INTERVIEW

Real-World Solutions

Researcher, Author Eric Toensmeier Explores Practical, Effective Carbon Farming Strategies

While this interview was being prepared a story surfaced on public radio about a couple of enterprising Americans who are taking advantage of changing policy to open a factory in Cuba. Their product? Tractors! The whole idea, the story helpfully explained, was to introduce "21st century farming" to the beleaguered island. By making it easier to tear up the soil. Clearly there is some distance to go before an accurate idea of 21st century farming penetrates the mainstream. It will take people like Eric Toensmeier. His book, The Carbon Farming Solution, *carries enough heft, range and detail to clear away forests of confusion. If the notion of leaving carbon in the soil is going to take its place next to that of leaving oil in the ground, this one-volume encyclopedia on the subject is exactly the kind of deeply informed work that's required. Reached at his home in western Massachusetts, Toensmeier was exhilarated over finishing a project years in the making, and more than happy to talk about it.*

Eric Toensmeier

Interviewed by Chris Walters

ACRES U.S.A. Carbon farming was unknown even a few years ago, and it is still obscure for many people who are otherwise well-informed. Could you establish the basic premise for us?

ERIC TOENSMEIER. Sure. Excess carbon dioxide in the atmosphere is there because of burning fossil fuels and also because of the degradation of land. Whether it's forests being cleared or prairie being plowed or a badly grazed pasture, when those ecosystems are degraded, carbon that was stored in soil and in biomass bonds with oxygen and heads up into the atmosphere as carbon dioxide. There are practices that can bring it back. They all use photosynthesis, which takes carbon dioxide out of the air and turns it into sugars in the plant; then those sugars are converted into various other things such as lignins. Some of them end up in the plant itself, and some of them end up in the soil. Some get there quickly through root exudates, and some end up in the soil more slowly through decomposition. Some of them are off-gassed to go back up into the atmosphere. We can pull down a bunch of that excess atmospheric carbon and store it in the soil and in perennial biomass. The amount that is possible is quite hopeful and could be just about enough to do the job if it's coupled with a drastic reduction in emissions. It's not enough to do the job on its own.

ACRES U.S.A. If carbon storage via agriculture is essential to an overall climate strategy, how do you lay it out to a skeptic who doesn't believe farms can play a big part?

TOENSMEIER. That's a really important question. We're not going to stop climate change, but we can't get it to a manageable level without farmers, and here's why. Even if we stopped all emissions today – all deforestation, all fossil fuel burning – there's already too much carbon dioxide in the atmosphere. That's partly because carbon dioxide takes a couple decades to kick in. We're already in for a lot more warming than we can tell from what we've emitted. We can pull it back down, and to do that we have to stop emissions, but we also have to sequester carbon. Neither one works on its own. There's not enough land available for reforestation to do all the sequestration we need with land leftover for agriculture. So agriculture itself has to be part of the solution. What's cool is that almost all of these agricultural solutions weren't invented for climate change mitigation – they were invented because they make farms work better. They make farms more resilient. They make farms more productive. They're good ideas anyway! There are plenty of tradeoffs and drawbacks, but as far as I can see it's quite a good news story.

ACRES U.S.A. A recent study declared that planting large stands of trees without careful consideration can actually produce a blowback effect.

TOENSMEIER. It depends where you do it. If you do it in boreal regions, the albedo impact outweighs the carbon sequestration. If you do it in areas where water is a limited resource, then it can have other negative impacts as well. It's a little more complicated. There are no silver bullets with carbon farming or climate change mitigation in general. People really want an easy thing so they don't have to change their lifestyle or change their civilization, and there's no solution like that of which I'm aware.

ACRES U.S.A. What is albedo impact?

