MICHIGAN
CONSORTIUM
of BOTANISTS

Michigan Threatened and Endangered Plants Assignment

This assignment is to research a Michigan threatened and/or endangered (T&E) plant, generate an annotated bibliography and locate a list of resources currently available in the internet which relate to your plant species. The annotated bibliography will detail results from research studies and written reports related to the selected T&E plant species selected. Results from this bibliography will be used to generate an on-line database for T&E plants in Michigan. Results will be posted on the Michigan Consortium of Botany (MICOB) website MiCOB.org and will be credited to the students doing the literature research.

Assignment specifics:

Choosing a Species:

A list of potential species is available at the Michigan Natural Features Inventory (MNFI) site:

http://web4.msue.msu.edu/mnfi/data/specialplants.cfm

Before confirming your plant, do a little research to see what you can find. Make sure you are prepared to thoroughly review the literature on this plant. Some plants have little published on them others have been extensively studied. Review this so you are prepared for the work it takes to do an exhaustive review.

Annotated Bibliography:

A good description of an annotated bibliography can be found at:

http://owl.english.purdue.edu/owl/resource/614/01/.

The authors of this site define a ***bibliography*** as a list of sources (books, journals, websites, reports etc.) used when researching a topic; this list usually just includes bibliographic information (i.e., the author, title, journal, etc.). They define an ***annotation*** as a summary and/or evaluation, therefore an annotated bibliography is a summary and/or evaluation of each of the sources.

You will be expected to do a comprehensive literature review. This includes all references related to your plant of study. A good place to start and get some "preliminary information" is Google. A Google search may find references from websites, the Flora of North America, the Michigan Natural Features Inventory Explorer and Abstracts, the Michigan Flora, the USDA, the International Plant Name Index, and surveys and status reports (just to name a few). This may also give you preliminary information you can use to select key words and alternative plant names. Google Scholar is also an excellent source. Of course, you should definitely look in the Web of Science. Once you see the full text of an article and have the accompanying bibliography, review the bibliographies of the publications to assure you have seen (and cited) all pertinent referenced sources. Also, use Google Scholar and Web of Science to see who has cited the articles you have found. When you are no longer finding new references, you know you are done.

When conducting your searches ***try all versions of your plant name***, both common and Latin. Make sure to check synonyms. Explore your plant genus as well, to see what is known about close relatives to your plant.

Some references will be about just your plant and others will include it peripherally. All these items must be referenced and annotated. If an article is not published in English, it needs to be cited and the annotation should note the language barrier. Often the abstract is in English, if so this can be noted with some comments about the content. You will encounter references not available through the University or College library at your institution, you will be expected to

request these articles, read them once available and include them in your review. “We don’t have it at our library” or “I didn’t have time to request it” are not legitimate reasons to not include a reference.

For each source you need to include bibliographic information (properly cited), an annotation and a copy of the reference itself. Your summaries of each reference (including the citation itself) should be no longer than an third to half a typed page (see attached formatting guidelines), and should be written in complete sentences. These should be organized in alphabetical order into a single document and accompanied by a stack of references also in alphabetical order.

Bibliographic information:
The bibliographic information for the source (title, author, publisher, date, etc.) should follow the format of the journal ***Wetlands*** (see attached formatting guidelines).

Example citation:

Beetle AA (1943) Studies in the genus *Scirpus* L. VI. The section *Schoenoplectus* Palla. American
Journal of Botany 30:395-401.

Annotations:
The annotations for each source should be written in paragraph form (see attached formatting guidelines). Lengths of the annotations can vary from a few sentences to a couple paragraphs, but generally should be about one or two paragraphs in length and no more than one half page single-spaced including the citation. Most of your bibliography should focus on the content of each source, but I expect you to include a few sentences of reflection for each source.

Annotations for each source should address the following questions:

a) *Content*: What is the overall topic of this citation? What is the research goal (if a research paper) or intent of the publication (if a report or white paper)? What were the findings and conclusions as they relate to your T&E plant?

b) *Reflection*: Comment on the area of research/study/information this reference covers. Is the content and/or research exhaustive or does research remains to be conducted in this study area for your T&E plant?

