# Application of GIS Technology To Develop A Framework For A Persistent Perennial Weed Biocontrol Program in NW Saskatchewan

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**Abstract**

*The objective of this paper* is to *discuss the* application *of GIS technology for a* perennial *weed biocontrol program.*
*The GIS based survey and mapping of perennial species has provided the* baseline *data for* setting *priorities for target weeds. Application of GIS for biocontrol program management will be discussed.* Topics *will include use of GIS to: identify problem areas; choose release sites; evaluate and monitor* establishment of biocontrol agents and their impact on weed populations. Other GIS *applications to* be *discussed include: evaluation of risk potential of weeds based on landscape characteristics; and justification of the biocontrol agent screening process.*

## Introduction

### Studv Area and Perennial Weed Control Problems

The study area for this project includes 10 rural municipalities in the Prairie and Boreal Plain ecozones of the northwest part of the agricultural portion of Saskatchewan. Due to the favourable climate and fertile soils a wide diversity of crops are grown including cereals and oilseeds as well as forages and several specialty crops.

The northwest region of the agricultural portion of Saskatchewan has a high percentage of uncultivated land which provides an idea1 habitat for persistent perennial weeds such as: *Linaria vulgaris* (yellow toadflax), *Euphorbia esula* (leafy spurge), *Artemisia absinthium* (absinth), *Tanacetum vulgare (tansy),* and *Matricaria perforata* (scentless chamomile). All of these weeds are introduced species from Europe or Eurasia. On cultivated land in this area of Saskatchewan there is a trend towards reducedtillage and zero-tillage farming systems (Benjaminson, et al., 1994). It has been noted that the occurrence of some persistent perennial weeds in annual cropping systems has increased with the trend toward reduced tillage. For example, scentless chamomile is well adapted to reduced tillage farming practices (Blackshaw, Harker, 1996); and adoption of minimum tillage techniques could lead to greater abundance of toadflax (Saner, et al., 1995). Therefore, the acreage at risk of being infested by these weeds and the detrimental economic impact of these weeds on farms in this area is increasing.

Herbicide options for the listed perennial weeds are limited. In many cases herbicide application is impractical because of the large areas to be sprayed, damage done to non-target plant species, the high herbicide rates necessary for control, high cost, and risk of contamination of ground water and soil. Tillage is not an acceptable option for controlling these weeds as it must be intensive to be effective and the probability that wind and water erosion will result is high. It is also difficult and costly to re-establish forage stands.

### Classical Weed Biocontrol

Classical weed biocontrol uses a weed's natural enemies, that feed specifically on the target weed, to establish a long term balance between the biocontrol organism and the target weed. When effective, classical biocontrol requires minima1 cost and effort because established agents will be self-propagating and dispersing. Biocontrol can be a safe, effective, environmentally sustainable, and economic method of controlling weed species. Biocontrol is not a substitute for good land management, however and must be part of an overall land management plan. Weeds will persist if the surrounding vegetation is not vigorous enough to take advantage of the weed's reduced competitive ability.

Biocontrol Control Programs of the Persistent Perennial Weeds

Two adventive insects which attack the reproductive structures of toadflax occur in Saskatchewan (Harris, 196 1). Brachypterolus pulicarius is a flower-feeding beetle, and Gymnetron *antirrhini* feeds on the developing seeds of yellow toadflax. Although these insects have been reported to reduce seed production of yellow toadflax (Harris 1961, Darwent et al. 1975, McClay 1992), the weed continues to be problematic in NW Saskatchewan. It is suspected that additional insect agents are required for yellow toadflax control. Fortunately, a number of European insect agents for yellow toadflax were recently screened by the International Institute of Biological Control (BBC), Switzerland and approved for release in Canada. They include a root-feeding moth and beetle, and a stem-boring beetle. The root-feeding moth, *Eteobalea serratella,* was released in the Senlac area in 1993; however, more releases are needed in order to evaluate its effectiveness. *Mecinus janthinus*, the shoot-boring beetle, was released in the Cutknife area in 1996, and a detailed study was undertaken to assess it's establishment and impact on toadflax populations.

