Request For Comments RFC-20040915NHa: Fix for airborne spread algorithm.

1st draft, Neil Harvey and Mark Schoenbaum, 15 September 2004
2nd draft, Neil Harvey and Mark Schoenbaum, 17 September 2004

Applies to: Model document v1.0, 20040519.

Type of change: Bugfix, for next minor version.

Summary: This RFC proposes a fix to a formula used for airborne spread.

Justification: The current formula yields values that do not match the given parameters. Noted in email communications from Neil Harvey (circulated by Caroline Dubé on Wed 25 Aug 2004) and Mark Schoenbaum (Wed 15 Sep 2004) reproduced below.

Change: The definition of *DistanceFactor*(*A*,*B*) in section 4.3 (Airborne spread) would be changed to read:
DistanceFactor(*A*,*B*) = (maximum distance of spread - distance from *A* to *B*) / (maximum distance of spread - 1)

Change: Step 1(c)i would be changed to read:
Check whether *B* can be the target of an infection. That is, is it Suspectible, is the distance from *A* to *B* < the maximum distance of spread, and is the direction from *A* to *B* inside the wind direction range?

The current document contains the wording "is the distance from *A* to *B* ≤ the maximum distance of spread". The changed version is more efficient since it can eliminate units that are at the maximum distance (for which the probability of spread will be zero) at step 1(c)i, rather than continuing to step 1(c)iii and calculating the probability.

Change: Step 1(c)iii would be changed to read:
Compute the probability of infection *P* = probability of infection at 1 km × *DistanceFactor*(*A*,*B*) × *HerdSizeFactor*(*A*) × *HerdSizeFactor*(*B*).

The current document calls *P* the probability of exposure rather than infection.

End of changes.

Attachment: email communication

From: Caroline Dubé <dubecm@inspection.gc.ca>
To: <Aaron.P.Reeves@aphis.usda.gov>, <Barbara.A.Corso@aphis.usda.gov>, <dastacey@cis.uoguelph.ca>, <Ashley.Hill@colostate.edu>, <m.d.salman@colostate.edu>, <Abdel.Maarouf@ec.gc.ca>, <Magda.Little@ec.gc.ca>, <Michel.Jean@ec.gc.ca>, <Real.D'Amours@ec.gc.ca>, <bruce.mcnab@omaf.gov.on.ca>, <nharvey@uoguelph.ca>, <Claudia.I.Cartwright@USDA.GOV>, <Francisco.Zagmutt-Vergara@USDA.GOV>
Date: Wed, 25 Aug 2004 11:07:38 -0400
Message-Id: <s12c737c.015@NCRXEM7>
Subject: Fwd: Airborne spread calculations

Hello,

Attached an e-mail from Neil discussing the calculations for airborne spread in the model. I would like to get people's opinion on the relationship for fall-off of the virus. I don't remember either if the experts discussed using a squared or exponential relationship. Please let Neil and I know what you think.

THanks,

Caroline

---------- Forwarded message ----------
From: Neil Harvey
To: "Caroline Dubé" , Bruce McNab , Deb Stacey , Greg Klotz
Date: Tue, 24 Aug 2004 14:18:46 -0400
Subject: Airborne spread calculations

Hi,

One of my to-do items from our meeting in the cafeteria was to propose alternative calculations for airborne spread.

The current one is:

P = (p infection at 1 km) * (1 - distance / max distance of spread)

Then that number is further scaled by herd size factors.

