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Improved regional Predictions for the Sugarbeet Root Maggot, *Tetanops myopaeformis*

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Introduction

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* Roder, is the major insect pest of sugarbeet in the Red River Valley. Although other insect pests may cause more damage than do root maggots in a given year, SBRM are a more consistent threat with at least some area in the sugarbeet growing area of MN and ND suffering damaging populations every year. Occasionally, widespread outbreaks occur wherein much of the Red River Valley suffer high populations of sugarbeet root maggot. Unfortunately, these outbreaks tend to be cyclic and are very difficult to predict.

Larvae (maggots) of SBRM overwinter in the soil at a depth of 6”-10”. Maggots become more active in the spring with warmer temperatures, moving to within 1” - 4” of the surface. SBRM larvae then pupate near the soil surface and become adults, emerging in mid-May. Adult SBRM spend several days in the field into which they emerge before flying into sugarbeet fields to mate, find suitable plants and lay their eggs. It is these immigrating adults that are most easily monitored, making the sticky stake traps a relatively efficient method of monitoring populations. Mating and oviposition occurs until mid-July with larvae hatching in early June when they start feeding on the maturing sugarbeet root. Although there are a number of suitable host plants for SBRM, including native non-crop species, females do show preference for laying eggs on sugarbeet. This indicates that adult female SBRM are capable of evaluating certain environmental factors and/or host characteristics. Larvae stop feeding in September and initiate diapause (a physiological dormancy) in order to overwinter.

The dynamics of an insect’s population are often associated with a number of resources. Climate, available food, and soil type, for example, may influence an insect’s rate of reproduction and survivorship. Because these resources vary spatially, they will have an obvious effect on an insect’s population distribution. Historical patterns of distribution, therefore, can often provide insight into areas that may be at risk during outbreak years. This is especially true with insects that have only one generation per year and whose populations are not influenced by successive generations that build throughout the growing season. Sugarbeet root maggot is such an insect.

For a number of years the grower cooperatives, to assist growers in making management decisions, have conducted seasonal scouting programs for SBRM adults. American Crystal personnel would establish sample sites at between 100-200 locations selected throughout the region based on personal knowledge of previous SBRM activities. Each sample location had three sticky stake traps and was monitored weekly. Because this effort was started before the advent of inexpensive, hand-held Global Positioning System (GPS) receivers, legal descriptions were used to indicate the location of sample sites. In addition to the township, the range, and the section number (TRS) of each sample location, in most years the quarter within each section was also recorded. These data are available for growing years going back to the late 1980's and represent a database of the seasonal distribution and abundance of SBRM adults that is spatially explicit to a 0.25 mi^2 resolution. Unfortunately, financial exigencies dictated that this effort not be conducted in the growing season of 2002.

The monitoring of SBRM populations is useful to growers. In addition, the historic trap data is useful to researchers studying the regional population dynamics of this insect pest. To continue this effort, a cooperative arrangement was made between the University of Minnesota, North Dakota State University, American Crystal Sugar Co., and the Minnesota Dept. of Agriculture. Unfortunately, available resources precluded using the same number of sites usually monitored by American Crystal in past years. It was decided to investigate the potential for using historical data to target monitoring effort in such a way that fewer locations might still provide a good estimate of seasonal SBRM populations. Trapping data from American Crystal was used to construct a historical database of SBRM abundance and distribution within the Red River Valley. Traps were monitored by personnel from the two universities and the Minnesota Department of Agriculture. To assist in management decision, weekly maps of adult SBRM abundance and distribution were prepared throughout the growing season and were made available via the WWW.

Methods & Materials

Historical trapping data for the Red River Valley north of Moorhead was obtained from American Crystal Sugar Co. Data from each site included the number of SBRM adults per stake, the number of sticky stakes per location, and the location (TRS and quarter section) of each sample site. Sites were sampled with a minimum of three sticky stake traps constructed from a 12" orange garden stake attached to a 1"x1" white, wooden post approximately 18"-24" long. Posts were driven into the ground facing north at the edge sugarbeet fields. The orange garden stakes were covered with Tanglefoot® (The Tanglefoot Co., Grand Rapids, MI). Traps were checked at weekly intervals and adult SBRM stuck to the stakes were counted and removed and the stake recovered with Tanglefoot®. The cumulative mean adult SBRM catch per stake was calculated at each location for the entire sample year. Cumulative seasonal catch was used because we were more interested in annual populations than weekly dynamics.

