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Opinion

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Fatal attraction: the intuitive appeal of GMO opposition

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Public opposition to genetically modified organisms (GMOs) remains strong. By contrast, studies demonstrate again and again that GM crops make a valuable contribution to the development of a sustainable type of agriculture. The discrepancy between public opinion and the scientific evidence requires an explanation. We argue that intuitive expectations about the world render the human mind vulnerable to particular misrepresentations of GMOs. We explain how the involvement of particular intuitions accounts for the popularity, persistence, and typical features of GM opposition and tackle possible objections to our approach. To conclude, we discuss the implications for science education, science communication, and the environmental movement.

Explaining public opposition to GMOs

Concerns about health, environmental, and socioeconomic hazards have resulted in a strong public opposition to GMOs [1–3]. These worries tend to have a large impact on national and international policies. For instance, in India, the government suspended the culture of *Bacillus thuringiensis*-engineered *Solanum melongena (Bt* brinjal), despite initial approval for commercialization [4]. In Europe, the lack of public support for GMOs has led to a *de facto* moratorium within the EU on new GM crops from 1999 to 2004 and has steered the development of an extremely strict and expensive regulatory framework concerning the import and cultivation of GM crops [5]. In Africa and Asia, the resistance to GMOs has had tragic consequences, costing thousands of lives [6,7].

However, research shows that cultivation of GM crops does not pose any specific health or environmental risks, but instead can bring benefits to local farmers [8–11]. The reason for the discrepancy between public opinion and scientific evidence needs clarification. Some people suggest that post-Christian beliefs or romantic notions of nature are responsible, whereas others blame the lack of direct benefits for Western consumers [6,12,13]. These accounts are definitely on the right track. Nonetheless, they fail to explain why opposition also occurs in non-Christian cultures, why people do not reject every technology that brings no immediate benefits, or why people prefer romantic views in the first place.

We suggest a cognitive approach to account for the opposition to GMOs. In other words, we use ideas from the cognitive sciences, evolutionary psychology, and cultural attraction to rationalize the popularity and typical features of this phenomenon. We argue that intuitions and emotions make the mind highly susceptible to particular negative representations of GMOs. We propose ways to rectify the current situation and improve science education and communication.

An intuitive understanding of GMOs

Although generally we feel as if we control willfully what we think and do, much of our thinking depends on intuitions, of which the working largely stays below the radar of conscious awareness [14]. Among other things, these intuitions, which evolved in response to particular adaptive situations, automatically shape expectations about the world or induce reflexive risk assessments [15]. Under ecologically relevant conditions, these intuitions tend to generate rational responses [16] but, when confronted with abstract and complex situations, these intuitions tend to break down [17]. For instance, people are more easily scared by spiders than by cars, although in modern society the number of mortal car accidents is much higher [18]. As to our understanding of the world, cognitive predispositions can result in deeply engrained biases that, if not dealt with by education, lead to persistent resistance to counter-intuitive scientific theories in adulthood. Dualist intuitions, for instance, make it difficult to accept that mental states result from physical processes [19]. Nevertheless, our thinking relies on at least two types of reasoning processes. In addition to the fast and automatic intuitions described above, humans can resort to an effortful and reflective type of reasoning that allows them to consciously evaluate and relate different information types [14,20,21]. By exercising this reflective capability, and thanks to the development and use of social and epistemic methods, tools, and practices, scientists have been able to tweak and build on their intuitions and, thus, to gain a more objective and scientific understanding of the world [22–24].

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Box 1. The role of intuitions in cultural domains

The opposition to GMOs is not the only complex of beliefs that piggybacks upon folk intuitions. For instance, religious beliefs are typically explained in terms of the appeal they exert on ordinary human cognition that includes essentialist reasoning, a hyperactive agency detection system, and an intuitive theory of mind [32–34]. In addition, pseudoscience taps into these and other intuitions, a trait that can persist in the face of scientific discovery. Creationism is anchored in essentialist, teleological, and intentional intuitions. Moreover, creationists even explicitly call upon these intuitions to bolster their case [51]. Pattern recognition leads us to over-detect correlations and causation, leaving the mind susceptible to all kinds of superstition, such as fear of black cats or walking under ladders. Furthermore, medical pseudoscience owes its success largely to placebo thinking by which people who are ill can get better merely by thinking that they will [52]. In fact, intuitions affect a wide range of social and cultural domains, such as social institutions and the development of science [52–54]. The cases of GMO opposition and pseudoscience demonstrate that intuitions can even favor the distribution of beliefs that are flatly contradicted by evidence.

The intuitive mind is not well equipped to address intricate questions, such as 'what is biotechnology?', 'how does it work?', or, most importantly, 'is it dangerous?' The ability to understand such issues and, hence, to have a subsequent objective and rational judgment requires an important effort and, even then, the mind is still liable to relapse into biased thinking. Lay people are often unable or are simply not interested in investing large amounts of time and energy to acquire a profound grasp of complex technologies. Therefore, when lay people are confronted with and have to evaluate information about GMOs and the risks involved, they will predominantly rely on their intuitive mind. As a result, lay people tend to prefer GMO representations that are most in line with their intuitive expectations and, thus, are easier to understand and remember. Anti-GMO groups have successfully tapped into people's intuitions to promote their cause, thus making their campaign highly attractive to the human mind (Box 1).

We explore below which intuitions make people vulnerable to GMO antagonism, and show how our approach explains the popularity, persistence, and typical features of the GMO hostility; we also briefly counter some objections that might be raised. Finally, the implications for science education, communication, and the environmentalist movement are discussed.

The intuitive appeal of anti-GMO representations

Folk biology

The human mind intuitively understands how the biological world functions. One constituent of this folk biology is psychological essentialism [25] that amounts to the belief that organisms hold an unobservable, immutable core determining their identity and, thus, their development and behavior. Psychological essentialism makes sense evolutionarily because it allows individuals to categorize automatically the biological world. As such, valuable information becomes immediately available, enabling apt responses to living entities in the environment. For instance, when one is confronted with a tiger, the immediate realization that one is coping with a specimen of the category 'tiger' and, thus, that with its mighty claws and sharp fangs it might catch and eat its prey, is a more adaptive reaction than to reassess each and every encountered stripy feline [26]. Nevertheless, despite the obvious adaptive rationality of this cognitive predisposition, psychological essentialism regularly interferes with a scientifically informed biological understanding [27]. Notoriously, it impedes people's understanding of basic aspects of evolutionary theory and, moreover, it also affects people's comprehension of GMOs, primarily because they interpret DNA as the essence of organisms [28]. In a US survey, more than half of the respondents did not reject the idea that tomatoes of the which the genome had been modified by insertion of catfish DNA would taste like fish [29]. Apparently, people assumed that the fish's essence had been introduced into these tomatoes, including a fishy taste. That people systematically prefer cisgenic over transgenic organisms provides another indication of an essentialist bias [3]. In their campaigns, opponents of GMOs explicitly appeal to these essentialist intuitions by distributing edited images of tomatoes with fish tails or by claiming that biotech companies insert scorpion DNA elements into corn (*Zea mays*) to produce crispy cornflakes. The notion that growing GM crops with herbicide tolerance will promote so-called superweeds falls back to the same misconception that a weed can be characterized by a single gene. On the contrary, typical weed characteristics such as withstanding harsh environments, competing for light, water, and minerals, and fast reproduction are the result of the interplay of numerous genes.

Teleological and intentional intuitions

Another aspect of the intuitive mind that affects people's preferences for particular GMO representations and the perception of the risks involved are teleological and intentional intuitions. These intuitions tend to translate in religious beliefs, but they can also contribute to a quasi-religious view on nature [30,31]. Indeed, large parts of Europe, where resistance against GM food is strong, are highly secular. In the cognitive science of religion, religion is commonly assumed to be a byproduct generated by the peculiarities of our mental make-up that includes essentialist thinking, but that is also highly receptive to the feeling that the world has been designed for a particular purpose [32–35]. This design illusion has effectively been debunked by evolutionary theory, but the mix of essentialist, teleological, and intentional biases continues to allure many people into believing that a certain order exists in nature that should not be meddled with. Indeed, genetic engineering is considered to be the opposite of 'natural' [3,36]. GMO opponents accuse scientists who produce transgenic plants of 'playing God' and condemn their acts as 'against nature'. Biotech food is often referred to as 'Frankenfood', suggesting that, as with Mary Shelley's artificial creature, the technology will escape the control of the haughty scientists and result in horrific environmental doom scenarios.

Emotions

A category of mental features that particularly interferes with people's risk assessment of GMOs are emotions. Disgust is especially important in this context. In

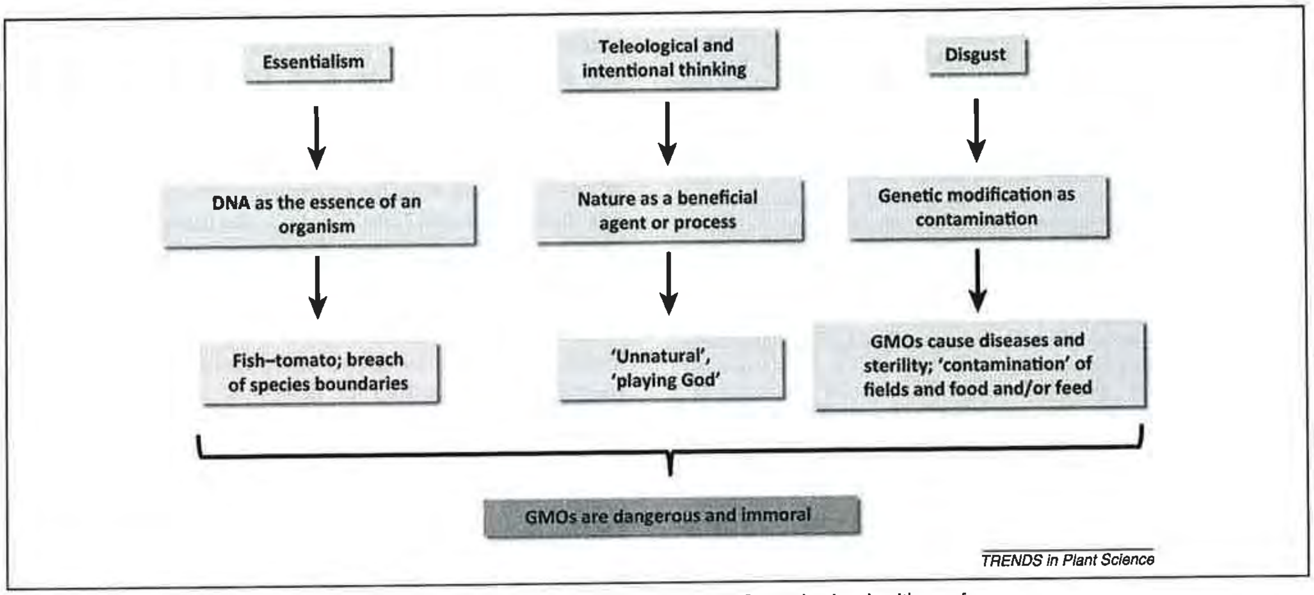

Figure 1. Unsubstantiated negative representations of GMOs tapping into intuitive preferences.

particular, revulsion may influence the reactions to GMOs because people object more to GM food than to GMOs developed for other applications [37]. Disgust evolved probably in response to adaptive problems related to pathogen and poison avoidance [38–40]. The evolutionary rationale explains why the emotion is on a hair trigger: to forego a nutritious meal because it is erroneously considered toxic or contaminated is potentially far less harming than to consume spoiled food under the misguided assumption that it is perfectly edible [40]. Hence, distaste can be elicited by food that is completely innocuous. Indeed, food taboos offer clear examples of disgust regulated by cultural conventions, often involving meat derived from animals that are fit for human consumption, but that are considered vile and dirty. In experiments, scientists induce revulsion by presenting orange juice stirred with a sterilized cockroach or dog feces-like shaped caramelized biscuit spread [41]. In the case of GM food, feelings of disgust possibly arise because of psychological essentialism by which people intuitively interpret gene modification as an unwarranted and contaminating intervention into the essence of an organism, rendering the organism impure and, therefore, no longer consumable. The effect will probably be enhanced when the introduced DNA derives from a different species, or a species that is considered dirty. Anti-GMO activists bombard the public with edited images that imply that GM food cannot be trusted, such as tomatoes with syringes or suspiciously blue biotech strawberries amid fresh red ones. *Bt* crops are described as poisonous and instigate the fear that biotech crops will 'contaminate' the surrounding environment. Moreover, disgust also affects our moral judgment [38,40,42]. Hence, the emotion incites people to condemn not only the GM food itself but also the producers and developers of GM products as immoral. Linking socioeconomic abuses to GM products has become today's major focus of the anti-GMO critique. To trigger moral disgust, stories are brought up of big multinationals that chain farmers to ruthless contracts and patents, or even push resource-poor farmers into debt and suicide after they have been 'seduced' to buy the 'killer' seeds. Plant biotech research institutes are pictured as a scientific community that burns tax money while becoming totally dependent on research contracts with big industry. The current socioeconomic implantation of GM technology into agriculture merits further analysis because this issue raises important questions about the place and role of science in our complex society. For instance, how should science relate to industry? Nevertheless, the current situation is certainly not as black-and-white as activists maintain, and it is plainly wrong to name a single breeding technology as the cause of these complex issues.

How the opposition to GMOs does – and does not – take shape

Some representations are more popular than others. The popularity of a representation is determined by the relevance of the information it purveys. Whether information is relevant depends on its ability to capture attention and the ease by which the mind can process it. The more information is in line with our intuitive expectations, the more easily it is apprehended, remembered, and, thus, communicated. Because intuitions are universally shared, appropriate representations stand a greater chance of becoming widely distributed and culturally stable. At the population level, an outline emerges in which representations converge into and stabilize around hypothetical points termed cultural attractors [43,44]. This pattern of attraction also occurs in the case of the GMO opposition. The negative representations produced by anti-GMO activists happen to reflect essentialist and intentional understandings of nature and suggest contamination, hence becoming highly salient to the corresponding intuitions (Figure 1). Owing to their aggregated relevance, these depictions will tend to outcompete the demonstrations of scientists and other experts that require an enhanced cognitive effort. As such, the anti-GMO campaign has been

Box 2. Reasonable doubt?

The influence of intuitions largely accounts for the typical features and popularity of the opposition to GMOs. Moreover, many of the arguments leveled against GMOs articulate concerns that clearly arise from intuitions and emotions. Other arguments only become relevant in the context of GMOs because people seek ways to rationalize their intuitively felt resistance. In turn, some of these arguments tap into and exploit moral concerns about fairness (i.e., multinationals exploit small farmers) and environment (i.e., GMOs kill butterflies) that can consequently become amplified with intuitively appealing allegations about sickness and unnaturalness. Arguments against GMOs sound even more convincing when they come from an allegedly trustworthy source, such as an environmentalist organization or a friend, or when they are popular among the social group one wants to be part of. Hence, people oppose GMOs for reasons other than mere intuitive appeal, such as trust and conformity. Are there any reasonable scientific worries to account for the opposition against GMOs? Some reports and studies have claimed that GMOs *per se* badly affect health, environment, and small farmers in developing countries. These studies, however, turned out to be unsubstantiated. Anti-GMO activists continue to refer to these studies. As such, they cloak their arguments under a scientific veil, thus exploiting the cultural authority of science. In this regard, the opposition to GMOs resembles pseudosciences, such as 'scientific' creationism and homeopathy, that mimic science in an attempt to gain respectability [52]. At the same time, anti-GMO activists also adopt pseudoscientific tactics to undermine the authority and autonomy of the science that contradicts their claims, for instance by overstating the impact of industry on plant sciences. As a result, people may wrongly assume that there are good scientific reasons to oppose GMOs.

For sure, our cognitive analysis does not render every public concern unfounded *a priori*. Some of these apprehensions can be legitimate. For instance, herbicide resistance in weeds has indeed become a problem in areas such as the USA and Argentina where farmers have over-relied on a single herbicide-resistant crop that was tolerant to glyphosate. However, these concerns are typically unrelated to the technology of genetic modification, and instead result from unsound agricultural practices and policy that also can cause problems in the case of 'conventional' crops. Moreover, whether a particular GM application has unwanted effects needs to be tested on a case-by-case basis, thereby focusing not on the technology, but on the resulting product.

extremely successful, not only to the surprise of scientists, but also of the instigators themselves [45].

The preferential adoption of negative GMO representations takes place reflexively, instantaneously, and largely under the radar of conscious awareness. However, the resulting negative affect is consciously registered and, consequently, prompts people to justify their feelings. A form of motivated reasoning emerges in which arguments become highly prominent that are applicable equally to other technologies but are suddenly ignored. The alleged unnaturalness of genetic engineering or the involvement of multinationals can equally easily be applied against medical biotech applications, but only seem to be relevant in the case of GMOs. Other arguments make sense because they are attuned to particular components of the mind's intuitive appraisal. To a mind that is primed with feelings of disgust, it seems evident that GMOs can provoke sickness or contaminate the environment (Box 2).

Nevertheless, intuitions interact with other sensitivities and with the cultural environment. For instance, people who may reap direct and considerable benefits from the development and commercialization of GM products will become apt to adopt more positive viewpoints. Moreover, they may trust information sources such as scientific reports that demonstrate that GMOs are safe and even beneficial. As such, the human mind is not predetermined to think that GMOs are poisonous, disgusting, or unnatural. However, once these negative representations become culturally available, for instance because of intense campaigning by environmental groups or lack of any strong cultural counterforces, the human mind will be highly susceptible to them. Furthermore, because cultural attraction addresses statistical effects, we can expect intragroup varieties in the adoption of negative representations of GMOs. In a culture that predominantly opposes GMOs, members will also be present that are pro, and vice versa. Indeed, the opposition to GMOs is not everywhere as strong as it is in Europe, although it is more common than people tend to think.

Concluding remarks and implications

The human mind comprises evolved intuitions that shape and constrain cultural preferences. In the case of GMOs, folk biology, religious intuitions, and emotions such as disgust leave the mind readily seduced by representations of GMOs as abnormal or toxic. By pointing out how public aversion to GMOs thrives on such preferences, it is understandable why people continue to resort systematically to concerns about GMOs that are scientifically unsubstantiated. With such a perspective that is not intended to characterize public worries in general as irrational, we hope that a cognitive understanding can contribute to a better insight into and perhaps a more lenient attitude toward the anxieties of the public. In addition, we expect to open the eyes of those who reject GMOs as a whole – and hope to let them realize that their concerns arise from sources that cannot be trusted *prima facie*, and that the risks and benefits can only be assessed on a case-by-case basis, depending on the result and not the process [46].

Education can, at least to some extent, abate the intuitive appeal of negative GMO representations. Instruction of young people about biotechnology and its implications will require educational strategies that specifically target and tweak intuitive modes of thinking. However, this method of immunizing minds is certainly not foolproof. Intuitive thinking remains a trap, even to the minds of experts. At the same time, scientists and institutions, companies and governments that communicate about GMOs and their potential risks can also appeal to the intuitive mind. Although GMOs are at a disadvantage because they are commonly associated with unnaturalness and trigger disgust, emphasis on the benefits would effectively induce sympathy [37,47]. Even though individual people may not always experience a personal advantage by purchasing and/or consuming GMOs, it will certainly help to inform the public that, for example, (i) *Bt* corn contains less mycotoxins and is thus healthier than conventional maize [48]; (ii) herbicide-resistant crops require less tilling and, thus, improve the soil quality; (iii) *Bt* crops enhance insect biodiversity [49]; (iv) biotech crops help reduce poverty in India [50], and so on.

Finally, our approach suggests that people who are genuinely concerned about the environment may intuitively adopt strategies that have the opposite impact on what

they set out to achieve. GMOs can be a formidable tool in the realization of a sustainable form of agriculture. By leading people to choose the wrong adversaries and to urge policy makers to take counter-effective measures, negative GMO representations may indeed exert a fatal attraction.

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References

1 Jayaraman, K. and Jia, H. (2012) GM phobia spreads in South Asia. *Nat. Biotechnol.* 30, 1017–1019
2 Arthur, G.D. (2011) Benefits and concerns surrounding the cultivation of genetically modified crops in Africa: the debate. *Afr. J. Biotechnol.* 10, 17663–17677
3 Gaskell, G. *et al.* (2010) *Europeans and Biotechnology in 2010: Winds of Change?* (Eurobarometer Survey Series No. 7; Report EUR 24537), Publications Office of the European Union
4 Editorial (2010) India bows to negative sentiments on Bt Brinjal. NatureIndia 9 February. http://www.natureasia.com/en/nindia/article/10.1038/nindia.2010.10
5 Devos, Y. *et al.* (2006) The interplay between societal concerns and the regulatory frame on GM crops in the European Union. *Environ. Biosafety Res.* 5, 127–149
6 Paarlberg, R. (2008) *Starving for Science. How Biotechnology is Being Kept Out of Africa*, Harvard University Press
7 Wesseler, J. and Zilberman, D. (2014) The economic power of the Golden Rice opposition. *Environ. Dev. Econ.* 19, 724–742
8 Mannion, A.M. and Morse, S. (2012) Biotechnology in agriculture: agronomic and environmental considerations and reflections based on 15 years of GM crops. *Prog. Phys. Geogr.* 36, 747–763
9 Qaim, M. and Kouser, S. (2013) Genetically modified crops and food security. *PLoS ONE* 8, e64879
10 Snell, C. *et al.* (2012) Assessment of the health impact of GM plant diets in long-term and multigenerational animal feeding trials: a literature review. *Food Chem. Toxicol.* 50, 1134–1148
11 Brookes, G. and Barfoot, P. (2012) The income and production effects of biotech crops globally 1996–2010. *GM Crops Food Biotechnol. Agric. Food Chain* 3, 265–272
12 Silver, L.M. (2006) *Challenging Nature. The Clash between Biotechnology and Spirituality*, HarperCollins
13 Fresco, L.O. (2013) The GMO Stalemate in Europe. *Science* 339, 883
14 Kahneman, D. (2011) *Thinking Fast and Slow*, Farrar, Straus and Giroux
15 Tooby, J. and Cosmides, L. (1992) The biological foundations of culture. In *The Adapted Mind. Evolutionary Psychology and the Generation of Culture* (Barkow, J. *et al.*, eds), pp. 19–136, Oxford University Press
16 Gigerenzer, G. (2008) *Rationality for Mortals. How People Cope with Uncertainty*, Oxford University Press
17 Haselton, M.G. *et al.* (2005) The evolution of cognitive bias. In *The Handbook of Evolutionary Psychology* (Buss, D.M., ed.), pp. 724–746, John Wiley & Sons
18 Öhman, A. and Mineka, S. (2001) Fears, phobias, and preparedness: toward an evolved module of fear and fear learning. *Psychol. Rev.* 108, 483–522
19 Bloom, P. and Weisberg, D.S. (2007) Childhood origins of adult resistance to science. *Science* 316, 996–997
20 Sloman, S.A. (1996) The empirical case for two systems of reasoning. *Psychol. Bull.* 119, 3–22
21 Evans, J.S.B.T. (2010) *Thinking Twice. Two Minds in One Brain*, Oxford University Press
22 Haack, S. (2003) *Defending Science – Within Reason. Between Scientism and Cynism*, Prometheus Books
23 Goldman, A.I. (1999) *Knowledge in a Social World*, Clarendon Press
24 Heintz, C. (2013) Scaffolding on core cognition. In *Developing Scaffolds in Evolution, Culture and Cognition* (Caporael, L. *et al.*, eds), pp. 209–228, MIT Press
25 Gelman, S.A. (2004) Psychological essentialism in children. *Trends Cogn. Sci.* 8, 404–409
26 Barrett, H.C. (2001) On the functional organs of essentialism. *Mind & Society* 2, 1–30
27 Shtulman, A. and Schulz, L. (2008) The relation between essentialist beliefs and evolutionary reasoning. *Cogn. Sci.* 32, 1049–1062
28 Gelman, S.A. and Rhodes, M. (2012) 'Two-thousand years of stasis': how psychological essentialism impedes evolutionary understanding. In *Evolution Challenges. Integrating Research and Practice in Teaching and Learning about Evolution* (Rosengren, K.S. *et al.*, eds), pp. 3–21, Oxford University Press
29 Hallman, W.K. *et al.* (2004) *Americans and GM Food: Knowledge, Opinion and Interest in 2004 (Food Policy Institute Publication RR-1104-007)*, The State University of New Jersey
30 Kelemen, D. and Rosset, E. (2009) The human function compunction: teleological explanations in adults. *Cognition* 111, 138–143
31 Kelemen, D. *et al.* (2013) Professional physical scientists display tenacious teleological tendencies: Purpose-based reasoning as a cognitive default. *J. Exp. Psychol. Gen.* 142, 1074–1083
32 Barrett, J.L. and Lanman, J.A. (2008) The science of religious beliefs. *Religion* 38, 109–124
33 Boyer, P. (2001) *Religion Explained. The Evolutionary Origins of Religious Thought*, Basic books
34 Kelemen, D. (2004) Are children 'intuitive theists'? Reasoning about purpose and design in nature. *Psychol. Sci.* 15, 295–301
35 Järnefelt, E. *et al.* (2015) The divided mind of a disbeliever: Intuitive beliefs about nature as purposefully created among different groups of non-religious adults. *Cognition* (in press)
36 Rozin, P. *et al.* (2012) European and American perspectives on the meaning of natural. *Appetite* 59, 448–455
37 Savadori, L. *et al.* (2004) Expert and public perception of risk from biotechnology. *Risk Anal.* 24, 1289–1299
38 Tybur, J.M. *et al.* (2013) Disgust: evolved function and structure. *Psychol. Rev.* 120, 65–84
39 Curtis, V. *et al.* (2011) Disgust as an adaptive system for disease avoidance behaviour. *Philos. Trans. R. Soc. B: Biol. Sci.* 366, 389–401
40 Kelly, D. (2011) *Yuck! The Nature and Moral Significance of Disgust*, MIT Press
41 Rozin, P. *et al.* (1986) Operation of the laws of sympathetic magic in disgust and other domains. *J. Pers. Soc. Psychol.* 50, 703–712
42 Haidt, J. (2001) The emotional dog and its rational tail: a social intuitionist approach to moral judgment. *Psychol. Rev.* 108, 814–834
43 Sperber, D. (1996) *Explaining Culture: A Naturalistic Approach*, Blackwell
44 Claidière, N. *et al.* (2014) How Darwinian is cultural evolution? *Philos. Trans. R. Soc. Lond. B: Biol. Sci* 369, 20130368
45 Lynas, M. (2011) *The God Species. Saving the Planet in the Age of Humans*, National Geographic
46 Ammann, K. (2014) Genomic misconception: a fresh look at the biosafety of transgenic and conventional crops. A plea for a process agnostic regulation. *New Biotech* 31, 1–17
47 Rommens, C.M. (2010) Barriers and paths to market for genetically engineered crops. *Plant Biotechnol. J.* 8, 101–111
48 Wu, F. (2006) Mycotoxin reduction in Bt corn: potential economic, health, and regulatory impacts. *Transgenic Res.* 15, 277–289
49 Ammann, K. (2005) Effects of biotechnology on biodiversity: herbicide-tolerant and insect-resistant GM crops. *Trends Biotechnol.* 23, 388–394
50 Subramanian, A. and Qaim, M. (2010) The impact of Bt cotton on poor households in rural India. *J. Dev. Stud.* 46, 295–311
51 Blancke, S. and De Smedt, J. (2013) Evolved to be irrational? Evolutionary and cognitive foundations of pseudosciences. In *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem* (Pigliucci, M. and Boudry, M., eds), pp. 361–379, University of Chicago Press
52 **Boudry, M. *et al.* (2014) What makes weird beliefs thrive? The epidemiology of pseudoscience. *Philos. Psychol.* Published online October 27, 2014. http://dx.doi.org/10.1080/09515089.2014.971946**
53 Boyer, P. and Peterson, M.B. (2011) The naturalness of (many) social institutions. *J. Inst. Econ.* 8, 1–25
54 Blancke, S. *et al.* (2014) From ends to causes (and back again): the paradox of natural selection. *Sci. Educ.* 23, 793–808

LETTER

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Comparing the yields of organic and conventional agriculture

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Numerous reports have emphasized the need for major changes in the global food system: agriculture must meet the twin challenge of feeding a growing population, with rising demand for meat and high-calorie diets, while simultaneously minimizing its global environmental impacts[1,2]. Organic farming—a system aimed at producing food with minimal harm to ecosystems, animals or humans—is often proposed as a solution[3,4]. However, critics argue that organic agriculture may have lower yields and would therefore need more land to produce the same amount of food as conventional farms, resulting in more widespread deforestation and biodiversity loss, and thus undermining the environmental benefits of organic practices[5]. Here we use a comprehensive meta-analysis to examine the relative yield performance of organic and conventional farming systems globally. Our analysis of available data shows that, overall, organic yields are typically lower than conventional yields. But these yield differences are highly contextual, depending on system and site characteristics, and range from 5% lower organic yields (rain-fed legumes and perennials on weak-acidic to weak-alkaline soils), 13% lower yields (when best organic practices are used), to 34% lower yields (when the conventional and organic systems are most comparable). Under certain conditions—that is, with good management practices, particular crop types and growing conditions—organic systems can thus nearly match conventional yields, whereas under others it at present cannot. To establish organic agriculture as an important tool in sustainable food production, the factors limiting organic yields need to be more fully understood, alongside assessments of the many social, environmental and economic benefits of organic farming systems.

Although yields are only part of a range of ecological, social and economic benefits delivered by farming systems, it is widely accepted that high yields are central to sustainable food security on a finite land basis[1,2]. Numerous individual studies have compared the yields of organic and conventional farms, but few have attempted to synthesize this information on a global scale. A first study of this kind[6] concluded that organic agriculture matched, or even exceeded, conventional yields, and could provide sufficient food on current agricultural land. However, this study was contested by a number of authors; the criticisms included their use of data from crops not truly under organic management and inappropriate yield comparisons[7,8].

We performed a comprehensive synthesis of the current scientific literature on organic-to-conventional yield comparisons using formal meta-analysis techniques. To address the criticisms of the previous study[6] we used several selection criteria: (1) we restricted our analysis to studies of 'truly' organic systems, defined as those with certified organic management or non-certified organic management, following the standards of organic certification bodies (see Supplementary Information); (2) we only included studies with comparable spatial and temporal scales for both organic and conventional systems (see Methods); and (3) we only included studies reporting (or from which we could estimate) sample size and error. Conventional systems were either high- or low-input commercial systems, or subsistence agriculture. Sixty-six studies met these criteria, representing 62 study sites, and reporting 316 organic-to-conventional yield comparisons on 34 different crop species (Supplementary Table 4).

The average organic-to-conventional yield ratio from our meta-analysis is 0.75 (with a 95% confidence interval of 0.71 to 0.79); that is, overall, organic yields are 25% lower than conventional (Fig. 1a). This result only changes slightly (to a yield ratio of 0.74) when the analysis is limited to studies following high scientific quality standards (Fig. 2). When comparing organic and conventional yields it is important

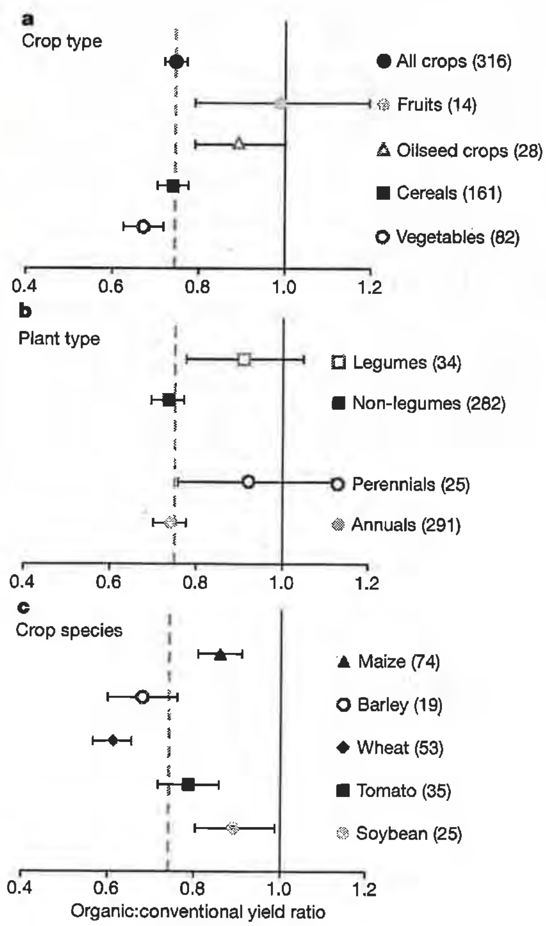

Figure 1 | Influence of different crop types, plant types and species on organic-to-conventional yield ratios. **a–c**, Influence of crop type (**a**), plant type (**b**) and crop species (**c**) on organic-to-conventional yield ratios. Only those crop types and crop species that were represented by at least ten observations and two studies are shown. Values are mean effect sizes with 95% confidence intervals. The number of observations in each class is shown in parentheses. The dotted line indicates the cumulative effect size across all classes.

