the possibility, as is known for other insects, that the prepupal stage could diapause for a full year or more before transforming to an adult.

Adults:

Adults are found actively roaming the dunes during warm fall days. No mating activity has been observed during this time. These adults apparently burrow into the damp sand near the base of the dune or in swales between dunes at the end of each day's activity period. It is likely that some are buried to a greater depth by wind-blown sand that accumulates above them during the November to February period. The winter winds tend to blow the dry sand off the small dunes and into the swales and depressions. This results in the flattening out of many smaller dunes during the winter. During warming periods from January to March the over wintering adults burrow to near the surface. With any major warming period with air temperatures above 60 degrees Fahrenheit the adults emerge and commence to feed preparatory to mating.

Adults have been observed as early as the third week of February actively foraging on the dune surface, and it is possible that they are active in mild winters as early as the last week of January. Mating probably occurs during March in years with a more typical temperature and precipitation pattern. Adults are more commonly seen on open dunes in the early spring, but tend to be more concentrated along the edge of the open dune system nearest the larval habitat at this time of year.

Unmated adult males and adult females were collected in the fall of 1994 and maintained in the laboratory under conditions approximating those of the field. In the spring of 1995, the one surviving male beetle was mated with the three surviving female beetles. A general description of the behavior associated with pairing is given here. Both sexes ran from each other at the first encounter. Shortly, both the male and the female commenced to make short runs during which they dragged the tip of the abdomen in the sand. These "tail drags" produced a pronounced, but shallow furrow about one inch long. Shortly thereafter when the male and female met each other amplexus and mating occurred in rapid order. It is assumed that beetles in the field use this tail drag line to lay down pheromones for the purpose of attracting mates and/or coordinating mating behavior.

It is noted here that none of the three female beetles that mated in the laboratory in the spring of 1995 are known to have laid any eggs even though they ate prey and burrowed in a manner like the female beetles had done the previous year when they were laying eggs. These three females died during mid to late summer. Since they died underground a time of death could not be determined.

After mating, males remain on the open dunes where they continue to forage and await the arrival of other females. Females, by contrast, move from the open dunes after feeding to areas that support larval development. Here, they commence to lay eggs. Laboratory observations indicate that females burrow underground to a depth greater then one inch to lay eggs. Oviposition probably starts in late March and continues until the very hot, dry weather in late May or June.

This is the first recorded instance where female tiger beetles burrow completely underground in order to oviposit. Pearson's review article of 1988 indicates that the female uses the ovipositor and abdominal thrusting to excavate a hole to a depth of up to 1 cm. After laying an egg the female removes her ovipositor "and fills in and covers the hole". In the laboratory females were observed to burrow on a 45 degree incline to a depth of about two inches below the surface. The female backfilled the tunnel during her burrowing. This better protected her from surface threats. The female used the ovipositor to prepare a small cavity and appeared to affix the egg to one side of this cavity. After oviposition the female returned to the surface along the same path used when digging down.

On the basis of our lab work females are thought to lay from one to four eggs in the area around the bottom of the burrow they dig in order to oviposit. It is common to find two newly opened first instar burrows very close to one another in the field. This supports two eggs being the normal number laid for each oviposition burrow that is dug. Intuitively this is probably the most energetically efficient approach. It would be a waste of energy to lay only one egg after digging to such a depth. However, in order to lay more than two eggs the female would need much greater nutritive stores. To acquire these reserves she would have to forage much longer on the surface at a time when predatory lizards are quite active. If a lizard ate her during this extended foraging period all her efforts would be negated. By returning underground to lay two eggs she enhances the likelihood of a genetic return on her energetic investment to that point in time.

In the laboratory some females remained underground for upwards of two days, emerging to feed and return underground in as little as 15 minutes on one occasion. The females are certainly much less vulnerable to predation when they are underground. Predation is believed to have provided the selection pressure that produced the distinctive oviposition behavior evidenced by this species.

