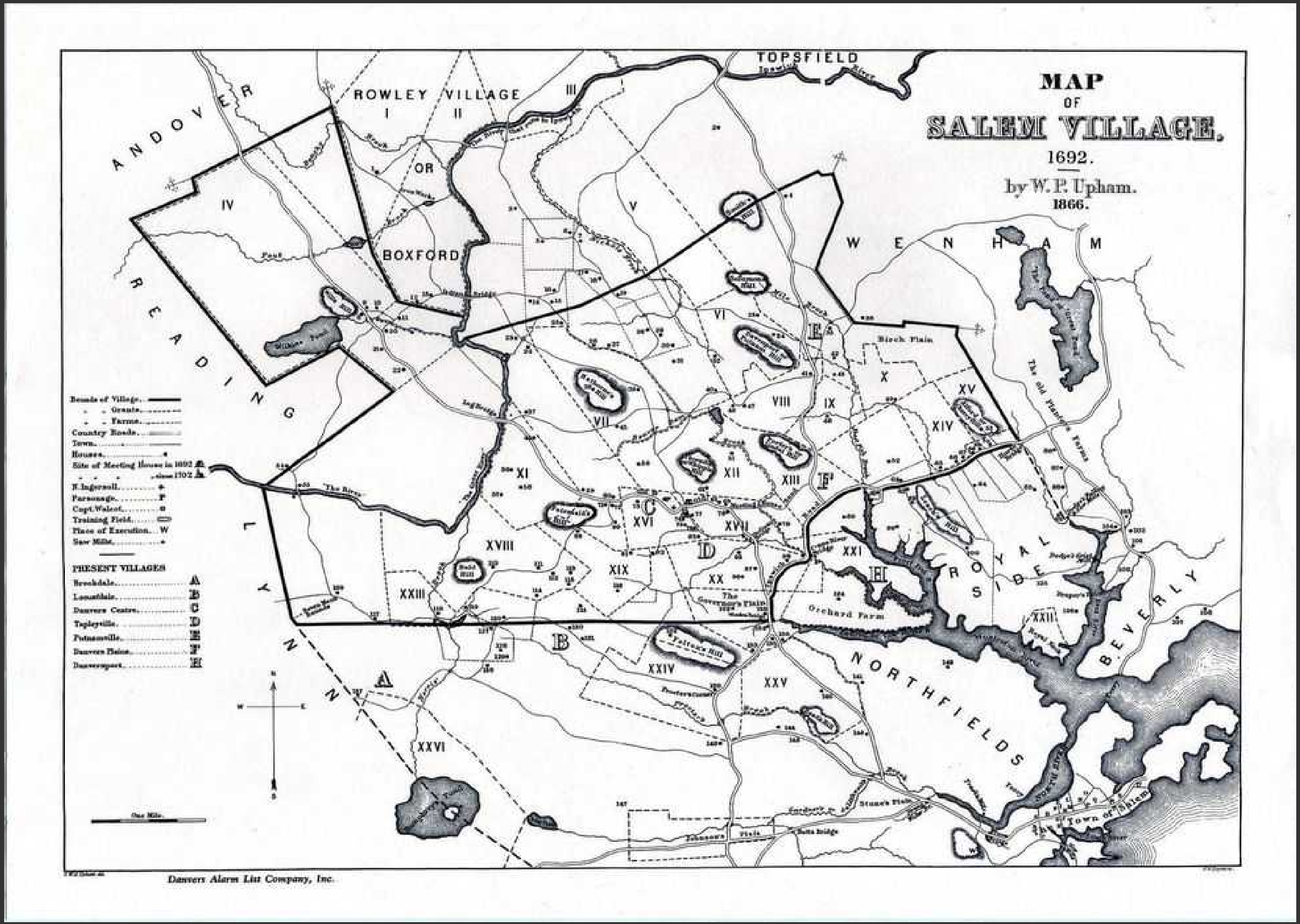
Plant pathogens

Topics (just the very basics):

- Why plant pathogenic fungi have gotten WAY more attention than human pathogenic fungi
- Appreciation for the economic and evnironmental impact of plant pathogenic fungi
- Understanding of "the disease triangle" and how it relates to pathogenicity
- Know a few examples of plant pathogenic species
- Have an idea of the sorts of things that plant pathologists study



The trouble in Salem began during the cold, dark Massachusetts winter, in January of 1692. Eight young girls began to take ill. The girls suffered from delirium, violent convulsions, incomprehensible speech, trance-like states, and odd skin sensations. The worried villagers searched desperately for an explanation. Their conclusion: the girls were under a spell, bewitched — and, worse yet, by members of their own pious community.

And then the finger pointing began. Ultimately, more than 150 “witches” were taken into custody; by late September 1692, 20 men and women had been put to death, and five more accused had died in jail. None of the executed confessed to witchcraft. Such a confession would have surely spared their lives, but, they believed, condemned their souls.

Trial of Giles Corey.

During the **Salem Witch Trials,** even spectral evidence (like seeing witchcraft in dreams) was accepted against the accused.

The Witch Hotel, Salem, MA

Ergotism: The Satan Loosed in Salem?

Convulsive ergotism may have been a physiological basis for the Salem witchcraft crisis in 1692.