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to consider the food output per unit area and time, as organic rotations often use more non-food crops like leguminous forage crops in their rotations[7]. However, the meta-analysis suggests that studies using longer periods of non-food crops in the organic rotation than conventional systems do not differ in their yield ratio from studies using similar periods of non-food crops (Fig. 2 and Supplementary Table 5). It thus appears that organic rotations do not require longer periods of non-food crops, which is also corroborated by the fact that the majority of studies (that is, 76%) use similar lengths of non-food crops in the organic and conventional systems.

The performance of organic systems varies substantially across crop types and species (Fig. 1a–c; see Supplementary Table 5 for details on categorical analysis). For example, yields of organic fruits and oilseed crops show a small (−3% and −11% respectively), but not statistically significant, difference to conventional crops, whereas organic cereals and vegetables have significantly lower yields than conventional crops (−26% and −33% respectively) (Fig. 1a).

These differences seem to be related to the better organic performance (referring to the relative yield of organic to conventional systems) of perennial over annual crops and legumes over non-legumes (Fig. 1b). However, note that although legumes and perennials (and fruits and oilseed crops) show statistically insignificant organic-to-conventional yield differences, this is owing to the large uncertainty range resulting from their relatively small sample size ($n = 34$ for legumes, $n = 25$ for perennials, $n = 14$ for fruits and $n = 28$ for oilseed crops; Fig. 1), and combining legumes and perennials reveals a significant, but small, yield difference (Fig. 2).

Part of these yield responses can be explained by differences in the amount of nitrogen (N) input received by the two systems (Fig. 3a). When organic systems receive higher quantities of N than conventional systems, organic performance improves, whereas conventional systems do not benefit from more N. In other words, organic systems appear to be N limited, whereas conventional systems are not. Indeed, N availability has been found to be a major yield-limiting factor in many organic systems[9]. The release of plant-available mineral N from organic sources such as cover crops, compost or animal manure is slow and often does not keep up with the high crop N demand during the peak growing period[9,10]. The better performance of organic legumes and perennials is not because they received more N, but rather because they seem to be more efficient at using N (Supplementary Table 7 and Supplementary Fig. 4). Legumes are not as dependent on external N sources as non-legumes, whereas perennials, owing to their longer growing period and extensive root systems, can achieve a better synchrony between nutrient demands and the slow release of N from organic matter[11].

Organic crops perform better on weak-acidic to weak-alkaline soils (that is, soils with a pH between 5.5. and 8.0; Fig. 3b). A possible explanation is the difficulty of managing phosphorus (P) in organic systems. Under strongly alkaline and acidic conditions, P is less readily available to plants as it forms insoluble phosphates, and crops depend to a stronger degree on soil amendments and fertilizers. Organic systems often do not receive adequate P inputs to replenish the P lost through harvest[12]. To test this hypothesis we need further research on the performance and nutrient dynamics of organic agriculture on soils of varying pH.

Studies that reported having applied best management practices in both systems show better organic performance (Fig. 3c). Nutrient and pest management in organic systems rely on biological processes to deliver plant nutrients and to control weed and herbivore populations. Organic yields thus depend more on knowledge and good management practices than conventional yields. However, in organic systems that are not N limited (as they grow perennial or leguminous crops, or apply large N inputs), best management practices are not required (Supplementary Table 11).

It is often reported that organic yields are low in the first years after conversion and gradually increase over time, owing to improvements in soil fertility and management skills[13]. This is supported by our analysis: organic performance improves in studies that lasted for more than two seasons or were conducted on plots that had been organic for at least 3 years (Fig. 2, Supplementary Fig. 5 and Supplementary Table 13).

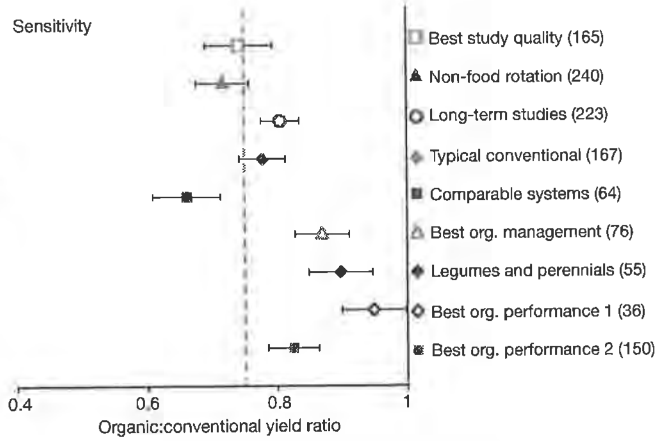

Figure 2 | Sensitivity study of organic-to-conventional yield ratios. Best study quality, peer-reviewed studies using appropriate study design and making appropriate inferences; non-food rotation, studies where both systems have a similar duration of non-food crops; long-term studies, excludes very short duration and recently converted studies; typical conventional, restricted to commercial conventional systems with yields comparable to local averages; comparable systems, studies that use appropriate study design and make appropriate inferences, where both systems have the same non-food rotation length and similar N inputs; best org. management, excludes studies without best management practices or crop rotations; legumes and perennials, restricted to leguminous and perennial crops; best org. performance 1, rain-fed legumes and perennials on weak-acidic to weak-alkaline soils; best org. performance 2, rain-fed and weak-acidic to weak-alkaline soils. Values are mean effect sizes with 95% confidence intervals. The number of observations is shown in parentheses. The dotted line indicates the effect size across all studies.

Water relations also influence organic yield ratios—organic performance is −35% under irrigated conditions, but only −17% under rain-fed conditions (Fig. 3e). This could be due to a relatively better organic performance under variable moisture conditions in rain-fed systems. Soils managed with organic methods have shown better water-holding capacity and water infiltration rates and have produced higher yields than conventional systems under drought conditions and excessive rainfall[14,15] (see Supplementary Information). On the other hand, organic systems are often nutrient limited (see earlier), and thus probably do not respond as strongly to irrigation as conventional systems.

The majority of studies in our meta-analysis come from developed countries (Supplementary Fig. 1). Comparing organic agriculture across the world, we find that in developed countries organic performance is, on average, −20%, whereas in developing countries it is −43% (Fig. 3f). This poor performance of organic agriculture in developing countries may be explained by the fact that a majority of the data (58 of 67 observations) from developing countries seem to have atypical conventional yields (>50% higher than local yield averages), coming from irrigated lands (52 of 67), experimental stations (54 of 67) and from systems not using best management practices (67 of 67; Supplementary Fig. 10 and Supplementary Table 8). In the few cases from developing countries where organic yields are compared to conventional yields typical for the location or where the yield data comes from surveys, organic yields do not differ significantly from conventional yields because of a wide confidence interval resulting from the small sample size ($n = 8$ and $n = 12$ respectively, Supplementary Fig. 10a).

The results of our meta-analysis differ dramatically from previous results[6]. Although our organic performance estimate is lower than previously reported[6] in developed countries (−20% compared to −8%), our results are markedly different in developing countries

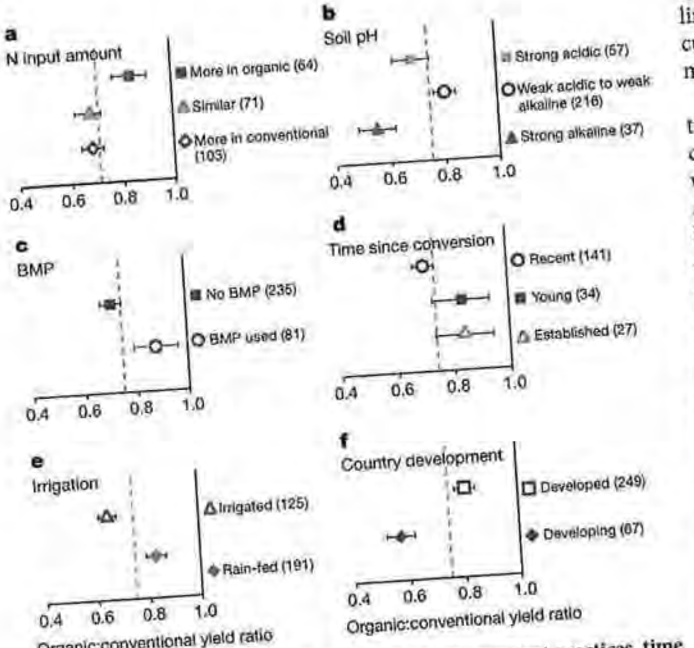

Figure 3 | Influence of N input, soil pH, best management practices, time since conversion to organic management, irrigation and country development. a–f, Influence of the amount of N input (**a**), soil pH (**b**), the use of best management practices (BMP; **c**), time since conversion to organic management (**d**), irrigation (**e**) and country development (**f**) on organic-to-conventional yield ratios. For details on the definition of categorical variables see Supplementary Tables 1–3. Values are mean effect sizes with 95% confidence intervals. The number of observations in each class is shown in parentheses. The dotted line indicates the cumulative effect size across all classes.

(−43% compared to +80%). This is because the previous analysis mainly included yield comparisons from conventional low-input subsistence systems, whereas our data set mainly includes data from high-input systems for developing countries. However, the previous study compared subsistence systems to yields that were not truly organic, and/or from surveys of projects that lacked an adequate control. Not a single study comparing organic to subsistence systems met our selection criteria and could be included in the meta-analysis. We cannot, therefore, rule out the claim[16] that organic agriculture can increase yields in smallholder agriculture in developing countries. But owing to a lack of quantitative studies with appropriate controls we do not have sufficient scientific evidence to support it either. Fortunately, the Swiss Research Institute of Organic Agriculture (FiBL) recently established the first long-term comparison of organic and different conventional systems in the tropics[17]. Such well-designed long-term field trials are urgently needed.

Our analysis shows that yield differences between organic and conventional agriculture do exist, but that they are highly contextual. When using best organic management practices yields are closer to (−13%) conventional yields (Fig. 2). Organic agriculture also performs better under certain agroecological conditions—for example, organic legumes or perennials, on weak-acidic to weak-alkaline soils, in rain-fed conditions, achieve yields that are only 5% lower than conventional yields (Fig. 2). On the other hand, when only the most comparable conventional and organic systems are considered the yield difference is as high as 34% (Fig. 2). In developed countries or in studies that use conventional yields that are representative of regional averages, the yield difference between comparable organic and conventional systems, however, goes down to 8% and 13%, respectively (see Supplementary Information).

In short, these results suggest that today's organic systems may nearly rival conventional yields in some cases—with particular crop types, growing conditions and management practices—but often they do not. Improvements in management techniques that address factors limiting yields in organic systems and/or the adoption of organic agriculture under those agroecological conditions where it performs best may be able to close the gap between organic and conventional yields.

Although we were able to identify some factors contributing to variations in organic performance, several other potentially important factors could not be tested owing to a lack of appropriate studies. For example, we were unable to analyse tillage, crop residue or pest management. Also, most studies included in our analysis experienced favourable growing conditions (Supplementary Fig. 8), and organic systems were mostly compared to commercial high-input systems (which had predominantly above-average yields in developing countries; Supplementary Figs 6b and 10a). In addition, it would be desirable to examine the total human-edible calorie or net energy yield of the entire farm system rather than the biomass yield of a single crop species. To understand better the performance of organic agriculture, we should: (1) systematically analyse the long-term performance of organic agriculture under different management regimes; (2) study organic systems under a wider range of biophysical conditions; (3) examine the relative yield performance of smallholder agricultural systems; and (4) evaluate the performance of farming systems through more holistic system metrics.

As emphasized earlier, yields are only part of a range of economic, social and environmental factors that should be considered when gauging the benefits of different farming systems. In developed countries, the central question is whether the environmental benefits of organic crop production would offset the costs of lower yields (such as increased food prices and reduced food exports). Although several studies have suggested that organic agriculture can have a reduced environmental impact compared to conventional agriculture[18,19], the environmental performance of organic agriculture per unit output or per unit input may not always be advantageous[20,21]. In developing countries, a key question is whether organic agriculture can help alleviate poverty for small farmers and increase food security. On the one hand, it has been suggested that organic agriculture may improve farmer livelihoods owing to cheaper inputs, higher and more stable prices, and risk diversification[16]. On the other hand, organic agriculture in developing countries is often an export-oriented system tied to a certification process by international bodies, and its profitability can vary between locations and years[22,23].

There are many factors to consider in balancing the benefits of organic and conventional agriculture, and there are no simple ways to determine a clear 'winner' for all possible farming situations. However, instead of continuing the ideologically charged 'organic versus conventional' debate, we should systematically evaluate the costs and benefits of different management options. In the end, to achieve sustainable food security we will probably need many different techniques—including organic, conventional, and possible 'hybrid' systems[24]—to produce more food at affordable prices, ensure livelihoods for farmers, and reduce the environmental costs of agriculture.

METHODS SUMMARY

We conducted a comprehensive literature search, compiling scientific studies comparing organic to conventional yields that met our selection criteria. We minimized the use of selection criteria based on judgments of study quality but examined its influence in the categorical analysis. We collected information on several study characteristics reported in the papers and derived characteristics of the study site from spatial global data sets (see Supplementary Tables 1–3 for a description of all categorical variables). We examined the difference between organic and conventional yields with the natural logarithm of the response ratio (the ratio between organic and conventional yields), an effect size commonly used in meta-analyses[25]. To calculate the cumulative effect size we weighted each individual observation by the inverse of the mixed-model variance. Such a categorical meta-analysis should be used when the data have some underlying structure and individual observations can be categorized into groups (for example, crop species or fertilization practices)[26]. An effect size is considered significant if its confidence interval does not overlap with 1 in the back-transformed response ratio. To test the influence of categorical variables on yield effect sizes we examined between-group heterogeneity (Q_B). A significant Q_B indicates that there are differences in effect sizes between different classes of a categorical variable[26]. All statistical analyses were carried out in MetaWin 2.0[26].

Full Methods and any associated references are available in the online version of the paper at www.nature.com/nature.

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1. Godfray, H. C. *et al.* Food security: the challenge of feeding 9 billion people. *Science* **327,** 812–818 (2010).
2. Foley, J. *et al.* Solutions for a cultivated planet. *Nature* **478,** 337–342 (2011).
3. McIntyre, B. D., Herren, H. R., Wakhungu, J. & Watson, R. T. *International Assessment of Agricultural Knowledge, Science and Technology for Development: Global Report* http://www.agassessment.org/ (Island, 2009).
4. De Schutter, O. *Report Submitted by the Special Rapporteur on the Right to Food* http://www2.ohchr.org/ english/issues/food/docs/A-HRC-16-49.pdf (United Nations, 2010).
5. Trewavas, A. Urban myths of organic farming. *Nature* **410,** 409–410 (2001).
6. Badgley, C. *et al.* Organic agriculture and the global food supply. *Renew. Agr. Food Syst.* **22,** 86–108 (2007).
7. Cassman, K. G. Editorial response by Kenneth Cassman: can organic agriculture feed the world-science to the rescue? *Renew. Agr. Food Syst.* **22,** 83–84 (2007).
8. Connor, D. J. Organic agriculture cannot feed the world. *Field Crops Res.* **106,** 187–190 (2008).
9. Berry, P. *et al.* Is the productivity of organic farms restricted by the supply of available nitrogen? *Soil Use Manage.* **18,** 248–255 (2002).
10. Pang, X. & Letey, J. Organic farming: challenge of timing nitrogen availability to crop nitrogen requirements. *Soil Sci. Soc. Am. J.* **64,** 247–253 (2000).
11. Crews, T. E. & Peoples, M. B. Can the synchrony of nitrogen supply and crop demand be improved in legume and fertilizer-based agroecosystems? A review. *Nutr. Cycl. Agroecosyst.* **72,** 101–120 (2005).
12. Oehl, F. *et al.* Phosphorus budget and phosphorus availability in soils under organic and conventional farming. *Nutr. Cycl. Agroecosyst.* **62,** 25–35 (2002).
13. Martini, E., Buyer, J. S., Bryant, D. C., Hartz, T. K. & Denison, R. F. Yield increases during the organic transition: improving soil quality or increasing experience? *Field Crops Res.* **86,** 255–266 (2004).
14. Letter, D., Seidel, R. & Liebhardt, W. The performance of organic and conventional cropping systems in an extreme climate year. *Am. J. Altern. Agric.* **18,** 146–154 (2003).
15. Colla, G. *et al.* Soil physical properties and tomato yield and quality in alternative cropping systems. *Agron. J.* **92,** 924–932 (2000).
16. Scialabba, N. & Hattam, C. *Organic Agriculture, Environment and Food Security* (Food and Agriculture Organization, 2002).
17. Research Institute of Organic Agriculture (FiBL). *Farming System Comparison in the Tropics* http://www.systems-comparison.fibl.org/ (2011).
18. Crowder, D. W., Northfield, T. D., Strand, M. R. & Snyder, W. E. Organic agriculture promotes evenness and natural pest control. *Nature* **466,** 109–112 (2010).
19. Bengtsson, J., Ahnström, J. & Weibull, A.-C. The effects of organic agriculture on biodiversity and abundance: a meta-analysis. *J. Appl. Ecol.* **42,** 261–269 (2005).
20. Kirchmann, H. & Bergström, L. Do organic farming practices reduce nitrate leaching? *Commun. Soil Sci. Plan.* **32,** 997–1028 (2001).
21. Leifeld, J. & Fuhrer, J. Organic farming and soil carbon sequestration: what do we really know about the benefits? *Ambio* **39,** 585–599 (2010).
22. Valkila, J. Fair trade organic coffee production in Nicaragua—sustainable development or a poverty trap? *Ecol. Econ.* **68,** 3018–3025 (2009).
23. Raynolds, L. T. The globalization of organic agro-food networks. *World Dev.* **32,** 725–743 (2004).
24. National Research Council. *Toward Sustainable Agricultural Systems in the 21st Century* (National Academies, 2010).
25. Hedges, L. V., Gurevitch, J. & Curtis, P. S. The meta-analysis of response ratios in experimental ecology. *Ecology* **80,** 1150–1156 (1999).
26. Rosenberg, M. S., Gurevitch, J. & Adams, D. C. *MetaWin: Statistical Software for Meta-analysis: Version 2* (Sinauer, 2000).

Supplementary Information is linked to the online version of the paper at www.nature.com/nature.

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Author Contributions V.S. and N.R. designed the study. V.S. compiled the data and carried out data analysis. All authors discussed the results and contributed to writing the paper.

Author Information Reprints and permissions information is available at www.nature.com/reprints. The authors declare no competing financial interests. Readers are welcome to comment on the online version of this article at www.nature.com/nature. Correspondence and requests for materials should be addressed to V.S. (verena.seufert@mail.mcgill.ca).

METHODS

Literature search. We searched the literature on studies reporting organic-to-conventional yield comparisons. First we used the references included in the previous study[6] and then extended the search by using online search engines (Google scholar, ISI web of knowledge) as well as reference lists of published articles. We applied several selection criteria to address the criticisms of the previous study[6] and to ensure that minimum scientific standards were met. Studies were only included if they (1) reported yield data on individual crop species in an organic treatment and a conventional treatment, (2) the organic treatment was truly organic (that is, either certified organic or following organic standards), (3) reported primary data, (4) the scale of the organic and conventional yield observations were comparable, (5) data were not already included from another paper (that is, avoid multiple counting), and (6) reported the mean (X), an error term (standard deviation (s.d.), standard error (s.e.) or confidence interval) and sample size (n) as numerical or graphical data, or if X and s.d. of yields over time could be calculated from the reported data. For organic and conventional treatments to be considered comparable, the temporal and spatial scale of the reported yields needed to be the same, that is, national averages of conventional agriculture compared to national averages of organic agriculture or yields on an organic farm compared to yields on a neighbouring conventional farm—not included were, for example, single farm yields compared to national or regional averages or before–after comparisons. Previous studies[27] have illustrated the danger of comparing yield data drawn from single plots and field trials to larger state and national averages.

The use of selection criteria is a critical step in conducting a meta-analysis. On the one hand, scientific quality and comparability of observations needs to be ensured. On the other hand, a meta-analysis should provide as complete a summary of the current research as possible. There is an ongoing debate about whether meta-analyses should adopt very specific selection criteria to prevent mixing incomparable data sets together and to minimize variation in the data set[28] or whether, instead, meta-analyses should include as wide a range of studies as possible to allow for an analysis of sources of variation[29]. We followed the generally recommended approach, trying to minimize the use of selection criteria based on judgments of study quality[30]. Instead, we examined the influence of quality criteria empirically by evaluating the differences between observations with different quality standards. We did not therefore exclude yield observations from non-peer-reviewed sources or from studies that lacked an appropriate experimental design a priori. The quality of the study and the comparability of the organic and conventional systems were assessed by evaluating the experimental design of the study as well as the form of publication. Studies that were published in peer-reviewed journals and that controlled for the possible influence of variability in space and time on experimental outcomes through an appropriate experimental design were considered to follow high quality standards.

Categorical variables. In addition to study quality criteria, information on several other study characteristics like crop species, location and timescale, and on different management practices, was collected (see Supplementary Tables 1–3). We also wanted to test the effect of study site characteristics on yield ratios and we thus collected information on biophysical characteristics of the study site. As most studies did not report climate or soil variables we derived information on several agroecological variables that capture cropland suitability[31], including the moisture index α (the ratio of actual to potential evapotranspiration) as an indicator of moisture availability to crops, growing degree days (GDD, the annual sum of daily mean temperatures over a base temperature of 5 °C) as an indicator of growing season length, as well as soil carbon density (C_{soil}, as a measure of soil organic content) and soil pH as indicators of soil quality from the latitude × longitude values of the study site and global spatial models/data sets at 5 min resolution[32,33].

We derived the thresholds for the classification of these climate and soil variables from the probability of cultivation functions previously described[31]. This probability of cultivation function is a curve fitted to the empirical relationship between cropland areas, α, GDD or C_{soil}. It describes the probability that a location with a certain climate or soil characteristic is covered by cropland. Suitable locations with favourable climate and soil characteristics have a higher probability of being cultivated. Favourable climate and soil characteristics can thus be inferred from the probability of cultivation. For α, GDD and C_{soil} a probability of cultivation under 30% was classified as 'low' suitability, between 30% and 70% as 'medium' suitability, and above 70% as 'high' suitability (Supplementary Table 3). Sites with low and medium suitable moisture indices are interpreted as having insufficient water availability, sites with low and medium GDD have short growing seasons, and sites with low and medium soil carbon densities are either unfertile because they have too small a C_{soil} and low organic matter content (and thus insufficient nutrients) or too high a C_{soil} in soils in wetlands where organic matter accumulates because they are submerged under water. For soil pH, instead, we defined thresholds based on expert judgment. Soil pH information was often given in the studies and we only derived soil pH values from the global data set if no soil pH value was indicated in the paper.

To assess whether the conventional yield values reported by studies and included in the meta-analysis were representative of regional average crop yields, we compared them to FAOSTAT yield data and a high-resolution spatial yield data set[34,35]. We used the FAO data[35], which reports national yearly crop yields from 1961 to 2009, for temporal detail and a yield data set[34], which reports subnational crop yields for 175 crops for the year 2000 at a 5-min latitude by 5-min longitude resolution, for spatial detail. We calculated country average crop yields from FAO data for the respective study period and calculated the ratio of this average study-period yield to the year-2000 FAO national yield value. We derived the year-2000 yield value from the spatial data set through the latitude by longitude value of the study site and scaled this value to the study-period-to-year-2000 ratio from FAOSTAT. If the meta-analysis conventional yield value was more than 50% higher than the local yield average derived by this method it was classified as 'above average', when it was more than 50% lower as 'below average', and when it was within ±50% of local yield averages as 'comparable'. We choose this large yield difference as a threshold to account for uncertainties in the FAOSTAT and global yield data set[34].

Meta-analysis. The natural log of the response ratio[25] was used as an effect size metric for the meta-analysis. The response ratio is calculated as the ratio between the organic and the conventional yield. The use of the natural logarithm linearizes the metric (treating deviations in the numerator and the denominator the same) and provides more normal sampling distribution in small samples[25]. If the data set has some underlying structure and studies can be categorized into more than one group (for example, different crop species, or different fertilizer types) a categorical meta-analysis can be conducted[26]. Observations with the same or similar management or system characteristics were grouped together. We then used a mixed effects model to partition the variance of the sample, assuming that there is random variation within a group and fixed variation between groups. We calculated a cumulative effect size as weighted mean from all studies by weighting each individual observation by the reciprocal of the mixed-model variance, which is the sum of the study sampling variance and the pooled within-group variance. Weighted parametric meta-analysis should be used whenever possible to deal with heteroscedasticity in the sample and to increase the statistical power of the analysis[36]. The cumulative effect size is considered to be significantly different from zero (that is, the organic treatment shows a significant effect on crop yield) if its 95% confidence interval does not overlap zero.

To test for differences in the effect sizes between groups the total heterogeneity of the sample was partitioned into the within group (Q_W) and between group heterogeneity (Q_B) in a process similar to an analysis of variance[37]. The significance of Q_B was tested by comparing it against the critical value of the χ^2 distribution. A significant Q_B implies that there are differences among cumulative effect sizes between groups[26,38]. Only those effects that showed a significant Q_B are presented in graphs. All statistical analyses were carried out using MetaWin 2.0[26]. For representation in graphs effect sizes were back-transformed to response ratios.

Each observation in a meta-analysis is required to be independent. Repeated measurements in the same location over time are not independent. If yield values from a single experiment were reported over several years therefore the average yield over time was calculated and used in the meta-analysis. If the mean and variance of multiple years was reported, the weighted average over time was calculated by weighting each year by the inverse of its variance. Different experiments (for example, different tillage practices, crop species or fertilizer rates) from the same study are not necessarily independent. However, it is recommended to still include different experiments from the same study, as their omission would cause more distortions of the results than the lack of true independence[38]. We therefore included different experiments from a single study separately in the meta-analysis.

If data from the same experiment from the same study period were reported in several papers, the data were only included once, namely from the paper that reported the data in the highest detail (that is, reporting s.e./s.e. and n and/or reporting the longest time period). If instead data from the same experiment from different years were reported in separate papers, the data were included separately in the analysis (for example, refs 39, 40).

In addition to potential within-study dependence of effect size data, there can also be issues with between-study dependence of data[36]—data from studies conducted by the same author, in the same location or on the same crop species are also potentially non-independent. We addressed this issue by conducting a hierarchical, categorical meta-analysis (as described earlier), specifically testing for the influence of numerous moderators on the effect size. In addition, we examined the interaction between categorical variables through a combination of contingency tables and sub-categorical analysis (see Supplementary Information for the results of this analysis and for a more detailed discussion of this issue).

We performed a sensitivity analysis (see Supplementary Table 14) to compare the robustness of results under more strict quality criteria (see discussion of definition of study quality earlier) and to assess organic yield ratios under a couple of specific system comparisons.

27. Johnston, M., Foley, J. A., Holloway, T., Kucharik, C. & Monfreda, C. Resetting global expectations from agricultural biofuels. *Environ. Res. Lett.* **4,** 014004 (2009).
28. Whittaker, R. J. Meta-analyses and mega-mistakes: calling time on meta-analysis of the species richness–productivity relationship. *Ecology* **91,** 2522–2533 (2010).
29. Hillebrand, H. & Cardinale, B. J. A critique for meta-analyses and the productivity–diversity relationship. *Ecology* **91,** 2545–2549 (2010).
30. Englund, G., Sarnelle, O. & Cooper, S. D. The importance of data-selection criteria: meta-analyses of stream predation experiments. *Ecology* **80,** 1132–1141 (1999).
31. Ramankutty, N., Foley, J. A., Norman, J. & McSweeney, K. The global distribution of cultivable lands: current patterns and sensitivity to possible climate change. *Glob. Ecol. Biogeogr.* **11,** 377–392 (2002).
32. Deryng, D., Sacks, W., Barford, C. & Ramankutty, N. Simulating the effects of climate and agricultural management practices on global crop yield. *Glob. Biogeochem. Cycles* **25,** GB2006 (2011).
33. IGBP-DIS. *Soildata (V 0): A Program for Creating Global Soil-Property Databases* (IGBP Global Soils Data Task, 1998).
34. Monfreda, C., Ramankutty, N. & Foley, J. A. Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000. *Glob. Biogeochem. Cycles* **22,** GB1022 (2008).
35. Food and Agriculture Organization of the United Nations (FAO). *FAOSTAT* http://faostat.fao.org (2011).
36. Gurevitch, J. & Hedges, L. V. Statistical issues in ecological meta-analyses. *Ecology* **80,** 1142–1149 (1999).
37. Hedges, L. V. & Olkin, I. *Statistical Methods for Meta-Analysis.* (Academic, 1985).
38. Gurevitch, J., Morrow, L. L., Wallace, A. & Walsh, J. S. A meta-analysis of competition in field experiments. *Am. Nat.* **140,** 539–572 (1992).
39. Liebhardt, W. *et al.* Crop production during conversion from conventional to low-input methods. *Agron. J.* **81,** 150–159 (1989).
40. Drinkwater, L., Janke, R. & Rossoni-Longnecker, L. Effects of tillage intensity on nitrogen dynamics and productivity in legume-based grain systems. *Plant Soil* **227,** 99–113 (2000).

