Documentation of Changes in CEAP Integrated Pest Management (IPM) Indicator Scoring from CEAP I to CEAP II

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Background

The CEAP IPM Indicator is a semi-quantitative ranking system used to describe the level of pest management applied on an operation. The scoring system was first developed to report on the CEAP I (2003–2006) Farmer Survey, which asks farmers about their adoption of select prevention, avoidance, monitoring, and suppression (PAMS, Appendix 1) activities directed at weeds, insects and mites, and disease. Documentation of the scoring procedure used for CEAP I is available on the CEAP Cropland Assessments website. The IPM Indicator score only includes scoring assignments for the adoption of practices assessed by the CEAP Farmer Surveys, and changes described here reflect the IPM Indicator scoring system used with the CEAP II (2013–2016) survey response.[1]

Scores were assigned to each survey point that included pest management practice responses, and can be categorized (low, moderate, moderately high, etc.) to reflect the overall level of IPM on a given field or the average across a given geography. This scoring system enables reporting on the quality and comprehensiveness of IPM practice across the country, rather than presence/absence of practices alone, and is used in developing no-practice scenarios for modeling pesticide runoff at the edge of field. The scoring system was reviewed by experts for necessary changes reflecting the current science, and new questions asked in CEAP II were scored for the first time. These changes are highlighted and described below.

Key Changes

CEAP I IPM Indicator scoring used a combination of default scoring based on corn-soybean cropping systems in the Upper Mississippi River Basin, and regional and/or crop-specific adjustments for each practice based on the applicability or effectiveness in each region or crop rotation. Scoring in CEAP II was shifted to a more simplified system that applies one default set of scores to all cropping systems and regions, rather than applying these minor modifications to reflect differential impact of some practices on some crops.

Grouping of practices under PAMS activity type was modified so that prevention and avoidance are grouped together due to the nuanced distinction between activities for prevention of insect infestation and avoidance of crop impact due to existing pests. As a result of this change, practices were grouped into one of three purpose categories: prevention and avoidance (PA), monitoring (M), or suppression (S), and this change required an alteration of the categorical weights assigned to the PAMS categories. These changes are described in detail below and in Table 1.

[1] In CEAP II reports where these data were compared between time periods, both CEAP I and CEAP II responses were assessed with the CEAP II IPM Indicator scoring system to support comparability between time periods.

While scores were reviewed by experts, the point values for questions included in both surveys were not modified, but newly asked questions were scored during this process.

Score Overview and Changes

The application of the CEAP IPM Indicator began with scoring each practice described in the CEAP Farmer Survey with a score on a 0-10 scale, where 0 was of limited use or impact and 10 was of critical importance. Each practice was assigned to a PAMS category based on its primary use for pest management, and categories were weighted to eliminate the influence of the number of questions included in our survey for each category.

In the CEAP I scoring system, monitoring was given a greater weight than prevention, avoidance, or suppression to recognize the thought that keeping track of pest pressure in a field could be considered the most crucial to successful IPM. While some experts remain split over the relative influence of PAMS strategies, it is increasingly understood that including practices representing each of the PAMS categories is important to applying a comprehensive IPM plan, so CEAP II scoring reflected a more even distribution of weights between the PAMS categories. Additionally, delineation of practices between prevention and avoidance categories can be difficult, with prevention practices meant to prevent pests from infesting a crop and avoidance practices meant to avoid damage to that crop when pests may be present. For these reasons, the updated scoring system considered prevention and avoidance a single category worth 50 percent of the weighted score, and monitoring and suppression remained individual categories worth 25 percent each. Changes are summarized in Table 1, and a list of practices associated with each category can be found in Table 2, which outlines the changes to the point assignments from the CEAP I default scores.

