00:06 Sarah Crespi: Welcome to the Science Podcast for June 19th, 2020, I'm Sarah Crespi. First up this week, we have senior correspondent, Jeffrey Mervis. He's gonna talk about the financial turmoil that's been brought to universities by the coronavirus pandemic. Next, we have researcher, Nicole Culbert. She and her colleagues write in Science Robotics this week about dropping sterile mosquitoes from a drone in order to combat mosquito-borne illnesses like Zika, dengue and malaria. Now we have senior correspondent, Jeffrey Mervis. Hi, Jeff.

00:42 Jeffrey Mervis: Hi, Sarah, nice to be with you.

00:45 SC: So you wrote this week on the financial picture at universities as the coronavirus pandemic rolls on. And it's a complicated story, but would you say there's an overarching theme to what's happening at universities right now?

01:00 JM: Yes and no. You have to remember that there are thousands of universities and each one has its own unique challenges. But in general, research universities, those that do the lion's share of federally funded research, have managed to keep their research enterprise going. And in the last few weeks, they are starting to reopen those labs, long before they have figured out exactly what the fall semester is gonna look like for undergraduates.

01:29 SC: When we talk about the continuation of federal funding, this is grants. So researchers at universities are still receiving those funds despite the fact that the universities are pretty much shut down?

01:40 JM: Right. So the big difference between the revenues that universities get from research and all their other revenue sources is that the former were not affected by the pandemic in any significant way. The federal government stayed open. So unlike every other area of revenues, including from tuition and housing, athletics, state support, endowments, what they call "sponsored research," in other words, monies that universities get to do research, most of which is funded by the federal government, has remained steady. And in fact, it's even increased over the last couple of months because Congress has included research in a number of the economic release bills that it's passed.

02:28 SC: So what is happening with those other sources of funding? Take for example, endowments. A lot of them are tied to the stock market. Is that something that universities are taking a hit on?

02:39 JM: Well, again, yes and no. Three months ago, when the pandemic lockdown began and the market had plummeted, universities were projecting large reductions in their endowment. But then, the stock market has rebounded, at least until last week. But even so, I think equities are holding pretty steady. Some universities rely heavily or significantly on their endowments for operating.
Other universities rely almost not at all. And just like every other revenue source, public universities that receive a significant amount of money from state appropriations are almost certainly going to have to see that cut. Private universities, of course, don't receive those kind of state appropriations so they're not affected.

03:30 SC: But they might rely more on endowments than the state?

03:33 JM: Well, you go down the line and there really is a half dozen or more sources. Universities are entrepreneurial and everything has been affected by the economic freeze.

03:46 SC: Right.

03:46 JM: Which is a result of the pandemic and the lockdown directly.

03:52 SC: Do we know much about tuition income, and undergraduates returning in the fall? Is there any projections about how that's gonna impact universities?

04:01 JM: Recently, those projections have really turned up. A couple of months ago, again, universities were projecting that a significant percentage of their student body might not return. Well, there are indications that that's not going to be a problem. Universities require incoming freshmen to put down a deposit and universities around the country, large universities, are reporting that their freshmen classes are holding steady, if not increased. Foreign students, which was a source of concern, it's turned out that a lot of those students actually didn't leave the country because they were concerned about visa restrictions coming back. It's likely that there will be fewer coming in, but that varies from university to university.

04:51 SC: One thing you know in your stories that even though the grants are being paid, researchers aren't necessarily going to their lab and continuing that part of their work. They're still writing, they're still proposing, they're still managing their budgets, but they're not conducting research in itself. Does that leave us with a research deficit?

05:09 JM: That's an important issue. So when the federal government awards a grant to an institution, it expects the scientists to perform X research. It doesn't always know what that's going to result in, but it's going to produce some gain in knowledge at the very least. If they're not running experiments, then the scientists are not collecting data and are not able to pursue that research. As you said, however, there are lots of other things that are part of a grant. Labs don't run experiments continuously, they don't do field work 12 months of the year. So scientists have had to look at what they can do to maximize the people who are available now, even if they're not in the lab, and what kind of work they can do to be productive. In the end, though, scientists are worried that if their grant is going to end next year, and they haven't performed that work, then they may run into what you call the "research deficit."

06:17 JM: Now, the federal government a few months ago changed the rules to allow universities to continue to pay researchers on the grant, even if they weren't carrying out their research. That was part of the larger effort to keep as many Americans employed as possible. That change actually
expires next week, and it could well be extended. But even if it is, university administrators are still trying to juggle the fact that they can spend down that money, but then there will be less of it available when they come back and reopen the labs. And that's another factor that's driving the desire to reopen the labs.

