Title Slide — Bees, both wild and managed, such as the honeybee, are facing challenges throughout the world. So, how are the bees in Maine doing?

Slide 2 — Bees as a group are quite numerous (diverse). There are a bit more than 20,000 species in the world and about 2,500 species in the U.S. As one goes from south to north the number of bee species or types declines. Maine has a low number of species relative to the states south of us, but we still have 250 species!!! Photos: on the left a bumblebee, on the right a small cellophane bee.

Slide 3 — The honeybee is not a native bee, it was brought over to the colonies in 1624.So, it is from away! It is a valuable bee that is reared by local Maine beekeepers and it is brought into Maine from all over the country for pollinating Maine's fruit crops. However, the honeybee is in TROUBLE…last year 45% of the colonies in the U.S. perished. Currently honeybees are plagued by 20 different virus pathogens, three bacterial pathogens, 3 fungal pathogens, and three parasitic mites. Honeybee health is at an all time low. On top of this honeybees are exposed to pesticides at record levels and their own genetic diversity is at an all time low….trouble on the horizon for our most important pollinator.

Slide 4 — Since 2009, Dr. Drummond has been involved in three large honeybee research projects. One project, the national stationary hive project will be discussed briefly.

Slide 5 — The national stationary hive project involved the states of Maine, Pennsylvania, Florida, Minnesota, Texas, California, and Washington. There were three trials (2009, 2010, and 2011; where in each state in each of the trials a apiary was established with 30 honeybee colonies by installing packages and then the colonies were re-queened with a queen from the same family. The colonies were followed as in an epidemiological trial and their fate was tracked. NO medications or any pest management was conducted. In general, our results reflected the state of honeybee health. It was rare to have a colony live for two years. The causes of death were determined by statistical modeling shown here and described below… This is a model for tall three trials (the year effect). This model is providing evidence for factors that affect the probability of colony death. It shows that year or trial is a factor, meaning that the trials differed in their overall survival rates. Apiary site is a factor other main factors are Varroa, Nosema, and IAPV…interactions with site suggest that the force of death is not the same across sites. The relative risk shows that colonies that have high mite loads are 4.9 times more likely to die out than the average colony, less for Nosema (2.1 times) and less again for IAPV (1.3).

Slide 6 — However, in addition, to pathogens and parasites, many of these colonies were exposed to pesticides. The levels were low, mostly sub-lethal. As it turns out the level of exposure was related to the amount of intensive agricultural production in the vicinity of the apiary. If we look at colony loss in a year there is a marginal effect at $P = 0.092$ for 2009 and 2010 trials, but not for the 2011 trial. So, these effects do not occur every year, but again the exposures are at very low levels.

Clearly, pesticide exposure is something to worry about, but is not always consistent, most likely because it is also dependent upon the other factors such as pathogens and parasites that affect honeybee health.

Slide 7

So, in summary, the national honeybee study and the other two studies conducted in Maine and elsewhere across the U.S. suggest that the main causes of honeybee colony losses are: 1) the parasitic *Varroa* mite (#1 and introduced in 1986 to U.S.) that compromises the immune system of the honeybee, transmits virus pathogens, and is becoming very difficult to control in colonies due to resistance development to the acaricides that have been developed to kill the mite; 2) the relative new comer fungal pathogen *Nosema ceranae*, that also has been shown to compromise the immune system of the honeybee and is difficult to control with fungicides which also now have been found to compromise the bee's immune system, 3) a suite of viruses that are transmitted by *Varroa* mite, 4) geographic location that represents weather stresses and forage (flowers for food)…Need to plant forage to help all bees…this is where NRCS can help, 5) and pesticides…there is no doubt that bees can be killed by pesticides, especially insecticides…what is controversial is whether sub-lethal very low doses can affect honeybees…the national stationary hive study has shown that in 2 of 3 years…yes, the additional action of exposure was correlated with pre-mature with colony death.

Slide 8

Honeybee are not done yet…BUT there are new additional issues that keep emerging… In 2012 a study was published that documented a new threat to honeybees…the parasitic phorid fly that resulted in honeybees becoming "zombie bees"…The parasitic fly kills the bee and just before death the bee's behavior is taken over by the fly and the bees flies to a light and dies, where the fly maggot pops the head off of the honeybee and crawls out (LOWER LEFT PHOTO) and metamorphoses to a adult fly that looks for another honeybee to parasitize (RIGHT PHOTO). Up until now this fly parasite has been fairly rare in honeybee colonies…but an undergraduate student in Dr. Drummond's lab this year (2015) dissecting honeybees to look for another parasitic mite, the tracheal mite (UPPER RIGHT PHOTO) found that up to 30% of the honeybees sampled on the blueberry barrens were parasitized….THIS IS VERY ALARMING.