The cumulative mean number of adults per sticky stake data were used to create digital maps representing the annual population density and distribution of SBRM in the Red River Valley. Point maps were created for each year's data in the geographic information system (GIS) ArcGIS 8.2© (ESRI, Redlands, CA). The legal description (TRS) and quarter section information was used to assign a point location to each sample site. The average number of adult SBRM per stake was associated with each point location. The cumulative catch data was tested for spatial autocorrelation using the program *GS+* (Gamma Design Software, Plainwell, MI). Interpolated surfaces estimating the average catch across the region were created for each year by Kriging the average catch per location across the entire region. Although data was available for a number of years we only used data from 6 years (1996 – 2001) to construct historical maps. This was because we felt the population dynamics of SBRM prior to the mid-1990's may be different than are currently being observed. Changes in agronomic practices, insect management and the amount of land in sugarbeet production may have influenced SBRM population dynamics to the point where patterns observed prior to 1995 may not be relevant to today's SBRM abundance and distribution. An interpolated surface estimating the mean adult SBRM regional for the 6 year period was prepared from the annual mean estimates. This 6-year average map was used to target trap locations. All maps, including 2002 population maps, were kriged with a cell size equivalent to $0.25mi^2$, the resolution of the dataset.

A total of 52 trap sites, each with 3 sticky stake traps, facing north, were established beside sugarbeet fields throughout the Red River Valley. Trap locations were recorded using a GPS and were evenly distributed across the Red River Valley to provide a good overall representation of SBRM adult abundance in the region. In addition, because potential outbreaks would likely be noted first in areas that historically have had higher populations, a number of trap locations were concentrated in those areas.

Traps were monitored 1-2 times per week. Adult SBRM present on the traps were counted and then removed and the trap re-coated with Tanglefoot®. Weekly counts were used to prepare interpolated maps that estimated the regional population of adult SBRM abundance and distribution. The resulting interpolated estimates were assessed for accuracy using the "Validation" function in ArcGIS' *Geostatistical Analyst* module. This function compares observed values with the expected results from the interpolation, calculates and then estimates Standard Errors for the Kriged surface. Although referred to by ESRI as a "validation" function, this is not really accurate. The function compares values from the original data with values from the the same location on the interpolated surface. However, because it utilizes the original data from which the surface has been interpolated and not an independent dataset, it is not a true validation of the estimated model, rather an estimate of how accurately the resulting surface represents the point data. In this way, it is more an assessment of how well the interpolation techniques fit the dataset.

A website was established (http://nwroc.umn.edu/ent/sbrm2002.html) and interpolated estimates were posted weekly, providing both weekly peak counts and the cumulative seasonal catch.

Results & Discussion

Variograms indicated that the population distributions of SBRM as recorded by American Crystal trapping efforts, were spatially autocorrelated. In other words, values at closer sample locations tended to be more similar than those from distant sample locations. Data must be spatially autocorrelated for the interpolation techniques used in this study (i.e. Kriging) to be valid. The 6-year average map was used to target sample locations for 2002 (fig. 1). Figure 1 indicates the relative mean annual abundance of SBRM through the Red River Valley, consequently, there is no absolute scale provided with the figure. We felt it was more important to illustrate areas that generally had higher populations of SBRM. Sample locations were evenly distributed throughout the Red River Valley with additional sample locations being concentrated in those areas that historically have had high populations of SBRM.

The weekly population maps illustrated population peaks well (fig. 2). The cumulative seasonal population estimate (fig. 3) showed peak SBRM populations were once again in Pembina county in N.D. To assist in management decisions, both weekly counts (used to estimate the peak emergence period of SBRM adults) and the cumulative catch (used to indicate the seasonal abundance and distribution of SBRM) were presented on the website.

The accuracy of the Kriged surface based on the original dataset (fig. 4) indicates a reasonably good fit close to the sample locations but the accuracy of the estimates decreases quickly away from these points. This lack of fit may have been due to three sample locations with extremely high cumulative catches (fig. 5). These three sample locations may have been adjacent to areas which had very high survivorship of SBRM adults. Consequently, it was decided to interpolate the dataset without these data to examine their influence on the overall interpolation. The resulting interpolated estimate (fig. 5) shows lower catches in northern Minnesota, which better reflects the observed data from 2002. In addition, the map of calculated standard errors indicates a better overall fit throughout the region (fig. 6). While the comparison of the standard error maps is simply visual and statistical comparisons have yet to be calculated, this situation is indicative of the influence extreme values have on interpolated estimates when dealing with decreased numbers of sample locations.