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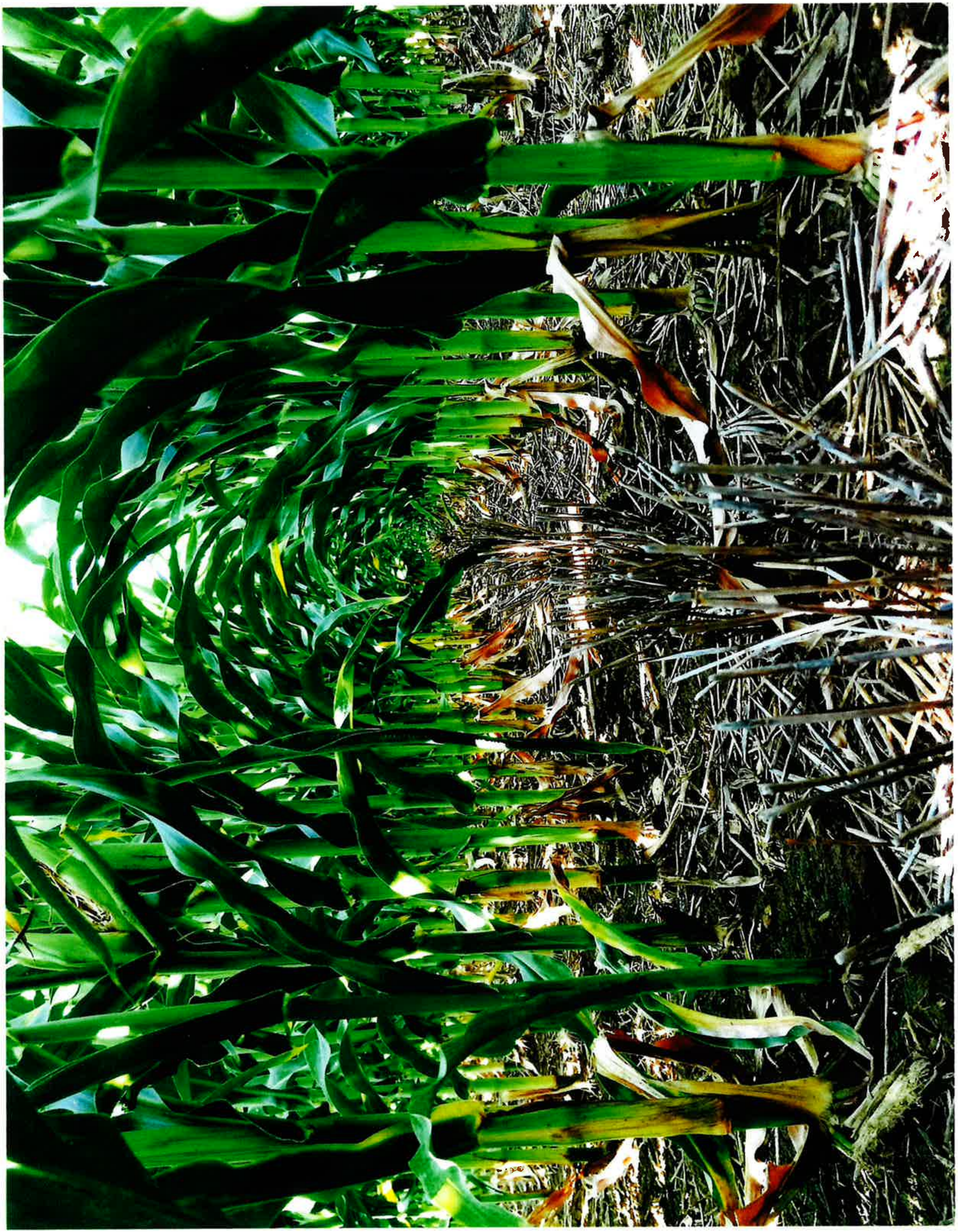
Feb 5, 2016



Cropland Policy Mtg.
2/5/2015
Andrew Staehelin

GM crop meeting: Boulder County Commissioners, February 5, 1:30 pm, 2016

Andrew Staehelin, Professor Emeritus, MCD Biology, University of Colorado,
staeheli@colorado.edu

Issues to be discussed

• **Safety of GM foods:** >2000 peer-reviewed scientific studies published during the past 10 years all show that GM foods are safe to eat. Largest food safety study of farm animals ever conducted published last year included **~9 billion farm animals** (4 billion fed GM foods, 4 billion fed non-GM foods). Animals were evaluated over two 20-year periods for growth, health, fertility and meat quality by farmers, meat inspectors and scientists. By all criteria, the **GM food fed animals performed at least as well as the non-GM food fed animals**.

The quality of studies claiming that GM food have adverse health effects is abysmal. However, these studies are still used by the organic food industry to support its claim that they are bad for your health. Fear sells.

During the past 10 years, hundreds of people have died eating organic foods, zero have died eating GM foods.

• The **Open Space GM crop – organic crop co-existence rules** adopted by the County Commissioners 15 years ago have been working well. If the planting of GM crops would be banned, then the traditional farmers would have to use insecticides to control corn borers (bad for environment), soil quality would deteriorate, and crop yields would go down (less income for farmers).

• **What is a GM crop?** 10-15 years ago the answer was simple: GM crops could be identified based on the presence of **T-DNA** from Agrobacterium, and the presence of **foreign genes**. Now we know that all sweet potatoes we consume contain T-DNA and four foreign genes. This means that they are GMOs! However, the genes were inserted by nature several hundred years ago, and humans have consumed these GMO sweet potatoes for many years.

More importantly, today, increasing numbers of crops are genetically engineered using novel methods without the use of T-DNA and without the insertion of foreign genes. These are **RNAi** modified crops and **CRISPR-Cas9** modified crops (see my Daily Camera article). Both of these techniques are also constantly being employed by plants naturally to protect themselves from pests and pathogens. The results are often indistinguishable from mutations caused by radiation or by chemicals used by organic crop breeders. How do we define today a GMO?

• **Note:** if you cannot define a GM crop, how can you write rules governing the planting of GM crops?

• **New focus** of Open Space farmland rules should be **Sustainable Food Production**. Sustainable food production requires the use of ALL available farming resources. In this context, GM crops would be one of many operational parameters. Sustainable food systems will be discussed in more detail by Professor Pete Newton at his February 19 meeting.

GM Food hysteria – mid 1990's

Which predictions of doom have turned out to be true?

Frankenfoods term invented in 1992 by a London *Daily Telegraph* reporter

Original Method of Plant Genetic Engineering

Lateral gene transfer, the mechanism of DNA transfer exploited by Agrobacterium, is natural, predates sex, and is still used by billions of organisms every day

Examples:

- transfer of antibiotic resistance between bacteria
- 8% of human DNA is viral DNA
- transferring foreign DNA into a plant cell is as easy as dipping a shoot into a DNA solution and collecting transformed seeds a few weeks later

Agrobacterium tumefasciens – a soil bacterium

Ti plasmid contains 25 vir genes, which can be injected into plant cells by bacterium

T-DNA sequences in plasmid allow for the insertion of plasmid vir genes into plant cell DNA

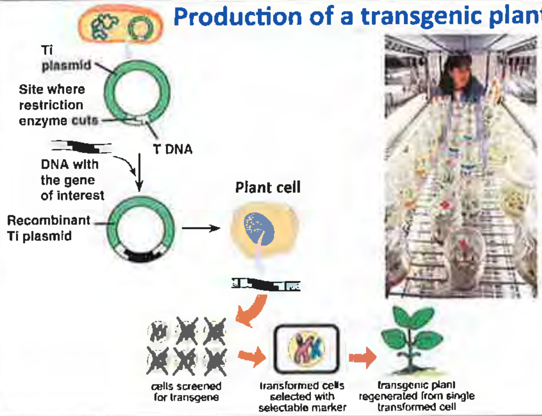
Vir genes code for enzymes for producing
- plant hormones (auxin, cytokinins) that promote uncontrolled cell divisions (tumors)
- unusual amino acids (opins) that provide food (N- and C-sources) for the bacteria

The Agrobacterium transformation system

Modification of Ti plasmids for transformation experiments

- removal of vir genes coding for opin synthesis enzymes
- removal of vir genes coding for hormone synthesis enzymes (no tumor formation)
- insertion of desired gene plus selection marker gene into emasculated Ti plasmid

Production of a transgenic plant



Bt crops – Cry protein producing crops

Crops: corn, cotton, soybeans, potato, tomato, egg plant (Bangladesh)

Mode of action of Cry proteins
- Insect guts have alkaline pH, which converts the Cry protein to a membrane pore-forming toxin
- In acidic intestines (mammals, birds, fish) the Cry proteins remain inactive and are digested

Benefits of Bt crops
- Very effective for combating European corn borer, cotton bollworm, and corn rootworm (every cell produces Cry proteins)
- Farmers planting Bt corn and Bt cotton report using 30-70% fewer insecticides, and having a 10-30% increase in yield
- Safer foods (google: *spina bifida babies texas corn*)

Roundup Ready (glyphosate-resistant) crops

Crops: corn, soybeans, sugar beets, canola, alfalfa

Mode of action of the herbicide Roundup (glyphosate)

- **glyphosphate inhibits** the activity of the **plant EPSPS enzyme** needed for the synthesis of aromatic amino acids
- this enzyme is also found in many **bacteria**, but **not in humans and animals (glyphosate is non-toxic)**
- Roundup Ready plants contain **bacterial EPSPS** that is **not inhibited by glyphosate**

Roundup Ready crops

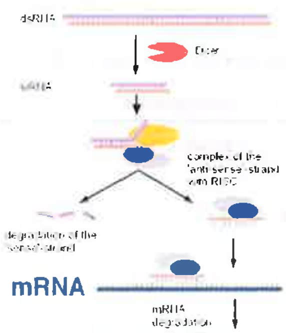
Control soybeans Roundup Ready soybeans

Roundup Ready crops are resistant to the herbicide glyphosate, which enables farmers to kill weeds without affecting the crop plants

Benefits: • **increased productivity** (Boulder county farmer +30%)
• no-till farming → **90% reduction in soil erosion**

Problem: **Overuse!** Every farmer wants to reap the benefits.

RNAi technique used for protecting crops against pathogens



RNA from pathogen

Small interfering RNA with **pathogen recognition code**

Enzyme complex that binds to single RNA strand and can **cut recognized DNA**

Recognition and cutting of pathogen mRNA -> **no protein**

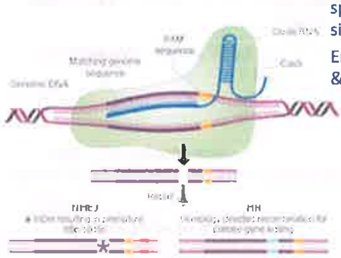
Successful applications of RNAi in crop breeding

(RNAi is also used naturally by plants to protect themselves)

- Ringspot virus-resistant **papaya** (Hawaii)
- Virus-resistant **beans** (Brazil)
- Virus-resistant **cassava** roots (Africa)
- Fungal-resistant **bananas**
- Nematode-resistant **soybeans**
- Reduced gluten **wheat**
- high oleic acid **soybean oil**

CRISPR-Cas9 method for editing (precisely modifying) DNA

(requires knowledge of DNA sequence of gene)



Synthetic RNA with specific DNA recognition site

Enzyme that holds RNA & DNA together, cleaves

Plant DNA

Cut plant DNA

Modified plant DNA

Summary: Some benefits of GE crops

- Better insect pest control -> reduced chemical insecticide applications and greater yield
- Drought tolerance -> greater yield with less water
- Facilitates no-till farming for soil and water conservation.
- Effective viral, bacterial and fungal disease control
- Improved nutritional properties (Golden rice)
- Better weed control -> greater yield
- Safer foods (e.g. spina bifida babies)
- Greater profitability, shared throughout the agricultural system (farmers and consumers)

Opinion – Daily Camera, Boulder 11-14-15

Andrew Staehelin: All certified organic sweet potatoes are GMOs

By Andrew Staehelin
Posted: 11/13/2015 08:25:25 PM MST

Many crop plants, including sweet potatoes, have been improved or saved through the use of genetic modification, the author argues. (*Provided by Thinkstock / The Denver Post*)

During the past 30 years, research in molecular biology has progressed at a breathtaking pace, in many cases even faster than the field of electronics as defined by Moore's law. For example, during the last 15 years the cost of sequencing the human genome has dropped from $100 million to $1,000. The resulting changes have revolutionized biological research and led to technical advances that even challenge the definition of what constitutes a GMO (genetically modified organism).

Over 90 percent of current GM crops contain genes transferred into plant genomes using T-DNA (transfer deoxyribonucleic acid) molecules from the soil bacterium Agrobacterium. In the wild, this bacterium injects its T-DNA into plant cells to force them to produce food molecules that only Agrobacteria like to eat. Plant breeders use T-DNA molecules because they can transport foreign genes into cells, and because they have "sticky" ends that enable them to insert a valuable foreign gene into the plant cell's DNA. By replacing the undesirable genes in T-DNA with desirable genes, plant breeders have inserted DNA from several sources into plants and thereby changed their genetic makeup. GM plants have therefore been defined as plants that contain both T-DNA and foreign genes.

Anti-GMO activists claim that GM crops and foods are dangerous because the T-DNA-mediated transfer of genes into non-related plants is unnatural. A recent paper in the Proceedings of the National Academy of Sciences has shown this claim to be wrong by demonstrating that all 291 sweet potato varieties cultivated by farmers contain at least four foreign genes with associated T-DNAs that were not inserted by scientists. Wild-type sweet potatoes lack these genes and T-DNA. This means that for hundreds of years farmers have selectively bred natural GMO sweet potatoes due to their desirable properties, and that all certified organic sweet potatoes are by definition GMOs.

Advances in molecular biology have led to two new methods for transforming the genetic makeup of crop plants. These are known as RNAi and CRISPR-Cas9. RNAi (ribonucleic acid interference) is a process used by cells to turn off a gene that codes for a specific protein by producing a small piece of RNA that triggers the destruction of the RNA used to make that protein. Plants naturally produce many types of RNAi to fight diseases and to regulate growth. When the sequence of a gene is known, it is easy for scientists to produce a new RNA fragment capable of suppressing the synthesis of the protein it encodes. Plant breeders like the RNAi technique, because it is a very efficient and environmentally friendly method for controlling viral diseases and insect pests. In Hawaii, starting about 15 years ago, the distribution of free seeds for ringspot virus-resistant papaya trees produced with RNAi technology saved the papaya farming industry. Other RNAi protected crops include virus resistant beans (Brazil), fungal-resistant bananas, and nematode-resistant soybeans. RNAi has the potential of helping farmers fight rootworms that have become resistant to Bt-toxins.

CRISPR-Cas9 is the newest tool being employed by plant breeders. It is a very precise, gene-editing method; it can make specific changes in existing genes. CRISPR-Cas9 can produce single base changes in DNA similar to naturally-occurring mutations or mutations created by X-ray mutagenesis, but unlike the "shotgun" approach of X-ray mutagenesis, CRISPR-Cas9 can target a specific gene and change defined bases. It also allows researchers to precisely alter small DNA domains, to remove a gene or to exchange it for a different gene. By doing so the ratio or type of plant products can be altered. For example, the amount of healthier oleic acid-type oils can be increased in soybean oil. CRISPR-Cas9 has become very popular, because it is precise, cheap (chemical ingredients about $30 per experiment; previous tools $5,000), and fast (one week per experiment).

Using the above techniques, scientists have learned to control the activity of genes with amazing results. Lengthening the vegetative growth period allows soybean plants to grow bigger and to produce more seeds. In another vein, by promoting more vigorous photosynthesis and root system growth, rice production can be increased by up to 29 percent in well-watered plants, and by 14-40 percent under drought conditions.

These new techniques are designed to augment, not to replace traditional plant breeding. They enable plant breeders to produce crops with desirable properties more precisely, faster and more cheaply. They are not "Frankenstein" technologies as claimed on anti-GMO websites.

Andrew Staehelin is a professor emeritus of the Department of Molecular, Cellular and Developmental Biology at CU Boulder. He lives in Boulder.

Cropland Policy Meetings
From Theresa Beck
1pm 2/5/2016

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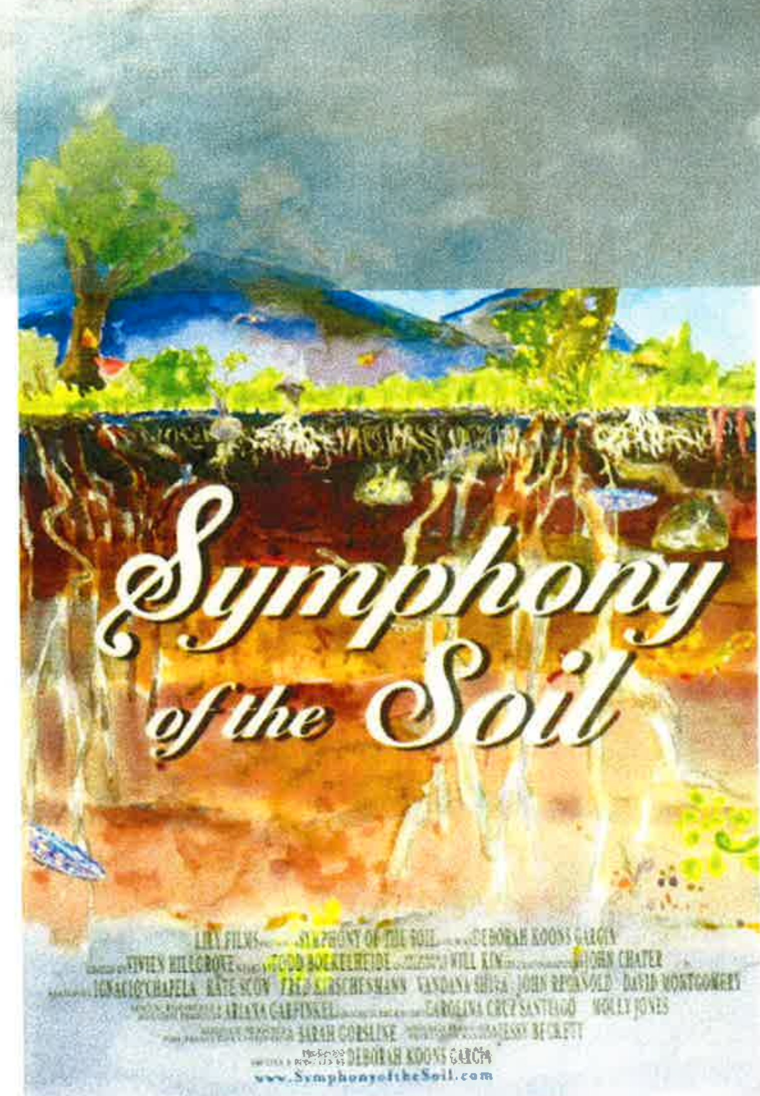
Symphony of the Soil (2012)



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Symphony of the Soil (2012)

Edit Tags

Cropland Policy Mtg.
2/5/2014
Scott Schlagel

My name is Scott Schlagel, I live at 1260 County Rd 20 ½, Longmont, CO. After graduating from college and working for a couple of different companies, I came back to the farm and have been farming with my dad for the past 4 years. Along with our family farm we lease a Boulder County Open Space Property on the very east side of Boulder County. Our family has been farming in the Longmont area for over 100 years. I am a fifth generation farmer. Our family has made the conscious decision to preserve our family farm for agriculture, so that my family can continue to farm for many years to come.

I'm sure that you are aware that 1/3 of the CO2 emissions in the US are related to agriculture. Because of this fact, I am happy that new farming practices are allowing me to play a role in reducing our carbon footprint dramatically over what my dad and grandfather have done. We have invested in farming practices that does substantially reduce greenhouse gasses. Our farming practices can only be accomplished with some of these newer technologies. Since, I became more involved we have been embracing more technology on the farm. We are working toward sustainable practices to assure these farms will continue to produce food and fiber for many years to come.

At this time we are soil testing extensively, applying nutrients, precisely in small amounts throughout the growing season. Our next step with the help of John Deere software, we will be able to map yields as we harvest and overlay the soil testing information and be able to variably apply seed and nutrients as called for. This is very exciting for me. These practices also hold very true for water conservation and minimizing soil erosion.

In the past few years, with the assistance of NRCS, we have been investing capitol into sprinkler irrigation. We have just been approved to construct a new lateral move sprinkler on the Boulder County Open Space that we farm. This lateral sprinkler concept fits very well with this particular acreage.

We are very proud of the way we farm and the advancements that we have made over the years. We are very proud of the way we take care of the soil and water.

We are proud of our rich history in sugarbeet production and suppling the Front Range and Boulder County with inexpensive, natural sugar. And as we always say sugar is essential but use everything in moderation.

Also sugarbeets are grown on a four to five year rotation which allows use to grow other crops. We have been investigating growing other crops and trying to find new markets that can add value to what we do. This has been very exciting working on other local market possibilities.

I know that you have a very difficult decision coming up regarding Boulder County Open Space and I would like to ask you to make a special effort to come out to our farm once the snow melts, to see firsthand what we are doing and the improvements we have made to this property.

The Cropland Policy that was instated has worked very well. I would hope this current policy can continue.

Here are some examples of some of the things we have done. Such as:

Conservation Tillage Machine

Is a one pass machine where you go through the field in mid to late spring. To be able to run this piece of equipment you have to have a GPS guidance system with + - one inch accuracy with a tractor that has at least 300 hp. The reason that you need precession accuracy is because when we come back later to plant you only have a small tilled area of where that seed needs to be planted in. When we use conservation tillage we use the residue in the field to add to our soil health.

When we use conservation till we are also saving 537% of CO2 from being released compared to conventional farming

Cropland Policy Mtg
2/5/2016
Chad Musick

My name is Chad Musick and I live at 14661 County Road 5, Longmont. I am a 3rd generation farmer, and I farm roughly 1,200 acres in the Longmont area, with my grandfather and brother. Farming is our livelihood and we hope to be able to continue in this area.

With urban development encroaching much of the farming communities on the Front Range, I feel that Boulder County has done a great thing by preserving this land to be used for agriculture purposes. In the future, I really hope that I can be able to lease more of this open space land to be used for conventional farming practices.

As a young farmer I feel it is imperative to be able to use the technologies that are available within agriculture. With the use of genetically engineered crops, we have been better able to implement the method of conservation tillage. We are able to leave the previous years crop residue as organic matter, which reduces soil erosion and also prevents water run off during the winter. In the Spring, we can make one tillage trip and then plant the seeds, thus leaving a much smaller carbon footprint than previous cropping methods. Furthermore, once the weeds surface we can use glyphosate (approximately 1 soda can worth of chemical to a football field size area of crop) to control weed pressure instead of disrupting the soil health. We soil test all of our ground annually to insure proper soil health. With the use of genetically engineered seed we are better able to manage that land, only applying what is needed in very small precise amounts, instead of the broad spectrum of fertilizer or chemical that we used to use without technical guidance.

Water is a scarce and expensive resource in parts of Colorado, and when drought years come the farmer gets the last straw for water use. Thankfully, there are now drought-tolerant traits available within certain seed varieties, which provides a very climate-smart approach to growing corn with increased water efficiency. We can still grow a corn crop in environmentally stressed conditions.

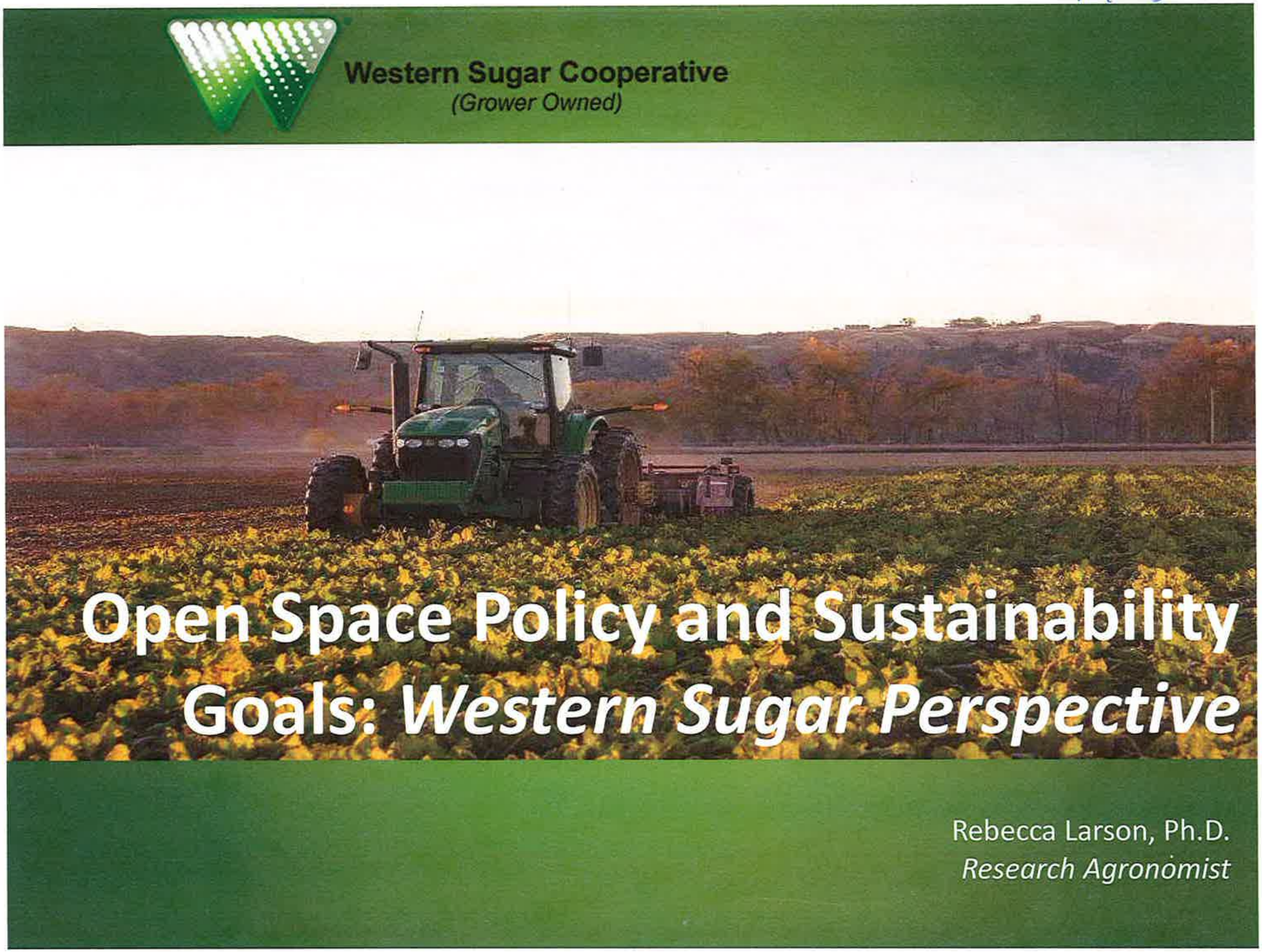
It is critical, especially as young farmers, that we are able to use the best of the science-based, safety-tested, agricultural methods which allows us to grow food in a way that is increasingly sustainable and productive, contributing to a local food system and participating as business owners in a local economy.

The current cropland policy that we have has worked very well, and I hope to look forward to a future of farming in Boulder County that is sustainable and adaptive to the technology of modern agriculture.

Thank you,

Chad Musick

Cropland Policy Mtg
2/5/2015



Who we are

- Grower-owned cooperative (850 growers)
- Farmers own the whole process from planting of the seed to sale of the sugar
- Multigenerational, small family farms
- Proud of our 100 year+ commitment to the land & community




Our commitments

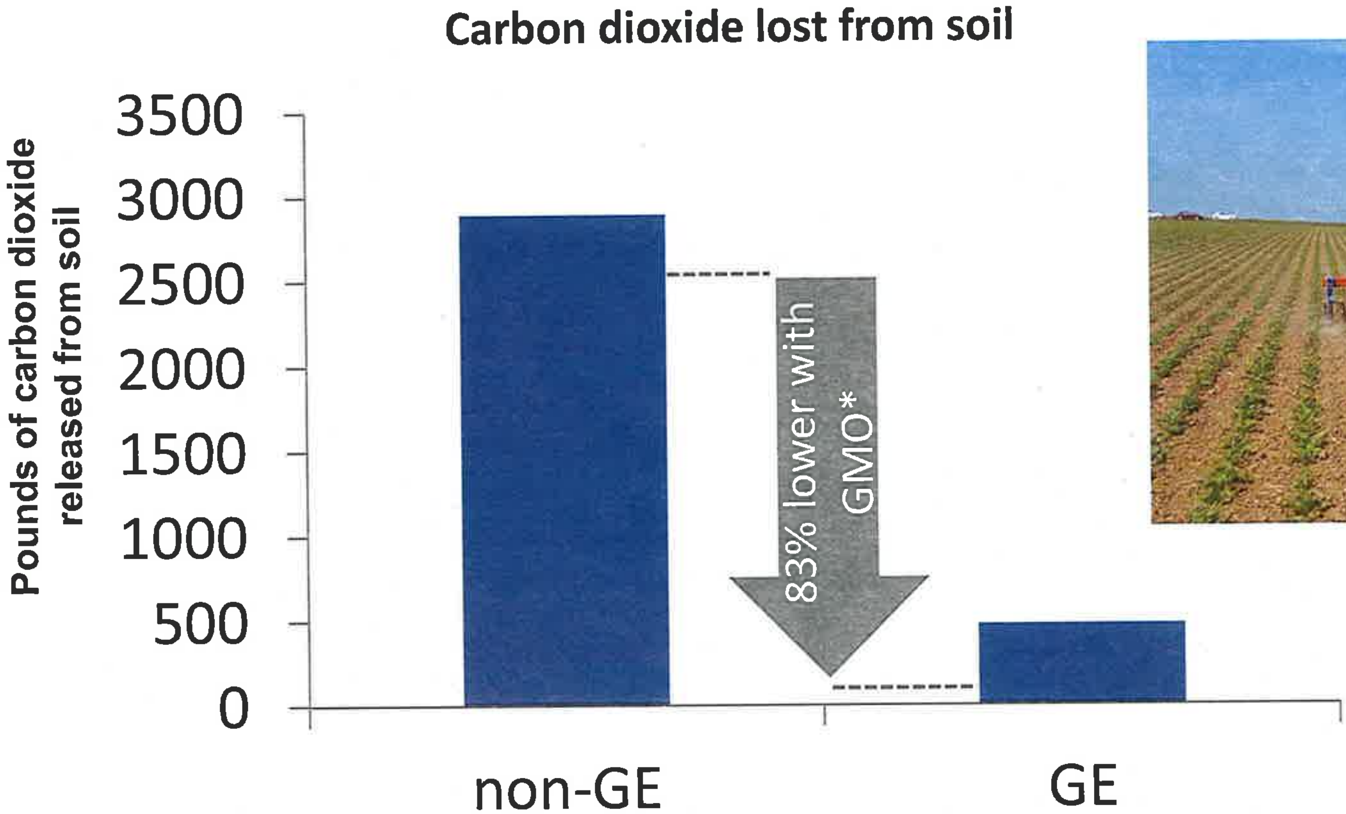
- We want to protect the land for future generations of farmers
  - Precision agriculture reduces chemical inputs, conserves water, improves soil health, and reduces weed and pest/pathogen pressure
- We want our future generations be able to afford to farm
  - Precision agriculture results in higher yields, producing more with less makes farming more sustainable
- We want to keep agriculture in Boulder
- We want to protect the tools of our trade
  - We invest heavily in developing and implementing proper stewardship practices to protect GM technology
- We want to coexist
  - Combining organic and conventional farming practices provides diversification while still delivering on climate change goals & protecting biodiversity

Benefits we see & feel: on farm benefits of GMOs

Environmental benefits of GMO sugar beets	
Herbicide usage improved	• Fewer herbicides applied in lower quantities • Less toxic herbicides • Fewer applications • Herbicide breaks down quickly • Worker safety greatly improved • Difficult & expensive hand labor eliminated
Plant Health	• Less disease incidence • Increased yields • Less stress induced by chemicals • Less weed competition for nutrients, water, sunlight • Long term weed populations greatly improved • Elimination of cultivation so less root damage
Soil Conservation	• Conservation tillage reduces wind and water erosion • Fewer weeds means less field to field transfer of weed seed
Water Quality & conservation	• Better water absorption with reduced soil compaction • Better water retention with conservation tillage • Healthier plants use more nutrients so less loss to storm water
Reduced Greenhouse Gases	• Less soil disturbance (carbon sequestration) • Fewer trips through field = carbon dioxide reduction • Healthier plants convert more carbon dioxide to oxygen
Reduced Crop Storage Losses	• Healthier beets and reduced debris in the piles = less respiration during storage

[Source: U.S. Beet Sugar Industry Submission to the National Academy of Science National Research Council Committee on Genetically Engineered Crops 2015; Boulder County Parks &Open Space Economic & Environmental Implications of cropping systems in Boulder County, 2015]

Sugar beet farming by the numbers in Boulder County

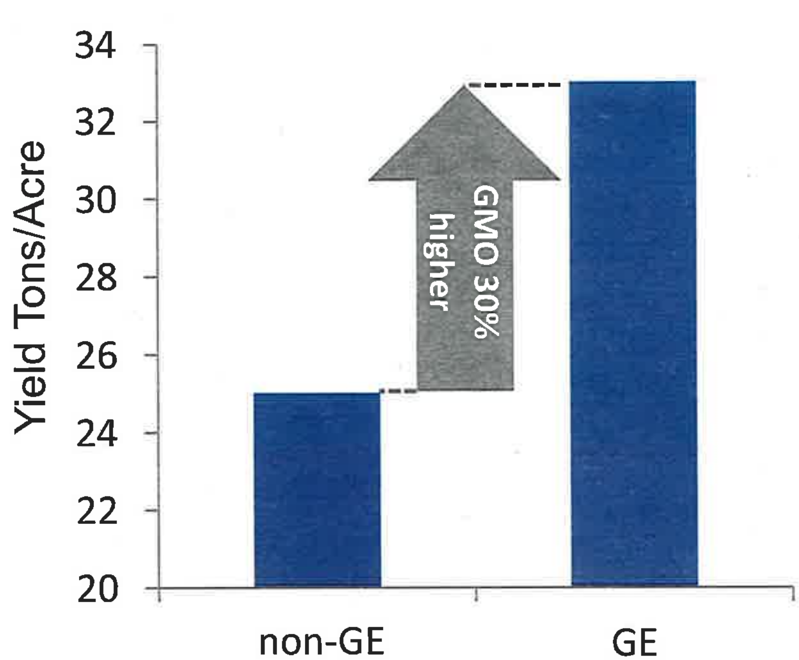


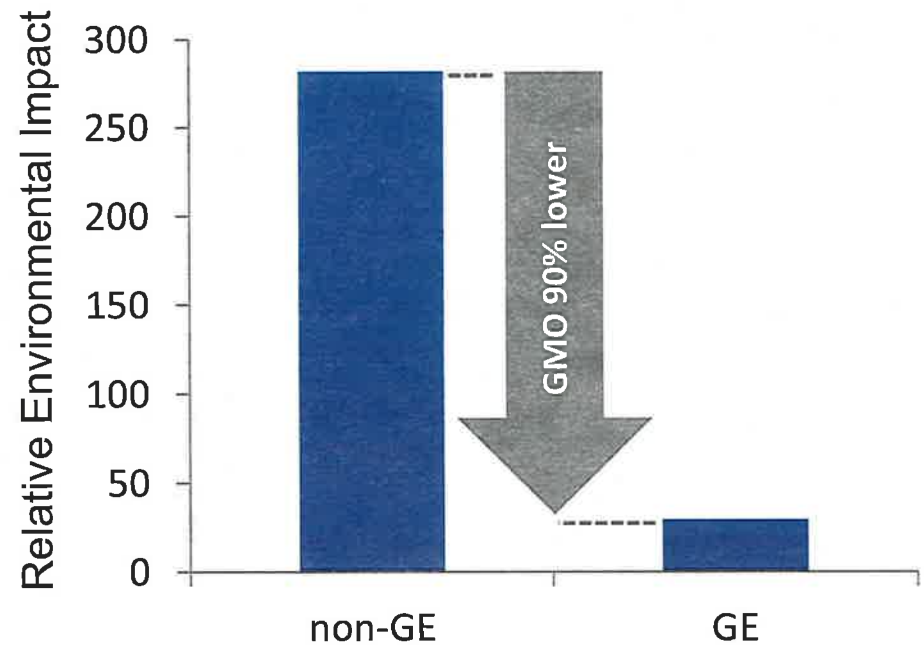
* Organic production estimated 5% higher than conventional

Genetically engineered crops enable conservation tillage, smaller carbon footprint, healthier soils & healthier plants

[Source: Boulder County Parks &Open Space Economic & Environmental Implications of cropping systems in Boulder County, 2015]

Sugar beet farming by the numbers in Boulder County





Genetically engineered crops are key to meeting sustainability goals

- More production from fewer acres = less environmental impact
- Safer chemicals used less frequently = less environmental impact

[Source: Boulder County Parks &Open Space Economic & Environmental Implications of cropping systems in Boulder County, 2015]

We need to trust scientific consensus regardless of whether it fits our ideologies

Agree to disagree?