TOENSMEIER. Albedo is what you feel if it's a hot summer day and you're standing on dark asphalt. It's hot, but if you step onto a lighter sidewalk it's not as hot. Darker surfaces absorb heat more. So let's say you are way up in the northern latitudes, like northern Canada. Imagine the winter on a grassland or annual cropland. There is snow covering the ground for a long part of the year. It's reflecting sunlight back. It doesn't absorb much of the heat, but if you put a bunch of pine trees over that or fir trees over that, they're much darker. If you imagine viewing the Earth from space and seeing a big evergreen forest, the snow is obscured quite a bit more, and you get this dark surface that heats up much more. The farther you get from the equator, the more albedo has an impact. In temperate latitudes like Austin where you are and Massachusetts where I am, evergreen trees impact somewhere between 10 and 50 percent of the carbon that is sequestered, offset by the albedo effect. It's actually a pretty big deal, although, that said, there are very few evergreen crop trees for those latitudes. Thus, it's not as big a deal as it might seem. Nitrogen-fixing plants off-gas nitrous oxide, which is problematic. Livestock, of course, create problems with methane. Each of these strategies has its own trade-offs. It's a complex situation – it's a big planet with a lot going on. We've been messing with it, and now we have to clean up our mess. It's not always as simple as it appears.

ACRES U.S.A. What would you say to somebody skeptical about climate change – not accepting the overarching-emergency argument – whom you want to convince of the advantages to the techniques you recommend?

TOENSMEIER. All of these practices are worth it anyway. Courtney White's G*rass, Soil, Hope* lays that argument out really well. Another argument for doing things that are already a good idea, quite frankly, is the vast potential funding stream for doing them. That is certainly part of my interest. I would also encourage people who feel that way to go to the skeptical science website, which takes something like 200 of the most common arguments against climate change and provides the scientific rebuttal, from the sun is doing something to other planets are warming too so it can't be us – it provides nice responses to all those. There's even an iPhone app for people who are interested in refuting those arguments.

ACRES U.S.A. What is a good example of an important carbon farming sequestration tool or method, along with the ins and outs of it?

"A lot of the most successful techniques that spread most quickly seem to be things that build on a pre-existing practice or tradition, don't cost a lot of money, but maybe get systematized and formalized. You start with things people already know how to do, you don't make them buy anything new, and the ideas are more likely to spread quickly."

TOENSMEIER. One example I really like, and it's not talked about enough, is agroforestry or incorporating trees into annual cropping systems. Here in the United States we often call this alley-cropping. It's when you place wide-spaced rows of trees with annual crops. Often the argument goes, "that's going to compete with my crops for water and nutrients and light, and it's going to mess up my equipment spacing." Trees don't like crops, and crops don't like trees. That's been shown to be false – it depends on your design. If you have a bad design, then yes, they compete with each other, or if you choose the wrong species or choose the wrong spacing. But that kind of

intercropping of trees and annual crops is being done on a huge scale in many parts of the world, including some here in the United States. The biggest example I know of in a cold climate is in China, where there are 3 million hectares of Paulownia trees intercropped with annual grains. Three million hectares is about 7.5 million acres. That's a pretty respectable amount of land. With proper spacing of trees, it actually increases the yield of grain because there is so much more organic matter coming into the field from the leaves. Typically they're doing winter grains there, and the trees leaf out really late in the season, meaning there is little overlap between the key season of growth for the grain and the key season of growth for the trees. Goji berry is a fruit tree widely grown in China that's grown in similar kinds of systems. I've seen small-scale examples of that here in the United States with apples and pears intercropped with various kinds of annuals, certainly the black walnut and pecan are both used in systems like that on a reasonably large scale. That is to say, a relatively small number of farmers on decent-sized farms.

ACRES U.S.A. Does a tree such as bamboo, which is pretty easy to cultivate and has more than one use, have a large, untapped potential we're not exploiting?

TOENSMEIER. I write a good amount about bamboo in the book. I'm a big fan of bamboo. Here in the United States and Canada, bamboo is vastly underutilized. Even our native bamboo is almost never seen in the wild anymore. There are bamboo agroforestry systems all through Asia, including some temperate zones, and we're missing out on tons of opportunity. For example, over 100 years ago some people did studies looking at bamboo as feedstock for paper, and it produced about six times more than pine plantations. Nobody will ever tell you it's hard to grow bamboo – wherever there is decent soil and enough water the stuff wants to grow. I write about bio-based feedstocks for industry to replace stone, metal or petroleum. These days, about 5 percent of the raw material for industry is bio-based, and most of that right now is corn and soy – GMO corn and soy. I think we can do a lot better than that. I like to emphasize the importance of different raw ingredients for materials, chemicals and energy. Materials would be everything from cardboard and paper to advanced bio-plastics and such. Chemicals could include solvents or almost anything else, and energy is straightforward. There's not enough land in the world to grow all the energy that people use today, but there will always be a role for some bio-based energy, even if it's just firewood.

