our speaker is dr matthew gray he is a
professor of forestry wildlife and
fisheries
uh dr gray is a founding member of the
one health initiative
and he's also the associate director of
the utia center for wildlife health
he specializes in disease ecology and
his interests include transmission
dynamics of emerging infectious disease
and identifying management strategies
that can thwart or eradicate
outbreaks dr gray has degrees in
wildlife
ecology mathematics and statistics
and he uses these skills to unravel
complex
epidemiological interactions with his
students post-docs and colleagues
dr gray also studies wetland ecosystems
especially
focusing on anthropogenic impacts on
wetland communities
and management activities to conserve
biodiversity
now dr gray i want to add is one of the
few folks that i know
who has overcome geographic language and
other barriers
and managed to build multiple global
teams
to tackle emerging pathogens
these teams are composed of folks who
have historically refused to work with
or share the results with anyone and in
many cases they have been
on opposite sides of an issue but
dr gray has been able to bring these
people to the same
table and impress upon them the
importance of working together
by creating these platforms where each
team member
explicitly states the details of their

work
and then as a team they brainstorm and
divvy up tasks
research has been streamlined data has
been
shared and most importantly research
findings have put into
been put into action and this
i am not hearing deb is oh yeah i think
she's frozen
oh a flattering introduction thank you
deb
i'll take it from here uh you're you're
muted or something or froze up that so
i'll just go ahead and continue but
thank you very much for that
introduction it was very nice um
and as deb kind of hinted um
the the work i'm talking about today and
and a lot of the work that i've done in
the past is multi-disciplinary
and it really takes a team approach to
address some of these complex
issues related to one health
and so what i'm going to talk about
today is uh really focused around
the project that the ut-1
health initiative is supporting through
a sea grant
and uh because we just started um really
just a few months ago
um we're not going to provide any uh
data or anything like that we'll talk a
little bit about our progress
so it's really heavy on the
justification for our work
and uh and really what we hope will be
the
the long-term outcome of our efforts so
first of all i do want to acknowledge uh
my
the co-pis for the seed grant which are
neelam pudial
who's a social scientist within fwf

and nina fefferman who's a mathematician
from utk which you all know and one of
the co-directors
of the one health initiative
um we also have collaborators at uh
multiple
other universities which you can see
listed below which include ecologists
economists folks that specialize in
trade etc
so just want to acknowledge them as well
and we do have partnerships which you'll
see
as i go through with the fish and
wildlife service
industry which is p-jack and then the
state wildlife agencies
so our question is really focused around
this big issue of wildlife trade and
global movement
of pathogens and wildlife trade is a is
a fairly large business
it comprises around uh 300 billion
dollars
uh annually and encompassing you know
2.5 million animals per year over a
thousand species and 180 nations
and it's the high income countries
especially the united states and the eu
that's driving over 75 percent of that
demand
although many of those animals are not
coming from our
particular countries they're coming from
other parts of the world often
underdeveloped parts of the world
this figure here on the left really kind
of shows on the bottom you can see the
increase
in the number of shipments per year
going up it's continuing to go up
as far as wildlife imports and
really just as far as imports into the
united states which again

this talk is going to focus on really originating from all different continents but especially originating from asia the americas outside of north america and um africa and then going to various regions within the united states so really all uh pulling from across the globe and really dispersing across the united states and one thing we don't know very much about is we know what comes into our country but we don't know how it disperses within the country okay so we know very little that little about the domestic trade network um the other thing that um you may not know if if you haven't dealt with wildlife or wildlife trade is that there are no u.s policies or regulations to control regulate or support the clean trade of wildlife you know with agricultural animals um there's a the world health organization uh oie and uh they list diseases as being or pathogens as being notifiable and usda aphis controls requires animal health certificates for any any agricultural animals that are that are traded but that does not exist they a aphis which we'll talk about a little bit uh later usda aphis does not regulate wildlife and they consequently there's this regulatory loophole so basically you can trade wildlife across international borders um and not

have to declare things as being
free of notifiable pathogens and you
know that really just leaves the
floodgates wide open
you know we have basically open borders
where pathogens can move
uh freely across the globe and you know
we're really talking about millions of
animals
per year being traded um and there are
industries associated with obviously
wildlife trade which i just you know we
just mentioned here
and so that can affect those economies
by moving
uh maybe novel pathogens that can
negatively impact their stocks
um their captive stocks but there's also
this opportunity of this chance
um that there can be spill over to wild
uh wild populations and and there's
multiple examples
of that occurring which i'll reference a
few a little bit later on
the um particular model system that
we're focusing on
is trying to take um a sliver of the
wildlife trade industry about just one
percent of trade
which is the amphibian trade industry
but it has all the complexities just not
as the magnitude
of typical wildlife trade which makes it
a nice model system
and within the united states um well
globally
uh trade is comprised mostly of frogs uh
and that's what you see with these big
bands here on the top and then the
caudates or the salamanders are
down on the bottom so there is a small
salamander trade as
well and again uh if you can see
with um