Slide 9

So, we talked about honeybees, what about the OTHER 274 bees in Maine, the wild bees? What about their health? Are there species declines, new exotic bees colonizing Maine, Shifts of some species doing better and some doing worse? Well, we do not know as much about our native bees as we do about the honeybee…the wild native bees have just not been studied very much and there are a lot of them to study!

Photos:

1) Exotic giant resin bee, been in Maine for three years (upper left photo)
2) Exotic wool carder bee, been in Maine for 4-5 years (upper middle photo)
3) Native sweat bee entering its ground nest (upper right photo, photo credit Alison Dibble)

4) The boreal bumble bee on a mint flower (lower left photo, photo credit Amy Campbell)
5) The yellow banded bumble bee, once in decline now on the increase (lower right photo)

Slide 10 ONE factor that makes it difficult to determine if native wild bees are in decline is that bee abundances fluctuate drastically from year to year as observed in the graph above for the four groups of bees (bumble bees (Bombus), leafcutting bees (Megachilidae), sand or digger bees (Andrenidae), and sweat and other bees (Halictidae and others). This data comes from a 27 year survey (with some years skipped, † notes when field was converted to every other year production) that Dr. Drummond conducted in a wild blueberry field in Winterport, Maine. One can see that depending on where you start to assess bee abundance and the number of years that one surveys…results might lead one to opposite conclusions of increasing or decreasing abundances. Only a very long-term survey will be able to determine if a group of bees are in decline..this is very expensive to do.

Slide 11 However, there have been some very real declines documented across the globe, including the U.S. and Maine.
Photo: one of Maine's most common bumble bees, the orange belted bumble bee (photo credit is Amy Campbell)

Slide 12 Looking at the numbers of bee species, Ignast Bartomeus, the lead author on a study based upon insect museum specimens from the Northeast, found that there are bee species that are declining, yes, but overall many more bee species are stable and increasing. It does remain important to think about the impacts of pollinator decline, but the situation isn't nearly as dramatic as it has been played out to be. However, four species have been reported to be in drastic decline…have any of these been in Maine?

Slide 13 Here is some bumble bee data of Dr. E. Osgood (1963) and Dr. Drummond's (1993 – 2014) for Maine. It shows four bumble bee species and their abundance relative to each other. It shows that the common orange belted bumble bee (orange bar) has faired well over the past 50 years. The rusty patch bee (blue bar) was once fairly common, started to decline in early 2000 and cannot be found now. The yellow banded bumble bee (yellow bar) was also once very common and also started to decline in early 2000, however, it never totally disappeared, but remained uncommon until 2012 when it appeared to start on the increase. The last bee, the impatient bumble bee (black bar), was never common in Maine prior to the 1960's, but since the late 1990's it has been on the increase. This is a southern northeastern bumble bee, but it is also commercially reared and sold to growers in Maine. So, is the impatient bumble bee's increase due to climate change and milder weather conditions or is it due to escapes from the commercial hives brought into Maine and establishment of populations in areas where it never was found before? We do not know the answer to this.

Slide 14 The rusty patch bumble bee, the blue bar from the graph on the previous slide, has declined not just in Maine, but all over its original home territory in the eastern U.S. This is a species that may be listed as endangered, with good reason as can be seen.

Slide 15 The yellow banded bumblebee also declined in Maine (decline shown in two previous slides). However, there is reason to be optimistic that some bees either recover from declines or maybe many bee species have long-term fluctuations in abundance levels. The next few slides document the recent increase of this bumblebee.

Slide 16 Prior to 2013, the yellow banded bumblebee was only found in 1-2 sites for every 20-30 that we sampled. In 2013, we saw a bit of an increase (red dots).

Slide 17 In 2014, a tremendous surge in locations that we saw the yellow banded bumblebee.

Slide 18 Last year the increase kept going. Hopefully this will continue for the future.

Slide 19 So, most of the wild native bees appear to be either increasing or stable in their abundances…BUT some ARE in decline. What might be the factors.

