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An Effective Method of Measuring Seed Dissemination

Abstract

*Seed dissemination, an important factor in determining the reproductive success of many plant species, is seldom examined because effective measurement techniques have been lacking. A simple method for measuring seed dissemination is described that has low labor and material requirements. The method was developed to evaluate distribution of wind-borne seed of plains silver sagebrush (*Artemisia cana *ssp.* cana*). It was field tested successfully to determine how much, when, and where seed fell with reference to distance and direction traveled from the parent plant. The method should prove suitable for measuring seed dissemination of many other species under a variety of environmental conditions.*

Key words: *Artemisia*, dispersal, dissemination, methodology, propagule, seed.

Introduction

Successful reproduction of a plant species depends upon several interrelated factors. Attributes, such as seed production, germination variables, and early seedling growth, have all been recognized as important and have received considerable research attention. In contrast, seed dispersal, an important factor in establishment and maintenance of a plant population, is seldom studied. Knowledge of seed dissemination may be especially critical in achieving effective control of weeds.

Most research efforts dealing with seed dissemination have been directed toward defining the principle mechanism by which seeds are distributed from parent plants. As a result, seed can generally be categorized as wind (anemochory), water (hydrochory), or animal (zoochory) disseminated according to the primary method of distribution. Daubenmire (1967) considers wind to be the most common and efficient agent of seed dissemination among terrestrial plants. In conjunction with this observation, there have been numerous descriptions of seed adaptations, such as wings, that facilitate wind dispersal.

Quantitative measurements of wind dispersal with respect to seed number and dispersal distance have been very limited. In early work, Isaac (1930) described lateral distribution of seeds in Douglas fir (*Pseudotsuga menziesii*), and Siggins (1933) discussed distribution of conifer seeds with reference to their rate of fall. Mueggler (1956) documented potential distances that seed may be carried by wind, but did not quantify the number of seeds achieving this potential.

Quantitative data on seed dissemination is scarce, largely due to the lack of a suitable measurement technique. Available methods generally require elaborate seed traps and are usually labor intensive. Sindelar (1968), for example, described a method in which seeds were collected from layers

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of cheesecloth placed in the bottom of pie pans. Although accurate counts can be achieved by this method, development of a simple, inexpensive technique would facilitate routine measurement of seed dispersal.

The purpose of our research was to devise an effective method of collecting wind-borne seed under field conditions. To accomplish this successfully, it was desirable to determine time, direction, distance and quantity of seed disseminated from parent plants.

Materials and Methods

The method we devised was used to measure seed dissemination in plains silver sagebrush (*Artemisia cana* ssp. *cana*) (Wambolt *et al.* 1989). Silver sagebrush is a widely distributed shrub that occupies an estimated 13 million ha in the western US (Beetle 1960). The plant is 1 m or less in height, although larger plants are not uncommon. Seed production is abundant and dispersal normally takes place by wind after seeds ripen in October or November. Each plant has been estimated to produce as many as 54,000 seeds per year, which average 2.14 mm in length, .90 mm in width, and 681 μg in weight (Harvey 1981). Therefore, these seed dimensions and weight are comparable to those of many other small-seeded species (Reed 1977).

Our seed collection technique was relatively straight-forward. The procedure involved: (1) selecting parent plants on which to make measurements, (2) placing collection equipment in the desired spatial configuration, and (3) removing and counting disseminated seed. Because each aspect of this procedure might require some changes for other species or the individual objectives being considered, we have not attempted to present a detailed description of the many variations that might be applied to the technique. Instead, a method is described that was successful for plains silver sagebrush.

Seasonal seed dissemination patterns were measured on 15 reproductively mature silver sagebrush plants, five each from three separate study sites in southeastern Montana. Variation among study sites is discussed in Wambolt *et al.* (1989), but all sites averaged 340mm of annual precipitation with a peak received in May and June. The first three weeks of November, when silver sagebrush seeds are disseminated, are typically dry. Individual plants were selected to typify the average adult size for this species in each community. Shrub heights ranged from 1.0 m to 1.5 m, and crown canopy cover varied from 1.0 to 4.0 m^2. During the selection process, care was taken to choose plants with sufficient area around them to accommodate at least six unobstructed line transects. This facilitated placement of collection equipment. Floral parts from nearby plants within a 10m radius were then cut off to eliminate cross contamination during the sampling period.

