

## Assessment of Invasive Species in Indiana's Natural Areas

### \*\*\*OFFICIAL SWEETCLOVER (*Melilotus alba* and *M. officinalis*) ASSESSMENT\*\*\*

Answers are underlined and in **bold**, comments are inserted in *italics*

Members of 8/1/2005 assessment subcommittee: Ellen Jacquart (TNC), Rick Phillabaum, Larry Nees, Keith Johnson, and Hilary Cox.

Invasive Ranking Summary	Score
Ecological Impacts	24
Potential For Expansion	20
Difficulty of Management	17
<b>Total Score:</b>	<b>61</b>
	<b>Medium</b>
<i>Rankings: Low &lt; 45, Medium 45 – 80, High &gt; 80</i>	

#### Contents of the Assessment:

**Section I** – Invasion Status. Determines whether the species being evaluated is invasive in Indiana.

**Section II** – Ecological Impacts of Invasion. Evaluates the significance of impacts of the species.

**Section III** – Potential for Expansion. Evaluates the actual and/or potential expansion of the species.

**Section IV** – Difficulty of Management. Evaluates how hard it is to control the invasive species.

**Section V** – Commercial Value. Evaluates how valuable the species is economically in Indiana.

Questions in Sections I – V may direct you to one or more of the following sections for particular invasive species:

**Section A.** For species which have impacts limited to a few sites, assesses the potential for further spread.

**Section B.** For species which have medium impacts but high value, assesses whether species could be used in specific circumstances that would prevent escape and invasion.

A worksheet for use with the assessment is found on page 9.

### Automatic Exemption From the Assessment

Is this species listed on any federal or on an Indiana state noxious, or prohibited plant lists?

If **YES** then do not proceed with assessment but indicate a conclusion of  
**Do not use this plant** on the front of the response form.

If **NO** then go to Section I.

### Section I

### Invasion Status

#### 1-a Current Invasion in Indiana

1. Does this species occur in any natural areas in Indiana?

If **NO** then go to Section III-c.

If **YES** then go to 1-a 2.

2. Does it **ONLY** occur in natural areas of Indiana because it has persisted from its previous cultivation (e.g., in abandoned farmland or homesteads)?

If **YES** then go to Section III-c.

If **NO** then go to Section 1-b (below).

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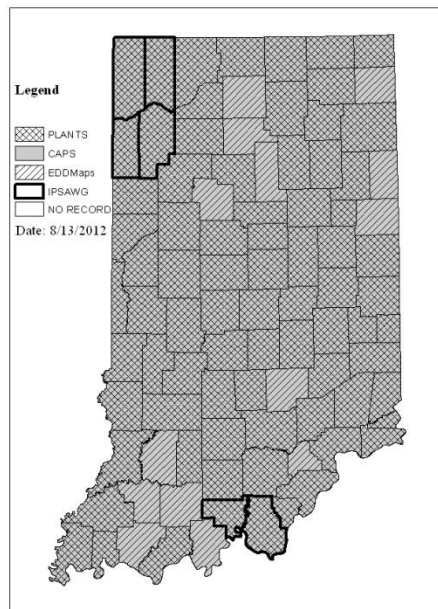
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**1-b Invasion Status in Indiana**

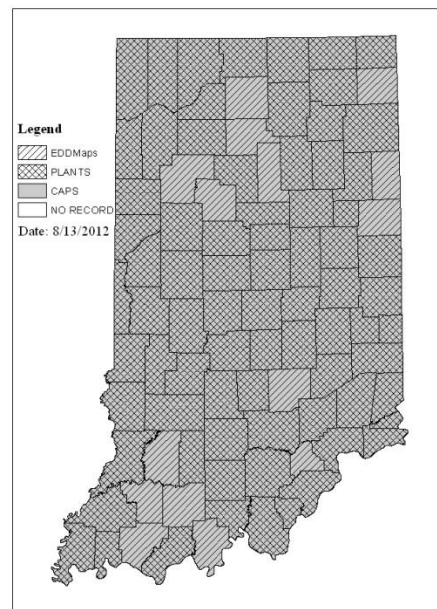
Evidence of invasion (forming self-sustaining and expanding populations within a plant community with which it had not previously been associated) must be provided. If not available in a published, quantitative form, this evidence must include written observations from at least three appropriate biologists.