A biocontrol program for scentless chamomile was begun in the late 1980s with the screening of the European seed weevil, *Apion hookeri* by Agriculture and Agri-Food Canada, Regina Station. Approval for release was granted in 1992, and some of the first releases were made in Saskatchewan (St. Walburg and Lloydminster). An adventive population of the weevil also was found in Nova Scotia, and the majority of releases made in Saskatchewan subsequent to 1992 have been from this population. Although *Apion hookeri* has become established at several release sites in Saskatchewan, its numbers are currently low. Additional European insects are currently being screened by IIBC and hopefully will be available for release in the near future,

The biocontrol program for leafy spurge has been ongoing in Canada since 1965, with 17 European insects being released against the weed to date. The greatest control success has been with the *Aphthona* beetles. Although all *Aphthona* species feed on the roots of leafy spurge during the larval stage, each has its own unique habitat requirements. For instance, *A. nigriscutis* prefers sunny, south-facing slopes, whereas, *A. flava* prefers wetter, more shaded sites. Information on establishment success of *A. nigriscutis in* relation to soil attributes also is available.

There is no biocontrol program for absinth or tansy in Canada.

Developing The Framework Using GIS

The initial step in the development of a framework for a biocontrol program for the targeted weeds in the study area was to conduct the weed survey. ArcView was the Geographic Information System (GIS) software used to map the survey results and is currently being used to help manage this project.

The 1994 persistent perennial weed survey was a project of the District 35 Agriculture Development and Diversification Board that obtained funding for the survey from the Canada-Saskatchewan Agriculture Green Plan Program. The Green Plan is also providing funding for the other biocontrol projects taking place in the NW portion of agricultural Saskatchewan during 1996/97.

ArcView

A view in ArcView is an interactive map that lets you display, explore, query, and analyze geographic data. Each view is a collection of themes which represent a distinct set of geographic features in a particular geographic data source. Arc View accepts three types of data: spatial data, image data, and tabular data. ArcView can be loaded on Windows, Macintosh, and UNIX systems. ArcView was run from Windows for WorkGroups on this project. The minimum recommended hardware requirements, as determined by PFRA, are 486/66, 16Mb RAM, Quad-speed CD-ROM, and a 2Mb Video Card.

Weed Survey and GIS Methods

Yellow toadflax, scentless chamomile, absinth, tansy, and leafy spurge were surveyed to identify their location and abundance.

A roadside survey was conducted by stepping off how far the weeds extended down the roadside. For example, if 75 metres of weeds were paced off within a 500 metre distance then 75/500 = 15% on the abundance scale. The actual location on the roadside was also identified to the nearest 100 metre segment. First the legal land location was identified, then the segment of roadside on that land location was identified. The segments for the north and east road sides of a section were always identified starting at the NE comer. South and west road sides were identified always starting from the SW comer. Concomitantly, the adjacent land was observed as to the land use and estimated density of each of the five weeds on adjacent land. The data collection sheet used for the roadside and adjacent land survey is shown in figure 1. Thirty-three percent (147.2 km of 444.8 km) of road sides surveyed had one or more of the weeds present.

(figures at end of paper)

Figure 1 Perennial Weed Survey Data Sheet, example

The information collected was entered into an Excel database and converted to a Dbase IV file with pf locator (pfl). A pfl is a 14 character location identifier, specific to each quarter section in the PFRA township fabric database. Shape files were made from the Dbase files and the weed populations were mapped. ArcView was used to map the weeds in the centre of each quarter section identified for each roadside surveyed.

**Results and Discussion**

Applications of GIS technology identified for managing the persistent perennial weed biocontrol program in NW Saskatchewan included: database management, mapping, data analysis, prioritizing the weed problems identified, choosing release sites, and analysis of landscape risk potential. Other applications of GIS for biological weed control include: justification of expenses for a biocontrol program prior to agent screening by the IIBC, prediction of best sites for release of agents if those preferences are known; and after release: ascertaining the impact of released agents and identifying landscape and climate conditions conducive to agent establishment where this information is not known.

In terms of overall program management, the perennial weeds GIS database for the region is easily accessible, convenient for storing and retrieving the data, and maps can be created to give a visual look at the problem. The maps are also useful for extension of the information through factsheets, news articles, and other media.

The weed maps (Maps 1 - 6) and survey information are the baseline data used for setting priorities for the target weeds. Toadflax and scentless chamomile were made the top priorities for biocontrol due to their abundance and distribution and the availability of biocontrol agents approved for release by AAFC. ArcView was useful in identifying the problem weed areas and several of these areas were used as release sites for agents of yellow toadflax and scentless chamomile during 1996/97.