Percent of U.S. adults and AAAS scientists who say the following...

	U.S. ADULTS	SCIENTISTS
GMO foods are OK to eat.	37%	88%
Humans have evolved.	65%	98%
Require childhood vaccines.	68%	86%
Humans worsen climate change.	50%	87%
Increase fracking.	39%	31%
Drill more offshore.	52%	32%

PBS NEWSHOUR

SOURCE: PEW RESEARCH CENTER
GRAPHIC BY LAURA SANTHANAM

We need to trust scientific consensus

- Contrary to popular misconception, GM crops are the most extensively tested crops ever added to our food supply [Source: American Association for the Advancement of Science]
- A review of 10 years of independently published peer reviewed experiments shows GMOs safe or safer than conventional and organic counterparts [Source: Nicolia et al (2013) Critical Reviews in Biotechnology]
- Meta-analysis of GM cultivation concluded GM crops use 37% fewer pesticides, yield 22% higher and increase farmer profits by 68%; providing "robust evidence of GM crop benefits for farmers" [Source: Klumper & Qiam (2014) PLoS ONE]
- Analysis of 18 years worth of GMO animal feed (nearly 1 billion animals) showed animal health equal or better post GE food source introduction [Source: van Eenennaam & Young (2014) Journal of Animal Science]

The accredited scientific organizations that state GMOs are SAFE

NATIONAL ACADEMY OF SCIENCES

Institute of Food Science + Technology ifst

The ROYAL SOCIETY of MEDICINE

OECD

WHO

Food and Agriculture Organization of the United Nations

FIAT PANIS

GSA

Genetics Society of America

There has never been a single study in the 30 year history of testing GMOs showing any health or safety dangers related to genetic engineering

INTERNATIONAL ACADEMY OF SCIENCE

American Diabetes Association®

IFT

feeding the minds that feed the world

AMA

AMERICAN MEDICAL ASSOCIATION

ACSH

American Council on Science and Health

Science. Not Hype.

THE AMERICAN SOCIETY FOR CELL BIOLOGY

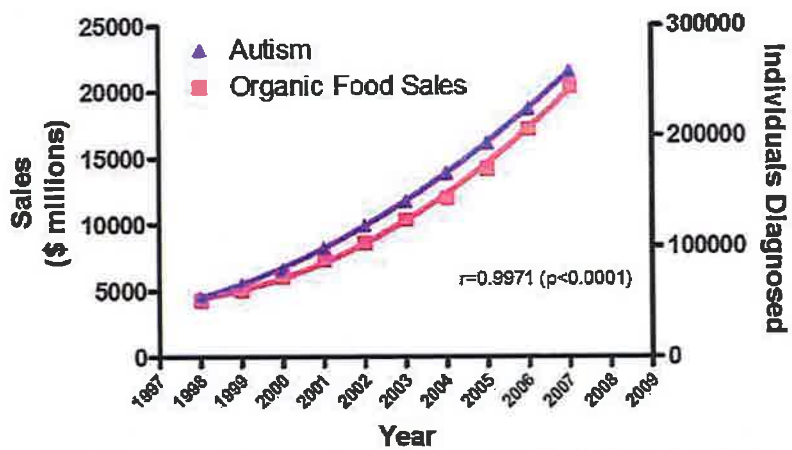
American Institute of Biological Sciences

SOT | Society of Toxicology

AMERICAN SOCIETY FOR MICROBIOLOGY

Our worst nightmares...

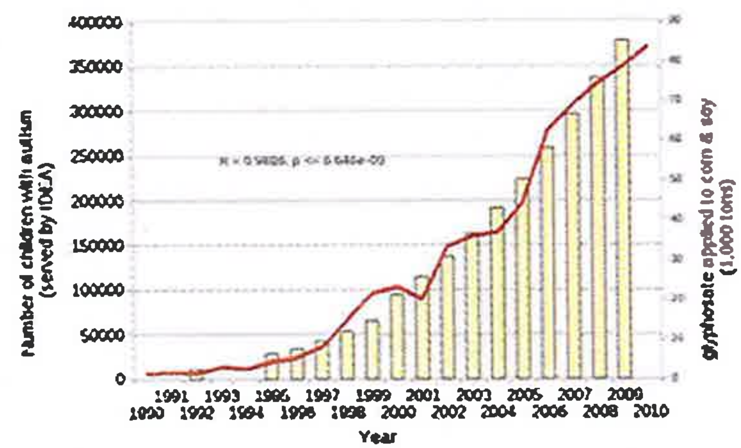
The real cause of increasing autism prevalence?



Sources: Organic Trade Association, 2011 Organic Industry Survey; U.S. Department of Education, Office of Special Education Programs, Data Analysis System (DANS), OMB# 1820-0043: "Children with Disabilities Receiving Special Education Under Part B of the Individuals with Disabilities Education Act

Glyphosate and Autism*

Number of children (6-21yrs) with autism served by IDEA plotted against glyphosate use on corn & soy



* http://www.examiner.com/article/data-show-correlations-between-increase-neurological-diseases-and-gmo

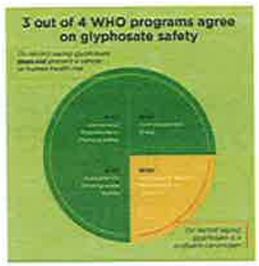
Western Sugar Cooperative (Grower Owned)

Does glyphosate really cause cancer?

¼ of one agency — International Agency Research on Cancer → Probably…

…but "there is little evidence for a link to cancer in humans"

The rest of that agency — WHO



→ NO

The rest of the major global scientific safety organizations

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Confederation
Federal Department of Economic Affairs, Education and Research EAER
Federal Office for Agriculture FOAG

Australian Government
Australian Pesticides and Veterinary Medicines Authority

agriculture, forestry & fisheries
Department: Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

Health Santé
Canada Canada

United States Environmental Protection Agency

BfR
Risiken erkennen – Gesundheit schützen

Food and Agriculture Organization of the United Nations

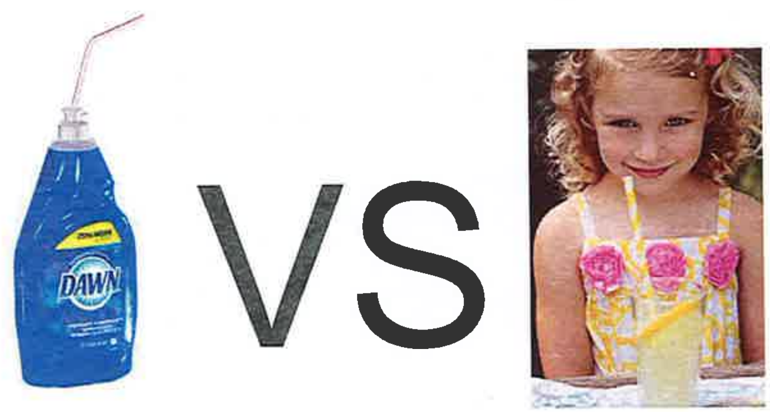
efsa
European Food Safety Authority

service public fédéral
SANTE PUBLIQUE, SECURITE DE LA CHAINE ALIMENTAIRE ET ENVIRONNEMENT
federale overheidsdienst
VOLKSGEZONDHEID, VEILIGHEID VAN DE VOEDSELKETEN EN LEEFMILIEU

→ NO

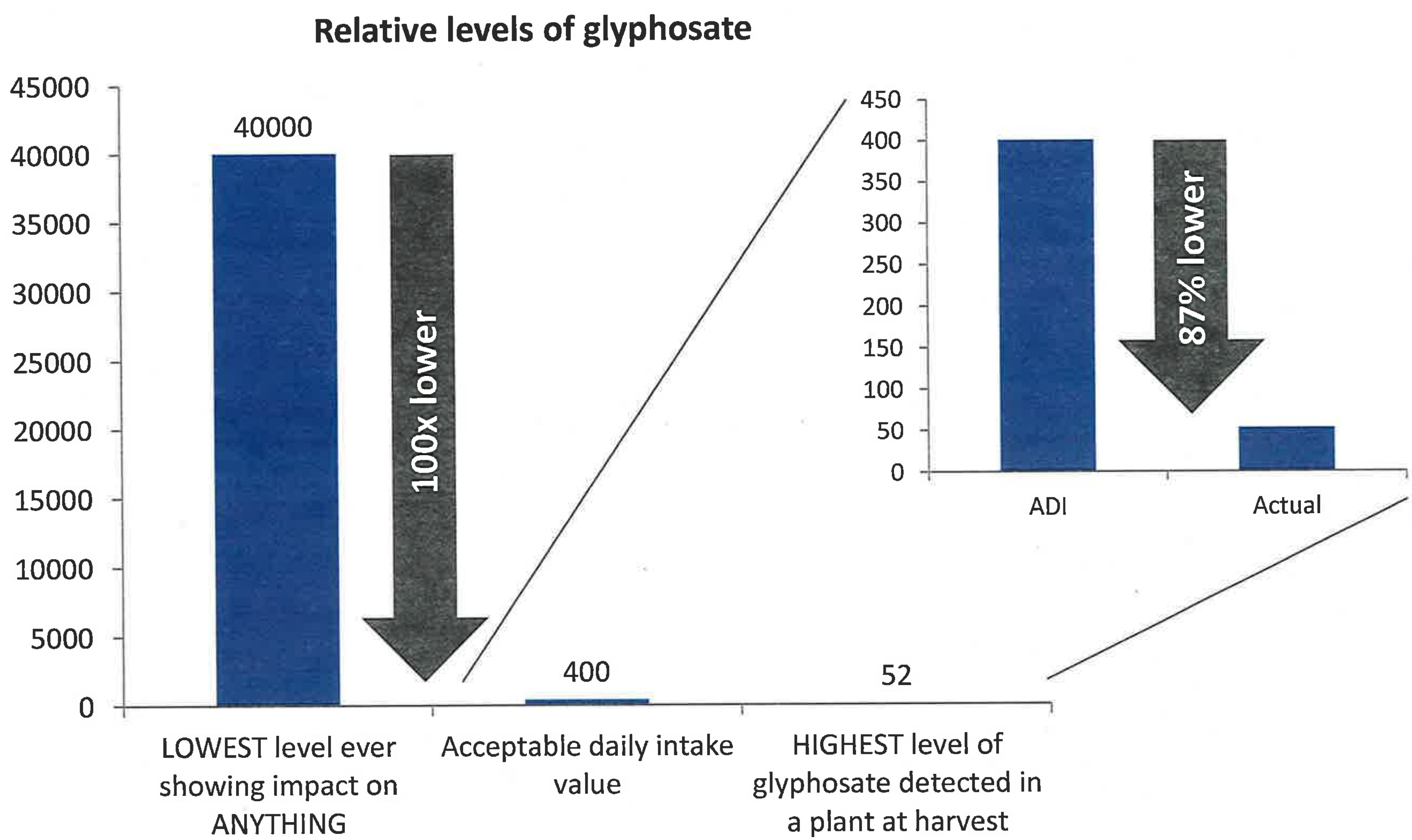
The safety scale in IARC's terms

- The dose makes the poison
- Most comprehensive study of US farm workers (with routine exposure) concluded no tie between glyphosate & cancer



[Sources: Science 2015; Dr. Andrew Kniss, University of Wyoming; IARC Monographs]

Further facts on safety



[Source: GMOAnswers.org]

The reality of the situation

- Natural does not mean safer
  - Most synthetic products are based off of natural compounds, but designed to be MORE effective at LOWER doses
- All methods of crop production use pesticides
  - 470 chemicals available to organic farmers; 100 banded in the US as deemed too toxic (imports still labeled organic)
  - Less effective so applied more often at higher concentrations

[Sources: Scientific American 2013; UC Berkley ; Colorado State University; USDA National Organic Program Approved List of Pesticides]

Fear not!

According to a study conducted by UC Berkley scientists published in The Proceedings of the National Academy of Sciences:

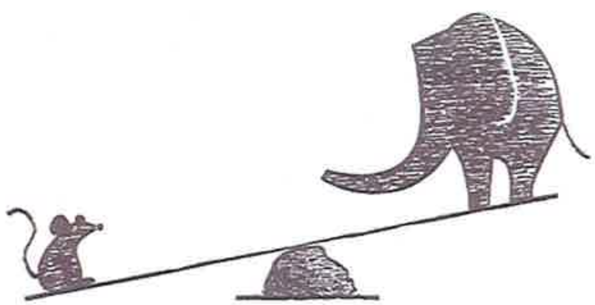
- The average **American eats 1.5 grams of naturally occurring pesticides every day**
- That is **10,000 more than all the synthetic pesticide residues combined**!
- That means: **99.99% of all the pesticides we consume are those produced naturally in the plant** and 0.01% are from agricultural application

The American Medical Association says:

- **Eat more fruits and veggies** regardless of whether they are organic or conventional
- The **health benefits of eating more FAR OUTWEIGHS any negative effect** of the pesticide residue

[Source: PNAS; Safefruitsandveggies.com]

Why the existing Crop Land Policy works



- Provides farmers the opportunity to use all the tools in the tool box to deliver a safe, reliable source of food
- Farmers know farming best; gives them flexibility to steer decisions and adapt as needed
- Creates opportunity to enter into agriculture: Let's grow the 2% any way we can!
- The coexistence has been successful; no contamination issues
- Scientific consensus overwhelmingly shows there are no health, safety or environmental issues with GMOs. The most widely tested products ever entered into food supply

Cropland Policy Mtg.
2/5/2014
Jennifer Musick

My name is Jennifer Musick and I live at 14661 County Road 5, Longmont. I am a 4th – generation farmer in the Longmont area. I received my bachelors of science from Colorado State University in 2011 and then came back to our family farm. My family raises corn, sugar beets, wheat, hay, Coors barley, cattle, and hogs. I have had a Coors barley contract for over 10 years, and have marketed cattle since I was 8 years old. I proudly market local beef to private customers, as well as 3 farm-to-table restaurants across the Front Range.

Farming is our livelihood, I not only grew up in this lifestyle but I married into it as well. My great grandfather came here to farm sugar beets over 100 years ago, and I intend to keep that heritage going. The future of Ag is vibrant if we are allowed to utilize the resources that are in front of us. As farmers, we are not at fault in pursing the use of technologies and developments, which are scientifically proven safe and sustainable.

We are again faced with the discussion surrounding the use of genetically engineered seeds and conventional crop production on Boulder County Open Space farms. The discussion surprisingly arises in one of the most technologically advanced counties in the world. The benefits of modern conventional farming practices, such as genetically engineered seed and conservation tillage are second to none.

As a young women in farming, being able to lease land, such as that in Boulder County Open Space, would be very beneficial to my operation. I have been unsuccessful in trying to lease land from Boulder County for my natural beef operation, but I look forward to being afforded that opportunity in the future.

People need to understand where their food comes from. Google does not tell you that, but mearly brings to the front lines the misinformation that is so widely spread about our livelihoods. I feel that education is key in allowing people to understand conventional farming practices.

I believe that the current cropland policy has worked very well, and I would urge you to vote and leave it as such.

Thank you.

Cropland Policy Mtg
2/9/2016

Michale Brown

BEYOND GMOs AND PETROLEUM FARMING

Four years ago I was among the group of Boulder County residents who were asking to ban GMOs on our publically-owned farm lands. The Commissioners at that time voted to add GMO Sugar Beets to the already approved GMO corn, but they also increased the acreage of land to be used for organic agriculture and agreed to take another look at neonicotinoid use if there was new evidence. There is now new evidence on GMOs, Roundup that is used on 80% of GMOs and on neonicotinoids linked to the death and weakening of all our insects, including bees.

So in 2011, in order to find out if there were practical non-toxic options to manage larger pieces of farm land (like 200-300 acres), I traveled to Ohio to an Acres USA Conference. Attending that conference were over a thousand farmers and ranchers. ACRES has been guiding eco-agriculture for 45 years now; the last conference I had attended was in 1977. I met farmers and attended talks by farmers who were managing 100-1000 acres without GMOs and without toxic chemicals.

They were not only promoting and teaching ecological agriculture, but what they called "biological agriculture". This focus on biology emphasizes the function and value of soil life. The beneficial bacteria, fungi and other soil organisms are Nature's system for creating soil fertility, and the valuable tilth of the soil which allows the entry of water and air, and the movement of plant roots and human tools.

Our soil can be supported to benefit the growth, health and drought tolerance of plants, or it can be limited and killed by harsh chemical fertilizers and by toxic herbicides like Roundup and toxic pesticides like neonicotinoids.

I do know about this from my own experience in managing a commercial nursery using organic methods for 25 years.

I am taking your valuable time to explain this because the future of our county and our planet could be moved significantly in a sustainable direction if you clearly understand that there is a practical and viable alternative to the chemical approach that is the product of oil thinking and marketing. Biological thinking is much more earth friendly.

In the 21st Century, we must consider more than making money or a product; we must consider the effects of what we are doing.

We cannot simply use the soil for short-term gains, without helping to regenerate it. We must consider what we are leaving for our children and for their economy. It used to be common for farmers to say " I'm gonna leave the land in better shape than when I got it."

Chemical, petroleum-based agriculture has been killing the land, killing the soil life that build fertility, tilth and nutrition in the food we eat. Now after 60 years of mistreatment, our soils are less fertile, less productive, require more costly inputs and are more vulnerable to erosion which is a major threat to food production and the environment. This is clearly not sustainable.

I feel very sympathetic for the farmers who have been educated to buy a petroleum-based system that fights against the power of Nature, and that poisons the environment they live in and the water they drink. And that has been giving the farmers a very meager living.

Isn't it time we moved on to a system based on 21st Century science instead of WW II science? Even GMO technology is still old thinking, using a gene gun to slam genetic material together with often unforeseen consequences. More and more research and field testing is proving that we can build soil naturally and powerfully by feeding the soil life and partnering with Nature's power to regenerate.

Look what happens when agriculture fights Nature: Nature adapts, so 12 major weeds have developed resistance to RoundUp. Oil thinking responds by designing GMO crops that are 2,4-D Ready, so now farmers are using more 2,4-D herbicide. Does Boulder County really want to keep going in this direction?

The so-called Green Revolution was really the Petroleum Revolution or the Poison Revolution. It wasn't Green at all. It has had 60 years to prove its worth and it has failed. When chemical fertilizers were designed from natural gas, they didn't realize that NPK (Nitrogen, Phosphorus and Potassium) only made plants grow; they did not provide the valuable micronutrients that plants depend on for their immune systems and overall health and vitality.

The early scientists didn't see that Pesticides don't know when to stop killing. They didn't see that the beneficial insects that keep the pests under control would die also. They didn't see that pests would develop resistance and that newer and more pesticides would have to be applied for control. Of course all this was good for the oil business.

GMOs are just another money-maker in the chemical farming approach. We were told that GMOs would reduce the use of herbicides and pesticides, but the record shows there has been a great increase. 80% of GMOs require the use of RoundUp (glyphosate) which has been classified by the World Health Organization as a probable human carcinogen. Neonicotinoids which are applied to many or most GMO crops are now recognized as a major cause of death and weakening of bees, butterflies, earthworms, ladybugs and all insects including soil-dwelling forms so important for soil fertility and tilth. Neonics are often required to be used on GMO sugar beets and neonics make it impossible to use IPM Integrated Pest Management, because all parts of the plant are toxic all the time.

Graeme Sait author of Nutrition Rules has written:
"The GMO companies have sold us the story that their GM varieties are the solution to feeding a growing world population. However, it is becoming increasingly obvious that these finely tuned hybrids require very specific and precise conditions to deliver their promise. They can be

very productive when given the correct fertilizer, moisture requirements and climate conditions, but they can really struggle in challenging conditions. They do not have resilience, and resilience is the single most important requirement in a world that is becoming considerably less predictable."

It seems clear to those of us not dependent on chemicals and poisons, that the time for action has come to clean up our world, to partner with Nature, to take carbon from the air and sequester it into our soil where it contributes to fertility. More and more research and trials by Rodale Institute etc are showing the tremendous capacity of soil under organic culture to reverse climate change. But we have to stop killing our partners and help them instead.

We can rebuild our public land and attract organic farmers to produce healthy food for our Farmers Markets and local grocery stores. We already have some good organic farmers and if we create a distribution center or system, we would be a lot more food secure, better nourished and GMO farmers could be making better money growing organic. The price and demand for organic corn is sky high, and the market for organic is growing rapidly.

We do not need oil to grow plants: we can mow or cultivate or use non-toxic herbicides; we can grow with diversity, magnetize beneficial insects, and create plant vitality through soil health. Sometimes you have to spray, but it doesn't have to be a poison.

Our company, Harlequin's Gardens has been growing healthy plants for 25 years without toxic pesticides. We just purchased one acre of land next to us to build a large production greenhouse that will be fossil fuel-free where we will grow pesticide-free perennials and vegetable starts. This will be a benefit to our bees, insects, frogs, birds and community. We believe this is the direction of the NEAR future, and we hope Boulder County will join us in making a practical commitment to sustainability, to cleaning up our world and to creating a healthy environment with healthy food.

Question #1 is: Is Boulder County going to continue to use our publically-owned land to support an oil economy, WW II science and poison-based agriculture that kills our soils, pollutes our water and our environment and undermines the heath of our citizens,
OR are we going to invest in the growing 21st Century biological direction of agriculture that partners with Nature, builds healthy soil, cultivates nutrient-dense foods, is good for our bees, birds, worms and beneficial microorganisms, and for the health of our citizens and our planet.

Question #2 is: If we choose to transition to biological agriculture, how can that transition be compassionate to our farmers so they can learn a new approach to farming without going broke? And beyond that, to become more profitable than they are now with GMOs and poisons?

We don't have to reinvent the wheel. There are thousands of farmers already on the biological/ organic path that we can learn from. Acres USA, the Rodale Institute, the USDA Natural Resources Conservation Service, the Natural Science and Technology Center and dozens of other organizations are resources for the transition. And we should perhaps reduce rents and subsidize non-toxic pesticides and herbicides and possibly help with marketing.

Change is rarely easy, but the direction of the future for our agriculture and for our planet has to be forward. And we believe that Boulder County should be one of the leaders.

Please ban GMOs and neonicotinoids on our public land, or at the very least ban them on 50% of our land for a start.

MIKE BRAWNER
Harlequin's Gardens

Cropland Policy
Feb 9, 2016
David Wheeler

GMOs and Bees: Pesticides, Pollinators, People and the Planet

County Commissioners Domenico, Gardner and Jones,
Thank you for taking the time to listen to me today, speaking to you as the Director of the Boulder County NPO Bee Safe Boulder, also as a parent, and as a soon to be grandparent, regarding the use of Genetically Modified seed on Boulder County-owned lands.

I am not here to argue the ethics GMOs per se, of for example artificially inserting the DNA of a flounder into the DNA of a tomato seed so as to produce a tomato that will survive cold weather better. I am here, rather, to disucss the ethics of, and to present evidence regarding, the concomitant use with GMOs of two alarmingly dangerous and longlasting pesticides (the herbicide Glyphosate and insecticide family Neonicotinoids).

By way of doing so, I will first simply introduce the NPO Bee Safe Boulder, and what Bee Safe Boulder and its allies have achieved over the past year.

I will then address the issue at hand, the use of GE seed, and more specifically, the pesticides that are part of that package, on Boulder County lands. This discussion will review the history of the most widely used herbicides and insecticides in the world, ever, how they are used and what this means for the cropland, for our food future, our economic future, and for the future health of our local envrionment. I will refer to the overwhelming and still growing body of peer reviewed scientific evidence showing the dangers of these pesticides, both for the ecosystem and the farms in Boulder County and for its residents, including all farmers and citizens, both current and future.

I will compare current practices in the US and other countries, where the Precautionary Principle has ruled decisions and policy around issues like this one, and also look at the concept of prophylactic applications of Neonicotinoids as seed treatments in the context of the IPM, Integrated Pest Management, which is a central element of Boulder County's Cropland Policy.

Finally, I will ask that we make the future we are creating for ourselves and our children be healthy, sustainable and still profitable, and that it be a model for others.

Bee Safe Boulder is one example of how public awareness surrounding these issues continues to grow. Bee Safe Boulder was established in the spring of 2014, after the Melody-Catalpa Neighborhood became the first Bee Safe Neighborhood in the US. A Bee Safe Neighborhood is a neighborhood where 75 contiguous households pledge not to use bee and other pollinator-killing pesticides. This is a means of creating community around the issue of pesticides and how they affect us and our environment.
We facilitate the creation of Bee Safe Neighborhoods by collecting these pledges and mapping them so that progress can be monitored.

This is our map of Boulder County, with each happy bee icon representing a pledge.
Now let's zoom in on the Newlands Neighborhood in North Boulder.
Once a Bee Safe Neighborhood is achieved, we celebrate and spread the buzz.
In June of 2014, Bee Safe Boulder joined Friends of the Earth to spread the word of the dangers of neonics in potted plants in big box stores like Home Depot and Lowe's.
Home Depot responded by labeling its neonic drenched plants, but their label looks more like an advertisement for Neonics.
Here is the local McGuckin Hardware store label, which tells the truth.
We may love bees because they provide us honey, or more importantly because they pollinate about one third of the food that is our diet, but perhaps their greatest value to us is as the proverbial Canary in the Coal mine that is our environment. Unlike the miners, however, we don't have the option to evacuate when our "Canary's" death indicates unacceptable toxicity.
Here are some Bee Safe Boulder accomplishments from 2015.
They indicate the extent to which citizens are sitting up and taking notice of this issue, much moreso than 5 years ago, when the last Cropland Policy was put in place.
We got 500 Facebook Likes
We presented at the WAS Conference.
We established a Board of Directors
We helped create Pollinator Appreciation Month in September.
We got the city to pass a Bee Safe Resolution in May
Ypsilanti, Michigan joined our effort
We helped Lafayette pass a Bee Safe Resolution in September
Boulder County passed a Pollinator Protection Resolution in September
Bee Safe Boulder reached out to retailers to encourage labeling and reducing sales of neonics.
Remember McGuckin Hardware's label.
Our final accomplishment of 2015 was McGuckin's nenonic-free announcement.
How toxic are neonics?
They are much more toxic than DDT.
Here are some sample toxicities. You can find extended information in articles like this http://link.springer.com/article/10.1007/s11356-014-3332-7#/page-1
And they are wreaking havoc on bees.

Glyphosate has its own problems.
http://www.i-sis.org.uk/Banishing_Glyphosate.pdf
Meanwhile, overwhelming evidence of glyphosate toxicity across the globe has come to light. Everywhere, people are see- ing steep rises in cancers, birth defects and other serious illnesses as glyphosate use increases. The World Health Organisation's recent re-assessment of glyphosate as a 'probable carcinogen' vindicates the evidence witnessed by communities, researchers, doctors and campaigners for many years.

The GMO can has been discussed in county cropland policy for the past 15 years. It's time to stop kicking this can of poisons down the road any further, especially given the new science that shows both Glyphosate and Neonicotinoids are even more dangerous than previously thought. Last spring, the WHO upgraded its rating of Glyphosate from "Possible Human Carcinogen" to "Probable Human Carcinogen," not to mention its known endocrine disruptor effects on human health. Increasingly, peer-reviewed scientific studies are showing that neonicotinoids are having far broader deleterious effects on our environment, and are much more persistent and pervasive in our environment than previously thought.

Talk about my kids, and my granddaughter who will be born in April.
Talk about prophylactic seed treatments flying in the face of the standard IPM practices that county policy endorses.
Encouraging the commissioners to look and step outside the box of "the current modus operandus", and to encourage lessees farming on county lands to do the same, so that we can unhitch from this toxic treadmill and leave for the coming generations a cleaner, more sustainable environment.