the window over here um you can see
that this is the origin countries here
and these are the destination countries
where the united states
comprises over 50 percent of the global
amphibian imports um into the into our
country
so it's about uh about a three billion
dollar
a year industry and
um what we are particularly interested
in
are um three uh globally emerging
pathogens uh there's two species of
kitrid bd and b
sal and ronovirus uh and i'll talk a
little bit about those in a second
and they've collectively been
responsible for the decline of over 500
species of amphibians
so let's talk a little bit about um just
give a little bit of a background about
those
three pathogens so bd or betrayal
kendrim dental batteries
is um the if you study emerging
infectious disease especially with
wildlife you've heard of it
it's responsible for the greatest uh
biodiversity loss
in modern history associated with with
pathogens
okay so um we within the last 40 years
uh 34 years we've documented a species
distinctions
associated over 100 species extinctions
associated with this one pathogen
it has a global distribution of trade is
facilitating that which we'll talk a
little bit later about and what it does
is it causes epidermal hyperplasia or
thickening of the skin
and if you're an amphibian that's not a
good thing because

uh amphibians use their skin as
semi-permeable
and they osmo regulate through their
skin okay so they change the the
composition of you'll take up
electrolytes etc
from water they take water in and and
etc through their skin also let
water out they also respire through
their skin
so what happens when you have thickening
of that skin that permeability is
compromised
and that creates this dysfunction and
it's actually that
that reduction in osmoregulation that
causes electrolyte imbalances
and ultimately that affects muscle
function leading to paralysis and
cardiac arrest
and so the this animal here
before i show that this animal here
speaking of paralysis
is an animal the top left let's see if i
can find my cursor
okay well i don't seem to see my cursor
but
the okay the the image the the right
image
of the really nice stoic glass frog
that animal's dead um it's actually sat
there it's got ketrial mycosis
and it's had cardiac arrest it's sitting
on a leaf and it is paralyzed
and that's what that pathogen that
pathogen does
um the new species so again vp is
relatively
recently discovered 1997 more recently
just within the last decade
a new betrachurian was discovered the
kitchen settlement of orange and it's
originally thought to be
from asia where it's been documented

living
with infected hosts and just basically
subclinical infections and no apparent
disease in the wild
but now is emerging uh in europe and
moving across the continent from from
from north to south and um
it's really been associated with
declines especially in salamander
salamander that you can see here which
is the fire salamander
and um it's called cause uh
multiple population extra patients
across across its range
and what b cell does unlike bd it does
affect the skin too
but it actually creates these necrotic
ulcerations through the skin so it
pearls
literally kills the cells and and
and the the pathogenesis hasn't been
um worked out quite yet of this pathogen
that's part of deb's work
uh but it's probably again a cons a
function of
of a reduced ability to do
osmoregulation
potentially affecting cutaneous
respiration which many of our
salamanders
uh in the united states don't have lungs
so if your skin they
totally respire through their skin so if
your skin isn't functioning that's not
good
and then finally uh these little
necrotic ulcerations create
opportunities for
uh for bacteremia so for bacteria to
enter get in the blood system and cause
complications
um this is a
a stripe newt which is a
a threatened species of great

uh species of greatest conservation need
here in the united states and this
animal here is in its later stages of
cycle treated mitosis
again paralysis lethargy an inability to
to have a writing reflex to flip
yourself over
um are our diagnostic signs of the later
stages of disease
this animal uh was mainly euthanized
immediately after this the other
major pathogen that has been associated
with declines
um are rhona viruses uh fe3 or frog
virus three is the type species there's
actually six different species of
rhinoviruses that
have been recognized um they do have a
global distribution
they're discovered back in the 60s and
they've been associated with declines in
in wild populations and captivity now
the interesting thing about
rhona virus is they infect amphibians
reptiles
and fish and they've been associated
with with die-off events and over 100
species of amphibians
30 species of reptiles and over 50
species of fish
so lots of reservoirs associated with
with that pathogenic and
unlike the kitchens which are a skin
pathogen
rhinoviruses are a hemorrhagic disease
they call hemorrhagic disease
very similar to ebola in fact it's been
called the ebola of ectothermic
vertebrates and it attacks and and
destroys the liver
the the spleen and the kidney and brain
um and you can see it it
causes significant hemorrhaging which
you can also see often you'll see