List of Resource:

A list of clickable links needs to be generated for the T&E plant species. This list must include the specific link for the selected T&E species at the following sites*:

- Michigan Flora
- Michigan Natural Features Inventory Rare Species Explorer
- Michigan Natural Features Inventory Abstract
- USDA Database
- vPlants
- Flora of North America
- Tropicos
- Encyclopedia of Life

*In some cases the species may not have information on one or more of these sites. Before reaching this conclusion be sure to check all synonyms!

Formatting Directions
MiCOB Annotated Bibliography:
Michigan threatened and/or endangered plant species

Margins and ALL font:

Margins should be set to one inch on all sides of the document. The document must be single spaced with Calibri font, size 11. This should be consistent in the header and footer.

Header:

The header of the annotated bibliography should be right justified and include the student's last name and plant name in italics (no authority) on all pages except for page one. Please follow the example format.

* To remove the header from page one in Microsoft 2010, click **design** under **header and footer tools** and select the box that says **different first page.**

Example:

Shiels: *Schoenoplectus torreyi*

Footer:

In the footer of the paper, there should be the page number, right justified, on all pages including page one.

Title section:

The title section begins with a line including the assignment and name of plant with authority (all in bold). The second line states "Submitted" followed by the semester and year submitted. The third line remains blank. The fourth line states the student author. Fifth line includes the instructor's name. The sixth line is left blank. Seventh line includes the statement "In partial fulfillment of the requirements for". Eighth line is the designator, class number and name of the course. The ninth and final line is the student university or college. Follow the example format below including all punctuation.

Example:

Annotated Bibliography: *Silphium perfoliatum* L.
Submitted Fall 2011

Student Author: Rachel Hackett
Instructor: A. K. Monfils Ph.D.

In partial fulfillment of the requirements for
BIO 597: Wetland and Aquatic Plants of the Great Lakes Region
Central Michigan University

All sources:

All sources should be in alphabetical order by the author's last name. Each source should be in bold font and have a hanging indent. The bibliographic information for the source (title, author, publisher, date, etc.) should follow the format of the journal ***Wetlands***.

* To make a source have a hanging indent using Microsoft Word 2010, highlight the source, right click and then click **paragraph** under the indentation section choose **hanging** from the **special** drop down menu. In the **by** field, next to where **hanging** is selected, type **0.5**".

Examples:

Beetle AA (1943) Studies in the genus *Scirpus* L. VI. The section *Schoenoplectus* Palla. American Journal of Botany 30:395-401.

Belanger L, Bedard J (1994) Role of ice scouring and goose grubbing in marsh plant dynamics. Journal of Ecology 82:437-445.

Paragraphs:

For each Paragraph in the annotated bibliography, there should be no indentations or tabs. Each paragraph should be separated by a single spaced line.

Example:

Clevinger, J.A. and J.L. Panero. 2000. Phylogenetic analysis of *Silphium* and subtribe Englemanniinae (Asteraceae: Heliantheae) based on ITS and ETS sequence data. American Journal of Botany, 84:565 – 5572.

The objectives of this taxonomic study including the genus *Silphium* were to determine if *Silphium* and related sections evolved from a single ancestor, evaluate the subtribe Engelmanniinae, determine the validity of the Mesoamerican origin hypothesis of Engelmanniinae, and examine the evolution on the cypsela complex. Clevinger and Panero used nuclear ribosomal DNA analyzed using data from the Internal Transcribed Spacer (ITS) and the External Transcribed Spacer (ETS) regions.

This information provides evolutionary clues to the origin of *Silphium* and subtribes related to the genus and sections within the genus. Knowing more evolutionary data allows for more studies of *Silphium* extracts, which appear to be important for the medical field, in not only *Silphium perfoliatum* but closely related species.

