**Elvenia J. Slosson Endowment Fund**
**Final Report for Work Performed from July 2006 through June 2007**

**Title:** "Relationship of Artichokes and Cardoon to Invasive Artichoke Thistle: Should They be Discouraged in the Home Garden?"

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## Introduction

Crops (including ornamental plants) are highly domesticated and the evolution of weeds is often linked with the domestication of crops. Weeds and crops often originate from a common progenitor (De Wet and Harlan 1975) and in cases where weeds and crops are genetically related, cross-pollination can contribute to the further evolution of weeds, the degradation of desirable crop traits, or both (Baker 1991, Ellstrand *et al.* 1999).

*Cynara cardunculus* L., which includes artichoke thistle, is an invasive perennial species native to the Mediterranean basin and found widely in regions with a Mediterranean climate, including California (Moore 1982, Wiklund 1992) where it occupies over 150,000 acres of grassland, most commonly in coastal areas (Hickman 1993, Thomsen *et al.* 1986). It is listed by the California Invasive Plant Council as a widespread wildland weed (CalEPPC 1996, CalIPC 2006). This plant is not weedy in its native range.

Both cultivated globe artichoke and cardoon are in the species *Cynara cardunculus* with artichoke thistle (= wild cardoon). Cultivated globe artichoke, cultivated cardoon and artichoke thistle are referred to as *C. cardunculus* var. *scolymus*, *C. cardunculus* var. *altilis*, and *C. cardunculus* var. *sylvestris*, respectively (Acquadro *et al.* 2003, 2005, Portis *et al.* 2005, Sonnante *et al*. 2002), although multiple synonyms exist (Wiklund 1992). We are conducting the first genetic studies of this species in California to determine whether California's artichoke thistle is the same as wild cardoon in Europe, or if it is a crop/cultivar-wild hybrid derivative, and to clarify the relationship of the cultivars with their weedy relative (Figure 1).

This research seeks to determine the origin of this weed in California and whether globe artichoke or cardoon in the home garden contributes to problems with weedy artichoke thistle by means of gene flow as pollen or seeds. Our research focuses on these questions: (1) What is the origin of weedy artichoke thistle in California? (2) What is

the relationship of artichoke thistle with the two crop varieties grown in California? (3) How does this relationship contribute to increased weediness in artichoke thistle?

**Goals/Objectives,**

Objective 1 – Relationship of invasive artichoke thistle to European populations.
In the summer of 2005 Ms. Garcia collected seeds from 17 California populations locally identified as artichoke thistle. In the summer of 2006, Ms. Garcia collected seeds from 16 additional populations in their native habitat in Europe, specifically Spain and Italy (Figure 2). These included sites from which plants were most likely introduced into California based on historical notes. Tissue samples from 29 of these populations underwent microsatellite marker analysis to identify a genetic profile for each potential source population and introduced population.

Objective 2 – Relationship of invasive artichoke thistle to cultivated artichokes.
Tissue samples from up to 20 artichoke thistle individuals per population for 13 California populations and 10 samples each of 8 cultivars of cardoon and artichoke were harvested and are undergoing genetic analysis. Thirteen microsatellite markers with an average of 13 alleles each were used for identifying hybrid-derived and feral cultivar (often revertant) populations.

Objective 3 – To investigate the effect of specific genetic heritage on the success of an introduced plant population.
Seedlings from the California seed collection were planted in the first of three common garden sites in the spring of 2006. Seeds from Europe were germinated in the winter of 2006/2007 and placed along with a replicate set of California seedlings into a second common garden experiment conducted at two geographically distinct sites to measure morphological traits and fitness in different environments: UC Riverside's Agricultural Experiment Station (AgOps), with extreme temperatures and low rainfall (Figure 3), and UC Davis's South Coast Research and Extension Center (SCREC) in Irvine, California, with more moderate temperatures and more mesic conditions (Figure 4). The purpose of these experiments is to determine the weediness of populations within California relative to each other, and of California as a whole relative to Italy and Spain (transplanted to California). Two primary questions investigated here are: i) is artichoke thistle transported directly into California from Europe as weedy as that currently growing in California, and ii) does weediness in California vary with the specific genetic heritage of a population, or more specifically, is it positively correlated with the inclusion of crop genes?