grossly underneath the skin
and we've had die offs uh in right up in
the great smoky mountains national park
and uh near kate's cove upon called
gorilla
there's been die offs of turtles like
you see here
um in in blount county and um
you know turtles uh really uh it affects
their respiratory system this one here
is a box drill that's in respiratory
distress and uh dying from rhonda virus
and you'll often find this one here that
i found was uh
actually still alive covered in this mud
puddle covered with
soot and everything and could barely
move
and and was still moving it a little bit
and respiring
but uh really a horrific pathogen
um all of these pathogens have
tremendous uh transmission capability uh
one contact one one second contact from
host the host is
sufficient to result in transmission and
they have a fairly
decent environmental persistence which
can add uh to that
those transmission pathways and the r
naughts
have been estimated between 5 and 10 for
for these pathogens which really
emphasizes the ability for a very rapid
invasion and we often see these dials
happening and
ending with you know hundreds of
thousands of animals dying within a
couple weeks
um you know the the concern of these
pathogens in the wild
it's been well documented in their
impacts on natural populations but again
we're also talking about industry

and uh the amphibian pet industry as
well as the amphibian food industries
affair
is a big industry and there could be
pretty significant losses so this was
one that we were associated with
diagnosing for
this company and in in basically a
couple of weeks they lost over a hundred
thousand dollars in profit
um because ron of our this is associated
with ron of ours ron's
virus got through transmitted through
their tanks and boom they they
lost um tons of animals so what two
thousand
uh tadpoles of horn frogs and three
thousand five thousand animals dead
within a week
so industry doesn't like these pathogens
either
uh and so we want to keep them out of
industry we want to keep them out of the
wild or
or and especially minimize how trade may
impact those movements
and it is happening we there has been
some previous research especially on a
global level
uh some work that's been done that's
coming into our into the united states
and also in other ports
and so um you know american bull frogs
are a big
part of the trade actually it's a big
part of the amphibian food trade
if you didn't know um there are
amphibians
are there american bull frogs all over
the world um
that we have shipped for basically bull
frog farming and actually we receive
generally half of those frogs back
ironically there aren't very many

bullfrogs farms here in the united states anymore because it's not that profitable but in developing countries it still is a very profitable way to make a living it's also an excellent food source uh for local communities and of course we eat bull frog lakes here so lots of frogs being moved around the world this is uh some work that was done in one of the largest um eastern ports for amphibian trade which is the hong kong port and uh they documented a prevalence ranging for for bd around 12 to you know the average prevalence for ronna virus being around 60 percent so these animals are being moved around um there are different strains that exist and species of rhinovirus that exist globally there's also different strains of ketrad that exists and and b sal uh hasn't yet been detected here in the u.s so you know trade there's a big concern that trade is moving these around and there's some evidence that that is certainly happening in fact that is the main hypothesis that exists for how b cell got to europe is through the amphibian pet trade uh particularly with asia and asian salamanders often are very brightly colored and they dominate the international salamander trade and um so some of the collections here that with some work that was done over in europe has shown that you know at least 64 of the breeders

that
were sampled had positive b cell uh
within their system some had ongoing
outbreaks of b
cell or losing animals uh this is what
we don't want happen
you know coming to the united states we
don't want that pathogen getting here or
if it does
we develop ways that we can squash out
and minimize its impacts to industry as
well as the potential for spillover
and you know that potential real the
potential that for that pathogen getting
here
is is pretty high is to me uh
very likely it has crossed our borders
um within the last
you know decade or so um there have been
some regulations which we'll talk about
kind of put into
place to try to prevent that but uh just
as an example this publication that uh
uh reported you know basically the
prevalence of agents
of b-cell and asian salamanders that are
commonly traded
with the united states uh b-cell
prevalence is about three percent in the
wild where they're collecting these
animals
and based on uh us importing around two
million over ten years
uh they suggested that the united states
could have already had
you know sixty to seventy thousand be
sell positive
asian salamanders come through our
borders um in the last ten years and so
um the uh
that's really exacerbated by the fact
that um
that we now know that b cell can
actually infect frogs

and it's been documented this is a very very common frog you might some of y'all may have seen these in pet stores the fire belly toad they can become infected with b-cell these comprise a huge percentage of our under our frog imports into the united states we've imported 3.5 million in in the last eight years and um in germany the prevalence rate for for the for b cell with this with this animal the species is around eight percent and if you multiply that out we could have potentially been importing you know 35 000 b cell positive fire belly toads per year last eight years so you know the the risk is is of entry is or the probability of entry i should say is is pretty high um and uh what we really need to do is kind of understand the movements um and how to potentially reduce infection the other pathway of of introduction you know into the um of any pathogen into the united states or elsewhere is through illegal trade right and so there have been cases um that have documented uh infection prevalence just a few though uh there hasn't really been a a and a really exhaustive um investigation of illegal trade and how that that facilitates pathogen movement and wildlife um but here are a couple with um you know with bd that you know 67 percent were infected

