GUIDELINES FOR ESTIMATING CONE AND SEED YIELDS OF SOUTHERN PINES

James P. Barnett

Abstract: --Our ability to predict cone and seed yields of southern pines (*Pinus* spp.) prior to collection is important when scheduling and allocating resources. Many managers have enough historical data to predict their orchards' yield; but such data are generally unavailable for some species and for collections outside of orchards. Guidelines are presented to allow prediction of cones per tree, to convert numbers of cones to bushels, to estimate numbers of seeds per cone, and to convert numbers of seeds per bushel to pounds of seeds per bushel. Once we have these data, crop prediction is a straightforward process.

Keywords: *Pinus* spp., crop prediction, seed orchards

INTRODUCTION

Orchard managers, seed dealers, and others interested in obtaining quantities of southern pine (*Pinus* spp.) seeds need to know the quality and quantity of cones and seeds before they plan collections. Depending on seed needs for various clones in the orchard or other seed sources, it may be economically prudent to plan collections only when the crop size justifies it. To concentrate efforts on those areas or clones that have the highest seed yield, it is important to have accurate prediction methods prior to cone collection. The most common way to predict crop size prior to cone maturity is by evaluating flowers or immature cones. Although orchard managers have developed procedures for predicting seed crops 20 months before cone maturity, using estimates of female flowers (also termed strobili or conelets) (Fatzinger and others 1988), binocular ground counts of flowers are unsatisfactory estimators in seed production areas (Shoulders 1968). Flowers are normally highly visible for only about 2 weeks in the spring between early flower development and the growth of needles. During this short period, a factor of 1.5 can be applied to binocular count to estimate the total numbers of flowers. Usually such estimates do not adequately predict cone and seed production, which occur nearly 2 years later, although they are a fair indicator of crop size.

Prediction techniques that incorporate historical, site-specific yield information, as well as estimates of the impact of changes in management strategies, are now available for many orchards (Byram et al. 1986, Byram et al. 1999, Fatzinger et al. 1990). Such techniques have been developed for loblolly pine *(Pinus taeda L.)*, but are not nearly as functional for species like longleaf pine (*P. palustris* Mill.), where research has been limited. A tremendous increase in the demand for longleaf pine seeds has made predictions of cone and seed yields of this species important. Also, because longleaf seed quality is much influenced by cone maturity at the time of collection (Barnett 1997), it is important to more precisely determine its stage of maturity.

Evaluations of seed yield are made in two phases; the first estimates the cone crop, the second predicts seed yield. The methods of determining cone and seed maturity are beyond the scope of this paper

ESTIMATING THE CONE CROP

With reasonable accuracy, Wenger (1953) estimated the number of maturing loblolly pine cones in late summer by counting visible cones through binoculars from single vantage point and doubling that count. Binocular counts made in midsummer on only 4 to 5 percent of loblolly pines in a seed orchard provided good estimates (Wasser and Dierauf 1979). Webb and Hunt (1965) successfully used a similar approach

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'USDA Forest Service, Southern Research Station, Alexandria Forestry Center, Pineville, LA 71360

to estimate cone crops in a slash pine *(P. elliottii* Engelm.) seed production area. Seidel (1970) successfully used a two-person counting system in a 40-year-old shortleaf pine (*P. echinata* Mill.) seed production area. To facilitate estimates, the number of cones per tree should be determined for particular collections of interest, e.g., clones, stands, or species. The number of sound seeds per cone may vary from year to year (McLemore 1975), and it is advisable to estimate this number as well as the number of cones (Bramlett and Hutchinson 1964). Knowing the number of cones per bushel is important, because that is the measure normally used in market transactions.

Assumptions on the number of cones per bushel are needed to make projections, and that number varies greatly within as well as between species. For example, ranges given for loblolly are 400 to 1,100, and for longleaf 60 to 120 per bushel (USDA Forest Service 1948). A study conducted in Louisiana describes a quick way to estimate the number of cones in a bushel using a small sample (McLemore 1972).

Various sizes of fresh, unopened loblolly, longleaf, slash, and shortleaf pine cones were selected. The number of cones per bushel was measured using a specially constructed box with the inside dimensions of 12.9 inches on edge (a common Winchester bushel, the U.S. standard, contains 2,150.4 cubic inches or 35,239 cubic centimeters). The volume of cones in each bushel was determined by water displacement. Despite wide ranges in cone size among the samples, the cubic volume of cones did not vary greatly among species. Of the 35,239 cc in a bushel, only 18,000 to 20,000 cc were occupied by cones (table 1). Although differences were small. loblolly consistently had less volume per bushel than the other species, probably because the spininess of its cones allows looser compaction.

To determine the number of cones per bushel, therefore, a collector should determine the average volume of several samples to the nearest cc (or 0.1 cc when measuring shortleaf) by immersing them in a graduated cylinder. The average per cone, in cc, can then be divided into 18,162 for loblolly and 19,608 for the other species. For example, if longleaf cones average 300 cc each, then 19,608 divided by 300 equals 65 cones per bushel. From the variability of sizes encountered in the study, it is estimated that about 60 cones from a single species will yield an average with an error of no more than 5 percent (McLemore 1972).