Cropland Policy Mtg
2/9/2016

Western Sugar Cooperative
(Grower Owned)

Open Space Policy & Sugar Beet Production: *Western Sugar Perspective*

Mike Otto & Sue Inness
Agriculturalists

Why we need sugar

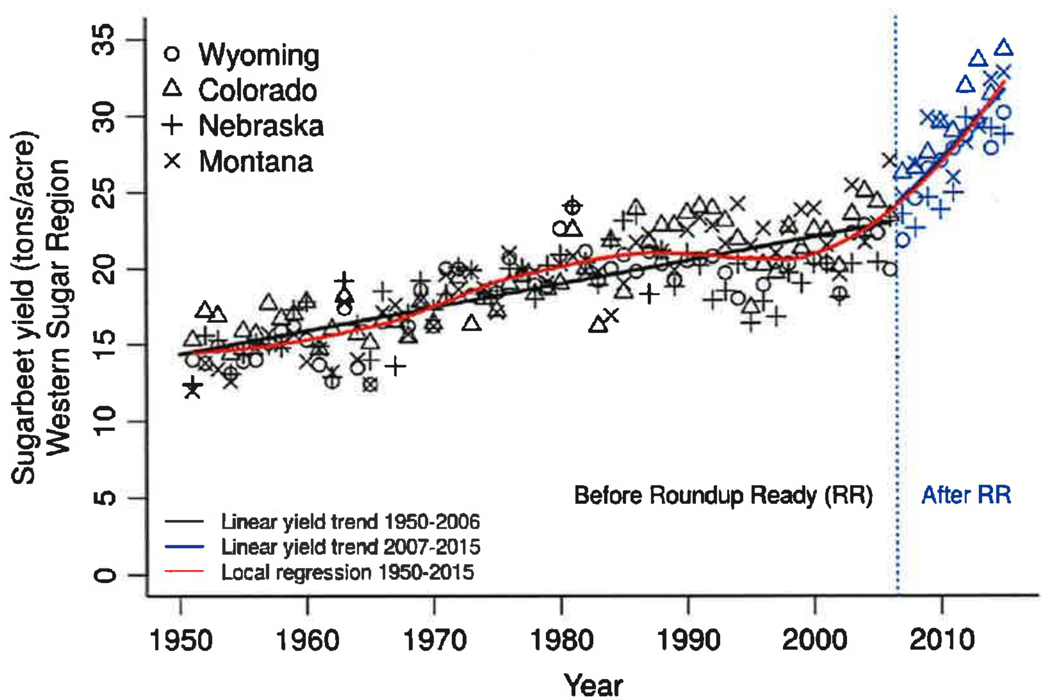
- Preservative
- Leavening agent
- Equalizes consistency of many food products
- Drives fermentation
- Slows the setting of glue and cement
- Used in manufacturing detergents
- Used as fabric finisher in textile industry
- Used in manufacturing of pharmaceuticals
- Hospitals use it to kill bacteria in ulcers & bedsores

What farming sugar beets used to mean

- Weed control was the number one issue
- Hard to control broadleaf weeds in a broadleaf crop
- Chemicals minimally effective
- Only effective in cocktails
- Only effective when applied frequently and ON TIME
- Chemicals only effective in combination with mechanical removal

Broadleaf weeds in a broadleaf crop

- Old chemicals stressed and stunted beets
  - 30% lower yields
  - Higher use of pesticides



[Source: Dr. Andrew Kniss, University of Wyoming]; USDA

Old chemicals were not very effective

Anti-GMO movement would lead one to believe that "super weeds" are unique to GMOs

- Weed resistance happens with all chemistries, whether applied to GM crop or conventional crop
- Weed resistance was worse in our conventional productions since we had to apply chemistries at lower rates (to not kill beets) so more weed survivors evolving resistance
- Resistance also made worse since we had to apply chemistries more often; greater exposure = more resistance development

Preventing super weeds

- Our growers **value** the RR technology so we work proactively to protect it
  - Use proper rotation so we can use a variety of agrichemicals
  - Use alternate chemicals in tank mixes and pre-emergence to introduce multiple modes of action
  - We fund over $240K of research annually through third parties, including research on weed herbicide resistance management strategies
  - Collaborate with universities to understand and manage weed populations
  - Educate our growers about weed resistance management

Use of GMO sugarbeets reduces chemical usage over 5-fold

Crop type[1]	Herbicide used (oz/acre)[2]	Average trips across field required[3]
Non-GMO	**323.25**	**5**
GMO	**60.11**	**3**

[1] GMO = genetically modified organism. The GMO sugarbeet has been engineered to contain tolerance to glyphosate.

[2] Herbicide usage was calculated using on farm data collected sixteen conventional fields raised in 2004 & six GMO fields from 2012 to 2015

[3] Conventional herbicides require more frequent application to be effective, including a typical pre-plant application. The GMO crop requires fewer applications thereby reducing fossil fuel consumption & soil compaction as well

Benefits of better weed control

- Beets are healthier
  - We apply fewer pesticides and see higher yields
- We have largely eliminated cultivation
  - Reduced carbon emission
  - Improved soil health
  - Reduced compaction/erosion
  - Reduced run-off
  - Improved water use efficiency
- Cleaner fields
  - Reduce weed populations for all crops in rotation
  - Fewer weeds means nutrients and water being used by crop, not weeds

Benefits of better weed control

- Storage is better
  - Hauling less dirt and weeds into the pile
  - Respiration reduced
  - Quality is maintained; protects the gains made in the field
- Can focus our efforts on additional environmental gains
  - Developed disease prediction models to reduce pesticide applications
  - Able to change our hybrid approval system to mandate 7 native disease tolerance traits, again reducing pesticide usage
  - Improved yields so substantially we have reduced production acreage by 1/3 creating a smaller carbon footprint

Why our farmers choose to use GE sugar beets

- Our growers have options; they chose to grow GE beets
- GE beets protect the health of their land and the viability of their operations
- They also make farming safer for the farmers and their workers
  - Safer chemicals
  - No longer need intensive hand labor for weed control

Western Sugar Cooperative (Grower Owned)

What would happen if GE sugar beets couldn't be planting on open space

- Growers plant conventional seed imported from Europe
  - Seed not designed for our growing conditions = lower yields
  - Lack of disease tolerance = more pesticides used
  - Introduction of annual weed beets = new weed pest in North America
- Growers shorten their rotation
  - Growers today have 3-4 year rotation on each parcel of land to minimize pest and weed pressure
  - Reduction in rotation = more disease & greater chance for weed resistance issues
- Boulder County growers will negatively impact their neighbors' crops
  - Hauling more dirt, disease and weeds to the pile will increase respiration and loss of sugar in the pile

Why sugar beets are the "perfect" crop for coexistence in Boulder County

- Sugar beets are biennial so they do not flower during production
  - No flowers = no pollen = no contamination of organic crops with close relations to sugar beet
- Solid weed control means open space fields are cleaner for next inhabitants
- Moved to conservation tillage which has vastly improved soil health and reduced water usage, leaving open space in better shape after usage
- Conservation tillage has reduced greenhouse gas emissions 80%, which contributes to Boulder County climate change initiatives

Cropland Policy Mtg.
Jerry Darnell
2/9/2016

Benefits of sugar beet production using genetically modified seed

A National Perspective on a Local Issue

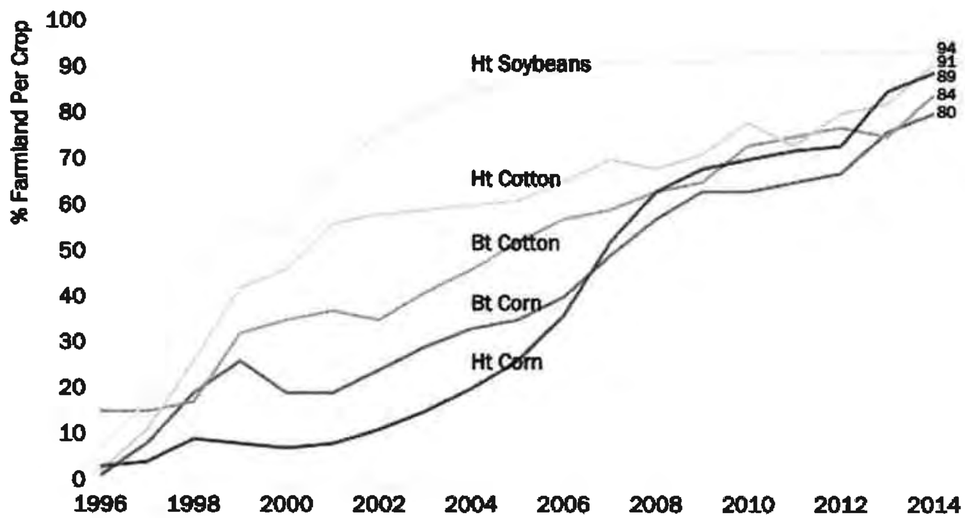
Jerry Darnell, President Beet Sugar Development Foundation
Denver, Colorado

Sugar beet production in the US

- Since 1970, thirty-eight U.S. sugar beet processing facilities have closed
- The twenty-two factories left today are open because the small family farmers raising beets leveraged their own farms to create grower owned cooperatives
- Constant adoption of new technologies to improve efficiencies is key to keeping these cooperatives viable for generations to come

GMO sugar beets widely accepted

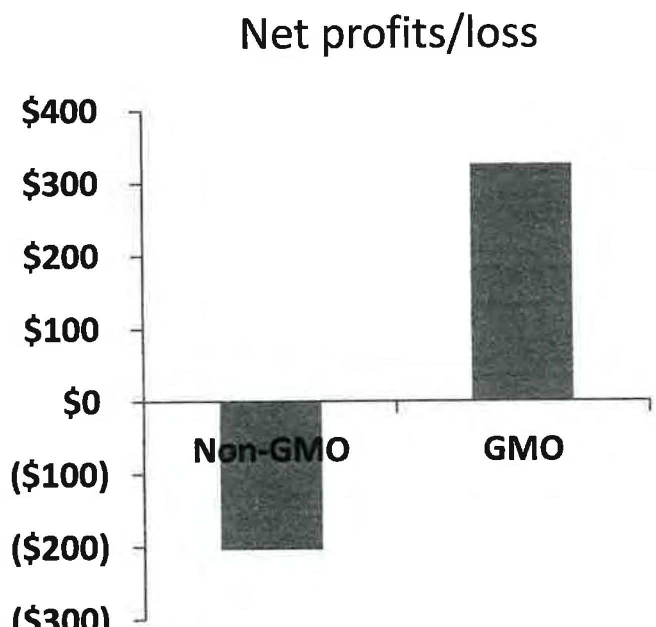
Adoption of GMO Crops in the US, 1996-2014



Ht: Herbicide-tolerant **Bt:** Insect-resistant
Source: USDA Economic Research Service

- 95% of sugar beet producers switched to GMO beets within a year of introduction (fastest adoption of any crop)
- Why?
  - 13 different & costly herbicides = alternative
  - Required exact timing, conditions and specialized equipment
  - Also needed multiple cultivations & supplemental, expensive hand labor

Embracing GMOs good for small, family farms



[Source: POS Staff]

- Commodity prices are down 30% across the board
- Since sugar beet is a hybrid, biennial, famers have always relied on seed companies to supply seed
- Even with technology fee assessed on seed, farmer profits are up using the technology which offsets losses from lower commodity prices and rises costs of inputs
- Result of increased yields and lower input requirements

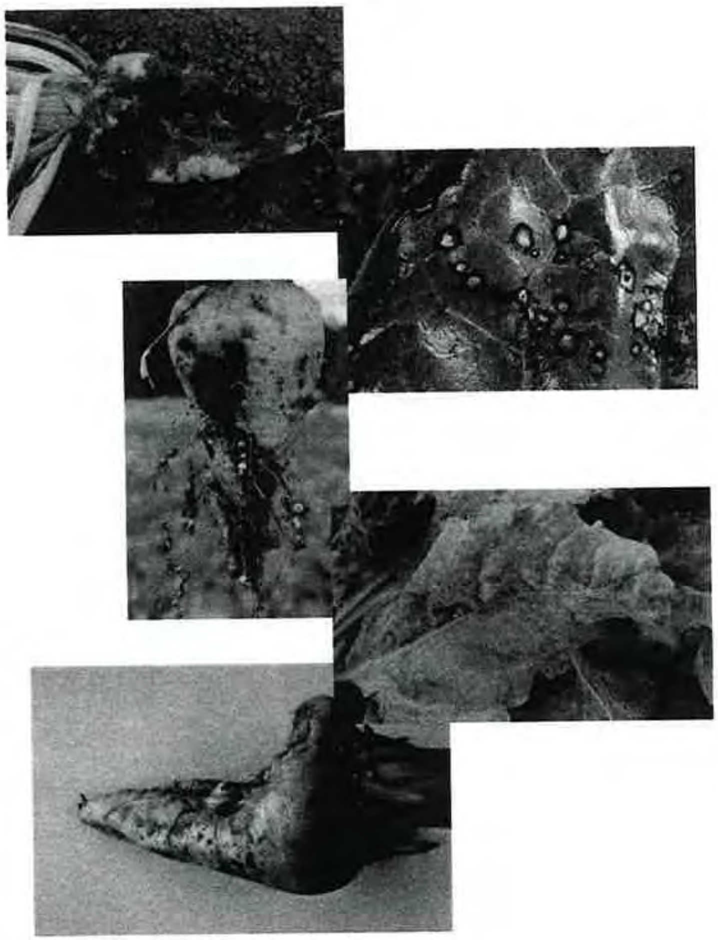
Embracing GMOs is good for the environment: *Fewer, safer chemicals*

Then	Now
Clethodim	Glyphosate
Clopyralid	
Cycloate	
Desmedipham	
EPTC	
Ethofumesate	
Phenmedipham	
Pyrzon	
Quizalofop-p-ethyl	
Sethoxydim	
Trifluranlin	
Triflusulfuron-methyl	
Dimethenamid-p	

Glyphosate safety

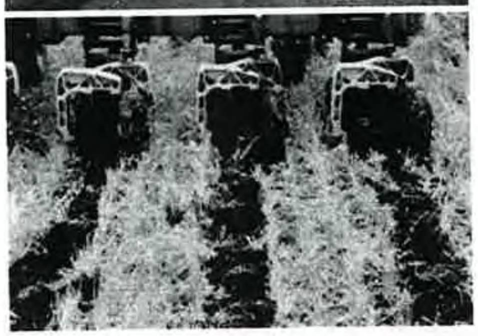
- Rapidly and completely biodegrades in soil and water [Source: Rueppel et al Journal of Agricultural and Food Chemistry]
- Within 3-14 days glyphosate is completely undetectable in water [Source: US EPA}
- Glyphosate has no negative impact on soil fungi [Source: Salilaja and Satyaprasad Journal of Environmental Science and Engineering]
- Glyphosate has no negative impact on soil bacteria [Source: Lupwayi et al Canadian Journal of Plant Science]
- Glyphosate residue has no negative impact on human health [Source: Williams et al. Regulatory Toxicology and Pharmacology]

Genetic engineering has made sugar beets healthier



- Eliminated stress-inducing herbicides creating more vigorous plants
- Eliminated cultivation so no longer moving disease throughout the field or repeatedly wounding roots
- Less weed competition results in faster growth with fewer nutrients and water
- Better weed control methods means efforts now focused on better disease tolerance

GMOs have made our soils healthier

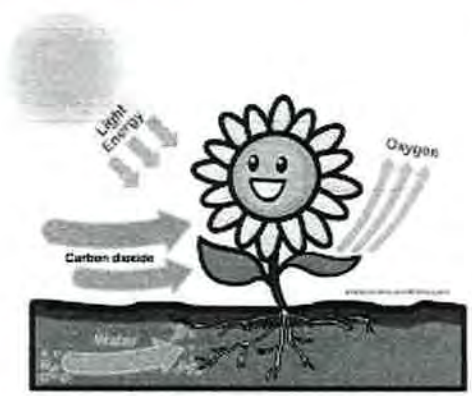


- Conservation tillage and the use of cover crops has reduced wind erosion
- Conservation tillage has also reduced water erosion
- Fewer trips across the field to apply chemistries and "work the ground" has resulted in less soil compaction
- Better weed control has reduced the weed bank in soils and reduced risk of transfer field to field through irrigation water

GMOs allow us to conserve water

- Fewer trips across the field = less soil compaction = better water absorption
- Conservation tillage reduces evaporation
- Fewer weeds in the field so all the water usage is going to crop growth

GMOs reduce greenhouse gas emissions



- Conservation tillage reduces carbon dioxide emissions by 80%
- Cut trips across the field in half; reduced fuel consumption by 3.25 gallons/acre which further reduces carbon dioxide emission by 76.8 million pounds per year nationally
- Healthier plants convert more carbon dioxide to oxygen
- We are producing the same amount of sugar on fewer acres

Cropland Policy Mtg.
2/9/2016

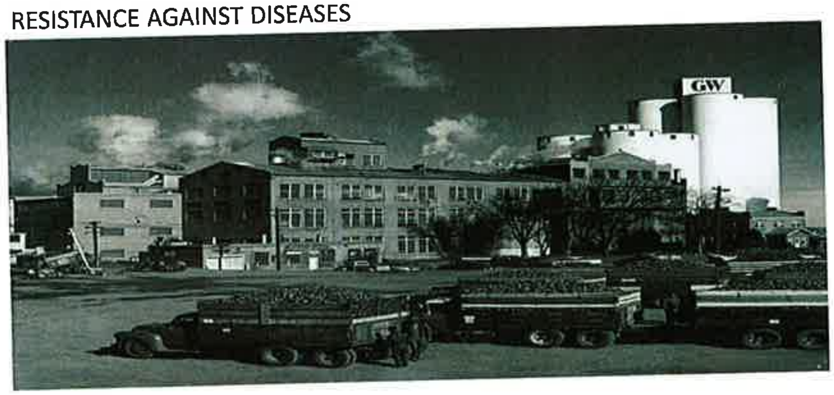
Western Sugar Cooperative
(Grower Owned)

Storage and Processing of GM Beets versus Non GM Beets

Anurad Jayasooriya
Chief Chemist
Fort Morgan CO

Benefits of GM Beets

- YIELD
- SUCROSE CONTENT
- SELECTIVITY OF NON SUGARS
- RESISTANCE AGAINST WEATHER CONDITIONS
- RESISTANCE AGAINST DISEASES



Sugar beet is not easy to grow

Sugar beet farming requires a lot of theoretical knowledge and experience

- High yield with GM beets
  - -Proper weed control
  - -Sufficient disease and insect control
  - -Less stress from herbicides and pesticides

- High Sugar content with GM beets
  - -elimination of unexpected diseases
  - -Resistance against severe weather conditions
  - - Non sugar selectivity

Sugar loss due to Tare

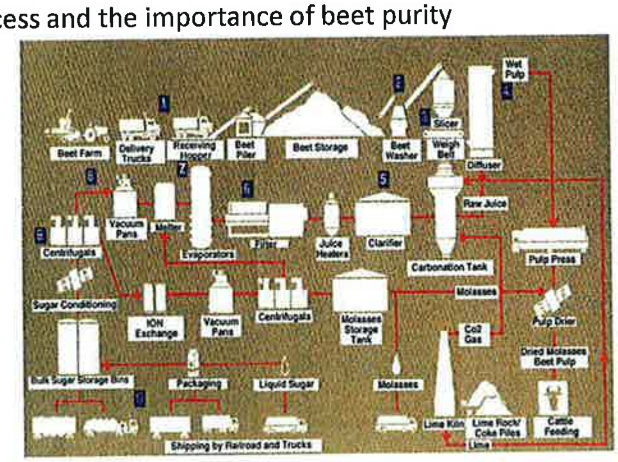
- Beets bring in impurities (tare) such as soil, weed and leaves.
- Non GM beets will bring in more soil and weeds than GM Beets
  - - More soil, weed, dirt means there is a higher rate of respiration
  - - It also means processing costs go up due to damage to equipment
  - - higher water consumption
  - - waste water processing costs will go up

So how does GM Beets solve these issues ?

- Less soil brought in: Soil inhibits air circulation within piles and therefore increases pile temperatures leading to higher respirations rates
  - More tare is brought in from sugar beets gown in eroded fields. This problem can be solved with conservative tillage by GM beet farming practices
  -Weeds will carry more soil with it. GM beets allows us have a better weed control and therefore less soil carry over
- Less weeds brought into the factory with better weed control
  -reduction of operational issues and costs
  -lower respiration rates in the piles
  -less waste

Processing of GM Beets versus Non GM Beets

- Overview of the process and the importance of beet purity



1. Beet receiving
2. Beet cleaning
3. Slicing
4. Diffusion
5. Juice purification
6. Filtration
7. Juice evaporation
8. Crystallization
9. Centrifugation
10. Sugar drying , storing , packaging and shipping

Beet and Juice Purity (Sucrose: Non-Sucrose)

- Beet purity is probably the most important factor in beet processing
- Anytime the purity drops, we will face operational difficulties.
- Our aim is to improve non sucrose elimination during beet purification to increase sugar production
- Factors that affect beet and juice purity :

  -dirt carryover

  -Bacterial spoilage leading to inverts

  -Higher rate of respiration in the piles

  -higher temperatures

  - pesticide/herbicide carryover

  -stressed beets and improper fertilization practices

How does GM Beets Help Beet and Juice Purity?

- Less soil in the piles means less soil carry over to the process
- Less soil in the piles mean higher air circulation and therefore lower temperatures in the piles
- Less soil means less pesticide, herbicide and fertilizer carryover to the process
- Less soil means less soil bacteria getting into the diffuser eg *Bacillus subtilis*

How does GM Beets Help Beet and Juice Purity?(continued)

- Better beet storage with GM beet practices means that there is less chance for bacterial infections

  -Infections destroy sucrose to produce acids and inverts

  -Infections lead to higher operational issues/costs and lower sugar production
- Any chemicals added to the process (such as herbicide and pesticide carry over from the beets) will increase the non removable impurities and therefore will increase molasses production

Mechanical and operational issues

- Non GM Beets will carry more weed, dirt and soil
- Dirt/soil can damage the beet slicing knives
- Weed can clog, blind screens
- More wear and tear on cleaning equipment due to abrasive nature of soil
- Higher dirt/soil content can cause fluming of beets very difficult
- High foaming in the factory due to bacteria and dissolved pectin from weeds
- Color rise in the process due to higher invert content in the beets
- higher chemical usage to inhibit bacterial growth and color rise
- HIGHER MOLASSES PRODUCTION!

Summary

- **Processing Non GM Beets is a challenge and can cause a detrimental impact on the sugar beet industry**
- Higher respiration in the piles will lead to higher sugar loss in piles
- Increases amounts of pesticides and herbicides can increase molasses production and therefore decrease sugar yield
- Increased tare will cause major process upsets
- Operational costs will increase (mechanical and supplies)
- Environmental costs/impact will increase with more dirt and waste water

Our industry relies heavily on GM Beets to maintain good pile grounds, to maintain low process costs, maintain efficient operations and to produce the best quality sugar.

Thank you

Cropland Policy Mtg
2/9/2016
Al Summers

Al Summers

From:	Al Summers <summers@ichibanenterprises.org>
Sent:	Tuesday, February 09, 2016 12:52 PM
To:	Al Summers
Subject:	Emailing: Bee health what can farmers and the industry do to help

AGROW
WORLD CROP PROTECTION NEWS

Bee health: What can farmers and the industry do to help?

A third of the plants eaten by human beings benefit to some extent from pollination by bees or other insects.

By Coralie van Breukelen-Groeneveld

Published: 01 December 2015 08:39 AM

A third of the plants eaten by human beings benefit to some extent from pollination by bees or other insects. The estimated value of pollination to agriculture is over €150 billion ($165 billion) a year. At the same time, the health of pollinators, and particularly bees, is claimed to be under severe threat from agricultural practices worldwide. What is the true situation and what can farmers and the crop protection industry do to further improve bee health?

Although pollinators include honey bees, bumble bees, solitary bees and other wild bees, butterflies, wasps, flies, beetles, birds and bats, most scientific research, academic publications and activist rhetoric has tended to focus on honey bees. That is understandable. For many millennia, humans have been emotionally attached to honey bees as the most important source of sweetener and wax, and have valued them economically as pollinators and suppliers of honey. Consequently, concerns about bee health are by no means a modern-day phenomenon.

Bee mortality – past and present

The close relationship between honey bees and human beings goes back at least 7,000 years. Evidence unearthed by archaeologists indicates that bees were kept in human dwellings in Mesopotamia around that time. Columella (4-70 AD), the Roman Empire's most important agricultural author, wrote a practice-oriented treatise on beekeeping in which an average loss of hives of 10-15% per year is described as normal.

The first recorded incident of bee mortality was in Ireland in 950 AD. Historical records throughout the Middle Ages repeatedly refer to large-scale colony losses and by the end of the 17th century, scientists in Europe were beginning to analyse the reasons for repeated incidents of mass bee mortality. The most frequently identified issue was adverse weather conditions, although factors such as pathogens or parasites may also have played a role.

Ever since the earliest recorded shipment of the Western (or European) honey bee (*Apis mellifera*) to the Americas in 1621, bee mortality incidents in North America have been the subject of both observation and scientific research. Colony Collapse Disorder (CCD), for example, first came to light in the US in 2006. In recent years, there have been substantial losses of honey bee colonies in certain regions, particularly in Europe and North America, during or directly after the winter months. These incidents have turned the attention of apian scientists and NGO activists to the emotionally charged issue of bee health.

Pressures on pollinators

There is a huge discrepancy between our knowledge of wild bees and of honey bees, especially in terms of their numbers, distribution and ecology. This is largely because of the economic and emotional significance of honey bees. Yet there are around 30,000 other bee species worldwide, including solitary bees and bumble bees. Some of these species have undoubtedly declined over time, mainly due to changes in land use and a reduction in the habitat they rely on for food or nesting. But the question of whether the situation is still deteriorating is a matter of conjecture as there are few historical records of the abundance and range of many solitary bee species.

One thing, however, is clear. Most pollinating insects face numerous pressures in much of the modern world. The need to produce more food and fodder to feed the growing global population has led to more intensive agriculture, and this has contributed to a reduction in the abundance and diversity of flowers in agricultural areas. The impact of weather, parasites and diseases, a lack of suitable nesting sites, agricultural and apicultural practices, and exposure to wrongly applied environmental chemicals, including pesticides, have also been implicated in poor pollinator health.

Are honey bees in decline?

Overall, the number of managed honey bee colonies has remained either relatively stable or shown positive increases over the past ten years across North America. Meanwhile in Europe, colony numbers have been relatively stable at approximately 15-16 million hives. However, the total number of managed honey bee colonies worldwide increased by some 45% between the 1960s and 2010. In other words, there is no statistical evidence that honey bees are in general decline. But bee health is indeed a complex issue that is affected by many different factors.

Multiple causes of bee mortality

Two acclaimed bee scientists, Dennis van Engelsdorp and Marina Meixner, come down firmly on the side of multi-causality in explaining bee mortality. In their study of managed honey bee populations in Europe and the US published in 2009, they concluded that "*Varroa* mites, together with the virus complex associated with mite parasitism, are likely (to be) one of the major causes for considerable overwintering losses documented by many northern nations over the last several years (...). Modern pesticides with reduced acute toxicity may have sub-lethal effects that are more difficult to quantify. Additional factors, such as reduced bee forage, climate, narrowing of the gene pool, poor queens, and socio-economic factors all have measurable effects on managed honey bee populations."

The deadly Varroa mite

If bee health experts are asked to name the greatest threat to apiculture, the consensus of opinion points to the honeybee mite, *Varroa destructor*. Having appeared in Europe in the 1970s and in North America in the 1980s, the Varroa mite is a relatively new parasite affecting the European honey bee. But since then, it has spread rapidly to the rest of the world, leaving Australia as the only significant land mass where there are currently no mite infestations thanks to high biosafety protocols designed to prevent mites entering the country.

Varroosis, the Varroa-induced disease, affects both adult bees and the brood. Moreover, this parasite also affects bee health by spreading a variety of viruses that result in dead pupae, swollen and shortened abdomens, lack of pigmentation and deformed bees with legs or wings missing. Untreated infestations of Varroa mites can kill entire honey bee colonies.

Since the 1980s, the pesticide industry has been researching effective solutions for treating infested honey bee colonies. Bayer's first product was registered as early as 1986, a second one followed in 1991 and a third in 2001. Currently, Bayer researchers and bee experts from universities in several countries are working on Varroa Gate, a solution to effectively combat the Varroa mite at the entrance to the hive, thus preventing renewed infestation or stopping the mites from spreading from the outset. If registration of the Varroa Gate goes well, the product could be on the market in 2017.

Self-defense brood cannibalism

Asian honey bees are not totally defenseless against this parasite. Their self-defense mechanism involves removing the Varroa parasite from a hive by means of selective brood cannibalism. Worker bees bite off the cover of brood cells, pull out the Varroa-infested pupa and devour it. Bee experts refer to this behavior as Varroa Sensitive Hygiene (VSH). The non-profit Arista Bee Research Foundation is working to strengthen this protective behavior among European honey bee colonies through breeding bees with highly effective VSH habits. Bayer is supporting the Fo*undation's* highly promising work.

Invasive threats to bee health

Unfortunately, the Varroa mite is just one of the invasive species endangering honey bee health. The Asian hornet (*Vespa velutina*) was first reported in western France in 2004 and has since spread across the European mainland. This pest hunts and feeds on other insects, including worker honey bees, and also enters the hive, feeds on the honey and removes the brood. Although Asian honey bees have developed strategies to defend themselves against these hornets, the European honey bees have not. Research into the hornets' behavior, partly funded by Bayer, will be useful in helping develop effective solutions to control this predator.

Natural detoxification by bees

Another self-defense mechanism comes from the honey bee's genome in that it encodes detoxification enzymes to protect itself from insecticides. Bayer and Rothamsted Research are running a bee toxicogenomics project that aims to understand the molecular basis of insecticide selectivity in different bee pollinator species (honey bees, bumble bees and solitary wild bees) using a functional genomics-driven approach. That includes the development of tools to assess insecticide selectivity in biochemical screenings in order to identify chemical scaffolds in insecticides that inherently provide bee safety.

Neonicotinoids in the spotlight

Neonicotinoids are an important class of insecticides of low toxicity to mammals and humans. They help farmers worldwide to manage harmful pests that would otherwise limit crop production and quality. Another advantage of neonicotinoids is their systemic distribution in the plant, which enables them to be applied as seed treatments to protect the entire plant in its early growth stages. Applying the pesticide at seed level radically reduces environmental exposure and does away with the need for multiple spray applications in the early growth stages of the crop. Hence, neonicotinoids have been extensively used to replace older, less environmentally friendly insecticides.

In the past decade, there has been a marked increase in the number of scientific publications dealing with the potential effects of neonicotinoids on bees. Discussions within the scientific community have focused on colony mortality issues, the sub-lethal and acute lethal effects of neonicotinoids, the dust that may be released while sowing neonicotinoid-treated seeds, and residues from neonicotinoid seed treatment products. Although no conclusive scientific evidence was produced that neonicotinoids were a relevant cause of widespread bee mortality, highly emotional yet effective lobbying of the EU bodies by NGOs and environmental activists led the European Commission to restrict the use of three neonicotinoid seed treatment products on bee-attractive crops from December 2013.

The fatal effects of false agricultural policy

What happens when agricultural policy decisions are based not on sound scientific evidence but on activists' arguments has been evident in the past year at oilseed rape (OSR) farms in the UK, Germany and Poland, for example. By autumn 2014, numerous OSR crops in the UK had been decimated by cabbage stem flea beetles (*Psylliodes chrysocephala*), a pest previously controlled most effectively by neonicotinoid seed treatments. Losses were estimated at around 20-50% in what, climatically speaking, should have been a good growing year.

To assuage the farmers' plight, some EU governments gave a number of OSR, maize, and sunflower growers exceptional permission to use neonicotinoid seed treatments on their crops in 2015. Farmers who were not able to benefit from such derogations were left with no option other than to control the pests that would otherwise destroy their crop with multiple spray applications of broad-spectrum insecticides. Even then, nearly 30,000 ha of OSR were lost to insect damage.

The situation in Germany's OSR stronghold, Mecklenburg-West Pomerania, is no better than in the UK. Here, huge beetle-induced OSR losses led to a decline in OSR acreage in 2015. That put additional pressure on bees and other pollinators since nectar- and pollen-rich OSR is one of the most important sources of early-season forage. In south-west Poland, Stanislaw Szpara, an experienced agricultural adviser, spoke of the severe impact on OSR crops: "The ban means our farmers are having to spray several times during the season. This is not only more expensive than buying treated seed, it is also worse for beneficials and the environment."

The EU's "save the bees" restrictions seem to have been counterproductive.

Field studies on neonicotinoid impacts

Much of the scientific evidence that pointed to the intrinsic bee toxicity of neonicotinoids came from model experiments in which levels and conditions of neonicotinoid exposure greatly exceeded real-world exposure. Field trials, in contrast, provide a more realistic test of the true impact on bee colonies of neonicotinoid use. Such trials have to be conducted on a large scale. They require significant resources and crop protection companies such as Bayer have been involved.

One such large-scale study in Ontario, Canada, led by Professor Chris Cutler and Professor Cynthia Scott-Dupree involved ten fields of canola seed treated with clothianidin, one of the three EU-restricted neonicotinoids. The five control fields and five test fields were at least 2 ha in size and at least 10 km apart. No adverse effects were observed on honey bee colonies.