in this particular case for these
animals that were confiscated
and 60 in fact with bd and i'll just
mention as far as
the prevalence estimates that have been
uh reported
in typical legal trade have generally
for
for kitchen have been around 10
to 20 percent so you know illegal trade
may facilitate you know the increase in
prevalence of pathogens perhaps they're
more crowded they're more stressed
underneath those conditions so it's
really important for us to take into
consideration a legal trade as well
uh albeit it may be a smaller pathway it
may
have higher prevalence or an increased
risk
so for y'all that um you know work with
domestic animals
livestock etc you know that um oie that
you need to have animal
health certificates that are required i
alluded to you before that
right now we're in a regulatory loophole
um within the united states when it
comes to
wild animals um so usda requires that
all imported uh
animals for agriculture or aquaculture
uh need to be free of oie pathogen
oiu listed pathogens and actually uh
rhonda virus and both kitrets are listed
as oiu notifiable
but um usda will not
require animal health certificates
because they do not regulate wildlife
at the same time fish and wildlife
service does
has no authority to regulate
pathogens so we're in this loophole
of these two major federal agencies not

being able to
solve this problem because nobody has
been directed
of what they can do now when b cell was
discovered
in in the threat to to amphibians here
um in the united states fish and
wildlife service said we have to do
something
and so what they did do and and what
they can do is they can
regulate wildlife trade underneath of
the lacy act
which is basically the regulation to
prevent the international movement
of threatening endangered species um or
invasive species that could threaten
threaten native biodiversity and so the
interesting thing is they listed this
interim rule which listed that actually
the species
themselves that could be potential hosts
for b-cell were injurious to our native
species
because they could um become infected
with b-cell
and it's really kind of unprecedented to
to do that
um and is to really
list the species as injurious because of
the microorganism
on it um and so they listed
if if there was any evidence that a
genus could be
uh potentially infected with b-cell they
listed all the species under it as
injurious so that still has not really
been challenged in court yet it's it
exists out there and so
what that did is it essentially stopped
international trade of salamanders
now as you can imagine um well p jack
which represents the pet industry
um uh for all pets um

were in the the amphibian trade industry they were
upset about this uh but salamanders only comprised six percent of the market
so they were willing to go
along and basically say okay yeah we support
uh this this ban in fact we'll do a voluntary ban on it
anyways you know and so but uh
frogs are another story because they comprise a
sh the majority uh now 99 of our
of our international trade okay
so um you know how does do pathogens move again this could be any wildlife species
but you know they're moving globally um
they're coming through our borders
for wildlife they're being checked to
make sure that they're not you know
globally listed species that are listed underneath of societies
and um so that's basically equivalent of
our like endangered species act these
are species of concern or they're not
listed as being injurious
in the context that they could um really be a concern as far as an invasive species
first of all the load of of
trade into our borders is way beyond
the the the surge capability of the
wildlife inspectors okay so only a small percentage
maybe one percent of the shipments are
really actually opened and looked at in the first place
um and so uh
with and then if they are it doesn't
matter if they're infected with
something because they
there's no monitoring at all so as you can imagine you know

wherever these animals come from they're
shipped in they go to distributors
and eventually um you know they get to
consumers
and um those consumers may have actually
different values
um you know maybe a more a specialist
uh that really is trying to get certain
types of amphibians
uh maybe very knowledgeable about
pathogens or
when it you know necessarily release an
animal uh they know that being not a
good thing but
maybe the uh less knowledgeable
consumers just would they maybe
think it's a good thing to take their
salamander they no longer want or their
frog they no longer want
and take it to the great smoky mountain
national park and let it go and be
free with its you know with its fellow
amphibians out there in this beautiful
habitat
unbeknownst to them that animals
infected with a deadly pathogen from
around the world on the other side of
the world
and then of course we have um um
our native amphibians here and i'll
touch on this a little bit later but
for those of you all that don't know
when it comes to salamander biodiversity
the united states leads the entire world
in salamander biodiversity 50
of the biodiversity of salamanders
exists in north america
and right here in southern appalachia we
are the global hot spot
so it's a big concern with respect to
something that could impact like b-style
that biodiversity
so uh it does happen i just went on
caudate.org and googled uh salamander

release or or detections and this is a
fire bell
a chinese firebelly newt and so this is
a posting from a couple people
interacting and discussing this was
found
outside of the san francisco bay area
and uh this particular newt can be
infected with b
cell it's one of the most traded species
that exists
out there in the pet trade and it's
going around a wetland here
okay and um you know this person's you
know
asking you know is this do you think
this could be a concern i left it out
there and somebody's coming back
and he says well i don't i i'm not i'm
not an expert
although when i read the the uh
the blog uh the person knew a lot about
the life history
of of salamanders but i see no reason
why this species uh
couldn't thrive here except for possibly
being out competed by a larger native
newt species
and then you know the guy comes back
says you know i'm not i'm not condoning
you know releasing these animals in the
wild what i'm saying it's unlikely that
they could be a threat to other species
so it may be true that if you release
one animal and it's a male and it's of
one species or a female
most of our and amphibian species can't
just reproduce by themselves
uh some can actually but um this one
can't
and and so maybe they're thinking about
it's not really that big of an effect
but they're not thinking about the
microorganisms on