ACRES U.S.A. What about the potential of industrial oil crops?

TOENSMEIER. Most of the attention they're getting these days concerns biodiesel, which is fine, but industrial oils have tons of other applications, from bioplastics to lubricants. Where would civilization be without W-D 40 and hydraulic fluid? These are essential things that have been made out of plant oils in the past, and we need to figure out how to do so again. My interest is really in economic development based on the production of these crops, but also the regional processing facilities and regional cooperatives to drive a sort of rural economic development. I think the greatest crops in the world and greatest farming systems will fail without markets and without processing, so I think there's an argument to be made for making us more resilient while driving sustainable economic development.

ACRES U.S.A. What is an example of an industrial oil crop with great carbon and commercial potential?

TOENSMEIER. One that's actually grown down there in Texas is the castor bean. Castor is interesting in that the beans are incredibly poisonous, but the oil has been used for a long time. It's been grown in intercropping systems with food plants for millennia. The oil from it can be used directly as a lubricant in engines, and was used in airplanes during World War II – although it gums up the works after a little while if it hasn't been filtered. Another interesting one from the southwest United States is jojoba, which is a liquid wax that's produced from a desert shrub. You see it in your shampoo and other products. That can be used directly in engines as a lubricant as well. A fair percentage of petroleum goes not to energy, but to chemicals and plastics and hydraulic fluid, also to synthetic rubber. A lot of the inedible oil trees are tropical, but we do have some for cold climates, like the Chinese tallow tree, called the popcorn tree in the Southeast. It's one of the highest-producing inedible oil trees in the world. Its yields are almost as high as African oil palm, and it's naturalized in the Southeast as a big weed. That would be interesting to take advantage of, as is chinaberry, another big weed tree in the Southeast that produces high yields of inedible oil that has tons of interesting industrial uses. If we as a civilization are serious about reducing fossil fuel use dramatically, it has to be about the chemicals and materials along with energy. That's where these perennial oilseeds can really come into their own. Out in the drier West you have buffalo gourd seed. In the upper Midwest they're starting to look at yellowhorn, which is a tree crop that produces edible oil that can be used for all those same things. While the tropics are ahead, there is quite a lot of opportunity here in the United States. I love the hydrocarbon plants, too – milkweed is one that's loaded with long-chain hydrocarbons. Basically there's rubber in there, the milk is rubber and has tons of potential industrial uses as does milkweed's fiber. I'd love to see it domesticated, and it's not hard to grow either.

ACRES U.S.A. You'd be able to utilize the rubber-like material without accidently liberating carbon in the process of growing it? Does it have carbon sequestering potential?

TOENSMEIER. As a perennial, it's likely to be a carbon-sequestering plant. Herbaceous plants tend to sequester less carbon than woody plants. In the process of removing those hydrocar-

bons, surely there is some off-gassing. There's no perfect closed-loop system, but you're able to hang onto most of it and make many of the things that we make from petroleum today. That's still developing, this idea of petro-farming where we use these plants to replace petroleum as the sort of material that can be made into so many things. That's where we need experimental data. Some of the other, more traditional uses of hydrocarbons from plants like turpentine and rubber and various kinds of lubricants from plant resins – those have been around for thousands of years. Only the idea of additional applications is relatively new. It was proposed in a big way in the 1970s by Melvin Calvin, a Nobel prize-winning chemist who spent the last years of his life looking at how to grow petroleum in plants, mostly with euphorbia. One of his best hydrocarbon potential candidates in the United States is leafy spurge, which is loaded with hydrocarbons and again not hard to grow. It's hard to make it not grow in western pastures. Experiments were done with burning hay bales made of leafy spurge, and they burned with four times the energy of wheat straw. These plants have real potential to open up lots of new markets for farmers.