1. Is species invasive ONLY when natural disturbance regime and scale have been altered? (e.g. where frequency, extent, or severity of fires have been reduced by human activity).  
 If YES then go to questions 1-b 2.  
If NO – the species is invasive, go to Section II (below).
  
2. Has this species ever been known to persist, following colonization, when the natural regime is resumed and the natural flora/communities recover? (e.g., is not an early successional species that only temporarily invades disturbed sites.)  
 If YES (or unknown) - the species is invasive, go to Section II (below).  
 If NO (known not to persist) the species is currently not invasive in Indiana. Go to Section III-c to assess the species' potential for future invasion.

Reported Status of White Sweet Clover, *Melilotus alba*



Reported Status of Yellow Sweet Clover, *Melilotus officinalis*



**Section II**

**Ecological Impacts of Invasion**

**Impact Index**

**II-a Known Impacts at WORST SITE(S) (without, or before, any control effort)**

Add up points for ALL impact statements (i through vi) that are true at the worst affected site(s) then go to question II-b. Evidence of impacts must be provided. If not available in published, quantitative form, this evidence must include written observations from at least *three* appropriate biologists, including specific locations of observations. Scientific names of impacted species (e.g., State-listed or native species with which hybridization occurs) must be included on the response form. If there is no evidence of an impact, then assign 0 points unless the impact is considered very likely (e.g., fixes N<sub>2</sub> in low nutrient soil that can change the flora) or the impact (except vi) has been demonstrated in similar habitats in states. In these cases assign 0.5 points.

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- i) Causes long-term, broad alterations in ecosystem processes changing the community as a whole (e.g. invasion of cattails changes hydrology, drying the site and allowing open aquatic systems to become forested). 15  
*Melilotus alba* and *Melilotus officinalis* are nitrogen fixers which increases the nitrogen levels in the soil (Nichols & Johnson, 1969) and could (potentially) change species composition in areas of low nitrogen levels (Weber, 2003; Fellows, 2005; Van Riper cited by Fellows, 2005; Gucker, 2009) though this nitrogen enriching effect was found to be unsubstantial and more dependent on previous vegetation cover or precipitation (Van Riper & Larson, 2009). We did not have strong enough evidence of this to count these points.
- ii) Has negatively impacted Indiana State-listed or Federal-listed plants or animals (choose one of the following): 12  
 Displacement, death or hybridization has been documented AND occurs in at least 20% of known locations of the listed species, OR these effects occur in less than 20% of known locations of the listed species, but at least 4 different listed species are affected.  
 Displacement, death or hybridization occurs in less than 20% of locations of the listed species OR impacts are considered likely because the listed and invasive species closely co-habit (e.g., compete for light). 4  
*Affecting mottled duskywing skipper at one site in Indiana.*
- iii) Displaces or precludes native vegetation (affecting mortality and/or recruitment) by achieving infestations in the state that have at least 50% coverage of this species (as defined in the glossary) in the affected stratum that meet any of the following criteria: 12  
a) collectively add up to at least 10 acres  
 b) are 5 infestations of at least 0.25 acres  
 c) are 5 infestations that cover an entire localized community (e.g. sinkhole, seeps, fens, bogs, barrens, cliffs)  
 d) are 5 infestations some of which are at least 0.25 acres and others of which cover entire localized communities.  
*10 survey reports from 7 Indiana counties, ranging in size from 1/4 acre to 10-20 acres.*
- iv) Changes community structure in ways other than vegetation displacement (e.g., alters wildlife abundance, adds a new stratum, or increases stem density within a stratum by more than 5-fold). 4
- v) Hybridizes with native Indiana plants or commercially-available species. 4
- vi) Covers over 15% of invaded stratum (but if 12 points were assigned for statement iii, do not assign points here) on > 10 acres in the state. 3
- Total points** (place in worksheet page 9): **16**

