Proceedings of the Second Annual Northeast USA Rice Conference

August 6, 2011

9:00am – 4:00pm
Akaogi Farm
Westminster West, Vermont

The Second Annual Northeast USA Rice Conference is a collaboration between the McCouch RiceLab at Cornell University and Akaogi Farm. It is funded in part by the National Science Foundation.

Table of Contents

Acknowledgements **2**

Agenda **3**

Speakers **4**

Background **6**

Proceedings **6**

Welcome: Mia Murphy ***6***

NSF Grant and Cornell Rice Research Project: Susan McCouch ***6***

Rice Growing and Conservation: Takeshi Akaogi ***10***

The Natural History and Conservation of Pool Breeding Amphibians in Windham County, VT: Jim Andrews ***15***

Dragonflies and Damselflies: Mike Blust ***27***

Lunch ***33***

Integrated Rice and Duck Farming: Erik Andrus ***33***

Rice Growing in Asia and Northeast USA: Peter Hobbs ***38***

System of Rice Intensification (SRI): Erika Styger ***45***

Closing and Group Photo ***56***

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- Thank you Matt Murphy for providing solar power to run the computers, projector, and audio system needed for the conference presentations.

Mia Murphy
Outreach Coordinator

Agenda

8:00-9:00am	**Registration**
9:00-9:10am	**Introduction** Mia Murphy
9:10-9:30am	**NSF Grant and Cornell Rice Research Project** Susan McCouch
9:30-10:15am	**Rice Growing and Conservation** Takeshi Akaogi
10:15-10:30am	**Break**
10:30-11:15am	**The Natural History and Conservation of Pool Breeding Amphibians in Windham, County, VT** Jim Andrews
11:15am-12:00pm	**Common Dragonflies in Vermont** Mike Blust
12:00-2:00pm	**Lunch** 12:00-12:30pm Chefs' Presentation: menu and cultural background 12:30-1:30pm Lunch 1:30-2:00pm Rice Paddy Tour: Takeshi Akaogi will lead a tour of the rice paddy system
2:00-2:15pm	**Integrated Rice and Duck Farming** Erik Andrus
2:15-3:00pm	**Traditional Rice Growing Practices** Peter Hobbs
3:00-3:45pm	**System of Rice Intensification (SRI)** Erika Styger
3:45-4:00pm	**Closing and Group Photo**
4:00-5:00pm	**Rice Growers Meeting** (optional)

Speakers

Susan McCouch
Susan is the Project Director of the Rice Research Lab in the Department of Plant Breeding and Genetics at Cornell University. She received her PhD from Cornell in 1990 and spent 5 years with the International Rice Research Institute (IRRI) in the Philippines before joining the Cornell faculty in 1995. Her research focuses on rice and includes publication of the first molecular map of the rice genome in 1988, early quantitative trait loci (QTL) studies on disease resistance, drought tolerance, maturity and yield, development of the essential repertoire of SSR markers now used globally as a genomic resource in rice genetics and breeding, and cloning of genes underlying critical traits for rice improvement.

Takeshi (Ogi) Akaogi
Since 1985, Takeshi and his wife, Linda, have been farming organically in Westminster West, VT on 10 acres of land that is part of the Earthbridge Community Land Trust. In 2006 they started experimenting with growing rice and as a result of two Northeast SARE Grants in 2008 and 2009 they have helped initiate a regional effort to grow rice in the northeastern United States.

Jim Andrews
Jim is a herpetologist who serves as chair of the Vermont Reptile and Amphibian Scientific Advisory Group to the Endangered Species Committee, coordinates the Vermont Reptile and Amphibian Atlas Project, and teaches Vermont Field Herpetology at the University of Vermont where he holds the position of adjunct assistant professor. Conservation of Vermont's native reptiles and amphibians is a common theme running through his activities.

Erik Andrus
Erik farms in Ferrisburgh, VT on 110 acres of Champlain Valley clay plain. He is currently growing a little under an acre of rice with ducklings managed for weed control, with plans to expand to five or six acres in 2011. This rice project takes place in the context of a diversified farm with dry land cereals, roots, haying, grazing, and the use of working animals.

Mike Blust
Mike has a background in entomology with extensive knowledge about dragonflies and damselflies (insects in the order Odonata) that live in Vermont. He is a recently retired professor of biology at Green Mountain College, where he taught for 25 years. Mike and his wife have joined the Peace Corps and will be leaving for Mexico at the end of August.

Peter Hobbs
Peter is a crop scientist and agronomist with 30 years experience with the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CIMMYT). He has taught as an adjunct professor in the Crop and Soil Sciences Department and is currently the Associate Director of International Programs in the College of Agriculture and Life Sciences at Cornell University.

Erika Styger
Erika is the Director of Programs at the System of Rice Intensification (SRI) International Network and Resources Center at Cornell University. She has 20 years experience in Africa leading and undertaking analytical studies and designing, implementing, and evaluating research and development.

Background

Following the 2009 Sustainable Rice Production for the Northeast Workshop, this conference focused on wildlife conservation issues associated with rice paddy systems in the morning and general rice agriculture topics in the afternoon. Lunch highlighted the importance of rice as a staple food for many cultures and included short presentations by local chefs about the rice dishes they had prepared. This conference was a collaboration between the McCouch RiceLab at Cornell University and Akaogi Farm and was funded in part by the National Science Foundation.

The following proceedings are an edited transcription of the conference. Some of the text may be difficult to understand without the accompanying images from the presentations. Videos of the presentations, which include the PowerPoint slides, are available at www.ricenortheasternus.org.

Proceedings

Welcome: Mia Murphy

Thank you all for coming to the Second Annual Northeast USA Rice Conference. We are calling it the second because back in 2009 my parents, Takeshi and Linda Akaogi, wrote a Northeast SARE Grant to host the first conference (workshop) to get people together to talk about rice and the possibility of growing rice in this northern climate. I would like to introduce Susan McCouch and we really need to thank her because she came to our last conference and has been working with my parents for several years now. She has seen the possibility of growing rice in the Northeast and has been very supportive. She has written this project into a small part of her NSF Grant so that we can have a conference for this year and hopefully the next three years. We also have a website that has been newly launched and I hope to add more to it over time so that the information gets out to everyone here today and everyone interested in growing rice in the northeastern United States.

NSF Grant and Cornell Rice Research Project: Susan McCouch

I will introduce the Rice Diversity Project that is underway at Cornell to try to give you a little bit of background about why we are interested in the work that is going on here at the Akaogi Farm, and the ways in which our grant support and our research interests are becoming integrated with interest that many of you share who we meet at these conferences. First, a few words about the Rice Diversity Project. It is a collaborative project. We are funded by the National Science Foundation and the grant involves coordinated research taking place at Cornell University and the National Rice Research Center for the United States, which is located in Stuttgart, Arkansas. Arkansas produces 60% of the rice in the US so that is why our national research center is there. There is also an international rice research institute in the Philippines, which is actually the source of most of the germplasm we use in our research. The IRRI Gene Bank contains much of the underlying germplasm that forms the basis of rice production in both the temperate and sub-tropical zones of the United States, and as well as rice production throughout the world. The head of the International Rice Research Institute (IRRI) seed bank is here today. Ruaraidh, where are you? He has come all the way from the Philippines. IRRI is also the source of some of the books and the information that you receive.

I do want to mention the objectives. The objectives of our grant under the National Science Foundation are: first, to better characterize and utilize natural genetic variation. That just means the variety of seeds and sources of genetic variation that exist, both wild and cultivated sources. Secondly, to enhance adaptation of rice to different ecological niches and rice production systems. That is ongoing research. What are the genetics that underlie adaptation to the temperate zones or the tropics or irrigated or dry fields, etc? And thirdly, to promote awareness of the diversity of cultural, biological, and culinary traditions and uses of rice. We are interested in the spectrum of things related to rice. We are in the Plant Breeding and Genetics Department at Cornell so we focus mostly on what we call rice improvement through crossing and selection. There is a lot of diversity in rice. Here in the temperate zone we only accessing a very, very tiny fraction of it, that which is normally adapted to the temperate zone. Because it is a tropical crop, that is a very narrow selection from within the larger pool of variation. I am going to walk through four or five examples of this. As you know we have varieties of rice that are adapted to the irrigated paddy system, which is the predominate high yielding system throughout the world. In those parts of the world, rice is still hand transplanted into the flooded paddy, hand harvested, and hand hulled or threshed in the field. The vast majority of rice that people eat on this planet is still planted and harvested in very traditional ways. It is not mechanized. We also have upland varieties that grow in dry, acid soils. An example is the Solfados of Brazil. The breeders have bred varieties of rice that actually withstand the acid soils. The roots are able to grow even though the level of aluminum and other toxic micronutrients would actually kill most of the rice varieties that we grow elsewhere. These varieties have a very distinct package of genetics and this has been achieved just through crossing and selection. There are no transgenics in any of it.

Audience: A quick question. Could you comment on how recently evolved those methods are. This type of rice genetics. Is it new or is it very old?

Susan: It goes back to about the late 1800s when people started knowing about crossing. I mean Mendel and Darwin. Before that it happened, of course, in nature. It happens all the time but people didn't make crosses. They didn't select consciously but they were doing it unconsciously. It is just a matter of what we understand versus what we do.

Deepwater rice elongates with rising floodwaters. Some of you may be aware of this because there are some genes that have been cloned recently and it has been in the news all over. On the left you see a rice breeder up to his neck in water. You can see his hand. If you look carefully he is making selections. Making sure that the rices that appear to be floating are actually rooted and that they will set seed. You can harvest this seed by boat. This is in parts of Thailand where maybe a third of the country floods every year. They plant it in the rising water, which triggers the elongation of these rice varieties. As you see on the left when you drain those paddies what you see is that in those regions the rice has actually elongated to 23 feet. These are rices that have a trigger. They are sensitive to the environment and it has to be moving, rising water or they do not elongate that way. When the water stops rising, they stop growing. If it comes in again, they grow. There are rices that, for instance, will hold their breath underwater for up to two weeks, and they can survive. These are called submergence tolerant rices. IRRI has been deploying these widely for instance in Bangladesh, which has been experiencing massive flooding and drought in the same season as we live through this climate change.

We are interested in genetics. There are natural genetic opportunities. If you understand what is out there in the wild or in the ancient systems, you can bring those genetics into your cultivated systems and that is what we do. There are varieties adapted to very high altitudes, as many of you know, such

as the terraces in the northern parts of the Philippines in the Banaue Rice Terraces. This terracing technique is used all over the world for potato, for rice, for many crops grown in the mountains. It is quite remarkable that rice is grown up in regions where it gets very, very cold at night.

Then we have rice in temperate zones, and these rices can be grown right here in Vermont. It is not really surprising that rice can be grown in Vermont because it is grown at latitudes much like this in Japan and down south in Chile. At the extremes of our latitudinal spread, we see rices that are cold-adapted. That is part of the trick here. We are trying to introduce and bring in rices from other parts of the world that are adapted to a similar growing environment. Then through crossing and selection, we find things that local markets really like or that are particularly productive and reliable in a particular environmental niche. You have a niche and the niche here in the Putney area may be different than the niche up in the Champlain Valley or it may be different than the niche in Oneonta, New York where we do have some rice production going on. There is general local adaptation (to soils, pests, diseases, micro-climates) and there is the more general adaptation to photoperiod and temperature ranges. The point of this is really just to say that natural variation is something that if you understand and have access to it, you can bring it into the crops you grow. It can help drive the rice industry. You can also look for novel traits that are culinary. Because we access rice from all over the world we interact with the cultures that have maintained those rices for thousands of years. This is a picture from Bali, Indonesia and I am showing the offering to the rice gods. This is offered to the gods twice a day to ensure the rice harvests. People do this as a ritual every day at the edge of the field when they enter and when they leave. There are lots of rituals. Some have to do with slaughtering chickens and putting blood on the soil. Some have to do with offering like this one. There are many different ways of growing and harvesting rice, and you will be hearing more about the agronomy of rice from others. I always like this photo because it shows a person harvesting from what is essentially a wild stand. Because the rice shatters when you walk through it you can harvest it without picking it and there is no sickle and there is no cutting.

At Cornell we are also studying genetic variation at the DNA level. We are interested in understanding the genetic basis of the variation that you see phenotypically all about. I just want you to realize we are not working with transgenics, but we do work with DNA. Ever since I joined my first molecular biology course and they showed me this image, I thought to myself how similar it is to the ways in which humans have actually been able to capture in black and white something that is otherworldly. For many of you music is something you are familiar with. Don't be afraid of DNA. It has its own voice. We are listening to it and it is telling us a lot of things that are useful to us. If you can listen to rice, if you can hear it, it will speak to you. It will sing to you. That is really what we are trying to train our students and our lab group to do. Many of you met Gen Onishi who was out there making crosses early this morning. Gen was a farmer in Japan before he came to the United States and he has been managing the rice in our greenhouse for the last 17-18 years. When the students come in and they start working with Gen, they are taught without words. They just have to watch and listen and that is a lot of what we are about.

This figure happens to represent the diversity of *Oryza glaberrima*, which is a different form of rice. It is not Asian rice. It was independently domesticated in Africa. It has its own variation, its own pool of genetic variation. We can draw on that pool as well and most people aren't that familiar with that. The accessions that I am showing you here, the variation in the patterns of the DNA represent the center of origin and domestication of *Oryza glaberrima*. There is a lot out there in the world and I think part of it is just learning what it is because so many different cultures have cultivated rice, cared for it, and have it integrated into their daily routines.

Now I want to show you two more slides. We can quantify variation at the DNA level, which is what I was showing you here. We can see whether two rices are similar at a certain base pair position along the DNA, or whether they are different. Because we can do that and we can count the differences, we can also quantify variation. We can ask, "How variable is all of the gene pool of rice compared to say all of the gene pool of humans or all of the gene pool of any other species on the planet?" I have chosen a few organisms here just because I think they illustrate a point I want to make. Rice, *Oryza sativa*, is here and *Oryza rufipogon*, its wild ancestor, is here, flanked on the low-end by humans. There is much less variation between two randomly selected human beings on the planet than there is between two randomly selected rice plants, even if the rice looks very similar to your eye. On the other side, there is more variation in maize or in potato than there is in rice, in part because they are out-crossers and because of the evolutionary history of those species. The point here is that you can't tell by looking at organisms how genetically diverse they may be, and the second point is that when we cultivate plants, we make selections and reduce the amount of variation that there once was in the wild. Ten thousand years ago when people started cultivating crops, they selected from the wild. There is a huge amount of variation in the wild ancestor of rice. *Oryza rufipogon* is the wild ancestor of cultivated Asian rice. We have only captured about 40% of it through the domestication process, so domesticated varieties are much less diverse than the wild populations. In maize, about 75% of the variation in the wild has been captured in cultivated varieties. As a naturally cross-pollinating species, maize is continually out-crossing with its wild ancestor, while cultivated rice is naturally inbreeding and rarely crosses back to the wild. In wheat only 30% of the diversity found in the wild ancestors has moved into the domesticated forms. There is a lot of genetic variation in the wild ancestors that we are not accessing in modern agriculture or in even traditional agriculture and it is actually sitting locked up in the wild species. A great deal of what we do in my research program is to go back to the wild and selectively bring in new variation that improves the performance of our elite crop varieties. I call it "new" but it is actually ancient variation. We bring it into the cultivated lines that we are working on, using crossing and selection as our way of accessing the natural forms of genetic variation.

I want to just mention the International Rice Research Institute in the Philippines because that is where the largest collection of seeds, of diversity, diverse seeds, sits. Ruaraidh Hamilton who manages that gene bank (or seed bank) will ship you an accession or a source of those seeds free of charge upon request. It is an amazing thing-- we still have something that is almost like a lending library. We have destroyed a lot of what used to exist in nature. But we had the foresight to collect all those seeds and preserve them in our gene banks. This means that some of the variation which would have been exterminated, is now accessible. In 1966 when the gene bank at IRRI was introduced to the world, at the beginning, people were asked to send seeds. They sent bags of seeds from villages in Nepal, from farmers' fields in India, from regions of Thailand, and backwoods of Borneo. They sent packages of seeds in paper bags in the post. They arrived with handwritten explanations of the variety name on them in Thai, in Hindi, in all of these amazing languages that are written in different formats. They had to be translated into English. This is part of what Ruaraidh does. He is probably the world's most knowledgeable person about what is in the gene bank at IRRI. It is an amazing thing to realize that all those hand written words had to be translated, seeds had to be put into boxes and bags, and regenerated to make sure the seeds were alive. Today, the gene bank is a fairly sophisticated seed repository, and it works much like a lending library. The seeds are in fact, as you know, living organisms. They have to be kept dried and frozen to retain viability over a long period of time. When you get them, if you give them the proper water and moisture and temperature conditions, they will grow. This is the job of the seed bank manager. It is

to make sure that the variation is there and when he sends it to you, it still grows. I won't go on and on about this except that I think that the seed itself is such a miracle. Last night we had a discussion about sake, which is derived from the endosperm. Of course it is the embryo that is going to give rise to the living plant, and that is what the plant breeders are most concerned about. We plant seeds with living embryos and we grow a lot of wild and exotic accessions, we make crosses between them, and we try to introduce new variation that will actually improve the performance and the adaptation of the varieties that people like to eat. The variation could come from varieties that are ancient. They could be the red rices, the purple rices, the black rices, the long grain rices, or the short grain rices. You name it. We can make crosses and we try to improve their traits in ways that improve their adaptation and performance. Currently, a major issue of our time is resiliency in the face of climate change. A lot of resilient traits reside in crop wild ancestors, whieh have helped them survived for tens of thousands of years, since long before agriculture. We are really interested in accessing the genetic potential of wild accessions.

I want to say thank you from the lab group at Cornell. Some of our members are here today. One of the things that the grant is doing is funding a website. It is www.ricediversity.org. I forgot to download a picture of the website but if you go on ricediversity.org and you look under the "Other Resources" button you will find "Ecological Rice in the Northeastern United States". That is the website for this group. Right now it is accessible through our project, the ricediversity.org website. It is a standalone. Anyone can help develop it and add to it. It is a listserv. At the moment it is run by Mia and Darcy. We encourage you to use it. You can send in questions and queries. Make sure you get your names on the listserv if you want to engage. One of the things we said we would do is to provide that website and try to initiate ongoing dialogue. The web site doesn't belong to the Rice Diversity Project, and we hope it will continue to exist long after the Rice Diversity Project is no longer funded. We are just starting to launch now. With that I would like to thank you for your attention and pass it back to Mia.

Rice Growing and Conservation: Takeshi Akaogi

Thanks for coming today. My name is Takeshi Akaogi. I am growing the rice you see out there in the paddy. I am going to talk a little bit about the wildlife conservation component of rice growing which I am still learning about.