This formula is actually kind of weird because it yields (p infection at 1 km) at 0 km, not at 1 km. A corrected version would be

P = p * (1 - (distance - 1) / (max distance of spread - 1))

I can't remember whether folks at the expert meeting were recommending a squared or exponential falloff. So, the calculation giving squared falloff would be:

P = 1 / (distance * (sqrt(4/p)/2 - 1) + 1)**2

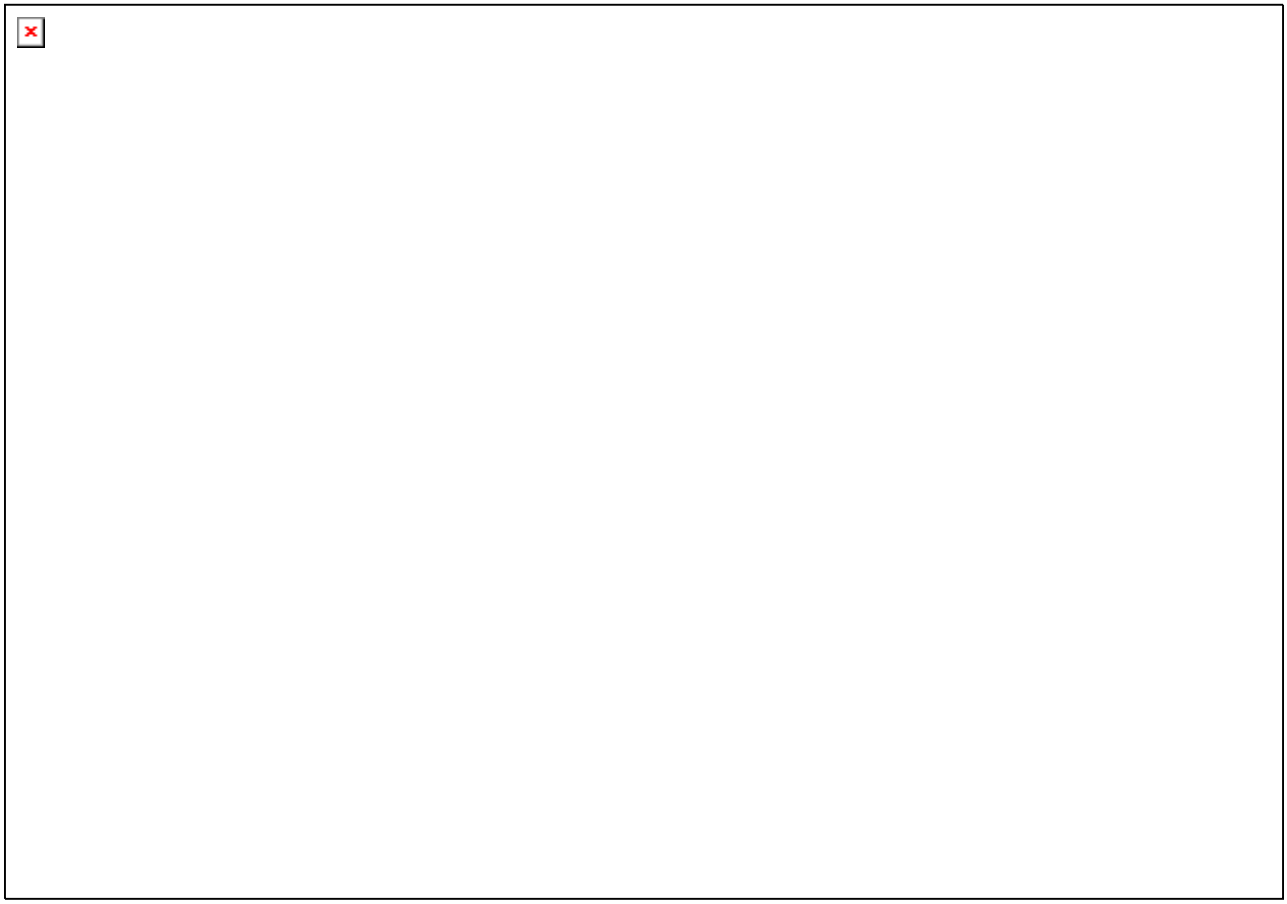
and the calculation giving exponential falloff would be:

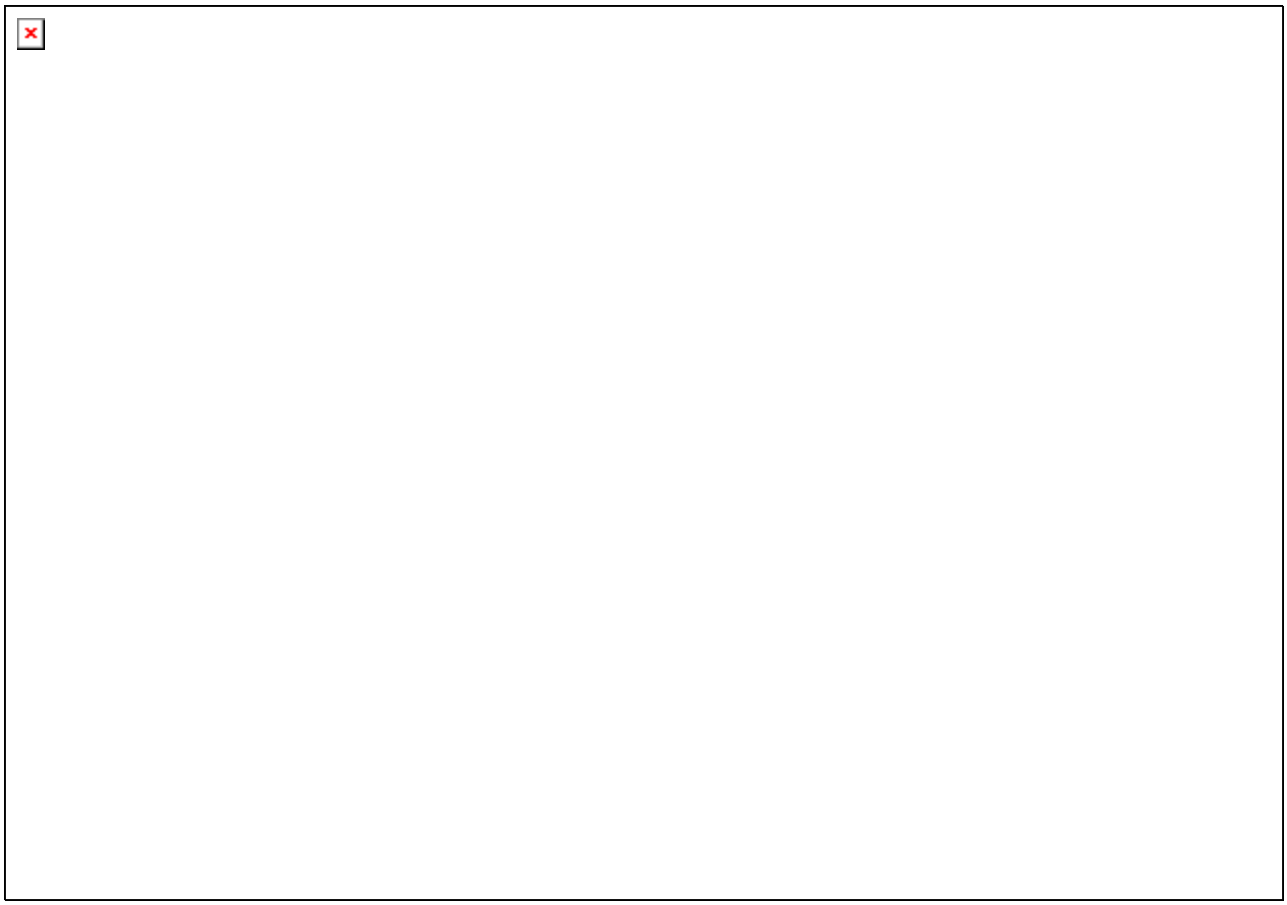
P = 1 / (1/p)**distance

Attached are two plots showing the functions.

Feel free to forward to the rest of the group if you feel this is worth carrying forward.