(maps at end of paper)

Maps 1 - 6 Distribution of each weed surveyed.

Background information on weed distribution and abundance is a prerequisite for a classical biocontrol program. First, a full biocontrol program for a weed, including a European survey for natural enemies and subsequent screening of candidate agents, is costly. Agents are usually scarce in their native regions because weeds are often at a low population level there. Agents must be collected, propagated, and adapted to

Canadian climates prior to their widespread distribution. It can take several years to allow for adequate population build up and distribution of the agents necessary to control a given weed. Hence, information on a weed's rate of spread and economic impact is needed in order to justify the expense if a biocontrol program has yet to be initiated. Second, once agents are screened and approved for release, it is expedient to the biocontrol program to have release sites pre-chosen based on weed density or on habitat conditions conducive to agent establishment. Agents may not be successful in every situation as precise habitat requirements are not always known at the time of release. GIS could facilitate the use of soil, landscape and climate data with weeds data for predicting the best sites for biocontrol agent release. Maps showing the distribution and abundance of weeds targeted for biocontrol, together with geographic landscape and climate data will help in choosing experimental sites for initial releases. Subsequently, success or failure of agent establishment may then be related to the geographic data to determine if an agent has a habitat preference. If adequate habitat information is acquired from the agent's native distributional area (eg. Europe), then the ArcView database can also be used to select release sites that are the most suitable for agent establishment. For example, habitat information is available for A. *nigriscutis,* hence, it is an easy step to use the GIS database for leafy spurge when choosing appropriate release sites for *A. nigriscutis.* Such measures can both speed and increase the chances for success of a biocontrol program. Lastly, once agents are established at sites, their impact on weed density can be monitored through continued surveys and mapping of weed distribution and abundance.

If future surveys are done GIS can be used to evaluate and monitor establishment of the biocontrol agents and their impact on weed populations. Comparison of weed data from future surveys to the 1994 survey could be used to determine the "radius" of biocontrol. The "radius" being measured in terms of weed abundance. Lower abundance indicating effectiveness of the biocontrol agents in terms of weed suppression and how far the biocontrol agent establishes and spreads out from the initial release sites. Several surveys of weed abundance and distribution could also monitor the movement of biocontrol agents over time. Certainly there could be many factors in addition to biocontrol agents that could affect weed abundance and distribution over time. Hence, detailed field studies of agent impact on weed populations are required to establish a cause and effect relationship between agent presence and changes in weed density. Such a study currently is being conducted on the impact of a stem weevil on yellow toadflax in the North Battleford Region. Also, *A. nigriscutis* is well established and has been shown to be controlling spurge in parts of Saskatchewan, so GIS could be used to monitor spurge population changes at a regional level.

The weeds database will be useful for comparing infestations of these weeds among geographic locations to determine if there are soil, landscape and climate factors that favour the presence of these wee&. For example, scentless chamomile was found on dark gray chemozemic and gray luvisolic mineral soils. Ninety percent of the scentless chamomile sites were on knoll and kettle topography with 4% to 9% slopes and sandy loam surface textures. Ninety-two percent of the scentless chamomile sites were on soils with moderate to strong pH. If there was another survey area in the province it might be possible to substantiate some of the soils and landscape data analysis findings. These survey results were obtained from a narrow geographic area and so the findings are preliminary and not conclusive in terms of what landscapes and soils may be at higher risk of becoming infested by these weeds. It would be interesting to compare the soil, landscape, and climate factors of other weedy sites to see if there are trends that would indicate increased risk potential of these weeds. GIS would be useful for doing this type of analysis.

Cost of ArcView

At the North Battleford PFRA District Office the cost of the hardware to run ArcView was approximately $2500. Hardware included a P75 pentium with 16Mb RAM, a quad speed CD-ROM, a 2Mb video card, and Windows for Workgroups. The North Battleford office already had a colour printer. A multiple site license for ArcView software was purchased for district offices by the Regina headquarters GIS Unit. North Battleford's share of this cost was $570. District offices were not charged for the PFRA GIS Data Library Users Guide and CD which included the spatial locations of the township fabric for Saskatchewan used to locate the weed survey data.

Staff GIS training costs are not included in the above costs.