I built the smallest paddy in 2006. As soon as I built that paddy and flooded it, dragonflies and frogs just showed up all by themselves. I became interested in identifying them and learning their life cycles. During the course of doing this, I started to learn about watershed and wetland issues. I learned the most interesting but saddest thing. We had 200 million acres of wetlands before European colonization. In 200 years we have lost half of them. We have lost half of the natural wetlands already and we are still losing them. With that in mind, I am now thinking that introducing rice growing to the Northeast can mean restoring and creating wetlands. Instead of small ponds in golf courses, we could do it in a little more meaningful way. The greatest benefit from this is that we have a grain and it is very productive. There is also good support from academia. Today I just want to show some things.

First I would like to show our rice paddy, what it looks like and how it was constructed. This is what it looks like right now. This past May. There is a pond and three small paddies. On the left side there is a small swale, which drains excess water when needed. We started building in 2005. During the

summer, I just tilled the wet area. Next year, in the early spring, I used a shovel and wheelbarrow and obtained seed from the West Coast. The variety I used was Koshihikari. You can see that they did grow very well but we didn't get any seed that season. They didn't start heading up until September 1st and the seeds didn't mature. During that winter, we started looking for seed and first contacted Susan that spring. We got some seed from Gen and also from the National Small Grain Collection. We tried them out. They grew nicely and in September most of the varieties had ripened. In August, we could tell that they looked promising and we contacted the Vermont Department of Agriculture and they were willing to provide some funding for the construction of additional rice paddies. We mowed the area. This is from the south before construction. A week later with big machinery it was constructed. This is the pond before the liner was put in. Remember it was dry land and it was transformed into a rice paddy system and looks like a wetland now.

I am talking about the rice paddy system as a man-made wetland. I would like to go over natural wetland functions. Hydrologically, there is flood control, erosion control, water filtration and purification, and groundwater recharge. Biologically, wetlands support a rich diversity of organisms. Lets go back to flood control and how it works. Imagine if we had 6 inches of rain today. It would all get stored in the rice paddy system and slow down the flow downstream. In that way flooding would be reduced. Not 100% perfect, but definitely an improvement. Erosion control usually refers to a mudslide or something like that. In New England or the Northeast, most farmland is gently sloped. If you imagine heavy rain coming all at once, it doesn't matter if it is covered with grass or protected; it always erodes an unbelievable amount of soil. With rice paddies the land is completely flat and there is a bank that surrounds it completely. They can hold a certain amount of rain and the soil doesn't move. This can be applied to regular vegetable crops or an orchard in the same way. You can build a terrace and carefully drain the water. Water filtration and purification is another important aspect. When water runs through a wetland nutrients or sometimes pollution is reduced, absorbed by plants or by microorganisms in that area. The out flowing water would be purified. This rice paddy also does same thing. If you put very rich water in one side and from the other side you measured the nutrient levels there would be a significant difference. Just running the water through the paddy reduces nutrients by a significant amount. Groundwater recharge is more long-term but very important. We lost half of the natural wetlands already. That means half of the ability to recharge. Not actually half because naturally wooded areas also recharge to some degree but wetlands and rice paddies do as well. Unfortunately, my rice paddies do as well. One of the paddies, the one on the south side, probably use 3-4 times more water than the middle one. We tried to make it the same way and we were hoping it would have the same ability to hold water but there isn't as much clay content in that part. If you go to the west of the Green Mountains, you have lots of clay. The third paddy recharges really well. Now the last aspect of natural wetlands, biodiversity. This is the thing I am going to talk about today. Before I explain more, I just want to run a slideshow with music. These photographs were taken during the last several years both of the rice paddies and wildlife. I just want you to feel how the rice paddy changes from spring to fall.

["Seasons of Change" slideshow, available on www.ricenortheasternus.org]

I would like to show one more thing. I recorded frog breeding songs on three different days. The first one is from May 19. There are three species singing (Spring Peeper, Gray Treefrog, and American Toad) so you have to pay attention. Then a week later, there is only Gray Treefrog. It is very loud. Then in early June, the Treefrogs have passed their peak but you can still hear them and Green Frog comes in.

[Frog breeding calls audio, available on www.ricenortheasternus.org]

Takeshi: Are there any questions so far?

Audience: Did you say that clay soil is best for rice paddies because it holds water best?

Takeshi: Clay usually holds water better. The amount of clay content matters greatly. If you have more clay in your soil, it holds water better.

Audience: What about the depth of water in a rice paddy? What is the best depth to have?

Takeshi: I cannot answer that question but I can tell you what I do. You will find out over the course of the day that there are many different approaches, different depths, different timing, and different ways. I will explain later what I do here.

Audience: When we were here last September or August, you were having a lot of birds come in to eat the seeds. What kind of impact did that have on the production?

Takeshi: It does greatly reduce the production. They like when the grain is not fully ripened or mature yet. When the grain is at its most juicy stage. English Sparrows come and chew, not eat, the grain. The result is no grain afterward. You have to do something about that.

Audience: All the animal observations, are they recorded? Is what you are observing somehow communicated? It is a very rich observation.

Takeshi: You have to go a little bit back. This was dry land that was turned into wetland so I can see the changes much easier. I was working around the paddy every day. Not all the time but every day I would be there for 5 minutes for watering and I could see lots of things coming in and going out. That is why I started learning how to take photographs. They are not all good photographs and I am missing a lot too. This is not a scientific study with clear numbers but I wanted to visually record the change each year of all the different species that are showing up. The number of individuals is also increasing. That is pretty astonishing.

Audience: I hear you say that after the rice is headed up, which would be in July?

Takeshi: Depends on the variety, but middle of July.

Audience: That's when it does in my little white bucket paddy. If the temperature goes below 50°F and it can in July the pollen will be destroyed? Did I hear that correct?

Takeshi: It is also depends on the variety but even the hardiest or cold-tolerant varieties, if there are 3 days of continuous temperatures below 55°F probably half of the pollen is destroyed.

Audience: Would that be for the entire period or just for an hour at night?

Takeshi: It would be an average. This would be an extreme occasion but occasionally the temperature will go below 50°F for the entire night. If the timing is right, which for some grains if this occurs during a specific stage of development they will suffer more. Before and after this time they may escape any negative effects.

Audience: We had such a cold spell this year but the timing must have been right because we are okay.

Susan: Heat will do it also.

Audience: We had that too.

Susan: Depending on the variety, pollen will become sterile under cold conditions or excessive heat.
Audience: By excessive heat do you mean over 95°F or over 100°F?
Susan: It all depends on the variety. That's one of the things we breed for.

Audience: You said that the first season you tried to grow Koshihikari. It is widely contended as one of the best quality varieties of Japan.
Takeshi: And for south of here but not for Akaogi Farm.
Audience: I wonder what the market for that is in the USA and would you want to grow that kind of quality here?
Takeshi: Yes.
Susan: We grow that in California.
Audience: What variety is that?
Susan: Koshihikari.
Takeshi: Probably if you live in Rhode Island or south of there you can try it.

I would like to talk a little bit about how to consider the surrounding environment and the rice paddy. Our rice paddy consists of a pond, which stores water, the paddies, and swale. The paddies themselves are shallow, flat-bottomed ponds and are usually temporarily flooded. A swale is a kind of ditch that they usually recommend to keep smooth so that water runs fast but for conservation I think there are other ways. When you think about wildlife conservation there are two things to consider. Not just how to improve your rice paddy to make it more friendly to wildlife but also you have to think about connectivity with the surrounding habitat. Some species, like the Gray Treefrog, breed in the paddy but they need wooded areas for the summer and winter. If you have a paddy without that you cannot do anything for that species. This is a photograph. We are right here. East of us there is a nice wooded, undeveloped piece of land and west of us is also an undeveloped hillside. The entire ridge is called Hickory Ridge. We are kind of in between these two pieces of undeveloped land. This is a little bit closer view. You can see the paddy and this is the neighbor's pond, which is the closest pond. There is a pond here and a small pond here. If you look carefully you can see that a connection exists that I didn't even have to create. There is a property boundary line that is trees. You can see the tall trees and underneath probably 10-15 feet of brush. I planted windbreaks 25 years ago and planted more around this. The orchard is surrounding the west and north sides of the paddy. This side is vegetable gardens and this is a meadow. If you have 50 acres of land to manage or 100 acres to manage, you can think a little bit more about designing your landscape without sacrificing your production. You can add all the wildlife connections into your landscape.

Another important thing is water management. In order to explain this, I calculated growing degree days for the last 10 years. I just calculated from May 1 to September 30 to get a rough figure for the rice growing season. I have only one year of records for Akaogi Farm, which is for 2009. The blue color indicates the coldest year and the red color is the warmest for each location. In general, 2009 was the coldest year in the decade and 2010 was one of the hottest. Akaogi Farm is one of the colder locations along with Ithaca, New York. Ithaca is cold too but not as cold as Quebec City. It is at a little bit higher latitude. With that in mind I figured out my water management, which was a question that was brought up before. I didn't plan my water management for wildlife conservation. I just figured out for growing rice what would be the best way for this short growing season. The white part indicates a dry paddy because this is during transplanting and preparation. After transplanting, I

flood right away. That is very important for the early stage of rice growth and for extending the season. During May and even during the middle of June, a late frost is not a surprising thing here. If you have a frost without water, most likely the rice plants will be killed. If you remember late frosts usually happen on a very calm day. During the day you have beautiful blue skies without wind. If you fill up the rice paddy with 4 inches of water it will warm up a lot during the day. Even if a late frost happens, most likely your paddy will have no problem. Another problem I discovered this year that can happen during the same time is gusts of strong, cold, dry air through your paddy. It will just kill the rice plants. If you have water in your paddy it will also protect against that. During the second stage, end of June to July, is the reproductive phase I mentioned before. I increase the water depth gradually up to 4 inches or 6 inches. If needed up to 8 inches of water for the coldest places to protect pollen development. This is what I do and we don't know what is going to happen in the future. Some years, like 2009, when the Northeast experienced a cooler year the rice certainly needed protection. Without that you will lose a lot of grain. Toward the end of the season, from now on until harvest, you can either keep the paddy flooded or just keep it wet. I try to keep it flooded all the time because it is easier to manage. At this time the plants are already mature and established and they need a large quantity of water. It is difficult to remember to keep an eye on the water level. If the paddy is too dry cracks can develop and when you fill it up again with water the water won't stay in the paddy. You won't be able to hold water in the paddy anymore. It will drain quickly. I am thinking that for next season I will change a little bit how I manage the water. During May I will keep the paddy wet. All the amendments, adding compost and fixing the side walls, will be done in September and early October. It will be flooded for the rest of the season. That is an easy way to manage water and probably the best for wildlife conservation.

This table is a comparison of different water management strategies. Other people here today can help out with all the other methods of water management. I just made a table with general practices for other approaches to growing rice in terms of water management. Akaogi Farm keeps the paddies flooded all year except for in September because of agronomic reasons. For the SRI method, they recommend wetting and drying during the early stage to make weeding easier and they think it helps produce a better crop. Toward the end of the season, they recommend shallow water, an inch or two. Furuno's duck and rice farming deals with ducklings so you have to have water during the early stage so that they will mix the soil and eliminate weeds. Towards the end of August, I think you have a choice either to drain and occasional flood the paddy or keep it flooded. A typical Japanese method is to flood for a while after transplanting is done.

Takeshi: Gen, is it before flowering or heading out that you want to dry the paddy out once?

Gen: Actually, some farmers dry out a couple times a couple weeks before the first flowering.

Then after that, many growers wet and dry until harvest. Fukuoka grew barley during the wintertime and harvested it around June. During that time the paddy is completely dry. When he harvested the barley the rice seedlings were already growing underneath with a heavy groundcover of clover. He usually floods for a week or two weeks, depending on the weather and how much water is available, until the clover is established. Then he wets and dries the paddy until the rice is ready to harvest. I wasn't sure about water management in California. In the early spring they cultivate and spread seed and keep the paddy flooded all the time.

Takeshi: No? Could you help me with that?

Peter: They cultivate the soil and then they flood. They let the water clear and then they fly over and seed by airplane. But I don't know if they drain out the water.

Susan: Is it drained when they drop the seed?

Peter: Sometimes it is dropped right into the water. When I was there I actually saw the seeds being dropped into the water.

Takeshi: After that you keep it flooded?

Peter: Yes, they keep it flooded.

Takeshi: Through the rest of the season.

Peter: They have an area next to the paddy, which is for wildlife, birdlife, so they need to keep water for them. They use a lot of water.

Erika: Maybe for the SRI method, make a correction for the vegetative state. It should be wet and dry. During the reproductive and ripening stage is when water is introduced and at the end for harvest the paddy is dry.

During harvesting time the rice paddy is dry for all the methods. If you look at this table there are many different ways to manage water and they are related to other decisions you make. From the conservation point of view you would like to have it flooded all the time, as long as possible and continuously. Any method you choose there is probably some way to consider conservation concerns if you know more about each species' life cycle and habitat requirements. You can target those species even if your method is completely different than my approach.

This is something that Mia and I put together. Some questions. This is going to be part of the roundtable discussion and we can discuss them then. For the closing, I just wanted to show how introducing rice to the Northeast is related to various issues. For agriculture there are important things, for conservation, and of course you can use this for education and for a residential backyard. Dragonflies can fly long distances. These are just my thoughts. Mike will talk about this more soon and will have more accurate information. As a community, we should get together and dig a small pond and create more wetlands. Or we should do what Erik did. Invite high school students to come and help transplant or harvest the rice and learn about agriculture and get wet and at the same time they can get some sense of the wildlife too. I think the two most important things are creating rice paddy systems, growing rice, and creating and restoring wetlands. This is a very significant thing even if it is not done at such a large scale. We can add small things here and there while at the same time the grain production adds more diversity for the farmers and the consumers. Those two things will happen at the same time and that is my closing message. Thank you.

The Natural History and Conservation of Pool Breeding Amphibians in Windham County, VT: Jim Andrews

I am Jim Andrews. I am an Adjunct Associate Professor of herpetology at the University of Vermont. I have coordinated a project, The Vermont Reptile Amphibian Atlas, since 1994 to try and get an idea of the distribution of reptiles and amphibians in the state. This includes a lot of citizen science and getting folks like yourselves to contribute records of what they have been seeing. We are really pleased with the maps that we have been able to generate and it is with that information that we can then make what we think are appropriate conservation recommendations to the Endangered Species Committee in Vermont. I chair another committee called the Scientific Advisory Group for Reptiles and Amphibians in the state. We use the data we gather to try to make conservation recommendations.

I am really pleased that this farm as we have heard is spending so much time and has given so much thought to conservation of wildlife species, reptiles and amphibians and other species. Takeshi did a tremendous job covering a lot of the things you need to be concerned about, connectivity,

hydroperiod, etc., in terms of what species might be able to persist in the wetlands that you create. Indeed most of our wetlands have been drained, filled, etc. In Vermont we continue to do that at a rate of about 200-400 acres a year for the smaller wetlands because they don't get the kind of protection that the larger wetlands do. We are continuing to lose them annually in the state. A lot of these little wetlands didn't initially get any attention and didn't get mapped. For a wetland to get protection in the state it has to show up on a National Wetlands Inventory map. Some seasonal wetlands and many small wetlands don't show up on that map so they don't get protection. Unless somebody goes out personally and finds them and adds them to a list, they don't get the attention that they should get. We are losing many of them and habitat loss is definitely the major cause of diversity loss worldwide. Although it gets less attention than global warming, which certainly needs more attention from us, habitat loss and the whole idea that we can have perpetual growth and continually consume more and more wildlife habitat is bogus. We cannot. We cannot do that any more than we can continually consume more and more farm habitat or forest habitat. There is a finite amount and we have to decide somewhere, okay here is the line. This population isn't going to grow beyond this point and our needs cannot grow past this point. We have to draw those lines and sometimes they are tough lines to draw. However, loss of habitat has been the primary driver of loss of wildlife diversity and of course it is connected to our standard of living and that is connected to our population. In addition, we have been hearing more about global amphibian declines and those are a combination of not only the loss of habitat but of a disease that we are now spreading around, chytrid fungus, that has spread over much of the world. Unlike things like Dutch Elm Disease that have come here from other places in the world, it may well be that chytrid fungus was here and we are spreading it elsewhere because our species are pretty well adapted to that fungus. They have had that fungus for a long time and they are persisting. We don't see the big declines as a result of chytrid that South America or Australia do when chytrid gets there. We have had it and it is been around and our species have adapted to it somewhat. Not that it can't kill them but we are far more adapted to it.

The other point, other than just plain habitat loss, climate change, and disease spread, is that the whole idea of connectivity is tremendously important. We have a species here that most of you have seen, if you are local, which is the Red Eft or the juvenile stage of the Eastern Newt. You see it after it rains. You go out for a hike and you see lots of these little bright reddish/orangish critters with black spots. They can move around during the day as long as it is wet because they are advertising their toxicity. All amphibians once they dry out are dead in a matter of hours. If you take the same hike on a dry day you won't see the amphibians. They have got to hide. They tunnel under the leaves, they tunnel under the rocks, or they go under the course woody debris, which we all need to manage for, dead trees, etc. and hide until things get wet again. Then they can come out and move around again. But in Vermont we kind of take that species for granted, the Eastern Newt. Whereas a colleague of mine in Rhode Island, Chris Raithel, talks about that being a relatively difficult species to find in Rhode Island. Why would that be? Well, there are two pieces of information that I will present. One is, his claim, which was about 10 years ago, he said Rhode Island is about 20 years until build out. I said, "What do you mean 20 years until build out?" He said, "Within 20 years we will have developed all non-conserved land in this state." If it is not already conserved, at the rate they are developing land, within 20 years all of it will have been developed. That was about 10 years ago so I suspect right now that rate has probably slowed down a little bit. It is a good thing that at a time of economic decline, our rate of land consumption slows down. When that happens your conserved pieces of land become little islands scattered across the landscape. We heard about the importance of connectivity. If your habitat are little islands and you are a Red Eft, a stage of the Eastern Newt that is dependent upon movement, you might move a mile or two from one wetland to another one.

Beaver dams are natural transitional wetlands. They come and go as beavers run out of food. If they eat most of the food in the area of their dam and pond, they kick the kids out after about a year and even the adults will leave once they run out of food. When that happens, they go upstream or go into a different watershed. The population of newts that is in that pond will wash downstream because the dam is going to rot and when we get a heavy rain it is gone. That is okay because you have all your little colonizers, all your little Red Efts, out there running around the countryside and when they mature they drop into a new beaver pond somewhere and the population builds up. That kind of connectivity is required as populations move across the landscape. But in our conservation design we have created little islands of wildlife habitat. Sometimes we have uncrossable territory in between these conserved islands, whether it is an interstate, a city, or a neighborhood that they can't recolonize across. It is a concern, movement.