**Discussion and Implications**

Results of this research are expected to reveal the relationship of artichoke thistle within California to both wild cardoon in Europe and the related crop cultivars, cardoon and artichoke. This is important information as population genetic theory predicts a positive correlation between genetic diversity and founder population success. Increases in genetic diversity are most likely to occur in association with migration or gene flow

between populations. Multiple introductions, particularly from multiple source populations, including cultivated sources, provide an opportunity for the establishment of individuals with relatively high genetic diversity. Moreover, this diversity would be entirely unique if the source populations are spatially isolated in their native ranges. We should also be able to determine if there has been hybridization between the weed and its crop relatives and if this has inadvertently resulted in weedy populations being dispersed throughout the state. The information from Objective 2 in tandem with the results of Objective 3 will reveal if hybridized populations differ significantly in survival and fitness-related traits from true artichoke thistle.

Over the past year data has been compiled for a number of traits associated with establishment success in all three common gardens and will be analyzed along with the data set from 2005/2006 (Figure 5). Additionally, approximately 475 individuals from 38 populations are being genotyped by microsatellite analysis. The bulk of this work was performed in the winter and spring of 2007 and the data has already been collected. Initial visual analysis of allele patterns shows clear delimitation between cultivars, and apparent delimitation between Spanish populations and Italian populations. California populations exhibit extreme genetic variability and contain alleles from all 4 of the above groups. In an early analysis of growth-related traits there are highly significant differences between populations in California, with plants suspected of being feral or of hybrid origin appearing to be among the most robust in the common garden experiments.

It will require further analysis of the data to determine how plant robustness correlates with traits associated directly with reproduction, such as seed head production, and if these plants are indeed of hybrid ancestry. It is also possible that some of what we have historically identified as artichoke thistle in California might be an escaped, feral form of one of the crop varieties, often reverted to a spiny form (Figures 6 and 7). Of approximately 45 *Cynara cardunculus* herbarium samples examined at the California Academy of Sciences, approximately half are identified as established escaped cultivars. Our initial genetic analysis would suggest that the genetic history of many of the California populations is idiosyncratic and that the fully interfertile varieties may be promiscuous enough to produce a gradient of morphotypes capable of establishing and evolving into highly successful populations.

No established populations of artichoke thistle are known to us north of Lake County, and it seems that infestations are limited to mildly arid mild-winter climates (Figures 8, 9 and 10). The species is not known to exist in the US outside of California. Introduced established populations also exist in Mexico, South America and Australia, showing themselves to be particularly aggressive in the latter two locations. We recommend limited use and management of cultivated globe artichoke and cardoon in the home garden in order to prevent escape of genes via pollen or seeds, since it is likely that such gene flow could contribute to greater spread of this species in wildlands.

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Figure 1. *Cynara* cultivar varieties growing at UCR for genetic analysis and morphological comparison with weedy variety.

Figure 2. Collecting artichoke thistle in Italy; plants are considerably smaller than plants in California (even when grown in California).

Figure 3. Rana and Lauren collect size data for *Cynara* plants in the UCR common garden.

Figure 4. Second common garden location in Irvine, Ca. which includes wild *Cynara* plants from Europe.

Figure 5. Jocelyn and Kenny help with the *Cynara* flower head harvest in the UCR common garden, spring 2007.

Figure 6. *Cynara* population in Lake County; suspected feral garden plants "reverting" to a spiny form.  Note the large head size typical of cultivated artichoke.

Figure 7. Spines on a *Cynara* plant believed to be a hybrid between the wild variety and a cultivar.

Figure 8. An infestation at Crystal Cove State Park in Orange County. These *Cynara* plants are suspected of having a cultivated origin (native habitat in the background).

Figure 9. A population of escaped *Cynara* cultivars in San Diego County.

Figure 10. Janet Leak-Garcia bags a sample from a *Cynara* population in Sacramento County (Janet is 5'3" tall). This population is also suspected of having cultivar origins.