**II-b Range of Habitats in Which Species is Invasive**

- Forest: 1)Dry upland, 2)Dry-mesic upland, 3)Mesic upland, 4)Mesic floodplain, **5)Wet-mesic floodplain, 6)Wet floodplain**, 7)Bluegrass till plain flatwoods\*, 8)Boreal flatwoods\*, 9)Central till plain flatwoods, 10)Dry flatwoods\*, 11)Sand flatwoods\*, 12)Southwestern lowland mesic flatwoods\*
- Savanna: 13)Mesic savanna\*, 14)Dry sand savanna\*, 15)Dry-mesic sand savanna\*
- Barrens: 16)Limestone bedrock\*, 17)Sandstone bedrock\*, 18)Siltstone bedrock\*, 19)Chert\*, 20)Gravel\*, 21)Sand\*, 22) Clay\*

Prairie: 23)Dry-mesic prairie\*, 24)Mesic prairie\*, **25)Wet prairie\***, 26)Dry sand prairie\*, 27)Dry-mesic sand prairie\*, 28)Wet-mesic sand prairie\*, **29)Wet sand prairie\***

Wetland: **30)Marl beach\***, **31)Acid bog\***, **32)Circumneutral bog\***, **33)Fen\***, **34)Forested fen\***, **35)Muck and Sand flats\***, **36)Marsh**, **37)Sedge meadow\***, **38)Panne\***, **39)Acid seep\***, **40)Calcareous seep\***, **41)Circumneutral seep\***, **42)Forest swamp**, **43)Shrub swamp**

Lake: **44)Lake**, **45)Pond**

Stream: **46)Low-gradient creek**, **47)Medium-gradient creek**, **48)High-gradient creek**, **49)Low-gradient river**, **50)Medium-gradient river**, **51)Major river**

Primary: **52)Aquatic cave\***, 53)Terrestrial cave\*, 54)Eroding cliff\*, 55)Limestone cliff\*, 56)Overhang cliff\*, 57)Sandstone cliff\*, 58)Lake dune\*, 59)Gravel wash\*

Is this species known to be invasive in at least four habitat-types (note – rare habitat-types are marked with a \* and count as 2 when adding) OR does it occur in at least one habitat-type of each of the terrestrial and palustrine/aquatic lists (palustrine/aquatic habitats are shown in **bold**) *7 habitats invaded, each rare, is 7 times 2 equals 14*

If **YES** then multiply total score from II-a by 1.5  
then go to Section II-c (Below)

If **NO** then multiply total score from II-a by 1  
then go to Section II-c (Below)

Place point total in worksheet, page 9.

### **II-c Proportion of Invaded Sites with Significant Impacts**

Of the invaded sites, might any of the worst impacts [items i-v in section II-a] only occur under a few, identifiable, environmental conditions (i.e., edaphic or other biological conditions occurring in 1-10% of the sites)? Documentation of evidence must be provided for a **YES** answer.

If **NO** or **NO SCORE** on items i to v in section II-a  
then go to Section III

If **YES** then go to Section A

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## **Section III**

## **Potential for Expansion**

## **Potential Index**

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This section evaluates a species' actual and/or potential for expansion in Indiana.

### **III-a Potential for Becoming Invasive in Indiana**

1. Is information available on the occurrence of new populations of this species in Indiana over the last 5 years?

If **YES** then go to section III-b

If **NO** go to Section III-c to estimate potential for expansion based on the biology of the species.

### **III-b. Known Rate of Invasion.**

1. Was this species reported in more than two new discrete sites (e.g., lakes, parks, fragments of habitats at least 5 miles apart) in any 12 month period within the last 5 years?

If **NO** then P = Low; then go to Section IV

If **YES** then P = High; then go to Section IV

**III-c. Estimated Rate of Invasion.** This section is used to predict the risk of invasion for species that are 1) not currently invasive in the state, and 2) invasive in the state but for which no data on current rate of spread exists. These questions are based on Hiebert et al. 1995.