In Mecklenburg-West Pomerania, Bayer commissioned one of the most extensive landscape-level studies ever on clothianidin-treated winter OSR in 2014. The study, parts of which were conducted by scientists from the German Universities of Frankfurt and Cologne, covered 17-18 OSR fields totaling 600-800 ha in each 6,500-ha control and treatment area. Once again, no adverse treatment-related effects were found on honey bees, bumble bees (*Bombus terrestris*) and a solitary bee species (*Osmia rufa*).

Bee health evidence from overseas

Neonicotinoid insecticides are in widespread use in Australia. In February 2014, an overview report on "Neonicotinoids and the Health of Honeybees in Australia" published by the Australian Pesticides and Veterinary Medicines Authority (APVMA) concluded that "… the introduction of neonicotinoids has led to an overall reduction in the risk to the agricultural environment from the application of insecticides … Australian honey bee populations are not in decline despite the increased use of this group of insecticides in agricultural and horticulture since the mid-1990s". Significantly, the Varroa mite is not present in Australia. In New Zealand, a report on bee health published by a Parliamentary Committee in July 2014 said of neonicotinoids: "… although these pesticides are commonly used as a seed dressing (and) as foliar sprays, there is no evidence that these pesticides, when used correctly, are affecting bees' health in New Zealand …"

Industry initiatives to reduce impacts

FITBEE, a Germany-wide collaborative project involving 14 research institutions and companies from a range of affected industries (including Bayer), is working to gain a better understanding of the interactions between bees and their environment.

The Dropleg project, which is part of FITBEE, has developed a new way of spraying crop protection products to further minimize pollinators' exposure to them: hook extensions hanging from the spraying machine enable the product to be applied to the green parts of the plant instead of being sprayed onto the blossoms. Tests have shown that Dropleg significantly reduces residue levels in the pollen and nectar.

To minimize the risk of dust drift when sowing treated seeds, Bayer is proactively promoting stewardship measures, including the innovative SweepAir technology. Here, the exhaust air from a sowing machine, which may contain abraded seed treatment dust, is sucked into a cyclonic device that removes the dust from the air and deposits it in the soil.

These are just a few examples of how industry initiatives are working to better bee health.

Fruitful collaboration and smart apps

Due to the intensification of agriculture, most agricultural land now offers little long-term food or shelter for beneficial insects such as bees. However, a multi-year field experiment on two farms in the Upper Rhine Valley of Germany where 10% of the farmland has been sown with flowering plant strips is demonstrating that these measures can greatly increase pollinator species and insect numbers.

Bayer is also co-operating with farmers in south-west Germany, Brazil, Chile and other South American countries in crop attractiveness studies to discover which insects pollinate which crops and how or when. The Feed a Bee initiative launched in March 2015 by Bayer's North American Bee Care Program called on bee supporters to plant bee-attractive flowers. More than 200,000 individuals responded and the goal of 50 million flowers was reached in just 11 weeks.

Bee Care at Bayer

Bayer's intrinsic interest in bee health and safety is largely based on the important pollination role played by bees and its relevance for agriculture, global food supplies and the honey production industry. As a life science company, Bayer knows full well how commercially significant pollination is for hybrid canola (a variety of oilseed rape that produces edible oil) and vegetable seed breeding. In Canada, Bayer is one of the major users of bee pollination services for its canola seed production operations and Bayer's high-yielding canola hybrid, InVigor, would not be successfully bred without pollination by honey bees.

Bayer has been researching and developing products specifically designed to promote bee health for 30 years. Its dedicated Bee Care Program established in 2011 is proving to be an excellent central platform to promote bee health, support research and corresponding product development, and facilitate discussion and collaboration on bee health topics across all stakeholders. The Program also enables Bayer to combine and better utilize its in-depth expertise and experience in the fields of animal health and crop protection for the benefit of bees' health. The two Bee Care Centers, one in Germany and one in the US, serve as a platform for scientific exchange and communication, inviting discussions and joint projects with external partners. By proactively reaching out to stakeholders, Bayer strives to increase the transparency of its activities and generate open discussions and partnerships.

(Coralie van Breukelen-Groeneveld, Head of Bayer Bee Care Center)

Cropland Policy Mtg
2/9/2016
Al Summers

An Overview of Current Beekeeping Conditions in Colorado – 2015

Respectfully submitted by Al Summers, *Colorado Professional Beekeepers Association*,

Director of Communications

The current state of affairs among the beekeeping community in Colorado appears to be open to interpretation, depending upon which particular demographic of beekeepers is doing the reporting.

The newer (1 to 10 years) and recreationally - oriented beekeepers have been the decided majority for many years in Colorado. Traditional numbers have been around 800 to 1,000 Statewide, however those numbers appear to be increasing as more and more "newbees" try their hands at the craft. In addition, the attrition rate for new beekeepers here has usually been in excess of 50% drop-out rate within 5 years, and appears to be continuing as a trend. New and recreational beekeepers in the State probably represent no more than 20% of the total number of bee hives being kept here.

The other significant beekeeping demographic in the State is the commercial or livelihood based producers, which include the various ancillary industries of honey packers and marketers, bee equipment suppliers, and pollination brokers. This demographic is comprised of much smaller numbers in comparison to the recreationalists. There are estimated to be around 20 to 25 commercial beekeepers in the state with another 20 or so ancillary suppliers. However, the commercial beekeeping sector represents at least 80% of the bee hives owned and managed and produces the majority of honey and pollination services provided in the State. Last year Colorado produced over one-million pounds in wholesale honey returning over two-million dollars to the economy, from an estimated 27,000 commercial bee hives.

Beekeeping in Colorado, as with most aspects of agriculture here, has been an introduced and cultivated practice. European honey bees (Apis *mellifera)* are not native to either the United States nor to Colorado. They were brought to the U.S. in the 17th century by European immigrants and migrated slowly west as sustaining flowering crops were planted by settlers. In Colorado, and the Nebraska territories generally, sustainable beekeeping was not possible until settlers had planted and cultivated enough crops like Sweet Clover (Melilotus spp.) and Lucerne (Alfalfa), which occurred primarily after Colorado became a state in 1876. Subsequent cultivation and fruit production in the 1920's in Colorado further helped to sustain the beekeeping industry.

What many of the newer beekeepers in Colorado, particularly the recreationalists may not appreciate, is that beekeeping here has never been totally self-sustaining but rather has required periodic monitoring and management in order to be successful. And nowadays, with such stressors such as parasitic mites, viruses, changing habitat and environmental factors, good bee management practices are more important than ever.

An additional concern within the Colorado beekeeping community in recent years, primarily among the recreationalists, has been an apparently orchestrated effort to blame insecticide use for the problems that some beekeepers are experiencing. Much of this concern and the politicization of the issue seem to be coming from outside of the beekeeping community – by admittedly anti-pesticide activist groups. The problem for beekeepers in adopting these recommendations however, is that they do not address the practical aspects of what beekeepers need to be doing in order to remain viable and in some cases could well result in the functional demise of commercial beekeeping, which in Colorado accounts for over 80% of the honey and pollination services.

Successful and particularly the *heritage beekeepers* of Colorado have always had to contend with pesticide use but they have usually found ways to not only survive but thrive as members of the larger agricultural community. The current pesticide use landscape in Colorado is considerably safer and more manageable than just 20 years ago. The way that commercial beekeepers have traditionally dealt with pesticide issues (both in the hive and environmentally) is through applying good *Integrated Pest Management* practices. What many of the activists and recreational beekeepers propose, which is to adopt a *precautionary principle* with pesticide use, goes against the previous 138 years of beekeeping tradition in Colorado - applying good risk management practices - and is not only impractical for beekeepers but for the rest of the agricultural and stake holder community as well.

In conclusion, the current state of the beekeeping industry and community in Colorado is as successful and robust as is the level of conscientiousness that beekeepers apply in managing their hives. The examples of Colorado's heritage beekeeping families prove that. Those who do not monitor and intervene when problems arise are almost certainly assured to have problems and eventually dead hives.

Most livelihood-directed beekeepers realize that in order for beekeeping to be successful, we have to see ourselves as cooperating members of the larger agricultural and stake holder communities. Agitating for bans and boycotts of not only pesticides but against the growers and regulatory agencies that are responsible for helping to sustain our industry is not only counterproductive but dysfunctional as well.

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Al Summers

Al Summers

From:	Al Summers <summers@ichibanenterprises.org>
Sent:	Tuesday, February 09, 2016 12:36 PM
To:	Al Summers
Subject:	Emailing: ABJ Extra-News April 7, 2015 - "Beepocalypse" Not Alarmist Honeybee Claims Collapse Under Scrutiny.htm

April 8, 2015

"Beepocalypse" Not: Alarmist Honeybee Claims Collapse Under Scrutiny

by Angela Logomasini

Competitive Enterprise Institute

Executive Summary

Concern about the survival of the European honeybee has blossomed into a media frenzy during the past several years, with activists declaring, "Beepocalypse"! Beekeepers have seen see some of their honeybee hives disappear in recent years, and concerned observers have blamed the losses on everything from cell phones to genetically modified crops. The most frequently alleged culprit, though, is a class of pesticides known as neonicotinoids. But such alarmism is not supported by the facts. This parade of alarming news stories has led the European Union to place a moratorium on neonicotinoids, and U.S. policymakers are considering similar options. Such bans and restrictions will do more harm than good as more toxic chemicals replace neonicotinoids. This paper aims to sort fact from fiction and promote a more balanced understanding that will facilitate rational solutions for helping honeybees. It shows:

Colony Collapse Disorder is not the biggest threat facing honeybees. Lots of people blame hive losses in recent years on the so-called Colony Collapse Disorder (CCD), a phenomenon in which worker bees disappear, leaving behind the queen and honey. But according to a 2010 United Nations study, about 7 percent of hive losses are attributed to CCD, and the remaining 93 percent to other causes. In fact, the more significant problem is not really CCD, but instead compromised hive health, which is affected by a combination of factors, including: diseases and parasites, poor queen bee health, hive transport for pollination services, and nutritional issues. Pesticides are the least among these factors and neonicotinoids the least among those, if they have any impact at all.

CCD is not a new problem that can be easily attributed to modern pesticides. The mysterious disappearance of hives is not a new phenomenon. For example, the U. S. Department of Agriculture's (USDA) Agricultural Research Service, points out similarly curious honeybee disappearances in the 1880s, 1920s, and 1960s.

Honeybees are not even a "natural" part of any ecosystem in the United States. A narrative popular among environmentalists suggests that the problem is mankind's "tampering with nature," but honeybees are not even "native" to the United States. Instead, they are a farmed agricultural commodity, imported from Europe during the 17th century for honey production and crop pollination. Like cattle, they are largely an agricultural commodity that is farmed and managed by human hands, in this case beekeepers.

Honeybees are nowhere near going extinct. In fact, the number of hives has *increased* globally. Globally, far more honeybees are used for honey production than pollination services, and the amount of honey produced has increased. U.S. and European commercial hives have decreased because honey production simply moved to other nations, where the number of hives have grown substantially. According to United Nations Food Agricultural Organization (FAO) statistics, the number of beehives kept globally has grown from nearly 50 million in 1961 to more than 80 million in 2013.

Surveys in 2014 show that honeybee hives have improving survival rates. Hives kept for pollination services in the United States and Europe have shown better survival rates in recent years, much closer to what beekeepers consider normal. This occurred despite continued use of neonicotinoids.

Farming and food production is not about to collapse because of poor pollination. About one third of food production in the United States benefits from honey bee pollination, according to USDA. Poor hive health is unlikely to completely undermine production of these foods, but it could make them more expensive. Fortunately, improved hive survival can mitigate such issues.

There is no consistent correlation between neonicotinoids and hive losses. If neonicotinoids were a cause of significant hive losses, we would expect to see at least some correlation between their use and high hive losses, but no such pattern has been observed since their introduction in the 1990s. In many places where these chemicals are used widely, such as in Australia, CCD is not a problem. And in Europe during 2013-2014, hives survived well in many areas where neonicotinoids were used.

Field studies find no health effects from "sublethal exposures" to neonicotinoids. To date, there are no studies showing that honeybees have suffered ill effects from "field-relevant" neonicotinoid exposures. Only studies that feed the bees unrealistically high levels of the chemicals show adverse effects. Studies of bees in the field where neonicotinoids are used show no measureable effects.

Neonicotinoids do not present the most significant pesticide exposure to honeybees. While activists like to blame neonicotinoids for the disappearance of hibernating bees, little of these chemicals is actually found in the hives. Instead, most of the chemicals found in the hive are put there by beekeepers trying to fight various diseases carried by mites and other organisms. "It's like chemotherapy. They know it's bad, but it's a lot better than the alternative," says bee researcher Dennis vanEngelsdorp.

Alternative chemicals may prove more dangerous than neonicotinoids. The U.S. Agricultural Research Service notes on its website: "The neonicotinoids were developed in the mid-1990s in large part because they showed reduced toxicity to honey bees, compared with previously used organophosphate and carbamate insecticides." If farmers cannot use neonicotinoids, they will use other chemicals that are more toxic to bees.

Regulations will not solve the problem. Regulations are slow to develop, governed by political rather than practical and scientific goals, and hard to modify, even when they become counterproductive. In the case of honeybees, the best solutions will emerge with collaboration among the parties with an interest in protecting bees, including beekeepers, farmers and home gardeners.

Honeybee health issues are far broader than concerns raised by CCD alone and the solutions require a better understanding of the issue. Shortsighted pesticide bans will prove counterproductive, undermining food production and harming both honeybees and native pollinators because replacement products are likely to prove more dangerous. The best solution will strike a balance that recognizes the value of targeted and managed use of agrochemicals while minimizing risks.

Introduction

"Honey bees are disappearing across the country, putting $15 billion worth of fruits, nuts and vegetables at risk," laments the Natural Resources Defense Council.[1] They are joined by a chorus of activist, media and others who fear that mankind's intrusions on nature threaten not only the bees but the livelihood of beekeepers and our food supply. "For them [beekeeepers], catastrophe could be just one harvest away," notes one Minneapolis *Star Tribune* writer.[2] Media headlines have even declared this a crisis worthy of the name "Beepocalypse."[3]

Allegedly, the problem stems largely from our naïve trust in agro-technologies, particularly pesticides. One journalist writing in *Time* magazine claims: "Honeybees are suffering because we've created a world that is increasingly inhospitable to them." Specifically, Greenpeace and myriad others blame a class of pesticides called neonicotinoids, claiming that these chemicals "might just be the prime culprit in the honeybee plague known as Colony Collapse Disorder (CCD)."[4]

Beekeepers do face some significant challenges concerning the health of commercially farmed honeybee hives— but these problems are not primarily driven by Colony Collapse Disorder, a phenomenon in which bees leave the hive and honey behind for no apparent reason. Rather, beekeepers have suffered losses mostly due to other challenges to the health of the honeybee hives, mainly driven by natural forces such as the emergence and spread of diseases and parasites that affect honeybees and the need for a more diverse diet. These are issues that can and will be managed largely by beekeepers themselves along with some collaboration with farmers and even home gardeners. But we won't reach such solutions if we focus on the wrong issues.

The parade of lopsided and alarming news stories on CCD and the so-called Beepocalypse has led the European Union to place a moratorium on neonicotinoids, which has caused serious crop damage without helping honeybees. Policy in the United States has been more measured, but is moving in the wrong direction as well. Should U.S. policymakers turn to bans and restrictions, they will do more harm than good. Restrictions on neonicotinoids will likely harm honeybees as farmers are forced to use more environmental damaging replacement chemicals, and such policies will undermine farmers' ability to provide an affordable food supply to feed a growing world population.

The causes of, and solutions to, these challenges are far more multifaceted and complex than headlines suggest. This paper aims to sort fact from fiction and promote a more balanced under- standing that will facilitate rational public policies. Accordingly, it examines the most common misperceptions and faulty claims related to honeybee health.

Restrictions on neonicotinoids will likely harm honeybees as farmers are forced to use more environmental damaging replacement chemicals.

It shows that CCD is not as significant a problem as the headlines suggest; honeybees are not going extinct; pesticides are not the main challenge to hive health; the food supply is not about to collapse; and proposed pesticide bans will likely do more harm than good to honeybees.

CCD is really not the main challenge facing honeybees.

The Charges: Claims vs. Reality

Claim: Colony Collapse Disorder is the biggest threat to honeybees.

Reality: CCD is a relatively small threat to honeybees compared to other well-known challenges.

"With a third of honeybee colonies disappearing due to 'colony collapse disorder,' it's time to move into high gear to find a solution," claims one recent Mother Jones article on the topic.5 But to find a solution, we need to understand the problem, and CCD is really not the main challenge facing honeybees.

Not all honeybee losses are related to CCD. Honeybees die and disappear for many different reasons. The phrase "colony collapse disorder" refers to losses that occur along a very specific set of circumstances. Researchers attribute hive losses to CCD when most or all adult honeybees disappear from the hive, leaving behind honey, a live queen, and immature bees. According to a 2010 United Nations Environment Program study, about 7 percent of hive losses are attributed to CCD, and the remaining 93 percent to other causes.6

In fact, the real issue is not so much CCD, but instead hive health, which is affected by a number of factors. While each factor alone might not present much of an issue, it is the combination of such stressors that lead to poor hive health and periodic annual declines. Such stressors include diseases and parasites, poor queen bee health and limited generic diversity, hive transport for pollination services, nutritional issues, and a number of different pesticides.

Diseases and Parasites. Of all the factors impacting bee hive health, natural pests and diseases is quite significant. A 2009 study on hive health by Dennis vanEngelsdorp of the University of Maryland and other researchers underscores the significant role that pathogens play in hive health.[7] In January and February 2007, the authors examined 13 apiaries owned by 11 beekeepers with a total of 91 bee colonies.[58] They divided up the apiaries into one of two groups: a control group for those lacking CCD and another for apiaries that experienced CCD. They found that colonies affected by CCD had more pathogens—bacteria, viruses, and parasites—in the hive, and therefore a higher "pathogen load" than did the healthy hives, although no single pathogen or other variable was found to be more prevalent than others.

Some of these pathogens and parasites originate domestically but as beekeeping has become a global industry, different diseases have spread around the world through increased trade. These diseases may contribute to, or cause, some CCD cases. One researcher at the Department of Agriculture's (USDA) Agricultural Research Service (ARS) says the first two of these diseases listed below are recognized as "probable" contributing factors.[9] In any case, the diseases affecting honeybees are many.[10]
A few examples include:

- **Varroa destructor mites.** Accidentally imported into the United States in the late 1980s, the Varroa destructor mite is "the most detrimental honey bee parasite in the world today," according to honeybee researchers.[11] It has already nearly eliminated wild honeybee populations in the United States. These mites feed on honeybees and larvae. That is bad enough, but they also transmit secondary diseases, such as a virus called "deformed wing disease," that can decimate hives if left uncontrolled. These mites have not destroyed commercial beekeeping, but they have increased annual hive losses and raised beekeeping costs. That appears to have reduced the number of small beekeeping operations and increased larger scale commercial beekeeping.[12]

- **Nosema.** Nosema is a disease transmitted by microsporidian parasites that enter honeybees as spores and then develop in the honeybee gut, where they weaken the bee and lead to premature death of adult bees and queens. Bees pass the spores via excrement, which builds up in the hive, particularly during the winter. Symptoms are hard to detect and beehives may recover, but only after many bees are lost.

- **Tracheal mites.** First discovered in 1984 in Texas, these microscopic sized vermin inhabit the trachea of young adult honeybees, where they feed on the bees' blood, affecting the bees' development, ability to fly, and overall health. The mites easily spread from one bee to the next, with many infections occurring during winter hibernation and into the spring. Tracheal mites are controlled with Menthol crystals, which is a registered pesticide with the U.S. Environ- mental Protection Agency.[13]

- **American and European foulbrood.** American foulbrood is a bacterial disease that kills bee larvae in the honeycomb. The larvae first eat the bacteria's spores that have contaminated their food. The spores then develop in the larvae gut, consuming its food, releasing more spores into the hive, and spreading the disease. The disease is hard to control because spores can remain viable up to 40 years and because each attached bee larvae can release up to a million spores. Burning the hive and related equipment, and then starting a new hive with sanitary controls may be the only option in some cases. Antibiotics may help treat infection, but cannot eliminate the spores, and the bacteria are growing resistant. Fortunately, researchers are making headway in finding a cure.[14] European Foulbrood is similar, but not as dangerous, and some hives recover from it.

A United Nations Environment Program report notes: "CCD only accounts for about 7% of losses in the USA, and even less in Europe."

Queen Bee Health. In a healthy hive, queen bees usually lay eggs for about two years, populating the hive with worker bees as well as with the male drones that mate with the queen. But sometimes queen bees fail to produce enough offspring or mysteriously die, undermining hive health. In some cases worker bees will even kill off their own queens early if there is a health problem. Limited genetic diversity among the commercially farmed bees may contribute to poor quality queens, but the causes are not fully understood.[15]

A United Nations Environment Program report highlights the fact that poor quality queens is an even more significant problem. The report notes: "CCD only accounts for about 7% of losses in the USA, and even less in Europe. The loss of queen bees seems to be a much more common cause at about 25%."[16] In the United States, beekeepers reported premature death of queen bees in 32 percent of their hives.[17]

Hive Transport and Pollination Services. Honeybee hives in the United States are farmed at various locations around the nation and then trucked to farms in the spring and summer to pollinate crops, with many hives visiting more than one farm every growing season. Such movements, although necessary, represent yet another stress that affects hive health. A report in *Agricultural Research Magazine* notes: "At the same time [as honey production moved overseas], the call for hives to supply pollination services has continued to climb. This means honey bee colonies are trucked farther and more often than ever before, which also stresses the bees."[18] In addition, the movement of hives aggregates bees and diseases they carry, increasing transmission, as the bees move from one region to the next.[19]

Nutritional issues. Farmed honeybees spend much of their time pollinating a limited number of crops, which means their nutritional sources may be too one dimensional. And many times beekeepers supplement the hive diet with are fed high-fructose corn syrup, which offers limited nutritional value. Bees achieve better health when they can forage among a wider range of pollen and nectar sources. "Although honey bees may store food (in the form of honey and packed pollen) for times of dearth, lack of diverse floral resources is now demonstrated to diminish their immune response," explain researchers in *Environmental Science and Technology*.[20]

Pesticides. Ironically, the pesticides that pose the greatest exposure and risk to honeybees are also necessary to control some of the diseases that would otherwise destroy hives: fungicides and miticides used directly inside the hives. These products pose risks to hive health, but they are necessary for survival. Of all the causes discussed here, agricultural pesticides appear to play one of the smaller roles, yet headlines focus on them. This is in part because they are the subject of regulation in Europe that warrants news coverage. But much of the news coverage derives from misinformed alarmism about these chemicals.

Claim: CCD is a new threat, which indicates it is linked to modern technologies such as pesticides.

Realty: CCD does not appear to be a new phenomenon as there are reported cases of similar disappearances of colonies going back decades even before we employed modern pesticides.

The mysterious disappearance of hives is not a completely new phenomenon. University of Florida entomologist Jamie Ellis explains:

In fact, many colonies have died over the past 50-60 years displaying symptoms similar to those of CCD. The disorder as described in older literature has been called spring dwindle disease, fall dwindle disease, autumn collapse, May disease, and disappearing disease. We may never know if these historic occurrences share a common cause with modern-day CCD. They do, however, share the symptoms.[21]

The Agricultural Research Service, points out similarly curious honeybee disappearances in the 1880s, 1920s, and 1960s. On its website, ARS notes several cases, including the disappearance of 2,000 colonies in Cache Valley in Utah during 1903, "after a 'hard winter and a cold spring,'" as well as a the disappearance of 53 percent of the hives in Pennsylvania following the winter of 1995-1996.[22] We cannot be sure these disappearances happened for the same reason they do today, but they are reason to doubt that this is a new problem caused by modern pesticides.

Ironically, the pesticides that pose the greatest exposure and risk to honeybees are also necessary to control some of the diseases that would otherwise destroy hives.

Claim: Mankind's tampering with nature threatens the survival of the honeybee and the "balance of nature."

Reality: Honeybees in the United States are not natural; they are a non-native farmed species imported to provide honey production and pollination services.

A narrative popular among environmentalists suggests that the problem is mankind's "tampering with nature," which can only be solved by reducing our "footprint" on the planet by using fewer agro-technologies and less intensive farming. "Humanity is the perpetrator" of CCD, says Greenpeace activist Rex Weyler, and the "two most prominent causes appear to be pesticides and habitat loss."[23]

In fact, honeybees are not even a "natural" part of the ecosystem in the United States. They were imported from Europe during the 17th century for honey production and crop pollination, although some colonies now live in the wild. Like cattle, they are an agricultural commodity that is farmed and managed by human hands, in this case beekeepers. And it has been this way for a long time. Bee expert Eva Crane explained in 1975, ''Like the dog, the honeybee had accompanied man on most of his major migrations, and some of the early settlers in each part of the New World took hives of bees with them."[24] Thus, this debate is not about protection of a wild species we have somehow "disrupted," but about the management of a domesticated commodity.

Today, Americans continue to employ the European honeybee or honey production and pollination. Much honey is now produced overseas, while U.S. beekeepers farm the bees, which they rent out to farmers during spring and summer for pollination services. Beekeepers around the nation transport some 60 percent of all U.S. hives to pollinate California's almond farms in spring, and then move them throughout the spring into the summer to pollinate yet more crops around the nation.[25]

It is not surprising that honeybees in the Western Hemisphere generally do not survive as well as they do in Europe, where they have a longer history and greater genetic variability that makes them more resistant to disease.[26] In fact, in their recent survey on honeybee health, European researchers note annual honeybee losses due to natural factors are considered "acceptable" at a rate of 10 percent, while U.S. bee- keepers report higher acceptable loss rates ranging from 15 to just more than 21 percent.[27] Even annual losses of nearly 20 percent in the United States are considered acceptable according to a recent survey conducted by the Bee Informed research initiative, a collaborative effort of several universities and research labs led by the U.S. Department of Agriculture and National Institute of Food and Agriculture.[28]

Honeybees are not even a "natural" part of the ecosystem in the United States. They were imported from Europe during the 17th century.

Accordingly, beekeepers must replace a number of colonies every year, which they replenish by splitting hives or purchasing new bees and queens.[29] This involves obvious increased costs and possible downtime while new hives get established. Nevertheless, large annual losses are far from unusual.

Claim: Honeybee populations are declining and creating a crisis situation for farmers who need their pollination services.

Reality: Globally, the number of hives have increased although their locations have shifted.

The news about honeybee populations can be very confusing. Some point out that there are more honeybee hives today than there were several decades ago, while others claim the opposite. The Hoover institution's Dr. Henry Miller points out in *The Wall Street Journal* that U.N. Food and Agriculture Organization (FAO) data show that "honeybee populations are not declining."[30] In fact, FAO data show that the number of bee hives kept globally has grown from nearly 50 million in 1961 to more than 80 million in 2013.[31] Jennifer Sass of the Natural Resources Defense Council responds in a letter to the editor: "The number of managed honeybee colonies in the U.S. has dropped from four million hives in 1970 to 2.5 million today, according to White House statistics."[32]

Both of these claims may be technically correct, but Miller's data is more relevant, while Sass's data shows only part of the picture. Miller points to the "global" commercial honeybee hive count, which has grown considerably. Sass points to domestic colony numbers only, which have in fact declined for economic, not environmental reasons. Miller points out that U.S. and European hive numbers are relatively stable, and the Canadian numbers have actually increased. Miller is certainly correct to point out that honeybees are not about to disappear from the face of the Earth.

Honeybees are not about to disappear from the face of the Earth.

The FAO data Miller cites were analyzed by biologists Marcelo A. Aizen of Universidad Nacional del Comahue in Argentina and Lawrence D. Harder of the University of Calgary in a 2009 *Current Biology* journal article. They explain that economic rather than ecological forces have determined where and how many hives are commercially kept.[33]

Globally, far more honeybees are used for honey production than pollination services, and the amount of honey produced has increased with world population growth. U.S. and European commercial hives have decreased because honey production simply moved to other nations, where the number of hives have grown substantially. Aizen and Harder explain:

The FAO data also clarify that national or even regional declines in the health and/or size of the managed honey-bee population cannot substantiate claims of a global pollinator decline or an attendant pollination crisis. ... Until relevant data become available and clear patterns emerge, any claim of a global pollinator decline and associated pollination crisis must be considered as a matter of debate, rather than as fact. This conclusion does not detract from real biological problems in the honey-bee populations of some countries; however, it emphasizes that solutions to those problems must be motivated locally, rather than globally, and must acknowledge the dominant influence of economics in the pollination represented by every spoonful of honey.[34]

As a farmed commodity, the number of colonies and their locations will ebb and flow with the market.

In the final analysis, we see that whether there were more or less commercial bee colonies in 1960 than there are today in one nation or region is not clearly a matter for concern. As a farmed commodity, the number of colonies and their locations will ebb and flow with the market. Annual losses represent an important concern and economic challenge for beekeepers in the regions where they occur, but they should not be confused with the global supply of honeybees.

Claim: Regional losses of honeybees in Europe and the United States continue unabated.

Reality: Surveys in 2014 showed improved survival rates, which may indicate that better hive management is reducing losses.

"Honeybees have been disappearing at an alarming rate since 2005 … if the bees die, the human race will not be far behind," laments a 2015 article in the online news site Inquisitr.[35] In reality, hives kept for pollination services in the United States and Europe have shown better survival rates in recent years, much closer to what beekeepers consider normal. This reality indicates that the high losses in recent years, do not necessarily represent an inevitable long-term trend.

In the United States, a survey on honeybee health conducted by Bee Informed shows that bees did much better during the winter of 2013-2014 than in prior years.[36] The annual losses reported after the winter of 2013-2014 came to 23.2 percent, while the past eight year average was 29.6 percent, with a high loss rate of 36 percent in 2007-2008, and a low of 21.9 percent in 2011-2012. While challenges remain, efforts to improve hive health may have made the difference and provide a roadmap for future efforts.

No one can point to a single reason for improved hive survival, but as Dennis vanEngelsdorp explains, improved beekeeping practices may be limiting the impact of the Varroa mite. "What is clear from all of our efforts is that Varroa is a persistent and often unexpected problem," he said. "Even beekeepers who do treat for mites often don't treat frequently enough or at the right time. If all beekeepers were to aggressively control mites, we would have many fewer losses."[37]

CCD has not proven as much of a problem in Canada, but there are some isolated problems there as well. In 2014, beekeepers reported unusually high losses in Toronto, which experienced losses of 58 percent. But excluding Toronto, which appears to be a very unusual outlier, Canadian beekeepers report that winter mortality was just 19.2 percent that year. The report notes: "It is notable that the winter losses has been reduced by 25 per cent, going from as high as 35% from 2007-2008 down to on average 20 percent since 2009/10."[38]

Similarly, a 2014 European Union study indicates that honeybees are doing better in Europe than it originally appeared.[39] The study covered 80 percent of all honeybee hives in Europe. According to the survey, member states that suffered hive losses of 10 percent or less housed 47 percent of the hives in this study. European states that experienced between 10 to 15 percent losses were home to 27 percent of the hives. In other words, nations that were home to nearly 75 percent of the hives experienced losses below 15 percent, which is a reasonably good honeybee hive survival rate for a large portion of the hives in Europe. In fact, the highest losses (those above 20 percent) occurred in nations that housed just 5 percent of the hives.[40] "It's the first major study of pests and diseases that affect honeybees. A lot of it seems very encouraging," said Tom Breeze, Research Fellow in the School of Agriculture, Policy and Development at the University of Reading in the United Kingdom.[41]

Another study conducted by an international group called COLOSS (Prevention of Honey Bee Colony Losses), collected and analyzed survey data from beekeepers in 19 European nations as well as Israel and Algeria. With more than 17,000 respondents managing more than 375,000 hives, this comprehensive study reported some very good preliminary results:

A preliminary analysis of the data show that the mortality rate over the 2013 – 14 winter varied between countries, ranging from 6% in Norway to 14 % in Portugal, and there were also marked regional differences within most countries. The overall proportion of colonies lost was 9%, the lowest since the international working group started collecting data in 2007.[42]

2014 European Union study indicates that honeybees are doing better in Europe than it originally appeared.

Another study by the British Beekeepers Association (BBKA) showed great improvements in the United Kingdom during the winter of 2013-3014, with a total loss reported of 9.6 percent.[43] Although BBKA representatives still consider a 9.6 loss too high, this level is far lower than the peak loss of 33 percent in 2012-2013. Prior years have shown losses ranging from a high of 30 percent in 2007-2008. In other years, the losses were much lower with a high of nearly 19 percent in 2008-2009 and a low of less than 14 percent in 2010-2011. The BBKA identifies the Varroa mite and limited foraging plants available to bees as major challenges in the UK, which it is addressing through education on hive management and via a National Pollinator Program that encourages planting of valuable flowers for honeybee foraging.