Further research is being conducted to adapt the historic database to annual predictions. In addition, future seasonal data should be interpolated to further refine the technique.

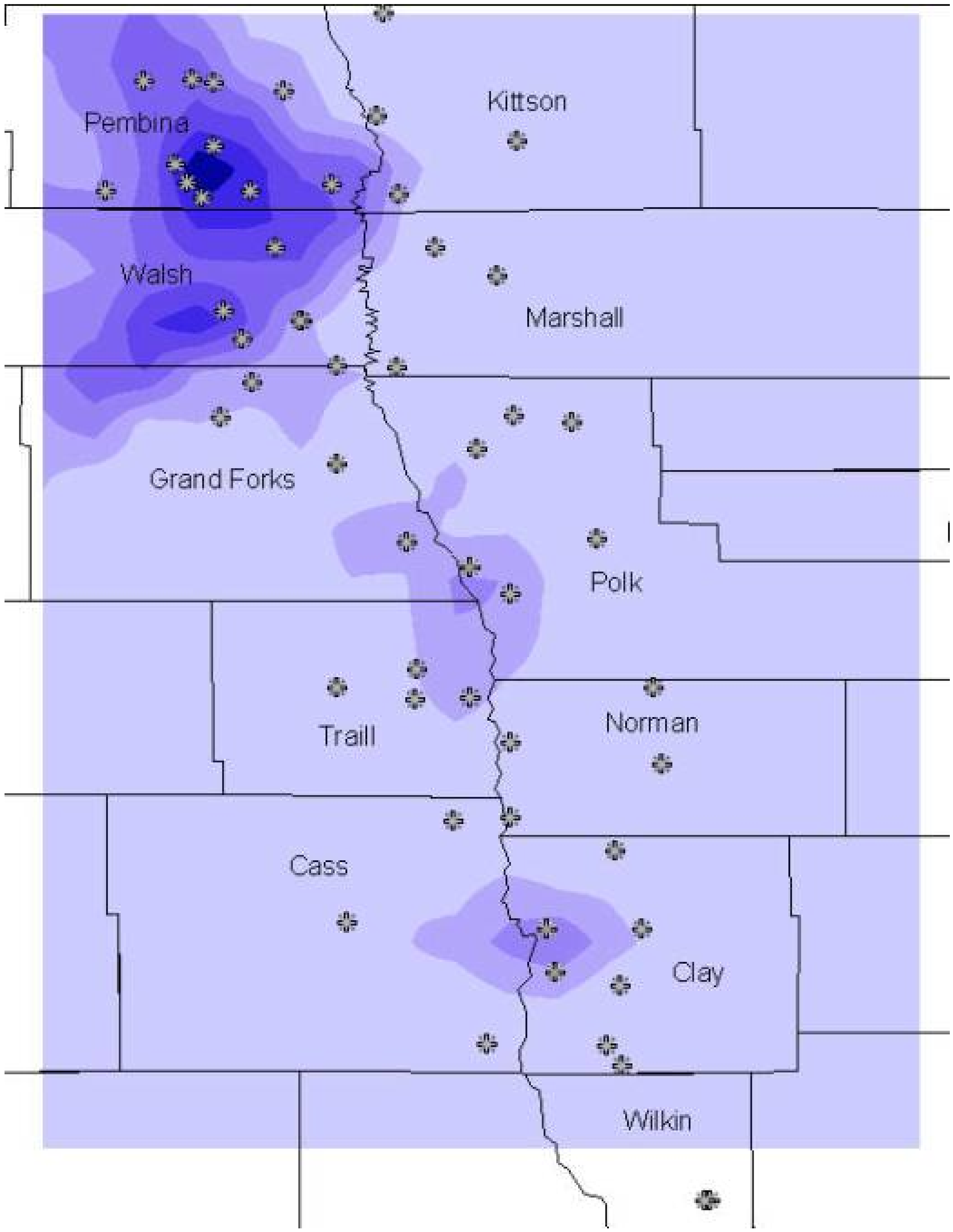

Figure 1. Interpolated surface estimating the mean adult SBRM abundance as calculated from American Crystal sticky stake trapping results, 1996-2001. Increasingly darker areas indicate heavier populations. In this case, absolute values are less important than are comparative values (i.e. of greatest interest are those areas which have high populations of SBRM annually). Maps were created using Ordinary Kriging in ArcGIS 8.2® (ESRI, Redlands, CA). Stars represent sample locations for 2002.