The intense heat and dry conditions during June and July are probably major factors causing adult mortality. Adults of C. arenicola normally are not seen during July, August, and September. After fall rains, adults emerge on warm days and forage on the open dunes until the arrival of persistent cold winter conditions. At this time they are not more concentrated on the dunes nearest the areas of larval habitat but are distributed more widely over the open dune area. As indicated earlier, with the close of the activity period of each day, the fall adults burrow into the sand at the base of the dunes or in the damp sand at the bottom of the swales between dunes. Here they await the arrival of warming conditions which can begin as early as late January of the next year.

Management Recommendations

The management recommendations given here follow the approach begun in the 1993 report. The three groupings of populations and subpopulations addressed in the 1993 report are again described here but in an updated manner.

Management Recommendations for Group One

Group one is a collection of generally smaller and rather scattered subpopulations and one large subpopulation found within Bruneau Dunes State Park. These subpopulations occur in a general arc to the east, south and west of the main dunes complex at the lower elevation of the park. Populations A and B in the reports written by Dr. Robert Anderson are included in this group. This area is situated nearer to the main recreation area than is the Group two area. Accordingly, there is a greater chance that park visitor activity can adversely impact beetles of this group.

Current park policies appear to adequately protect these subpopulations. This is especially so for the adult beetles. The adults are very wary, flying away at the approach of any larger animal. Few park visitors probably ever see them. Male beetles, more so than the female beetles, are likely to frequent the same dunes that visitors use for recreation. The female beetles are more often out in the small, established flats in the ecotone areas, and they would be underground laying eggs much of the time. It is doubtful that current visitor rates adversely impact the activities of the adult beetles.

The first instars could be killed by visitors walking on them during the first two or three weeks after they first open their burrows. Burrows of the first instar usually open between May 1 and June 15 following a precipitation event. Visitor use of the park normally drops greatly during the hotter days of May. Most of the areas of larval habitat are on the far side of the big dunes from the visitor parking lots. Few visitors probably access these areas during this critical period. Visitors walking the trails through these areas would probably not be a serious problem providing they stay on the trails during these six weeks.

It is recommended that activities involving surface disturbance such as hiking not be permitted in these areas other than on established trails during the period from May 1 to June 15. Camping by groups such as the Boy Scouts of America should not be permitted during this six week period. Livestock and motorized vehicles should not have access to this area of the park since the impact of each would be potentially more harmful than that of park visitors.

A general walking survey should be done every second or third year to verify the continued presence of both adults and larvae in the areas mapped out in this report. Annual surveys should be done if there is a perceived decrease in size of the areas where this beetle is found to occur.

Management Recommendations for Group Two

Group two is comprised of two large subpopulations which are located above the park rim on the higher elevation ground in the southwest corner of Bruneau Dunes State Park. The rather large Site C subpopulation is part of this group. A second subpopulation is located on the higher elevation ground that borders the sandy edge of the rim about a half mile east of Site C.

The area where the subpopulations of Group two occur is well removed from where most park visitor activity occurs. A new fence constructed along the western edge of this area in November of 1993 gives better overall protection to this low-dune ecosystem complex. The fence has accordingly provided better protection for the Cicindela arenicola of this area of the park. Fencing of this area appears to have been warranted in view of the occasional wheel tracks of motorized vehicles that are still seen here in the areas of beetle larval habitat.

Continued monitoring of the number of larval burrows of C. arenicola will be done for Site C so as to estimate total population trends. The quadrat grid system set up in 1993 will be used for this. We plan to continue this larval burrow inventory project through the 1997 season so as to have five successive years of data for projecting the population trend. Cursory surveys for adults on the open dunes will also be done each year.

It is recommended that current management practices for this area be continued. The impact of humans and domestic animals appears to have been minimal during 1994 and 1995. It is estimated that less than 3% of the habitat showed evidence of such impact at the time our field project work was done in the group two area during 1994 and 1995.

Continued monitoring of the area cleared of weeds in 1994 will be done even though it is quite unlikely that female beetles will commence to use this area for egg laying. Since the start of this study in 1993 female beetles have begun to use some areas previously not used for egg laying. These areas are generally just above the "vegetation line" that borders the dunes. These small pockets of more stabilized soil are thought to have been recently exposed by wind action removing the overlaying drift sand. Such new areas are thought to offset the loss of older areas that are colonized by plants, both introduced weedy species and native opportunists.