The amount of time it takes to learn GIS will vary according to how much computer experience a person has and whether or not they have used similar programs. Training using only the ArcView self tutorials can be very frustrating. A one day PFRA training session was very useful. Two to three days of training with practice time is recommended.

About 115 hours were spent learning ArcView, creating maps of the weed survey data, and completing the data analysis for the weed survey. This does not include the time spent exporting the maps and importing them into Core1 Draw for further labelling, colouring, and printing.

In terms of what was accomplished, 115 hours does not seem unreasonable. Future projects, data analysis, and information extraction will all be easier and take up less time for future projects.

**Conclusion**

GIS was useful for managing the persistent perennial weed biocontrol program and its use will continue.

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FIGURE 1

# PERENNIAL WEEDS SURVEY DATA SHEET

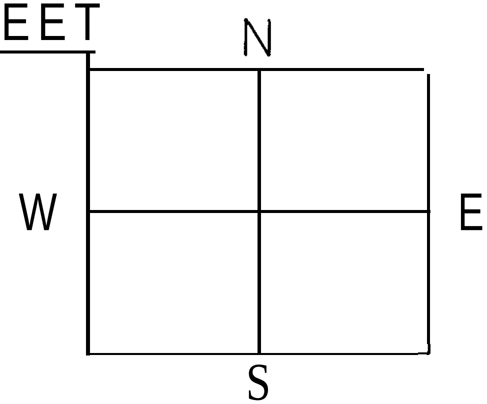
DATE: ____________________

WEED DESCRIPTION: ____________

NAME: ____________________

LAND LOCATION: ____________

WEED PRESENT: YES / NO




| SECTION SIDE | SAMPLE UNIT LOCATION | ABUNDANCE SCALE | ADJACENT LAND USE: DENSITY: |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**DENSITY SCALE**

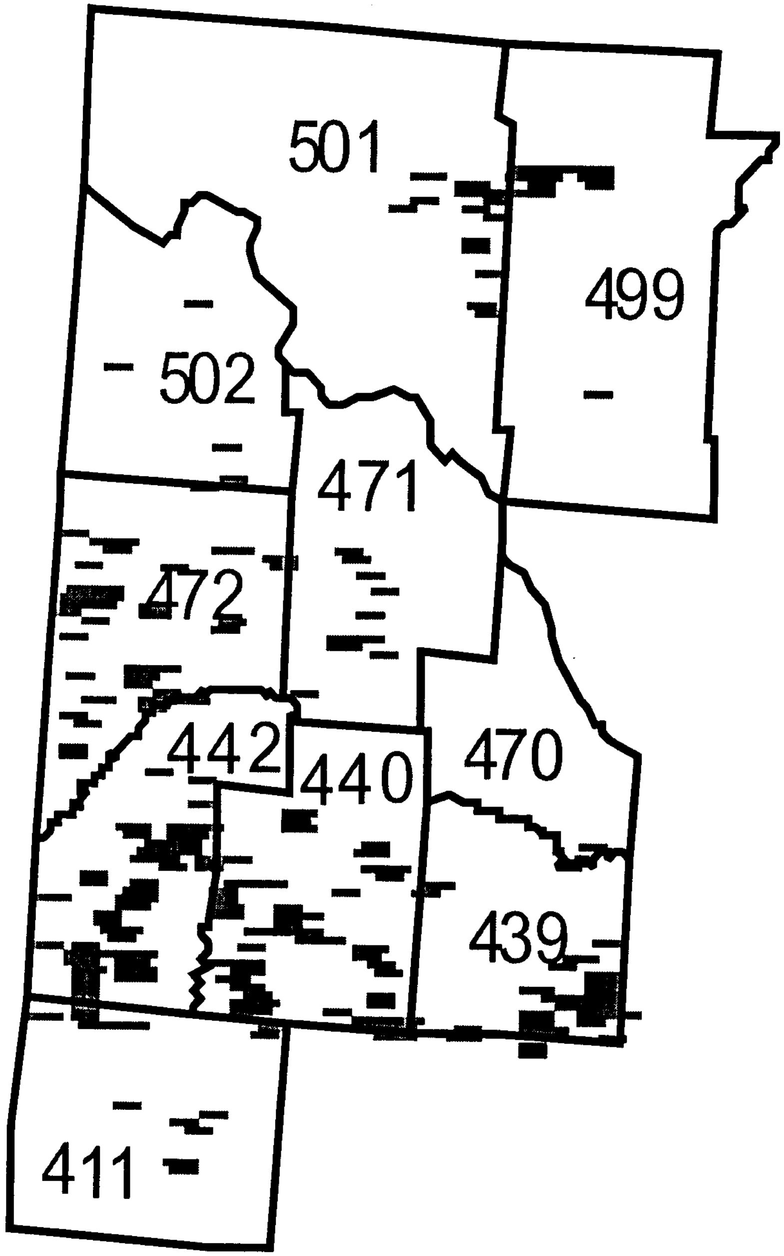
0 ABSENT
1 < 1% COVER
2 MODERATE 1-10% COVER
3 > 10% COVER