I am going to start with the life history of some of the frogs that you might be most familiar with, like this one the Green Frog. The Green Frog has these dorsolateral ridges. Those ridges right there help us out in the identification of frog species. We have three species of frogs with these green upper lips: Green, Mink, and Bull. Mink is kind of a northeastern rarity so I am not going to talk about that one too much. Bullfrogs and Green Frogs are permanent water breeders and our summers aren't long enough for them to mature. They are going to lay their eggs, they are going to grow to a certain stage in the tadpole life cycle, and then they are going to have to overwinter as tadpoles because they don't have enough time. They have to go through the first winter as a tadpole and they may have to go through two winters before they then grow their legs and mature.
Audience: And they lay their eggs late?
Oh yeah. Because you are adapted to permanent water the assumption is that it's not going to dry out so you are in no hurry. If you are a Wood Frog, you have to get there early, lay your eggs, hatch, go through a larval stage, and get out before the rice is harvested or before the wetland gets dried up so you are in a hurry. But these guys are in no hurry. They are in permanent water. They will start laying their eggs late May-June and have plenty of time but if you dry a wetland you are not providing breeding habitat at least for these guys. All amphibians need to stay moist. In order to stay moist the trick for Bullfrogs and Green Frogs is to just sit here in the pond or very close to it. They are not wandering around in the woods a lot, at least not on a sunny day. They would dry out too fast. On a wet day, it may surprise you when maybe you find a great big green frog in your swimming pool because it was out cruising. It was out feeding. It will feed on worms, salamanders, or anything that comes out on those rainy, wet nights. They will travel on land and feed on land and feed on all those different things. We had a Bullfrog that we caught one time that had eaten a chipmunk, which was quite a surprise to us that it had managed to take down something that big. That guy is not a Bullfrog, that's a Green Frog. He couldn't quite handle a chipmunk but they get big. The other trick is if you are a young permanent water breeder (Green, Mink or Bull) and you stay around home, mom and dad are going to eat you. It is pretty simple, pretty straightforward. You better leave. One study of Bullfrogs showed that 70% of the diet of the adults was young Bullfrog. You produce plenty of kids then you can eat some of them. You can get some meals out of those that stick around. Those Bullfrogs that have the initiative to take off, good for them. If they don't, eat them. What you will see almost anywhere that you create a wetland, you will see youngsters show up because they are just dispersing. They are just getting out of wherever they were and it may be your swimming pool, it may be your rice paddy, whatever. You will see lots of young. But just seeing young doesn't mean that you are going to establish a breeding population. They may move through, they may stay wet there, but they are going to have to keep on moving. You are not supporting permanent populations of these guys but they may try to breed because they don't know whether it

is permanent or not. They may try to breed but the tadpoles will get halfway through development and that will be the end for them. There's the Bullfrog.

Takeshi: Jim, one thing I would like to say, which I forgot to mention before, is that the rice paddy is very shallow and full of sunshine. It is much warmer and also we amend with chicken manure before transplanting, which stimulates all the microorganisms. There is abundant food. I have observed that they can transform before September.

Jim: Is that a question or do you think you have seen it?

Takeshi: That is what I have observed. The rice paddy situation is a little bit different from a natural wetland because it is so much warmer.

Jim: Because of the temperature and nutrition? I would want to check that.

Mia: You could do a study.

I pointed out the dorsolateral ridges so that you could see that on this one, it doesn't have those ridges on each side of the back. Green face, green upper lip. This is a permanent water frog. This is the Bullfrog, lacking those ridges. Both species have these bands going across their legs going at right angles to the axis of the legs. The Bullfrog again is going to be hanging around in the wetland and it can start breeding late but unless you had a tremendously productive season I would not expect those to be able to metamorphose in one year. I would think it would take at least one winter if not two. There's a Bullfrog tadpole. They get huge. You can see these fine well-delineated speckles on the top part of the fin that tell us Bullfrog versus mottling there on Green Frogs. They lay these films of eggs and they lay the eggs right where the emergent vegetation is. A rice paddy is perfect because it has emergent vegetation everywhere and they like to use that because the tadpoles are algae scrapers. They are feeding on algae. Any surface that algae can grow on is a food source for them and they are scraping away at the algae.

Audience: Is that true for all species of tadpoles?

Jim: It is true for all species of tadpoles. They are primarily algae scrapers. A couple of them, like Wood Frogs, will become carnivorous if pushed to the limit and there is not enough other food. But, primarily they are all algae scrapers.

Audience: Not mosquito larvae?

Jim: Not the tadpoles. It is the salamander larvae that are going to help you out there.

Audience: Are these native Bullfrogs?

Jim: These are native Bullfrogs and you bring up that question because there are areas of the world Bullfrogs have become invasive. They are another one of those species that has been introduced to different places around the world and have become an invasive species. It has been introduced because it is a huge frog and you get big legs out of it for frogs' legs. They are considered a gape limited species. They eat anything that they can get in their mouth. If their mouth is big enough, they will eat it. When Bullfrogs end up in Washington or California they eat the frogs that were there to begin with and so there are concerns about competition with native species. Each one of these females are producing a couple thousand eggs and out of those couple thousand eggs over the course of the lifetime of that Bullfrog, let's say it is maybe 15 years, in order to keep its population up it has to replace itself, one, and its mate. Two of those frogs have to survive to adulthood. The other thousands of frogs are food for everything that you could possibly imagine: snakes, toads, hermit thrush, green heron, blue heron, gull, skunk, fox, coyote. All those things are eating all the rest of those young. Whether they eat them as tadpoles, they may, or when they metamorphose, which they have done by now and you are seeing the little green frogs running around right now. Those are food for everything as well.

We do have these other breeders that are not permanent water breeders. They are temporary water breeders. They are adapted to ponds that dry up. The advantage being that if it dries up, you have fewer predators. There aren't going to be fish in there. Even if it dries up every three years, it is going to knock the fish population either down or out entirely. You will have fewer fish and you will have fewer of the other big predators, the newts. The newts are big predators of the egg and larvae of the other amphibians. Newts really do best in permanent water. By either naturally or artificially drying these wetlands out, you are keeping predator populations low and allowing these temporary water breeders the best advantage that they can have. Wood Frogs are the most sensitive to predation. Even the tadpoles, the algae scrapers, of the Green Frogs will scrape away at their egg masses. The egg masses will just fall apart and if you have dense enough populations of Green Frogs, the Wood Frogs won't survive. It is not that the Green Frogs are actually eating their eggs. We have not proven that yet. It may happen but they are just scraping away at the masses.

Here you are seeing a pretty typical situation, amplexus. At this time of year the males would be darker. The females would be the lighter red ones. They show absolutely no discrimination at all. You will occasionally find Wood Frogs hanging on to cattails, dead mice, or whatever happens to be floating around in the pond. They will grab it and hang out to it until it lays eggs, which may be, in the case of a cattail, a long time. Then again, they don't need to be really smart about it. When they succeed they get a lot of eggs out. In this case we are not talking thousands. We are probably talking 700 to 1,000 eggs. This is the first amphibian you hear calling in the spring and it has a clucking noise. It is one that you didn't hear in the tape. Wood Frogs are earlier. It is kind of a clucking or quacking sort of noise. They are the first breeders. The push is they have to get there and get their eggs there as soon as possible because the pool might very well dry up. Not just the amount of rain we get but the timing of rain is tremendously important. One thing that concerns me about global warming is that we get these massive storms, which are nice well maybe nice, and then we get nothing and then we get another storm. If it dries out in between, the guys are dead. It doesn't matter what the total was. There has to be water dispersed throughout the year. The eggs will survive maybe for a couple days but not long.

Takeshi: About water temperature for tadpoles, do they need cool temperatures?

Jim: No, I don't think that they need cool temperatures. These guys are ectotherms. The loose term is cold blooded but ectotherm essentially means solar powered. We are so inefficient as organisms, mammals, because we have to eat all the time to keep our body heat up. We burn a heck of a lot of fuel just to keep our temperature where it needs to be. They are using the environment, moving around in the environment to keep body heat up. They just need their fuel for reproduction and tissue growth and that kind of stuff. They are way more efficient than we are but they are dependent on the temperature. If the water temperature is warmer, that will probably just speed up their whole process of development. I have not heard of any danger.

Takeshi: In early June when the plants are quite small and the sun is strong, the rice paddy is probably around 80°F sometimes 90°F. Other species seem to be fine, but Wood Frogs seem to be having a problem.

Jim: Your feeling, is it because you are seeing dead stuff?

Takeshi: Yes.

Jim: You think it is getting hot enough that it is actually killing the tadpoles?

Takeshi: I don't know if it is that or a virus. I don't really know the reason but I have been wondering. At the same time, other species like Gray Treefrog or Green Frog don't have a problem.

Jim: All that I can say there is that I haven't read anything in the literature yet about too warm temperatures being a problem. But, you are certainly right that they would normally arrive at ponds that would be something like 40°F, maybe 4°C.

Audience: Wooded cover, canopy cover.

Jim: Yes, often with wooded cover. Unshaded they are going to heat up. Shallow they are going to heat up. I could see how there might be issues but I have never read about them.

A Wood Frog is such a cool critter. He is a nice example of connectivity because other than those permanent water breeders most of the rest of your amphibians are only in there to breed. They are in the woodlands the rest of the time. This guy ordinarily undergoes metamorphosis in I would say mid-July is pretty safe, mid-June would be the earlier ones. One of the things that these guys can do is develop faster and metamorphose faster if conditions allow that to happen. They may metamorphose at a smaller size and if they do that there is some additional risk. They do not want to leave a pond before they need to. If they can continue to stay as a tadpole in the pond where it is safer and metamorphose at a bigger size, more of them are going to survive. If the pond is drying up, heating up, they will metamorphose sooner at a smaller size. Then as soon as they have metamorphosed (they have gone through the tadpole stage, they have developed their back legs, and they have developed their front legs), they are looking for wooded, wetland areas. Where those might be, I don't know but somewhere nearby. They are headed out looking for those wooded wetlands where they are going to be feeding in the ferns and the herbaceous vegetation down at the bottom of those wetlands. It is ground but wet ground. They are feeding in those areas and then when winter comes along, they dig into the leaf litter and they actually freeze, which is just such a cool thing. They freeze (heart stops, breathing stops) and then in the spring they thaw out and go back down to the pools. When they freeze they have to have the fluids between the cells freeze. If the cells themselves freeze, then the cells will expand. When the cells expand they break and you have done cellular damage and are in trouble. What they do to protect themselves is concentrate their sugars in their cells. They essentially have sugar antifreeze in the cells, which allows them to super cool maybe to about 20°F. That usually is fine if you are under a blanket of snow under the leaves. If we get a rain mid-winter and we lose our snow cover and then it gets cold and then it gets really cold, so maybe it is -10°F for a week, then the depth to freeze is pushing down. On those years when you lose all your half hardy plants, rose bushes and that kind of stuff, you are losing your frogs and garter snakes and other things that were down at a depth that is usually safe but that winter the depth of freeze went down just too far.

Audience: Some of them do of course make it. Are they deeper?

Jim: Yeah, one of the things that we really try to encourage and that they are taking advantage of is deep leaf litter. That is one of the concerns now about the introduction of worms because worms are depleting leaf litter. As worm species are spreading away from fishing areas, gardens, etc. they are depleting the leaf litter depth and so in some places you may go into the woods and see roots. If there are lots of worms around you just see roots. You are not seeing this nice deep layer of leaves. What we are assuming is that the frogs that survive during deep freezes were deep enough or they were in some nice little shaded pocket that kept the snow. maybe on the north side of a hill or maybe they were in some little ravine. Those would be better areas.

Audience: Are we talking about Gray Treefrogs and toads here also?

Jim: We are talking about the four species that can do this: Wood Frog, Spring Peeper, Gray Treefrog, and Chorus Frog.

Audience: What about toads?

Jim: They can't do it. They would freeze and die.

Audience: Where do they hibernate?

Jim: They dig but they have to dig deeper. They are expert diggers.

Audience: Do they go in the duff in a coniferous area?

Jim: You don't find them as often. Amphibians in general don't like conifers as well. Whether that is the acidity, the dryness, or it is just a whole different set of invertebrates. Relatively few that live in the soil. I am not sure. If you have some pine plantations somewhere it is pretty dry, pretty sterile down underneath and pretty acidic. For most amphibians they like dense hardwood litter. One of the things that are ideal is sugarbushes, big old Sugar Maples. They just like those Sugar Maple leaves and they develop a nice big thick layer of litter. If you got your sugarbush right next to your rice paddy then you got a nice balance there.

Now this is one, you will see my little note there that it is not found on this farm. Northern Leopards would be one that could definitely move into a rice paddy but they are a little different. They are unique in that I call them a three habitat frog. They are a permanent water, wintering frog. They need permanent water to spend the winter in. They have to get down deep enough to overwinter. There has to be water around somewhere that is permanent. They lay their eggs in floodlands. It could be the paddy. They could move into the paddy and lay their eggs and they could develop and they could metamorphose and get out right about now. Once they leave the paddy or other flooded land they feed in grasslands, sedges, or cattails in open areas. This is the third habitat that they require. After feeding in the grasslands they will then move to the permanent water to overwinter. This permanent water has to be deep enough so that they could actually be underneath the ice.

Audience: Can it be plastic lined?

Jim: Sure it could be. The concern is going to be predation because these guys are a big food source. There they are lying around the bottom of these permanent water bodies and there is not as much food for fish in the winter. Ice fishermen often talk about cleaning their fish and finding Northern Leopard Frogs in their stomachs. They are just probing around feeding on these guys. Certainly you can have a plastic lined pond. By the way, fish don't coexist really well with most of these species of amphibians. Wood Frogs are not fish tolerant. Many people build ponds, like decorative ponds or fire ponds, and want to introduce fish. Well you can have fish but it is not going to be as good of an amphibian pond. You can do that but you are managing for something else. Yes you could have it plastic lined. There are two concerns: predation and dissolved oxygen. If dissolved oxygen gets low enough you could potentially have a winterkill. Frequently, you will find the frogs using the area where the spring is, where the stream comes in. There are a few other situations that really surprised me. I was in Prince Edward Island and it was a fairly shallow manmade dam. They left the dam and went into the river. There was a migration that took place. They got out of the dam and moved into the river and were under rocks in the river because the river maintained a water flow and the dissolved oxygen content was higher.

We have two species with these fairly defined spots: Northern Leopard and Pickerel. Northern Leopard is the lowland species and Pickerel is the more upland species. They have really compact egg masses, less jelly more embryo. Really compact egg masses with a couple thousand eggs. Leopard Frogs have black and white polar eggs, two colors. This is Shelburne Pond and it gives you

a feel for one of the habitats that they would persist in. They would overwinter out here in the deep part of the pond. Then they would lay their eggs in the shallow margins, the floodwaters, or the little pools that are scattered around in the wetlands. They would feed in the dense annual vegetation. They are unusual in that they are not a woodland species. They do not care about woods at all. They can feed in a sheep pasture or cow pasture. They feed in the annual vegetation and then go back to the permanent water.

Audience: How deep does the water need to be?

Jim: For breeding, they are just looking for shallow water a foot or two deep. For overwintering the trick is to be deep enough so that you don't get frozen. Below freeze depth. What, three feet? It gives you at least a foot underneath the ice.

This is what we know about the distribution of Northern Leopard Frogs. It is really a Lake Champlain Basin species, primarily, where it can get all three of those habitats in this lowland habitat. We have these scattered populations that have showed up in other areas. Why it is so unusual along the Connecticut River has always been a question for us. It may be because the water levels of the Connecticut River are pretty well controlled with a whole series of dams. It doesn't flood. It doesn't provide the floodlands that they might want to breed in. We are not talking just flood for a little while. They have to get out into those wetlands, breed, and go through their tadpole stage and get out before they drain. We are not finding them in most of the Connecticut River Valley but they are fairly abundant in the lowlands. They can be tremendously abundant in the lowlands of the Champlain Basin.

There is his upland relative, the Pickerel. It likes nice clean cold water. We don't really have a good handle on where it overwinters. Some of them overwinter in wetlands and seepage areas. Some of them in wet caves but I don't think we have enough caves to keep all these guys happy. We don't have as good a feel for where they overwinter but they breed later, say May. They do emerge in the same year so were you to dry a pond in September/October they would be out of there. They have very, very compact egg masses but these are a whole different color. These are brown and yellow, dense, compact egg masses. Eggs are really the easiest way, eggs and calls, to figure out what you have in your pond. Listening for calls or just going out and identifying egg masses. It can give you some idea of how abundant the species is. Unlike Leopard Frogs, Pickerel Frogs have bright yellow what are called flash colors. They can flash that to the predator if they want to so that they can see that bright yellow. In this case, they are advertising a little extra dose of toxicity. Many amphibians have toxins in their skin. These guys have a little more than usual and so they are advertising their skin toxins, which is not an issue for you or for handling them but I wouldn't go eating a lot of frogs' legs from Pickerel Frogs. If you do, well skin them.

Most of you folks are familiar with peepers, at least you are familiar with the call of peepers in the spring. Spring Peepers have no dorsolateral ridges. It is the smallest species that we currently have. They have a little rounded belly and "X" on the back, *Pseudacris crucifer*. Kind of like a crucifix on the back. Ounce for ounce the noisiest frog we have. Females select the males based on the amount of energy they put into the calling and the amount of noise they make. Given a few million years, we have some pretty noisy little frogs. In contrast, for Bullfrogs the sexy ones are the males with the bassy voices. So, you get bassier and bassier males that are selected for over the years. Though there are other males that don't have good voices or don't have the energy and so they go sit next to the males that have the good voices. They are called satellite males and it works perfectly well. You have seen humans do similar sorts of behaviors. Spring peepers are one of those that develop within a course of a year. If you dried the paddy in September, they should be out of there. The exception would be if you had a particularly cold year. If you had conditions where the water stayed cold for

some reason, everything would be slowed down. Development would be slowed down all the way through. The only time I see weird situations is when I see spring fed pools in the middle of the woods where the water is just pouring out of the ground and the water was kept at 45°F or 50°F all summer long. The development of those amphibians, which would normally be fast enough so that would have been out of there, is slowed down and they are still swimming around. It is just cold.

Gray Treefrog, which we saw some great pictures of before and heard the calls of. Gray Treefrog has that neat trill of a call. It is such a cool critter with a flexible neck. I think we can empathize with things more when they are more similar to us as a species. Most of the frogs don't turn their heads. They have pretty fused necks. But these guys will look because they are running around in trees most of the time catching insects. It is a big advantage to be able to watch that ant or katydid coming down the twig. This is another one that can freeze in the winter. They need woods somewhere and leaf litter. They are freezing in the leaf litter. We had a storm on the Middlebury College campus one year. It was about 8-10 years ago and Gray Treefrogs came down. Mid-winter they came down. Some of those frogs were in the trees over winter. They must have been in any crevices that they could get into. A big, big issue would be not having too much surface exposed because if your surface is exposed you dry out and you die. One would think that the temperature would have to be colder if you are up in a tree. One would think it would have to get darn cold but I don't know what kind of minimal temperature they can withstand. Gray Treefrog tadpoles are unusual in that they have red fins, reddish orange fins. They are one of the tadpoles that are fairly easy to recognize if you have them swimming around in your ponds. Once again, should be out by September.