Management Recommendations for Group Three

Group three includes all of the population of Cicindela arenicola at the Windmill Site. This population was first discovered in 1993. Because of its limited size and very isolated nature it is thought to be more vulnerable to human disturbance than is the collection of subpopulations at and around Bruneau Dunes State Park.

Annual site visitations should be continued in both the spring and fall to check on the general condition of the dunes and of the bordering areas of larval habitat. A small amount of disturbance due to human activities was noted in 1993, 1994, and 1995. It is quite likely that if this annual disturbance exceeds 5% of the of the habitat used for reproduction by the beetle then the population of the beetle could go into a decline. The percentage selected here is based on the knowledge that the larvae of this beetle tend to be clustered in their distribution. An overall disturbance rate of 5% could, if selectively done, negatively affect all of the larval habitat. We have carefully monitored larval burrow occurrence at Site C in the Bruneau Dunes State Park and have found that the larval burrows occur on only about 3% of the general dune area.

As previously noted (Baker, et al. 1994) the Windmill Site is so small and so isolated that it has considerable biological significance. It is again recommended that this site not be used for ecological studies of this beetle. Human activities associated with such studies could exceed the recovery capabilities of this site. Should such studies be deemed necessary it is incumbent on all participants that they exercise great care in minimizing their impact on the limited viable larval habitat at this location.

Table One

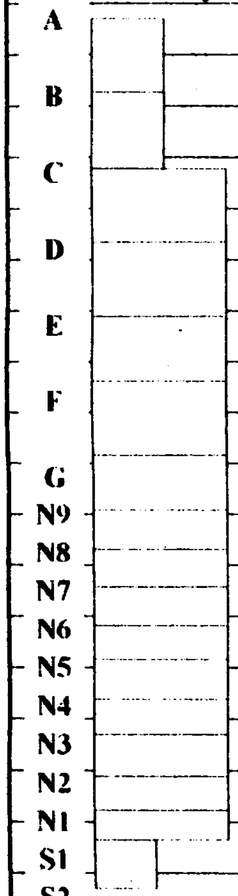
Year	Burrow Density	Range for 95% CI	Variance to Mean Ratio
1993	$0.019/m^2$	0.00983 to $0.29/m^2$	0.982
1994	$0.0279/m^2$	0.0146 to $0.0412/m^2$	1.32
1995	$0.0303/m^2$	0.0194 to $0.0412/m^2$	1.65

Table Two

Year	Total Population at Site C (84,250 sq. meters)	95% CI
1993	1634	828 to 2439
1994	2349	1228 to 3469
1995	2553	1634 to 3472

Figure 1 - Summary of Larval Burrow Data by Transect and Quadrat

Transect Map



Transect	1993 # of burrows	1993 location (M)	1994 # of burrows	1994 location (M)	1995 # of burrows	1995 location (M)	1996 # of burrows	1996 location (M)	1997 # of burrows	1997 location (M)	Total # of burrows/ transect
A	0		0		0						0
B	1	18	1	4	0						2
C	0		0		0						0
D	0		0		0						0
E	0		1	3	1	2					2
F	0		2	8. 8	2	47, 47					4
G	0		2	35, 37	0						2
N9	1	21	3	28, 32. 32	1	21					5
N8	0		0		1	8					1
N7	1	37	0		0						1
N6	2	66, 80	1	39	0						3
N5	1	61	0		1	63					2
N4	2	12, 26	5	0. 10. 24, 24. 80	6	0, 0, 22, 24. 28, 42					13
N3	0		0		0						0
N2	4	78, 80, 96, 98	2	75, 87	7	14, 10. 74. 76. 76. 76. 76					13
N1	1	9	4	1. 9, 63, 65	5	5. 63, 63, 63, 69					10
S1	2	4, 10	0		0						2
S2	1	35	2	25, 37	1	35					4
Totals	16		23		25						64