Table 1. Summary of changes to the weighting scheme for IPM Indicator scoring between CEAP I and CEAP II

CEAP I		CEAP II	
Prevention	20%	Prevention and avoidance	50%
Avoidance	20%	Monitoring	25%
Monitoring	40%	Suppression	25%
Suppression	20%		

As previously mentioned, CEAP I IPM Indicator scoring used a combination of default scoring based on corn-soybean cropping systems in the Upper Mississippi River Basin, and regional and/or crop-specific adjustments for each practice based on the applicability or effectiveness in each region or crop rotation. Upon expert review of the scoring system for CEAP II, it was determined that the minor regional and cropping system alterations to practice scores were not impactful enough to justify continued use. Literature quantifying the impacts of these types of management practices on pest populations, pesticide use, or pesticide edge-of-field losses is limited, which presents challenges to supporting that nuanced scoring system. Additionally, the effect of the regional and cropping system-based scoring system was limited in comparison to use of default scores. As a result, CEAP II IPM Indicator scoring was shifted to a more simplified system that applies one default set of scores to all cropping systems and regions.

Scores from CEAP I were assessed by experts in IPM with experience in both large row crop systems and smaller specialty crop systems, and questions that were not previously included in

CEAP I were scored for the first time by these experts. Scores for all CEAP II questions, sorted by PAMS category, are available in Table 2. Scores are identical for use in both surveys except where questions were asked in CEAP II but not in CEAP I. Final scores were weighted as described above, removing the influence of additional questions asked in CEAP II by ensuring that the percent of possible points is reflected, rather than the points directly. In this score normalization and weighting process, the PA category equated to 50 points out of the 100, so that regardless of the CEAP I or CEAP II question totals, points for these questions represent 50 percent of the score. For example, if a survey response indicated a score of 24 in the PA category, the normalized and weighted score would be calculated to be 31.6 as follows:

$$\frac{24}{38} = \frac{x}{50}$$

$$\frac{24 * 50}{38} = x$$

Similarly, for the M and S categories, the process is the same but the weighted score for that category is lower than the total possible points. For example, if a survey response indicated a score of 30 in the M category, the normalized and weighted score would be calculated to be 12.7 as follows:

$$\frac{30}{59} = \frac{x}{25}$$

$$\frac{30 * 25}{59} = x$$

Table 2. Summary of scores applied to CEAP I and CEAP II survey responses for summary in CEAP II reports

IPM Practices	CEAP I Score	CEAP II Score
Prevention and Avoidance Questions (PA)		
Plow down or remove crop residues	2	2
Chop, spray, mow, plow, burn field edges, etc.	4	4
Clean field implements after use	5	5
Rotate crops to manage pests	8	8
Use minimum till or no till to manage pests	5	5
Choose crop variety that is resistant to pests	5	5
Planting locations selected to avoid pests	3	3
Plant/harvest dates adjusted to manage pests	1	1
Grow a trap crop	N/A	2
Adjust grazing rotation(s), timing, or duration	N/A	3
Maximum PA Score	33	38
Monitoring Questions (M)		
Scouting practice: observations while performing routine tasks	2	2
Scouting practice: deliberate scouting	10	10
--established scouting practice used	2	2

IPM Practices	CEAP I Score	CEAP II Score
--scouting due to pre-determined schedule	N/A	1
--scouting due to pest development model	2	2
--scouting due to pest advisory warning	2	2
Scouting done by: (only highest of the 4 scores is used)		
--scouting by operator	2	2
--scouting by employee	2	2
--scouting by chemical dealer	1	1
--scouting by crop consultant or commercial scout	4	4
Scouting records kept to track pests?	4	4
Scouting data compared to published thresholds?	7	7
Diagnostic lab identified pest?	4	4
Weather a factor in timing of pest management practice	4	4
Field mapping data used for weed management decisions	N/A	6
Scouting done after pest control application to evaluate control	N/A	6
Maximum M Score	46	59