Seed collection devices consisted of thin (0.5 mm) aluminum sheet-metal plates (36 by 36 cm) that were coated with petroleum jelly as an adhesive. A 30.5 x 30.5 cm sampling grid with smaller 7.6 x 7.6 cm individual subsections was hand scribed on the sheet metal surface with an awl. The subsections simplified field counting of seeds. Two holes were drilled in opposite corners of the sheet metal plate, and 13 cm long nails were used to secure the plates to the ground. This insured that plates would not be blown away or otherwise moved, thereby allowing repeated measurements from the same locations.

Five aluminum plates were placed at 1 m intervals (0,1, 2, 3, and 4 m) from center to center along each of six equally-spaced line transects radiating from individual plants (Fig. 1). This sampling pattern resulted in a series of concentric circles around each plant and provided a spatial arrangement for

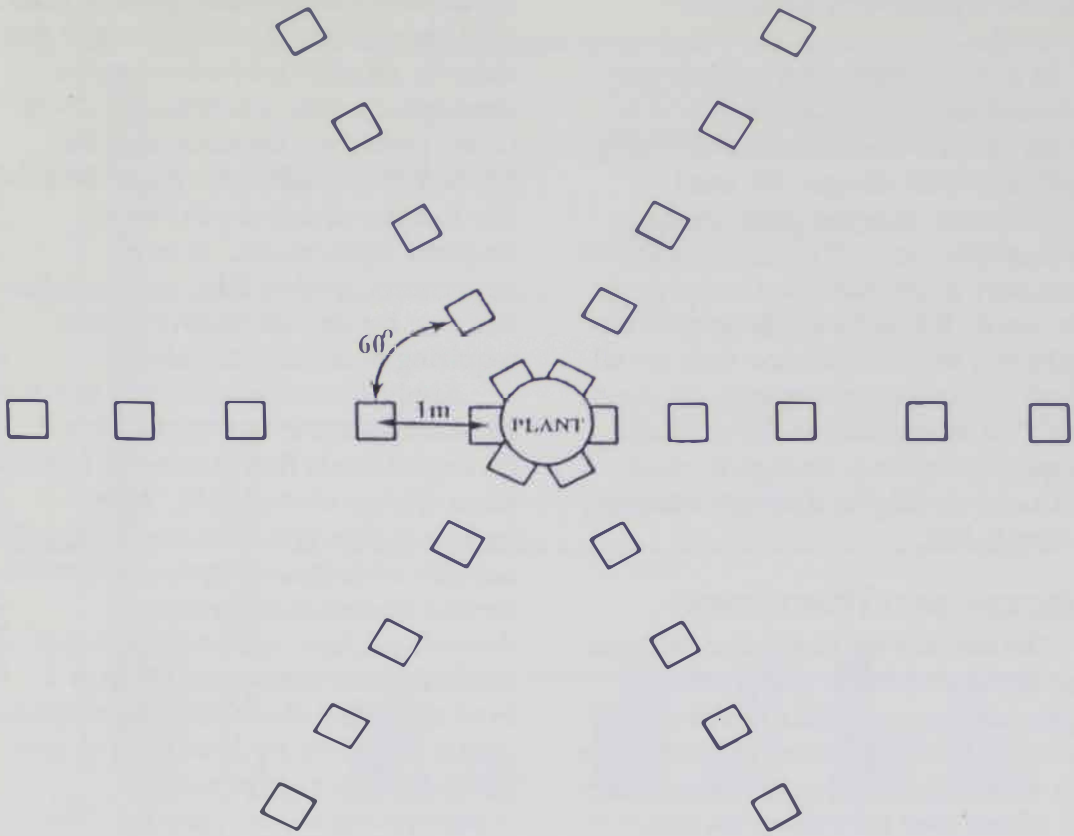

Figure 1. *Aerial view showing the spatial configuration of aluminum sheet metal plates used to catch seed from individual plants of plains silver sagebrush.*

evaluating direction and distance of seed dispersal. Seeds were collected and counted every 3 to 4 days throughout the seed dissemination period in November. After seeds had been removed, new adhesive was applied as needed to monitor seed fall during the subsequent sampling period.

Seeds that fell on the aluminum sheets were handled in one of two ways. If they were low in number and could be quickly counted, they were tallied in the field and removed by hand from the sampling grid. However, if seeds were numerous they were collected from individual aluminum sheets and saved for later enumeration. This situation was most commonly encountered immediately adjacent to parent plants where both filled and unfilled seed were present along with floral bracts. The collection procedure was rapid and simple. A paint scraper was employed to gather the petroleum jelly and seed mixture that was present on the sampling grid. This solidified mixture from each sheet was then placed in individual shallow-sided, disposable aluminum pans (22 x 15 x 3 cm) for later separation in the laboratory.