Challenges remain and no one knows for sure what next year or the following will bring in terms of hive losses. But with any luck, continued effort and research on causes and improvements to hive management will improve hive survival.

With any luck, continued effort and research on causes and improvements to hive management will improve hive survival.

Claim: Honeybee losses are largely an environmental issue that threatens our food supply.

Reality: Honeybee losses are largely a manageable economic issue and the farming industry is not about to collapse.

A 2013 *Huffington Post* headline exclaimed: "Honey Bees Are Dying Putting America at Risk of a Food Disaster."[44] And the Natural Resources Defense Council claims: "Honey bees are disappearing across the country, putting $15 billion worth of fruits, nuts and vegetables at risk."[45] Another article maintains that 70 percent of our food supply is pollinated by honeybees.[46] These claims are all flat wrong. While they make great headlines, they create a misleading impression that periodic honeybee losses seriously threatens our food supply.

It is true that hive health issues are of concern because farmers rely on honeybees for the production of many fruits, nuts, and vegetables. About one third of food production in the United States benefits from honeybee pollination, according to USDA.[47] California almond growers depend on honeybees exclusively to pollinate crops, requiring 60 percent of the commercial honeybee hives in the country to produce 80 percent of the world's supply of almonds. Almonds constitute California's highest-valued agricultural export, according to agricultural economist Hoy Carman of the University of California-Davis.[48]

While poor hive health is unlikely to completely undermine production of these foods, it could make them more expensive. In fact, according Carman, fees for pollinating almonds have increased substantially.

Average fees increased from $35.41 in 1995 to $53.67 [per hive rented] in 2004. The fees then increased to $72.58 in 2005 *when CCD first became evident, and shot up $45.31 to $136.98 between 2005 and 2006. Almond pollination fees continued to increase and peaked at an average of $157.03 in 2009.*[49]

A recent survey by the California State Beekeepers' Association reports that the fees have remained high: $151.26 for 2011, $154.74 for 2012, and $154.03 for 2013.[50] ARS researchers explain that continual losses at the 33 percent level would be costly for beekeepers. But they note further: "Honey bees would not disappear entirely, but the cost of honey bee pollination services would rise, and those increased costs would ultimately be passed on to consumers through higher food costs."[51]

High annual losses represent an expensive challenge for beekeepers and potentially consumers, but even then, we should not expect a catastrophe. Professor Jamie Ellis of the Institute of Food and Agricultural Sciences at the University of Florida notes:

Yet, no one believes that honey bees will disappear altogether, even with the concerns over CCD. Instead, the average American may experience increased food prices and decreased food availability if honey bees continue to die at the current rate. The almond industry illustrates this point well.[52]

Not all food depends on honeybees, and essential grains, particularly corn, rice and wheat, constitute the largest part of our diets and these are pollinated by the wind. Researchers from the University of Minnesota and U.S. Geological Survey, writing in *Environmental Science and Technology*, point out: "Thus the prospect of human starvation in the absence of bees is remote, but crop declines in the most nutritious—and arguably, most interesting—parts of our diet like fruit, vegetables, and alfalfa hay for meat and dairy production, are possible."[53]

Other researchers have raised concerns that the amount of honeybee-dependent crops has increased globally and exceeds the number of honeybees produced for pollination. They concluded that one of two things must be happening: Either the current number of hives is sufficient for pollination or wild pollinators are providing an important contribution. In the latter case, they suggest that policy makers consider the impact of land use policies to ensure that wild pollinators continue to have sufficient nutrition and nesting habitat. Intensification of "monoculture" may reduce the habitat diversity these wild pollinators require. For example, government subsidies and policies that promote planting of corn for ethanol trigger land use changes that reduce diversity of crops around the nation.[54]

If neonicotinoids were a cause of CCD, we would expect to see at least some correlation between their use and CCD, but no such pattern has been observed.

Claim: Outbreaks of CCD since the introduction of neonicotinoids indicate that these pesticides are a key cause of CCD.

Reality: There is no consistent correlation between neonicotinoids and hive losses related to CCD or other causes.

Environmentalists and many government officials have singled out crop protection chemicals called neonicotinoids as the potential cause of CCD. For example, Greenpeace claims that "neonicotinoids might just be the prime culprit in the honeybee plague known as Colony Collapse Disorder (CCD)" based largely on a single, flawed Harvard University study.[55] As a result of such claims, the European Union has even placed a temporary ban on the use of these chemicals based on largely speculative science about their possible link to CCD. But the data do not support such definitive claims or actions.

Neonicotinoids are a class of pesticide products that enhance a plant's ability to fight off pests. Specific chemicals include acetamiprid, clothianidin, dinotefuran, imidacloprid, and thiamethoxam. They are "systemic" treatments because they become part of the plant, making it unattractive to pests that chew on the plants. Neonicotinoids may be sprayed on the plants, applied on the ground near the plant's roots, or applied to seeds. But the overwhelming majority of uses are applications in which seeds are treated with the pesticide before planting, a practice that avoids broad environmental exposure.

Systemic pesticides have the benefit of limited environmental impact because little enters into the environment, especially when seeds are treated. However, minuscule amounts of the chemicals may appear in the pollen and nectar of these plants, and the question then is whether these levels have an impact on honeybees and other non-target insects.

If neonicotinoids were a cause of CCD, we would expect to see at least some correlation between their use and CCD, but no such pattern has been observed since their introduction in the 1990s. France banned Imidacloprid in 1999 and, along with Germany, banned clothianidin in 2008, yet those bans did not prevent the emergence of CCD in both of those nations.[56]

In Europe during 2013-2014, hives survived well in many areas where neonicotinoids were used. See the map for this distribution of losses from the recent EU survey on hive survival.[57] Ironically, Greek beekeepers complained in 2013 that the chemicals were wreaking havoc, yet Greece actually had a lower than acceptable hive loss that year.[58] This situation underscores the fact that some beekeepers and environmental activists are jumping the gun, blaming neonicotinoids for colony collapse disorder even in regions and years where evidence of a problem is not at all clear.

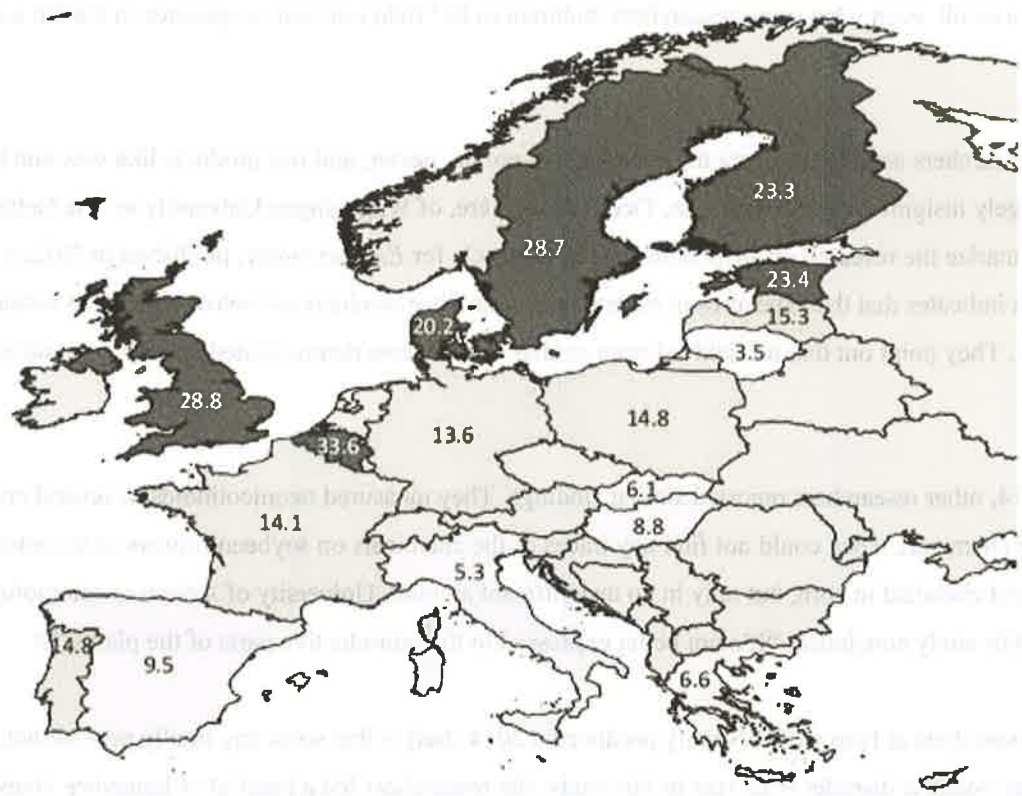
Conversely, in many places where these chemicals are used widely, such as in Australia, CCD is not a problem.[59] A 2014 Australian government report states: "Australian honeybee populations are not in decline, despite the increased use of this group of insecticides in agriculture and horticulture since the mid-1990s."[60] Similarly, in Canada, one beekeeper explains:

[T]here are colonies in Ontario and Quebec that are exposed to neonics on both corn and soy, with zero problems. And look at Western Canada. On the Prairies, 70 percent of Canada's colonies forage canola without issue. We are even exposed to corn and soy, and except for four beekeepers in Manitoba in 2013, there have been no issues there either.[61]

Claim: Studies demonstrate that "sublethal" levels of neonicotinoid pesticides impact hive health.

Reality: Studies of honey bee exposures to chemicals in real-life settings have not found any such effects, and studies that find effects at unrealistically high exposure levels are not particularly relevant.

Some environmentalists suggest that relatively low exposures that do not immediately kill the bees (sub-lethal exposures) make them too weak to survive other stresses. The Pesticide Action Network in the United Kingdom, for example, maintains: "Sub-lethal effects on individual bees can build up to colony-level harm, especially if exposure continues for several weeks."[62]



Source: Marie-Pierre Chauzat et al, "A pan-European epidemiological study on honeybee colony losses2012-2013," European Union Reference Laboratory for Honeybee Health, http://ec.europa.eu/food/animals/live_animals/bees/docs/bee-report_en.pdf.

Over-reliance on studies that feed or otherwise dose bees with chemicals in a lab and then measure hive losses after the bees are allowed to forage in the field creates a misleading impression about the risks.

However, much of the research to date has not proven particularly relevant to real-life exposure to chemicals in the field. In fact, the Pesticide Action Network plays down the fact that field-relevant studies show no such effects, and that real-world scenarios tell us more about how these chemicals actually impact wildlife. Several studies, notes Kim Kaplan of the USDA's Agricultural Research Service, "relied on large, unrealistic doses and gave bees no other choice for pollen, and therefore did not reflect risk to honey bees under real world conditions. Nor have the studies demonstrated a direct connection or correlation to CCD."[63]

Over-reliance on studies that feed or otherwise dose bees with chemicals in a lab and then measure hive losses after the bees are allowed to forage in the field creates a misleading impression about the risks for many reasons. First, they ignore the fact that regular feeding or dosing of bees every day for a period of time is completely different than intermittent exposures from pollen in the field. As a result, even what some researchers maintain to be "field relevant" exposures in the lab are not relevant real-life exposures.

In fact, when researchers actually measure the chemicals in pollen, nectar, and bee products like wax and honey, the levels reported are largely insignificant. For example, Tjeerd Blacquière, of Wageningen University in The Netherlands, and his colleagues summarize the research on such exposures in an article for *Ecotoxicology*, published in 2012.[64] They explain that the current research indicates that the exposures in pollen, nectar, and bee products are below levels that would pose acute or chronic toxicity. They point out that no field-relevant studies to date have demonstrated any adverse sublethal effects from neonicotinoids.

In February 2014, other researchers reported similar findings. They measured neonicotinoids in several crops grown from seeds treated with the chemicals. They could not find any traces of the chemicals on soybean flowers or in cotton nectar. They found one neonicotinoid chemical in corn, but only in an insignificant amount. University of Arkansas entomologist Gus Lorenz, who participated in this study concluded, "It's not being expressed in the reproductive parts of the plants."[65]

Nonetheless, researchers at Harvard University produced a 2014 study[66] that some say finally proved that neonicotinoids are to blame for colony collapse disorder (CCD).[67] In this study, the researchers fed a handful of honeybee hives a diet of high fructose corn syrup containing pesticides and then waited to see how many would survive winter compared to control groups fed the syrup without pesticides. When the bees fed the neonicotinoids suffered more losses than did the control groups, the authors concluded: "[T]he findings in this study reinforce the conclusion that sub-lethal exposure to neonicotinoids is likely the main culprit for the occurrence of CCD."[68]

The Harvard researchers maintained that the exposure levels they used in their study were similar to those that honeybees experience in the field and that the neonicotinoid-treated bees suffered losses that resembled CCD. But both claims were not compelling to other researchers who reviewed the study.

A statement released by Bayer Crop-Science maintained that the bees were fed a diet of neonicotinoids for 13 weeks that exposed them to a pesticide level 10 times higher than what bees encounter in real-life scenarios, a practice Bayer described as "unrealistic" and "deceptive."[69] Activists and others dismiss Bayer's analysis because of the company's financial interest in the issue, but they have not been able to dispute the data. In fact, Dennis vanEngelsdorp basically agreed with Bayer CropScience's position. He remarked to the press that the study was of limited value because all it shows is that "high doses of 'neonics' kill bees—which is not surprising."

Entomologist Joe Ballenger, in an analysis of the Harvard study on the blog Biofortified, explains that the exposure in this study was likely five times what bees would experience in the field and 33 times higher than what is typically found in the hives of honeybee colonies. "Bottom line," says Ballenger, the study "appears to have overdosed the colonies compared to what they are encountering in the real world."[70]

Ballenger points to another problem: The honeybee losses the Harvard study describes do not constitute CCD. While some honeybees abandoned the hive, there were lots of dead bees present and some hives lost queens as well as their brood. This does not resemble CCD, which involves *disappearance* of nearly all worker bees with few dead bees present, with live queens and brood left behind.

A couple of other studies, led by USDA entomologist Jeff Pettis, raised concerns about neonicotinoids similar to those in the Harvard study, but these too have important limitations that have been largely overlooked by the press. In one study, Pettis et al dosed young worker bees with neonicotinoids as they emerged from the hive for the first time. These bees had very little time to develop immunity and died in large numbers. Pettis concluded that the pesticides appear to have weakened the bees and made them more susceptible to the Nosema parasites. While that may be true for this lab experiment, it appears to have little relevance to real-world scenarios.

In an article reviewing this and other research on neonicotinoids, the authors explain:

Honeybees harbor a characteristic bacterial complex in the gut that plays an important role in nutrient processing, degradation of toxic compounds, and defending against pathogens. ...The establishment of a normal microbiota requires contact with the colony and food exchange with older nest mates. The isolation of newly emerged workers in cages for testing may lead to increased susceptibility to pesticides and pathogens because of an impoverished gut microbiota. Differences in physiology, stress levels, and the bacterial complex of the gut may explain why the standard practice of collecting newly emerged workers from brood frames placed in incubators for use in laboratory pesticide tests may lead to misleading and/or inaccurate results."[71]

In another study Pettis et al., found that honeybees exposed to the same neonicotinoid, Imidacloprid, had a *lower* number of Nosema spores present in the hive than the honeybees without such exposure.[72] Rather than acknowledge that this study conflicts with earlier findings, the authors downplay the disparity noting: "Specific results vary, and may depend on the pesticide or dose used." More appropriately, in their review of this literature, Fairbrother et al., point out: "The studies by Pettis et al. illustrate the difficulty in extrapolating laboratory effects to field conditions when investigating susceptibility to gut pathogens."[73]

In yet another study, researchers dosed bumblebees in the lab with neonicotinoids and inserted tiny devices that allowed researchers to track the bees' behavior after the insects were set free to forage.[74] Not surprisingly, these lab exposures were relatively high and led to disoriented bees, affecting their ability to forage and find their way back to the hive. The authors called their dosing "field realistic," but the doses were still done in a lab and those feeding conditions and type of diet—sugar water rather than a diverse diet in the field—can also affect results.[75]

Such studies may well show that at some level and given limited diets, pesticides can place additional stresses on bees. But these studies do not show that pesticide risks cannot be managed and kept low enough to have insignificant impact on hive survival, which is the goal. Several other studies that dosed bees with "environmentally relevant" levels of neonicotinoids found no adverse effects.[76]

Perhaps most importantly, studies of bees in the field where neonicotinoids are used show no measureable effects. For example, one study conducted by researchers in the United Kingdom's Department for Environment, Food and Rural Affairs found no difference between bumble bees that visited areas treated with neonicotinoids and control bees. It reported:

This study was not a formal statistical test of the hypothesis that neonicotinoid insecticides reduce the health of bumble bee colonies. Nevertheless, were neonicotinoids in pollen and nectar from treated oilseed rape to be a major source of field mortality and morbidity to bumblebee colonies, we would have expected to find a greater contribution of insecticide residues from nearby treated crops and for there to have been a clear relationship between observed neonicotinoid levels and measures of colony success. The absence of these effects is reassuring but not definitive. The study underlines the importance of taking care in extrapolating laboratory toxicology studies to the field, as well as the great need of further studies under natural conditions.[77]

More recently, a study that relies on data from actual field conditions confirms that farmers can protect their crops using these chemicals without harming honeybee hives.[78] The study, published in the online journal *PeerJ*, assessed the impact of neonicotinoid-treated canola crops on hives that foraged among these crops in 2012 in Ontario Canada. The researchers found no adverse impacts and very low exposure to the chemicals. The authors report:

Overall, colonies were vigorous during and after the exposure period, and we found no effects of exposure to clothianidin seed-treated canola on any endpoint measures. Bees foraged heavily on the test fields during peak bloom and residue analysis indicated that honey bees were exposed to low levels (0.5–2 ppb) of clothianidin in pollen. Low levels of clothianidin were detected in a few pollen samples collected toward the end of the bloom from control hives, illustrating the difficulty of conducting a perfectly controlled field study with free-ranging honey bees in agricultural landscapes. Overwintering success did not differ significantly between treatment and control hives, and was similar to overwintering colony loss rates reported for the winter of 2012–2013 for beekeepers in Ontario and Canada. Our results suggest that exposure to canola grown from seed treated with clothianidin poses low risk to honey bees.[79]

Studies of bees in the field where neonicotinoids are used show no measureable effects.

No one can completely dismiss the fact that agrochemicals can have an impact at some level to honeybees and non-target insects. The key is finding a level where risk is low-to-negligible in real-life settings, to allow beneficial uses of products necessary to grow food. That way we can have both effective pollination and agricultural productivity.

Claim: Neonicotinoids present the most significant pesticide exposure to honeybees.

Fact: Bees are exposed to much higher levels of other pesticides, including those that beekeepers use inside the hive to control mites and other disease-carrying vectors.

Worker honeybees are born in the early spring and pollinate crops for several weeks before they die. During their lifetime, they bring nectar and pollen to the hive to feed subsequent generations including the smaller number of bees that hibernate over the winter. Those wintering bees may be exposed to pesticides in the hive from pollen and nectar, which raises concerns about how those chemicals impact the hive's health. While activists like to blame neonicotinoids for the disappearance of some the hibernating bees, little of these chemicals is actually found in the hives. Rather, trace levels of many different chemicals appear in hives that may have some impact on hive health—to what extent is not fully clear.

While activists like to blame neonicotinoids for the disappearance of some the hibernating bees, little of these chemicals is actually found in the hives.

For example, a 2010 study measured pesticide residues in 887 wax and pollen samples as well as bees themselves.[80] It found traces of 121 different pesticides and metabolites of pesticides in the samples, of which neonicotinoids were among the lowest present. No neonicotinoid residues were found in bees, while 49 detections were obtained from pollen and wax. Only one sample contained a notable amount of one neonicotinoid, Thaicloprid, but it only appeared in 3 percent of samples with the low average amount of 2.1 parts per billion. Compared to the other chemicals, the traces of neonicotinoids were largely insignificant. For example, the chemical Fluvalinate appeared in 98 percent of the bees wax samples with an average concentration of 7,472 parts per billion. It also appeared in 88 percent of pollen samples at levels of 40 parts per billion and in 83 percent of bees at 1 ppb. The chemical Coumaphos appeared at levels nearly as high.

The high levels for Fluvalinate and Coumaphos are to be expected, given that beekeepers apply these products directly to the hive to control mites, which pose even greater risks to the bees than do the traces of chemicals. Still, there is some evidence that these two chemicals have adverse effects on queen bees, with obvious implications for overall hive health.[81]

While beekeepers may often blame agricultural pesticides for annual hive losses, biologist and beekeeping blogger Randy Oliver calls on his colleagues to acknowledge "the elephant in the room" because they themselves use pesticides. "The plain truth is," notes Oliver, "a colony of bees does not differentiate between agricultural pesticides, and beekeeper-applied miticides. What actually affects the colony is the cumulative load of all toxins that the colony is exposed to, whether from smokestack pollution, dust drifted over from China, pesticides sprayed by farmers, or miticides applied by beekeepers with the best intentions."[82]

"I think we have known for a long time that miticides can adversely affect queens and kill drone sperm," says vanEngelsdorp, who was one of the first to identify colony collapse disorder. However, he does not blame beekeepers for using them. "It's like chemotherapy. They know it's bad, but it's a lot better than the alternative."[83]

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"I think we have known for a long time that miticides can adversely affect queens and kill drone sperm," says vanEngelsdorp, who was one of the first to identify colony collapse disorder. However, he does not blame Neonicotinoid exposure is far lower than that of those products used in the hive. There are periodically incidents where bees die in large numbers because mistakes made during application of chemicals, such as bee kills when chemicals are applied to the soil and sprayed. These isolated incidents are unlikely to be part of a trend related to substantial hive losses or CCD, and they can be reduced with careful management, such as proper timing of applications. Indeed, just as we do not ban airplanes or cars because of accidents, we need not ban chemicals that have valuable uses because a limited number of accidents. Fortunately, as highlighted in a recent study on such issues in Canada, these incidents are relatively few.[84]

Accordingly, chemicals need to be used strategically and carefully for both farming and pest control in hives. In both cases, the products yield important benefits in disease reduction and food production, which is why risk management rather than product elimination offers the best course of action.

Isolated incidents are unlikely to be part of a trend related to substantial hive losses or CCD.

Claim: Banning neonicotinoids and using other products to be on the "safe side" will help honeybees.

Reality: Bans will promote the use of alternative chemicals that may prove more dangerous than neonicotinoids.

It is a given that farmers will look for products to protect their crops from damaging pests, so the only question is what products best meet their needs while keeping risks to non-target species low. Despite much misleading and negative publicity, neonicotinoids strike a very good balance and have reduced risks associated with the pesticides they replaced.

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strike a very good balance and have reduced risks associated with the pesticides they replaced.

The U.S. Agricultural Research Service notes on its website:

The neonicotinoids were developed in the mid-1990s in large part because they showed reduced toxicity to honey bees, compared with previously used organophosphate and carbamate insecticides.[85]

Similarly, in its review of the issue, the Australian government concluded:

On the basis of information available to it, the APVMA [the Australian Pesticide and Veterinary Medicines Authority] is currently of the view that the introduction of the neonicotinoids has led to an overall reduction in the risks to the agricultural environment from the application of insecticides.[86]

One of the key benefits of neonicotinoids is that, although they can be applied as a spray, much of their uses involve seed applications. This approach greatly reduces environmental exposures to non-target species, as the insecticide is absorbed into the plant and mostly affects those pests that would bore into or chew on the plant.

A recent group of studies, produced by the agricultural consultancy AgInfomatics for several agrochemical companies, interviewed farmers to estimate impacts of potential bans on neonicotinoids. According to one of these studies, seed applications represent about 98 percent of neonicotinoid uses for corn, soybean, wheat, cotton, and sorghum crops.[87] These neonicotinoid applications are necessary to control 17 groups of pests affecting these crops. Based on the farmer interviews, the study estimates that about 77 percent would find alternative chemicals, which would lead to greater environmental damage. Specifically, it reports that if farmers cannot use neonicotinoids, they will:

- Turn to other insecticides and increase the number of acres where they apply such chemicals by 185 percent.
- Replace the 4 million pounds of neonicotinoids they use for these crops now with 19 million pounds of non-neonicotinoids chemicals, a 116 percent increase of chemical use on a per-pound basis.
- Increase chemical applications to soil and direct foliar spraying of plants, increasing the relatively small current level of neonicotinoid spray applications of 4.5 million acres to spraying of 25 million acres of crops using replacement products.

The authors conclude:

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.*88

Another AgInfomatics case study involved interviews with Florida citrus growers to address how neonicotinoids benefit these farms and their surrounding communities.89 Citrus growers' very survival depends on having effective treatments for serious pests. In particular, they are plagued by a small insect called the Asian Citrus Psylid, which feeds on fruit trees and transmits a bacterial disease called Huanglongbing (HLB). If allowed to get out of control, HLB will undermine fruit productivity and eventually destroy citrus trees within a few years.

Such impacts are greatly minimized by the use of a number of pesticide products, key among them neonicotinoids. These are applied in liquid form at the roots of young trees as they mature, helping to produce trees that are more disease-resistant. The growers interviewed for the AgInfomatics study indicated that if they lose the ability to protect their crops using neonicotinoids, they may continue to harvest what they have until the trees are exhausted and then shut down their operations, ultimately leading to the Florida citrus industry's demise.

It is simply too difficult to survive without such valuable pest control technologies like neonicotinoids. "Losing viable citrus production in Florida would have a ripple effect on jobs in harvesting, processing and packing plants; transportation; and multiple agricultural services, including equipment sales and consulting," explain the researchers in this study.

Citrus growers' very survival depends on having effective treatments for serious pests.

"The further decline or loss of Florida citrus would have dramatic effects on communities throughout the citrus regions of Florida and would increase reliance on imported juice from other countries."90

In Europe, where neonicotinoids were banned starting in the 2014 planting season, farmers are already seeing serious crop damage and increased use of other chemicals that are likely more dangerous for bees. Rebecca Randall of the Genetic Literacy Project reports that damage to oilseed rape (canola) in England has increased because of a rise in beetle populations, whose larvae destroy plants by chewing on them.91 The British government eventually allowed emergency spraying of neonicotinoids, but much damage is done and the emergency use is temporary.

In 2014, farmers in the UK reported losses of 20 to 50 percent of their crops and the government and in Germany some farmers have completely pulled up their crops and replaced them.92 The only controls that farmers have left are potentially more damaging to honeybees than neonicotinoids. Randall reports:

[C]anola farmers are spraying almost twice as much alternative chemicals from the class of pyrethroids, said Manuela Specht from the German oilseed trade group UFOP in Berlin. Last fall, UK farmer Peter Kendall said he sprayed his crop with

pyrethroids three times last year before giving up, replanting and spraying again. This increased spraying with harsher chemicals may harm the honeybees, which the neonics ban intended to protect in the first place. A 2014 study by researchers at the University of London found that exposure to pyrethroids can reduce bee size. "There is a strong feeling among farmers that we are worse off and the environment is worse off," said Kendall.[93]

Wouldn't it be wonderful if we could waive a magic regulatory wand and solve the world's problems?

This situation illustrates the importance of considering the complete consequences of public policies. In this case, a shortsighted ban intended to protect the bees and their ability to pollinate crops will likely harm both honeybees and agricultural productivity in general.

Claim: We need regulations to address honeybee survival challenges.

Reality: Technological development, improved hive management, and private collaboration offer the best solutions.

Wouldn't it be wonderful if we could waive a magic regulatory wand and solve the world's problems? New regulations are often sold that way. Yet regulations are often slow to develop, governed by political rather than practical and scientific goals, and hard to repeal, improve, or modify, even when they become counterproductive. Indeed, while environmental activists may press for regulations, the resulting rules may serve other interest groups— including industry and agricultural interests—with whom the activists are not ideologically aligned.

In the case of honeybees, the best solutions will emerge with collaboration among the parties with an interest in protecting bees—beekeepers, farmers, conservationists, entomologists and other researchers, consumers, and even chemical companies. A balanced, proactive approach that recognizes both the need for food production and wildlife conservation will leverage current knowledge and technological advancements to address ongoing problems.

Ultimately, the survival of honeybees will result from careful hive management in the commercial bee industry. That means beekeepers need to continue to research and follow the best available science in beekeeping husbandry, just as farmers who care for cattle and other animals do. And they can work with other parties to achieve those ends.

Such improved hive management is already ongoing and progress is evident. For example, as noted, during 2013-2014 hive losses were lower and at manageable levels after several years of relatively high losses. What explains the improvement? Beekeeper and policy scholar Todd Myers of the Washington Policy Center explains: "Such a significant decline in winter mortality indicates beekeepers are effectively changing their management techniques in response to losing hives. It also shows how hyperbole about honeybees is harming thoughtful discussion about the causes of CCD."[94]

Dennis vanEngelsdorp noted that losses could have been much lower if beekeepers better managed Varroa mites, which present a major challenge to honeybee health. And pesticides—which beekeepers use in hive to fight mites and other insects that harm honeybees—are part of the solution. A press statement on the study explains:

Every beekeeper needs to have an aggressive Varroa management plan in place. Without one, they should not be surprised if they suffer large losses every other year or so. Unfortunately, many small-scale beekeepers are not treating and are losing many colonies. Even beekeepers who do treat for mites often don't treat frequently enough or at the right time. If all beekeepers were to aggressively control mites, we would have many fewer losses.[95]

In the case of honeybees, the best solutions will emerge with collaboration among the parties with an interest in protecting bees— beekeepers, farmers, conservationists, entomologists and other researchers, consumers, and even chemical companies.

In addition to providing a better understanding about hive survival, recent studies on hive health provide insights on some of the solutions. For example, studies have found that some bees have a propensity to basically isolate and essentially quarantine diseases and contaminants that enter hives, such as mites. This "hygienic behavior" is a genetic trait.[96] Therefore, beekeepers can breed larger numbers of these hygienic bees into hives to reduce risks and produce healthier, stronger hives.

Farmers and chemical companies are also part of the solution. They can work with beekeepers to ensure the careful and strategic use of neonicotinoids and other chemical products necessary to control pests. For example, Florida citrus growers have negotiated a deal with beekeepers to continue neonicotinoid use but are employing measures to limit impact on bees, such as timing the spraying so that beekeepers can temporarily relocate nearby hives to prevent exposure.[97]

Homeowners and anyone with a piece of land or flower box can contribute by planting certain wild flowers that are of particular value to bees and other wildlife.

Other assistance can come from environmental groups that can help promote private conservation efforts to improve and diversify the food available to honeybees. Simply planting wildflowers near farms and even in residential settings will not only help honeybees, it will help other pollinators and nectar-feeding creatures, such as hummingbirds. Creating such habitat in and around farms that otherwise plant single species of crops can be particularly helpful in providing a diverse diet for both honeybees and native bees that also play a role in pollination. In addition, homeowners and anyone with a piece of land or flower box can contribute by planting certain wild flowers that are of particular value to bees and other wildlife. Such activities may play an important role in helping not only wild honey bee populations but also native bees, which may play a larger role in pollination than originally believed.[98]

Collaboration on habitat cultivation and research efforts are already being promoted by public, non-profit and industry players. To that end, there is the Bee Informed Partnership between federal agencies and academic researchers, Operation Pollinator to advance pollinator habitat organized by Syngenta,[99] the Bayer Bee Care Program[100] to support research, and the nonprofit group the Keystone Center has established the Honeybee Health Coalition[101] to bring together farmers, chemical companies, nonprofits, beekeepers, and other stakeholders. But more importantly are the many local collaborative efforts between beekeepers, farmers, and communities.