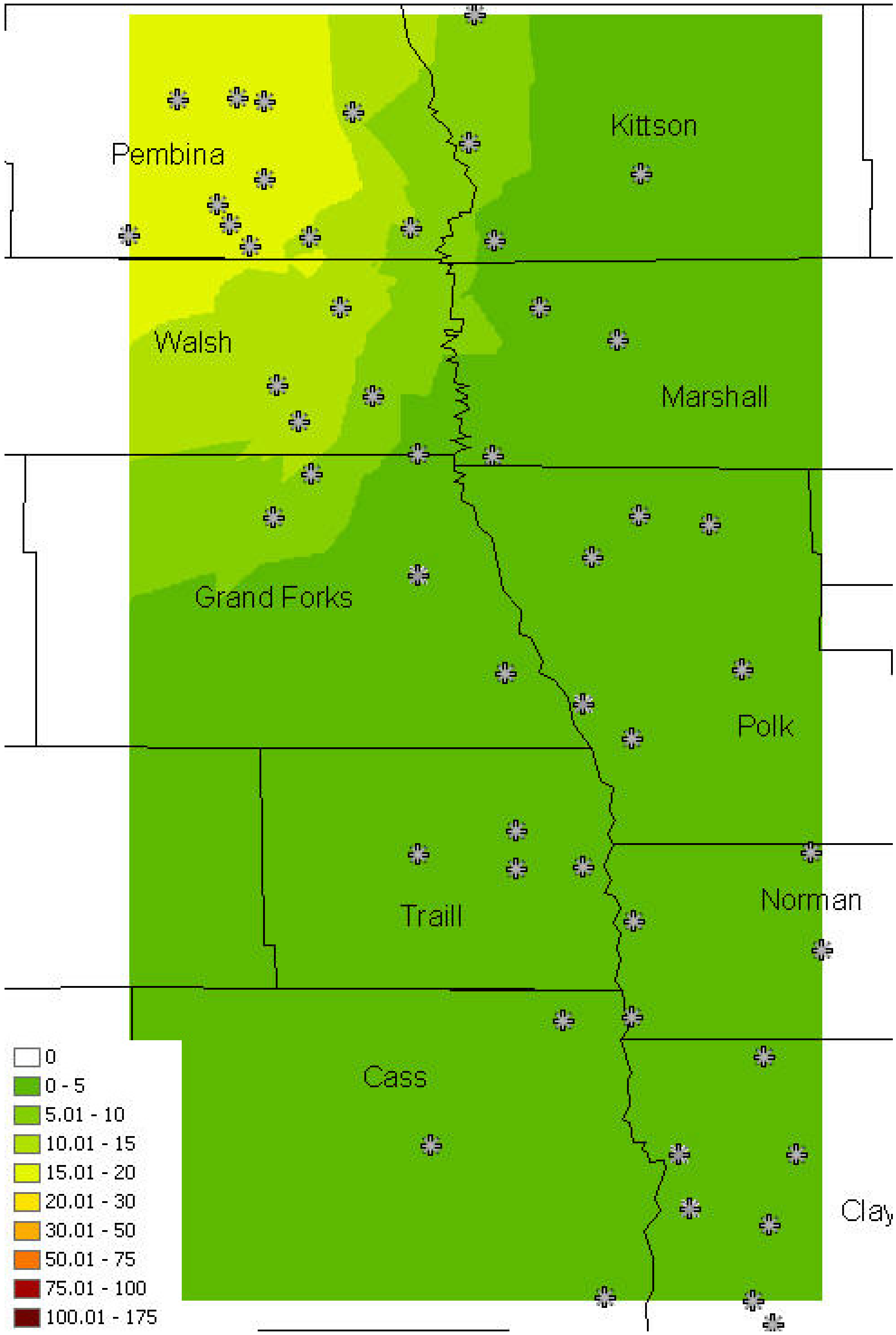

Figure 2. Interpolated surfaces estimating the mean SBRM catch per sticky stake trap July 3-10, 2002. Increasingly darker areas indicate increasing abundance of SBRM adults. Map was created using the *Ordinary Kriging* module in ArcGIS 8.2® (ESRI, Redlands, CA). Stars indicate 2002 sample locations.