ACRES U.S.A. Are these applications getting the kind of research and development funding that they need? Either privately or federally funded?

TOENSMEIER. Nope! There is some. There is certainly ongoing research on lots of different kinds of industrial crops that are grown in the United States, but almost all of the interest has been in bio-energy, primarily ethanol and biodiesel. A small fraction of the effort goes into materials and chemicals. The high-end estimates of how much of the world's energy needs could be met with bio-based energy are somewhere around 10 to 20 percent. That's really not enough to do the job. Whereas we can grow all the world's plastic on 4 or 5 percent of world cropland. We could probably cut the amount of plastic we use by a lot because we waste huge amounts of it. Meeting the needs for plastics, other materials and chemicals is much more feasible on the amount of cropland we have compared to using it for energy.

ACRES U.S.A. You're not leaving the biomass energy people many reeds they can grasp.

TOENSMEIER. Here's an interesting exception to that. Researchers are looking at these big biomass grasses, great big giant grasses, switchgrass or even taller ones, like miscanthus and giant reed and others. I'm a fan of those, and they are looking at planting large areas of them for energy sources. It turns out it's easy to remove the protein as a by-product in a form called leaf protein concentrate, which is something I make at home with my juicer. It's 50 percent protein on a dry-weight basis and has all the vitamins and minerals and such that are in the leaves. That's something that can be fed to humans. It's not the tastiest thing in the world, though I mix it with guacamole, and it tastes awesome. It turns out that when you grow energy and protein in the same area you end up being able to greatly reduce the amount of cropland needed. In other words, you could grow less soybeans and fewer energy crops because the protein grows in the same place.

ACRES U.S.A. Are you a supporter of the switchgrass initiative?

TOENSMEIER. Frankly, I'm not wild about switchgrass unless you're in a really dry place. There are much better, more productive crops that can be grown most of the time. Politically I'm not in favor of the big biomass energy initiative. But this particular proposal really caught my eye, and the researchers are saying we could do these giant grasses. Often that might be something that you would grow, for instance, as a riparian buffer crop. Let's say you have a regular, annual crop farm, and along the streams and rivers you plant nice, wide swaths of giant perennial grasses. They will perform water filtration, cleaning up extra nutrients that are leaching out of the field. Water quality is protected at the same time you're raising a biomass crop for energy and protein. If this kind of thing replaced 20 percent of the soybean meal that's used for livestock, which is about 24 million metric tons a year, that would enable a huge reduction in soybean acreage. That's a win-win as far as I'm concerned. And that would allow a reduction of 16 million hectares of soybeans and 8 million hectares of biofuel. That's a big deal.

ACRES U.S.A. Why are perennials so important to carbon farming?

TOENSMEIER. There are a couple of reasons. One is that perennials, or at least the perennials I'm talking about, are either no-till or can be managed in a no-till fashion. Almost by definition, they don't need plowing after establishment. Tillage is one of the worst contributors in terms of burning up soil carbon and releasing it to the atmosphere. So a no-till system, all other things being equal, is going to be superior. It's actually going to sequester carbon instead of release it, as a general rule. They also sometimes have very substantial biomass above ground and below ground that are made of carbon. If you draw out a tree or a giant graph, roughly half of what's there is going to be carbon. If you're harvesting that above-ground biomass

in the case of grasses, and doing something with it such as making it into long-lived material as with bamboo, that does count as carbon sequestration as long as it's a part of your house. If you're going to burn it, then it's going back into the atmosphere again pretty quick. But that below-ground biomass and the soil it's helping to build remain in place.

ACRES U.S.A. Has anyone worked out a rough calculation about how much crude petroleum we could leave in the ground if these oil crops were fully developed?

TOENSMEIER. Realistic estimates range from 40 to 85 exajoules of energy produced from plants by 2050. For some perspective, total world energy in 2009 was 388 exajoules. So the answer is some but not most, not half. It's a sizable dent. If you also increase efficiency and reduce energy use and meanwhile build out wind and solar and everything else, it's really doable. Scientists pretty much agree.

