Leafy Spurge Patch Expansion

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Leafy spurge has a mature root system of abundant vertical and horizontal roots laden with regenerative, adventitious buds (Raju, 1985). Roots as deep as 15 feet and an enormous reservoir of food stored in roots contribute to survival of the weed during unfavorable conditions (Bakke 1936).

Experiments by Hanson and Rudd (1933) demonstrated the ability of leafy spurge to sprout new shoots from small root segments. Messersmith et al. (1985) stated that natural dispersal of leafy spurge root fragments has not been reported, but humans transport root portions to new locations by tillage, moving landfill soil, road excavations, landscaping, transplanting sod, and transplanting nursery plants.

Leafy spurge seems to thrive on disturbance. Removal of top growth by herbicides or tillage often results in increased densities of the weed. Removal of 1 foot of the surface roots does not markedly affect density or vigor of plants. Removal of underground growth to a depth of 2 feet will decrease densities but will not destroy the plant. This robust perennial weed will occasionally recover and produce vegetative shoots from 3 feet of removed underground parts (Selleck et al., 1962).

Dehiscence of the leafy spurge seed capsule occurs with explosive force, throwing seeds up to 15 feet from the parent plant (Bakke, 1936). Distribution of the seed is fairly uniform around the parent plants, but the wind may influence the direction of dissemination (Hanson and Rudd, 1933). Less than 10 percent of the seed rain is dispersed beyond the edge of a patch (Thomas and Bowes, 1976). One flowering leafy spurge stem on a native grassland will yield an average of 252 seeds (Selleck et al., 1962). Seed may remain dormant in the seed bank five years (Selleck et al., 1962), and according to Bowes and Thomas (1978a), potentially eight years.

Man, wild and domestic animals, birds, insects, and water are agents of leafy spurge seed dissemination (Messersmith, 1983). Approximately 1 percent of the seed will successfully germinate and become established as vegetative seedlings (Bowes and Thomas, 1978b). Seedlings will develop vegetative buds seven to 12 days after emergence (Selleck et al., 1962). New seedlings make up 9 to 16 percent of the stems of a stable population of leafy spurge (Bowes and Thomas, 1978b).

New seedlings in a developmental stage, in a native grassland habitat just outside the boundaries of an established leafy spurge patch, will be overrun by the parent's vegetative growth. Best et al. (1980) claim that patch expansion is almost entirely the result of lateral root spread. Each year, 19 percent of the stems in a leafy spurge patch are contributed by new lateral shoot development (Bowes and Thomas, 1978b). Selleck et al. (1962) noted, "Leafy spurge displays a remarkable capacity for vegetative reproduction."

Undisturbed land can have established stands of leafy spurge because the plant's root system is not disrupted as in cultivated land (Bybee, 1976). Grazed rangelands infested with leafy spurge densities of 50 percent or more will experience a decrease in annual herbage production of at least 35 percent (Lym and Kirby, 1987).

Cattle partially or totally avoid leafy spurge infested sites on rangelands (Lym and Kirby, 1987). Sheep willingly graze small spurge plants and nibble on large plants (Johnston and Peake, 1960). After eight years of continual sheep grazing, leafy spurge density was reduced to the growth of 5 to 10 shoots per square meter from perennial rootstocks (Bowes and Thomas, 1978a). Flowering stems per square meter decreased by more than 50 prcent when goats grazed in an area heavily infested with leafy spurge for 12 consecutive days (Fay et al., 1989).

PATCH EXPANSION MODEL

Effective management of native grasslands, rangelands, or wildlands in the Upper Great Plains requires an understanding of leafy spurge ecology. Information on spreading characteristics, area of coverage, and population densities of leafy spurge are examples of practical knowledge needed by land managers. Many plant population models have been developed. See, for example, Auld et al. (1978/1979), Auld and Coote (1980), or Sagar and Mortimer (1976). Bowes and Thomas (1978b), Watson (1985), and Maxwell et al. (1988) developed population models specifically for leafy spurge. These models include many environmental and physiological variables that simulate profiles of leafy spurge communities. Unless estimated coefficients and percentages, precalculated charts, or computers are used these growth models are of little use in applied situations.

A proposed simple formula, developed from a review of the literature, gives symbolic estimates of dynamic leafy

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spurge populations. The formula's foundation, based on leafy spurge research on native grasslands in the upper Great Plains, reveals contemporary or projected information on one leafy spurge seed germinating, maturing, and reproducing for (y) years into a patch covering (x) amount of land area and yielding (z) number of stems.

Leafy Spurge Patch Expansion Formula

(Metric System)

$$X = \pi*[(Y - 4)*0.61m]^2$$
$$Z = X*(100\ stems/m^2)$$

where Y = years
m = meters
X = area of patch in square meters
Z = total stems in patch

(English System-approximate conversion)

$$X = \pi*([Y - 4)*2\ ft]^2$$
$$Z = X*(10\ stems/ft^2)$$

where Y = years
ft = feet
X = area of patch in square feet
Z = total stems in patch

The formula is based on the premise that more than four years are required before a leafy spurge seedling, growing in the competition of a native grassland, will start to spread vegetatively at an average rate. Morrow (1979) reported that a new leafy spurge seedling growing with competition will produce no more than the original shoot through the second growing season. Lateral root development of leafy spurge seedlings is usually delayed until the second or third season, especially if growing in areas with extensive vegetation (Raju et al., 1963).

The area of the leafy spurge patch is based on computing the area of a circle (πR^2), assuming that a leafy spurge patch has a circular periphery and will maintain a somewhat circular shape as it enlarges. Portions of the patch boundary may retreat some years, while other boundary areas may advance a greater-than-average distance, producing a zig-zag circular periphery (Selleck et al., 1962).