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Conrad, M., A. Biertümpfel, and A. Vetter. Optimization of the cropping system for cup plants as a coferment in biogas plants as well as implementation in agricultural practice: The cup plant (*Silphium perfoliatum*) – an alternative biogas crop poster. Agency for Renewable Resources.

This poster (the project paperwork nor cited works could be found with the resources available) evaluates the use of *Silphium perfoliatum* as an energy fuel crop. It displays results from studies completed by Dornburg from 2006 – 2009 and a few others from 2008-2009 including a comparison of dry mass yield between maize and *S. perfoliatum*, a relationship study of planting distance and dry mass yield, a comparison of dry mass yield of cup plants in different locations around the world, an evaluation of the method of planting *S. perfoliatum* under a cover crop of *Sorghum*, and a comparison of harvest time on methane content over four years.

This is a nice visual compilation of studies relating to the practicality of using *S. perfoliatum* as a fuel crop. As the authors point out, the planting system and the processes of the plant needs further studies to prove its validity. There are also problems related to silage of *S. perfoliatum* that need to be examined, as other papers focus on, before it could be considered. Also missing from this poster is a comparison of the net gain of energy in a *S. perfoliatum* fuel against other biofuel crops.

Daniel, P. and R. Rompf. 1994. Possibilities and limits in the utilization of *Silphium-perfoliatum* as a fodder plant, renewable raw-material and a landscape conservation plant. Agribiological Research-Zeitschrift Fur Agrarbiologie Agrikulturchemie Okologie, 47:345-353.

Article only available in German, but abstract available in English.

Based on the abstract, Daniel and Rompf's study examines the pros and cons of using *S. perfoliatum* as a fodder plant, energy source, or landscape plant. The abstract only mentions those characteristics relating to the use of *S. perfoliatum* as fodder: It has a high yield with high carbohydrates, but its high water content and decreasing digestibility with age calls its practicality into question. Daniel and Rompf recommend more breeding and engineering of the

plant to improve its usability.

This study, or possibly literature review, looks practically at *S. perfoliatum*'s potential for human value. Its conclusions could point further researchers to fill the gap that exists between *S. perfoliatum*'s theoretical utilization or cause researchers to abandon this perennial for another one with more potential.

Davidyants, E. S., J. M. Putieva, V. A. Bandyukova and N. K. Abubakirov. 1984a. Triterpene glycosides of *Silphium-perfoliatum* .2. Khimiya Prirodnykh Soedinenii:666-667.

Article only available in Russian. No English abstract available on Web of Science.

Davidyants, E. S., Z. M. Putieva, V. A. Bandyukova and N. K. Abubakirov. 1984b.Triterpene glycosides of *Silphium-perfoliatum*. Khimiya Prirodnykh Soedinenii:750-753.

Article only available in Russian. No English abstract available on Web of Science.

Davidyants, E. S., Z. M. Putieva, V. A. Bandyukova and N. K. Abubakirov. 1986. Triterpene *Silphium-perfoliatum* glycosides .5. Structure of silphioside-A. Khimiya Prirodnykh Soedinenii:63-66.

Article only available in Russian. No English abstract available on Web of Science.

Davidyants, E. S., Z. M. Putieva, A. S. Shashkov, V. A. Bandyukova and N. K. Abubakirov. 1985. Triterpene glycosides of *Silphium-perfoliatum* .4. The structure of silfioside-C. Khimiya Prirodnykh Soedinenii:519-522.

Article only available in Russian. No English abstract available on Web of Science.

Davidyants, E. Z., Z. M. Putieva, V. A. Bandyukova and N. K. Abubakirov. 1984c.Triterpene glycosides of *Silphium-perfoliatum*. Khimiya Prirodnykh Soedinenii:120-121.

Article only available in Russian. No English abstract available on Web of Science.

Dudkin, M. S., N. K. Cherno and N. G. Shkantova. 1979. Characterization of the water-soluble polysaccharide of the leaves of *Silphium-perfoliatum*. Khimiya Prirodnykh Soedinenii:771-774.

