AgInfomatics

The Value of Neonicotinoids in North American Agriculture:

Estimated Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers

2014

This report series, researched and produced by AgInfomatics, LLC, is a comprehensive analysis of the economic and societal benefits of nitroguanidine neonicotinoid insecticides in North America. The research was sponsored by Bayer CropScience, Syngenta and Valent in support of regulatory review processes in the United States and Canada, with Mitsui providing additional support for the turf and ornamental studies.

AgInfomatics, an agricultural consulting firm established in 1995 by professors from the University of Wisconsin-Madison and Washington State University, conducted independent analyses exploring the answer to the question: *What would happen if neonicotinoids were no longer available?* Comparing that answer to current product use revealed the value of neonicotinoids.

Robust quantitative and qualitative study methods included econometrics modeling of insecticide use, crop yield data and market impacts; surveys of growers, professional applicators and consumers; regional listening panel sessions; and in-depth case studies.

Active ingredients in the study included clothianidin, dinotefuran, imidacloprid and thiamethoxam.

The Value of Neonicotinoids in North American Agriculture

Reports include:

Estimated Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers

Methods and Assumptions for Estimating the Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers

Value of Insect Pest Management to U.S. and Canadian Corn, Soybean and Canola Farmers

A Meta-Analysis Approach to Estimating the Yield Effects of Neonicotinoids

An Economic Assessment of the Benefits of Nitroguanidine Neonicotinoid Insecticides in U.S. Crops

A Summary of Grower and Agri-Professional Perspectives From Regional Listening Sessions in the United States and Canada

A Case Study of Neonicotinoid Use in Florida Citrus

A Case Study of Neonicotinoid Use in Mid-South Cotton

Executive Summary

The Value of Neonicotinoids in Turf and Ornamentals

Reports include:

Estimating the Economic Value of Neonicotinoid Insecticides on Flowers, Shrubs, Home Lawns and Trees in the Homescape

The Value of Neonicotinoids to Turf and Ornamental Professionals

A Case Study of Neonicotinoid Use for Controlling Chinch Bug in Florida St. Augustinegrass

A Case Study of Neonicotinoid Use for Controlling Emerald Ash Borer—The Naperville, Illinois, Experience

A Case Study of Neonicotinoid Use for Controlling Silverleaf Whitefly in Ornamentals

Executive Summary

For more information, please contact AgInfomatics@gmail.com

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Executive Summary

As part of a broad assessment of the economic benefits of neonicotinoid insecticides, this report highlights main findings regarding the impact of neonicotinoid insecticides on farmer pest management practices and costs. The source of this summary is *Methods and Assumptions for Estimating the Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers*.

Neonicotinoid insecticides are the most widely used class of insecticides by U.S. corn, soybean, wheat, cotton and sorghum farmers. The annual average for 2010-2012 was 133 million base acres treated at least once with a neonicotinoid insecticide or almost 56 percent of the 240 million acres of corn, soybean, wheat, cotton and sorghum planted annually during this same period. Corn accounted for 61 percent of neonicotinoid product acres during this period, with 89 percent of corn planted acres treated with a neonicotinoid insecticide; for other crops, 65 percent of cotton acres were treated with a neonicotinoid insecticide, 43 percent of sorghum acres, 40 percent of soybean acres, 25 percent of spring wheat and 18 percent of winter wheat acres. Seed treatments are the primary method of application of neonicotinoid insecticides for these crops, accounting for more than 98 percent of the 133 million base acres treated. This popularity suggests that U.S. commodity crop farmers find neonicotinoid insecticides and seed treatments to be a valuable class of insecticides and application method.

Wireworms were the most commonly reported target pest group, accounting for 29 percent of neonicotinoid product acres across these crops; seed maggots, corn rootworms and white grubs were the next most important target pest groups. Together, these four soil-dwelling pest groups comprised 70 percent of all neonicotinoid product acres with specifically reported target pests for these crops. A variety of above-ground pests constituted the remaining target pest groups, most commonly including aphids, bean leaf beetles, thrips and cutworms. In total, 17 different pest groups were reported as important targets for neonicotinoid insecticides used on these crops, with several more minor pests mentioned.

Methods and Assumptions for Estimating the Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers developed a non-neonicotinoid scenario that projected what farmers would have used for insect management without neonicotinoid insecticides. Farmers would still find insect control economical on many acres, even without neonicotinoids, but would switch to non-neonicotinoid active ingredients, while some would adopt cultural control practices. This analysis used GfK Kynetec market share data for non-neonicotinoid active ingredients by target pest for each crop to replace neonicotinoid insecticides, with allowances for acres to remain untreated as part of integrated pest management (IPM) and to use cultural practices (see section 1.0 of *Methods and Assumptions for Estimating the Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers* for explanation of GfK). The process reallocated acres for the nitroguanidine neonicotinoid insecticides clothianidin, dinotefuran, imidacloprid and thiamethoxam to 28 non-neonicotinoid alternatives, as well as to non-insecticidal practices.

The analysis projected that 77 percent of neonicotinoid acres would use alternative non-neonicotinoid insecticides if neonicotinoid insecticides were not available. Furthermore, as a result of switching from a neonicotinoid seed treatment to a foliar-based IPM program, 10 percent of neonicotinoid acres would be scouted but not treated for the original target pest. Finally, due to lack of registered soil-applied chemical alternatives for some crops, about 13 percent of neonicotinoid acres are assumed to switch to cultural control, using higher initial seeding densities or replanting to compensate for stand loss due to soil-dwelling pests.

As a result of these changes, acres treated with non-neonicotinoid insecticides are projected to increase 185 percent, adding almost 105 million product acres annually. The largest increases were projected for pyrethroids and organophosphates, which would add 66 million and almost 38 million acres respectively; all other insecticides classes were projected to add less than 1 million product acres in total. In terms of total pounds of insecticide active ingredients applied, the non-neonicotinoid scenario replaced 4.0 million pounds of neonicotinoids with 19.1 million pounds of non-neonicotinoids, so that the total pounds of insecticide active ingredients applied to these crops would increase from 13.0 million pounds to 28.2 million pounds, a 116 percent increase. Total pounds of organophosphates applied to these crops tripled and pyrethroids quadrupled, even though only 77 percent of neonicotinoid treated acres continued to use insecticides under the non-neonicotinoid scenario.

These projected changes also imply a substantial increase in soil-applied and foliar insecticides. The non-neonicotinoid scenario replaces 131 million acres of neonicotinoid seed treatments with 80 million acres of soil insecticides, of which 77 million are in corn, the rest in sorghum and cotton. Because no soil insecticides are registered for soybean and wheat to control key pests, the analysis estimates that these crops would use higher seeding densities and/or replant reduced stands on 17 million acres. The non-neonicotinoid scenario replaces 4.5 million acres of foliar-applied neonicotinoids with 25 million acres of non-neonicotinoid foliar-applied insecticides, with another 15 million acres scouted but not treated.

These projected changes raise several concerns. The non-neonicotinoid scenario implies greater reliance on fewer and older modes of action, such as pyrethroids and organophosphates, which raises concerns about problems with insect resistance. Increased use of these two broader-spectrum insecticide classes is also more likely to have negative impacts on non target insects and organisms, including beneficial insects that farmers using IPM rely on to contribute to lower pest populations. Furthermore, the projected shift also removes other benefits of seed treatments compared to foliar treatments, such as reduced potential for spray drift and field runoff as well as fewer passes through fields.

The projected changes for the non-neonicotinoid scenario imply a net cost increase of $848 million per year for U.S. farmers growing these crops. Of this total, increased spending on insecticide active ingredients accounts for $157 million across these crops. Seed treatments are essentially costless to apply compared to foliar and soil insecticides, and so increased application costs total $383 million, constituting the largest component of the cost

increase. Crop scouting costs increase $210 million as a result of the increased use of foliar pest management systems. Finally, costs for increased seeding rates and/or replanting costs for crops without neonicotinoid insecticide alternatives for soil-dwelling pests total $97 million.

Corn accounts for $677 million of the $848 million cost increase for the non-neonicotinoid scenario, and soybean accounts for $100 million. The remaining $71 million is distributed roughly equally among sorghum, wheat and cotton. Converting these increases to costs per acre treated with a neonicotinoid insecticides, the average cost increases range from $10.39 for sorghum, $8.29 for corn, $3.30 for soybean, $2.76 for winter wheat, $2.21 for cotton to a low of $1.97 for spring wheat.

1.0 Introduction

This report highlights some of the main findings regarding the impact of neonicotinoid insecticides on farmer pest management practices and costs based on the analysis reported in *Methods and Assumptions for Estimating the Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton, and Sorghum Farmers*. The report focuses primarily on providing a detailed and comprehensive description of the process and assumptions used to reallocate neonicotinoid acres to alternative non-neonicotinoid active ingredients and cultural practices for a hypothetical non-neonicotinoid scenario. The main data used were the extensive GfK Kynetec data on insecticide use by U.S. crop farmers for 2010-2012. The report is quite lengthy and technical, with numerous tables and figures reporting results. Though *Methods and Assumptions for Estimating the Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers* provides short verbal summaries of the crop-specific results in its Executive Summary, the broader conclusions and implications regarding the impact of neonicotinoid insecticides on U.S. crop farmers may be difficult to pull from the tables and figures. As a result, this report summarizes and integrates some of the main findings from *Methods and Assumptions for Estimating the Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers* and compares them across crops.