1. Does this species hybridize with any State-listed plants or commercially-important species? (E.g., exhibit pollen / genetic invasion.)

If **YES** then go to Section B

If **NO** then go to question III-c 2.

2. Add up all points from statements that are true for this species. Points

i. Ability to complete reproductive cycle in area of concern 0  
 a. not observed to complete reproductive cycle 5  
 b. observed to complete reproductive cycle

ii. Mode of reproduction 5  
 a. reproduces almost entirely by vegetative means 1  
 b. reproduces only by seeds 3  
 c. reproduces vegetatively and by seed 5

iii. Vegetative reproduction 5  
 a. no vegetative reproduction 0  
 b. vegetative reproduction rate maintains population 1  
 c. vegetative reproduction rate results in moderate increase in population size 3  
 d. vegetative reproduction rate results in rapid increase in population size 5

*Gucker, citing Willard, note that “vegetative regeneration is rare and limited to damaged plants” (Willard cited in Gucker, 2009).*

iv. Frequency of sexual reproduction for mature plant 5  
 a. almost never reproduces sexually in area 0  
 b. once every five or more years 1  
 c. every other year 3  
 d. one or more times a year 5

*On the whole, biennials reproduce every two years. However, there are cases where a fall germinating sweetclover plant could reproduce the next summer, making d. true. We went with the more common scenario; they are thought to be obligate biennials and die after flowering in their second\* year of growth (Klemow & Raynal 1981; Eckhart, 1987).*

v. Number of seeds per plant 5  
 a. few (0-10) 1  
 b. moderate (11-1,000) 3  
 c. many-seeded (> 1,000) 5

*We recognize that large sweetclover plants may have more than 1,000 seeds but we used an average-sized plant as our guide. Gucker notes that a revised estimate of viable seeds produced per plant over a 5-year study were 171 to 5000 seeds per plant (Klemow & Raynal 1981; Klemow 1982).*

vi. Dispersal ability 5  
 a. little potential for long-distance dispersal 0  
 b. great potential for long-distance dispersal 5

*Seed dispersal by water is the most important long-distance dispersal method (Turkington et al., 1978; Eckhart, 1987). Experiments have shown that clover seeds recovered from animal feces were viable: sweetclover has no innate structure to facilitate long-distance wind dispersal (Gucker, 2009).*

- vii. Germination requirements
  - a. requires open soil and disturbance to germinate 0
  - b. can germinate in vegetated areas but in a narrow range or in special conditions 3
  - c. can germinate in existing vegetation in a wide range of conditions 5
- viii. Competitive ability
  - a. poor competitor for limiting factors 0
  - b. moderately competitive for limiting factors 3
  - c. highly competitive for limiting factors 5

*It was noted that sweetclover really only grows aggressively in soils with pH greater than 6.5; in acidic soils it does not fix N and is not as competitive (Turkington et al., 1978; Martin & Leonard, 1949 as cited in Eckhart, 1987).*

**Total points for questions i – viii (place in worksheet page 9): 20**

Section IV	Difficulty of Management	Management Index
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**IV Factors That Increase the Difficulty of Management**

Add up all points from statements that are true for this species then go to Section V. Assign 0.5 point for each statement for which a true/false response is not known.