**LAND USE**

0 BUSH
1 FALLOW
2 PASTURE
3 CROP
4 YARDSITE
5 SLOUGH

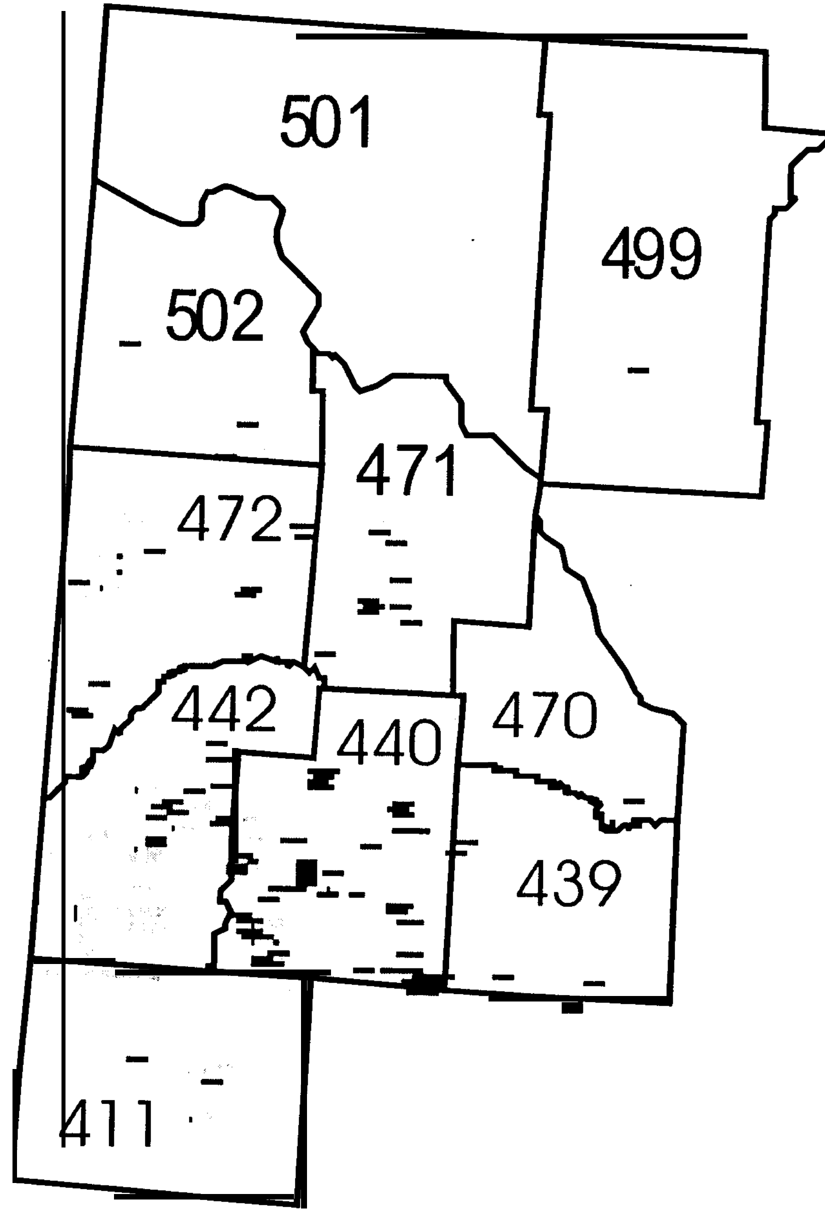
COMMENTS: ____________________

## District 35 Perennial Weed Survey
### - All sites sampled



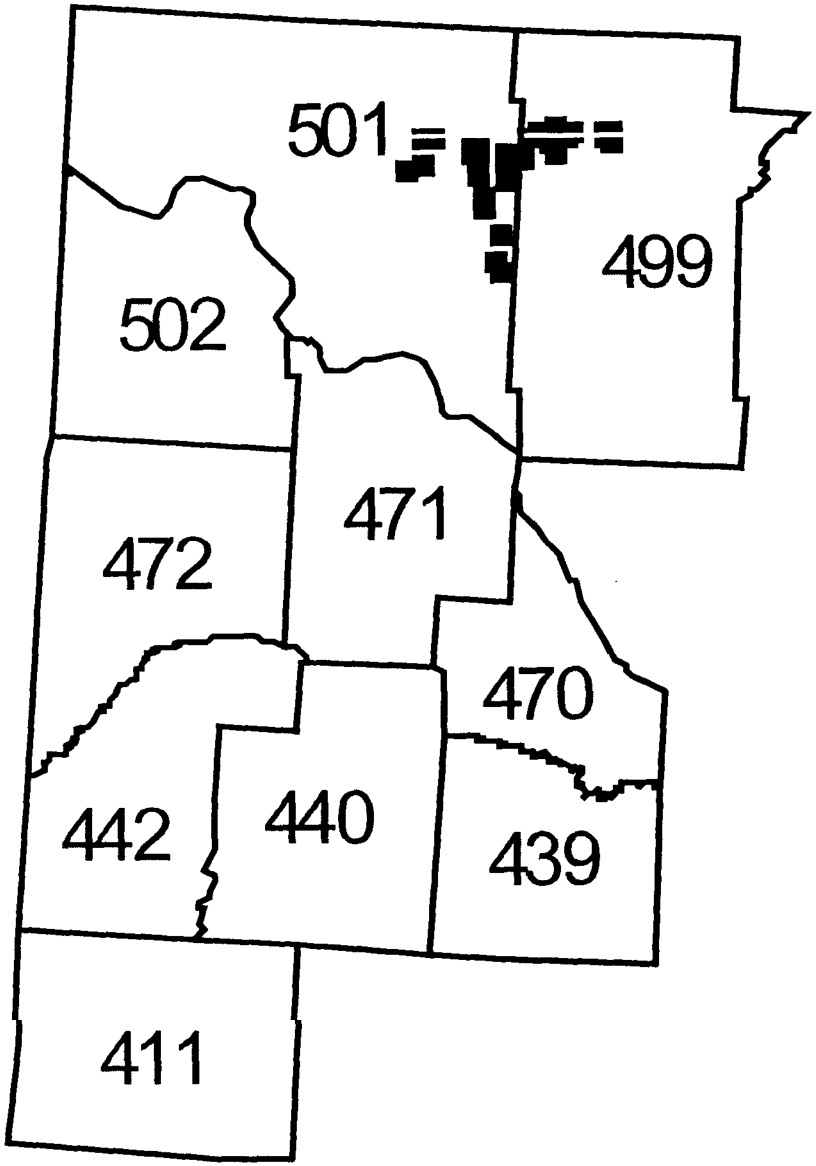