Audience: Can you say something about their chameleon capacity?

Jim: They are pretty cool, *Hyla versicolor*. They can adjust their color. All the young are going to be bright emerald green. You sometimes hear that somebody claims they have found a green treefrog. We don't have green treefrogs. They show up here occasionally when somebody brings their boat up from Florida but otherwise we don't have green treefrogs. Little baby Gray Treefrogs are bright emerald green and smooth. You would find them when you are poking right around the edge of the wetland. They haven't dispersed very far. They are going to be primarily green when they are feeding, up to about an inch in length maybe, in herbaceous growth around the pond.

Audience: What are they feeding on at that point?

Jim: They are feeding on insects that are eating the plant material but the advantage of the color is that they are blending in with their background, which is all herbaceous stuff. Then as they get bigger they are going to head out into the trees, which are white, gray, dark gray, green. Here is when they start using that diversity. You will see dark gray, light gray, white, and green treefrogs. An individual can change based on its background color, which is pretty cool.

Audience: Do they know how they perceive this to drive that change?

Jim: Somebody probably does. I don't know how that is controlled but there are people who do that kind of study specifically and mess around with that kind of stuff. I do know, for peepers and wood frogs you do see color variation but it is just degree of darkness. It is light brown, dark brown. It is light green, dark green. It is not a big change and it has to do with the amount of sun exposure and temperature. The colder it is the darker. The darker it is the darker. The advantage would be, being dark, you can collect more radiation and heat up.

Audience: They seem to have a more intelligent or conscious mating habit. I have seen two Gray Treefrogs sitting side-by-side each other during the day and they come off at night. In the trees around the paddy they seem to talk to each other.

Jim: Most of the calling amphibians will time their calls and they do it kind of nicely. First two are pretty nicely spaced. When there are three, they kind of end up pretty evenly spaced. But then when you get a hundred calling at once, then it is just pandemonium. In terms of more intelligent approach to breeding, I don't think so. It is almost as bad as us.

Audience: They don't pair up?

Jim: No. You would not expect that. Only the territorial ones, the Bullfrogs and the Green Frogs, which are breeding late and hang around the water all the time. They are setting up a territory. Males are setting up a territory and they are trying to attract females into their territory. If they do, then the eggs are laid in their territory and they can eat some of them. When the tadpoles metamorphose, the rest can escape. They will defend a territory from a different male. With Wood Frogs it is just a party. It is hundreds of them in one little corner of the pond grabbing each other and frequently the females will drown. You can find five or six hanging onto a female and you come to the pond in the morning and there are dead females. There are separate calls, which are aggressive calls. You will be listening to your Gray Treefrogs' normal call and all of a sudden you will hear a completely different thing. It is one male getting ticked off at another male and he is driving it out of wherever he is calling from.

Here are the flash colors again, bright yellow on the concealed surfaces of the hind legs that indicates a higher toxin load. I have made that mistake from time to time. If you handle a wounded frog hit on the road, they are pumping out their toxins and so you get them on your hands. Then you rub your eyes, it will burn. You will still be able to see if you don't get into a car accident in the next hour or so because of course I am driving roads at night grabbing these things on purpose. You want to wash your hands when you are handling injured frogs, particularly those with a higher toxin load. There's a little one. A little Gray Treefrog.

Mia: If you look in the rice plants today, when you get to the paddy, you might see some of the little Gray Treefrogs.

Audience: Do you have any sense of how long the Gray Treefrog lives?

Jim: In general for American Toad, Bullfrog, and Green Frog, it might be 10-15 years. Peepers have a very short lifespan, maybe 3-4 years. If you figure in an average of course, the average would be almost nothing. If you factor in all those eggs and figure average lifespan it would be a very small number. First of all you have to figure out once you make it to adult, how long might you expect to live. A couple years for a Peeper, 5 or 6 for a Wood Frog, and maybe 10 for a Green Frog. In that range.

Audience: A large Gray Treefrog might be how old?

Jim: We would guess maybe 4-5 years.

We do have a rare toad or at least we used to in the Connecticut River Valley. It hasn't been seen since 2007. We have two species of amphibian that have entirely disappeared in the last couple decades from Vermont. One is the Boreal Chorus Frog. Charles [Johnson] may have been one of the few people to see Chorus Frogs in the state. The other is Fowler's Toad but the toad that is widespread throughout the state and widespread throughout the Northeast is the American Toad. It has these large warts in these black spots. This is a big female. Females are bigger and they have the high contrast colors. They are prettier, whereas the males are kind of solid brown. This is such a

cool thing. I have to talk about it a little bit. That is a capillary bed. Amphibians don't need to drink. They take in their moisture through their skin. They lose moisture through their skin but they also take it in through their skin. They have a capillary bed with particularly dense capillaries. If they can find a mud puddle they go sit in the mud puddle and soak up the water directly into their blood. If they don't find a mud puddle, they dig and they dig down until it rains again. That's why when we get a little rainstorm and you are driving around some summer night, there are toads all over the surface of the roads. They have dug themselves back to the surface and sadly for them they are feeding on all those dead or injured insects on the road surface. Then many of them meet the same end. Then the crows and the raccoons and the skunks feed on them. These guys also have toxins in their skin. It is just so cool. The more intelligent birds, the crows, the ravens, the jays, they will peel them. They will catch these guys and they will peel them and they won't eat their skins. They will take the meat and they won't eat the skin. Other animals just won't eat them. These are toxin glands. They are called parotoid glands and they produce toxins. Other than kids licking them to get high, which happened with this relative *Bufo marinus*, if a dog or something chews on them they froth at the mouth as if they have rabies. It is a temporary thing. The eggs are so cool. They are strings. They don't lay globular masses. They lay strings that are tangled amongst the vegetation. That is actually looking into a mud puddle. The adaptation that has allowed toads to survive in many drier places than other species is that they develop very, very quickly. They wait for a rain, no matter what time of the year. They wait for the rain, well I shouldn't say anytime of the year but often late spring through early summer. They deposit their eggs and the eggs develop really quickly and metamorphose really quickly at a total length of about ¾ the diameter of a dime. They are tiny, tiny, tiny when they first metamorphose. They are out now. You should be seeing them.

Audience: We had a flood in central Vermont and I have never seen so many little toads. They probably benefited from the additional water.

Jim: They might have had lots of little pools to breed in.

Audience: Is that true for other people around the state? Are you seeing them over your way? I have lived in the area we are for 31 years and I have never seen this many. You can't walk out into the backyard for two minutes without seeing five.

Jim: I think it depends on where you are and what species are common in your area. In the Otter Creek Valley, Northern Leopard Frogs just took off because the creeks were all flooded. There was just a huge amount of breeding and habitat. When that started drying up, armies of Northern Leopard Frogs started leaving those pools.

You can see the little embryos. I am going to switch now to a couple salamanders.

Audience: You didn't say anything about the eggs of the Gray Treefrog.

Jim: They are in small masses.

Audience: In the rice paddy I found just a few.

Jim: To be honest I have less experience with them because I have stopped watching for eggs before they breed, which is late May to June. What I read tells me masses of 10-15 eggs.

This is a Red Eft eating a worm. We talked about Red Efts a little bit. They travel around on land for years and then as adults, they turn green and move to permanent water bodies. They are very adaptable though. Sometimes you will find that even if a wetland dries up, the adults will leave. They will move to the woods and when the water comes back they will move back. They can adapt. They have done some interesting local adapting. Single eggs so you are not going to find egg masses with these amphibians. They have single eggs that are attached to vegetation. Like I said before, they are big predators of the other eggs.

Spotted salamanders are ones that you will see and you saw some pictures of their egg masses. They will definitely take advantage of created wetlands. A pretty common species but because it is fossorial, lives underground, you don't see it all that often except when it is moving to breed or disperse in the early spring. We are seeing some egg masses here. The egg masses of the Ambystoma salamanders are coated in a very, very thick layer of jelly, which protects them from predation from the newts. The Wood Frog doesn't have that protection so it is way more sensitive to newts. These guys have much better protection. Plus, if their pond dries up for a few days, they will live. They are coated in jelly. They will live as long as it rains and the waters come back.

One not found here but that really should move into wetlands, even rice paddies, would be the Blue-spotted. Blue-spotted is a lowland floodplain species. We are a little up from the floodplain but if you were you in the Champlain Basin of Vermont or down close to the Connecticut River Valley, these guys may well move in and they would breed in the rice paddies. They would be perfect for them. They would be out of there by the end of the summer and these guys would be back up under cover on land for the winter. They would adapt well to a rice paddy sort of situation. You can see where we have them here in Vermont. The Champlain Basin primarily and we have a couple other spots, the Victory Bog population and a couple southern Connecticut River Valley locations. Where the Victory Bog population came from has always been a mystery to us. But they are a lowland species.

Audience: What County is that in central Vermont?

Jim: I think what is going on here is we are following the Winooski River Valley.

Audience: So that might be Washington County. Is that Washington?

Jim: This is a whole county here and the town right there what is it, Waterbury or somewhere in there.

Audience: Where are we now?

Jim: Which one of these? You are one of these right here, over in southeastern Vermont.

Audience: Are Blue-spotted eggs like the Spotted?

Jim: Blue-spotted eggs are single eggs so you are not going to really notice them. They do hybridize and the hybrids produce 2-3 eggs.

There is the spermatophore that Mia was talking about earlier. Males put that down and try to get the female to pick it up. She squats on it and inseminates herself if he convinced her to. Here are spermatophores looking down into the water in the spring. Egg masses, looking at Wood Frog eggs masses there. Wood Frog in the upper left. They are not protected by a thick layer of jelly. Spotted Salamander down on the right. Fewer eggs but very well protected.

Of course, they have to get to the wetlands and roads are a big issue. If you create a nice little wetland and there is a big, busy road and the woodlands are on the other side of the road, you are tempting them across the road and there is going to be huge mortality as they cross that road. We are getting to the point in Vermont where next year we will create our first underpass for amphibians.

Audience: Where?

Jim: Between Monkton and Vergennes on the Monkton/Vergennes road.

Audience: In Amherst, Massachusetts they have done that about 10-20 years ago.

Jim: Yes and the advantage that they had there was that it was in a piece of protected land. It was a small road within a piece of protected land. In our case we are working with town of Monkton Selectmen on a town road but it is happening. It is working. Thanks in large part to the fact that a Fish and Wildlife person lives in that town and

a Department of Transportation person lives in that town and they are both very interested in the project.

This salamander is saying thank you for your concern.

Dragonflies and Damselflies: Mike Blust

While we are being setup I will just mention that I did get my degree in entomology and I did my Masters work with dragonflies. I did not continue working with dragonflies until the year 2000 because the big manuals that you needed, which were the only thing around to work with dragonflies, were out of print. They got republished around the year 2000. Then people started putting out some field guides as well and I took that as a sign to jump back in. I looked at Vermont and Vermont was by far the least well surveyed of the New England or the northeastern states for dragonflies and damselflies. I started trying to learn about them, the diversity, myself and traveled around the state to see what we had.

The order of insects that we are dealing with is the order Odonata and that includes the dragonflies and the damselflies. First I want to start out with the word "fly", which confuses a lot of people. You have a lot of insect names where the word "fly" is separate in the name and a lot of insect names where it is part of the name. The reason is the order Diptera is the true flies. If an insect is a true fly, then the word "fly" is separate. If it is an order that is not the true flies, like the dragonflies or the mayflies, caddisflies, things like that, then the word "fly" is part of the name.

A lot of people don't know the difference between damselflies and dragonflies so a little bit on that. Damselflies are generally smaller and daintier. One of the big points is that when they are at rest, their wings are folded along the length of the body. They are folded together generally over the back of the body. As always there are some exceptions. There is a group of damselflies called spreadwings, which have them slightly spread but in general they don't have them flat out. Damselfly eyes are more extended on the head on stalks, almost shark-like. Whereas dragonflies, when they are at rest their wings are pretty much out flat to the sides. They are generally stronger, bigger insects and their eyes are closer together. Sometimes touching, sometimes almost looking like a single unit.

The general life history of Odonates is that the adults lay the eggs in the water or near water. The eggs hatch and the nymphal stage is in the water and then you get emergence to the adult stage. In some ways I like to think of this like flowers. Everybody recognizes a lot of plants by the flowers that they produce. Most people when they think about dragonflies and damselflies see the reproductive stage, the stage that is flying around. In reality these underwater stages are the major part of the life cycle. The adults are around for maybe a month, two months max but the entire life cycle is usually one year. On many of the river species they can be nymphs in the water for three maybe even four or five years before they become adults. Then they are adults just for that month or two. That is the reproductive and dispersal stage of the life cycle.

Going through that life cycle this is a sight you will often see, the tandem flight. The males are in front. The males have claspers, which they put around the female's neck, and the female is behind. It was long thought that this was a kind of chivalrous type of behavior. That when the females were laying eggs, the male was holding on ready to pull her to safety if a bird or other predator came around. Well, more recent studies have shown that is not quite the case. With insect reproduction,

the females have structures called spermatheca, which store the sperm when they mate. The sperm can remain viable in these spermatheca for a fairly long period of time, even a month or more. It is only when she actually lays the eggs that the sperm are released to fertilize the eggs as they are being laid. If you have a female that is already mated, she has that sperm stored. These studies were first done with these damselflies that some of you have probably seen. These metallic greenish ones with the black wings that you see along streams a lot called Ebony Jewelwings. They found that the reproductive structures of the male had a lot of complexity. When you have an external skeleton, you can have a lot of complexity in your structures including the reproductive structures. There is this brush-like structure on there. It was found that when the males mated, they first used this brush to clean out the sperm from the spermatheca of any previous matings so that they could replace it with their own. Now what we understand about this is that this male is doing this to protect his investment. He has already put sperm in there and he doesn't want any other males coming along and removing them and replacing them. He is not doing that to be chivalrous. He is being selfish.

The mating system of dragonflies and damselflies is something that is evolutionarily very difficult to comprehend how it evolved. The males produce the sperm from the tip of their abdomen but their actual copulation structures are located underneath the second abdominal segment. They bend their abdomen tip around and store their sperm there and when they mate with the female that is the structure that she is going to couple with. The male has these claspers, which are often species specific, to fit around the neck of the female. Then she bends around and will couple her reproductive structures with these structures on the underside of the second abdominal segment of the male making what is called "the wheel". You get this complete connected circle and it happens both in dragonflies and damselflies.

This is a Common Green Darner. In some species the coupling will remain while the female is ovipositing. This female is inserting eggs into the plants here and the male is still guarding her. In some other species, the male will hover nearby but will not remain coupled with the female while she is laying the eggs. Sometimes if you have particularly attractive plant, you get group oviposition. I am sure when you took a look at these leaves you thought, "Wow, those are really attractive leaves for laying eggs." Here we have a bunch of Bluets. These are probably Familiar Bluets and they are ovipositing in these leaves. They are inserting the eggs into the plant material.

There are other forms of oviposition in damselflies and dragonflies. Here we have one that is also putting eggs in plant material but this is plant material, these are reeds that are above the water surface. They have this knife-like ovipositor or egg laying apparatus and the male is coupled to the female while she is inserting that into the plant. You can see afterwards these little scars on the plant where she has inserted eggs. As we will see later, the young will emerge and drop out into the water. Then there are the species that simply dip. They produce the eggs a little bit at a time and they keep dipping their abdomen into the water and just disperse the eggs into the water.

Audience: Is that what you see when you see a dragonfly flying over the surface of the water and dropping down?

Mike: Right. If they are doing that repeatedly, they probably are, especially if it is with the tip of the abdomen. They are washing the eggs off of the tip of the abdomen and letting them disperse into the water.

Most of the pictures that I have in here are pictures that I have taken in Vermont but these are some that I took off the web because they are a nice micrographic series of the eggs and the young. This is a species that can be found in Vermont, the Blue Dasher, and these are the eggs laid on the surface of water lilies. Here we have ones where the eggs are attached onto a plant. This one is a little more

developed. You can see a little bit more definition of the nymph inside here. This is of a species that is not from here. That is an Asian species of damselfly but it is the only one that I could find with this kind of photo of the eggs in the process of development.

Audience: What is the scale on those photos?

Mike: I am not really sure but I would guess that those eggs are maybe half a millimeter, somewhere around there.

Here we show the scars for the species that lay the eggs in plants above the surface of the water. It is a little hard to see in this light but there are little tiny nymphs that are emerging and they will drop down into the water.

This is one of what is called the first instar larvae. Instar is kind of a stage. Every time they molt, they molt to another instar and dragonflies and damselflies typically go through roughly a dozen, plus or minus, instars in the process of growing. Dragonflies and damselflies are predatory both in the immature or nymphal stage and in the adult stage. In the nymphal stage, the feeding apparatus is really kind of interesting in its uniqueness. They have this lower lip, which looks like jaws or kind of like a mouth, but it is actually part of this modified lower lip that can be extended. The actual mouth is here and this fits over as a kind of mask. It can shoot out, grab prey, pull it back, and they hold it over the mouth while they eat. The size of the prey will depend on the size of the dragonfly nymph. I have had dragonfly nymphs that are pretty good size, say about an inch and a half, that I had in the lab and have seen them grab minnows that were an inch and a half to two inches and be able to catch, hold them, and eat them. Here is an actual photograph. This is of a damselfly from underneath. You can see this elbowed lowered jaw, which can shoot out. There is a picture of that jaw extended. This is a dragonfly nymph. This is the same species that I saw grab the minnow and here is its labium, its lower lip, partially out. You can see on this species how jagged the front edge of that is for grabbing its prey. Probably pretty nasty looking if you were the wrong size.

The nymphs themselves can be a variety of sizes and shapes. They are normally pretty camouflaged with the substrate. I put these on some brighter backgrounds so that you could see some of the differences in shapes. One of the things about working with dragonflies, in terms of surveying for them, is the nymphs are often easier to find for some species than the adults. The skins at the right time of the year are even easier to find but the adults are easier to identify. What I have been doing in some cases is collecting the nymphs when I can find them and bringing them into the lab to rear so that I can get a tentative identification on the nymphs and then get a positive identification when I get the adults. The reason why some of the adults are so hard to find is either they are relatively rare or there are a number of species that we don't really know their adult feeding behaviors that well. We think that they feed primarily in the canopy where we hardly ever see them.