- |  | <u>Points</u> |
|--|---------------|
| i) Control techniques that would eliminate the worst-case effects (as listed in Section II) have been investigated but none has been found.  | 15            |
| ii) This species is difficult to control without significant damage to native species because: it is widely dispersed throughout the sites (i.e., does not occur within discrete clumps nor monocultures); it is attached to native species (e.g., <b>vine</b> , epiphytes or parasite); or there is a native plant which is easily mistaken for this invader in: (choose one)   |               |
| ≥ 50% of discrete sites in which this species grows;   | 10            |
| 25% to 50% of discrete sites in which this species grows.  | 7             |
| <i>We could not agree on this answer. Ellen commented that because it usually grows well-dispersed in a site, chemical control usually results in unacceptable non-target damage. Therefore, control is limited to handpulling or weed whipping in many cases. Due to the labor intensiveness of these methods, she suggested counting 10 points. Keith pointed out that the size of infestations is generally small, and therefore the overall labor involved is not that great. He suggested not counting these points. We agreed to bring it to the full IPSAWG meeting Sept. 6. <b>Per the 9/6 IPSAWG meeting, we agreed these points should not be counted.</b></i> |               |
| iii) Total contractual costs of known control method per acre in first year, including access, personnel, equipment, and materials (any needed re-vegetation is not included) > \$2,000/acre (estimated control costs are for acres with a 50% infestation)  | 5             |
| iv) Further site restoration is <i>usually</i> necessary following plant control to reverse ecosystem impacts and to restore the original habitat-type or to prevent immediate re-colonization of the invader.   | 5             |
| v) The total area over which management would have to be conducted is: (choose one).   |               |
| ≥ 100 acres;   | 5             |

- < 100 but > 50 acres. 2  
 ≤ 50 but > 10 acres. 1  
 ≤10 acres ½  
*This is our best estimate of how many acres of sweetclover there are in all natural areas in the state.*
- vi) Following the first year of control of this species, it would be expected that individual sites would require re-survey or re-treatment, due to recruitment from persistent seeds, spores, or vegetative structures, or by dispersal from outside the site: (choose one)
- at least once a year for the next 5 years; 10
  - one to 4 times over the next 5 years; 6
  - regrowth not known 2
- vii) Occurs in more than 20 discrete sites (e.g., water-basins, parks, fragments of habitats at least 5 miles apart). 3
- viii) The number of viable, independent propagules per mature plant (e.g., seeds, spores, fragments, tubers, etc. detached from parent) is > 200 per year AND one or more of the following:
- A. the propagules can survive for more than 1 year;
  - B. the propagules have structures (fleshy coverings, barbs, plumes, or bladders) that indicate they may spread widely by birds, mammals, wind or water;
  - C. the infestations at 3 or more sites exhibit signs of long distance dispersal. Some possible indicators of long distance dispersal include: the infestation has outlier individuals distant [>50 yards] from the core population; the infestation apparently lacks sources of propagules within ¼ mile. 3.
- ix) Age at first reproduction is within first 10% of likely life-span and/or less than 3 months. 2
- Total points** (place in worksheet page 9): 17

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Section V	Commercial Value	Value Index
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**V-a**     Commercial Value

Does this species have any commercial value?

If response is **NO** then V = 0 and Go to Conversion of  
Index Scores to Index Categories

If response is YES then go to Section V-b

*Larry and Keith provided input on the use of sweetclover in the state. Over the last 10 years, use has decreased perhaps 90% due to change in farm practices and government assistance for farmers. Sweetclovers were once an important part of 'plow down' mixes that were recommended for 'set-aside areas'. Now programs like CRP have replaced the old 'set-aside' programs. Sweetclover is used primarily as green manure, an overwintering planting that is plowed under in the spring. White sweetclover is still popular with beekeepers, as it blooms during a time when few other species bloom. It is not widely used for forage, as mold on sweetclover can lead to blood thinning. It is not used by INDOT for roadside plantings (per Rick).*

**V-b**     Factors that Indicate a Significant Commercial Value

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Add up all points from statements that are true for this species. Assign 0.5 point for each statement for which a true/false response is not known.