Map by K. Benjaminson PFRA North Batleford

## District 35 Perennial Weed Survey
### -Toadflax



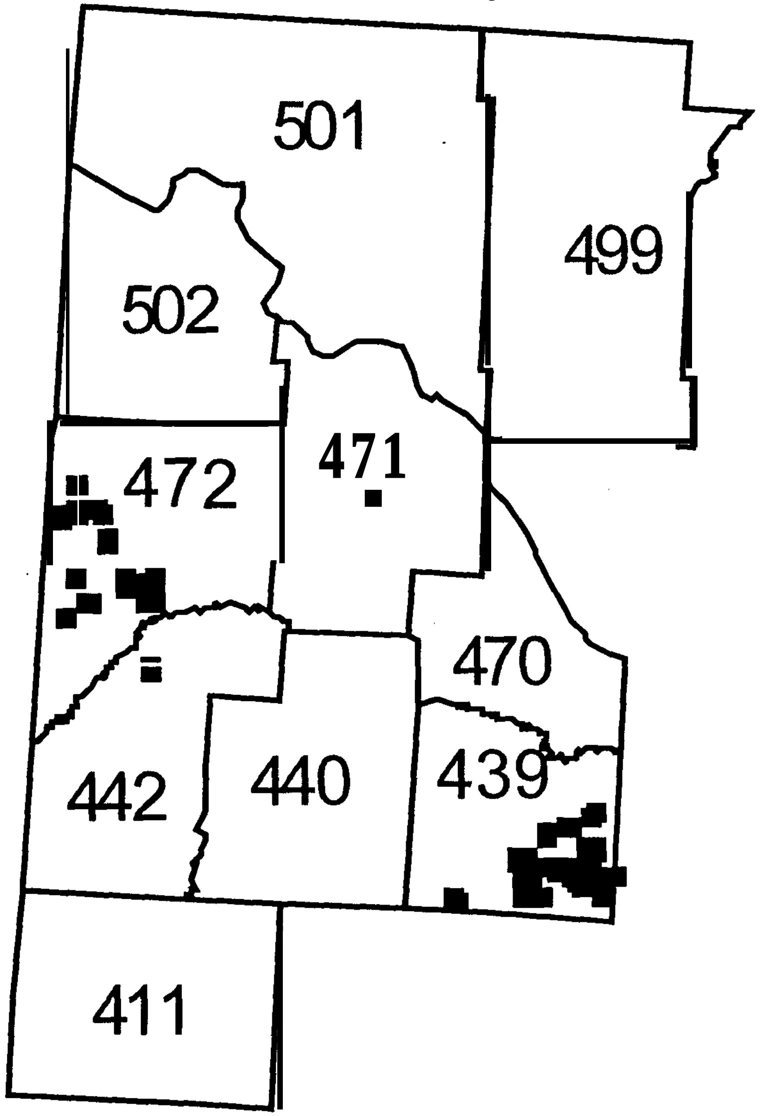

Map by K. Benjaminson PFRA North Battleford