on them that could have a substantial effect on
survival of populations so that's where our work is really focused on
a lot um in the last five years is trying to understand the threat
um in particular of b-cell to potential biodiversity losses here in the united states if it if if or when
it it emerges and so we've been you know fortunately supported by
the fish and wildlife service and nsf
and and lots of other collaborators state agencies and even private organizations providing funds
and uh what i'll just do is i'm just going to give you a quick overview
of this threat just as a case example of why we need to be concerned about pathogen movements and trade and
and what we've done again over the last several years is we've tested the susceptibility of 36 species
of amphibians to this particular pathogen b
cell and biosecure facilities here at ut
and a couple of the other collaborating universities
and what we've learned as far as our native species
is that 72 percent of them can become infected
and uh that includes um these most specious families uh so we've got the the the newt
families and we also have the lungless fam this is the lung with salamander family which is
the most specious and what are our biodiversity lies up in the smokies
this is actually a blue ridge two-line salamander that's very susceptible to b-cell
but we've also found invasive species

such as the cuban tree frog can become infected
and another highly traded species the mexican
mexican axolotl which is actually dangerous endangered mexico but
it's a big part of the medical and pet trade which we'll talk about
a little bit later and of those you know over a third of the species actually developed the disease so you do have some species that become infected and live with it with subclinical infections and even uh may clear the infection and then you you do have about a third they actually develop the disease and what we did when we did this research was attempt to provide or attempt to test across the phylogeny that exists within the united states attempt to get a representative estimate or sample of what invasion might look like within a community here and i think we did a pretty good job in doing that and assuming that you know 36 percent of our species you know could potentially uh develop the disease um that you've already seen that video over 60 species in the us and over 140 species in north america could experience declines and be in threat of extinction if b-cell gets here so we've done some pretty exhaustive work to demonstrate that we have a this that here in north america our uh our communities are composed of of lots of species that could be suitable hosts and about a third or a little more of those species could develop the disease and

experience declines or extinctions
and so what we did after we did those
um initial analyses is that we did some
geographic analyses of invasion risk
so we coupled our species suitability
you know where those species are located
that the distribution of species and
environmental suitability of b
cell within the united states to
map risk of invasion within communities
so this is the likelihood of infection
and you can see that uh the northwest
here
but uh pretty much the entire united
states has excellent climate and
suitable hosts
there aren't too many places where they
would escape
the likelihood of a b cell getting into
those communities
that's just risk of infections so we
combine that
with risk of mortality of disease
developing and
the the map changes a little more again
the eastern united states being
highlighted
uh in the western united states being
highlighted
uh for at high at-risk communities
um composed of species that have a high
likelihood of mortality
and then we combine those to really look
at extinction risk
and that's what you finally see here in
the far right here
with tennessee and kentucky and several
the southeastern states
really you know southern appalachia here
having a high risk
of extinction as well as again the
western united states here
um we took that and this is just looking
at risk of extinction

and we combine that with um actually species richness where do we expect the greatest biodiversity losses
um and as i mentioned before fifty percent of the world's salamanders are in north america
tennessee is number two in the united states georgia's number one north carolina's number
number three so i mean all the biodiversity
is centered as you can see right here in southern appalachia
and we do expect the greatest biodiversity losses to occur
within the appalachian region and right here within like the tri corners here
um and of course the western united states we expect pretty high biodiversity losses too okay um
where are the where are their resistance species
are where communities most compose the resistant species not
many places okay uh the upper midwest is expected to have
uh less declines because they have their dominated
their at least salamander communities dominated by a
a group of of of salamanders that are pretty resistant they're called the mole elements and viscomatity they may get infected but they usually don't develop the disease
okay so you know why should we care again this is just building on this justification of amphibians for those of y'all
that don't study wildlife or or don't study amphibians is that
amphibians are in peril in fact they're the most imperiled class of verbal vertebrates that exist on on the earth

on earth
so um over a third of them are in threat
of extinction which you can see here as
listed by the iucn
and it's estimated that 40 to 50 percent
of the species are in decline in
comparison to 12 percent of birds
and 23 of mammals um
and and we should care because they're
important components of our ecosystems
there's a variety of ecosystem services
that that they provide this is really
that one health connection
um and so they are important in carbon
sequestration and nutrient cycling
the biomass of salamanders in appalachia
can exceed per unit area all the other
vertebrates combined
so you can add up all the biomass of the
salamanders
and then take your bears and your
raccoons
and your your birds that your snakes
that are in an acre and it can exceed
that biomass so as you can imagine
they're extremely important with respect
to
sequestering carbon organic carbon in
their biomass but also nutrient cycling
through their consumption of of
invertebrates so all
amphibians are insectivores and they
take that matter and obviously consume
uh
uh in invertebrates and um and then
defecate that and break those down into
different nutrients and stuff
and so you know the food web is
extremely reliant
on on amphibians so you have various
mammals and reptiles
that are eating amphibians and they
in turn are eating thousands upon
thousands on millions of insects and

