LEAFY SPURGE (*Euphorbia esula* L.) PATCH EXPANSION

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Leafy spurge (*Euphorbia esula* L.) is distributed in North America and Eurasia, in habitats ranging from xeric to subhumid and from subtropical to subarctic. From Eurasian origins, leafy spurge has spread into 6 Canadian provinces and 26 states (Dunn 1985). Leafy spurge is most common in moderately moist (mesic) undisturbed or noncultivated habitats existing in the continental climate of North America (Selleck et al. 1962). It has become a troublesome weed in the upper Great Plains where it grows largely devoid of insect and disease pests, which help control leafy spurge in its native Eurasian habitats (Messersmith et al. 1985).

Estimates of the economic impact of leafy spurge were developed to provide direction for the U.S. Department of Agriculture's APHIS research program as well as for evaluating both chemical and biological control methods. A critical component in the economic assessment was a projection of leafy spurge expansion. While much was known about individual plants, absent from the literature was any workable model of patch expansion.

A review of the literature on weed spread functions and weed density models (Auld et al. 1978/1979), and spreading plant population models (Auld and Coote 1980) provided the foundation for a rudimentary patch expansion model (Stroh et al. 1990). The model was developed from secondary information on leafy spurge spread (Selleck et al. 1962), secondary information on patch density (Selleck et al. 1962, Best et al. 1980, Lym and Kirby 1987) and field observations of patch density. Leafy spurge patch densities were observed (by one of the authors) in 100 selectively sampled 0.25-m^2 quadrats at 20 different sites in the Sheyenne National Grasslands of North Dakota.

The following equation contains contemporary or projected information on one leafy spurge seed germinating, maturing, and reproducing for Y years into a patch covering X land area and yielding Z stems.

Leafy Spurge Patch Expansion Formula

Metric System:

$X = \pi[(Y-4)0.61m]^2$

$Z = X(100 \text{ stems}/m^2)$

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

English System-approximate conversion:

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

$Z = X(9.3 \text{ stems}/ft^2)$

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 competition with a native grassland, will start to spread vegetatively at an average rate. The area of a leafy spurge patch is based on computing the area of a circle, assuming that a leafy spurge patch has a circular periphery and will maintain a somewhat circular shape as it enlarges. The 0.61 m parameter is an estimate of average annual radial spread of a leafy spurge patch. The 100 stems/m^2 or 9.3 stems/ft^2 is an estimate of leafy spurge stem density per unit area.

Patch size in any year can be estimated by using the appropriate year in the equation. For example, a 10-year-old patch will cover approximately 42 m^2: $X = 3.14\ [(10-4)\ 0.61]^2$; while a 20-year-old patch will cover nearly 300 m^2. Once the patch size is known, the number of stems in a patch can be estimated by multiplying the size (square meters) by 100.

A single leafy spurge plant will inhabit an acre (4047 m^2) in approximately 63 years. A leafy spurge patch that annually expands at the predicted rate will cover proportionally more land each year than the previous year. As the leafy spurge patch increases in size, the total number of stems will also increase.

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The equation, based on growing conditions found in the upper Great Plains, does not include the influence of management practices and assumes unrestrained growth, with no interruptions from natural inhibitors, cropland, other leafy spurge patches, or roadways.

The patch expansion equation estimates increases in patch area from established seedlings, but does not generate information on new patches being formed from seed dispersal. Thus, the equation does not estimate the influence an established patch will have on creating new patches through seed mobility. Bowes and Thomas (1978) reported only about 1% of leafy spurge seed successfully germinated and became established as vegetative seedlings and also contended that new seedlings only made up 9–16% of the stems of a stable leafy spurge establishment. Best et al. (1980) claimed that patch expansion resulted almost entirely from lateral root spread.

This simple patch expansion model has been extremely useful for estimating the potential future economic impact of leafy spurge in the upper Great Plains (Thompson et al. 1990, Bangsund and Leistritz 1991, Wallace et al. 1992). 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.

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