This was from the masters study that I did. This was with a particular dragonfly, the Least Clubtail, which is a stream species. This was the size range that I got on a single date in April. This was down in Pennsylvania and what this shows is that there were three cohorts existing in the stream at the same time. These were freshly hatched, these were a year old, and these were two years old. Since this is April, these would probably emerge a couple months after this. This shows the sequence of emergence. The dragonfly nymphs crawl out of the stream. In some cases, they will only crawl out a few inches from the edge of the water. Some may crawl onto horizontal surfaces. Some may crawl onto vertical surfaces. There are some species that you need to really look for because they may go 10 meters from the edge of the body of water and crawl up tree trunks a fair distance before they emerge. The process is basically similar in that they split right along the back here. It is a little hard to see but these things are wing pads. The wings are pleated very tightly and they are like wet tissue

paper when they first emerge. They split along the back. They pull out and they start pulling those wings out of those wing pads. They pull out a bit more and get the front legs free but the front legs are soft at that time and can't hold onto anything so they pause for 5 or 10 minutes and let their front legs and claws harden up. If you are trying to photograph the series you are sitting there tapping your fingers waiting, come on do something, and then all of a sudden they flip forward and grab onto the tree or twig or whatever they are on and then they have the leverage to start pulling their abdomen out of the rest of the nymphal skin. Once they are out they have a bunch of hemolymph, which is the insect term for blood (it is not really blood), that they pump into the wings and start inflating the wings. Being a dragonfly, it gets to the point where it puts the wings to the side. You will notice that this is very pale. All dragonflies and damselflies when they first emerge are very pale. It takes a little while for the coloration to develop because it is part of a chemical process that is related to the same process of hardening up that external skeleton. The darkening process is related to the hardening. In fact here is a little anecdote from the bird world. If you look at a lot of birds that are white they have black wing tips, like most of the gulls, white pelicans, things like that. It is because the color black in nature is more durable than white and so the wing tips, which get the most abuse have often evolved to be black. This dragonfly here once it has fully developed looks like that. This is about a little over an inch long. This is one of our smaller dragonflies.

Skins are a good way to survey and identify dragonflies because the nymphs have to move to the edge of the body of water. Whether you are talking about a stream or a pond (well in ponds they can also climb up on the vegetation that may be emergent in the water) it is fairly easy to spot them with a little training and it is easy to collect them. They are easy to store too because they are just the external skeleton. They are just chitin. There is no living material there to preserve.

As adults they are predators too. Here we have a female Eastern Forktail eating a small moth. Here we have a Black-Shouldered Spinyleg with the remains of a deerfly, something we like to see. Here is a damselfly that is being eaten by a backswimmer. Sometimes when they get too close to the water and there is a predator under the water, the predator can grab them and can feed on them. Here we have a larger damselfly, a Swamp Spreadwing, eating a male Eastern Forktail.

One other thing about the life cycle is this bluish-gray color that you see on a lot of dragonflies and we saw this particular dragonfly out here this morning. This is the Twelve-Spot. The male Twelve-Spots develop these grayish colors with aging. It is kind of like turning gray as you age. It is a sign of maturity and it is referred to as pruinosity and there are a number of dragonfly species that develop this. It kind of changes their color pattern as they mature.

In our surveying work, so far, we have found 42 species of damselflies in the state of Vermont and 98 species of dragonflies for a total of 140. These species are spread through different habitats. A number of these are river species. A number of them are pond species. There are bog species. In order to find some of these species you have to go to fairly specialized habitats and they are not evenly distributed in those habitats either. This is the list that Ogi [Takeshi] sent me for species that he has photographed and a colleague of mine, Bryan Pfeiffer, identified these from the photographs. One of the things that stood out when I looked at this list was this first species here *Enallagma aspersum*, the Azure Bluet. This is a species you only find in ponds without fish. Jim was referring to that and it is the same thing with a bunch of dragonflies and damselflies, particularly in the damselflies. Mark McPeek at Dartmouth has been doing a series of really interesting studies on the ecology of damselflies. For damselflies, if you have a pond with fish there are a fewer number of dragonflies because the fish eat the dragonflies. The types of damselfly species that you get in these

ponds are damselflies that are adapted to avoiding fish. The way to avoid fish is to move slowly, don't attract attention, and to freeze if a fish comes near. In ponds without fish you have a lot of dragonflies, which will eat the damselfly nymphs. The damselfly species that occur in those ponds are very active and will swim rapidly when approached by a dragonfly. There is even evidence that there has been some splitting of species over evolutionary time. A single species evolving into two species: one adapted for ponds with fish as the primary predators and one adapted to ponds with dragonflies as the primary predators.

Audience: Are the species distinguished by their color or can the same species be different colors?

Mike: Depending on life stage, depending on gender, and in some cases color morphs, you can have different colors for a single species. But in large part color is fairly reliable. However there are about 13 species of Bluets, which are little black and blue damselflies, and many of them look very, very similar to the point where in order to be sure of the identification I need to pick them up and look at their reproductive parts with a hand lens in order to tell them apart. Those reproductive parts, including the claspers that go around the neck of the female, are slightly different shaped for each species. They have evolved. That is part of what keeps them as separate species.

Audience: For all the species you have identified in Vermont, are you sure that what you found is what you found or are you maybe finding species that you don't really know what they are?

Mike: Well, we are pretty sure of our identifications on just about everything. There was one nymph that I found in the Poultney River, which I looked at and tried to key out. It was a damselfly and it seemed to key out to a species that we didn't have in Vermont. I sent the photograph to Mark McPeek and he said, "Yeah, you are right on that." But I went back the next year to that spot looking for adults and I haven't been able to find them and I am reluctant to put that species on the list until I get an adult identification because the nymphal identification is a little too risky on that.

Here we have something related to what Jim was talking about earlier. These are slides from Mark McPeek. You have this hydroperiod gradient: places where there is water only for a few weeks or so each year, places that might dry every couple years, places that might dry every once in a while on a term of decades or centuries, and essentially a permanent body of water. Overlaid on top of that you have the predator gradient, which is related in that you often have no predators at all in these situations. Then in these situations you get dragonflies as the top predator. In permanent bodies of water, you often have fish as the top predator. Jim also alluded to our habit. Many humans find a small body of water and even a fairly deep pond out in the woods somewhere and it has its own ecology, perhaps because it doesn't have fish. To many humans a pond without fish is dysfunctional and so they immediately go and grab some fish and throw them in and it changes the whole ecology of the pond including the particular species of damselflies and dragonflies that may be there. In Mark McPeek's study with damselfly species along this gradient there are certain species that you find associated with each one of these conditions. You can see for instance all these *Enallagma* or Bluet species are in with the permanent fish with the exception of a few that have evolved to be in ponds where dragonflies are the top predator. The *Lestes* genus are more towards this end of the spectrum with *Lestes dryas* being one that is perhaps something you might look for, it has not been found here yet. Particularly if you flood earlier in the spring because this is an early spring species, that one may turn up.

Lets just look quickly at a few of these. This is the Azure Bluet. The pictures I am showing are of species that have been reported here. This is one of those blue and black species. Most of these have

one or two segments blue at the tip but this one is a little easier to identify though because it has three segments that are blue at the tip and that makes it stand apart at least in this part of the country. This is the Slender Spreadwing, a species that tends to like somewhat shaded areas. One of the things to realize is that when you have species reported at a pond like this, at the rice paddies, if you are monitoring adults they could be flying in from nearby. The only way to be sure that things are breeding is to actually watch them ovipositing and ideally to sample the larvae that you find in a body of water. The Sedge Sprite is a really tiny but pretty damselfly associated with wet meadows, primarily. If you go out to that paddy right now, the Eastern Forktail is what you are going to see the most of. You may think you are seeing a number of different species. This is the male here: green thorax, blue tip on the tail with a couple of vertical stripes on the tip. This is a female. It is orangey on the thorax and the first couple segments. This is also a female but it is a more mature female. As this female becomes more mature, it will turn this bluish-gray color. The fact that through most of the summer I can find these orange females tells me that this seems to be a rolling reproduction, perhaps multiple generations during the course of the summer. This is one of our more ubiquitous Odonates. You go to just about any body of water almost any time of the spring, summer, or fall and you can find Eastern Forktails there. The Green Darner is one of our common large dragonflies, which has some interesting aspects as far as its life cycle. There was a study done up in Canada, which I have excerpted here. Basically in the same pond in Canada they found a permanent resident generation, that had a one-year life cycle, and a migratory species. They are the first ones to appear in the spring. They migrate up and apparently in Canada they are able to migrate up in the spring, lay eggs, get off a generation in three months, and the adults will migrate south. They are coexisting in the same pond that has the same species with the one-year life cycle. This time of year we are beginning to get the Darners out and about, especially towards evening. If you get a bunch of large dragonflies that are forming feeding swarms, they are usually a mixed group of Darners. There are a number of species of Darners and they are a little tricky to tell apart. The patterns of the stripes on the thorax are one of the more diagnostic things but it takes practice. This is the Canada Darner. This little dot in between these two stripes and the irregular edge on the front here identify it as a Canada Darner rather than one of the other species. This is a Common Whitetail. It is obvious why it is named that. One interesting fact about this pruinosity is that it rubs off. This looks like a fairly fresh male. Because of the way they mate, the males grabbing onto the females and the females holding onto the male and bending around, a male that has mated quite a bit will have a lot of this pruinosity rubbed off in the spot where the females were holding on while they mated. One of the photographs that Ogi [Takeshi] showed earlier in his presentation was this very easy to remember name, the Dot-Tailed Whiteface. It is a small dragonfly, a little over an inch, but fairly common in wetlands. Also, on the list was *Arigomphus villosipes* (Unicorn Clubtail). I've got to talk to Bryan about that because as it turns out if we look at our distribution maps there are two species of *Arigomphus* in the state and *villosipes* so far is restricted to the southwest portion of the state. We don't have any records from this side of the Green Mountains. I suspect that perhaps that was *Arigomphus furcifer* instead but if it is *villosipes* then that may give us a record on this side of the state. The Twelve-Spot is the species we saw flying around out here. This is the female Twelve-Spot. She does not develop the pruinosity, the gray patches in the wings. The Blue Dasher has green eyes and a bluish-white abdomen with a black tip. This time of year, starting in mid-summer, you start getting these red dragonflies. There are several species of them. The Autumn Meadowhawk is one of the latest ones and this is the latest dragonfly we have in Vermont. I have gotten these after Thanksgiving once or twice here in Vermont. They are one of our more cold hardy adult species.

Lunch

Lunch included various ethnic rice dishes prepared by local chefs: Kanha Sengaloun (Anon's Thai Cuisine), Tristan Toleno (Entera Catering), Aida Avery (independent caterer, Mexican cuisine), and Shital Kinkhabwala (Shital's Indian Vegetarian).

Integrated Rice and Duck Farming: Erik Andrus

I would like to say thanks for including me and giving me the opportunity to talk about this as we put this all together kind of at the last minute. I am not a birth right farmer. I knew since I was seventeen that I wanted to farm but as a young adult it really wasn't obvious how to get there. I did a couple of apprenticeships and I had a career as a builder and then five years ago I bought the farm that I am on now. I have experimented with a lot of different grains (wheat, barley, oats) and many times I have been very much thwarted but the nature of my land, which is very heavy and very slow to release water.

Anyway, ten years ago before I became a farmer, I lived in Miyagi prefecture in Japan for a year. I toured a lot of farms while I was there. I saw rice systems and combined rice and dry land systems in Japan, which are integrated in an incredibly clever way in Miyagi agriculture so that the dry land drains and the paddies fill all when they are supposed to. I thought it was interesting but I never really considered that I might actually need to pay a lot of attention to how rice was being grown there because I never considered that it could be done in my native ground but now I know better. I heard about the Akaogis' work and I attended their workshop in February of last year and I went home from the workshop and I got immediately to work. Last year I grew just a seed plot of a couple hundred feet and that was enough to get me seed so that this year I was able to plant a little under an acre. We would have been able to do a whole acre, but we didn't have quite enough seedlings. Next year we are going to expand to 5-5½ acres so I am really serious about trying to supply an important staple crop to my community in an environmentally benign way. I am the kind of person that when I encounter a new idea and I like it I ask myself, "How far can I go with this?" The answer for me I think is going to be around 5-5½ acres because at that point I will probably be physically maxed out to where I can't farm more than that well. Whether I will even be able to farm that much well kind of remains to be seen but I am going to go for it anyway. I am here today to tell you about what I have done so far and what I have learned and to suggest some directions where rice as a viable crop for the Northeast might be headed. By no means am I an authority in it. I have basically 1½ seasons of growing rice but it is incredibly inspiring and I feel like the entire region owes the Akaogis a huge debt of gratitude. They are a source of inspiration.

Last year I just grew a little seed crop and I was granted accessions from the gene bank in Arkansas. I went from having 20 grams to about 22 pounds and planted that. Actually I didn't quite have the nerve to plant all of the seed this year. I only planted half of it. If I had planted all of it I wouldn't have run short of seedlings but I just didn't have the nerve.

How many of you have read The Power of Duck? Just a few people. The Power of Duck is a great book. It is very hard to get your hands on. There are not that many copies. It is written by Takao Furuno, who is an ecological farmer in Japan, and he has been developing the rice duck method in Japan over a period of decades to the point where it is very, very well researched and refined. It is now gaining a real following in community groups and environmentally conscious farming operations not just in Japan but also throughout Asia. I decided that I was going to take a stab at this

method as well and I bought a hundred Khaki Campbell ducklings and I used them to weed my rice crop. It pretty much worked. Not perfectly but I learned a lot and next year I am going to be able to do an even better job at it. I have also been corresponding with Takao Furuno who is a really neat guy. You can tell that he really sees through the line of crap that comes out of agricultural officialdom in the US as well as in Japan. He is a very, very perceptive guy. I hope to have the opportunity to visit him next year but we will see.

I have some pictures for you. This is my rice paddy. You can't quite see it all in one frame but this is the smaller of two paddies. I am growing three Hokkaido varieties. Here you can see some ducks in there. Unlike the Akaogis' field, which was pretty uniformly dry when it started, mine was already pretty wet. It was what you would call a very wet pasture. It already had water tolerant plants living in it and doing quite well. When I bulled them over and created the paddy, it didn't knock them back for very long. They came right up through the rice so you can see a few little tufts of weeds coming up there. The ducks went right after those and they didn't do any damage to the rice other than occasionally knocking them over, like where the rice plants were poorly rooted or a little bit small. The ducks would just go over the top of them but they didn't eat the rice.

Audience: Are you on clay?

Erik: Yes. I have that Champlain Valley clay and you couldn't ask for a better template, a better area.

Audience: How did you sow the rice?

Erik: We transplanted. I had a 100 high school students out in the rice paddy in May. Twenty thousand seedlings were planted that day.

Audience: Wet planting or dry?

Erik: Wet. They were wading into the mud on a cold, windy day in May. We had this whole operation field marshaled where we had the seedlings coming down the hill from the hoop house, which is a quarter mile walk through water logged land. They are carrying them on these trays and then they break apart the seedlings and plant them one at a time. We had a string that had flags on it every foot. We had everybody all lined out in the field and when the whole line was done then we would advance the string one foot. Everybody would be responsible for just like four feet in front of them. It got the field done pretty quickly that way and if you have enough people it can definitely work for a very large area. Next year we are buying a transplanter. Don't get me wrong you still need a lot of labor to support a transplanter. It is not just driving it. You need a whole support crew to keep it moving because it runs through plants pretty quickly and they have got to be constantly brought out to the field if you want to make effective use of it. Even five acres with a transplanter is several days of work. We are still going to have our work cut out for us.

Audience: Did you buy the ducks as ducklings?

Erik: Yes. Actually that is really the key to doing this successfully, getting your ducklings the right age for the level of growth of your rice plants. Because if your ducklings are oversized for how well established your paddy is, it really doesn't work very well. Fencing is extremely important too because you have to keep your ducks in and you have to keep predators out. I regret to say that because my paddies are still under construction I don't have permanent fencing in yet. I just have temporary stuff of one kind or another and the ducks have gotten out and the predators have gotten in. I think some of them were killed by hawks and I can't do anything about that. I definitely did not preserve the lives of every one of my ducklings. Many of them are

still alive but they are at large on the farm now. I can still catch them if I wanted to but at this point I want them out of the paddies anyway. At best, if you do everything perfectly, your ducks ought to be in the paddy for maybe 6 weeks to 2 months. That is the period when they are really useful, when the rice is sparse and there is a lot of potential for weeds to germinate. Once the canopy of the rice is established you don't need the ducklings so much because they are shading out the competition. Also, once the rice plants get heavy and start to dip a little bit with the weight of the seeds, the ducks will reach right up and have a little snack. You want to have them long gone before there is any potential of that. The key to why this works is the ducks don't actually eat the rice leaves because they are high in silica. For a duck mouth that is like eating sand paper. They don't eat the rice leaves but they will eat the rice seeds. There are many benefits besides weed control and Furuno's research really spells this out. The prodding of the ducks as they eat little critters around the base of the plants provides a stimulative effect that helps the plant develop and they also muddy the water. Furuno has established that water that is kept churned and agitated leads to better plant development than water that is clear. Also, the water being occluded prevents the sunlight from helping water plants germinate on the paddy floor.

Audience: These ducks will eat grasses but they won't eat rice?

Erik: That is right. Amazing but true.

Audience: Do you need some good duck recipes?

Erik: Well the thing is I raised Khaki Campbell ducks and a big Khaki Campbell duck dresses out at two pounds and half of that is bone. I butchered up a couple of them and boy it was not worth the trouble. The problem is if you raise a big duck then it can't fit between the plants and your system doesn't work. There may be some compromise to where you have a big enough duck to have it be somewhat market worthy. Frankly, it is not that important to me because far and away the most important function is the weeding function and helping the rice develop. If the ducks all fly away when they are done with that they are a relatively small part of the economic equation. I can buy the ducklings and if they all fly away at the conclusion of their work, that is fine with me. I don't need to sell every duck in order to make that method useful for me. That is my analysis.

Audience: Furuno also pointed out that the ducks help seal the pond.

Erik: Yes, by keeping a silty layer settling around the outside of it. With my clay I have very little problems sealing a pond to begin with.

I am probably already out of time but if I can, I can tell you a little bit about how we created the project. Okay. This is an aerial view of the property here. Generally, there is a low ridge that runs this way and then there is another one that is further off. I did a watershed analysis. At first I thought that it was only a 126 acres but then I realized there is a culvert underneath the town road and there is about another 50 acres over here. All of this water sheds into or near my project area and this is the project area. The blue arrows show the direction that water moves. Like I said earlier, this one is wrong because the water there actually goes under the road and down this swale. I have a huge land base that is shedding surface water onto my fields. It is a small wonder that I have never been able to take a cut of hay off this field because every time it rains it loads up with surface water. After a heavy storm sometimes you can have a foot of standing water down there. Of course this spring there was water everywhere.

Audience: Do you have a problem with too much water in the paddy? Is there a way to drain it off?