that really links into this other aspect
when it comes to public health and so uh
just like bats
um amphibians are excellent insectivores
they eat insects as larvae so in the
aquatic stage
which could be very important for
consuming like mosquito larvae
and they're very effective at
controlling mosquito larvae
as well as adults like this one inch
this this is a cricket frog one inch
cricket frog
um can a thousand of them can eat five
million insects per year
so you can have substantial control uh
of of insects some of these which have
you know agricultural pest uh
consequences
or connections as well as links to
zoonotic pathogens
so they can play a big role in public
health
and they also have tremendous biological
potential
amphibians um are the first land
vertebrates
uh they have existed for uh over uh 300
million years on this planet they've
survived
three mass extinction events including
the one that ended the dinosaurs
and they have a tremendous amount of
potential
biological mysteries locked up within
their evolution
and so um one a couple of
known um aspects of their
of their physiology as they produce
antimicrobial peptides
one discovery made by louise rollins
smith who's down at vanderbilt
university that we collaborate with
she's

demonstrated that some of those
antimicrobial peptides
can inhibit hiv um
some work that was done by john daly and
the late john dalia nih
uh was uh looking at sequestering some
of the skin toxins out of amphibians
and um using those for for analgesics
and uh so it's been demonstrated that
these toxins can uh
uh target the the the uh the the
the nicotinic and the the opioid
receptors uh
uh with for for pain pain relief and be
20 to 40 times more potent
than than morphine and not be addictive
um and lastly
um they are there's a lot of work being
done with axolotls this
mexican axolotl uh with respect to limb
regeneration
and uh so unlike our cells that become
programmed
into skin muscle connective tissue cells
they can never go back to
the original stem cells amphibian cells
are different
amphibian cells can change back into
undifferentiated cells like stem cells
and help regenerate limbs and so right
now there are
there are various uh medical
professionals scientists that are
attempting to understand
how that program occurs and can we
replicate that to be able to
grow organs or to grow limbs or etc in
humans so there's a lot of biomedical
potential
and among a variety of other areas of
research that folks are doing
they also as i mentioned play a big role
in the food and pet trade
and lastly you may have heard that

amphibians are good ecological indicators and
and the reason is and that's true the reason is because
they use both the aquatic and the terrestrial environments they're exposed to stressors in both environments plus they have that semi-permeable skin where they can absorb you know various uh toxins
etc um in the chemicals in the environment so there
if you see amphibians dying they could be good ecological
indicators for other wildlife species and humans for that matter
but with that that's our model system um you know amphibian trade is just
our attempt to really get at a bigger question
which is you know global wildlife trade
and so this uh article that was published in national geographic i encourage you to go and take a look at it by jonathan colby right during the admits the uh the coveted pandemic he published this
and raise the concern about um
you know every year 200 million live wild
animals are imported into the us every year
and the global movement of animals without
any um requirements for clean trade is asking for negative impacts
on wild populations on domestic populations
and on human health and um i mean we just lived a pandemic that
from a pathogen that evolved in bats right
and and so uh these these species jumps

have occurred multiple times in history
they will occur again
and uh the unregulated trade
um of the the lack of requirement for
clean trade
and the support of government for clean
trade is uh is really
um uh is needed and
has been for a long time and and so we
need to
to begin to understand pathogen
movements and wildlife and start
thinking about clean trade
and i i stole this from the one health
initiative
uh presentation website
and um you know just to to recap uh for
those that
um um may not be aware is that
is that as far as emerging infectious
diseases 75
of emerging infectious diseases are
zoonosis okay they
they move between animals and humans and
of that about 70 percent of them come
from wildlife so around 50 percent of
the emerging infectious diseases
associated with
zoonoses are wildlife derived
okay so it is you know it's critical
that that we think about
uh pathogen movement and trade now this
uh used to be a big number to think
about when we think about how zoanosis
impact um the us economy of
causing around seven billion dollars per
year in losses but now with covid
and the coveted emergence it's kind of
almost laughable
um that's a big number seven billion but
when you think that the estimates out of
harvard are someplace close to
16 trillion by the time this pandemic
ends you know that's 90 percent of the