	<u>Points</u>
i) This species is sold in national or regional retail stores ( e.g., WalMart, Home Depot, Publix).	10
ii) State-wide there are more than 20 commercial growers of this species. .	7
iii) More than five growers in Indiana rely on this species as more than 10% of their <b>nursery's</b> production. <i>We need to change this statement in the assessment to be more general – the word 'nursery' should be deleted. The intent of this section is to measure commercial value not only to the nursery industry but to other interests – beekeepers, cattle raisers, etc. – as well. If 'nursery' is removed, this statement can be interpreted that there are more than five growers of sweetclover in IN that rely on this species for more than 10% of their production of honey. This is a true statement.</i>	<u>3</u>
iv) This species has provided a crop, turf, or feed source (e.g., forage, nectar) that has been, or resulted in, a significant source of income for at least five farmers for over 20 years. <i>It is an important source of nectar.</i>	<u>3</u>
v) This species is utilized statewide.	<u>3</u>
vi) There are more than 100 retail seed outlets statewide	3
<b>Total points</b> (place in worksheet page 9):	<u>9</u>

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### Section A (from Section II-c)

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A1 Can the habitats in which the worst-case ecological impacts occur (items i to v in Section II-a) be clearly defined as different from invaded sites where there are no such impacts (e.g., defined by edaphic or biological factors)? (If ecological impacts include negative effects on a State-listed species, then the specific habitats in which that State-listed species occurs must be clearly distinguishable from habitats in which it does not occur.)

If **NO** then return to Section III

If **YES** then Go to question A2 and prepare such a site definition

A2 Can an estimate be made of the maximum distance that propagules (or pollen if hybridization is a concern) might reasonably be expected to disperse?

If **NO** then return to Section III

If **YES** then prepare instructions for Specified and Limited Use based on maximum dispersal distance (e.g., may be acceptable for use in specific areas but not near habitats where impacts are high.) Reassess if the incidence of worst-case impacts increases above 10% or within 10 years, whichever is earlier. THEN resume the assessment at Section III to provide scores for the other indices.



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**Section B (from Section III-c or if Value = High and Impact = Medium)**


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B1 Are there specific circumstances in which this species could be used that would not be expected to result in escape and invasion? (E.g., foliage plants that are only used indoors and which can be reasonably prevented, by conspicuous labeling, from use or disposal in the landscape.)

If **NO**, then retain the previously derived Conclusion.

If **YES**, then Acceptable for Specified and Limited Use where regulations and educational programs for penalties and enforcement of misuse exist. Reassess this species every 2 years.

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**Worksheet for Assessment**


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**Section I:**

Follow directions to different sections.

**Section II:**

Impacts Point Total: 16 X (1 or 1.5) = 24 **Impacts**

**Section III:**

Potential = High Medium or Low 20 **Potential for Expansion**

**Section IV:**

Difficulty of Management Point Total: 17 **Difficulty of Management**

**Section V:**

Commercial Value Point Total: 9 **Value**

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**Invasive Ranking Summary:**


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<b>Invasive Ranking Summary</b>	<b>Score</b>
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	<b>Medium</b>
<i>Rankings: Low &lt; 45, Medium 45 – 80, High &gt; 80</i>	

**Literature Cited**

Eckardt, N. 1987. Element stewardship abstract for *Melilotus alba*, *Melilotus officinalis*. The Nature Conservancy. <<http://www.imapinvasives.org/GIST/ESA/esapages/documnts/melioff.pdf>>. [Accessed on Jun 19, 2012.]

Fellows, M. and Maybury (rev.) 2005. *Melilotus officinalis*. U.S. Invasive Species Impact Rank (I-Rank). NatureServe Explorer. <[www.natureserve.org](http://www.natureserve.org)>. [Accessed on Jun 19, 2012.]

Gucker, C. L. 2009. *Melilotus alba*, *M. officinalis*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). <<http://www.fs.fed.us/database/feis/>> [Accessed on Jun 19, 2012].