Erik: When you have a heavy rainfall event you have water falling into your paddy so that raises the level in your paddy. If you get an inch of rain, the level in your paddy goes up an inch. If you have a watershed event, like I have a 126 acres shedding, I can have well over an inch of water pooling up at the base of this valley. We would get heavy rains in the spring and the water would rise in the paddy but not that much and the water would rush in down the swale. The water rushes down the swale and towards my project area. I can illustrate this best with a drawing. Here is the normal landscape and then I had a drainage ditch and I had the paddy wall and then I have the rice plants in here. Under normal conditions I have a little bit of water in here because the water table is very near the surface. When you had a storm condition, like I said you would have maybe an inch of rise in here but for a brief period you could have up to a foot of water here. This water goes away and it never got high enough to breach that paddy wall. If it got high enough to breach the paddy wall, it would flood the plants. As long as this distance is greater than your maximum flash runoff condition you are fine and there is no reason not to make this extra tall if you are worried about it. It is not hard to make a dike. For that reason even though I am prone to flash runoff here it never bothered the plantation.

We did this analysis prior to creating the project. We don't have a stream or lake to pump out of so we need abundant water and one of the big questions for me was just how much water do we need? We need a pond and I knew from the start that creating the pond was going to be the most expensive part of the project so you don't want to make the pond bigger than necessary. In the end I decided that I wanted about 100,000 cubic feet. The estimates from the engineers that I was working with ranged between 100,000 to 400,000 cubic feet. In the end I decided that I was going to do the 100,000 give or take and see how well that worked. I could expand it later if I needed to. In May we created the one acre paddy and we started digging a pond. We didn't get very far with it. We maybe dug about 75,000 cubic feet in all. Although, it is hard to say because we could never see the bottom of it. We were actually digging in waterlogged conditions and as soon as we took a scoop out it would fill in with water so you couldn't really see what the bottom looked like. I figure that there is probably 50,000-75,000 cubic feet and it still has plenty of water in it now and it hasn't really rained for how many weeks now. Anyway I feel like that type of storage and redistribution system is going to be quite cost effective for us. The cost of creating the pond is not so great that it would sink the profitability of the project. Through the sale of rice we should be able to pay for our pond in just a few years. I also figured out that if you have a pretty promising site that your heavy equipment costs, if you rent equipment and can come up with an operator, are probably going to run in the neighborhood of $5,000.00/installed acre of rice paddy. At least that is what it will be for me by the time I am done, which is not so much when you consider the potential value of rice for sale. As far as capital cost for creating a project, I feel it is bearable. You have to have a sound design that will work.

This is a more close up view of the larger picture that I showed before. Here is my pond and there is a farm road that runs in between the pond and the rice paddies. The paddy that we are farming this year is actually not even on this drawing because it is an older drawing but we put it over here. We pump from the pond to the rice paddy and it flows back into the pond when the paddies brim over. On August 15th we are going to start this next phase of paddy creation. That will be the remainder of our project. Then I will have my work cut out for me for the rest of my life.

Audience: Are you using a tractor powered pump to pump the water or do you have electricity there?

Erik: I have a gas powered semi-trash pump. They are a couple hundred bucks from mail order places. It uses flexible hose and it is nasty and it is noisy but it does the job and it is cheap. It is a temporary solution. Ultimately, we want to move water with wind power and I am hoping to develop a vertical axes wind turbine in conjunction with Archimedes screw that will do a really great job. I could explain a lot about how I want that to work but I am sure that I don't have the time to get into it.

Audience: I think that there are also solar powered irrigation pumps on the market that you might want to look at. We stumbled into talking about it out at the rice paddy and what is fascinating about this is that you said you would be harvesting it with a combine.

Erik: With a reaper/binder.

Audience: Okay and what is fascinating is that you are getting into how to take this crop and integrate it into an existing American system of mechanized commercial agriculture.

Erik: Well, 50-75 year old mechanized commercial agriculture because I am not farming at the scale like dairy farmers.

Audience: Which in the end, in the world that we are probably heading into, may be a lot more sustainable and sensible than what has happened in the last 50 years.

Erik: Yeah, it could be.

Audience: The other side of the coin is, talking to you and a couple other people here, land that is too wet and has too much clay and hardpan is probably among the most despised farmland. You can't plow this crap. Vegetable roots don't go down far.

Erik: Not to mention the times that I have just been stuck. Stuck with tractors. Stuck with horses and sometimes even with feet. I am stuck out there just trying to get from A to B.

Audience: What you are sharing with us is that none of this would happen without the Akaogis and other people like Christian Elwell. The next question is can you commercialize it and could you also mention a little bit about your marketing to the grain CSA that you were telling me about?

Erik: My motivation is primarily that I want to provide staff of life food products to my immediate community for a price that anybody can afford. That has been my real motivation for farming. I think that New England is now becoming better and better served by very, very creative pastoral farmers that do all kinds of dairy products and cheeses. We have a lot of very highly skilled vegetable growers and horticulturists but there is a real need for people who are going to provide basic staff of life things that will really carry people through their day. Right now as a region we depend on importing these commodities from systems in the far west or elsewhere that are known to be unsustainable. These systems are known to be operating on borrowed time. I feel that it is incumbent upon me to try to develop a way to farm with technologies that I myself can control and manage in a way that will be durable and can provide me a way to enter into exchange with my neighbors. I think it would be great if every resident of Ferrisburgh and Vergennes had a little rice paddy or potato patch in their backyard. In Japan, I think you do see a variety of scale operations. Some of them are home scale paddies or they are farmed by several households in cooperation, whereas others are larger and more market type in scale. I am interested in being the guy in my community who can give you a 50-pound bag of wheat or rice or whatever. That is what I want to be and I would like my two boys to grow into adulthood with the opportunity, if they should wish it, to be that guy too. Maybe on a different farm. I don't know. We will see. That is what makes me tick.

Audience: In the creation of your paddies, how did you leave enough topsoil in your paddy and was it enough or have you found what is enough?

Erik: In our conditions topsoil is a real relative term because basically we have gray clay and then there is dark gray clay. The dark gray clay is what you are maybe thinking is topsoil. If we look at the pictures, you can actually see where a lot of the topsoil we mounded up beside the project to breakdown and decompose. As a result, because it was a new paddy and a lot of it was compacted and a lot of it was soil that hadn't seen the light of day in a couple hundred thousand years, a lot of the plants suffered as a result. We have a herd of beef cows. We have a huge barn that is full of broken down manure pack. When this crop is harvested we will get out there and we will work in some composted manure and next year will be totally different. We have that tool to use, the manure pack from the beef herd, and we can use it to enrich the rice paddy just like we use it to enrich vegetable crops or dry land grain crops.

Audience: Is the rice on what you have now finding enough nutrients?

Erik: Oh yeah. It doesn't look as beautiful as this paddy here but it is coming into grain and it looks pretty good.

Rice Growing in Asia and Northeast USA: Peter Hobbs

Thank you very much. I am really honored to be asked to come back a second time. That must mean I said something right the last time. I was here in 2009. One of the things I want to say at the moment is, "I am sure you will have questions." My answer that I give to a lot of questions is, "It all depends." I think as rice growers in this region one of the things that you can do is experiment. Somebody was asking me, "What happens if I use direct seeding versus transplanting?" Well, why don't you take a pot put some seeds in and in another pot put some transplants in and collect data and answer your own question. We have double the number of people here that we had last time and this community can share its experiences. I think this is really important.

I spent 30 years of my life in Asia, two years in Thailand and the other 28 years in South Asia. I want to use today to show you how they grow rice in Asia. Some of you may have visited Asia. Some of you may have seen how rice is grown in Asia. I want to do that first and then at the end I will try and give a few ideas that I have about how they grow rice in Asia and the differences with growing rice here in the Northeast. Before we start we should really understand where rice is grown in the world. If we look at where rice is grown in the world, you can see that there is about 158 million hectares. There are 2½ acres per hectare so multiply this by 2½ and you can see that there is a lot of rice grown in the world. Asia has 89% of that rice so 90% of the rice is grown in Asia. For Asia I am talking about China, Southeast Asia, and South Asia. The USA is just under 1% of the rice acreage and that includes California, Arkansas, Louisiana, and Texas. You can see rice is not a particularly big crop. If we put Vermont in there or if we put New York, I would have to use a different scale. Then you can see in terms of production, there is about 685 million tons. If you look at the average yield for Asia versus the world it is about the same, almost 4.4 tons/hectare. I don't work in bushels but if you convert 4.4 tons/hectare into bushels, it is about 87 bushels/acre. That is the average yield of rice in the world these days, which is pretty good. If we took specific countries, it might be lower than that because we have China included in here and China has some of the highest production in the world. The production of rice in the USA is almost twice as much as the world average. That would be around 8 tons/hectare so that would be close to about 150-160 bushels/acre. This is the 2009 data from FAO (Food and Agriculture Organization of the United Nations).

Various people have said that we have different ways of growing rice. Probably the most important one is transplanted rice. Here is a picture of transplanted rice. You often see these sorts of things in different parts of Asia. Particularly in Southeast Asia, you will see some fields already being harvested while some fields are still in the vegetative stage. You see a mixture. Other parts of South Asia and China you grow one crop per year and they more or less all come to maturity at the same time. In Asia, 55% of the rice area is irrigated (full and partial) and 25% is rain fed (rain fed would mean just natural rainfall). However, 75% of the production is coming from irrigated areas and about 17% from rain fed areas. They are both transplanted.

Audience: By rain fed you mean?

Peter: It means that you just rely on whatever rain comes. When the rains start, you start rice production. Rain fed lowland areas are one of the major rice growing systems. Whereas in irrigated areas, which can be fully irrigated or partially irrigated, some additional irrigation water is given to the crop.

Then we have upland and dry land rice and here is a picture. Many of the places where they grow upland rice are where you obviously can't puddle the hillside. You see this row of people here. They probably have a planting stick and they are direct seeding rice. Thirteen percent of the rice area in Asia is upland or dry land and it only produces 4% of the production. The last one is deep-water rice, which has about 7% of the area and only 4% of the production. Here you can see the farmer actually harvesting his rice from a boat. These are some of the deep-water rice areas in Bangladesh, eastern India, Bangkok, and in any of these flood prone areas. We have three systems. The most important one in Asia is transplanted rice with about 70-80% of the rice being transplanted. There is also direct seeded rice Where seeds are directly seeded into the soil either dry or wet – no puddling or puddled.

For land preparation it is normally plowed dry, flooded, and then it is plowed wet. What we call puddling. Seed beds are used to raise the seedlings. I am only talking about transplanted rice. For transplanting, you are uprooting the seedlings and transplanting them into the main field. You have a separate field for the seed bed and the main field is where you transplant the rice. Weeding is usually done by hand. Some farmers are now using herbicide and some rotary weeders. I know Erika who follows me will be talking about SRI and the rotary weeder. I also have a video at the end to show you what the rotary weeder looks like. Fertilizer is mainly in split doses. You have a basal application of fertilizer and then you top dress your fertilizer during the vegetative phase. Irrigation can be manual or through use of pumps. For pest control some farmers use pesticides and some farmers don't use pesticides. These days the recommendation we give to farmers is to use IPM (Integrated Pest Management). If you have any questions about Integrated Pest Management we can discuss that topic. Harvest and threshing is usually done by hand. I think that storage is an important part of the whole system. I think some figures estimate that you lose 25-30% of your produce through storage. That is kind of crazy. You spend all this effort to grow this crop and then you let the insects come and eat it or you don't store it properly. This is a really important aspect of growing any crop, whether it is rice or other crops.

I am going to go through each one of these. Puddling of rice fields. Lowland rice is grown in a reduced soil. What we mean by reduced soil is that you have flooded the soil and it has become anaerobic. Rice is able to deal with that because it has cells in it called aerenchyma cells that allow the plant to take oxygen from the air and bring the oxygen down to the roots so they can respire aerobically. Lowland rice has a shallow root system and it is deeper in upland rice. Two main reasons for doing rice puddling are to reduce the percolation of water and to control weeds. Ponding the

water is a really good way of controlling many of the weeds that you would have. If you go to a dry seeded system or wetting and drying, then some of the aerobic weeds will come in and then you do have a serious problem of controlling weeds. Let's have a look at some of the pictures.

Audience: Did you say that the aerenchyma cells are in the roots?

Peter: Yes, it is a channel through these aerenchyma cells from the leaves all the way down to the roots that provides oxygen to the roots.

First step is to dry land plow. This is a picture of a woman. You can imagine if you have a 500-acre farm how long it would take her to do this plowing. Animals are usually part of this. Today, modern agriculture is bringing in more tractors whether they are small two-wheeled tractors or larger tractors. This is an important part of land preparation. The next step is puddling. This is the modern way of doing puddling. This little two-wheeled Chinese tractor, is actually quite a useful tool to have. In China you can buy one of these things for about a thousand dollars and you can find all sorts of attachments that you can add to it. There is a reaper. You can add a pump to it. There are lots of different ways of using this. You have done dry plowing, you have flooded the fields, and then you are using this machine to puddle the soil.

Audience: Does anybody sell anything like that here?

Peter: I am sure the Chinese would be interested in selling them to you. You just have to set it up some way. Like with these small paddies, this would be much better than some of the big John Deere tractors that you have here.

Audience: Is this a rototiller?

Peter: This is actually a rototiller. It has these cage wheels on the tractor so it doesn't sink and then it has a rototiller in the back.

Audience: It is gasoline powered?

Peter: Diesel powered. There is a lot of work going on in South Asia. In Bangladesh now there must be a half of a million of these two-wheeled tractors because this young guy here didn't like to go behind a bullock all day long. Imagine how many miles you would have to walk behind a bullock to plow a one-acre field. You go up and down, up and down and so these people prefer to sit on a seat and do the puddling this way.

That is what we want to get. They want to get this puddled soil. But it really destroys any soil structure. When you try to grow another crop after rice it is a bit of a problem but if you are only growing rice then it is fine. This is what they are essentially doing. They are breaking down the structure. They are trying to make it so that it is impermeable to water flow. You can do it with water buffalo. This is in the Philippines, I think, or it might be in Thailand. These are water buffalo but you can also use cattle. He is using a harrow to do the puddling. Or you can do it this way.. This is in Bangladesh. He has already harvested the previous crop. He is just doing minimum tillage and then he is coming back and you can see the transplanted field behind. That is not a job for me. I think if I was a young person I would say there must be a something better to do than that.

Then the other thing they do is planking. It is a sort of leveling process to try and get the paddy level. You can see that they have taken a piece of bamboo using this thing here and he is just leveling the field. When you transplant you want the field to be reasonably level. This is a way of leveling the fields.

Here is a rice seedbed. Sometimes you can see it in the same field. Sometimes it is in a separate field. They prepare the soil. Sometimes they put fertilizer in. They broadcast the seed on there. They let the seedlings come up. This is the seedbed. Then you have to pull those seedlings up. Here is a young man, once again in a very labor-intensive way, pulling up these seedlings and making small

bundles of them. This is actually the small seedbeds that are being prepared for the rice transplanter. This is a different one. This is an interesting machine. It is called the drum seeder. I am not sure you would want to do it here but if you could direct seed rice, you could use a drum seeder. What they do is sprout the seeds, put them in the drum, and as that drum rotates around it drops the sprouted seeds onto the surface of the puddled soil. It is another way of planting rice. For transplanting you take the seedlings from wherever you produced them, put the seedlings on your back, walk out to the field, and then you give them to the ladies and let them do the transplanting. Or, if you are lucky enough to have Erik, he can get 100 school kids to come out and you can train them to transplant properly. You see how this lady has got a handful in her hand and she is just putting them in as quickly as she can. Erika will show you that what they really want to do is to maybe put them in rows and be very careful how they transplant but I will leave the SRI to her.

Audience: So you stunt the growth of the plants by pulling them out?

Peter: Yes, you get this transplantation shock.

Audience: And how long is that for rice?

Peter: Transplantation shock depends on the age when you pull them up. The older the seedlings the longer it takes for them to recover. There is definitely a transplantation shock.

Audience: Why can't they be directly seeded?

Peter: Well, they can be direct seeded but I want to get to that at the end. The trouble is that if you direct seed, the amount of time that you have had the seedlings in the seedbed has to be added to the time you have the rice in the field. China does the same thing. In some parts of China they can't grow direct seeded rice because they have only 90 days in which to produce the rice crop. With the 20-25 days they have in the seedbed and a couple days for transplantation shock, they are saving 20 field days. I think that is the case here. Maybe we can have a discussion about that later.

This is the sort of thing you see. Here are four ladies doing this. This is in India. This is the way that they do it in Japan. Japan is just like the US. They don't have school kids that want to come out and transplant and they don't have a lot of labor, so they have gone to mechanical transplanters. I have a little video at the end to show you what that looks like.

For weeding, once again, they are bent over backwards weeding by hand. You can see the weeds that are in here and you can see after she has done the weeding. Here are a group of ladies weeding here. The man is standing up while the women are bending down doing the weeding. This is the rotary weeder that we are talking about but notice that to use the rotary weeder you have to put the rice in rows. We will see that on the video.

Audience: Is weeding typically done in paddies?

Peter: Oh, absolutely. If you go back and look here you see this is transplanted rice. Somebody said the other day we don't have any weeds yet in our paddies. The answer to that is you just wait another few years and they will find their way into your paddy fields. If you puddle and keep standing water you will have a different type of weed. You will have a weed that does well in aquatic environments. If you dry seed you just get killed by weeds. It is the number one issue when you go to direct seeded rice is how to control the weeds. Weed control is really important. I will raise the issue of GMO rice because to me direct seeded rice, the answer is Roundup Ready rice. I am sure that could create a really good heated discussion here with this group. The people that oppose it are not these people.

Fertilizer is really like feeding anything. If you have a baby and you want the baby to grow up strong you have to feed it and it is the same with plants. If you want to get a high yield you have to provide nutrients. This is one way of providing nutrients. I don't think it is a particularly efficient way. Here are two young men. They probably have urea fertilizer in here and they are just broadcasting the fertilizer. This is probably not very efficient but it is simple. It is a quick fix. You broadcast that nitrogen on and immediately see a response to nitrogen. Now in many parts of the world you can't get fertilizer so you don't have that as an option. The other way to do it is to use manure. You can use organic manure, if you have it. Here you can see these young people. It is a lot simpler to apply chemical fertilizer than bulky manure this way. They have to get it from wherever the animals are, then they have to get it out to the field, and then they have to spread it out. There is a lot of labor involved with organic production. Plus, a lot of this manure in South Asia is used in cooking as fuel. The ladies go out and pick up the cow dungs, make the patties, and they put these together in here. Throughout the year they are taking these manure patty cakes and that is their fuel source for cooking. Here is another design of the same thing. This lady here is cooking on this stove and is probably using some wood but she is also using manure to provide the heat for cooking. You have competing uses for the organic fertilizer. One of the questions is, "Does the farmer have enough organic fertilizer to be able to put appropriate amounts on his rice paddies?"