annual u.s gdp
you know so movement of
of zoonotic pathogens in trade
their emergencies and the consequences
on on economics are substantial
and the key is early monitoring
detection and control
okay and eradication you don't want to
wait until it gets into your general
population of humans
or wildlife for that matter because
controlling it as we all saw
is very difficult it's very political
it's
a challenge okay so we want to be able
to monitor and respond
all right so let's uh quickly turn here
towards the last part of the
presentation i see we're at 1250
to what our system sort of looks like
and um the uh
and how you know it may move and it's
really this trade system the amphibian
trade system is like most wildlife trade
systems where you have
imports that can be coming from legal
and illegal pathways
um they're moving to distributors
they're uh they could be going to
breeders uh
one unique thing about the amphibian
trade uh
industry is that they also have
hobbyists so you may have some folks
that just have maybe
five ten tanks and that there's a whole
hobbyist group
as opposed to a commercial breeder and
then of course you've got retailers like
petsmart and other places like that
um and and of course the consumers are
interacting here right so they're
purchasing from this trade network
okay and uh when we think about

um you know when we think about the threats to
wildlife it's really this network itself
um as well as the consumers both have this
opportunity to have spill over to the natural ecosystem
uh either through deposition of of contaminated
aquarium contact uh contents into the environment
or release of unwanted animals um and so
um we've got this opportunity for spillover
and the really cool thing scientifically
uh kind of the edge
of i think our proposed research is
really looking at how humans
affect and modify the movement of pathogens
the amplification of pathogens across
across this network so how do
you know how do consumers make different decisions that drive
industry dynamics you know to if that could affect
um you know pathogen movements and amplification how can government
uh policies change that how can
industry strategies change those dynamics
and right now we don't have a good model
to do that and so that's what
we've proposed to do over the next
several years uh for the
one health initiative project is just a sliver of that okay
um just to get some preliminary data so
you know ultimately you know the kind of big questions
is you know what is pathogen prevalence
in international shipments and domestic trade
what factors in industry and nodes

contribute to amplification
how are factors driven by the social
economic feedbacks of industry and
consumers
what's the willingness of industry or
consumers to implement strategies to use
to reduce disease risk and what is the
you know the the non-mar the perceived
non-market
value of wildlife in this case
amphibians
uh that the public has or consumers have
and so as you can imagine there's
uh you know what you saw from one of the
first slides we have
a group of economists social scientists
mathematicians
ecologists that are working together
to attempt to start to tackle this
question
for this system that can hopefully be
applied to
um later to other trade
networks and so this is what we propose
for
our one health initiative grant
is to get initial estimates of pathogen
prevalence
in the amphibian pet industry um obtain
estimates of of total
trade volume economic value and
husbandry practices in each of these
these nodes of the of of the industry
and the connectivity of those nodes
um and to evaluate consumer preferences
and and also then to build a simplified
model using our sampling that we do
within industry
use a model to basically say this is
where we should be focusing
our efforts in the future on sampling as
we begin to roll out the larger project
the larger project has been proposed nsf
uh deb division environmental biology

the id program and uh we just found out unfortunately
this morning um that uh we weren't ranked as highly competitive the highest ranking you can get
uh from this panel but uh that it wasn't supported
um and so they want a few more details on
some of our methods and they also said they ran out of money
unfortunately so um we're excited to revise the proposal and resubmit it
and uh hopefully bring these funds to the university of tennessee
uh with that i'm at 12 55 i do have like another
probably 15 slides to go through but uh we're at the end so i'll just open it
for questions and so let me actually
so uh flip to the end this is just going through how we're going to do everything
so it's you know just basically methods we can uh discuss
offline share a proposal um
and and how sampling can work thank you for providing those nina
i'm sorry to get to talk about with a really good illustrations of how we can identify the network
um and where we are right now so we have been in discussions with the pet industry we have weekly meetings with them they've been great and very eye-opening with respect to the
uh the implementation of this project
and we've got some really good partners they're willing to champion this for they're kind of leaders in the industry which is cool
that's the nsf grant i wanted to end oh yeah oh john nash with uh game theory the
super interesting cool part of the

modeling aspect
that we proposed that nina was a big
part of
um and but this is where we kind of want
to be at the end
is you know to help develop this
knowledge is in a predictive capacity
and partnerships necessary to establish
clean trade
you know and and you know have that
ultimately be supported by
ideally by the federal government to
facilitate the program
but not just amphibians you know
wildlife wide i mean this is what
really needs to be to be done and so
with that i'll leave it on that slide
for questions
and sorry for running a little bit late
i meant to leave more time but i don't
have anything after this for anybody
that
wants to stay on longer
thank you um does anybody have questions
you can either type them
in the chat or or just unmute yourself
and ask
so i do want to point out that and i'm
sorry i got cut off earlier
this is an excellent example as i know
matt already pointed out
of of one taking a one health approach
and i hope that that's obvious to
everybody
so it's clearly something that
uniting across across
disciplines and building
a team that will do something that's
going to have
far-reaching effects
stop the share there
and see everybody
any questions
and also if nina or neelam i'm not sure