Neil





Attachment: email communication

From: Neil Harvey <neilharvey@gmail.com>
To: Caroline Dubé <dubecm@inspection.gc.ca>
Cc: aaron.p.reeves@aphis.usda.gov, barbara.a.corso@aphis.usda.gov, dastacey@cis.uoguelph.ca, ashley.hill@colostate.edu, m.d.salman@colostate.edu, abdel.maarouf@ec.gc.ca, magda.little@ec.gc.ca, michel.jean@ec.gc.ca, real.d'amours@ec.gc.ca, bruce.mcnab@omaf.gov.on.ca, nharvey@uoguelph.ca, claudia.i.cartwright@usda.gov, francisco.zagmutt-vergara@usda.gov
Date: Wed, 25 Aug 2004 11:27:57 -0400
Message-ID: <aa35ac3c04082508275daf551a@mail.gmail.com>
Subject: Re: Airborne spread calculations

A quick addition -- I (somewhat carelessly) copied those formulas from my plotting program, where "raised to the power of 2" is written as "**2". Sorry if that caused any confusion.

A better way to write those would be:

squared falloff: P = 1 / (distance * C + 1)^2

where C = sqrt(4/p) / 2 - 1

(I wanted to pull out the bit with the square root to emphasize that it's a constant term that doesn't have to be recomputed every time.)

And

exponential falloff: P = 1 / (1/p)^distance

Neil

Attachment: email communication

From: mark.a.schoenbaum@aphis.usda.gov <mark.a.schoenbaum@aphis.usda.gov>
To: Barbara Corso <barbara.a.corso@aphis.usda.gov>
Cc: Aaron Reeves <aaron.reeves@colostate.edu>, Neil Harvey <neilharvey@gmail.com>, Caroline Dubé <dubecm@inspection.gc.ca>, Francisco Zagmutt-Vergara <francisco.zagmutt-vergara@usda.gov>
Date: Wed, 15 Sep 2004 12:05:08 -0600
Message-ID: <OFEE9CBAA0.77992365-ON87256F10.005F3E80-87256F10.00636F02@aphis.usda.gov> Subject: Aerosol infections counting issue and a modeling formula issue

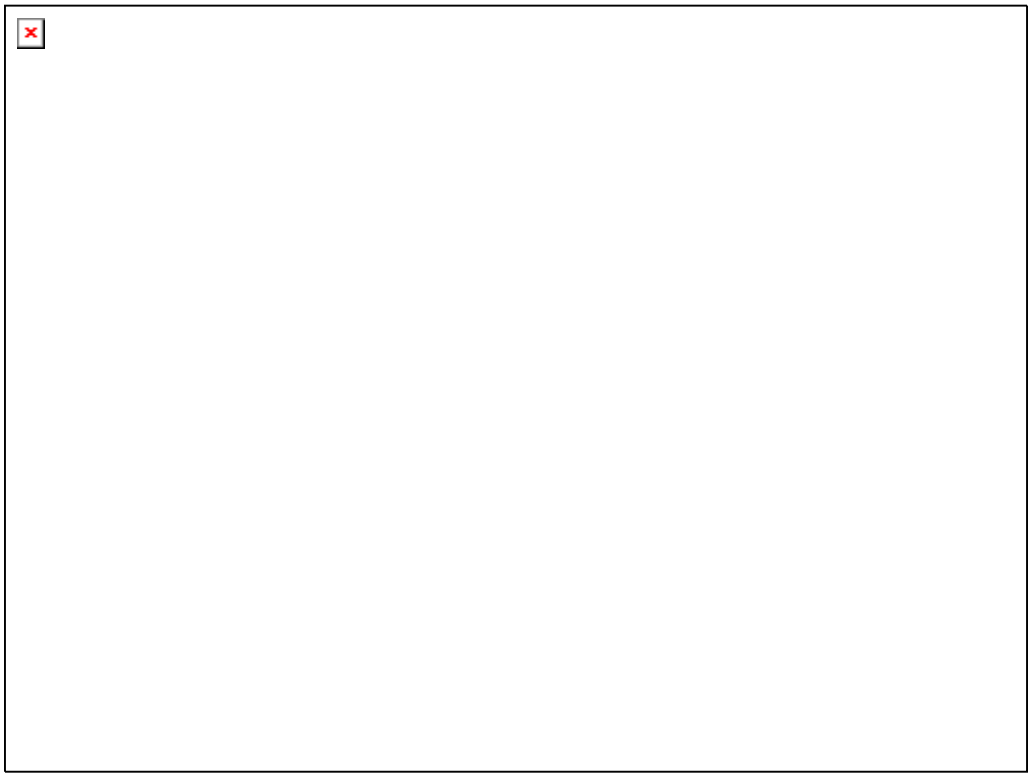
Barbara. In response to your finding odd output from the aerosol, and Neil's questions about this, Aaron and I have found a couple of issues on first look. The output reveiled that the number of infected-by-aerosol units was always an even number. This was a double counting issue that has been identified and will be corrected in the next version.