Article only available in Russian. No English abstract available on Web of Science.

El-Sayed, N. H., M. Wojcinska, K. Drost-Karbowska, I. Matlawska, J. Williams and T. J. Mabry. 2002. Kaempferol triosides from *Silphium perfoliatum*. Phytochemistry, 60:835-838.

This descriptive study isolates and identifies two new kaempferol triosides extracted from *Silphium perfoliatum*. Although this study marks the discovery of two new naturally occurring kaempferol triosides, it does not discuss the implications of such a discovery.
This study points out a unique characteristic that could be applicable to the medicinal or food industry. Kaempferol is a flavonoid believed to have antioxident, anti-inflammatory, antimicrobial, anticancer, anti-allergenic, cardioprotective, neuroprotective, antidiabetic, anti-osteoporotic, antiestrogenic, anxiolytic, and analgesic properties. More studies are needed to classify how these two new kaempferols could be valued.

Fiedler, A. K. and D. A. Landis. 2007. Attractiveness of Michigan native plants to arthropod natural enemies and herbivores. Environmental Entomology, 36:751-

765.

Fiedler and Landis select 43 species of Michigan native perennials and 5 species of exotic annuals that are recommended for their attractiveness to beneficial arthropods (natural enemies of pests). They hope to show that 1) some plant species are more attractive to natural enemy arthropods than others, 2) some native species would be of more or equal attractiveness than exotic species recommended for attracting beneficial arthropods, 3) different plant species would attract different numbers and types of beneficial arthropods, and 4) the attractiveness of native perennial species would increase as the plant matured. Although the exotics are more favorable in the first year of the study, the native perennials dominate the second season. The study starts with immature plants and only lasts two growing season which limits its ability to prove or disprove hypothesis 4.

Silphium perfoliatum is one of the native species selected. In the late blooming season, it is one of the species that attracts more beneficial arthropods than herbivores. This could give the plant a value as a biological control plant and increase cultivation.

Han, K. J., K. A. Albrecht, D. R. Mertens and D. A. Kim. 2000. Comparison of in vitro digestion kinetics of cup-plant and alfalfa. Asian-Australasian Journal of Animal Sciences, 13:641-644.

This experimental comparison study aims to explain why *Silphium perfoliatum* is so much more digestible in vitro than *Medicgo sativa*, alfalfa, as previous studies had shown. Han et al. compares the digestive kinetics of the two plants to determine if *S. perfoliatum* has a shorter lag time, a higher digestion rate, higher potential extent of digestion, or less indigestible fraction than *M. sativa*. Their ratio of estimated digestible dry matter to in vitro digestible dry matter is 44 – 81 g/kg for *M. salvia* and 65 – 177 g/kg of *S. perfoliatum*. Their results show that *M. sativa* has a shorter lag time, and the acid detergent lignin (ADL) is less in *S. perfoliatum,* but otherwise there is no significant difference between the species. Although the data shows no significant difference in the indigestible fraction between the plants, the authors try to support their hypothesis by explaining that *S. perfoliatum* showed a higher indigestible portion at mid-flower stage than *M. sativa*, thus has a slower increase of the indigestible fraction.

This study relates to the use of *S. perfoliatum* as fodder for cattle or other animals. Previous studies show its potential to be a better fodder than *M. sativa*, and Han et al. want to determine why. This study is unable to locate the factor that gives *S. perfoliatum* the advantage over *M. sativa*. It tries to supports its argument that *S. perfoliatum* has a less indigestible fraction, but the data is not significantly different.

Han, K. J., K. A. Albrecht, R. E. Muck and D. A. Kim. 2000. Moisture effect on fermentation characteristics of cup-plant silage. Asian-Australasian Journal of Animal Sciences, 13:636-640.