Figure 2 - ***Burrow Locations : 1993 - 1995***

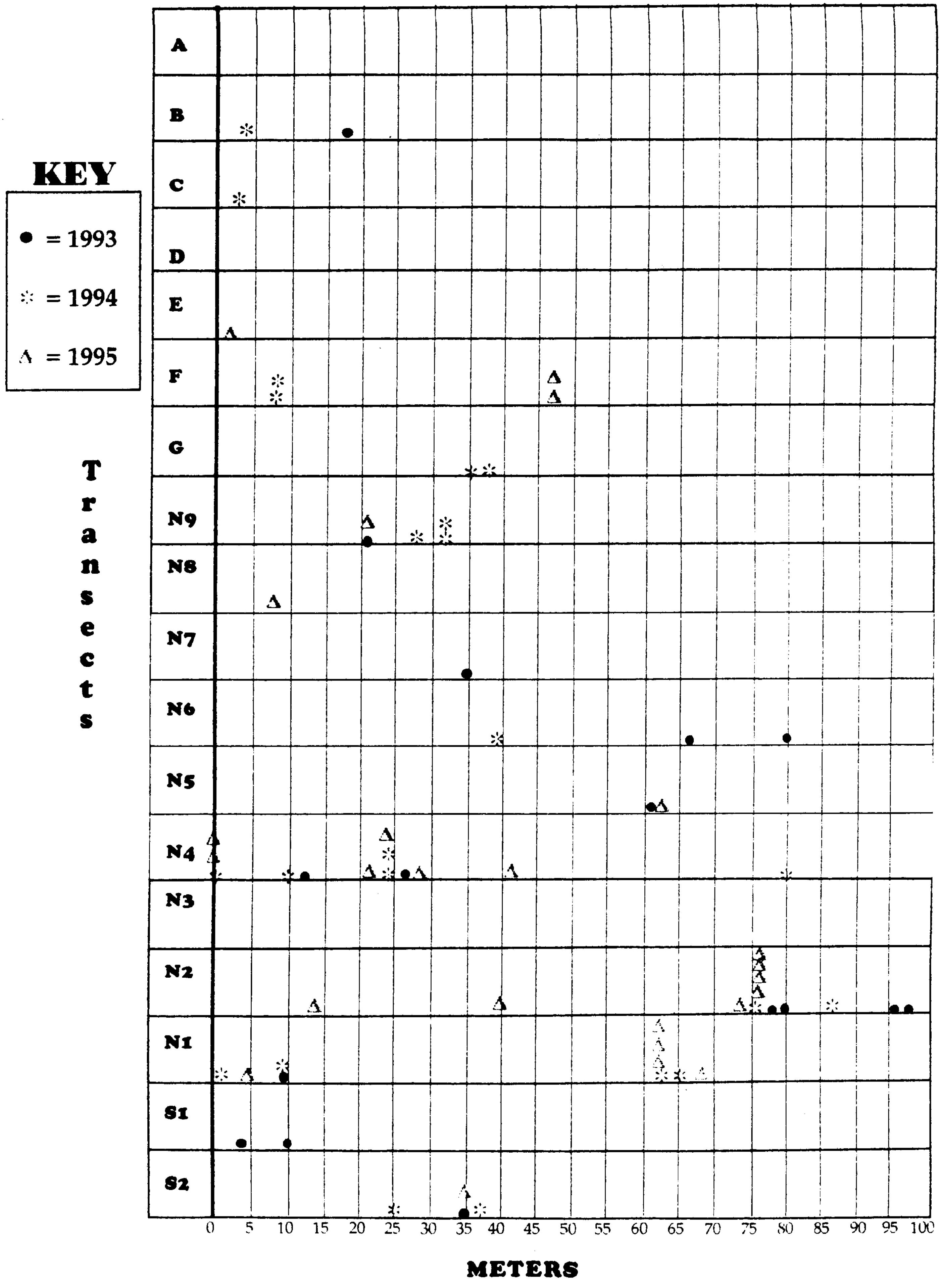
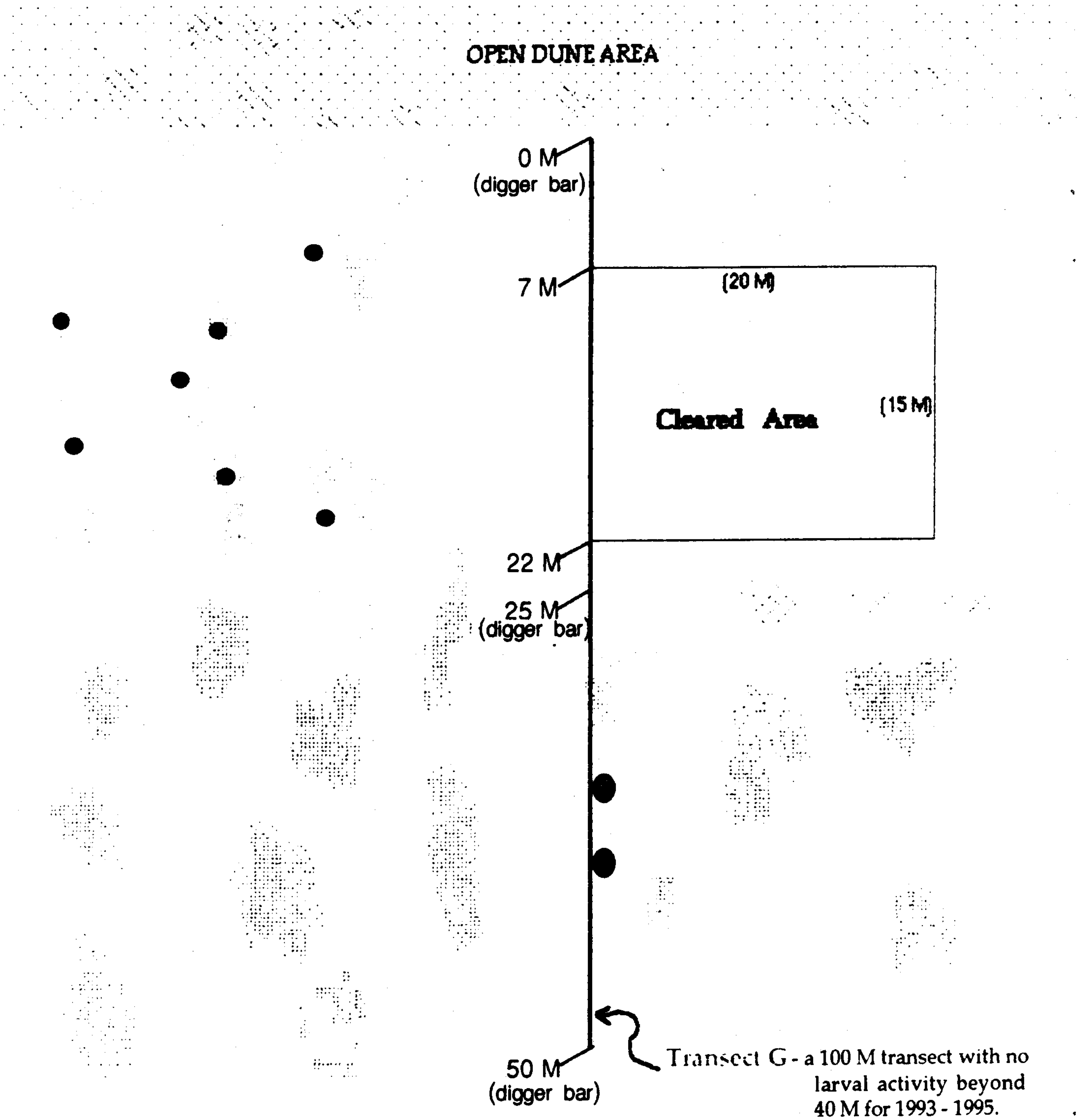