Table I. Ranges in cones per bushel and cone volumes (from McLemore 1972).

Pine Species	# Cones per bushel	Volumes of cones Per bushel (cc)	Average volume per cone (cc)
Longleaf	24-95	19,164-20,071	204-590
		av. 19,452	
Slash	120-200	17,747-20,582	98-172
		av. 19,490	
Loblolly	254-503	17,775-18,512	36-72
		av. 18,162	
Shortleaf	1,320-2,102	19,447-20,156	9.5-15.0

ESTIMATING SEEDS PER CONE

Formulae have been developed to estimate seed yields of southern pine cones from the number of full or sound seeds severed when slicing cones longitudinally with a sharp knife (fig. 1) (McLemore 1962, Bramlett and Hutchinson 1964). If the number of cones per bushel and seeds per pound are known, the formulae will compute seed yields per bushel of cones.

Figure 1. Longleaf pine cone positioned for cutting.

The sampling of cones for cutting tests should not be started earlier than about 45 days prior to cone collection, when the seeds are fully developed and coats are hardened. Green cones are preferred, however, because ripe cones tend to split, even when the knife is sharp. Immediately following collection, cones are cut longitudinally and the number of dissected (exposed) sound seeds on the cut surface are recorded. A seed is counted as exposed when enough of the coat is cut away for the white megagametophyte (endosperm) to be visible(fig. 2). Both halves of the cone should be examined to determine the number of seeds exposed, as not all cut seeds are visible on one half of the cone.

A regression in the form of Y = a + bX is appropriate for predicting sound seeds per cone (Y) from the number of exposed seeds (X). The formulae developed by McLemore (1962) and Bramlett and Hutchinson (1964) for the major southern species are:

(1) longleaf pine, Y= 11.18 + 6.02X

(2) loblolly pine, Y= 18.06 + 6.52X

(3) slash pine, Y= 4.93 + 7.49X

(4) shortleaf, Y= 2.36 + 4.84X.

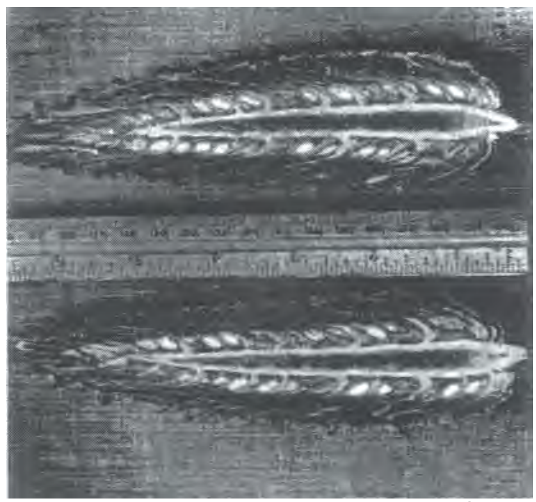

Figure 2. Exposed seeds in a longleaf pine cone.

The regressions were developed with cones having little visible insect damage. So, an estimate of seed loss due to insect injury is needed to reflect this impact. Fatzinger et al. (1980) have documented approaches to estimate losses due to insects through standard methods.

ESTIMATING CROP YIELDS

For greatest accuracy in estimating seed yields, the number of seeds per pound should be known. Averages listed in the Seeds of Woody Plants in the United States (U.S.Department of Agriculture 1974) are 13,500 for slash, 4,900 for longleaf, 46,300 for shortleaf, and 18,200 for loblolly pine. An average derived from local experience may be better, since numbers per pound for orchard lots may be considerably different from those listed. However, seed sizes do not vary as much as numbers of seeds per cone or cones per bushel (McLemore 1972).

Once the prediction information on cone and seed data is determined, it is a straightforward process to scale-up the estimates of seed production. The numbers of cones per tree are converted to bushels per tree. Cone cutting tests then allow estimating seeds per cone, and numbers of seeds per bushel are converted to pounds of seeds per bushel. The total number of bushels can be projected by numbers of trees in the collection area.

CONCLUSIONS

Seed crops of southern pines vary from year to year due to environmental and biotic influences. Many orchards have historical, site-specific information that aids in the prediction of seed crops. The procedures described in this paper are useful for the many situations where such data are unavailable. Numbers of cones per tree can be estimated by doubling binocular cone counts during the summer prior to fall harvest. Accurate estimates of cones per bushel can be made by determining volume of samples by water displacement. Seeds per cone are predicted by counting cut seeds in cones sliced longitudinally and applying these numbers to regression formulae. To complete the predictions of seed production, numbers of seeds per cone are needed. Averages from the Seeds of Woody Plants (U.S. Department of Agriculture 1974) can be used, or averages derived from local experience can be applied. Use of this process provides a good estimate of southern pine cone and seed production.

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