1. Climate change…a recent study documented that the southern range of bumblebees (the southern eastern states) have seen a great decline in abundance. This is not surprising since bumblebees are mostly cool loving species.
2. Shrinking habitat…for Maine: we are the most forested state in the U.S. now (94% of our land area). In general mature forests are not optimal for bees…planting of flowering landscapes may ameliorate some of this loss of habitat…but on the other hand this is a natural phenomenon. But, farmers may want to consider this.
3. Pesticides…wise pest management practices are key…we need to be very careful and thoughtful in minimizing exposure of pesticides (especially insecticides) to all bees.
4. Pathogens and parasites…native bees have them as well as honeybees
5. Bees by nature have limited genetic diversity due to their reproductive biology, so when populations get low their genetic diversity decreases rapidly.
6. We have several species of new bees from Asia and Europe…are they a threat or a welcome addition? We don't know

Slide 20 Pesticides and native bees. My PhD student, Kalyn Bickerman has been researching threats of the insecticide, imidacloprid to bumblebees by exposing them to this neonicotinoid at different levels and then allowing them to experience field conditions

Slide 21 She has found that imidacloprid decreases colony growth over the season, consistently over two years of study

She also found that this affect is not simple to interpret, but depending upon the conditions that they recover from the dose affects their ultimate population size…in this study organic fields being less stressful than conventional low-medium input fields.

Slide 22 There are two sources of disease causing pathogens.

1) Native pathogens that have been with the bees from the beginning of time
2) Exotic pathogens that have been introduced and expose native bees

Slide 23 This also is Kalyn Bickerman's work…I should note that there are over 100 species of parasites that have been associated with bumblebees. In the interest of time, I'll be discussing the parasites and pathogens that are directly relevant to my own research looking at the health of bumblebees in Maine and what the threats to their populations may be.

Nosema bombi is a fungal pathogen that is spread through infective spores that are deposited in an infected bee's feces. Prevalence of this pathogen varies regionally but seems to be around 5 or 6% in Maine, although this number varies incredibly by species. The interesting part is that this prevalence is often seen to be very low in common species such as B. ternarius or B. impatiens, but then as high as 50 or 60% in more rare species such as B. borealis and B. terricola.

Keep in mind with the graph on the bottom that the sample sizes of the more rare species are low, on the order of only 3 caught all summer. Therefore it's more of a visual representation. However, a recent study in Virginia also found higher levels of Nosema infection in declining bumblebee species.

There is currently very conflicting evidence in the literature for what effects N. bombi infection has on an individual and colony level. Observed Individual symptoms include distended abdomens, sluggish movements, and death. Colony level effects that have been hypothesized to occur have been slower colony growth and reduced production of reproductives at the end of the season.

This pathogen was first seen in the 90's in North America and may be linked to the commercial bumblebee species *B. occidentalis,* which underwent a drastic decline in 1996. Coincidentally, this was also the time of the decline of several other wild bumblebee species, including *B. terricola*.

Slide 24 Spillover of virus from honeybees is it a concern. When native bees forage on the same flowers as honeybees there is a chance that pathogens will move from one species to another. In the stationary hive national study mentioned in the beginning of this slide show, we found that bumblebees collected near the honeybee apiaries in Maine, Minnesota, and Washington, had high percentages of detections (with molecular tools) of what are thought to be honeybee viruses (DWV = deformed wing virus, and BQCV = black queen cell virus). BUT this does not mean that the bumble bees have an infection, only that they have been exposed.

Slide 25 This study was conducted by colleagues at the University of Massachusetts (Dr. Ann Averill and Dr, John Burand).The graph on the left shows that honeybees are

just as likely to have high levels of these viruses if they come from local stationary hives compared to migratory out of state hives. The graphs on the right show that bumblebees are just as likely to have these honeybee viruses when they are collected from areas where there are stationary or migratory hives, but less likely to be exposed when collected from areas isolated from honeybees. The same is true for other (non-Apis) wild bees. So, this data shows that the flow of these viruses is from honeybees to native bees.
What does this mean? Too early to tell. We do not know whether exposure (what has been shown) translated into infection and poor health of the wild bees as it does for honeybees. THIS IS A VERY IMPORTANT QUESTION TO ANSWER!!!

Slide 26

So, what is the status of bee health and abundance in Maine? The honeybee is in TROUBLE, no doubt about this. I think that our native bee fauna is in relatively good shape, although we have seen species declines and there may have been declines that we know nothing about. There are increases (the yellow banded bumble bee) and stable abundances (the orange banded bumble bee). However, we have such an incomplete knowledge that it is good practice to enhance bee forage where possible due to shrinking suitable bee forage landscapes and it is a priority to practice good integrated pest management (IPM) to minimize pesticide exposure to all bees in crop production, power lines, and municipal and residential landscapes.
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