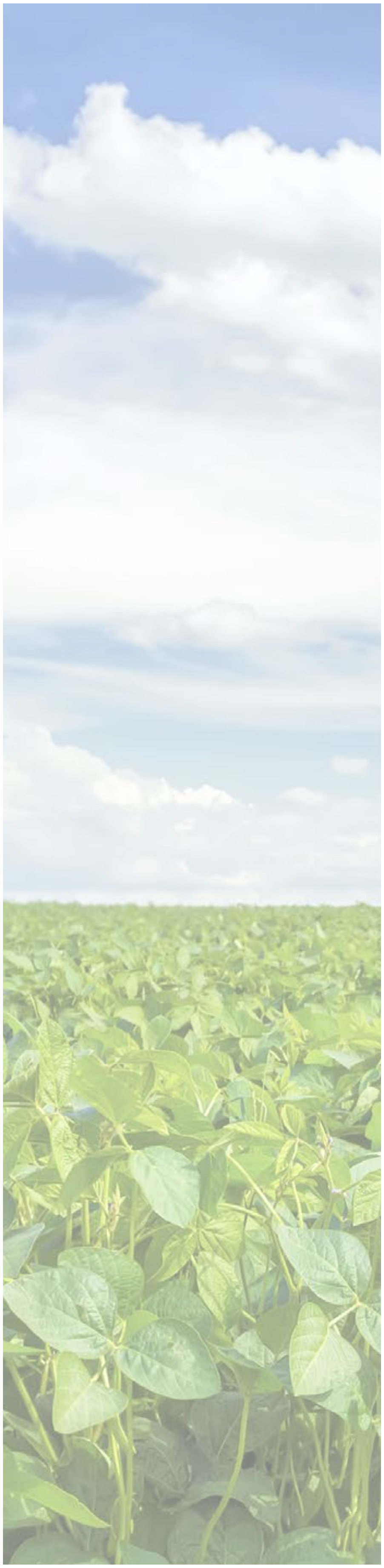
First, this report summarizes the use of neonicotinoid insecticides by U.S. farmers growing corn, soybean, cotton, winter wheat, spring wheat and sorghum, based on the GfK Kynetec data. Next, this report highlights how the availability of neonicotinoid insecticides impacts farmer pest management practices, focusing on crop acres treated with insecticides by active ingredient (AI), total pounds of insecticide applied by AI, the use of cultural control practices, and use of foliar-applied versus soil-based insect management systems. Last is a summary of how the unavailability of neonicotinoid insecticides impacts production costs for U.S. farmers growing these crops, not only costs for insecticides, but also costs for insecticide applications, pest scouting and higher seeding densities as a form of cultural control.

1.1 Use of neonicotinoid insecticides

Neonicotinoid insecticides are the most widely used class of insecticides by U.S. corn, soybean, wheat, cotton and sorghum farmers. The annual average for 2010-2012 was 133 million base acres treated at least once with a neonicotinoid insecticide[1] or almost 56 percent of the 240 million acres of corn, soybean, wheat, cotton and sorghum annually planted during this same period (Table 1). For these crops during this period, almost 61 percent were treated at least once with an insecticide of any type, showing the dominance of neonicotinoids[2]. The GfK Kynetec data show that on average during

[1] Base acres are the unique number of planted acres treated with an insecticide once or more, while product acres are the number of acres treated with insecticides, potentially the same acre more than once. For example, if a farmer treats the same planted acre twice, this acre counts as one base acre treated and as two product acres. The difference between neonicotinoid base acres and product acres is generally small (see Tables 1 and 2).

[2] Note that these statistics do not include Bt insecticides delivered as plant-incorporated protectants in Bt corn and Bt cotton.



2010-2012, about 89 percent of corn planted acres and two-thirds of cotton planted acres were treated with neonicotinoids, with 40 percent or more of soybean and sorghum planted acres treated with neonicotinoids. For these crops, wheat had the lowest proportion of planted acres treated with neonicotinoids, with 25 percent of spring wheat acres and 18 percent of winter wheat acres treated (Table 1).

The U.S. annual average for 2010-2012 was more than 135 million neonicotinoid product acres for corn, soybean, winter wheat, spring wheat, cotton and sorghum. All other insecticides applied to these crops in total comprised 61 million product acres annually or less than half of the neonicotinoid product acres (Table 2). As a result, neonicotinoids constituted 69 percent of all insecticide product acres for these six crops combined. Of the 135.5 million neonicotinoid product acres in these six crops, the majority were for corn (82.6 million acres) and soybean (30.5 million acres); these two crops comprised more than 83 percent of all neonicotinoid product acres for these crops (Table 2, Figure 1). Seed treatments were by far the main application method used for neonicotinoids in these crops, with 131.0 million of the 135.5 million neonicotinoid product acres applied as seed treatments; only cotton and soybean had significant foliar application of neonicotinoids (Table 2, Figure 2). This popularity suggests that U.S. commodity crop farmers find neonicotinoid insecticides and seed treatments to be a valuable class of insecticides and application method.

In terms of the reported target pests, neonicotinoid seed treatments were primarily applied to manage soil-dwelling and early-season insect pests. Based on the proportion of product acres with reported target pests across these crops, wireworms were the most important pest managed by neonicotinoids. Wireworms were the reported target pest for 29 percent of the neonicotinoid product acres with specifically named target pests in these crops. Using total neonicotinoid product acres, this proportion implies 39.6 million neonicotinoid product acres targeted at wireworms in these crops (Table 3). Though not the top target pest for each crop, wireworms were a key target pest for these crops, especially for corn and wheat. The next most important target pest group was seed maggots, a significant target pest in corn, soybean and sorghum (Table 3). After seed maggots, the next most important target pests were corn rootworms (only a significant target pest in corn) and white grubs in both corn and soybean. Neonicotinoid product acres targeted at these first four soil-dwelling pests together comprised 70 percent of all neonicotinoid product acres with specifically reported target pests for these six crops (Table 3). Aphids were the first significant above-ground target pest group, significant for all crops except corn. All other pest groups in Table 3 were significant targets only for one crop except for stink bugs, which were a significant target pest in both cotton and soybean.

In summary, neonicotinoids are the most widely used class of insecticides by U.S. corn, soybean, wheat, cotton and sorghum farmers, with on average almost 56 percent of total planted acres for these crops treated with neonicotinoid insecticides. Based on annual averages for 2010-2012, about 89 percent of corn, 65 percent of cotton, 43 percent of sorghum, 40 percent of soybean, 25 percent of spring wheat and 18 percent of winter wheat planted acres are treated with neonicotinoids.

1.2 Non-neonicotinoid scenario

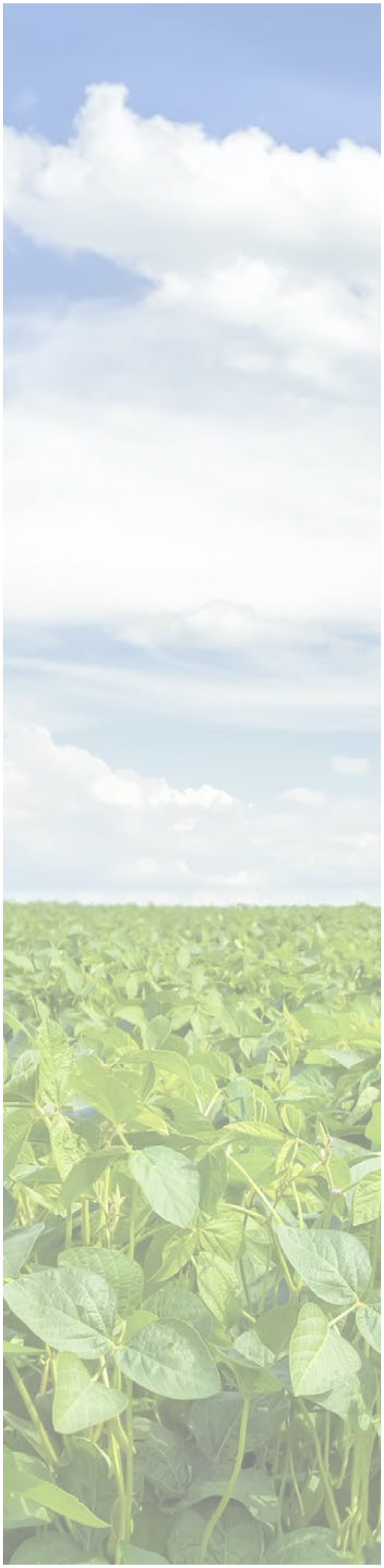
As part of a comprehensive assessment of the economic benefits of neonicotinoid insecticides, a non-neonicotinoid counterfactual scenario was constructed for these six crops (corn, soybean, winter wheat, spring wheat, cotton and sorghum). Counterfactual analysis is a commonly used technique that involves developing hypothetical scenarios and examining differences to estimate benefits. For this analysis, the counterfactual process involved developing a description of how farmer pest management practices and costs would change for these six crops if neonicotinoid insecticides were not available. Differences between the current base case and this non-neonicotinoid scenario then indicate the impact of neonicotinoids on farmer pest management practices and costs. A separate analysis estimates the impact of neonicotinoid insecticides on crop yields based on field plot data (*Value of Insect Pest Management to U.S. and Canadian Corn, Soybean and Canola Farmers*).