ACRES U.S.A. A theme running through the book is the idea of farmer-managed natural regeneration. What do you mean by that term?

TOENSMEIER. That's one of the most interesting techniques to emerge since organic took off, since holistic grazing took off. Farmer-managed natural regeneration got its start in Niger, the Sahel region of Africa. The area was very dry and heavily deforested. Small-scale farms were plowed by hand or with animals as opposed to tractors, and farmers had to replant their crops three or four times when sandstorms flattened everything. They tried lots of tree planting projects, which were unsuccessful for various reasons. Then they realized that there was plenty of what they called underground forests in their fields, tree roots that were still present, re-sprouting every year and getting plowed under or cut down. If you just allow those to grow, then you can cut some for firewood and harvest some for fodder. You can use some of the wood for mulch and the leaves to build organic matter. On a non-mechanized farm there is a lot more flexibility for having irregularly scattered trees around the property. The trees ended up cutting down on the impact of the sandstorms so people didn't have to replant all the time. There were some really great things about those techniques – and it didn't cost anything. It spread to 4.8 million hectares in Niger over the past 30 years. That's hugely successful.

ACRES U.S.A. It's natural to wonder why it wasn't tried sooner.

TOENSMEIER. One of the key things that had to change was policy. The government had way too much control over people's trees, and you weren't allowed to mess with them without government approval. When they removed that barrier, people got excited about planting trees and saw what a difference it made. They also had to get over the cultural notion that it's embarrassing and shameful to have trees on your farm. When they got over that and removed the policy barriers, this thing just spread like wildfire, and it's still spreading today. A lot of the most successful techniques that spread most quickly seem to be things that build on a pre-existing practice or tradition, don't cost a lot of money, but maybe get systematized and formalized. You start with things people already know how to do, you don't make them buy anything new, and the ideas are more likely to spread quickly.

ACRES U.S.A. How does it stack up in terms of carbon?

TOENSMEIER. It is estimated to sequester about 2 to 4 metric tons per hectare per year, as compared with conservation agriculture which has a global average of 0.6 metric tons. Managed grazing has a global average somewhere between one-third of a metric ton and 2 metric tons per hectare per year. These agroforestry systems show impressive yield increases, and that's particularly the case in really degraded soils like they had in Niger. I'd never heard of most of these systems when I started work on the book. I have about 40 different practices in there, and I'm struck by the huge scale on which they're being practiced. I'd never heard of rice intensification, for instance, but it's bigger than organic.

ACRES U.S.A. What is rice intensification?

TOENSMEIER. It's a small-scale rice production system that gets rid of a lot of the flooding. Flooding rice paddies is one of the biggest agricultural contributors to climate change. The methane from rice paddies is really bad, and it uses a lot of water as well. Rice intensification is a mulch-based system. You change the spacing, you change the age at which you plant the trees, and you get very impressive yield increases. The average increase in soil carbon is 150 percent, so it has half again as much carbon in the soil as a regular rice field. That's good. While producing better yields, that's great!

ACRES U.S.A. We ought to talk about NDHP crops as well. What are they and why are they important?

TOENSMEIER. An NDHP is a non-destructively harvested perennial. There are perennial crops that die when you harvest them, and in terms of soil carbon some of the benefit of their perennialness is lost when they die. Potatoes are perennial, but we dig them out of the ground, turning over the soil so that the benefit a potato would create if you left it in the soil for many years is lost by harvesting. The same way a pine tree that's harvested for timber can be very long-lived carbon if the wood itself is used in a building, but in terms of soil carbon it's not so helpful. There are perennial crops, lots of them, which harvesting doesn't kill.

ACRES U.S.A. Then the question of how perennials are managed is crucial, and I believe you've devoted a lot of thought to it.