Suppression: Questions Related to Pesticide Application (S)		
Weather data used to guide pesticide application	4	4
Biological pesticides or products applied to manage pests	1	1
Pesticides with different action rotated or tank mixed to prevent resistance	5	5
Planted seeds treated with fungicides or insecticides	N/A	4
Used product for plant health rather than pest control	N/A	1
Altered pesticide application to protect pollinators	N/A	7
Pesticide application incorporated into soil	N/A	4
Partial or spot application of pesticide	N/A	6
Suppression: Questions Not Related to Pesticide Application (S)		
Maintain ground covers, mulch, or other physical barriers	3	3
Adjust spacing, plant density, or row directions	4	4
Release beneficial organisms	2	2
Cultivate for weed control during the growing season	3	3
Planted cultivars with herbicide tolerance	N/A	3
Planted cultivars with rootworm resistance	N/A	3
Planted cultivars with other insect resistance (Bt)	N/A	3
Maximum S Score	22	53

The IPM indicator for each sample point was calculated by multiplying the normalized PAMS category by the category weight and summing over the categories, giving scores a 100-point total. Notably, there is one case in which two IPM practices are very unlikely to be used

together—use of minimum till or no till to manage pests and cultivating for weed control during the growing season, making the maximum possible score 98. With individual sample point scores assigned, these scores can be averaged over different geographies (e.g., national, regional, state, etc.), by crop rotation type, or by other practice types (e.g., tillage class or sediment management level) to report results on the overall IPM practice level in relation to other trends.

Appendix 1. A Framework for Characterizing IPM Practices—PAMS

Adoption of IPM systems normally occurs along a continuum from largely reliant on prophylactic control measures and pesticides to multiple-strategy, biologically intensive approaches, and is not usually an either/or situation. The practice of IPM is site-specific in nature, with individual tactics determined by the particular crop/pest/environment scenario. Where appropriate, each site should have in place a management strategy for **Prevention, Avoidance, Monitoring,** and **Suppression** of pest populations (the **PAMS** approach)[2]. In order to qualify as IPM practitioners, growers would use tactics in all four PAMS components.

Prevention is the practice of keeping a pest population from infesting a field or site and should be the first line of defense. It includes such tactics as using pest-free seeds and transplants, preventing weeds from reproducing, irrigation scheduling to avoid situations conducive to disease development, cleaning tillage and harvesting equipment between fields or operations, using field sanitation procedures, and eliminating alternate hosts or sites for insect pests and disease organisms.

Avoidance may be practiced when pest populations exist in a field or site but the impact of the pest on the crop can be avoided through some cultural practice. Examples of avoidance tactics include crop rotation in which the crop of choice is not a host for the pest, choosing cultivars with genetic resistance to pests, using trap crops or pheromone traps, choosing cultivars with maturity dates that may allow harvest before pest populations develop, fertilization programs to promote rapid crop development, and simply not planting certain areas of fields where pest populations are likely to cause crop failure.

Monitoring and proper identification of pests through surveys or scouting programs, including trapping, weather monitoring, and soil testing where appropriate, are performed as the basis for suppression activities. Records are kept of pest incidence and distribution for each field or site. Such records form the basis for crop rotation selection, economic thresholds, and suppressive actions.

Suppression of pest populations may be necessary to avoid economic loss if prevention and avoidance tactics are not successful. Suppressive tactics include *cultural* practices such as narrow row spacing or optimized in-row plant populations, alternative tillage approaches such as no-till or strip-till systems, cover crops or mulches, or using crops with allelopathic potential in the rotation. *Physical* suppression tactics include cultivation or mowing for weed control, baited or pheromone traps for certain insects, and temperature management or exclusion devices for insect and disease management. *Biological* controls, including mating disruption for insects, are alternatives to conventional pesticides, especially where long-term control of a troublesome pest species can be attained. Naturally occurring biological controls exist, where they exist, are important IPM tools. *Chemical pesticides* can be important components of IPM programs. As with any tactic, pesticides should be used when they are the best available tactic considering all risk issues.

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[2] Coble, H. "Measuring the Resilience of IPM Systems—The PAMS Diversity Index." Unpublished manuscript. U.S. Department of Agriculture. 1998.