if new one's still on
if either of you want to add anything
you can go ahead
thanks matt i thought you gave a great
talk on the the system and what we
wanted to do thank you
the real fascinating part of the
proposal is is the modeling stuff
[Laughter]
yeah this is joshua oh yeah
good match this is a great presentation
i learned a lot from this and um i i got
a question for you because i'm working
on the climate change
uh a lot and uh there is one is
involved to the uh a heat wave caused
the
waterborne disease uh well that
to linkage to the your result or you
consider that
to be a part of your model maybe nina
and
nina you have
yeah um so we we didn't propose that
uh that's something we could maybe
incorporate um
you know but these are captive systems
so they're relatively climate controlled
uh we didn't model anything outside of
the captive network that was our goal
and so they're kept under pretty strict
kind of
climate conditions based on the needs of
the species
but there's no doubt that um climate
change
um can impact uh the likelihood of
emergence of pathogens across
multiple sp uh systems including
amphibian diseases
and we expect okay we'll see anina we
expect that to have uh
different effects on different species
or even different pathogens so there are

some pathogens
such as rhinoviruses you increase the
temperature you increase the replication
rate you increase the pathogenicity
but for example for b-cell um
it's actually a fairly cool-loving
pathogen and if it increases up to you
if you even have an amphibian increase
it above 22c
it tends to clear the pathogen and
that's just thinking about temperature
moisture itself also can
uh affect the likelihood of transmission
um especially with the amphibians so the
more moist it is more humid is maybe the
environmental persistence of the
pathogen is greater so
uh climate change is really important um
you know and and it's a really good
point we do have some work where you saw
those
um you saw the risk map so the next step
with those risk maps
um that we're collaborating with bill
sutton at tennessee state university is
to incorporate
climate change into risk
thank you hey
i do wonder though that's a good point
and so
sometimes these species are collected
from the wild correct
so might there you might there be some
impact that we might see pathogens we
didn't
expect to see more likely to be
in the trade route with yeah
potentially yeah depending on how
they're holding them in captivity and
that could be
temperature humidity dependent but also
just you know how are they circulating
the water
you know their biosecurity practices the

density of the animals
and that's really the nitty-gritty of
our proposal is to try to understand
those basic husbandry animal care
practices
that would facilit that would cause this
like magnification the pathogen within a
facility
and to build models that would say okay
these are the key points
you know that basically industries
making this decision and this is how
they could change
humans could change the dynamics by
changing these few factors is
ideally you know that's that's the goal
hey man i i feel kind of a naive
question uh you mentioned
the water animal trading
not much inspection was down to look at
the pathogens
so so what what what what what kind of
is
inspection they're actually useful
to prevent the pathogens being treated
around
okay so what kind of inspections are
done with wildlife
the only inspections that are done are
to make sure that we are not importing
or exporting
species that are not allowed to be
imported or exported
based on their species status and their
listing
here in the united states or listing um
globally
from an endangered species sort of
standpoint
um so there is no requirement for
wildlife
to to test them for pathogens
um so it's the only thing that's close
that our fish that are not aquaculture

uh
they consider usda considers them a part
of
agriculture and so they will
do the inspections now the
infrastructure is all there
usda could just inspect you know
wildlife inspectors could
inspect um you know for the species
composition of of a shipment and then
usda could simply make sure the animal
health certificates are there or they
could
train fish and wildlife service to do
that but it's like that simple of a
solution
of okay we require animal health
certificates
and we're going to give the authority of
the fish and wildlife service to do it
for wildlife
so while you're doing your wildlife
inspections just make sure they have
these animals
that is a solution period i mean that
would solve it
but it's amazing that something so
simple like that
cannot be accomplished um they just look
at each other like
it's not my responsibility not my
responsibility so
we've got this open floor okay i assume
that we will see
some sort of in the future and that's
the goal some comprehensive um
you know legislation would be put
together to have to facilitate
clean trade you know like there is for
agriculture
because that's what's needed you know to
do it the thing is is it's
to be fair um it's like okay fish and
wildlife service

now this is your responsibility but it's
not like you just say it's your
responsibility you've got to have the
inspectors you got to have the resources
and if that tanks the entire industry um
because all of a sudden you go from a 5
amphibian to a
30 amphibian because you have to have
molecular testing done
well that's you know you're destroying
the industry so
there needs to be government support in
that capacity
so our goal is to actually estimate the
cost
the worth of the amphibian pet industry
or trade industry here in the united
states
and the cost of what would take to
implement these different strategies
what would be the most effective
strategies
so that you can you know approach this
issue you know with
um in the response to it and and maybe
future programs with with more
information right now there's
zero information for them it's it's
amazing when you talk about this to
think about all the potential risk of
oh yeah the packaging around yeah yeah
no doubt
yeah thank you for a very nice talk
okay it looks like we just have a few
folks left uh
any other questions
yeah okay looks like that's it yeah
all right thanks we'll see you later
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