TOENSMEIER. I looked at 700 different species of perennial crops and found only five basic management strategies. One is the standard tree, like an apple tree. You pick the apples,

but you don't kill the tree. Then we have a managed multi-stem such as bamboo where you cut out some but not all every year, so it always has some stems up and some stems getting harvested. We have woody plants that are cut down to the ground or maybe slightly higher, but essentially the whole woody part is cut and allowed to re-sprout. Then we have herbaceous standard plants, where you pick the beans or the artichoke head off the top, but the plant itself remains alive for years. Then we have herbaceous hay crops where the above-ground biomass is harvested while the soil remains intact. Those are the basic five methods – and you might use the fruit, you might use the sap, you might use the leaves, you might use the fibers. Aerial tubers and edible tree milks and plenty of other fascinating plants have been used by people extensively in the past. I argue for using the NDHPs as an essential component of a carbon-farming program. It's not that we're going to stop growing corn and tomatoes and watermelon and potatoes. Those are all great things, but there are places where we grow annual crops that are inappropriate, like slopes or areas being degraded. Certainly we can perennialize much more of agriculture, whether we shift completely to perennials for certain things, or we just integrate more perennials into annual cropping and more woody perennials into grazing systems.

ACRES U.S.A. Shifting gears again, what is a homegarden, spelled as one word as opposed to a standard home garden? How are homegardens a boon to carbon farming?

TOENSMEIER. One of the oldest agroforestry systems in the world is called the tropical homegarden, which doesn't make sense in English. What it means is highly diverse planting near and around the house on an intimate scale with trees, shrubs, vines, herbs, annual crops and often small livestock – what is often known in the United States as a food forest or forest garden. It was a result of the permaculture movement, but it's an idea that goes back as far as 13,000 years in some parts of the world. They have excellent levels of carbon sequestration and excellent levels of biodiversity. At the small scale, the homegarden is one of the most powerful tools that we have.

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ACRES U.S.A. Can it work on a tiny scale such as a typical American homestead of an acre or less?

TOENSMEIER. Absolutely. I have one here on a tenth of an acre, 300 species, not too many of any one species. That includes 50 species of fruit, mostly berries. There isn't room for 50 kinds of trees, so our trees are mostly dwarf and semi-dwarf trees. We have three species of bamboo, 70 or 80 species of perennials with edible leaves, and we grow some annuals. We raise fish and poultry and soldier flies and silkworms, so we have a small, highly biodiverse carbon-sequestering system. When we got here in 2004, our soil organic matter was 2.5 percent, and now it's gone up to 9 percent. Some of that comes from wood chips and compost we applied. We don't get credit for all of it, but it does appear to be a system that is actually sequestering carbon in the soil and in the biomass as well.

ACRES U.S.A. What would be included in a basket of policy changes that you would like to see for the kind of future you propose?

TOENSMEIER. Internationally we need to rebuild or replace the World Trade Organization because so many of its provisions prevent many countries from providing payments to their farmers for environmental services such as sequestering carbon. The United States is able to get away with it, but many countries are not. At the international level that's a big policy barrier. The kind of structural adjustment loans that countries get often require them to industrialize their agriculture in what *Acres U.S.A.* might consider an unsustainable fashion, and I would agree. That's at the international level. At the national level they could start getting rid of the incentives and subsidies for unsustainable agriculture. We need money for research. We need money for education. We need money for breeding some of these perennial crops. The big thing that would make a difference would be payment for environmental services for carbon sequestration, explicitly. We have the USDA EQIP program right now that pays farmers to carry on lots of different kinds of soil and water conservation activities, many of which happen to sequester carbon, but they won't pay for you to do that as such right now.

ACRES U.S.A. Do you think proposing something like that explicitly is possible, considering current political realities?

TOENSMEIER. We're unlikely to have a Congress that welcomes it anytime soon, but it would be a nice thing to happen. And of course we need a price on carbon, whether that's a carbon tax or a cap-and-trade system. I'm much more in favor of levying a carbon tax and then taking a bunch of that money and paying farmers to plant perennial crops, switch to managed grazing, switch to silvopasture, embrace agroforestry, reduce tillage, or even just add things like crop rotation and cover cropping. Even if you're just converting to organic from conventional, or switching to managed grazing from extensive grazing, a big barrier is the period of two to five years where you lose money while you

figure out how to make it work on your farm. The availability of low-interest loans specifically for farmers to make these changes would be huge. That money doesn't have to come from government; it can come from any number of different kinds of financing sources. I'd also love to see price premiums for carbon farmers as another way to encourage people to take it up. There would be a carbon farming certification, and you would get a premium price. That would be extremely helpful, and we don't need to wait for governments to get it together.