Silage spoilage is a great problem facing farmers. Upon evaluating *Silphium perfoliatum*'s practicality as a fodder crop, its storage ability must be studied and evaluated. Han et al. examine the difference between fresh growth and regrowth on the farm, and wilted and unwilted in the laboratory of *S. perfoliatum* as it relates to silage. In all tested cases the pH is too high or dry matter content is too low for desirable unspoiled silage. The closest case is the silaged regrowth of the *S. perfoliatum,* whose pH is desirable, but its dry matter is 30 g/kg less than desired. Two cases, wilted and unwilted, are performed in the laboratory, so that may affect some of the measured properties.

This study is important to determine whether *S. perfoliatum* is a practical feed crop and, if so, how it should be stored. Based on these experiments, it is not valuable as silage using these methods. More studies should be done concerning wilting time or adding dry content to reduce the moisture.

Konarev, A. V., I. N. Anisimova, V. A. Gavrilova, T. E. Vachrusheva, G. Y. Konechnaya, M.

Lewis and P. R. Shewry. 2002. Serine proteinase inhibitors in the Compositae: distribution, polymorphism and properties. Phytochemistry, 59:279-291.

This study examines the proteinase inhibitors of various species in the Compositae family including *Silphium perfoliatum*. They look at three proteinase inhibitors: Typsin, chymotrysin, and subtilisin. Konarev et al. hope to determine the distribution of these inhibitors in the plant, examine differences between the distribution in cultivars and wild populations, characterize the proteinases, and study evolutionary relationships in the plant family based on their findings. The seeds of *Silphium perfoliatum* contain an N-terminally blocked typsin of 11,439 using HPLC. Konarev et al. is unable to determine what is inhibited by this proteinase.

Thes results could show some evolutionary relationships with other species in Asteraceae. Until it is discovered what the typsin of 11,439 inhibits, this study does not directly contribute to practical knowledge of *S. perfoliatum*. Further research into the reactions of typsin of 11,439 could provide *S. perfoliatum* with more medical uses.

Kowalski, R. 2005. Analysis of lipophilic fraction from leaves, inflorescences and rhizomes of *Silphium perfoliatum* L. Acta Societatis Botanicorum Poloniae, 74:5-10.

Article only available in Polish, but the abstract was found in English.

Based on the abstract, this paper examines the leaves, inflorescences and rhizomes for lipophilic fractions. Like Kowalski and Wolski (2003 and 2005), the chemical composition of the leaves and inflorescences are similar, while the rhizomes differ “slightly.” It lists the main constituents of each of the plant parts and their concentrations, but does not discuss possible meanings or utilization of this information.

This paper provides a base point for further research into the chemical components of *S. perfoliatum*, and possibly its phenology and enthnobotanical uses.

Kowalski, R. 2007. Studies of selected plant raw materials as alternative sources of triterpenes of oleanolic and ursolic acid types. Journal of Agricultural and Food Chemistry, 55:656-662.

The objective of this study is to evaluate the possible use of three *Silphium* species (*S. integrifolium, S. perfoliatum, and S. trifoliatum*) for oleanolic and ursolic acid compared to two common herbal industry used species: *Panax quinquefolium* root (ginseng root) and *Calendula officinalis* flower (pot marigold). Oleanolic and ursolic acids are shown to have many medicinal properties: antibacterial, anti-fungal, insecticidal, anti-HIV, diuretic, anti-diabetogenic, liver protective action, anti-inflammatory, anti-tumoral, and immunomodulatory properties. Aside from the leaves of *S. perfoliatum*, the organs of *S. perfoliatum* do not contain a high enough concentration of oleanolic or ursolic acids for it to be compared to commercially used *P. quinquefolium* and *C. officinalis* nor to be compete with the other *Silphium* species.

S. perfoliatum is unlikely to be used for its oleanolic and ursolic acid concentrations. There are other species that yield more of the acids in more organs. This study will limit the use of *S. perfoliatum* for medial and herbal industries in favor of more productive species.

Kowalski, R. 2009. *Silphium* L. extracts - composition and protective effect on fatty acids content in sunflower oil subjected to heating and storage. Food Chemistry, 112:820-830.