Figure 3 - Weed Clearing Project



KEY:

= Russian thistles & other weeds. These often form a barrier line beween open dune area & larval habitat in dune-desert ecotone.

= Area where 4.0 mm burrows were seen in 1994 & 1995.

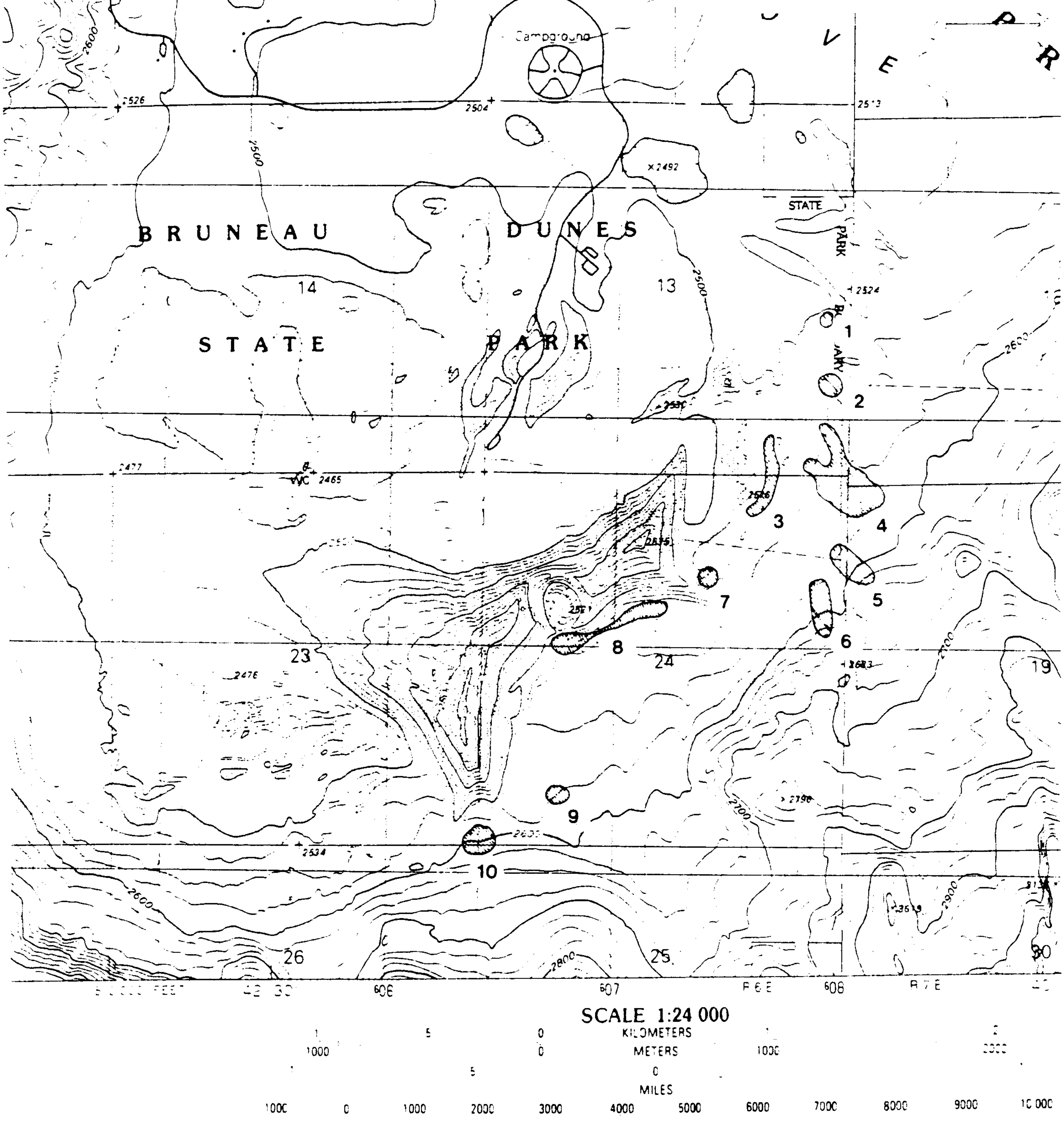
= Locations where 2.0 mm burrows were seen in 1995. All were at least 14M south of the line of Transect G, opposite the cleared area.