These six crops (corn, soybean, winter wheat, spring wheat, cotton and sorghum) were chosen for the analysis here because they are not only important commodity crops in terms of total acres and crop value, but also because farmers currently rely on neonicotinoid insecticides to manage serious insect pests when growing these crops. Furthermore, as key crops with federal commodity support programs, economic policy models exist that can be used to estimate the market-level benefits of neonicotinoid insecticides. Neonicotinoid insecticides are also important in the production of many specialty crops (e.g., potato, tomato, citrus, sugar beet, grapes), and the results of these analyses are presented in a separate report due to the use of different economic models (*An Economic Assessment of the Benefits of Nitroguanidine Neonicotinoid Insecticides in U.S. Crops*).

1.3 Impact of neonicotinoid insecticides on insecticide product acres and practices

The non-neonicotinoid scenario was developed by reallocating neonicotinoid product acres to non-neonicotinoid active ingredients and practices based on market shares, target pest information and application method data as reported by GfK Kynetec for 2010-2012. The process is described in detail in *Methods and Assumptions for Estimating the Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers*. The process reallocates product acres for the four nitroguanidine neonicotinoid insecticides clothianidin, dinotefuran, imidacloprid and thiamethoxam to 28 non-neonicotinoid alternative insecticides (Table 4), as well as to non-insecticidal cultural control and pest scouting practices.

For soybean, winter wheat and spring wheat, a non-neonicotinoid insecticide alternative did not exist to control certain target pests (e.g., wireworms), so these neonicotinoid product acres were reallocated to higher seeding densities or replanting as a form of cultural control to compensate for the stand-reduction effects of soil-dwelling pests. This simplifying assumption is useful for this analysis but does not capture the reality for some growers; populations of some soil-dwelling pests would be so severe without neonicotinoid insecticides that growers would likely change crops since non-neonicotinoid insecticide alternatives are not available. In addition, some neonicotinoid



product acres were reallocated from seed treatments to scouting-based foliar application of non-neonicotinoid insecticides to manage above-ground pests. As a result, some of these product acres would be scouted but not treated for the original neonicotinoid target pest, though these product acres could still potentially be treated for other pests.

In total, for the non-neonicotinoid scenario, the 2010-2012 annual average of 135.5 million neonicotinoid product acres are reallocated to the following: 104.6 million product acres use non-neonicotinoid AIs, 13.2 million are scouted but not treated, and 17.4 million use higher seeding densities, with a net decrease of about 300,000 product acres (Table 4). The analysis assumes that farmers generally would switch to a non-neonicotinoid insecticide alternative when possible, and so the non-neonicotinoid scenario replaces 77 percent of neonicotinoid product acres with product acres for alternative non-neonicotinoid insecticides. However, non-neonicotinoid seed treatment and soil-applied insecticide options are not available for key target pests in some of these crops, and so farmers must use more costly, less effective and/or riskier methods of insect control for the non-neonicotinoid scenario. As a result, the non-neonicotinoid scenario estimates that almost 10 percent of neonicotinoid product acres would be scouted but not treated for the original target pest as part of a foliar-based integrated pest managment (IPM) program, and almost 13 percent would use cultural control to manage soil-dwelling pests.

As a result of these changes, product acres for non-neonicotinoid AIs are projected to increase from the 2010-2012 annual average of 56.5 million to 161.1 million, a 185 percent increase, with the largest increases for AIs such as bifenthrin, tefluthrin, tebupirimphos and cyfluthrin (Table 4). As these AIs indicate, the majority of these neonicotinoid product acres are reallocated to two non-neonicotinoid insecticide classes: pyrethroids and organophosphates (Table 5, Figure 3). Of the 104.6 million product acres of non-neonicotinoid AIs added for the non-neonicotinoid scenario, 66.2 million product acres of pyrethroids are added and 37.6 million product acres of organophosphates, with less than 1 million new product acres added for the remaining insecticide classes (Table 5, Figure 3).

These estimated results show a substantial shift toward greater reliance on pyrethroids and organophosphates for the non-neonicotinoid scenario. Greater reliance on fewer and older modes of action raises concerns about increasing problems of insect resistance. The value of this resistance management benefit of neonicotinoids is not included in this economic assessment. Furthermore, these two broader-spectrum insecticide classes are more likely to have negative impacts on non target insects and organisms, including beneficial insects that farmers using IPM rely on to contribute to lower pest populations. Additional costs due to increased pests or secondary pest outbreaks are also not accounted for in this project's economic assessment. Furthermore, the projected shift also removes other benefits of seed treatment compared to foliar treatments, such as reduced potential for spray drift and field runoff, and fewer passes through fields, which are also not accounted for in this economic assessment.

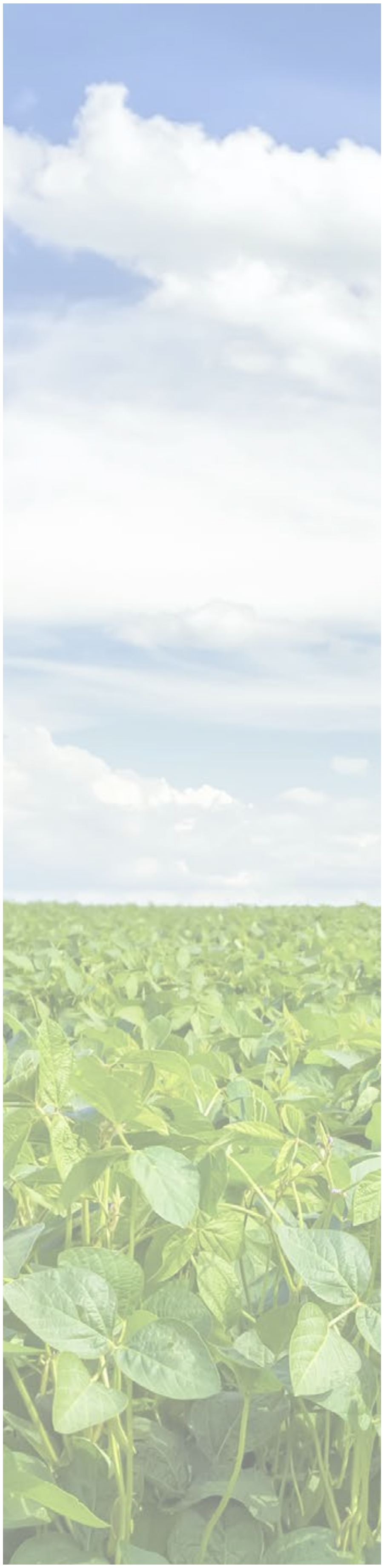
In terms of crop-specific changes, as expected most crops follow the general trends as summarized, with a few notable exceptions. For cotton, organophosphates gained the most product acres for the non-neonicotinoid scenario, while for all other crops, pyrethroids gained the most product acres. Furthermore, cotton is the only crop using a significant amount of other insecticide classes besides neonicotinoids, pyrethroids and organophosphates. The 2010-2012 average for cotton was about 11 percent of insecticide product acres using six other insecticide classes (Cotton Figure 1 in *Methods and Assumptions for Estimating the Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers*). Of the remaining crops, corn has 96.6 million insecticide product acres, with less than 23,000 product acres using carbamates; all other product acres for corn and the other crops are neonicotinoids, pyrethroids and organophosphates.

1.4 Impact of neonicotinoid insecticides on pounds of insecticides applied

In terms of total pounds of AI applied, the non-neonicotinoid scenario replaces 4.0 million pounds of neonicotinoids with 19.1 million pounds of non-neonicotinoids (a 15.1 million pound net increase), so that the total pounds of AI applied increases from 13.0 million pounds to 28.2 million pounds, a 116 percent increase (Table 6). The largest increases are for AIs, such as chlorpyrifos, terbufos, acephate, tebupirimphos and tefluthrin (Table 6). As these AIs indicate, the majority are organophosphates, so that of the 19.1 million pounds of replacement AIs added for the non-neonicotinoid scenario, 15.3 million pounds are organophosphates; the next largest is pyrethroids, which add 3.7 million pounds of AI (Table 7). This large increase for organophosphates partly occurs because this class of insecticide uses relatively higher average application rates compared to other major insecticide classes. The estimated net impact of the non-neonicotinoid scenario is that the total pounds of organophosphates triple, while pyrethroids actually quadruple (Table 7). Note that these large increases in total pounds of insecticide AIs occur, even though only 77 percent of neonicotinoid product acres are reallocated to non-neonicotinoid insecticides. In terms of crop-specific changes, the changes in total pounds of AI applied by insecticide class match these general results – total pounds of organophosphates applied increase the most among all insecticide classes for each crop, even though pyrethroid product acres increase more than organophosphate product acres for all crops except cotton.

1.5 Impact of neonicotinoid insecticides on pest management systems used

Farmers use neonicotinoids in these crops almost exclusively as seed treatments, with minimal foliar application and none as soil-applied insecticide (Table 1, Figure 2). The reallocation of neonicotinoid product acres to alternative AIs and practices for the non-neonicotinoid scenario implies a substantial shift from soil-based insect pest management systems in these crops to more foliar-based pest management systems. Nevertheless, the non-neonicotinoid scenario projects that farmers will still predominantly remain with soil-based pest management systems but switch to soil insecticides and cultural control due to a lack of other non-neonicotinoid alternatives. Because this analysis uses soil-based and foliar-based pest management systems and they are not standardized terms, clear definitions of these terms and the logic behind them are presented before proceeding.