This half descriptive and half experimental study examines the extracts of three species of *Silphium*: *S. integrifolium, S. perfoliatum, and S. trifoliatum*. Of the three, *S. perfoliatum* has the lowest concentration of glycoside-bonded oleanolic acid in both leaves and rhizomes; a high concentration compared to other plants, but the lowest concentration of glycoside-bonded ursolic acid; and the highest concentration of flavonoids. None of the three species have

significant fatty acids.

The experimental portion of the article examines the influence of *Silphium* extracts on the changes of fatty acids in sunflower oil when the sunflower oil is heated and stored for certain amounts of time. This part of the study may be more useful when determining and evaluating methods of extraction and fatty acids.

Silphium spp. has many historic ethnobotanical uses and this study looks to the differences between species of that genus. This information could be used to determine which plants have higher concentrations of key compounds and what parts of the plants are more worthwhile from which to extract.

Kowalski, R. and B. Kedzia. 2007. Antibacterial activity of *Silphium perfoliatum* extracts. Pharmaceutical Biology, 45:494-500.

Kowalski and Kędzia experimental study of the antibacterial activity of *Silphium perfoliatum* extracts shows a strong reaction with *Staphylococcus aureus, Enterococcus faecalis, Escherichia coli*, and *Pseudomonas aeruginosa*. Since they use an extract of the plant, it is unsure what chemical (or combination of) caused the reaction. They compare it superficially with the antibacterial activity of chamomile oil and based on the concentrations needed for inhibition of bacteria, the *Silphium perfoliatum* could have practical medicinal value.

The article's introduction includes good information about the history of *Silphium perfoliatum* and a summary of some preliminary studies that could have medicinal value. The chemical(s) responsible for the antibacterial reactions should be isolated and evaluated for practical value.

Kowalski, R. and T. Wolski. 2003. TLC and HPLC analysis of the phenolic acids in *Silphium perfoliatum* L. leaves, inflorescences and rhizomes. Jpc-Journal of Planar Chromatography-Modern Tlc, 16:230-236.

The descriptive study of the phenolic acids in *Siliphium perfoliatum* finds seven phenolic acids within the leaves, inflorescence, and roots. Caffeic acid dominates the phenonic acids. Caffeic acid is an antioxidant and inhibits carcinogens. This source of natural phenolic acids could be useful antioxidants for the foodstuff industry. Another acid found is protocatechuric acid, an antioxidative and anticancerogenic acid which has been shown to inhibit chemical cancerogenesis and initiation and post-initiation stages in animals.

The goal of this article is to provide and document baseline data about the species for further research. *Silphium perfoliatum* has values such as animal fodder, medicinal research, ornamental use, and cultivation. All of the specimens examined are cultivated in a laboratory. Those grown in the wild may have different properties as a result of their environment.

This study shows the potential of *Silphium perfoliatum* for the food and medicinal industries. A more in-depth analysis of the phenolic acids are needed to determine possible and practical uses of the plant and its components.

Kowalski, R. and T. Wolski. 2005. The chemical composition of essential oils of *Silphium perfoliatum* L. Flavour and Fragrance Journal, 20:306-310.

The purpose of this study is to evaluate and compare the content and chemical composition of the essential oils in *Silphium perfoliatum*'s leaves, inflorescences, and rhizomes. An analysis of the essential oils of *S. perfoliatum* show potential medical, agricultural, herbal, or fragrance uses. The leaves and inflorescences have similar compounds, but the essential oil from the rhizomes have a completely different composition.

Essential oils are increasing in popularity for their use in consumer products. Many have disinfecting, antibacterial, antifungal, or pest-repelling properties. This could increase the human value of *S. perfoliatum*. Future studies should focus on testing these properties of the *S.*

perfoliatum extracts.

Neumerkel, W. and B. Martin. 1982. *Silphium* (*Silphium-perfoliatum* L) - A new feed plant. Archiv Fur Acker Und Pflanzenbau Und Bodenkunde-Archives of Agronomy and Soil Science, 26:261-271.