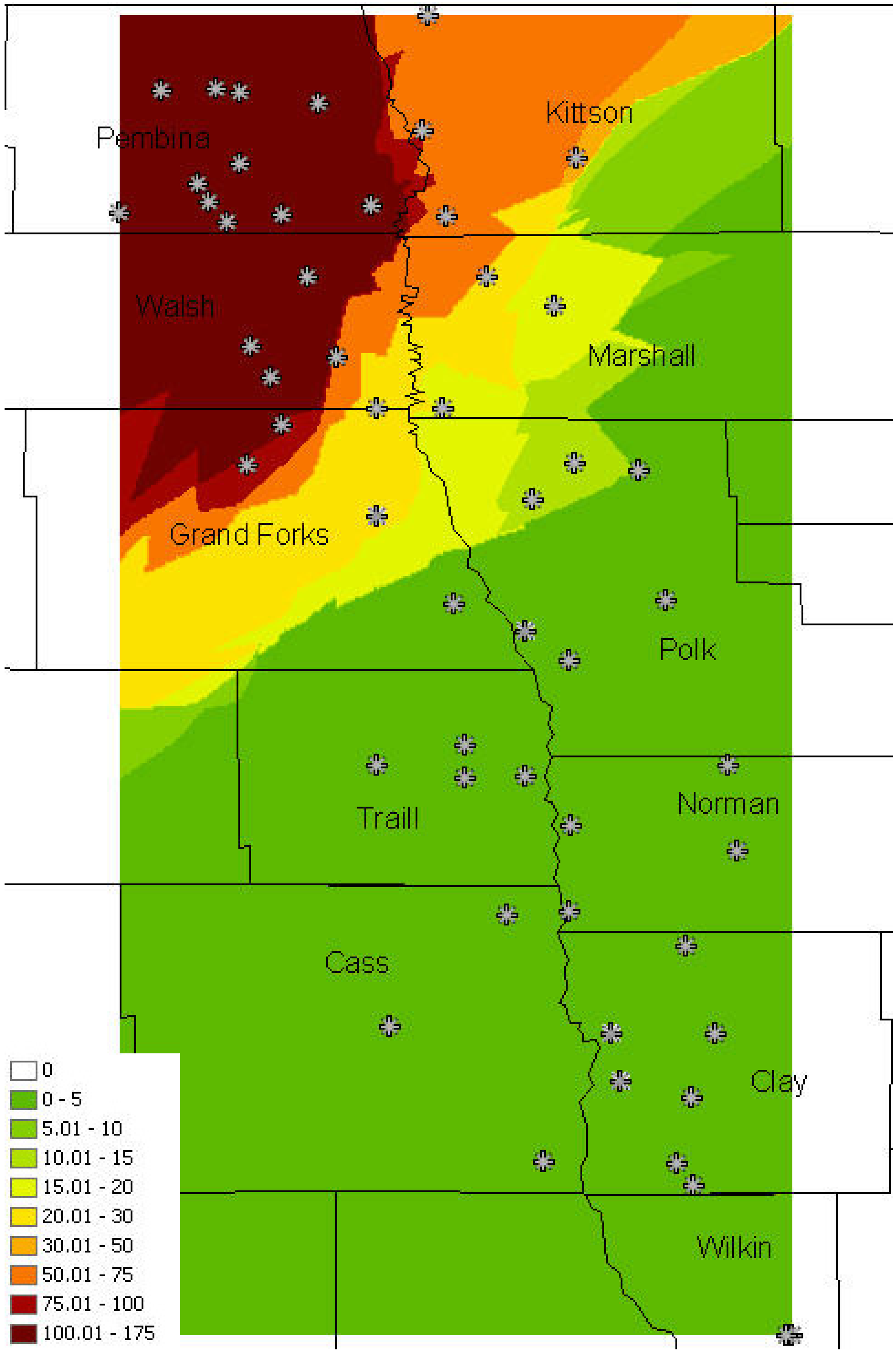

Figure 3. Interpolated surfaces estimating the mean cumulative SBRM abundance and distribution in the Red River Valley as calculated from mean adult SBRM catch per sticky stake trap May 30 – July 10, 2002. Increasingly darker areas indicate increasing abundance of SBRM adults. Map was created using the *Ordinary Kriging* module in ArcGIS 8.2® (ESRI, Redlands, CA). Stars indicate 2002 sample locations.