Seeds were separated by placing the solidified mixture on four layers of cheesecloth that had been stapled across the sides of the same aluminum pan. Pans were then placed in a 100 C oven until the petroleum jelly melted. After the petroleum jelly melted, it was drawn laterally along the surface of the cheesecloth. During this process, seed was spread across the cheesecloth and left behind after the liquid petroleum jelly ran into the pan below. Seeds could then be readily counted and evaluated with respect to filled or unfilled characteristics. Other debris that was originally present in the sample was also separated by using this approach.

In our experience, an appropriate statistical analysis of data collected by this technique was accomplished using a split-split plot design. We used transects and distances from mother plant as split plots. If measurements are taken over more than one time period, date would be used as a covariant. We conducted mean separation tests for all factors and combinations with Student's t test. We determined that our design sampled intensively enough for each parameter through a standard adequacy of sample test.

Results and Discussion

The method we devised to evaluate seed dissemination in plains silver sagebrush was successful under a variety of field conditions. Quantitative data were obtained that estimated when and where seed fell during the dispersal period (Fig.2). However, patterns of seed dissemination were complex. Factors such as phenological status of the plant, wind direction, and wind velocity affected individual dispersal responses and caused considerable variation between sample periods, direction, and distance from plant ($P \leq 0.01$) (Wambolt *et al.* 1989). However, no significance ($P \leq 0.68$) was found among the three sites where the method was tested.

Careful *in situ* observations of actual seed fall showed virtually 100% retention of seeds that fell on the aluminum plates. Other plant materials such as floral bracts and leaves were also caught by the seed traps. This could present problems if litter fall was heavy, and it might necessitate fairly frequent cleaning of the plates. Separation of seed from other debris might also become a problem under these circumstances. If this problem was severe, it might be advantageous to construct a litter screen of hardware cloth or similar material to mount over the adhesive-coated seed plate to filter out larger debris. Problems might also occur in situations where extensive atmospheric dust was present. Under these conditions, the surface of the petroleum jelly adhesive might become less functional and require more frequent replacement. In our application, neither litter accumulation nor dust became disruptive factors requiring remedial attention.

Application of our method to other species appears to be very feasible. Incidental seeds from a number of other plant species were caught. These included: blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), crested wheatgrass (*Agropyron desertorum*), Japanese brome (*Bromus japonicus*), and cheatgrass (*Bromus tectorum*). Seeds from additional species would undoubtedly have been caught had they been present and disseminating seeds in late fall. The presence of incidental seeds that were caught demonstrates the potential application of the technique with respect to a variety of seed sizes, shapes and weights. However, the configuration of aluminum plates might need to be changed to accommodate research requirements in other species (Reed 1977). Factors such as the size or shape of plates, distance from the parent plant, and number of azimuth directions that are measured can be readily modified to fit individual circumstances that might vary with different seeds and environments.

The effectiveness of our technique was enhanced by using aluminum sheet metal for seed traps. Aluminum was selected because it is relatively light and could be easily cut into the desired size and shape for measurement. It was also relatively easy to transport and handle the large number of collection plates needed in the field. Measurements and maintenance on all 450 metal plates (15 plants, 30 plates/plant) required about 4 hours with three people on any given