Conclusion

Honeybee health issues are far broader than concerns raised by CCD alone and the solutions require a more comprehensive understanding of issues affecting honeybees. A primary concern related to honeybee health is their value in promoting agricultural productivity. Shortsighted pesticide bans allegedly designed to help the situation are likely to prove counter-productive since these products are necessary to control pests that threaten our food supply. Such bans may also harm commercially farmed honeybees as well as wildlife, including native pollinators, because replacement products are likely to prove more dangerous.

The best solutions will strike a balance that recognizes the value of targeted and managed use of agrochemicals and minimizes any impact on commercially farmed honeybees and wildlife. Such policies can only be pursued when we dispense with misinformed alarmism and focus on science-based solutions and productive collaboration.

NOTES

1 "Vanishing Bees," Natural Resources Defense Council, undated, http://www.nrdc.org/wildlife/animals/bees.asp.

2 Josephine Marcottym, "Nature's Dying Migrant Worker," Minneapolis Star Tribune, September 6, 2014, http://www.startribune.com/local/264929101.html.

3 Kathryn Jackson Fallon, "The Harsh Economic Sting of the Beepocalypse," Fiscal Times, August 16, 2013, http://www.thefiscaltimes.com/Articles/2013/08/16/The-Harsh-Economic-Sting-of-the-Beepocalypse.

4 Jason Schwartz, "Bees: Study Points to Key Cause of Colony Collapse, Disorder," Greenpeace blog, May 23, 2014, http://greenpeaceblogs.org/2014/05/23/bees-study-points-key-cause-colony-collapse-disorder.

5 Amanda Kimble-Evans, "Colony Collapse Disorder: Are Potent Pesticides Killing Honeybees?" Mother Jones, October/November 2009, http://www.motherearthnews.com/nature-and-environment/colony-collapse-disorder-zmaz09onzraw.aspx#axzz3Q9fKwT9T.

6 Global Honey Bee Colony Disorders and other Threats to Insect Pollinators, United Nations Environment Programme, 2010, p. 4, http://www.unep.org/dewa/Portals/67/pdf/Global_Bee_Colony_Disorder_and_Threats_insect_pollinators.pdf.

7 Dennis vanEngelsdorp, Jay D. Evans, et al, "Colony Collapse Disorder: A Descriptive Study," PLoS ONE, Vol. 4, No. 8, March 6, 2009, http://www.plosone.org/article/info:doi/10.1371/journal.pone.0006481.

8 For a helpful summary of the study see Kim Kaplan, "Pathogen Loads Higher in Bee Colonies Suffering from Colony Collapse Disorder," Agricultural Research Service, U.S. Department of Agriculture, August 12, 2009, http://www.ars.usda.gov/is/pr/2009/090812.htm.

9 J. Kim Kaplan, "Colony Collapse Disorder: An Incomplete Puzzle", Agricultural Research Magazine, July 2012, Vol. 60, No. 6, http://www.ars.usda.gov/is/AR/archive/jul12/July2012.pdf.

10 Hachiro Shimanuki and David A. Knox, Diagnosis of Honey Bee Diseases United States, Department of Agriculture Agricultural Research Service, Agriculture Handbook, No. 690, undated, http://www.ars.usda.gov/is/np/honeybeediseases/honeybeediseases.pdf.

11 As cited by Dennis vanEngelsdorp, Marina Doris Meixner, et al in "A Historical Review of Managed Honey Bee Populations in Europe and the United States and the Factors that May Affect Them," Journal of Invertebrate Pathology, Vol. 103, suppl. (January 2010), pp. S80–

S95.

12 Ibid.

13 "The Honey Bee Tracheal Mite," Insect Information Series, Department of Entomology, Soils, and Plant Sciences, Clemson Cooperative Extension, undated fact sheet, http://www.clemson.edu/extension/beekeepers/factsheets/honey_bee_tracheal_mite.html.

14 "Discovery Aims to Fight Destructive Bee Disease," News Release, University of Guelph, December 16, 2014, https://www.uoguelph.ca/cpa/wp/2014/12/discovery-aims-to-fight-destructive-bee-disease.

15 Matt Shipman, "Researchers Find Genetic Diversity Key to Survival of Honey Bee Colonies," NC State News, June 17, 2013, https://news.ncsu.edu/2013/06/wms-tarpy-diversity2013.

16 Global Honey Bee Colony Disorders and other Threats to Insect Pollinators, p. 4.

17 Francie Diep, "Royal Pains: Why Queen Honeybees Are Living Shorter, Less Productive Lives Plus, Why Colony Collapse Disorder is Not that Big a Deal Anymore," Scientific American, September 16, 2012, http://www.scientificamerican.com/article/royal-pains-why-queen-honeybees-are-living-shorter-less-productive-lives.

18 "Colony Collapse Disorder: A Complex Buzz," Agricultural Research Service, May/June 2008, http://www.ars.usda.gov/is/AR/archive/may08/colony0508.htm.

19 Anne Fairbrother, John Purdy, Troy Anderson, and Richard Fell, "Risks of Neonicotinoid Insecticides to Honeybees," Environmental Toxicology and Chemistry, Vol. 33, No. 4 (April, 2014), pp. 719-731.

20 Marla Spivak, Eric Mader, and Mace Vaughan, and Ned H. Euliss, Jr. "The Plight of the Bees," Environmental Science and Technology, Vol. 45, No. 1 (2011), pp. 34–38, http://pubs.acs.org/doi/full/10.1021/es101468w.

21 Jamie Ellis, "Colony Collapse Disorder (CCD) in Honey Bees," IFAS Extension, University of Florida, revised September 2013, http://edis.ifas.ufl.edu/pdffiles/IN/IN72000.pdf.

22 Agricultural Research Service, "Honey Bee Health and Colony Collapse Disorder."

23 Rex Weyler, "Worldwide Honey Bee Collapse: A Lesson in Ecology," EcoWatch, June 11, 2013, http://ecowatch.com/2013/06/11/worldwide-honey-bee-collapse-a-lesson-in-ecology.

24 vanEngelsdorp and Meixner, "A Historical Review of Managed Honey Bee Populations."

25 Agricultural Research Service, "Honey Bees and Colony Collapse Disorder."

26 vanEngelsdorp and Meixner, "A Historical Review of Managed Honey Bee Populations," p. 588.

27 Pierre Chauzat et al., A Pan-European Epidemiological Study on Honey Bee Colony Losses 2012-2013, European Union Reference Laboratory for Honeybee Health, April 2014, http://ec.europa.eu/food/animals/live_animals/bees/docs/bee-report_en.pdf.

28 Dennis vanEngelsdorp,et al., "Preliminary Results: Honey Bee Colony Losses in the United States, 2013-2014," May 6, 2014, http://beeinformed.org/2014/05/colony-loss-2013-2014.

29 For an excellent analysis of how market forces facilitate hive replacement, see Randal Rucker and Walter Thurman, "Colony Collapse Disorder: The Market Response to Bee Disease," Property and Environment Research Center (Bozeman MT: 2012), http://perc.org/sites/default/files/ps50.pdf.

30 Henry I. Miller, "Why the Buzz About a Bee-pocalypse Is a Honey Trap," Wall Street Journal, July 22, 2014, http://online.wsj.com/articles/henry-i-miller-why-the-buzz-about-a-bee-pocalypse-is-a-honey-trap-1406071612.

31 Food and Agriculture Organization of The United Nations, Statistics Division, FAOSTAT Database, accessed online on March 24, 2015, http://faostat3.fao.org.

32 Jennifer Sass, "No Fable of the Bees Here; The Critters Are in Trouble" (letter to editor), Wall Street Journal, August 6, 2014, http://online.wsj.com/news/articles/SB200014240527023036365604580065412952517120.

33 Marcelo A. Aizen and Lawrence D. Harder, "The Global Stock of Domesticated Honey Bees Is Growing Slower than Agricultural Demand for Pollination," Current Biology, Vol. 19 (June 9, 2009): pp. 1-4, http://www.cell.com/current-biology/abstract/S0960-9822%2809%2900982-8.

34 Ibid. They also note that global data is insufficient to gauge the ecological well-being of wild pollinators, but that, although worthy of consideration, is a separate issue.

35 "Honeybees: Population Declines Continue, Is the American Food Supply in Jeopardy?" Inquisitr, January 3, 2015, http://www.inquisitr.com/1724473/honeybees-population-declines-continue-is-the-american-food-supply-in-jeopardy.

36 Kim, Kaplan, "Survey Reports Fewer Winter Honey Bee Losses," press release, U.S. Department of Agriculture, May 15, 2014, http://www.ars.usda.gov/is/pr/2014/140515.htm; Kim Kaplan, "Fact Sheet: Survey of Bee Losses During Winter of 2012/2013," May 12, 2014, http://www.ars.usda.gov/is/br/beelosses; and Winter Loss Survey 2012 – 2013: Preliminary Results, Bee Informed, May 2nd, 2013, http://beeinformed.org/results/winter-loss-survey-2012-2013-2.

37 Kim Kaplan, "Survey Reports Fewer Winter Honey Bee Losses."

38 Canadian Association of Professional Apiculturists, "CAPA Statement on Honey Bee Wintering Losses in Canada (2014)," July 2014, http://www.capabees.com/content/uploads/2013/07/2014-CAPA-Statement-on-Honey-Bee-Wintering-Losses-in-Canada.pdf.

39 Chauzat.

40 Ibid.

41 Barbara Lewis, "EU Study Finds Honey Bees Death Rates are Lower than Feared," Reuters, April 07, 2014, http://www.reuters.com/article/2014/04/07/eu-bees-idUKL6N0MZ4P920140407?irpc=932.

42 "Losses of honey bee colonies over the 2013/14 winter, Preliminary Results from an International Study," news release, COLOSS, Bern Switzerland, July 18, 2014, http://www.coloss.org/announcements/coloss-press-release-colony-losses-july-14.

43 "Honey Bee Colony Winter Survival Rate Greatly Improves: The 2013/14 Winter Was Kinder to Bees but Losses at 10 Percent Were still Double what they Should Be," news release, British Beekeepers Association, June 18, 2014, http://www.bbka.org.uk/files/pressreleases/bbka_winter_survival_release_18_june_2014_1403026705.pdf.

44 Todd Woody, "Honey Bees Are Dying Putting America At Risk Of A Food Disaster," Huffington Post, May 6, 2013, http://www.huffingtonpost.com/2013/05/06/honey-bees-dying-food-disaster_n_3225599.html.

45 "Vanishing Bees," Natural Resources Defense Council, undated, http://www.nrdc.org/wildlife/animals/bees.asp.

46 Inquisitr.

47 Agricultural Research Service, "Honey Bees and Colony Collapse Disorder."

48 Hoy Carman, "The Estimated Impact of Bee Colony Collapse Disorder on Almond Pollination Fees," Agricultural and Resource Economics Update. Vol. 14, No. 5 (June 2011): pp. 9-11, http://giannini.ucop.edu/media/are-update/files/articles/V14N5_4.pdf.

49 Ibid.

50 "CSBA 2013 Pollination survey Results," California State Beekeepers Association, undated, http://www.californiastatebeekeepers.com/resources/2013-Pollination-Survey%20.pdf.

51 Agricultural Research Service, "Honey Bees and Colony Collapse Disorder."

52 Ellis.

53 Marla Spivak, Eric Mader, and Mace Vaughan, and Ned H. Euliss, Jr. "The Plight of the Bees," Environmental Science and Technology, Vol. 45, No. 1 (2011), pp. 34–38, http://pubs.acs.org/doi/abs/10.1021/es101468w.

54 Jonathan Foley, "It's Time to Rethink America's Corn System," Scientific American, March 5, 2013, http://www.scientificamerican.com/article/time-to-rethink-corn.

55 Schwartz. The Harvard study is discussed in a subsequent section of this paper.

56 Kaplan, "Colony Collapse Disorder: An Incomplete Puzzle."

57 Chauzat.

58 Anastasia Balezdrova, "The government does not support the Greek beekeepers in the fight against harmful pesticides," GR Reporter, April 30 2013, http://www.grreporter.info/en/government_does_not_support_greek_beekeepers_fight_against_harmful_pesticides/9259.

59 Overview Report: Neonicotinoids and the Health of Honey Bees in Australia (Kingston: Australian Government/ Australian Pesticides and Veterinary Medicines Authority, February 2104,), p. 2, http://archive.apvma.gov.au/news_media/docs/neonicotinoids_overview_report_february_2014.pdf.

60 Ibid.

61 Lee Townsend, "Canada's Bees are Thriving: Public Needs Facts, not Fear," Guelph Mercury, March 19, 2014, http://www.guelphmercury.com/opinion-story/4417531-canada-s-bees-are-thriving-public-needs-facts-not-fear.

62 Pesticide Action Network UK, "Sub-Lethal and Chronic Effects of Neonicotinoids on Bees and Other Pollinators," Bee Declines and Pesticides Factsheet 2, 2012, http://bees.pan-uk.org/assets/downloads/Bee_factsheet2.pdf.

63 Agricultural Research Service, "Honey Bees and Colony Collapse Disorder."

64 Tjeerd Blacquière et al., "Neonicotinoids in Bees: a Review on Concentrations, Side-Effects and Risk Assessment," Ecotoxicology, Vol. 21, No. 4, (May 2012): pp. 973–992, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3338325.

65 "Neonicotinoids Barely Found in Pollen of Seed-treated Plants," Entomology Today, February 6, 2014, http://entomologytoday.org/2014/02/06/neonicotinoids-barely-found-in-pollen-of-seed-treated-plants.

66 Lu Chensheng, Kenneth M. Warchol, and Richard A. Callahan, "Sub-lethal Exposure to Neonicotinoids Impaired Honey Bees Winterization before Proceeding to Colony Collapse Disorder," Bulletin of Insectology, Vol. 67, No. 1 (2014): pp. 125-130, http://www.bulletinofinsectology.org/pdfarticles/vol67-2014-125-130lu.pdf.

67 James Maynard, "Honeybee Killer Neonicotinoids Caused Colony Collapse Disorder, Harvard Study Says," Tech Times, May 11, 2014, http://www.techtimes.com/articles/6843/20140511/honeybee-killer-neonicotinoids-caused-colony-collapse-disorder-harvard-study.htm.

68 Chensheng, Warchol and Callahan, p. 127.

69 "Study on Neonicotinoids and Honey Bees," Bayer CropScience, United States, Press Release, May 12, 2014, https://www.bayercropscience.us/news/press-releases/2014/05122014-bee-care-harvard-statement.

70 Joe Ballenger, "Are Neonicotinoids the Sole Factor Responsible for Colony Collapse Disorder?," Biology Fortified, June 5 2014, http://www.biofortified.org/2014/06/are-neonicotinoids-the-sole-factor-responsible-for-colony-collapse-disorder.

71 Anne Fairbrother, John Purdy, Troy Anderson, and Richard Fell, "Risks of Neonicotinoid Insecticides to Honeybees," Environmental Toxicology and Chemistry, Vol. 33, No. 4 (April, 2014), pp. 719-731, http://onlinelibrary.wiley.com/doi/10.1002/etc.2527/abstract.

72 Jeffery S. Pettis et al., "Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen Nosema ceranae," PLoS ONE, Vol. 8, No. 7 (July 2013): p. 7, http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0070182.

73 Fairbrother, Purdy, Anderson, and Fell, "Risks of Neonicotinoid Insecticides to Honeybees," p. 725.

74 Hannah Feltham, Kirsty Park, and Dave Goulson, "Field Realistic Doses of Pesticide Imidacloprid Reduce Bumblebee Pollen Foraging Efficiency," Ecotoxicology, Vol. 23, No. 13, April 2014, http://link.springer.com/article/10.1007%2Fs10646-014-1189-7.

75 Sara LaJeunesse, "Diet Affects Pesticide Resistance in Honey Bees," Penn State News, November 3, 2014, http://news.psu.edu/story/332959/2014/11/03/research/diet-affects-pesticide-resistance-honey-bees.

76 See G. Christopher Cutler And Cynthia D. Scott-Dupree, "Exposure to Clothianidin Seed-Treated Canola Has No Long-Term Impact on Honey Bees," Journal of Economic Entomology, Vol. 100, No. 3 (June 2007), pp. 765-772, https://dspace.lib.uoguelph.ca/xmlui/bitstream/handle/10214/2621/32546.pdf?sequence=1; J.P. Faucon et al., "Experimental Study on the Toxicity of Imidacloprid Given in Syrup to Honey Bee (*Apis mellifera*) Colonies," Pest Management Science, Vol. 61 (2005): pp. 111–125; as noted by Blacquière et al., in "Neonicotinoids in Bees: A Review on Concentrations, Side-Effects and Risk Assessment.".

77 "Effects of Neonicotinoid Seed Treatments on Bumble Bee Colonies Under Field Conditions," Food and Environment Research Agency, UK Department for Environment, Food and Rural Affairs, March 2013, http://fera.co.uk/ccss/documents/defraBumbleBeeReportPS2371V4a.pdf.

78 G. Christopher Cutler et al., "A Large-Scale Field Study Examining Effects of Exposure to Clothianidin Seed-Treated Canola on Honey Bee Colony Health, Development, and Overwintering Success" PeerJ, October 30, 2014, https://peerj.com/articles/652.

79 Ibid.

80 Christopher A. Mullin et al., "High Levels of Miticides and Agrochemicals in North American Apiaries: Implications for Honey Bee Health," PLoS ONE, Vol. 5, No. 3 (March 19, 2010), http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0009754.

81 T. Haarmann et al., "Effects of Fluvalinate and Coumaphos on Queen Honey Bees (Hymenoptera: Apidae) in Two Commercial Queen Rearing Operations, Journal of Economic Entomology, Vol. 95, No.1 (Feburary 2002): pp. 28-35.

82 Randy Oliver, "The Learning Curve—Part 2: Killing Mites without Killing Your Bees," undated, http://scientificbeekeeping.com/the-learning-curve-part-2-killing-mites-without-killing-your-bees.

83 Francie Diep, "Royal Pains: Why Queen Honeybees Are Living Shorter, Less Productive Lives," Scientific American, September 16, 2013, http://www.scientificamerican.com/article/royal-pains-why-queen-honeybees-are-living-shorter-less-productive-lives/.

84 G. Christopher Cutler, Cynthia D. Scott-Dupree, and David M. Drexler, "Honey Bees, Neonicotinoids, and Bee Incident Reports: the Canadian Situation," Pest Management Science, Vol. 70, No. 5 (May 2014): pp. 779–783, http://onlinelibrary.wiley.com/doi/10.1002/ps.3613/abstract.

85 U.S. Agricultural Research Service, Honey Bees and Colony Collapse Disorder.

86 Overview Report: Neonicotinoids and the Health of Honey Bees in Australia, p. 2.

87 AgInfomatics, "The Value of Neonicotinoids in North American Agriculture: AgInfomatics Estimated Impact of Neonicotinoid Insecticides on Pest Management Practices and Costs for U.S. Corn, Soybean, Wheat, Cotton and Sorghum Farmers," 2014, http://growingmatters.org/wp-content/themes/growingmatters/pdf/FINAL_AgInfomatics_EstimatedImpact_2014.pdf

88 Ibid.

89 AgInfomatics, "The Value of Neonicotinoids in North American Agriculture: A Case Study of Neonicotinoid Use in Florida Citrus," 2014, https://docs.google.com/viewer?url=http://growingmatters.org/wp-content/themes/growingmatters/pdf/FINAL_AgInfomatics_CaseCitrus_2014.pdf&chrome=true

90 Ibid.

91 Rebecca Randall, "Pests Invade Europe After Neonicotinoids Ban, With no Benefit to Bee Health," Genetic Literacy Project, January 27, 2015, http://geneticliteracyproject.org/2015/01/27/pests-invade-europe-after-neonicotinoids-ban-with-no-benefit-to-bee-health.

92 Forrest Laws, "Ill-Advised Pesticide Ban Costing European Farmers up to Half their Crops," Farm Press Blog, October 17, 2014, http://deltafarmpress.com/blog/ill-advised-pesticide-ban-costing-european-farmers-half-their-crops.

93 Randall, "Pests Invade Europe after Neonicotinoids Ban, with no Benefit to Bee Health."

94 Todd Myers, "Nationwide Survey Shows Dramatic Improvement in Honeybee Health" Washington Policy Center Blog, May 16, 2014, http://www.washingtonpolicy.org/blog/post/nationwide-survey-shows-dramatic-improvement-honeybee-health.

95 Kaplan, "Survey Reports Fewer Winter Honey Bee Losses."

96 Hasan M Al Toufailia et al., "Towards integrated control of varroa: Effect of variation in hygienic behaviour among Honey Bee Colonies on Mite Population Increase and Deformed Wing Virus Incidence," Journal of Apicultural Research, Vol. 53, No. 5 (December 2014): International Bee Research Association, pp. 555-562, http://www.ibra.org.uk/articles/Hygienic-behaviour-against-varroa-mites-and-virus.

97 John Buchanan, "Beekeeper Initiative Sets National Example," Highlands Today: An Edition of the Tampa Tribune, September 17, 2014, http://highlandstoday.com/hi/local-news/beekeeper-initiative-sets-national-example-20140917/.

98 Lucas A. Garibaldi et al., "Wild Pollinators Enhance Fruit Set of Crops Regardless of Honey Bee Abundance," Science, Vol. 339, No. 6127 (March 29, 2013): pp. 1608-1611, http://www.sciencemag.org/content/339/6127/1608.

99 See: Operation Pollinator website, http://www.operationpollinator.com.

100 See: Bayer Bee Care website, http://beecare.bayer.com/bayer-bee-care/partnerships-and-projects.

101 See: Honey Bee Health Coalition website, http://honeybeehealthcoalition.org.

About the Author

Angela Logomasini is a Senior Fellow at the Competitive Enterprise Institute, where she conducts research and analysis on environmental regulatory issues and manages the consumer education website, SafeChemicalPolicy.org. She is co-editor of the CEI book, The Environmental Source. Her articles have been published in the Wall Street Journal, New York Post, Washington Times, and other papers. Logomasini also makes regular media appearances. She has appeared on dozens of radio shows, including NPR's "The Diane Rehm Show," CNN Radio, and Radio America. Television appearances include Fox Business's "STOSSEL," ABC's "Nightline," C-SPAN, CNN, and more.

She served as Legislative Assistant to Senator Sam Brownback (R-Kan.) from 1996-1998, advising the senator on energy and environmental issues. Before that, she was Environmental Editor for the Research Institute of America. From 1989 to 1994, Angela worked for Citizens for a Sound Economy (CSE), serving as Director of Solid Waste Policy for a CSE affiliate, Citizens for the Environment, and as a policy analyst covering various economic issues.

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Alternative Arrangements for Transitioning to Organic Crops

Current situation: About 15,000 acres in crop share leases; about 2000 acres of corn each year in four-year rotation; remaining acres in alfalfa, grains, sugar beets, beans, and sunflowers. About 10,000 acres in cash rent and 500 acres vegetables. Corn and sugar beets are biggest money-makers for POS. Cash rent is about 25% of total revenues.

1. Current Crop Share Lease Method: POS pays 100% of seed costs, and ½ of fertilizer & pesticides.
   POS gets ½ of gross receipts after harvest.

2. Cash rent: fixed rent payment. (Current is about $28/ac.; may be for pasture) Avg. rent for Iowa corn is about $150 per acre for 2001-2010.

3. Risk sharing alternatives for corn:
   a. Direct compensation: payment to transitioning farmers for revenue loss compared to current base revenue for transition three years.

   b. Flexible lease agreements: reduced base rental rate with a percent of gross revenues paid to POS.

   c. Crop insurance subsidized by POS: farmer's transition crop is insured for 70% of county average at convention crop harvest price. After transition, the farmer's yield history is used for compensation (70%) and a harvest price for organic corn of $10 is guaranteed.

Below, we illustrate these alternatives.

Note that Direct Compensation can be used for three years followed by flexible lease arrangements and/or crop insurance. Alternative to crop share agreements for input purchase can be provided by a low cost loans repaid after harvest. Crop insurance may be subsidized only for transition period or there may be premium-sharing afterwards.

The advantage of crop insurance is that it provides for multiple perils (hail, drought, etc.) . Also. Insurance agents are trained in making actuarial judgements to avoid moral hazard.

2010 Situation for Corn based on POS Information, per acre basis
Basic Data for Chemical Farming Production from POS chart:
$622 total revenue (twice the indicated Gross $/A)
103 bu/ ac ($622 total revenue/$6 harvest price)
$222 cost of seed, fertilizer, pesticides (twice the indicated Gross – Net per acre)

a. Base Case Per acre: Current Cost Share Situation with Conventional Harvest Price $6/ bu

Farmer	BCPOS
$622 total revenue	
-$111 ½ cost of chem.&seed	-$111 ½ cost of chem. &seed
-$311 ½ rev. share to BCPOS	$311 ½ rev. share for land
$200 net return/ac to labor&mgmt.	$200 net rev./ ac

b. After transition: organic farmer with fixed land rent of $200, price premium of $10, & 20% yield reduction: 80 bu/ac; cost of seed & fert. $111 is half of conventional.

(i) Harvest Price of $10/ bushel (organic premium)

Farmer	BCPOS
$800 revenue	$200 rev./ ac
-$111 seed and fert.	
-$200 land rent	
$489 return to labor/mgmt.	

(ii) Price of $6 per bushel

Farmer	BCPOS
$480 revenue	$200 rev./ ac
-$111 seed and fert.	
-$200 land rent	
$169 return to labor/mgmt	

Note that organic farmer is better off with the price premium than in the base case; however farmer is worse off if the price premium is not received. BCPOS has same revenue.

Farmer Alternative Transition Policies

a. Direct Compensation to Base Situation, with fixed rent of $200

(i) Price $10/ bu. After transition
Farmer makes $489, more than base case $200 return to labor/mgmt., so no compensation needed. BCPOs makes $200/ ac as before.

(ii) Price $6/ bu (before transitional three years is over)
Farmer makes less than $200 base, so a compensation of $31 per acre makes farmer no worse off than in base case.

Farmer	BCPOS
$480	
-$111 seed&fert.	
-$200 fixed rent	$200 rent
$31 direct compensation	-$31
$200 return to labor/mgmt.	$169 net rev./ ac

For BCPOS, there is a reduction in revenues for each of transitional three years ($62,000 in total for 2000 acres, .5% of current POS gen. fund revenues of $12 million).

b. Flexible Leasing: Farmer pays $150 plus 30% of total revenue over $622 (base case revenue)

(i) Price $10/bu after transition

Farmer	BCPOS
$800	$150 base rent
-$111 seed&fert.	$53 revenue share
-$150 base rent	
-$53 (= 30% x ($800 - $622))	
$486 return to labor/mgmt	$203 total revenue/ac

(ii) Price $6/bu during transition

Farmer	BCPOS
$480	
-$111 seed&fert	$150 base rent
-$150 base rent	
$219 return to labor/mgmt	$150 base rent/ ac.

Note: Farmer is better off compared to base case with flexible leasing regardless of price situation. County is worse off with a low price ($100,000 revenue loss) for three years and about the same as base with the high price after transition.

c. In transition to organic, crop Insurance uses a harvest price of $6/ bu (conventional) and a guarantee of 70% of county avg. conv. yield of 135 bu = 94.5 bu/ac. Assume farmer has 80 bu/ac during transition. Compensation is based on (94.6-80) x $6 = $87.
After three years of transition to organic, farmer's own yield history and price of $10 are used; assume yield increases to 90 bu/ac after transition. However, payment is made if yield falls below 63 bu/ac due to hail, insects, etc. County may pay the premium of $65/ac. in all years, with a premium cost of $130,000 per year regardless of harvest price. Or, county may pay for insurance only for transition period.

(i) Harvest Price $6 for three year transition period

<u>Farmer</u>	<u>BCPOS</u>
$480 revenue	
-$111 seed&fert.	
-$200 base rent	$200
<u>$87 insurance payment</u>	<u>-$65</u>
$256 ret. to labor/mgmt	$135 net rev./ ac.

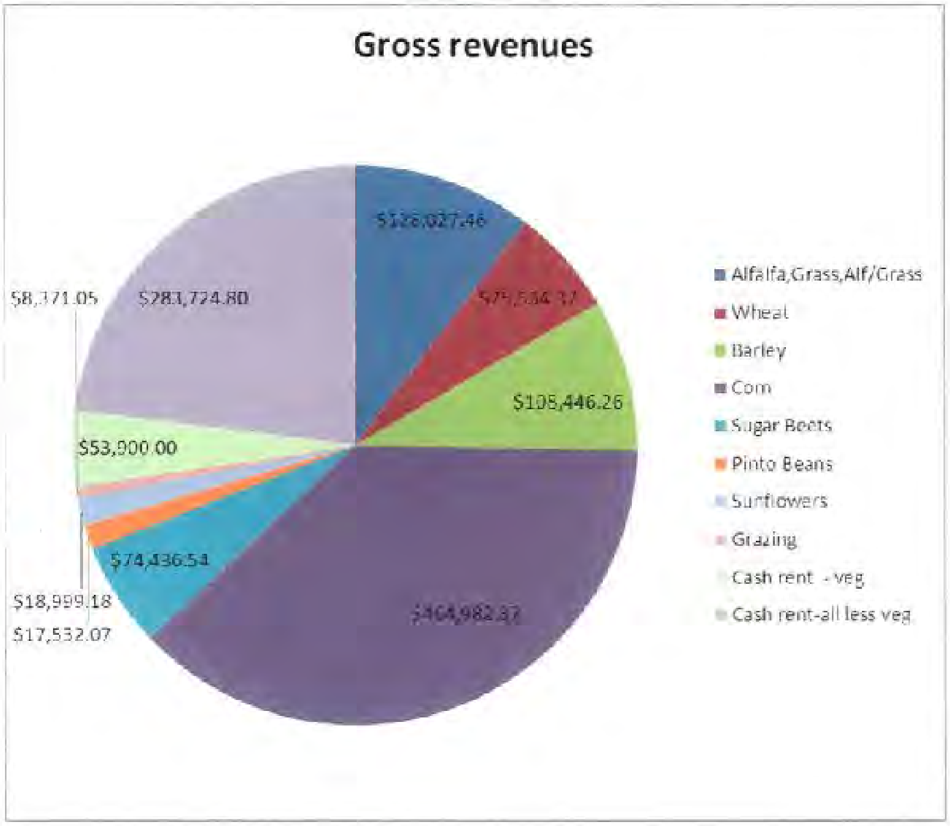
(ii) After three year transition period, assume farmer avg. yield of 90 bu/ac and harvest price of $10

<u>Farmer</u>	<u>BCPOS</u>
$900 revenue	
-$111 seed&fert.	
-$200 base rent	$200
$0 insurance payment	-$65
$589 return to labor/mgmt	$135 net rev./ ac

(iii) If harvest price of $6 because of marketing issues, insurance payment is received for price below $10: $4 x .7(90) = $252

<u>Farmer</u>	<u>BCPOS</u>
$540 revenue	
-$111 seed&fert.	
-$200 base rent	$200
<u>$252 insurance payment</u>	<u>-$65</u>
$481 ret. to labor/mgmt	$135 net rev./ ac

2010



Crop	Gross revenues	Acres	Gross $/A	Net $/Acre
Alfalfa,Grass,Alf/Grass	$128,027.46	2699	$47.44	$15.00
Wheat	$75,534.37	1124	$67.20	$35.00
Barley	$108,446.26	947	$114.52	$77.00
Corn	$464,982.37	1494	$311.23	$201.00
Sugar Beets	$74,436.54	200	$372.18	$214.67
Pinto Beans	$17,532.07	135	$129.87	$91.00
Sunflowers	$18,999.18	413	$46.00	$10.10
Grazing	$8,371.05	3305	$2.53	$2.53
Cash rent - veg	$53,900.00	539	$100.00	$100.00
Cash rent-all less veg	$283,724.80	9936	$28.55	$28.55
TOTAL	$1,233,954.10	20,792		

Cost (100% seed
½ of fert, herb, insect pests