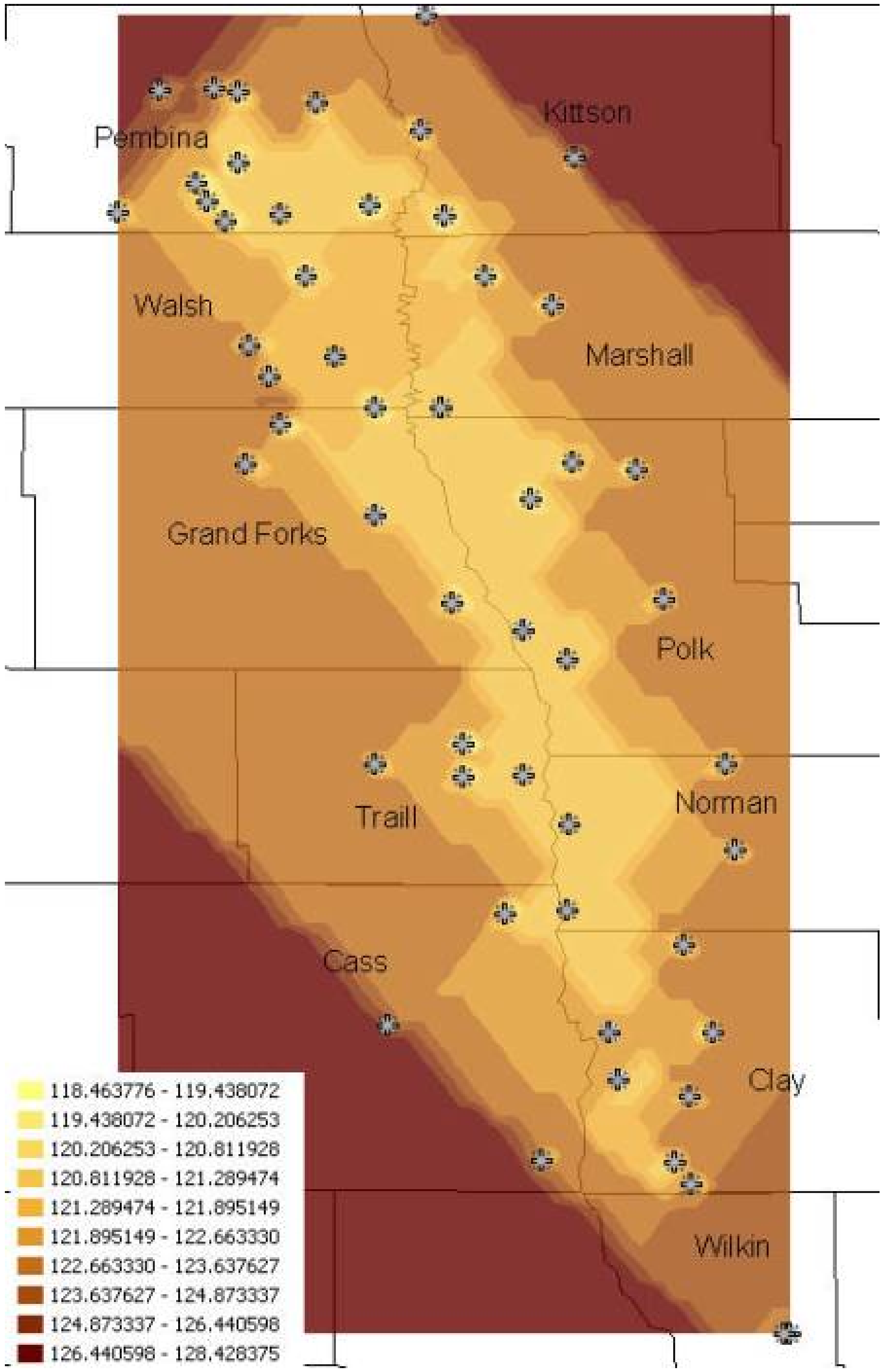

Figure 4. Calculated standard errors of interpolated surface estimating of mean seasonal SBRM abundance and distribution (fig. 3). Shading indicates relative fit of interpolated estimates compared to observed data. Increasingly darker areas represent decreasingly accurate estimates. Stars indicate 2002 sample locations. Map was created using *Geostatistical Analyst* in ArcGIS 8.2® (ESRI, Redlands, CA).