= Scattered grassy hummocks & sandy knolls.

= Area not surveyed for 2.0 mm burrows in 1995.

Bruneau Dunes State Park

Bruneau Dunes Quadrangle

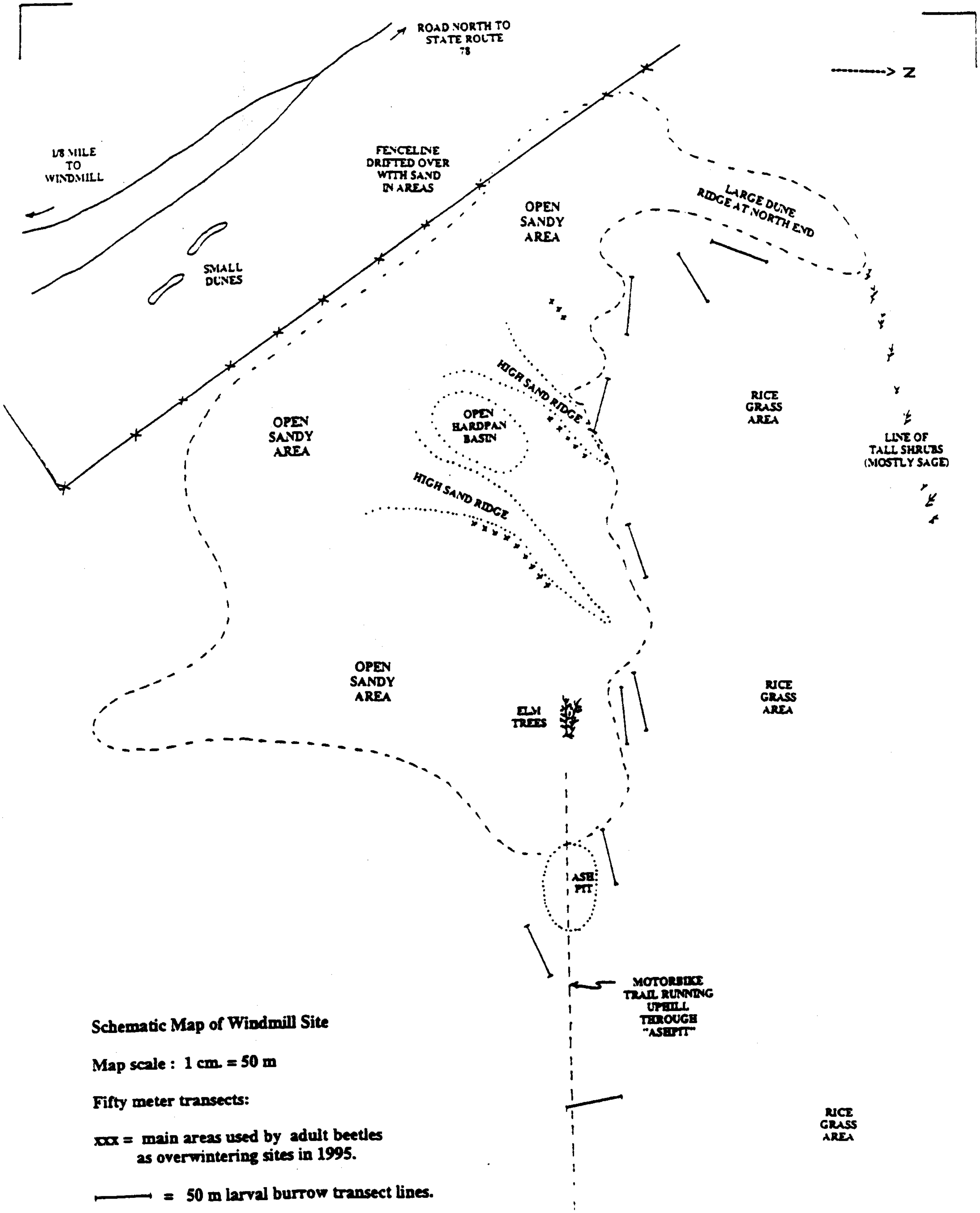


CONTOUR INTERVAL 25 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
TO CONVERT FEET TO METERS MULTIPLY BY 0.3048
TO CONVERT METERS TO FEET MULTIPLY BY 3.2808