Another issue that you brought up was that the formula from the conceptual model document (Neil's effort) did not seem correct to you. You are right, this is not doing what we thought or intended. This may have been my mistake in translating version 2 to 3. It probably does not make a great difference when the maximum-spread distance is great but it could when it is small. I highly recommend changing this in the conceptual model.

OLD FORMULA
DistanceFactor(A,B) = 1 - (Distance from A to B)/(Maximum distance of spread)
This distance factor does not take into account the probability at 1 km is different from the probability at 0 km distance.

NEW FORMULA
DistanceFactor(A,B) = ((Maximum distance of spread) - (Distance from A to B))/((Maximum distance of spread) - 1)

The graphic below is what we want to model - a linear decrease in probability of infection as distance between the units increases. Reference points are the probability at 1 km and a zero probability at the maximum distance of spread.



Aaron and Neil, can you double check that this formula does what we want? I am pretty sure but am open to the chance that I screwed it up again.

Neil, I have a couple of corrections to the concept document:

4.3.1.c.(i) ... "is the distance from A to B < the maximum", this should be a less than, rather than less than or equal to as it appears now
4.3.1.c.(iii) ... "probability of infection" rather than "probability of exposure" (I may have an old copy of this because I thought this was corrected before)
4.3.1.c replace DistanceFactor(A,B) with (Maximum distance of spread - Distance from A to B)/(Maximum distance of spread - 1)

The first change would bring the 2 models closer to agreement on the number of herds infected by aerosol. The second change is presumably need for both models to better do what we intended. Comments or corrections?

Mark
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Attachment: email communication

From: Mark.A.Schoenbaum@aphis.usda.gov
To: Neil Harvey <neilharvey@gmail.com>
Cc: Aaron Reeves <aaron.reeves@colostate.edu>, Barbara Corso <barbara.a.corso@aphis.usda.gov>, Caroline Dubé <dubecm@inspection.gc.ca>, Francisco Zagmutt-Vergara <francisco.zagmutt-vergara@usda.gov>
Date: Wed, 15 Sep 2004 13:06:30 -0600
Message-ID: <OF4ABD2608.D24BA3C7-ON87256F10.00684B6B-87256F10.00690D61@aphis.usda.gov>
Subject: Re: Aerosol infections counting issue and a modeling formula issue

Thanks Neil, I see you already had this issue come up a while ago but so many things get past me these days. For aerosol, there is an "exposure" of different degrees to all herds within the maximum spread distance of a herd in the infectious period. If an infection is generated, we track it but the exposures by aerosol without infection are not tracked as exposures since there are no consequences of the exposure. So, they occur and we are modeling them but we do not try to track them. Exposure is the action of coming into contact with the disease agent. Infection is subsequent or almost simulatious with exposure and is the multiplication of the agent after its transfer to the susceptible animal/herd.

Mark
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