This analysis categorizes seed treatments and soil insecticides as soil-based pest management systems because the insecticide is applied to the seed or directly into the furrow with the seed where developing root systems absorb the active ingredient. The target pests are often soil-dwelling pests such as wireworms, seed maggots or white grubs, but can also be early-season above-ground pests such as aphids, cutworms or thrips. Soil-based systems rely on protective IPM programs that use seed treatments or soil insecticides based on historical occurrence of the pest in fields in the region, pre-plant scouting and/or other informative signals. This analysis also categorizes using a higher seeding density to compensate for expected stand loss from damage by soil-dwelling insect pests as a soil-based pest management system, since the additional seed is placed in the soil, either as a higher initial seeding density or to replant inadequate stands resulting from pest damage. A key point to note is that acres can be in a soil-based pest management system and not receive an insecticide application, since they are still actively managed for insect pests.

On the other hand, foliar-based pest management uses foliar applications of insecticides to control above-ground pests, often as part of an IPM program based on regular scouting. With a scouting-based program, in some cases insecticides are not applied because the target pest populations never reach the appropriate thresholds. This analysis categorizes product acres that use foliar applications as a foliar-based pest management system. In addition, acres that are scouted but not treated for the pest that was the original target by the neonicotinoid seed treatment are also categorized as a foliar-based pest management system. Even though these acres may not receive an insecticide application, they are still actively managed for insect pests and could potentially receive a treatment. Thus, acres can also be in a foliar-based pest management system and not receive an insecticide application.

The 2010-2012 annual average is 143.9 million product acres in soil-based pest management systems for these six crops, of which 92.7 million are in corn and 29.1 in soybean; the remaining four crops constituted 22.4 million product acres (Table 8). On the other hand, the 2010-2012 annual average is 52.6 million product acres in foliar pest management systems for these six crops, with cotton and soybean together accounting for 43.8 million of these product acres (Table 8). Product acres in soil-based pest management systems decrease an estimated 33.8 million acres in total (a 23 percent decline) for the non-neonicotinoid scenario, with decreases occurring for all crops, but especially in soybean. On the other hand, product acres in foliar pest management systems increase an estimated 35.0 million acres in total (a 66 percent increase) for the non-neonicotinoid scenario, with increases occurring for all crops but especially in soybean (Table 8). The majority of these shifts for the non-neonicotinoid scenario are due to switching from neonicotinoid seed treatments to foliar applications of non-neonicotinoid insecticides (Figure 4, Table 8). However, including acres that are scouted but not treated for the pest originally targeted by the neonicotinoid seed treatment noticeably increases acres in foliar systems, as does including use of higher seeding densities in soil-based systems (Figure 4).

In terms of crop-specific effects for the non-neonicotinoid scenario, corn farmers continue to use soil-based pest management but rely on soil insecticides instead of neonicotinoid seed treatments. Of the almost 80 million non-neonicotinoid product acres added to soil-based systems, 77 million are in corn, with only 3.7 million acres of foliar-applied non-neonicotinoid insecticides added in corn (Table 8). On the other hand, soybean, winter wheat and spring wheat shift neonicotinoid product acres to foliar-applied insecticides for above-ground pests and to higher seeding densities for soil-dwelling pests, since no alternative non-neonicotinoid soil-applied insecticides or seed treatments are registered for use in these crops. The shifts for cotton and sorghum fall between these two extremes because non-neonicotinoid soil-applied insecticides are registered for use in these crops, but some key target pests are above-ground. For example, the non-neonicotinoid scenario replaces 6.3 million product acres of neonicotinoid seed treatments in cotton with 1.6 million product acres of soil insecticides and seed treatments, while the 3.1 million product acres of foliar-applied neonicotinoids are replaced with 8.2 million product acres of non-neonicotinoids, with another 1.5 million acres scouted but not treated (Table 8).

1.6 Impact of neonicotinoid insecticides on farmer cost of production

Because AIs have different costs, the changes in AIs used for the non-neonicotinoid scenario imply changes in farmer costs. Furthermore, these shifts in pest management systems imply changes in application methods, scouting and other practices, which also impact farmer costs. A partial budget analysis is used to capture the net impact of these changes in AIs and practices on farm costs of production.

Partial budget analysis[3] is commonly used to estimate the effect of a potential managerial change on net returns. Rather than develop detailed cost of production budgets for current and the hypothetical management systems, partial budget analysis focuses only on those costs and revenues that would change under the hypothetical managerial change. More specifically, partial budget analysis estimates existing costs that would be avoided if the hypothetical managerial change occurred and new costs that would be incurred for the hypothetical managerial change relative to the current system. Similarly, the analysis also estimates existing revenues that would be lost and new revenues that would be gained for the hypothetical managerial change relative to the current system. By focusing only on the costs and revenues that change, partial budget analysis does not require detailed cost of production budgets and complete cost accounting.

For analyzing the non-neonicotinoid scenario, the partial budget analysis in *Methods and Assumptions for Estimating the Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers* only focuses on cost changes for the non-neonicotinoid scenario relative to the 2010-2012 average. Revenue changes and associated changes in net returns are not estimated in that report but addressed in a separate analysis based on the estimated yield benefits of neonicotinoids. As a result, the partial budget analysis in the report specifically estimates the net change in farmer costs for insecticide AIs, insecticide applications, pest scouting and use of higher seeding densities.

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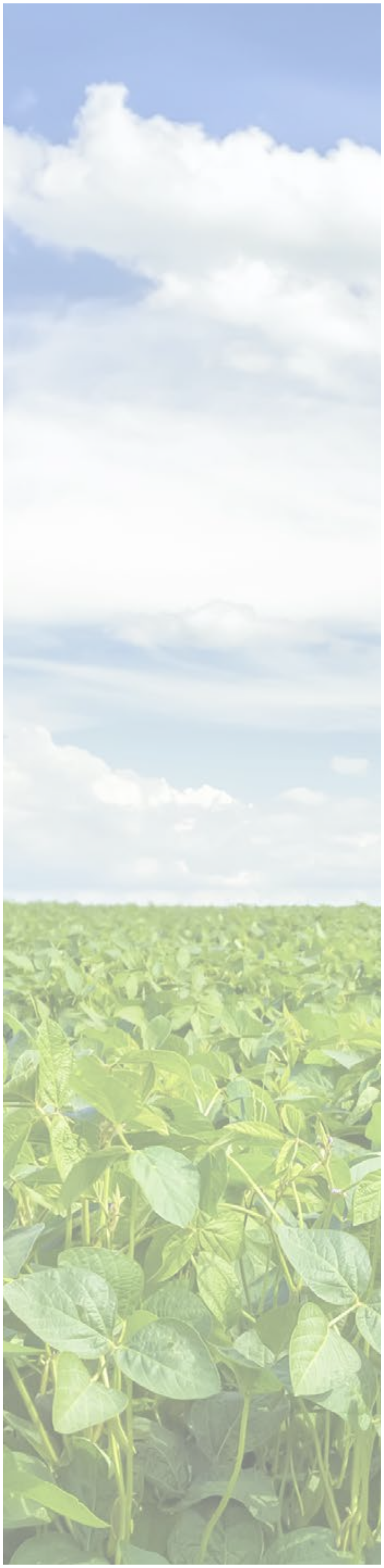
[3] For more complete descriptions of partial budget analysis and its application to farm management, see http://www.extension.iastate.edu/agdm/wholefarm/pdf/c1-50.pdf, http://www.arec.umd.edu/sites/default/files/_docs/Using%20the%20Partial%20Budget_0.pdf, and http://pubs.cas.psu.edu/freepubs/pdfs/ua366.pdf (accessed August 14, 2014).



Existing costs for neonicotinoids that would be avoided under the non-neonicotinoid scenario include the cost of neonicotinoid insecticides for these crops, plus the cost of pest scouting and application for foliar application of these neonicotinoid insecticides in cotton and soybean. Based on 2010-2012 averages, farmers spent $739 million annually on seed treatments and foliar-applied neonicotinoid AIs for these crops, with more than half of this total on neonicotinoid seed treatments for corn and almost one third of it on neonicotinoids used in soybean (Table 9). The analysis also estimates that $43 million was spent to scout and apply these neonicotinoid AIs. Thus, for the non-neonicotinoid scenario, farmers would avoid these existing costs totaling $782 million annually.

On the other hand, farmers would incur several new costs for the non-neonicotinoid scenario, including costs for alternative AIs, additional scouting and application costs, and added costs for using higher seeding densities. Based on 2010-2012 average prices, this analysis estimates almost $1.63 billion annually in additional farmer costs for the non-neonicotinoid scenario (Table 10). By far, the largest component of these added costs would be $896 million for non-neonicotinoid AIs, mostly soil-applied insecticides for corn (Table 10). As a result, most of the $238 million in added application costs for soil-applied insecticides is for corn, while 80 percent of the $178 million in added foliar application costs is for soybean and cotton. The estimated additional cost of higher seeding densities almost reaches $97 million. On a crop basis, corn accounts for almost $1.1 billion in added costs, with soybean accounting for almost $350 million, so that these two crops together account for 87 percent of the estimated $1.63 billion in added costs for the non-neonicotinoid scenario (Table 10).