Article only available in German. No English abstract available on Web of Science.

Olson, D. M. and D. A. Andow. 2006. Walking pattern of *Trichogramma nubilale* Ertle & Davis (Hymenoptera; Trichogrammatidae) on various surfaces. Biological Control, 39:329-335.

Olson and Andow examined the effect tricome density has on the walking speed and pattern of the minute parasitic wasp *Trichogramma nublale*. *T. nublale* is considered a beneficial insect, parasitizing the eggs and and larvae mostly of Lepidopterns. Olson and Andow believe tricomes may affect the wasp's ability to search and find suitable hosts. *Silphium perfoliatum* is chosen as one of the plants examined because it is “large, relatively smooth, and lacked tricomes.” The wasps walk considerably faster on *S. perfoliatum,* and the wasp's net displacement per second is higher than on the other plant species and surfaces examined.

This information and further research in this area could lead to the development of better cultivars for biological control. The easier it is for the wasps to find its hosts, the less damage the lepidopterns can cause the crops.

Pan, G., Z. Ouyang, Q. Luo, Q. Yu and J. Wang. 2011. Water use patterns of forage cultivars in the North China Plain. International Journal of Plant Production, 5:181-194.

Pan et al. examine the water requirement, water use efficiency, and annual evotransperation of common crop species in the North China Plain, including the perennials *Silphium perforliatum* and *Medicago sativa* (alfalfa), and the annuals *Secale cereale* (ryegrass), x*Triticosecale* Wittmack (triticale), *Sorghum biolor* x *Sorghum sundanense c.v.* (sorghum hybrid sudangrass), *Zea mays* (ensilage corn), and *Amaranthus paniculatus* (prince's feather). The objective of this study is to compare these species in water requirements in order to predict their success in the uncertainty of climate change. The North China Plain has monsoon rains during the late summer, but can also experience drought and water shortages as more people are relying on the same resource.

There is no significant difference in the annual evapotranspiration among all seven species, but there is a significant difference between the perennials. *S. perfoliatum* outperforms *M. sativa* with an annual evotransperation of 601 mm versus 789m mm of *M. sativa*, and an irrigation rate of 2.9-4.4 mm per day, which out-performs all but ryegrass and triticale.

This study shows that in the face of climate change, *S. perfoliatum* may be a better choice of perennial feed crop than *M. sativa*. The agricultural industry may soon turn to *S. perfoliatum* as a standard feed crop because of its water efficiency and lower irrigation need.

Pcolinski, M. J., R. W. Doskotch, A. Y. Lee and J. Clardy. 1994. Chlorosilphanol A and silphanepoxol, labdane diterpenes from *Silphium-perfoliatum*. Journal of Natural Products, 57:776-783.

This is a descriptive study of the chemical structure of two chemicals found in the leaves of *Silphium perfoliatum*. Chlorosilphanol A and silphanepoxol are isolated and analyzed to confirm their structure and absolute configuration. Also chlorosilphanol A is converted to silphanepoxol by first converting it to chlorosilphanol A 15,16-diacetate.

This study could give understanding to some of the chemical reactions going on inside the plant. Understanding those processes could lead to laboratory reproduction of chemicals found in

Silphium perfoliatum. This could prove useful if an ethnobotanical use of these chemicals is found.

Penskar, M.R. and S.R. Crispin. 2010. Special Plant Abstract for *Silphium perfoliatum* (cup plant). Michigan Natural Features Inventory. Lansing, MI. 3 pp.

This publication describes the taxonomy, range, description, habitat, status, and Michigan occurrences of *Silphium perfoliatum*. Its major threats in Michigan is habitat destruction and population isolation. In Michigan, natural *S. perfoliatum* colonies are found along rivers and in flood plains of southeastern and southwestern Michigan.

This publication is a good starting point for those researching *S. perfoliatum*.