## District 35 Perennial Weed Survey -Scentless Chamomile



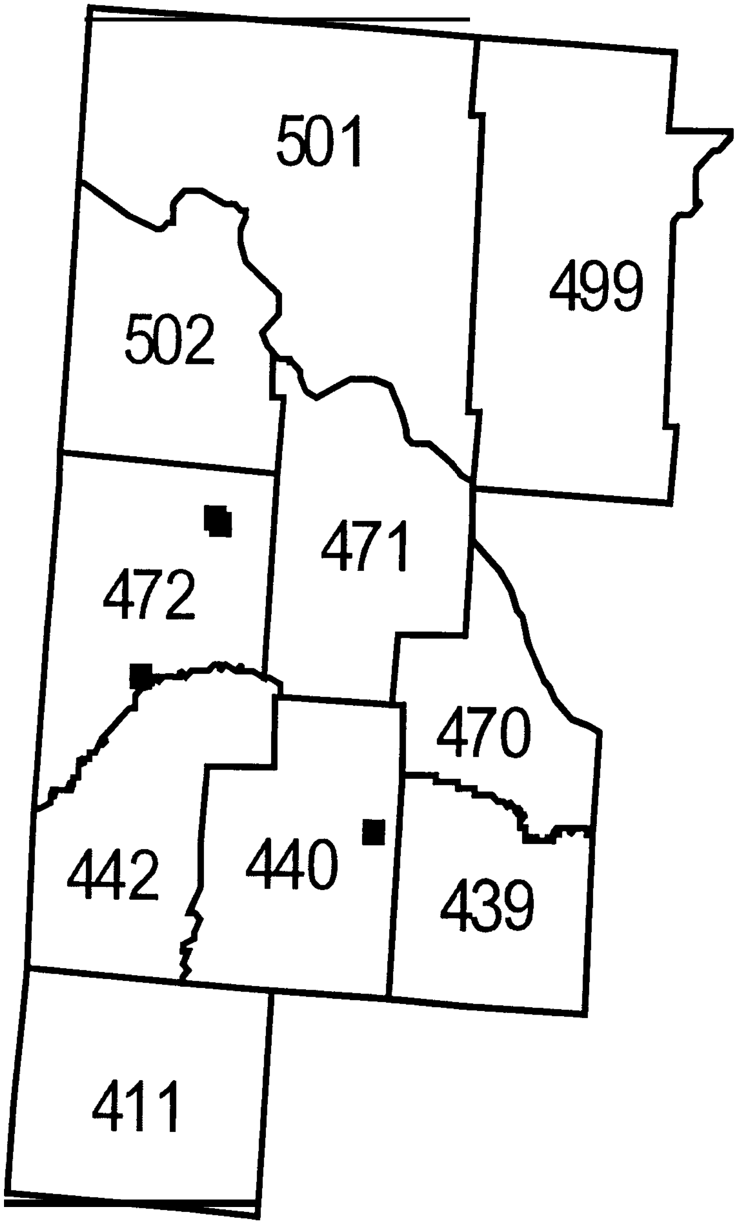

Map by K. Benjaminson, PFRA North Battleford

## District 35 Perennial Weed Survey -Tansy



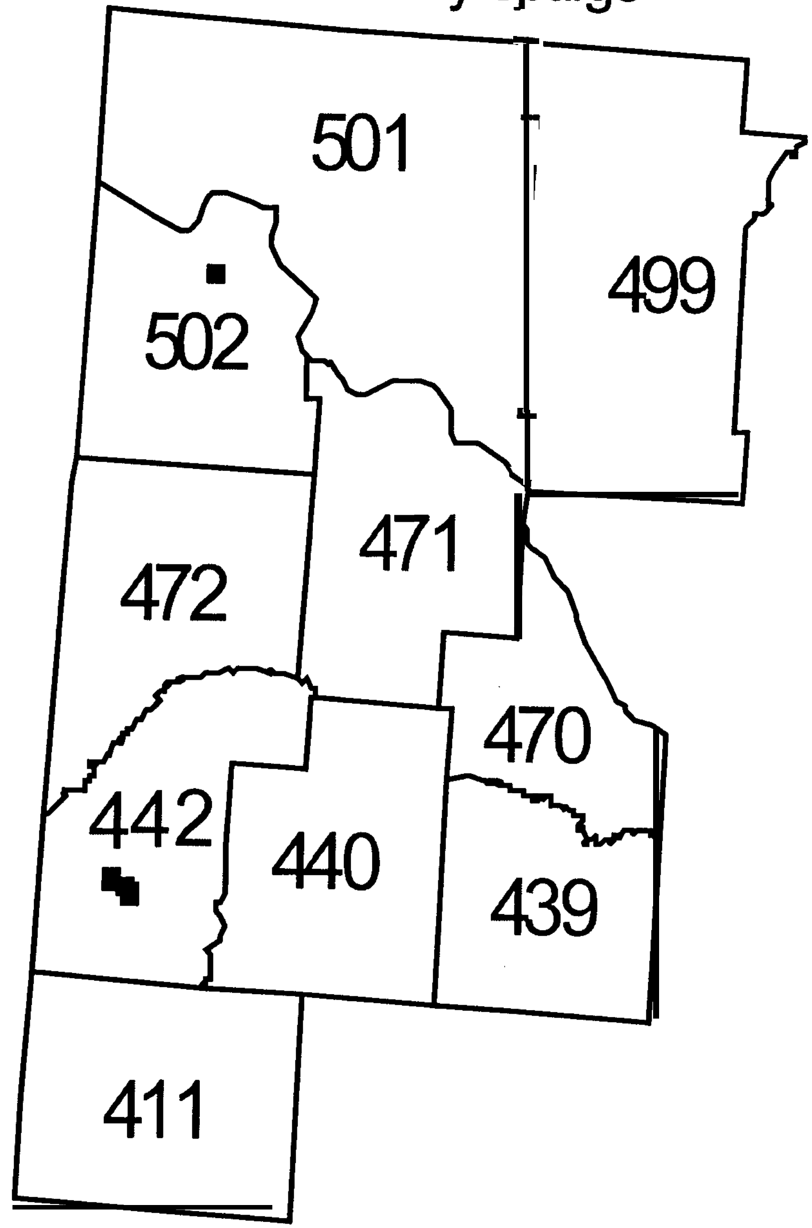

Map by K Benjaminson, PFRA North Battleford

## District 35 Perennial Weed Survey - Absinth




Map by K. Benjaminson, PFRA North Battleford

## District 35 Perennial Weed Survey - Leafy Spurge




Map by K. Benjaminson, PFRA North Battleford