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- Martin, J.H. and W.H. Leonard. 1949. Sweetclover. Principles of Field Crop Production. Macmillan Press, New York. pp. 685-699.
- Nichols, J.T. and J. Johnson. 1969. Range productivity as influenced by biennial sweetclover in western South Dakota. Journal of Range Management. 22: 342-347.
- Klemow, K.M. and D.J. Raynal. 1981. Population ecology of *Melilotus alba* in a limestone quarry. J. Ecol. 69:33-44.
- Klemow, K.M. 1982. Demography and seed biology of monocarpic herbs colonizing an abandoned limestone quarry. Ph.D. dissertation. College of Environmental Science and Forestry, State University of New York, Syracuse, NY. 228 p.
- Turkington, R.A., P.B. Cavers, and E. Empel. 1978. The biology of Canadian weeds. 29. *Melilotus alba* Desr. and *M. officinalis* (L.) Lam. Can. J. Pl. Sci. 58:523-537.
- Van Riper, L. 2005. The role of the exotic legume yellow sweetclover (*Melilotus officinalis*) in a low nitrogen system: a potential ecosystem transformer and facilitator of invasion. Ph.D. dissertation, Department of Ecology, Evolution and Behavior, University of Minnesota, St. Paul, MN.
- Van Riper, L.C. and D.L. Larson. "Role of Invasive *Melilotus officinalis* in Two Native Plant Communities" (2009). USGS Northern Prairie Wildlife Research Center. Paper 77.
- Weber, E. 2003. Invasive plant species of the world: a reference guide to environmental weeds. CABI Publishing, Cambridge, Massachusetts. 548 pp.
- Willard, C. J. 1927. An experimental study of sweet clover. Bulletin 405. Wooster, OH: Ohio Agricultural Experiment Station. 84 p.

## Glossary

- Anthropogenic disturbance.** Human-induced disturbance (e.g., mowing) or human-induced changes in natural disturbance regime (e.g., changing the frequency, extent, or severity of fires).
- Coverage.** Visual or quantitative estimate of the relative amount of area in a stratum where the canopy of the non-native species intercepts the light that would otherwise be available for other species in or below that stratum. Estimated cover may be dispersed or continuous in a site. Cover is usually measured when foliage is fully expanded. In the case of species that form a dense, continuous mat of rhizomes or stolons, the percent of the soil surface or upper level occupied by that root mat can be estimated as soil, rather than canopy, cover.
- Disturbance.** Mechanisms that limit biomass by causing its partial or total destruction.
- Discrete sites.** Disjunct habitat-types or fragments of habitats at least 1 mile apart that support invasive plant populations that likely arose by separate long-distance dispersal mechanisms.
- Documentation of evidence.** One publication including relevant, original research will suffice if data are specific to the taxon and zone(s) under evaluation. If such documentation is not available or needs to be up-dated, at least three individuals who have the expertise on the particular species and zone in question must be identified.
- Federal- or Indiana -listed.** Species that are listed by Federal laws or Indiana statutes or rules as threatened or endangered within the State of Indiana. This list with notes is available at <http://www.state.in.us/dnr/naturepr/endanger/plant.htm>
- Formal Risk Benefit Analysis.** Detailed economic studies of impact and management costs and commercial value

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for present and future infestations.

***Invasive.*** A species that forms self-sustaining and expanding populations within a natural plant community with which it had not previously been associated (Vitousek *et al.* 1995).

***Long-term alterations in ecosystem processes.*** Examples of ecosystem processes that could be altered: erosion and sedimentation rates; land elevation; water channels; water-holding capacity; water-table depth; surface flow patterns; rates of nutrient mineralization or immobilization; soil or water chemistry; and type, frequency, intensity, or duration of disturbance. For further explanation see Gordon (1998).

***Native.*** Species within its natural range or natural zone of dispersal (i.e., within the range it could have, or would have, occupied without direct or indirect introduction and/or care by humans. Excludes species descended from domesticated ancestors) (Vitousek *et al.* 1995).

***Natural areas.*** Natural areas: Areas with native plant communities supporting native plant and animal species, with long undisturbed soil systems, and hydrological regimes relatively intact or under restoration. Edges of historically or currently disturbed areas (roadsides, trails, adjacent to historically disturbed locations, etc.) should not be included in the assessment of invasion into natural areas. That invasion may have been facilitated by the edges, but has to have extended into the native communities for inclusion in this category.

***Pollen or genetic invasion.*** When a native species is displaced by a non-native species through hybridization.

***Stratum.*** A distinct layer in the architecture of vegetation (e.g., tree canopy or understory shrubs).