The net effect of avoiding $782 million in existing neonicotinoid costs and adding $1.63 billion in new costs for the non-neonicotinoid scenario is a net cost increase of almost $848 million (Table 11). Application costs for both soil insecticides and foliar insecticides together comprise a net cost increase of $383 million or about 45 percent of the total increase, with soil insecticide application costs in corn and foliar application costs in soybean constituting the largest crop-specific cost increases (Table 11). Net cost increases for additional scouting constitute $210 million, with most of this increase for soybean scouting, while use of higher seeding densities accounts for almost $97 million, again with soybean accounting for much of this net cost increase.

Of this $848 million net cost increase, additional costs from switching to non-neonicotinoid AIs only contributes $157 million or slightly more than 18 percent of the total (Table 11). A net cost increase occurs for each crop for foliar-applied AIs; but for soil insecticides, a net cost decrease for AIs occurs for all crops except corn and sorghum; corn shows an estimated $373 million net cost increase for soil-applied AIs, while soybean shows a net cost decrease of $223 million. The substantial shift from soil-based to foliar-based pest management systems, especially in soybean, contributes to the cost increase for foliar AIs. However, in corn, the shift from neonicotinoid seed treatments to non-neonicotinoid soil insecticides leads to an estimated net cost increase for AIs because of the higher aggregate costs for the non-neonicotinoid alternatives, even though total product acres in soil-based pest management systems actually decrease.

In terms of crop effects, $677 million of this $848 million net cost increase falls on corn farmers or almost 80 percent, while soybean accounts for $100 million or almost 12 percent (Table 11, Figure 5). Dividing these crop-specific net cost increases by total neonicotinoid base acres or planted acres for each crop gives the cost on a per acre basis. Costs per neonicotinoid base acres range, which are the cost effects for those farmers using neonicotinoids, from $10.39 for sorghum to $1.97 for spring wheat (Table 11, Figure 6). These costs per neonicotinoid base acre imply that crops, such as sorghum and corn, are relatively more dependent on neonicotinoid insecticides in terms of costs compared to the other crops. However, because not all acres are treated with neonicotinoids, the cost per planted acre for each crop ranges from $7.40 for corn to $0.50 for both winter wheat and spring wheat (Table 11, Figure 6). These costs per planted acre are used for the market-level economic assessment of the benefits of neonicotinoids since they affect aggregate supply of each crop.

2.0 Caveats

Several caveats and qualifications apply to the estimates reported here. The analysis is based on 2010-2012 market shares for the non-neonicotinoid AIs and the target pests during those years, both of which are subject to change. Also, the average prices of the non-neonicotinoid AIs are assumed to remain fixed, even though the analysis predicts that demand for some of these AIs would increase dramatically for the non-neonicotinoid scenario. Total crop acreages and rotations are held constant for the non-neonicotinoid scenario, even though both would shift as farmers dealt with new pest problems without neonicotinoids and responded to changes in relative profitability among these and other crops. Finally, neonicotinoid seed treatments provide farmers with a variety of non monetary benefits, which are not accounted for in this assessment. Benefits include resistance management, additional biological control, and increased convenience and safety.

Neonicotinoids provide a widely used alternative mode of action to help manage the development of insect resistance to other important and commonly used modes of actions, such as pyrethroids and organophosphates. Without neonicotinoids, farmers would increase their reliance on these classes of insecticides, which raises concerns about increased potential for the development of insect resistance to these important modes of action. Neonicotinoids also enhance biological contro since the widespread use of neonicotinoid seed treatments would be replaced with more foliar-applied pyrethroids and organophosphates. Greater reliance on foliar applications of these nonselective classes of insecticides raises concerns about negative impacts on beneficial insect populations that farmers rely on as part of an overall pest management strategy. With fewer beneficial insects, populations of current pests and secondary pests may increase and lead to additional insecticide use. Other benefits of seed treatment in comparison to foliar treatments are also not included, such as reduced potential for spray drift and field runoff, and fewer passes through the fields. Finally, farmers derive a variety of other benefits from neonicotinoid seed treatments, such as increased convenience, safety and reduced risk. These resistance management, biological control and managerial benefits are not included in this assessment of the impact of neonicotinoid insecticides on farmer pest management practices and costs for these crops.

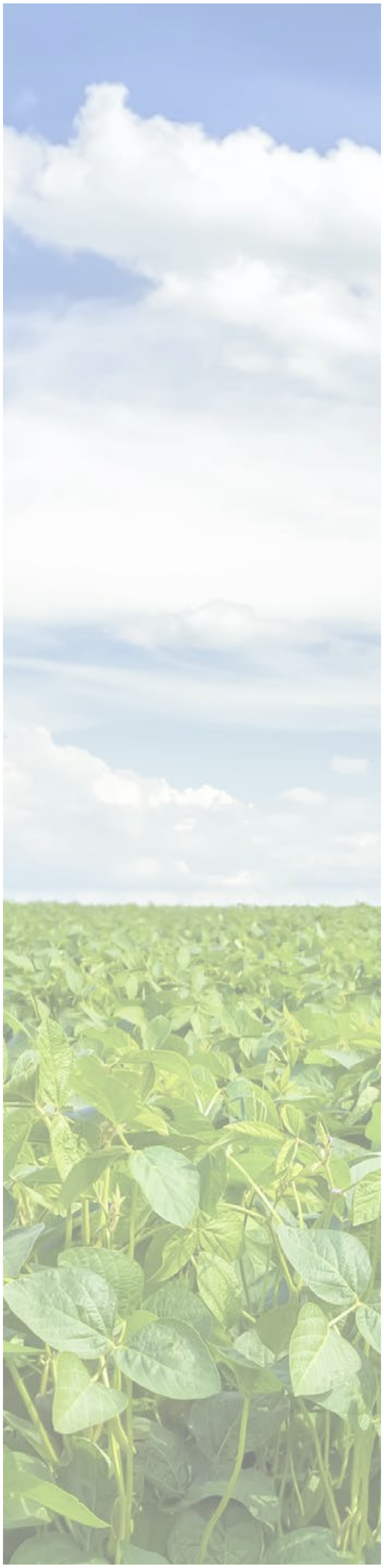


Table 1. 2010-2012 average planted acres and base acres treated (millions) for all active ingredients (AIs) and neonicotinoids by crop.

Insecticide Class	Corn	Soybean	Winter Wheat	Spring Wheat	Cotton	Sorghum	Total
Planted Acres	91.505	76.500	38.270	14.897	12.610	5.808	239.591
Base Acres Treated							
All AIs	82.733	37.505	8.323	5.173	8.603	2.770	145.106
Neonicotinoids	81.374	30.411	6.873	3.782	8.237	2.502	133.180
% Treated							
All AIs	90.4%	49.0%	21.7%	34.7%	68.2%	47.7%	60.6%
Neonicotinoids	88.9%	39.8%	18.0%	25.4%	65.3%	43.1%	55.6%

Table 2. 2010-2012 average product acres (millions) for all AIs and neonicotinoids by crop for foliar, seed treatments and soil insecticides.

---------------------------------- Foliar ----------------------------------

Insecticide Class	Corn	Soybean	Winter Wheat	Spring Wheat	Cotton	Sorghum	Total
Neonicotinoids	0	1.432	0	0	3.049	0	4.481
Non-Neonicotinoids	3.977	20.184	2.112	2.071	19.151	0.661	48.156
All AIs	3.977	21.616	2.112	2.071	22.200	0.661	52.637

---------------------------- Seed Treatment ----------------------------

Insecticide Class	Corn	Soybean	Winter Wheat	Spring Wheat	Cotton	Sorghum	Total
Neonicotinoids	82.551	29.055	6.880	3.782	6.270	2.501	131.038
Non-Neonicotinoids	0	0	0	0	1.446	0.028	1.474
All AIs	82.551	29.055	6.880	3.782	7.715	2.529	132.512

---------------------------- Soil Insecticide ----------------------------

Insecticide Class	Corn	Soybean	Winter Wheat	Spring Wheat	Cotton	Sorghum	Total
Neonicotinoids	0	0	0	0	0	0	0.000
Non-Neonicotinoids	10.117	0	0	0	1.287	0	11.405
All AIs	10.117	0	0	0	1.287	0.020	11.425

---------------------------------- Total ----------------------------------

Insecticide Class	Corn	Soybean	Winter Wheat	Spring Wheat	Cotton	Sorghum	Total
Neonicotinoids	82.551	30.486	6.880	3.782	9.319	2.501	135.519
Non-Neonicotinoids	14.094	20.184	2.112	2.071	21.883	0.690	61.035
All AIs	96.645	50.671	8.992	5.854	31.202	3.211	196.575

Table 3. Estimated 2010-2012 average neonicotinoid product acres (millions) by target pest and by crop.*

Target Pest	Product Acres (1,000,000s)	Corn	Soybean	Winter Wheat	Spring Wheat	Cotton	Sorghum
Wireworm	39.56	27.08	3.85	4.12	3.67	0.14	0.71
Seed maggot	21.45	17.34	4.06				0.05
Corn rootworm	19.73	19.73					
White grub	14.17	12.47	1.71				
Aphid	11.39		7.67	1.49	0.11	1.16	0.97
Bean leaf beetle	10.77		10.77				
Thrips	4.92					4.92	
Cutworm	4.62	4.62					
Plant bug	2.09					2.09	
Stink bug	1.39		1.03			0.36	
Flea beetle	1.32	1.32					
Hessian fly	1.27			1.27			
Threecornered alfalfa hopper	1.01		1.01				
Chinch bug	0.69						0.69
Fleahopper	0.64					0.64	
Japanese beetle	0.40		0.40				
Ant	0.09		0.09				
Total	**135.52**	**82.55**	**30.57**	**6.88**	**3.78**	**9.32**	**2.41**

*Product acres estimated by multiplying crop-specific product acre shares for each target pest by total product acres for each crop, with product acres shares calculated only using those product acres reporting specific target pests.