Irrigation can be done in lots of different ways. I think Erik was talking about using this. This is probably a diesel pump that is being used to bring up groundwater. This is in a seedbed. This farmer has some surface water here and he is using a traditional wooden balance to lift water. Here is one where it has a weighted balance here and they put it down manually. This one you have a swinging bucket. You don't need a health club. You can just come out every morning and water your rice paddies. This was in Bangladesh, this is Bangladesh, and I am not sure where this one was.

Pest control. Here is a farmer, not properly attired, broadcasting some pesticide. Not something we would recommend these days. Here is another one. He actually has a mask on and he is spraying some pesticide here. Now we recommend IPM. There are a lot of pests and a lot of diseases in rice. I think rice growing here is such that the pests haven't found the rice yet or maybe there is so little of it that they can't find it. You have stinkbugs. You have brown plant hopper. You have green plant hopper. You have stem borers. You have all sorts of insect pests and you also have many types of diseases that occur in rice. You have to think about how you control these in the paddy and also how you control these pests in storage.

A lot of harvesting and threshing is done by hand. Here is a lady doing this. See the farmers out in the field harvesting by hand. They take it to a central place. There is a log here and they are taking the rice stalks and banging them on the log to release the grain. Or you can do it with animals. They just walk around in circles, trample, and get the rice out. Then they use a bamboo tray and with the wind they winnow and clean the seed. Or you harvest somewhere and then you have to carry it back to the place where you are going to do the threshing. Then comes storage. This looks like it has already been dehulled. They are using this type of tray to clean the rice. They might store it in haystacks like this. Here is a storage device inside this little barn to keep the rats or keep the pests out. There are so many different types of grain storage. In something like this they may put in some insecticidal plant material to keep the pests down. Or they might keep it so tight that the insect pests can't survive. Sometimes they store it in a jute bag and when you go to look at it, it is like powder. When you open it up you think goodness what are those little black things in there that are crawling all over the place. There are a lot of storage problems. That is how they grow rice traditionally. They

have been doing it for thousands of years. The production of rice over those thousands of years just depended on the amount of nutrients the soil supplied to the plant.

Here are some issues for rice in the USA. One of them is the field time. How much time do you have in the field? I think this is really an important thing. If you have a cold spring and you have a cold fall, at the end of the season, you have a limited number of days that you can grow the crop. That is why it is important. Probably why you would need to transplant rather than direct seed. We can have a discussion on that. I think you have a lot of experience on this. Have you ever tried direct seeding?

Takeshi: No, I never did. I just gave up on that option.

Direct seeded looks very promising to someone like Erik. In California they just fly it on with airplanes but they don't have the cold season to worry about. The problem with the cold season is it can really affect the pollen. You get a lot more sterility if you get cold nights during the flowering period. That is why you have to be careful with this. Cold temperatures affect growth and reproduction. If you get cold night temperatures as Susan was talking about this morning, you can have a lot of sterility and therefore your yields will be low.

I want to talk a little bit about nutrient transformations because I think this is an important topic and then labor. Erik was lucky to get 100 students to come out and do this. I don't know what he gave them in return but labor is a big problem in the US. How do you handle the labor problem? You saw how labor intensive this was. Field time. A cold spring and early fall temperatures affect growth. If you have a cold spring or the water is cold, the seedlings don't grow very fast. They just sit there. That is going to extend the amount of time. If it gets cold in the fall, you have problems of maturity and sterility particularly with pollen viability. A short growing period means that it is best to use the transplanting method to save field time. That is the answer to that one. Direct seeding would add field time. It would be a problem. It would be even better to grow seedlings indoors. What I think Ogi [Takeshi] has is a greenhouse and he grows his seedlings there so that he can have them ready when the temperatures are right and on the date when he wants to transplant. There are lots of different ways of growing seedlings. I think you use trays, right? Or you can use other ways of growing these seedlings. Take advantage of the warmer temperatures inside the hoop house and you can grow the seedlings so that they are ready when you are ready. If you try to grow the seedlings outside and it is cold, they are just going to sit there and they are not going to grow very fast. Here is an example of seedbeds being grown inside a hoop house but you could also use Ogi's [Takeshi's] way of having a seed in each little depression. You have little seedling plugs that you can then use, right? It can also affect pollination so you need to select the right varieties that flower at the right time. You want to keep the paddies flooded at that particular time to moderate the temperature. The water has a big effect during the flowering time. If you didn't have the water there you would have a lot of variations in temperature, which would affect pollination. It also helps control the weeds.

The other interesting thing is that when you keep the soil flooded, the soil chemistry tends to make the soil neutral in pH. Keeping it anaerobic and keeping it flooded is important for the availability of nutrients. If we look at pH 7, which is neutral, you can see that most of the nutrients we need for plant growth are readily available. If we went to pH 5, acidic, you can see that some of these nutrients change. Iron becomes toxic, manganese becomes toxic, but some of these other nutrients become deficient. If you have alkaline soils, you can see you have even more of a problem. For example, we always had problems with zinc in the area I work because when the soil becomes oxidized instead of reduced the pH of the soil was closer to 8 or 9 and we would start to get zinc deficiency. That is another reason for keeping the soil flooded.

Audience: Why does keeping it flooded keep in nutrients?

Peter: Because under anaerobic conditions that is what happens. I don't really have an answer to that. If you took the pH when it is flooded, it is approximately pH 7.

Audience: Our soils around here tend to be on the acidic side.

Peter: Yes but when you flood them, they will tend towards 7. When you oxidize them and drain them, they will become acidic again.

Audience: How soon after the flooding does that happen?

Peter: Well it has to become anaerobic. I don't know the answer. It all depends.

This is really important because phosphorus is a really important nutrient. If you grow rice transplanted and flooded, phosphorus is really important. It is not a problem. If I dry the soil and try to grow it aerobically then phosphorus availability becomes a problem and aluminum becomes toxic. Understanding the chemistry of the soil is really important. If you imagine this is the soil surface, you have the rice roots down here. This the reduced zone down here. When you put the fertilizer in it usually comes in some ammonium form or it can be nitrate form. Some of that can go off as ammonia, if it is not applied properly. Some of it can go into the organic matter and if it is oxidized, this gets converted into nitrate. During oxidation nitrogen becomes nitrate. If we dry the soil and then we flood it, the problem is that the fertilizer becomes nitrate when it is dried and when you flood it the nitrate can be leached out. It is very soluble in water and it can be leached out of the soil profile.

Audience: Do you know denitrification?

Peter: Yes. Denitrification is number six. This would be where you take the nitrate and as it becomes more oxidized it can be converted to nitrous oxide or to nitrogen.

Audience: And that happens anaerobically?

Peter: I think that it can happen in both of these situations.

Audience: This is a case where the nitrogen you are adding ends up just not being used all the time.

Peter: You have to be really careful. When this is reduced, this nitrate will be converted into ammonium. It becomes reduced into ammonium. I think this is supposed to be up here. It will happen in the oxidized soil. Because this is going more oxidized I think. These are some of the things you have to be careful of when you are looking at nitrogen and whether you are going to flood or whether you are going to dry.

Audience: Yes, I understood it. This would happen in a case where you had very wet conditions. I am not talking in a paddy. I am just kind of curious, is this a problem typically with nitrogen in a paddy that you have this reaction going on and some of that nitrogen is lost.

Peter: I think this is probably like it is being reduced and it is going to nitrogen. Eventually it will go to ammonia. It would go around that way but before it got to there it would be lost as nitrous oxide or nitrogen.

The same thing happens to carbon. If you are adding organic matter you are supplying carbon, which is really important. Under reduced anaerobic conditions, the carbon is going to be converted to methane. Under oxidized conditions it is going to be converted to carbon dioxide. Carbon dioxide and methane are both greenhouse gases.. One of the main agricultural sources of methane emissions is from rice paddies. It is because of the reduction of the carbon here.

Audience: Is that an issue to be concerned about?

Peter: Yes, definitely because methane is 23 times more potent at warming the atmosphere than carbon dioxide. Nitrous oxide is 210 times more potent. Greenhouse gas emissions have significant effects on global climate change.

Audience: That would mean it is better to grow wheat instead of rice because rice contributes to greenhouse gases?

Peter: Except you can't grow wheat where you grow rice so you don't have very much choice. What you have to be careful of is the manure that you put into the field. In particular if you put a lot of manure into the field you are going to have more methane emissions.

Audience: So finding the right balance.

Peter: Finding the right balance, yes.

Audience: So is a swamp, just a natural wetland, giving off methane?

Peter: Yes it is giving off methane. A cow eating is giving off methane. Methane emissions are going to happen. It can be natural but also man can make it worse through poor manangement

Then of course the last issue is the high cost of labor in the US, which would be an issue for transplanting and also for weed management. Obviously you can't attract a lot of people to do the transplanting. We can make use of a mechanical transplanter. I have got a video for that. Or for weeding use of a rotary weeder or herbicide.

[Videos of mechanical transplanter and rotary weeder]
It has some spikes on it and you go down through the paddy field. You have a certain amount of water there. You don't want it to be too dry and you are just pushing it through. What they are saying is that this also aerates the soil a little bit. It is a bit like a duck going through and mixing up the soil. This is the mechanical transplanter. They could be made very easily. I think the main problem in Asia is getting a hold of them. This transplanter you can also get for use manually. You can buy this one for about a thousand dollars from China. I think Erik you have one. Buy plenty of spare parts. You can also buy more sophisticated ones from Japan and from Korea but they are like 10 times as expensive.

System of Rice Intensification (SRI): Erika Styger

Thanks so much for inviting me and giving me the opportunity to talk here. My background is mostly in Africa. I have worked for almost 20 years in Africa in different eco-regions, cropping and agrosystems and agroforestry. Since 2007, for the past four years, I have started working on this System of Rice Intensification (SRI). I will try to give you an introduction of what it is and then show you an example from Mali, which is in West Africa. In Mali, I was able to work on the system with the farmers. Then I will raise a few talking points of how that system could develop or what the opportunities are and the challenges.

What is SRI? SRI stands for the System of Rice Intensification. It is a methodology that was developed by a French Jesuit in Madagascar in the 1980s, in view of increasing the productivity of irrigated rice. It is based on changing the management of the soil, the plants, water, and nutrients while reducing external inputs. It is a little bit different than the conventional practices that are recommended today and it has shown benefits today in over 42 countries. I will now go into a little bit of what that means.

Father Henri de Laulanie developed six main practices. When approaching an irrigated rice system, we take his six practices as a starting point. The first practice is to work with only one seedling. Conventionally or traditionally, what Peter also explained, farmers usually transplant 2, 3, 4, or

sometimes 5 seedlings. Sometimes I have even seen 10 seedlings in one hill. With SRI, only one seedling is planted. The second practice is to transplant very young seedlings. What does that mean? It means that plants are at a two-leaf stage. In tropical, warm climates that is about 8-12 days in age. Transplant when the plants are very small. The third practice is to adopt wide spacing. Instead of decreasing the spacing, a common step in the intensification process, you increase the spacing. I think developing rice cultivation in the Northeast is a wonderful opportunity because you have a fresh start. You can really think it through from the start and experiment. I encourage this - my talk will show a different way of planting rice. We still have a lot to learn about how we do agriculture and a starting point can be to change practices. Instead of thinking that we need to intensify by putting more plants to ensure bigger output, we intensify by putting fewer plants. That is something that people usually don't believe at first and it has been that way for every farmer I have seen. Have traveled to many countries and worked with many farmers and technicians, the SRI planting method is against of what people are used to. Even after transplanting, people want to see lots of plants in their rice paddies. If they only see little seedlings sparsely spaced, they think that they haven't planted. They will feel really uncomfortable for about one month until the rice starts to tiller and grow. You will see some pictures of that.

The fourth practice is not to flood the rice paddies but give minimum water application during the vegetative state. Rice is not a water plant. It tolerates water. It can grow in water but when water is removed maybe it grows even better. The fifth practice is to ensure soil aeration and Peter showed you a little bit about that. It is often done with mechanical weeders, which also incorporate the weeds and gives the roots air to breathe. It is not that water is bad for the roots but it is the lack of oxygen that is bad for the roots. The sixth practice is to start with organic amendments to improve the soil as a base for fertilization. Then depending on your soils and yield level, famers can add chemical fertilizer or continue developing an organic system. These practices interact with each other and we can talk about that in greater length and detail.

The outcome of putting together this different way of managing plants is that the appearance, which is called the phenotype, of the rice plants changes. In this picture you see SRI plants on the left hand side. It is the same seed as on the right side and the same germination dates. It is the same rice, the same age, but it looks completely different from the rice planted under the conventional method. We have seen this behavior change in many countries. In a paper that has just been published, Thakur in India measured all these changes within the plants in the conventional system and in the SRI system. There is a long list of how he actually measured all of the phonological and morpholocial differences when planted under SRI. What is happening is that tillers become thicker and also stronger. He has measured that and quantified it to show significant differences. The plants also get taller which you could see in the picture I just showed. SRI plants have also more tillers that develop per plant. A very interesting difference is that the canopy angle of the rice plant is also changing. Under SRI conditions the rice plant opens up more and is able to take more sunlight than when it is planted under the conventional system, where the plants are spaced closer and grow taller. When I was involved in introducing this system in Haiti last year an old farmer came up to me and said, "You know, I have known this variety for all my life but now it looks different. Its leaves go way out, but before they were more erect." We are getting more and more evidence from around the World and with this paper, a quantification was done showing how these traits are changing.

A very important change happens in the root system. Roots grow much deeper and they double in volume and in weight. Also, in this picture you see that they stay active. When roots are in a flooded environment, under anaerobic conditions, they can't grow very well. Roots can't breathe so there is a

lot of deterioration in the root systems. Adding organic matter to the soil promotes biological life within the soil, they enter in symbiosis with the roots and strengthen the plants and make them more active and grow better. If roots are bigger, there will also be more shoots because there is always a root/shoot relationship. In Africa when taking farmers to the fields and we encouraged them to pull out a plant in the SRI plot and the control plot. Plants in both plots look good and the farmer often wonder about where the exercise will take them. Once the farmers see the roots, it was like, "I understand now. I can go home. I got it." It is pretty astonishing. It is a good exercise to pull out plants and look at the roots. What is happening underground is determining how the plant develops above-ground. Another change is that the leaves get longer, wider, and thicker. The leaves contain more chlorophyll and with these changes they can have a better photosynthesis rate. Also, the leaf senescence is delayed so they stay greener longer. The leaf area index, which indicates how much leaf surface area is covering the ground, is also higher with the SRI system.

What are the results from these phenotypic changes? Usually they have a big impact on yield performance. There are fewer plants growing per square meter but there are more or similar numbers of panicles per square meter, which determines yield. The panicles are usually longer. Here you see a woman, in a southern Mali lowland system, with two panicles, one from a SRI and one from the conventional system. You see that there is a difference even with the same seed planted at the same time. This panicle also has more grains per panicle. Usually the grains show better filling, the quality of the grain is better and the weight is heavier. This results in increased yields of more than 50%, which is huge. Less water is used, fewer seeds are used, less chemical fertilizer is used and yields can increase by more than 50%.

This is a map of where the benefits of SRI have been validated, which means that we have seen a better yield performance in all these different countries. It is interesting that SRI only started to leave Madagascar in 2000. It has been only for the past 10-11 years that this method traveled around the world and has been adapted to different rice cropping systems. Interestingly, the farmers are often the ones who have shown best understanding of the system, and the system is spreading rapidly through the channel of farmer to farmer.

Audience: How is it done in California or Arkansas? Peter said that the yield there was much higher.

Peter: In California they usually use airplanes to fly over and drop rice seed into the water. They don't use SRI and I think in some of these places like Arkansas they actually direct seed. They don't transplant.

Audience: At this time there is no SRI being grown in the US?

Peter: No.

Erika: At this point no. Actually if you like to start, you should let us know.

Peter: This is an example of where you can do your own experimentation and see.

Audience: I am a little bit confused when you say non-SRI versus SRI and there are six principles or variables. For the non-SRI are they using organic or are they using commercial fertilizer or are they using one seed or are they using 7 seed? You have six variables. With the non-SRI, what specifically or what type of cropping are you comparing?

Erika: It depends very much on the environment. In Cambodia, for instance, we find mostly a rainfed environment. Afghanistan is a high altitude environment. Cuba, Bhutan, are humid environments, and Mali, where I worked, was a very dry environments. There are different comparisons you can make. It is about taking the principle, trying to adapt it to the farming system, and then comparing it to what the

farmer is doing. I will walk you through an example of this in a little bit. The paper I just showed you compared it to the conventional standard recommended practices of rice growing in that area. For instance, with SRI the practices would be alternate wetting and drying during the vegetative stage, using a single seedling 12 days old, spacing 20x20 centimeters, and using a cono-weeder three times. The standard practices, which are recommended in that area, are continuous flooding, three seedlings/hill, 25 days old seedlings, closer spacing, and hand weeding. For his comparison fertilization was the same. If you are comparing systems and want to take all the factors, plot them out, and compare each factor with each factor, you will end up with a huge experiment with hundreds of plots. The bottom line is to improve the systems, and in each situation it is a little different.

Audience: It is a little more difficult when you are implementing a new system and have to figure out which of the six principles to follow. You could do five of the principles and still have a flooded paddy.

Erika: Exactly. Maybe I should talk about how we did this in Mali.

This is in the Timbuktu region. I worked there for three years. It is a pretty cool place. It is a very, very dry area. There is no rainfed agriculture because there is not enough rain, only 200 millimeters a year, to grow a crop. Not even sorghum can grow with that amount of rain. Temperatures are often above 100 Degrees Fahrenheit and the food insecurity in that area is among the highest in the country. This is the Niger River, which runs through Mali. This is also one of the areas where African rice was domesticated and farmers still cultivate a lot of *Oryza glabberima* in the area. Water access depends on seasonal flooding. With the rains the Niger rise, which results in flooding the river arms, which are only seasonally flooded. Once these river arms arrive at the villages in distance to the Niger, people pump the water into the rice paddies. I took this picture from the airplane. This is a seasonal arm. This is a village and this is the rice paddy that they are sharing. This village pumps the water into the rice paddy using a motor diesel pump, which can irrigate about 35 hectares. The perimeter is shared among 100 farmers, which provides each farmer a third of a hectare, which is a little less than one acre.

In 2007, I was an independent consultant in Mali. My husband was working for Africare, an American NGO. After coming home from his very first visit to the project site in Timbuktu, he had the idea of trying out SRI as most of the agriculture is based on rice cultivation. We downloaded a manual from Madagascar from the Cornell SRI Website, and sent it to the project staff in Timbuktu. A few weeks later they tried it out, and called us, letting us know that the SRI fields rshow improved performance over the control plot and that they will organize field days for villagers to evaluated the trial plots. I participated in the field visit, which turned out to be a big farmer meeting. We were also able to show a film from Madagascar. At the end of intense discussions, the farmers stood up and said they wanted to try this system more seriously. This request was brought to me by the farming community, and I realized that this was something that I needed to respond to. Up to that moment, I had no plan at all to actually work on SRI.