Distribution of Larval Habitat in Southeast Corner of Bruneau Dunes State Park - 1993 and 1994

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY

Map 2 - Windmill Site



Summary of Units of Accomplishment

1. Larval burrow population counts for Cicindela arenicola were done in 1994 and 1995 using the same transect/quadrat grid system used for this purpose in 1993 field season.
2. The field data from 1993 for the larval burrow counts was reevaluated so comparisons between all three years could be made.
3. Analysis of the data for three years (1993, 1994, 1995) showed a progressive increase in burrow density with a trend for clumping of burrows in areas which previously supported burrows.
4. A weed overgrown area next to habitat that supported larval burrows was cleared of weeds and monitored for two years. Cicindela arenicola was not observed to use this area in these two years. A map of this project is included in this report.
5. The southeast area of Bruneau Dunes State Park was more extensively surveyed for areas that support larval burrows of Cicindela arenicola. A map of our findings is included in this report.
6. The Windmill Site was surveyed for larval burrows and for adult beetles in both 1994 and 1995. The number of adults and larvae at this site increased progressively from 1993 through 1995. A updated map of the Windmill Site is included in this report.
7. Two mating pairs of Cicindela arenicola were captured at Site C and removed to the laboratory in the spring of 1994 so as to rear the life stages under laboratory conditions. Five adults were reared from eggs under laboratory conditions between March of 1994 and October of 1995 (18 months). All life stages except adult females were obtained and representative specimens were preserved for the description of the life cycle: eggs; first, second and third instar larvae; pupae; adult males.

8. Several discoveries unique at this time to Cicindela arenicola were made:

    1. The egg is larger than that reported for any other species of tiger beetle.

    2. The female burrows completely beneath the surface to oviposit.

    3. The male and female apparently use pheromones prior to mating.

9. Management recommendation are given for the areas discussed in this report.

10. Copies of the reports for the Independent Study Projects done by Steve Staufer and Kevin Cornwall (Boise State students) accompany this report.

11. A description of the probable sequence of activities for the life cycle of Cicindela arenicola for the area of Bruneau Dunes State Park is presented.

Acknowledgments

Many people provided valuable assistance on this project during 1994 and 1995. A very special thanks is given to the following:

Ann DeBolt, Boise District Office of the Bureau of Land Management for her help with technical matters.

Jim Klott, Twin Falls District Office of the Bureau of Land Management for his assistance with items pertaining to the Windmill Site.

Paul Makela, USDI Bureau of Land Management, Burley, Idaho for information on the phenology and distribution of Cicindela arenicola in Southcentral Idaho.

Wes Whitworth, Director of Bruneau Dunes State Park, for weather data and for his assistance on field surveys and data collection.

Dr. Robert Anderson, Biology Department, Idaho State University for consulation and for help in locating a very active population of C. arenicola in the American Falls area.

Dr. Gary Shook, Department of Health Sciences, Boise State University for information on the phenology of tiger beetles in southwestern Idaho.

Luana McCauley, Graduate Student, Biology Department, Boise State University, for her field and photographic assistance.

John McDonald, Instrumentation Engineer, Boise State University, for fabrication of additional field equipment.

Tamas Megyaszai, student volunteer for Fall 1994 and Spring 1995, for his extensive help with the collection of field data.

Conrad Colby, Charles Kerr, and Marilyn Olsen for assistance with field surveys .

Mark Gerber, Robert Higdem, Wade Petersen, Jeff Thompson, and Kathy Tuttle for their help in collecting data at Site C.

Kevin Cornwall and Steve Staufer for continuing to assist with data collection in 1995.

Tamsen Profit and Liz Baker for technical help.

Dr. James C. Munger for help with data analysis.

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