Since 2000, carbamate and organophosphate shares of insecticide use have decreased, while shares of less acutely toxic insecticides, such as pyrethroids … and neonicotinoids (e.g., imidacloprid, acetamiprid, thiamethoxam and clothianidin) increased.

Page 40, Fernandez-Cornejo, J., Nehring R., Osteen C., Wechsler S., Martin A., and Vialou A. (2014). *Pesticide Use in U.S. Agriculture: 21 Selected Crops, 1960-2008*, EIB-124, U.S. Department of Agriculture, Economic Research Service.

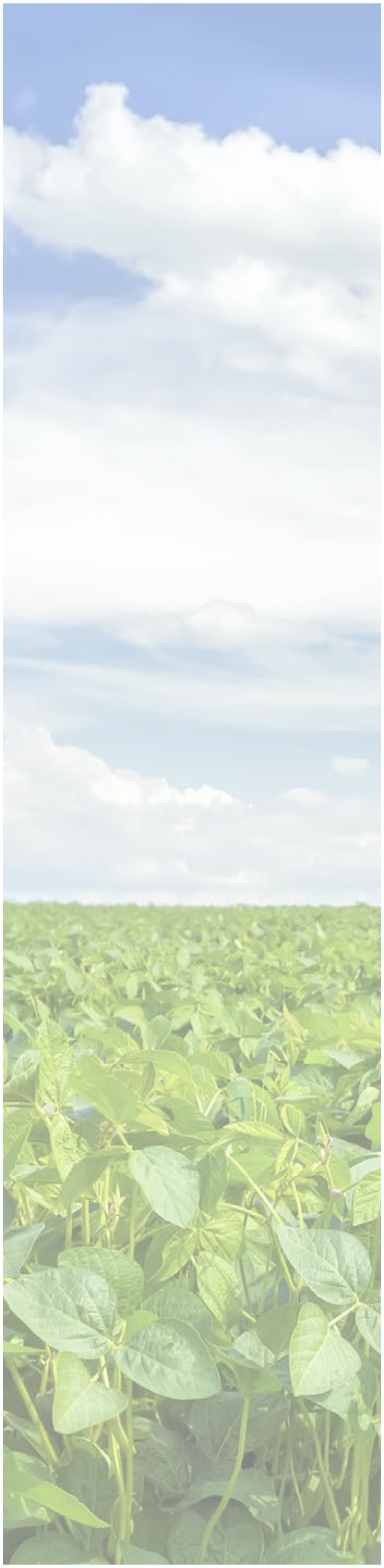


Table 4. Estimated impact of the non-neonicotinoid scenario on insecticide product acres (thousands) by AI for corn, soybean, winter wheat, spring wheat, cotton and sorghum.

		---------------- Product Acres ----------------			
MOA*	**Active Ingredient**	**2010-2012 Average**	**Reallocated**	**New Total**	**Change**
6	Abamectin	574	14	588	2%
1B	Acephate	7,604	6,073	13,676	80%
4A	Acetamiprid	292	230	522	79%
3A	Bifenthrin	8,223	21,524	29,747	262%
1B	Chlorethoxyfos	93	1,977	2,070	2125%
1B	Chlorpyrifos	6,107	8,395	14,502	137%
3A	Cyfluthrin	6,079	15,375	21,454	253%
3A	Cypermethrin	847	188	1,035	22%
3A	Deltamethrin	40	37	77	91%
1B	Dicrotophos	3,584	1,493	5,077	42%
1B	Dimethoate	291	15	306	5%
3A	Esfenvalerate	991	819	1,810	83%
9C	Flonicamid	282	145	427	51%
3A	Gamma-Cyhalothrin	1,098	1,206	2,304	110%
3A	Lambda-Cyhalothrin	11,037	7,814	18,852	71%
1A	Methomyl	22	42	64	185%
1B	Methyl Parathion	244	96	340	40%
1B	Naled	54	41	95	77%
4A	Neonicotinoids	135,519	-135,519	0	-100%
15	Novaluron	882	238	1,120	27%
1A	Oxamyl	494	149	643	30%
3A	Permethrin	532	374	906	70%
1B	Phorate	99	299	398	302%
5	Spinetoram	99	4	104	4%
1B	Tebupirimphos	1,695	15,943	17,638	941%
3A	Tefluthrin	1,895	17,114	19,009	903%
1B	Terbufos	230	3,274	3,504	1426%
1A	Thiodicarb	538	26	564	5%
3A	Zeta-Cypermethrin	2,552	1,705	4,257	67%
	Non-Neonicotinoids**	56,476	104,611	161,087	185%
	Neonicotinoids	135,519	-135,519	0	-100%
	Total Treated With These AIs**	**191,996**	**-30,908**	**161,088**	**-16%**
	Scouted, Not Treated to Replace Neonicotinoids***		**13,199**		
	Higher Seeding Density		**17,407**		
	Net Change		**-302**		

*Insecticide resistance action committee (IRAC) mode of action (MOA): http://www.irac-online.org/documents/moa-classification/?ext=pdf.
**Does not match Table 1 totals because totals here do not include minor use AIs.
***Product acres scouted but not treated with a foliar-applied insecticide for the pest originally targeted by the neonicotinoid.

Table 5. Impact of the non-neonicotinoid scenario on insecticide product acres (thousands) by insecticide class for corn, soybean, winter wheat, spring wheat, cotton and sorghum.

MOA*	Insecticide Class	Product Acres: 2010-2012 Average	Reallocated	New Total	Change
6	Avermectins	574	14	588	2%
15	Benzoylureas	882	238	1,120	27%
1A	Carbamates	1,054	217	1,271	21%
9C	Flonicamid	282	145	427	51%
4A	Neonicotinoids	135,519	-135,519	0	-100%
1B	Organophosphates	19,999	37,607	57,606	188%
4A	Other Neonicotinoids	292	230	522	79%
3A	Pyrethroids	33,294	66,155	99,449	199%
5	Spinosyns	99	4	104	4%
	Non-Neonicotinoids**	56,476	104,611	161,087	185%
	Neonicotinoids	135,519	-135,519	0	-100%
	Total Treated With These MOAs**	**191,996**	**-30,908**	**161,088**	**-16%**
	Scouted, Not Treated to Replace Neonicotinoids***		**13,199**		
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**Does not match Table 1 totals because totals here do not include minor use AIs.
***Product acres scouted but not treated with a foliar-applied insecticide for the pest originally targeted by the neonicotinoid.

Table 6. See next page

Table 7. Impact of the non-neonicotinoid scenario on total pounds (thousands) of insecticide applied by insecticide class for corn, soybean, winter wheat, spring wheat, cotton and sorghum.

MOA*	Insecticide Class	Pounds AI Applied (1,000s): 2010-2012 Average	Reallocated	New Total	Change
6	Avermectins	4.9	0.1	5.0	2%
15	Benzoylureas	37	10	47	27%
1A	Carbamates	231	75	306	33%
9C	Flonicamid	21	11	32	51%
4A	Neonicotinoids	4,004	-4,004	0	-100%
1B	Organophosphates	7,493	15,279	22,773	204%
4A	Other Neonicotinoids	13	11	24	79%
3A	Pyrethroids	1,241	3,745	4,987	302%
5	Spinosyns	2.1	0.1	2.2	4%
	Non-Neonicotinoids	9,044	19,131	28,176	212%
	Neonicotinoids	4,004	-4,004	0	-100%
	Total Pounds of These AIs	**13,048**	**15,127**	**28,176**	**116%**

*Insecticide resistance action committee (IRAC) mode of action (MOA): http://www.irac-online.org/documents/moa-classification/?ext=pdf.

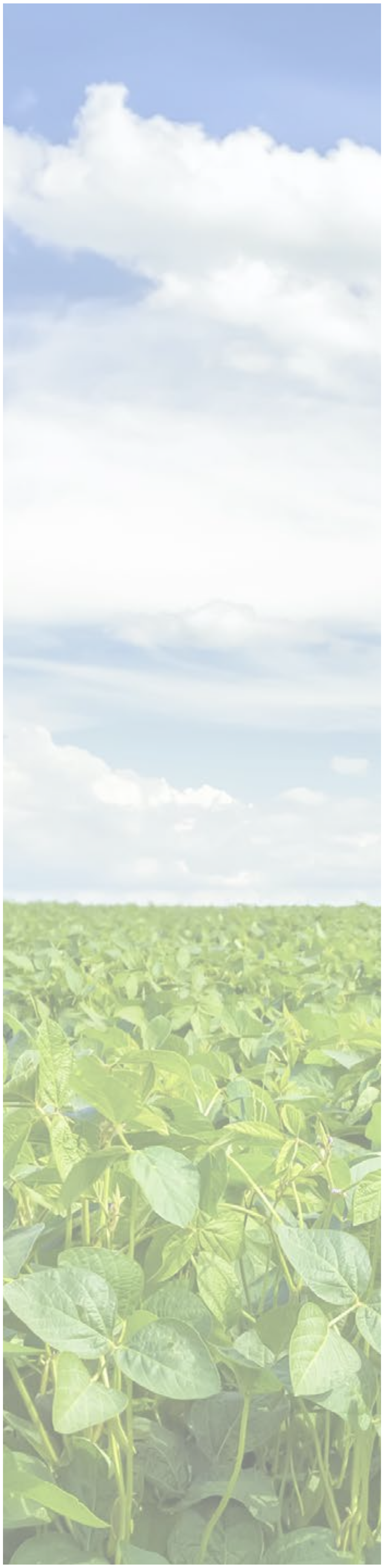


Table 6. Impact of the non-neonicotinoid scenario on total pounds (thousands) of insecticide applied by AI for corn, soybean, winter wheat, spring wheat, cotton and sorghum.