07:00 SC: Is there any intention to extend the grants to pay more money on the same ideas or proposals?

07:06 JM: Well, the community is certainly hoping that Congress will add to budgets of federal agencies starting with NIH and going on down the line. NIH has told Congress last month that they estimate $10 billion worth of their research has disappeared because of this loss of productivity. So there's an immediate deficit. There's also costs in restarting labs, in rebuilding colonies, animals, other material that was lost, what would have to be restarted. And then there is also the need to sort of have the money available once everyone is productive again, and whether that's an extension of the grant or whether that's funding for new grants. So all of that is wrapped up in the communities requests for several tens of billions of dollars. Whether Congress will go along with that or not, of course, it remains to be seen.

08:07 SC: Going back to the economic picture of universities, they have this mix of revenue, as we talked about federal money, endowments, tuition. In the meantime, as they try to see how things will turn out, they're doing certain things to pull down their cost. What are some of the cost-saving measures that you've seen so far?

08:26 JM: Pretty much across the board, universities declared a freeze on salaries, a freeze on hiring, a freeze on new construction. Some universities temporarily stopped contributing to retirement accounts. So all of that was designed for the short-term recovery of some money that otherwise they would be spending. Universities with major medical schools and hospitals probably suffered the largest projected losses because of the suspension of elective surgery and other procedures as well as the increased cost of caring for COVID-19 patients. But that's, in the universe of universities, a relative handful of the larger universities. I think that in the more recent weeks, universities are starting to temper those dramatic estimates of losses as things start to get back to the new normal, but it's still going to be a hit, and that's something they're gonna have to manage in the months to come. That's not something that's going to get reconciled immediately.

09:38 SC: And we talked about undergraduates coming back in the fall. What about graduate students who are starting a program? Are they gonna be kind of stepping into a very uncertain environment when they get to campus and maybe the lab started up, maybe not, maybe the grant's there, maybe not?

09:54 JM: I think universities are gonna keep a close eye on that, but the university administrators that I talk to seem to feel that their incoming classes in the graduate programs are holding steady. The big question mark there is whether international students who comprise a significant percentage in many scientific fields, if those students are actually going to be able to get visas. The universities may have accepted them and admitted them, but those students still need to be able to get their visas in order to show up in the fall. The heads of graduate programs that I've talked to said basically, "We're just gonna have to be flexible. Okay. If they can't start in August, then we hope they can
10:40 SC: As you said at the beginning, the theme here is grant funding kept coming in to these large research universities. But it does seem like another takeaway from this is that things looked really bad in March and April, but May and June have shown something of a turnaround in the projections and made the deficits, the gaps, a little bit less scary.

11:02 JM: Right. Although maybe you wanna add a footnote to that. Nobody knows if there is going to be a second wave. Nobody knows if the current increase in the number of cases in many states is going to continue. That could put a big damper on these plans if all these labs that have reopened suddenly have to go back into lockdown mode.

11:27 SC: That's gonna add a lot of cost.

11:29 JM: That's scary. I mean, no one I think has modeled that because it's just... It's impossible to know, but it's in the back of their mind, certainly.

11:39 SC: Alright. Thank you so much, Jeff.


11:42 SC: Jeffrey Mervis is a senior correspondent at Science. You can find links to his story and all of our coronavirus coverage at sciencemag.org/podcast. Stay tuned for an interview with Nicole Colbert about a drone adapted to fight mosquito-borne illness.

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12:01 SC: Mosquito-borne infections like Zika, dengue, malaria, and chikungunya cause millions of deaths each year. Many different approaches have been tried to prevent their bites: Bed nets, pesticides, fumigation and genetic controls. Nicole Colbert and colleagues wrote this week in Science Robotics about a new way to deal with deadly mosquitoes, using drones. Hi, Nicole.

12:24 Nicole Culbert: Hi, Sarah. How are you?

12:26 SC: Pretty good. How are you?

12:27 NC: I'm good. Thank you very much.

12:28 SC: This approach with drones, it starts with a type of genetic control used for tamping down mosquito populations. How does that part work?

12:39 NC: We kind of mass rear them in big laboratories. They're sterilized and then taken to the field, and then ultimately released to try and integrate them into the wild population with the females.
So if there's a bunch of sterile males out there, the females are not gonna have very much reproductive success.

Exactly. So when sterile mating occurs, the sterile male will transfer sterile sperm to the female and thus inducing a form of sterility within the wild population, which if done over time, with weekly releases, for example, you can sort of suppress the population down to quite a low level.

Why has this type of method been adopted, say, instead of pesticides or fumigating the area and trying to just kill all the insects?