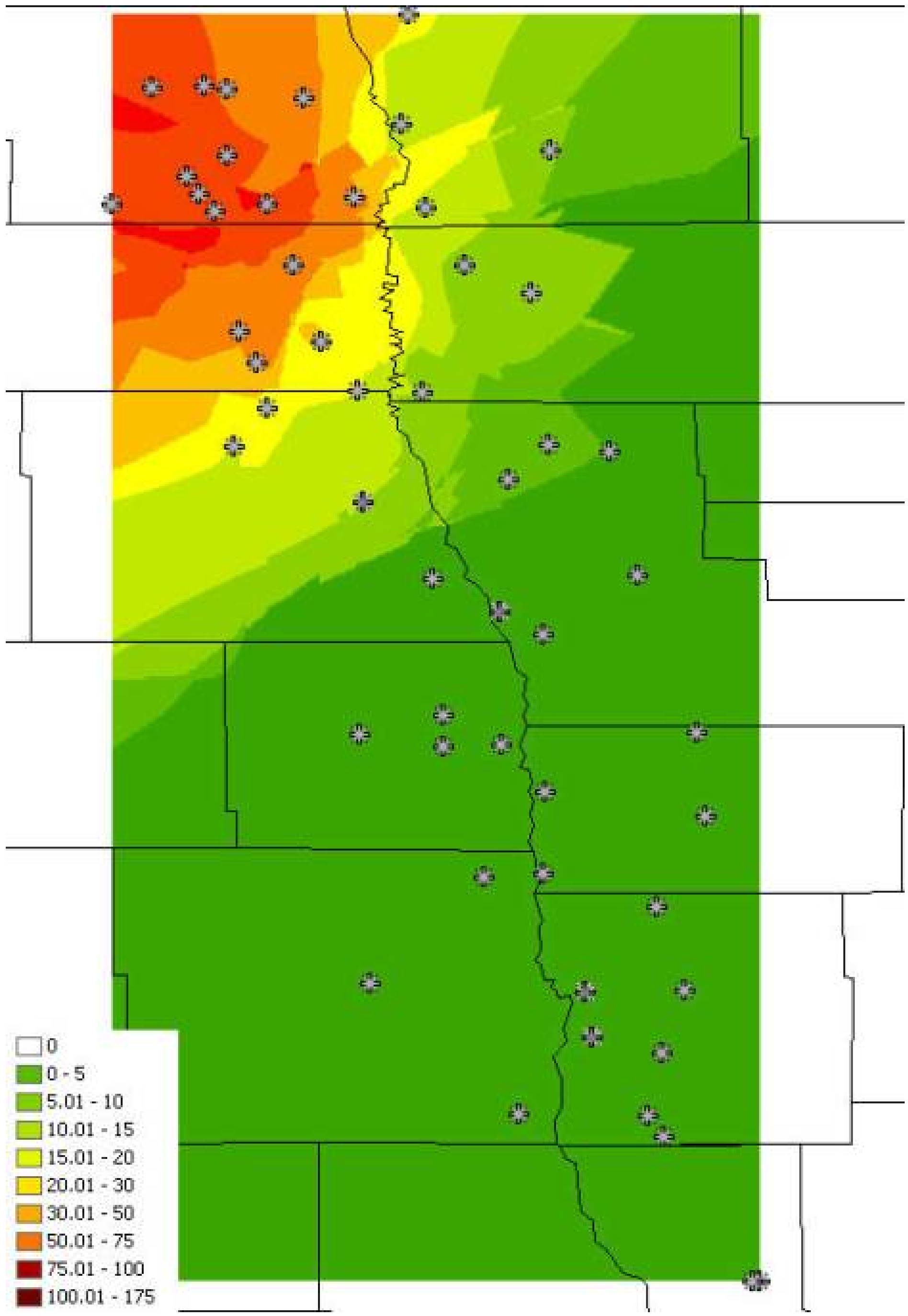

Figure 5. Interpolated surfaces estimating the mean cumulative SBRM abundance and distribution in the Red River Valley as calculated from mean adult SBRM catch per sticky stake trap May 30 – July 10, 2002 excluding extreme values at three sample locations (note circled stars). Increasingly darker areas indicate increasing abundance of SBRM adults. Map was created using the *Ordinary Kriging* module in ArcGIS 8.2® (ESRI, Redlands, CA). Stars indicate sample locations.