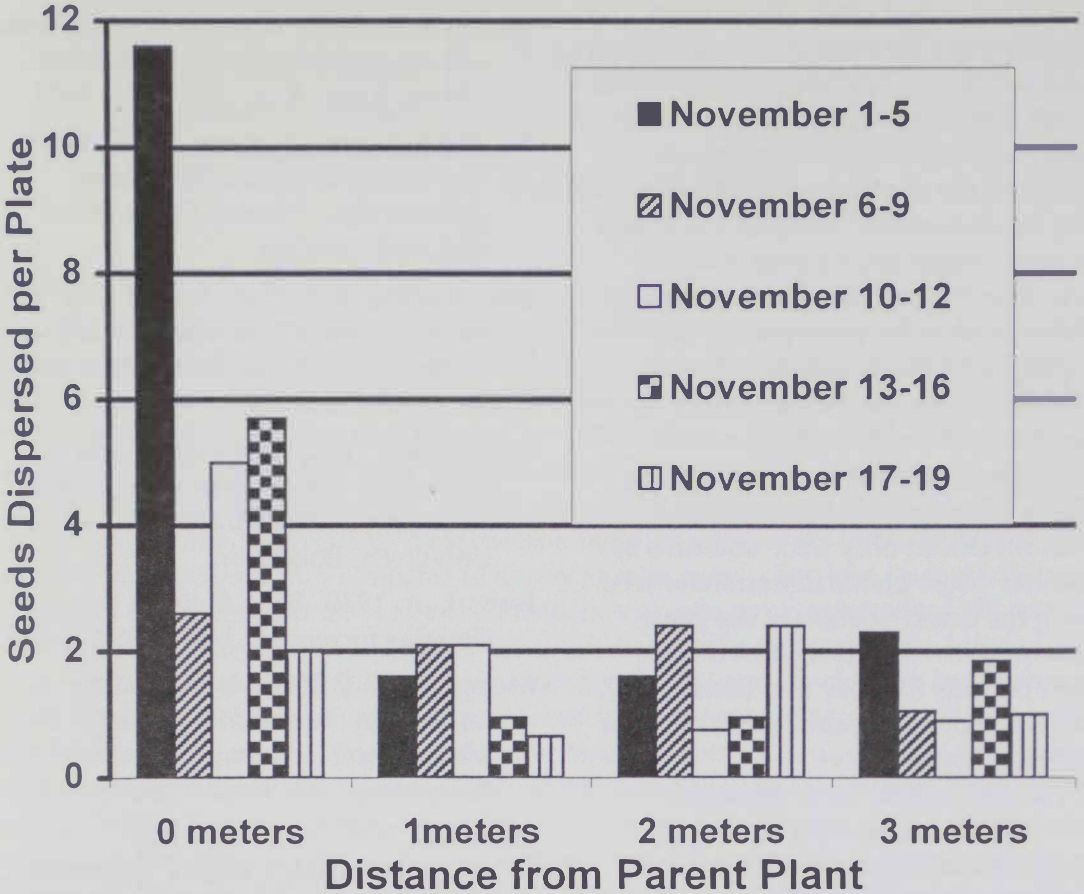

Figure 2. *Seed dispersal patterns measured for plains silver sagebrush in five intervals during the November 1 - 19 dissemination period. These data are means from a total of 15 plants at three sites (five plants per site). The seed counts were taken from 930 cm² sampling grids on each plate. Because almost no seeds were counted at the 4 m distance, these numbers are not included.*

sampling date. The method was relatively simple, but it enabled us to sample in a highly intensive manner. In addition, the shiny surface of the aluminum was readily detected, but not bothered by either livestock or wildlife.

Petroleum jelly was very effective in catching and holding seeds and offered several advantages as an adhesive. It is relatively inexpensive, yet it can be recovered and recycled if necessary. It is also easily applied and removed from the surface of the aluminum sheet metal. We placed solidified petroleum jelly in a clean metal can and heated it until it melted in the field over a portable camp stove. The melted petroleum jelly was then applied in a thin layer with a paint brush or roller. The most efficient application technique depended upon ambient temperature. If air temperatures were below 10 C, the roller was most efficient; at higher temperatures, the brush was more effective. Application by hand smearing was too slow and generally resulted in a thicker layer of adhesive than necessary.

Petroleum jelly also had an advantage over many adhesives because it could be used over a wide range of ambient temperatures. We used it successfully in late fall at temperatures that ranged from -18 to 25 C. Colder temperatures would probably present no difficulties. However, higher temperatures combined with direct solar radiation might melt the petroleum jelly on the sheet-metal plate. This could spread it into a very thin layer that would not be sticky enough to catch and hold all seeds. Precipitation caused no problems to seeds that were already adhered to the aluminum sheets, but water beads formed on top of the sheets that then caught and carried away newly fallen seed. An absorbent border of cloth around the perimeter of the sampling grid might alleviate these problems during extended rainfall. Our close observations found the problem was insignificant during our sampling because the infrequent precipitation events produced only trace amounts of moisture. Most plants disseminate seed during the driest portion of the year, following growth and seedset during wetter periods (Bewley and Black 1985). Thus, this potential problem should not occur frequently.

The method we have presented should prove useful for a variety of ecological and management oriented investigations that would be strengthened with knowledge of seed dissemination. Modification of our methodology may be necessary with different species or circumstances, but the general procedure should prove successful for measuring wind-disseminated seed.

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