So this is a technique that was developed in the 1950s. It's been used successfully against particularly agricultural pests such as fruit flies. It's a very environmentally friendly technique. It does not have any impact on the non-target organism. Pesticides are becoming more and more regulated around the world. Insecticides are producing resistance within the population of mosquitoes and becoming less effective over time. And at the same time, we're seeing an increase in mosquito populations around the world. Aedes albopictus has managed to rise from the forest of Asia and colonize every continent besides Antarctica in the last 40 years. Dengue incidence is increasing dramatically, and in light of this, the WHO have expressed an urgent need for alternative mosquito control methods.

Why would you need to use a drone for this method of population control?

In previous Sterile Insect Technique pilot trials with mosquitoes, they've always been carried out from the ground. To move towards an operational level, aerial release is most likely the way that will be going forward and it offers many advantages over ground release. You can cover a much larger area in a much shorter time. It's also much more cost effective. You have less vehicles on the ground, less labor costs, associated with less gasoline. And the idea of using a drone is that once you purchase it, you have a one-time cost, it's capable of flying for roundabout say, 20, 25 minutes, you could perhaps carry a few hundred thousand.

Wow.

We carried a little bit less, but it is possible with upsaling to carry a little bit more, and it offers the possibility to cover quite a large area in a relatively short time.

I was surprised to learn that mosquitoes don't travel very far, even though they can fly, they kinda stick around where they are, and so it makes sense to drop them all over the place instead of releasing them from one centralized spot.

That's very true. And that's particularly true of Aedes aegypti. It's estimated to only disperse 50 to 100 meters in its lifetime, so very short distances. By ground it would just be so much more tedious, but if you have a drone, you can just go up there and ensure you're making a nice homogenous distribution with your release, and perhaps aid in with the dispersal a little.
15:42 SC: Wen you tested this first in the lab, what did you have to optimize to get this little carrier that you made that attaches to the drone? What did you have to focus on to get it to work?

15:53 NC: It was a really intensive 12 months in the lab. There was so many things that had to be optimized, both from our side and also on the side of the Bubble-X NGO that we were collaborating with. We needed to look at things like the ideal storage temperature. Traditionally, when we conduct the aerial release of sterile insects, they're usually in a chilled state, so they're sleeping. We needed to know what the best temperature was for that, and also when we have kept them asleep for so long, how long did they take to wake up after they've been sleeping? And that's particularly important when releasing by air because you want them to wake up before they reach the ground.

16:33 SC: Yeah, for sure.

16:33 NC: So that will ultimately do determine the height that you can actually fly the drone at. So we were looking at that as well as things like the level of compaction. We wanna try and carry as many mosquitoes in one flight as we can, but when you put lots and lots of them you're talking tens of thousands put in one box, they're gonna be weighed down on top of each other, and the ones at the bottom, they'll eventually become damaged. So we were looking at optimizing the maximum amount that we could put in one canister, and ultimately how many mosquitoes we could release per flight. Another primer we looked at was wind resistance. When you're flying a drone at a certain speed, there's gonna be quite an effect of wind when they come out the drone, so we wanted to know, how affected are they. Does this damage wings? Can they still fly? Is it lethal? So we made a wind tunnel and we tested their flight ability after being subjected to various speeds of wind. And we also looked at the drop speed again to determine the height of release. So when you drop a sleeping mosquito, how quickly does it fall? And again that would help determine the height of release.

17:41 SC: So a lot of things to take into consideration when designing this module. How big is this little apparatus that attaches to the drone?

17:50 NC: The canister itself where the mosquitoes are stored is relatively small. It's a sort of rectangular box. If it was like an iPhone Pro that would probably be right, and the height is about 5 centimeters. We found that 5 centimeters was the maximum height of the column of mosquitoes that you could contain within the canister.

18:11 SC: Can you tell me about the test site where you released the mosquitoes. This is your field test. Where did you do that?

18:17 NC: We carried out our field test in an area of Brazil in collaboration with an organization known as Moscamed and it was an area of 20 hectares, a very small area. It was a sort of village area with a large football pitch in the middle which became our central point for releasing by drone.

18:35 SC: Did you go?

18:36 NC: I did, yeah.
18:37 SC: Were you worried about getting bit by a mosquito?

18:40 NC: No, no, I had lots of vaccinations. Like I was literally being injected for weeks and days prior, so yeah, no. I get bitten all the time in the lab, so it was okay.

18:51 SC: So the male mosquitoes don't bite, though, so it's not like you're releasing mosquitoes that are then gonna go bite people, which is nice.

18:58 NC: No, definitely.

19:00 SC: When you move from the lab to the field, what were your markers of success?