Puia, A. and A.T. Szabo. 1985. Culture experimentale d'une nouvelle espece fourragere (Experimental cultivation of a new type of forage). Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 15:15-20.

The article is in French, but the abstract is found in English.

This study examines the average production of *Silphium perfoliatum* over two years for silage and seed. The seeds are slow to germinate, but *S. perfoliatum* reproduces readily by rhizomes. There is no comparison of the production of *S. perfoliatum* to other crops mentioned in the abstract.

This is one of the first studies into using S. perfoliatum as a forage crop instead of a cultivar (in Europe). It starts many minds thinking about the practicality of using this prairie perennials as a feed crop

Ramos, M. H., J. W. Lehmkuhler, S. C. Arp and K. A. Albrecht. 2006. Investigating *Silphium perfoliatum* (cup plant) silage for growing cattle. Journal of Animal Science, 84:261-262.

Ramos et al. evaluates the use of *Silphium perfoliatum* as feed for cattle compared to and mixed with feed corn. Two experiments compare adult cattle's and young steer's average daily weight gain while being fed 100% corn silage, 1/3 *S. perfoliatum* mixed with 2/3 corn, or 2/3 *S. perfoliatum* mixed with 1/3 corn. The results show no significant difference between the 100% corn and 1/3 *S. perfoliatum* mix. The third experiment examines the feces of the cattle fed those mixtures to determine their dry matter intake (DMI). The 100% corn produces feces with the highest amount of DMI, while the feed with *S. perfoliatum* is not significantly different from each other.

Based on these studies, *S. perfoliatum* could be mixed into corn feed at low levels without diminishing the daily weight gain of the cattle or dry matter intake of the cattle. This study contributes to those researching the practicality of using *S. perfoliatum* as silage and fodder for livestock. More work should be done on the nutritional value of *S. perfoliatum* compared to other feeds.

Stanford, Geoffry. 1990. Cup plant (*Silphium perfoliatum*) as a new forage.

The paper summarizes the findings of scientific studies on *Silphium perfoliatum* up to 1990, paying more homage to those studies relating to taxonomy and agricultural purposes with one paragraph about herbal and medicinal use.

This paper acts as an old one stop shop for those interested in learning the basics about *S. perfoliatum*. It can be used to find older resources on *S. perfoliatum* that many not be easily located online.

Valant-Vetschera, K. M. and E. Wollenweber. 2007. Chemodiversity of exudate flavonoids

in seven tribes of Cichorioideae and Asteroideae (Asteraceae). Zeitschrift Fur Naturforschung C-a Journal of Biosciences, 62:155-163.

This article was not found in English, but has an English abstract.

This study examines and compares the structures of the flavonoids in various tribes of Asteraceae, including Astereae, which includes *S. perfoliatum*. The most diverse flavoniods are found in Astereae.

The flavoniods of *S. perfoliatum* are studied and examined long before this paper was published, so its impact on *S. perfoliatum* may be minimal.

Williams, J. D., M. Wojcinska, L. M. Calabria, K. Linse, J. A. Clevinger and T. J. Mabry. 2009. The Flavonoids and Phenolic Acids of the Genus *Silphium* and Their Chemosystematic Value. Natural Product Communications, 4:435-446.

This study builds onto Clevinger and Panero's phylogenic study of the *Silphium* genus based on ribosomal DNA (2000). Williams et al. examine the phylogenics of the genus based on flavoniods and phenolic acids found in eleven species including *Silphium perfoliatum*. The data supports Clevinger and Panero's division of the genus.

S. perfoliatum contains the most kaempferols (seven) of all the species, two quecetin flavoniods all the benzoic acids tested for, and several cinnamic acids, but is low in the concentration of total phenolic acid yields compared to others in the genus. Despite its low concentration, the authors believe that there could be commercial value of the p-hydroxybenzoic compounds in *S. perfoliatum*. Further research should examine the use and practical value of flavonoids and phenolic acids in *S. perfoliatum* for the medical, food, and chemical industries.