ACRES U.S.A. Do we need national and global legal activists to push for a stronger legal definition of environmental services and ecosystem services and then place a value upon those services?

TOENSMEIER. That's an interesting proposal. That would be really helpful. Many of these practices provide other ecosystem services along with the carbon sequestration and the benefit to production, so indeed that would be helpful.

ACRES U.S.A. What angle do you approach this subject from, biographically speaking?

TOENSMEIER. I'm a product of the permaculture movement here in the United States. The parts of that that always interested me the most were the perennial crops and agroforestry systems, especially the food forest, the homegarden. I spent about 25 years on that in one way or another, writing, researching and practicing. I ran a seed company for a while, but also managed an urban farm in my town for about five years, and I worked for another nonprofit where I did lots of business training for beginning farmers, sort of looking at all the least sexy parts of farming like researching legal requirements; getting the right kinds of insurance, business planning, enterprise budgets, market research and so on. That was invaluable. I'm really glad I did it. That was with the New England Small Farm Institute here in Massachusetts. I don't come at this from a Pollyanna, rainbows and unicorns type of perspective.

ACRES U.S.A. Do you regard dismantling or radically reducing the corn complex as an essential goal?

TOENSMEIER. Yes I do. I have great love for corn. My wife is from Guatemala, and corn is an important thing, but you could say we've gone a little overboard with it.

ACRES U.S.A. You have a talent for understatement.

TOENSMEIER. You have to respect a really productive crop, you have to appreciate that. Right after petroleum, corn is one of our big industrial inputs, and climate-wise it's not a whole lot better in many ways. In fact a lot of these biofuels end up having the same amount of climate impact as burning fossil fuels. Biofuels can be as bad as fossil fuels.

ACRES U.S.A. Do you think the ethanol subsidy should be eliminated?

TOENSMEIER. Yes. It's okay to grow corn within an agroforestry system – great, awesome, wonderful crop. But it's put to horrible uses and certainly part of the problem, just like African oil palm – an amazing crop used for terrible things. Sugarcane, cotton – these are great crops that have been used for horrible things. You can't blame the plants for people's greed and stupidity.

ACRES U.S.A. How are you spending your days now that the book is out?

TOENSMEIER. I have two interesting gigs right now. I lecture at Yale on carbon farming, one course a semester. I also work for an organization called Project Drawdown, which is setting up 100 climate solutions and intensively researching the economic and climate impacts that will occur by 2045. We look at land and buildings and transportation and energy and all sorts of different aspects. I work with the land aspect, so we're looking at managed grazing and agroforestry and nutrient management to see which ones actually have an optimistically plausible level of adoption by 2045, and what the impacts would be by then. It's really interesting stuff.

ACRES U.S.A. Can people see the results of Project Drawdown's work?

TOENSMEIER. It's still being written right now. There will be a book, and there will be a nice website. Right now they can go to drawdown.org and see some initial results. For example, we have a solution that involves feeding food waste to pigs. First we look at reducing food waste in general, and then with what remains we look at feeding it to pigs. If food waste goes to a landfill it produces methane, but if you feed it to pigs, you reduce the amount of methane and you also reduce the amount of cropland, which can then be reforested or used in another way. Then you can run the pig manure through a biodigester and so on. What happens when you start to plug those solutions into each other? What are the kinds of benefits that come from integration? It's fascinating to see how it all comes together.

Eric Toensmeier's *The Carbon Farming Solution: A Global Toolkit of Perennial Crops and Regenerative Agriculture Practices for Climate Change Mitigation and Food Security*, published by Chelsea Green, is available from Acres U.S.A. For more information visit *acresusa.com* or call 800-355-5313.