19:05 NC: One way that we measured the success of the project was to look at the number of sterile eggs that appeared in the experimental area. So we had set up ovitraps which is just another name for an egg trap in different locations within the pilot site. And we had also set those up a few kilometers away in a controlled area where we knew that our mosquitoes we're not gonna migrate into. Following the release, we collected these egg papers from these traps. They were subsequently returned to the lab and allowed to mature and eventually hatched by doing that, we could work out what percentage of these eggs were sterile. From that we can deduce the percentage of matings that have occurred, and this determines the competitiveness of our insects to be released.

19:51 SC: What percentage of the eggs need to be sterile for this to have an impact on disease transmission?

19:57 NC: That was beyond the scope of what our trial was. To get that sort of answer, you have to conduct releases for a much longer period than we did.

20:06 SC: Right.

20:06 NC: We only conducted over one week, which would give us a sort of idea if our insects are surviving, if they're able to successfully disperse and ultimately if they are finding females and mating with, all of which we managed to ascertain from our study. In longer term studies, these are conducted over months usually, and following one of these longer term pilot studies, you can work out a minimum percentage sterility within the population that you're gonna need when you look at the ones that are on operational program.

20:39 SC: How did your results with this drone compare with different ways of dispersing the mosquitoes?

20:45 NC: Within our study, we released from the ground and then we released from the drone also in the same location as the ground, so it was like fixed point. So we compared the fixed point both from the ground and the air, and then we released by air along release lines. By releasing from the ground, the dispersal rate was lowest. The dispersal rate actually increased by releasing from the drone. So from 50 meters it got better and then at 100 meters again it got better, and we were also
able to say that the survival between these three different groups were very similar. And releasing along the lines that the drone followed, we managed to recapture the sterile mosquitoes and 69% of our traps. So our recapture rate was quite high, if you compare it to other studies.

21:33 SC: We talked about how this was less expensive, it doesn't rely on as much labor, is the idea to scale this up, so there's a lot of drones flying every week dropping mosquitoes?

21:44 NC: That could be one method, and it is a method that's being looked into in different insect species in the US right now. You could have a... Not a swarm perhaps, but several drones working in different areas to target a larger area instead of using a single drone which you have to return each time after say, 20-25 minutes to reload a new cassette of mosquitoes and to also change the battery using several drones at once, but save you time in that sense. It would also be ideally possible to upscale to a system where you could carry not just tens of thousands, but hundreds of thousands or perhaps even millions, eventually, where we could use light aircraft to deploy the mosquitoes over a much larger area as is done with Mediterranean fruit fly over Mexico, for example. But that might be a long way away, who knows. For we're just getting started with the drones.

22:41 SC: What about getting mosquitoes? Is that something that is also possible to scale up?

22:46 NC: To take it to the operational level requires a lot of work. They don't really have any real operational facilities yet, for mosquitoes, besides in China, to the best of my knowledge. It's going from small scale up to the larger facility, there's so much optimization that has to be done in between. There's also lots of quality control that has to be maintained throughout. It's essential that the mosquito that's released at the end of the day is of the highest possible quality, and quality is known to be decreased, for example, by radiation. Chilling mosquitoes could be a potential stress where quality is reduced. So when any operational set and quality control guidelines have to be developed and implemented throughout each stage, to ensure that you're consistently rearing a similar standard of high quality insect.

23:38 SC: What's next for your team? What are you gonna be looking at?

23:41 NC: Following the successful demonstration in the fields, the way forward now is to look at things like reducing the weight of the drone which would allow us to increase the capacity, for example, maybe up to 150,000 mosquitoes in each flight. We're looking into the idea of perhaps releasing multiple drones at the same time. And one of the things that we noticed from our study in Brazil was that the temperature and humidity could have been a little bit more stable. So we're looking at ways in which we could better maintain the cold chain throughout the entire release itself.

24:15 SC: Thanks, Nicole.

24:16 NC: Thank you, Sarah. Thanks for having me.

24:18 SC: Nicole Colbert recently received her PhD from the University of Liverpool. You can
find a link to her Science Robotics article at scienmag.org/podcast. And that concludes this edition of the Science Podcast. If you have any comments or suggestions for the show, write to us at Science podcast at AAAS.org. You can listen to the show on the Science website at scienmag.org/podcast. There you'll find links to the research and news discussed in the episode, and of course, you can subscribe anywhere you get your podcasts. This show was edited and produced by Sarah Crespi with help from Podigy, Meagan Cantwell and Joel Goldberg. Jeffrey Cook composed the music. On behalf of Science Magazine and it's publisher AAAS, thanks for joining us.