The 0.61 meter or 2-foot parameter in the formula is an estimate of average annual radial spread of a leafy spurge patch. Sellect et al. (1962) found the average annual radial vegetative spread of leafy spurge patches on ungrazed native grasslands in Saskatchewan to be 0.64 meter or 2.09 feet over a seven-year period. They observed that patches continue to expand throughout the growing season under favorable moisture conditions, but that perimeter shoots may senesce if the soil becomes dry. Variations in average vegetative gains occurred in different years and habitats.

The 100 stems per square meter or 10 stems per square feet is an estimate of leafy spurge stem density per unit area. An average of 59 stems per square meter was found by Selleck et al. (1962) on three native grassland sites. After an eight-year study period, the maximum average for one site was 99 stems per square meter. Density usually did not increase over 200 stems per square meter in most habitat situations. After a density of 100 stems per square meter is reached, many stems appear stunted and grow no taller than 3 inches.

Best et al. (1980) measured stem density in a patch established on native grassland habitat in Saskatchewan and found an average of 113 stems per square meter. Lym and Kirby (1987) categorized leafy spurge stems on rangelands into four density classes: zero (0 stems per square meter), low (42 stems per square meter), moderate (112 stems per square meter), and high (170 stems per square meter). The four density classes correspond respectively to 0, 20 to 40, 40 to 60, and 60 to 80 percent leafy spurge canopy cover.

Leafy spurge patches were selectively sampled by the authors in the Sheyenne National Grasslands in North Dakota during May 1989. One hundred 0.25 square meter quadrats were sampled and revealed an average stem density of 106 stems per square meter.

RESULTS

Patch expansion over any time period can be estimated by using the numbers of years in the formula. The formula does not take into consideration a leafy spurge patch growing with competition or the influence of management practices such as selective grazing, spraying, or cultivation. The formula assumes unrestrained growth, with no interruptions from natural inhibitors (e.g., lakes and streams), cropland boundaries, other leafy spurge patches, or roadways to limit expansion.

A single leafy spurge plant once established will inhabit an acre in about 65 years based on the proposed leafy spurge expansion formula. A leafy spurge patch, if allowed to expand at a normal rate, will consume more additional land each year than the previous year (Figure 1). As a leafy spurge patch increases in size, the number of total stems increases proportional to patch growth (Figure 1).

Selleck et al. (1962) found "Rapidity of radial growth is related to circumference rather than to area." Small patches will have a larger percentage increase in area than large patches even though the increase in radii of patches is relatively equal. This is demonstrated by the fact that a leafy spurge patch 0.5 feet in diameter will increase 500 times faster than a patch 25 feet in diameter over a five-year period, with both patches having an average 2-feet per year radial spread (Selleck et al., 1962).

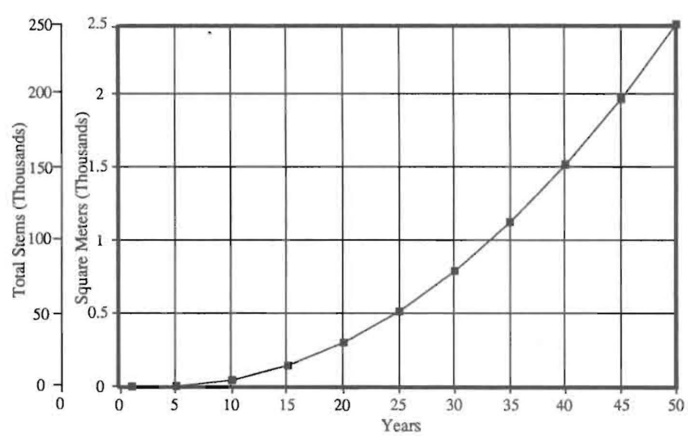

Figure 1. Leafy Spurge Patch Expansion in Area and Number of Stems.

During a determined length of patch expansion time, many new, small leafy spurge patches may cover more land area than one old, large patch, with both having equal 2 feet per year radial spread. Sellect et al. (1962) explained that in five years time 2,500 patches, 0.5 feet in diameter, will cover a surface area of approximately 825,000 square feet while a single large patch, 25 feet in diameter, will attain a surface area of only approximately 1,590 square feet. The many small patches, taken together had the same surface area (491 square feet) as the one large patch at the beginning of five years. From a weed control perspective, this expansion response highlights the importance of seeking out and controlling small patches rather than waiting until a patch is easily identified.

The leafy spurge patch expansion formula estimates increase in patch area from established seedlings but does not generate information on new patches being formed from seed dispersal. Thus, the formula does not estimate the influence an established patch will have on creating new patches through seed dispersal. Leafy spurge can infest land more rapidly if allowed to establish new small patches, providing patches expand at an average annual radial spread, than if contained to a few larger patches.

DISCUSSION

Leafy spurge patch expansion formula refinements, based on localized ecosystem surveys, might improve the formula presented. Field surveys could be undertaken on leafy spurge-infested land to determine the current number and sizes of patches before population interpretations or predictions are calculated. Other information can be extrapolated from the formula; for example, if the area of a leafy spurge patch is known, then total stems occupying the infested area or the age of the patch could be estimated. Data produced by this formula also may be used in one of the more complex weed population models.

Future research is needed to further define leafy spurge parameters. Weed spread models could be more valuable to land managers and researchers if the influence of management and environmental variables could be incorporated. Replacing or adding new variables into weed population formulas, functions, or models will enhance their usefulness. Leafy spurge patch expansion depends primarily on time, while overall infestation also depends on seed dispersal and constraints to expansion. However, in order that policies and recommendations about research directions could be made now, a simplified patch expansion model was necessary. General policy and management decisions, as well as projections of economic impacts, can be made using this simple model while natural scientists work to make it more robust.

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