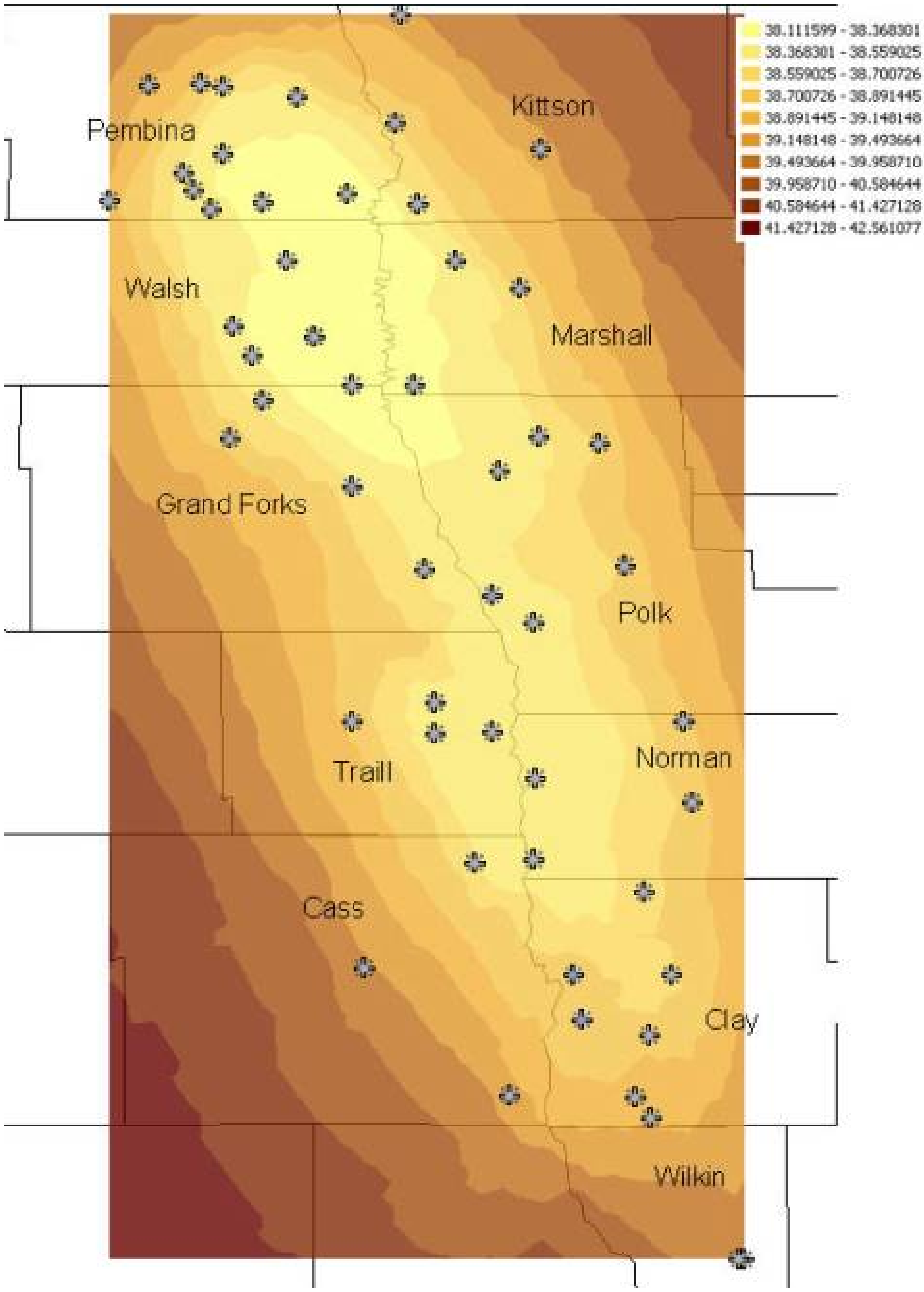

Figure 6. Calculated standard errors of interpolated surface estimating mean seasonal SBRM abundance and distribution excluding extreme values from three sample locations (fig. 5). Shading indicates relative fit of interpolated estimates compared to observed data. Increasingly darker areas represent decreasingly accurate estimates. Map was created using *Geostatistical Analyst* in ArcGIS 8.2® (ESRI, Redlands, CA).