Based on this serious request, I felt I needed to return to harvest the plots myself, which I did during Christmas time. This fiel you see here on this photograph produced 9 tons/hectare. The farmer's control plot that he looked after really well produced 6.7 tons/hectare, which was a very good yield as well.

The next season, Africare wanted to work with at least 12 villages because all the village leaders requested to apply SRI in their villages. We selected 12 villages and worked with 60 farmers. We

looked through the manuals and tried to figure out how to implement SRI in this dry climate. The manuals we consulted were from Madagascar with a much more humid climate. The manual from Madagascar for instance indicate the importance to drain the fields from too much water before starting soil preparation. In Timbuktu, the soils didn't have a drop of water for at last 9 months, very extremely hard and needed a pre-irrigation before plowing was possible. The farmers pre-irrigated the land, brought in some organic matter, and then plowed the land either by tractor or by hand. After plowing, the land was flooded, and farmers started breaking up the soil chunks. Puddling is not something farmers usually practice, so fields were minimally puddled. Field leveling had never been done before in this aera. We had to think how to do this. We got a board and started pulling it. For the fun of things, we gave each other the common names of cows and oxen, which was pretty hilarious. On the other side, work was pretty hard, but people encouraged each other saying "Let's just give it a try, and we how it turns out."

The SRI nursery was also a little bit different than the conventional nursery. For the SRI nursery, the soil is mixed with sand and manure to create a very nicely structured seedbed, which was established on a raised bed. Usually the conventional nursery systems are flooded. The seeds were soaked in water for 24 hours. This is a very hot climate. The seedlings appeared after only 2 days and were transplanted after 8 days. At transplanting, the seedlings are put on the plate with the aid of a hoe or shovel that cuts underneath the root zone and lifts the seedling up, in order not to disturb the roots. The SRI seedling uprooting and transporting, is not as labor intensive compared to the conventional nursery, where plants are pulled out of the seedbed, the roots are washed, the plants are packed into bundles and transported. Transplanting can happen days later. With the SRI system, the plants are lifted out of the nursery when very young, roots are kept protected with soil still surrounding them. Transplanting should ideally happen 15-30 minutes after uprooting. ,

Audience: That is the size of the transplant, right there?
Erika: Yes, this plant. We transplant when they are that little.
They are not very densely seeded in the nursery. Therefore, it is easy to pick up one plant after another and keep the soil around the roots more or less intact until planted. Here are two ways for transplanting, with a string or with a marker. It is at first a learning experience. The whole village came and wanted to try it out; so there were a lot of people at once in the paddy. This whole section in the photograph has been planted but you can't see the plants. Another way to transplant is by using a marker, with which you can create a square pattern. The seedlings are planted where lines intersect.
Audience: He is standing over his knees in the field?
Erika: Yes. This is in the mud.
Audience: It is over his knees right?
Erika: Not over. I would say up to about here.

Then there is irrigation. As I said before, during the vegetative period we don't want to irrigate the rice too much. Usually this means adding a thin layer of water and letting it dry out until you see a few soil cracks. Then you add another thin layer of water and let it dry out again. If you increase the organic matter in your soils, this should be possible here. In the tropics this is especially important. Organic matter enriched soils act like a sponge. When you integrate organic matter into the soil the water holding capacity is much, much higher.
Audience: Is this like dry land growing? Is this like an upland style? If I had drip irrigation on beds, plenty of organic matter, and I plant as you say a little wider apart, then later on

after the vegetative state…I am not sure exactly when that is. Is that before the panicle has booted? Is that what is considered the vegetative state?

Erika: Once it gets to the flowering stage people add more water.

Audience: I would water more then if I could?

Erika: Yes. The soil is not really dry or dried out. It is kept moist. There is also the problem with losing nitrogen if there is too much drying and wetting. You need to keep the soil moist. There are some nice videos and photographs of a Pakistani farmer who mechanized SRI, and practices organic farming methods. He designed his own machines and applies raised beds, doesn't flood the soil and he doesn't till. He was able to cut his water use by 70% and get really high yields. I could give you some material about that.

Cono-weeding is also something Peter has already talked about. It has several functions. It incorporates the weeds into the soil. Usually farmers take the weeds out and put them on the rice bunds. Instead, with cono-weeding they get incorporated into the soil and act as a fertilizer. Cono-weeding also brings oxygen into the soil and stimulates root growth. What we have seen, which is similar to the effects of using ducks for weed control, is the stimulation of growth after weeding. Here you can see that when you align the plants in both direction, do square planting, it is easy to weed in both directions. Also when you use the cono-weeder, organic matter in the soil gets mixed up again with water and enters the soil solution. The roots can now absorb the nutritious water. There is a nutrient flush right after weeding. This is well visible when a farmer weeds only half of the plot. Coming back two days later, the rice paddy has turned really green where the cono-weeder was used, and rice plants remain yellowish in color where weeding was omitted. Cono-weeding also helps leveling the field. Patches of standing water get redistributed, which has a homogenizing effect across the paddy. You will actually see more homogenous growth with the support of this tool.

Audience: What is that tool called?

Erika: It is the cono-weeder. There are many different types of weeders. In India especially they have developed many different types, including mechanized weeders.

Let me tell you what happened with the 60 farmers trial in Timbuktu. It was a field comparison with a SRI plot and a control plot side by side. Farmers used the same seed in both plots but they could use whatever variety they wanted. The nursery was started on the same day. Then we made comparisons. This is a farmer's SRI plot and this is his traditional plot. In this photo he had just transplanted this traditional plot the day before. He usually transplants seedlings after 30 days and sometimes 40 days, but for SRI he started with 12-day seedlings. You can see that the SRI seedlings are already well established and growing. In contrast, the traditionally raised seedlings have just been transplanted and will have to get over the transplanting shock, which will take several days. Tillering, which is the sprouting of new stems, has already started in the SRI field. In the traditional field, tillering can't happen at the same rate anymore compared to the seedlings that were planted young. Young transplants are very important if you want to have maximum tillering. This photo shows tow plants – one SRI plant compared to and 3 or 4 plants from one hill from a conventional plot. We have collected data in many countries that show the SRI plots are maturing faster. This is an aspect of SRI that might be interesting for this region because it would help reduce the growing season. Under SRI, the rice crop can be harvested 10-15 days earlier than under the control. Sometimes this is enough of a difference that the farmer can switch varieties. Sometimes farmers are afraid to make any changes. In Mali the cold season brings more birds that can eat the rice crop. If they have a good year they could try medium duration varieties, which yield higher than the used short duration varieties.

Audience: Because environmental issues are becoming larger and larger for all of us all over the world, it occurs to me that if this turns out in more temperate climates than ours to be the right way to go then in order to reap some of the environmental benefits of a wet paddy one could alternate them and still have the benefits for the amphibians and in terms of water impoundment, etc.

Erika: I think that is a nice point because for me the situation on the farm here and in Vermont is a new exposure to a rice paddy as a wetland system or a biodiversity hot spot. It depends on the scale and on your situation. At what scale are we talking? Maybe if it is at a small scale. If rice production here changes to a larger scale, maybe issues like flooding, methane emissions, and water availability will have to be discussed more. These kinds of things have to be discussed. I think it is always a question of what the objectives are and what kind of environment you are in.

Audience: I am not an agriculturalist and I don't think anyone has done studies of the impact on pest management with all these amphibians coming out into the area. I don't think we know the answer but obviously there are benefits to both.

Erika: As we have talked about there is no one landscape. There are always niches in the landscape and different watershed management strategies. If you have lowland like Erik that doesn't grow any other crop productively then maybe it makes more sense to plant rice. Why not use your land in a different way? Thinking about the ecological functions of the different components within your landscape should help. Rice paddies are one strategy. Where do they fit within the overall picture? I think that was really nicely discussed and showed today and it is very important to keep in mind.

The yields were really high with the 60 farmers. Once again the SRI fields got yields of up to 9 tons/hectare and the control plots got 5.5 tons, which is also a good yield. Because the farmers put a little bit more care into the control plots than in their usual village plots, the yields were a little higher. We randomly harvested plots. You can see that we had yield increases between 66% and 87%. I showed this already. These are the numbers that show how the panicles per hill, the size, and grains per panicle increased between the control plot and the farmer's practice plot. This is the cost and that is revenue. This publication is available. If you are interested, I can send it to you or you can find it on our website. If water use is decreased, there is less cost. By planting one seedling per hill and at a wider spacing they drastically reduced the amount of seeds needed by 85-90%. For many farmers this reason alone was enough to practice SRI. Yield and all the other benefits can come later. If they only need 6 kilos/hectare instead of 40 or 60 kg or sometimes 80 or a 100 kg, then SRI is worthwhile to do. They also reduced their fertilizer use because they used organic fertilization. We asked the farmers to really think about how they apply chemical fertilizers and to use only the amount they needed based on their observations. That reduced the consumption of chemical fertilizers by 30%. Irrigation water was a little difficult to change. In the beginning there was only a 10-30% reduction because farmers were scared to use less water especially in the hot environment. More and more numbers coming in from all over the world show that 30-40% of water can be saved, sometimes 50%, with SRI. Labor was increased a little bit in the first year. There were different steps that took more work. Soil preparation was more tedious in the beginning. Transplanting took a little longer because people weren't used to it. However, weeding took less labor than before. These are the calculations. If you look at the production costs, because the yields were high there is a 30% reduction in costs per kilo of paddy produced. The revenue more than doubled out of the same cropped surface area.

Audience: Why were the weeding costs less?

Erika: Because they had weeders and usually they would weed by hand like Peter showed. It was a huge saving in labor.

Audience: We were just talking about in the last presentation how rice is not really a crop that you can rotate. Is there any thought that perhaps by switching from a paddy to a dry ecosystem or from dry to paddy that you are just making different things available in the soil that would not normally be there and that these kinds of yields may not hold up over time? It might deteriorate as the soil becomes more used.

Erika: This is why organic fertilization is important. You need to keep fertilization and soil improvement in mind. I think maybe that is the key to why organic matter management will become more important in this system. You will need to develop associated practices to make sure you keep your soil organic matter available. Then if you add fertilizer, it will be used very efficiently and made available to the plants. I think it is important to combine chemical and organic fertilizers. The best results have always been when they are combined and you will get the best nutrient efficiency for your crop.

I want to go through a few challenges because of what you were just saying. This field was flooded and the water was high. They couldn't control the water level but maybe they can plant single seedlings and young seedlings. I think we need to have a pragmatic approach by taking the principles and seeing what they might mean in each environment. What can we do? Can we gain something? Can we experiment with it? If we gain something by changing these practices in this environment, we should adopt it. There are many places where you won't be able to manage the water, which is a very big constraint. These are all the challenges. The second challenge is reducing chemical inputs. What does that mean? It is both a challenge and an opportunity. If the soil is improved, nutrient holding capacity and water holding capacity will also improve. Actually in India and Indonesia, SRI has helped to show people more than before that going organic is possible. There are some really big movements in India, Indonesia, and Cambodia. People develop organic practices with the SRI system because they can get higher yields. Because the plants are spaced further apart, there is more wind blowing through the paddy and less humidity. In tropical areas humidity really accumulates within the plant canopy and helps proliferate fungal diseases. For instance in Vietnam the farmers told me that they are not really interested in increasing their yields that much but they think by using SRI they can reduce their chemical inputs. They are really suffering from all the chemical inputs that they are putting in their system. They used to have an integrated system with fish and crayfish but that is all gone now. By reducing chemical inputs through a different cropping system they can also get back to being more environmental friendly and get their fish and crabs back.

The motivation for changing to SRI is not only yield dependent. Very often farmers in Asia and Africa depend on seeds coming from the ministry of agriculture. Sometimes the seeds don't show up, are unavailable, or can't be bought. Farmers in Africa where I worked always complain that they have mixed varieties, they don't have good seed, they need new seed, and they can't produce well without new seeds. On the other hand, in Cambodia they have already developed a very good system. With SRI there is only one plant per hill. In conventional systems when there are 2-3 plants per hill there can be more than one variety per hill and it is easier to mix the varieties when you harvest rice for seed. In contrast, with SRI it is easy to spot which plants you would like to harvest for seed. The farmers can go into the field, select and harvest their own seeds because they only need 6 kilos/hectare. Often farmers don't even have a hectare of land. This woman in Cambodia has her four plants here that she wants seeds from. On the other side she had a plot where she dug out the soil in a 50x50 centimeter area. She added nice organic fertilizer and micro-gardened her

seed plants. This woman here harvests the seed plants. She looks at each panicle and removes the top and bottom of the panicle where the grains are not very nicely filled in. By going through each panicle she creates her seed pool for the next year. It is actually very empowering for people.

Another example that I have seen is in India. I went there last February. I went to this little NGO in a remote area of Orissa. They told me that with SRI they are multiplying 365 varieties in less than one hectare. They displayed the varieties in these little seed bags. They ask all the farmers that come for training to bring a handful of seed and the NGO plants out those seeds. If a farmer comes into the garden and says, "I would like to test this particular variety " They give him a handful of seed. At the local level, people are starting to maintain their varieties and the productivity of traditional varieties has increased. Traditional varieties, which were disregarded because they were low producing, are starting to have higher yields with the SRI system. Suddenly, farmers are not against traditional varieties anymore. With SRI these varieties are more productive and we see a shift to recultivating indigenous varieties. There is more than one way to do things. We shouldn't get stuck in this is the way that the system should work. We need to think about constantly innovating based on what people are doing, where constraints are, and how they can be overcome. I think these are some of the avenues that open up through the use of the SRI methodology, and at the global level we need to continue making innovations.

This is my last slide but it is also one of my dearest. When I was in Mali, the farmers cultivated wheat in the winter. They asked me, "We cultivate rice with SRI can we do it with wheat?" I said, "I don't know." They said, "Well let's try it." I wasn't aware of it at the time but at the same time in India, in 2006, they were conducting their first experiments with SRI on wheat. Today SRI wheat exists in India, Ethiopia, and Mali. These are pictures of plants from that plot and the panicles are much longer. We had a spacing issue in the first year and so in the second year we did a spacing trial. In the second and third year, the last year, these were the numbers that we got. With traditional wheat farming practices the yields were 2 tons/hectare. Now with SRI and single seedlings, they were getting maybe 5-5½ tons/hectare in Mali, which has never been seen before. The same thing happened in India. In Bihar, which is one of the poorest states in India, people have very tiny plots. The plots are maybe as big as this room here. With SRI, they were also able to double their yields. They can prolong their chapati production or consumption for a few months. There is no paper yet published about SRI with wheat, but we are trying to collect all the experiences from the three countries right now and we will publish something. For sugarcane in Tamil Nadu, India there is a manual. It is on our website. SRI practices can be adjusted to other crops. In Ethiopia they work with teff. In west India they work with finger millet. In eastern, northern India in the same system with the wheat I have also seen mustard. They are increasing their yields significantly.

Audience: What is your website?

Erika: At Cornell we are a small group. We provide global outreach, support, and knowledge sharing. We also try to help increase and better document the analysis of this system. This is a brochure and in the back here is our website. It is www.sririce.org.

Audience: It is very exciting. I have been doing spacing trials at the University of Massachusetts for the past three years with wheat. We space 12 inches apart that has resulted in 5 pounds/acre of land-raised wheat. We have also planted at 6 inches, 8 inches, and 10 inches apart. At a spacing of a foot apart we are getting enormous yields. Then we under-sow with clover. I have some of the heads of wheat in the car but it is just like your pictures. We under-sow with clover either in the fall or the early spring so there is no weed pressure. We let the clover grow for the next year and then till it in. We

get really big fat heads, 20-30 tillers per wheat plant, and enormous yields. It is all completely ecological. The large root systems are much more climate resilient.

Erika: I think I have some more pictures here. This is a spacing trial we did that I was talking about. This is tillering. I think there are 18 tillers per plant with SRI and only about 2-3 for the traditional method. This is our experimental set-up and these were the yields that we got with these different spacings.

Audience: The point to emphasize is that with deeper root systems the plant has enough space so that when there is a drought the roots can reach to the lower soil moisture. If there are torrential rains, the plant doesn't lodge because it has its stability. It is a very important strategy for climate change.

Audience: I have the publication here but you can also get it online at www.growseed.org.

Audience: Have you done anything with rice at the UMass farm?

Audience: No. I am just working with wheat. I will be doing rice at my farm.

Audience: I have a question for both you and Peter. I am curious what happens with the straw in both Africa and Asia. I am particularly interested in the use of it for building. I also wonder if you know what the nitrogen content of the straw is?

Peter: In Asia and in Africa too there are a lot of competing uses for the straw. It is used as an animal feed, it is used for thatching, and it is used even as a fuel for cooking. The straw doesn't have very much nitrogen in it. It has potassium and some of the other nutrients.

Erika: The competition for use is very high. In Africa, in the dry areas it is mostly fodder for cows. We actually started to dig some ditches and throw in the straw to produce compost next to the rice paddy. It doesn't need much. Put in a few cow excrements, fill it up with water, and cover it up. In three months you will have compost. It is a management issue of how to use it. I think it is important for farmers to think about these materials.

Peter: It is a very good question because only using chemical fertilizer and not supplying any organic matter except what the roots leave in the soil is not good. You have to have organic matter to give the soil structure and for the biological and physical properties. How do you convince a farmer to use some of that straw to improve soil health when he wants to feed it to his animals? The same issues arise with manure. Do you put the manure in the soil or do you use the manure as a fuel to cook your rice? These are some of the dilemmas that occur when we work in these kinds of situations.

Erika: It becomes important to take a systems approach if they used the cow manure for fuel. It might be useful to think about planting some fuel wood trees. The cow can be fed the tree leaves and then the manure can be used in the rice paddy. I have seen a farmer who has a fish pond. The pond is so heavily saturated with nutrients that he uses it to irrigate his rice paddy. In the meantime he eats the fish. These are the kinds of circles that we need to consider to make the system work together as a whole.

Peter: One really important point is that business as usual, mining your soil, harvesting all the straw, taking it away, and not putting any manure back, is not sustainable.

Erika: One good thing to do is to spread out your straw. In Africa, because straw may take some time to decompose in the soil, they plow after harvesting the rice and let the soil rest and the straw decompose. In the spring, they are almost ready to go because they don't need to plow and the organic matter is already integrated. Plowing the

straw into the soil is easier than taking it away, composting it, and bringing it back. Another option is to plant cover crops.

Peter: Or you can leave the straw on the soil surface.

Closing and Group Photo

After the final presentation, participants dispersed to talk in small groups with speakers and others in attendance. A majority of the participants were able to be present for a group photo.

Second Annual Northeast USA Rice Conference Group Photo