		--------- Pounds AI Applied (1,000s) ---------			
MOA*	**Active Ingredient**	**2010-2012 Average**	**Reallocated**	**New Total**	**Change**
6	Abamectin	4.9	0.1	5.0	2%
1B	Acephate	3,354	2,538	5,892	76%
4A	Acetamiprid	13	11	24	79%
3A	Bifenthrin	505	1,189	1,694	235%
1B	Chlorethoxyfos	17	364	382	2125%
1B	Chlorpyrifos	2,291	6,120	8,412	267%
3A	Cyfluthrin	105	168	273	161%
3A	Cypermethrin	41	12	54	30%
3A	Deltamethrin	0.2	0.4	0.6	240%
1B	Dicrotophos	1,060	445	1,505	42%
1B	Dimethoate	86	4	90	5%
3A	Esfenvalerate	26	25	52	96%
9C	Flonicamid	21	11	32	51%
3A	Gamma-Cyhalothrin	7.8	8.7	16.4	112%
3A	Lambda-Cyhalothrin	254	183	437	72%
1A	Methomyl	7.9	15	23	189%
1B	Methyl Parathion	77	40	117	52%
1B	Naled	50	39	89	77%
4A	Neonicotinoids	4,004	-4,004	0	-100%
15	Novaluron	37	10	47	27%
1A	Oxamyl	194	59	253	30%
3A	Permethrin	34	44	78	127%
1B	Phorate	110	333	443	302%
5	Spinetoram	2.1	0.1	2.2	4%
1B	Tebupirimphos	217	2,040	2,257	941%
3A	Tefluthrin	230	2,088	2,318	909%
1B	Terbufos	231	3,355	3,586	1452%
1A	Thiodicarb	29.1	1.4	30.5	5%
3A	Zeta-Cypermethrin	38	27	64	70%
	Non-Neonicotinoids	9,045	19,106	28,151	211%
	Neonicotinoids	4,004	-4,004	0	-100%
	Total Pounds of These AIs	**13,049**	**15,102**	**28,151**	**116%**

*Insecticide resistance action committee (IRAC) mode of action (MOA): http://www.irac-online.org/documents/moa-classification/?ext=pdf.

Table 8. Impact of the non-neonicotinoid scenario on product acres (millions) in soil-based and foliar pest management systems by crop (soil-based systems include seed treatments, soil-applied insecticides and using a higher seeding density; foliar systems include foliar-treated acres as well as acres scouted but not treated).

	---------- Product Acres (1,000,000s) ----------						
Product Acres in Soil-Based Systems	**Total**	**Corn**	**Soybean**	**Winter Wheat**	**Spring Wheat**	**Cotton**	**Sorghum**
2010-2012 Average (All AIs)	143.94	92.67	29.05	6.88	3.78	9.00	2.55
Non-Neonicotinoid Reallocation							
Neonicotinoid Acres Reallocated	131.04	82.55	29.05	6.88	3.78	6.27	2.50
Non-Neonicotinoid Acres Added	79.86	77.01	0.00	0.00	0.00	1.63	1.22
Acres Using Higher Seeding Density	17.41	0.00	9.62	4.12	3.67	0.00	0.00
Total Added	97.27	77.01	9.62	4.12	3.67	1.63	1.22
Non-Neonicotinoid Total (All AIs)	110.17	87.13	9.62	4.12	3.67	4.36	1.27
Net Change	**-33.77**	**-5.54**	**-19.44**	**-2.76**	**-0.11**	**-4.64**	**-1.28**
Product Acres in Foliar Systems							
2010-2012 Average (All AIs)	52.64	3.98	21.62	2.11	2.07	22.20	0.66
Non-Neonicotinoid Reallocation							
Neonicotinoid Acres Reallocated	4.48	0.00	1.43	0.00	0.00	3.05	0.00
Non-Neonicotinoid Acres Added	24.75	3.70	11.51	0.64	0.04	8.24	0.62
Acres Scouted But Not Treated	14.68	0.39	9.91	2.16	0.07	1.48	0.67
Total Added	39.43	4.09	21.42	2.80	0.11	9.72	1.28
New Total (All AIs)	87.58	8.06	41.61	4.91	2.19	28.87	1.94
Net Change	**34.95**	**4.09**	**19.99**	**2.80**	**0.11**	**6.67**	**1.28**

Table 9. Estimated 2010-2012 annual average grower expenditures ($ million) on neonicotinoid AIs, application and scouting that would no longer be paid under the non-neonicotinoid scenario by crop and in total.

Cost Category	Corn	Soybean	Winter Wheat	Spring Wheat	Cotton	Sorghum	Total
Soil Active Ingredients	396.6	222.8	26.7	9.7	46.7	15.0	717.5
Foliar Active Ingredients	0	4.4	0	0	17.1	0	21.5
Foliar Application	0	10.3	0	0	22.0	0	32.3
Foliar Scouting	0	10.7	0	0	0	0	10.7
Total	**396.6**	**248.1**	**26.7**	**9.7**	**85.8**	**15.0**	**781.9**

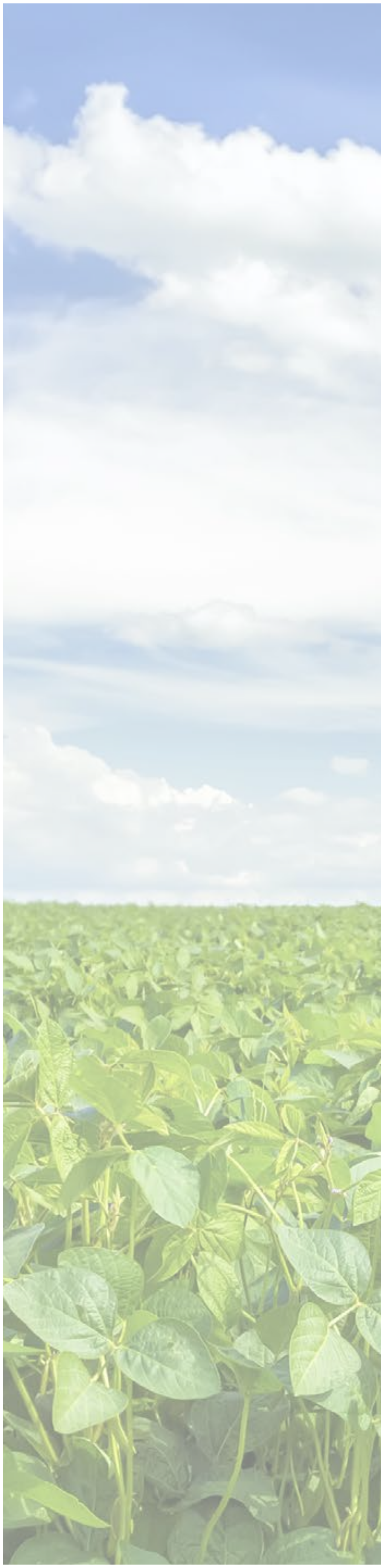


Table 10. Estimated annual average grower expenditures ($ million) on non-neonicotinoid AIs, application, scouting and higher seeding density that would be added for the non-neonicotinoid scenario by crop and in total.

Cost Category	Corn	Soybean	Winter Wheat	Spring Wheat	Cotton	Sorghum	Total
Soil Active Ingredients	769.1	0	0	0	8.6	20.5	798.1
Foliar Active Ingredients	16.3	43.2	2.5	0.1	33.3	2.9	98.2
Soil Application	231.0	0	0	0	2.8	3.7	237.5
Foliar Application	26.6	82.9	4.6	0.3	59.3	4.4	178.2
Foliar Scouting	30.4	159.4	20.8	0.9	0	9.5	221.0
Higher Seeding Density	0	63.1	17.8	15.9	0	0	96.7
Total	**1,073**	**348.5**	**45.7**	**17.1**	**104.0**	**41.0**	**1,630**

Table 11. Estimated net change in annual grower expenditures ($ million) and average per acre costs for the non-neonicotinoid scenario by crop and cost category.

Cost Category	Corn	Soybean	Winter Wheat	Spring Wheat	Cotton	Sorghum	Total
Soil Active Ingredients	372.5	-222.8	-26.7	-9.7	-38.2	5.5	80.6
Foliar Active Ingredients	16.3	38.8	2.5	0.1	16.2	2.9	76.8
Soil Application	231.0	0	0	0	2.8	3.7	237.5
Foliar Application	26.6	72.6	4.6	0.3	37.4	4.4	145.9
Foliar Scouting	30.4	148.7	20.8	0.9	0	9.5	210.4
Higher Seeding Density	0	63.1	17.8	15.9	0	0	96.7
Total	**676.9**	**100.4**	**19.0**	**7.4**	**18.2**	**26.0**	**847.8**
Neonicotinoid Base Acre	8.32	3.30	2.76	1.97	2.21	10.39	6.37
Planted Acre	7.40	1.31	0.50	0.50	1.44	4.48	3.54

Figure 1. 2010-2012 annual average of neonicotinoid and non-neonicotinoid insecticide product acres by crop.

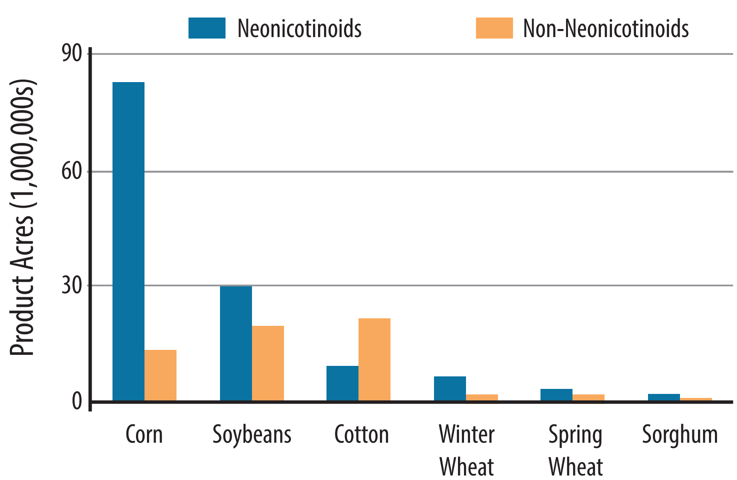


Figure 2. 2010-2012 annual average of the neonicotinoid and non-neonicotinoid insecticide product acres in corn, soybean, winter wheat, spring wheat, cotton and sorghum by application method.

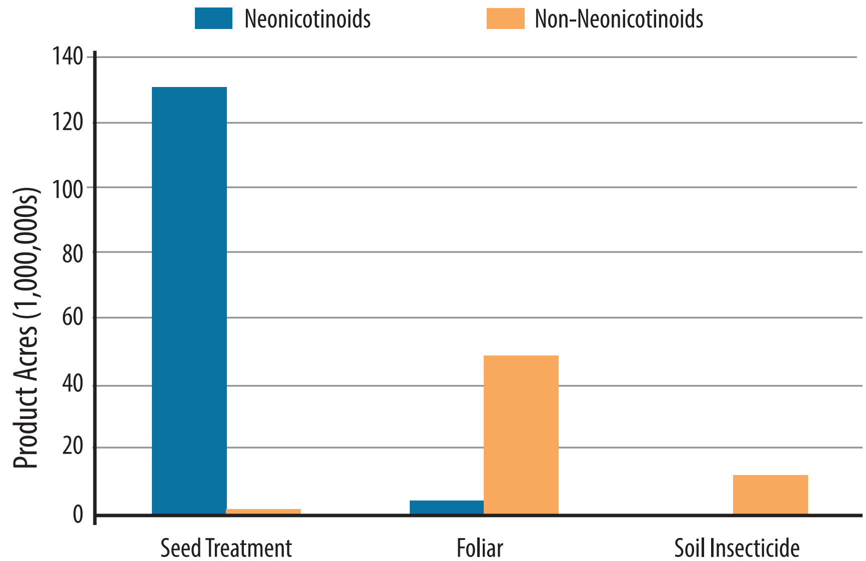


Figure 3. 2010-2012 annual average product acres and estimated product acres for the non-neonicotinoid scenario by insecticide class and practice for corn, soybean, winter wheat, spring wheat, cotton and sorghum. ("Scouted, Not Treated" are product acres scouted for the non-neonicotinoid scenario, but not treated for the pest originally targeted by the neonicotinoid. "Higher Seeding Density" are product acres using higher seeding densities or replanting for the non-neonicotinoid scenario to replace a neonicotinoid seed treatment.)

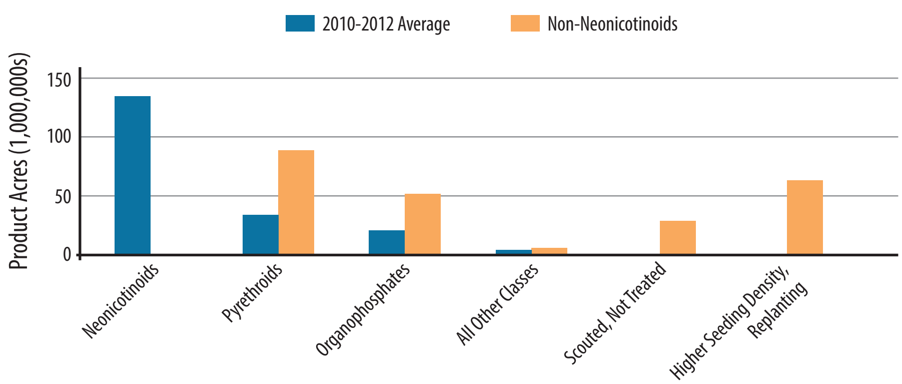
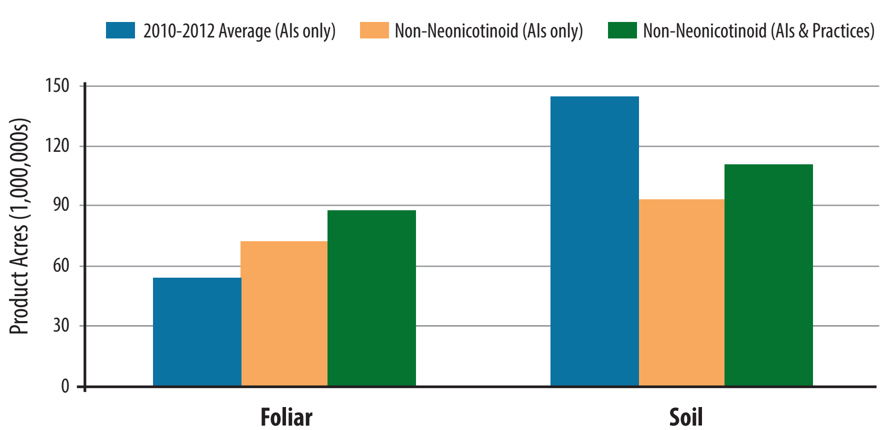


Figure 4. 2010-2012 average insecticide product acres and estimated total acres for the non-neonicotinoid scenario using foliar- and soil-based pest management systems when aggregated over corn, soybean, winter wheat, spring wheat, cotton and sorghum. ("AIs only" includes seed treatment and soil-applied insecticide product acres in soil-based system and foliar-applied insecticide product acres in foliar system; "AIs & Practices" also includes higher seeding density in soil-based system and scouted but not treated in foliar system.)



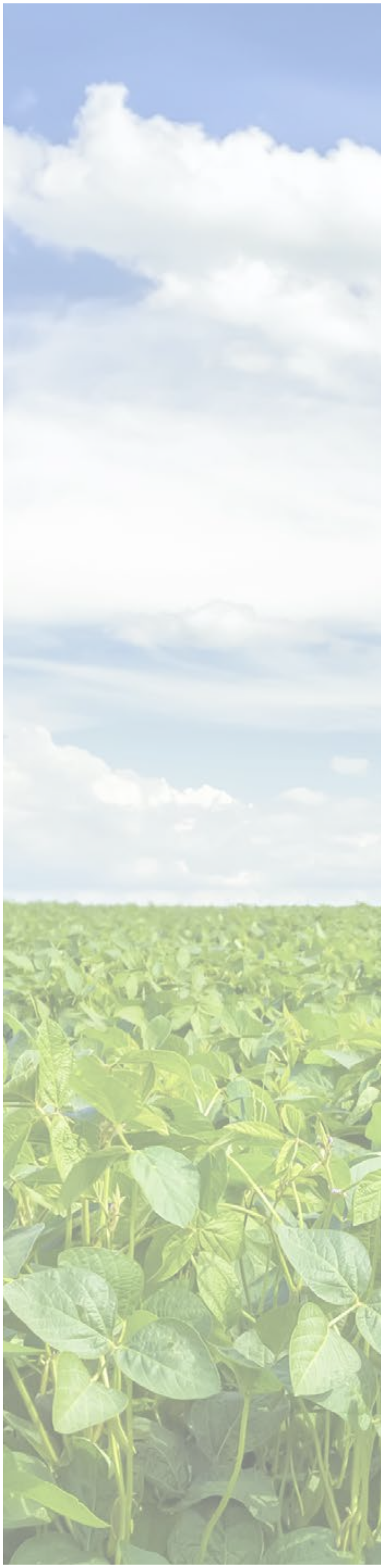


Figure 5. Distribution across crops of the estimated $848 million annual cost benefit of neonicotinoid insecticides.

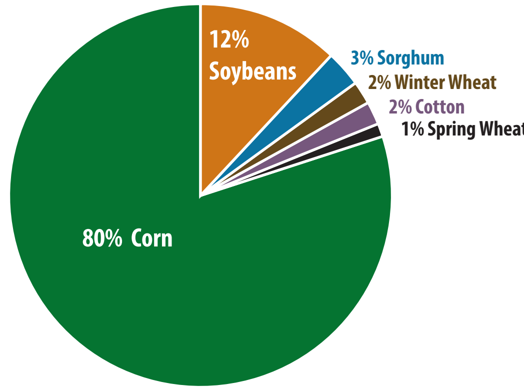


Figure 6. Estimated average cost impact of the non-neonicotinoid scenario by crop, expressed as $ per neonicotinoid base acre and $ per planted acre for each crop.