Linnda R. Caporael

From *Science* Vol. 192 (2 April 1976)

Numerous hypotheses have been devised to explain the occurrence of the Salem witchcraft trials in 1692, yet a sense of bewilderment and doubt pervades most of the historical perspectives on the subject. The physical afflictions of the accusing girls and the imagery of the testimony, therefore, is dismissed as imaginary in foundation. One avenue of understanding that has yet to be sufficiently explored is that a physiological condition, unrecognized at the time, may have been a factor in the Salem incident. Assuming that the content of the court records is basically an honest account of the deponents' experiences, the evidence suggests that convulsive ergotism, a disorder resulting from the ingestion of grain contaminated with ergot, may have initiated the witchcraft delusion.

Suggestions of physical origins of the afflicted girls' behavior have been dismissed without research into the matter. In looking back, the complexity of the psychological and social factors in the community obscured the potential existence of physical pathology, suffered not only by the afflicted children, but also by a number of other community members. The value of such an explanation, however, is clear. Winfield S. Nevins best reveals the implicit uncertainties of contemporary historians (1: 2, p. 235).

Of course, ridiculous religious hysteria was relatively commonplace back then…

It would be comforting to think there was a rational explanation for stupid human behavior, but –------>

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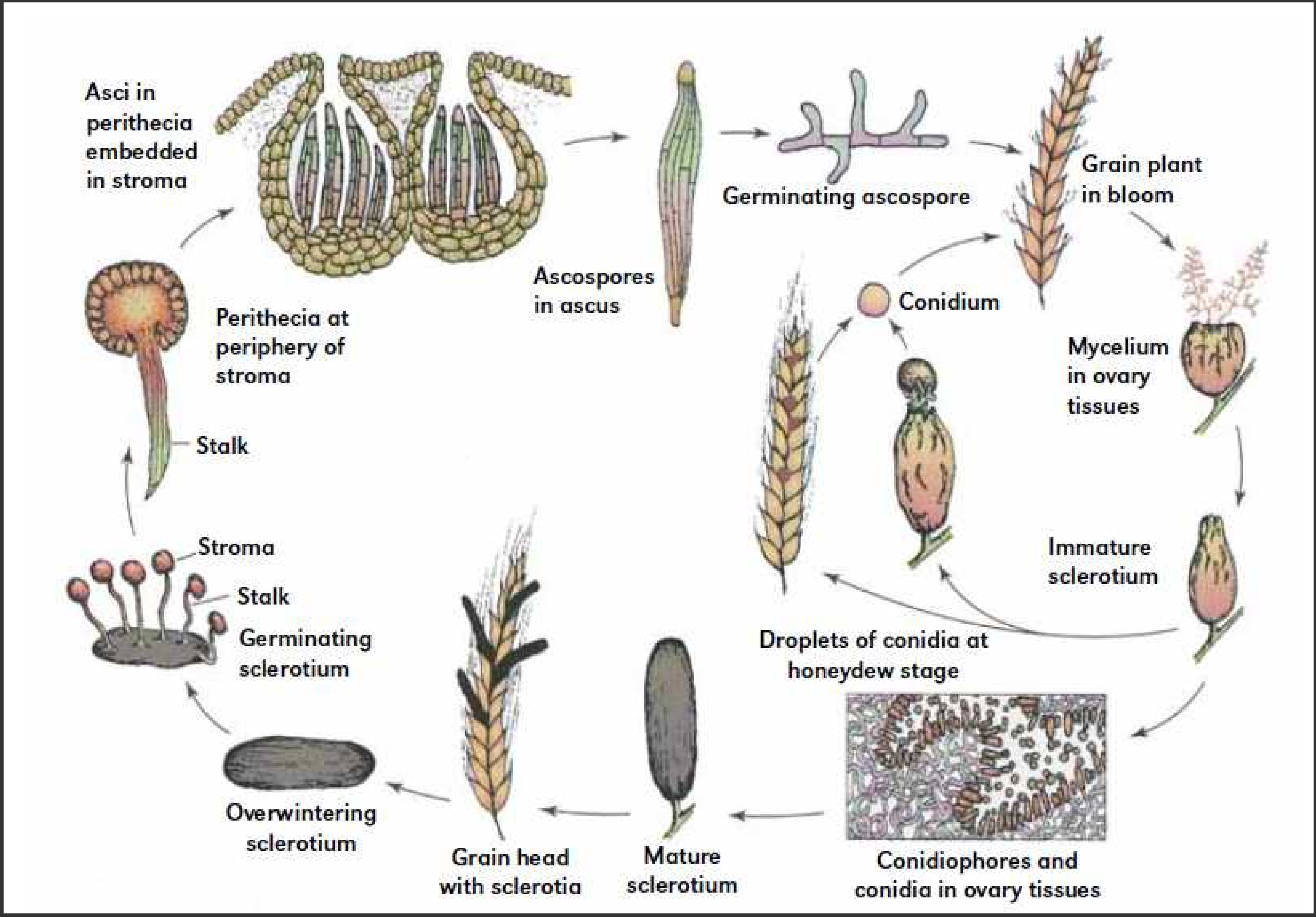
Claviceps purpurea

“Ergot”

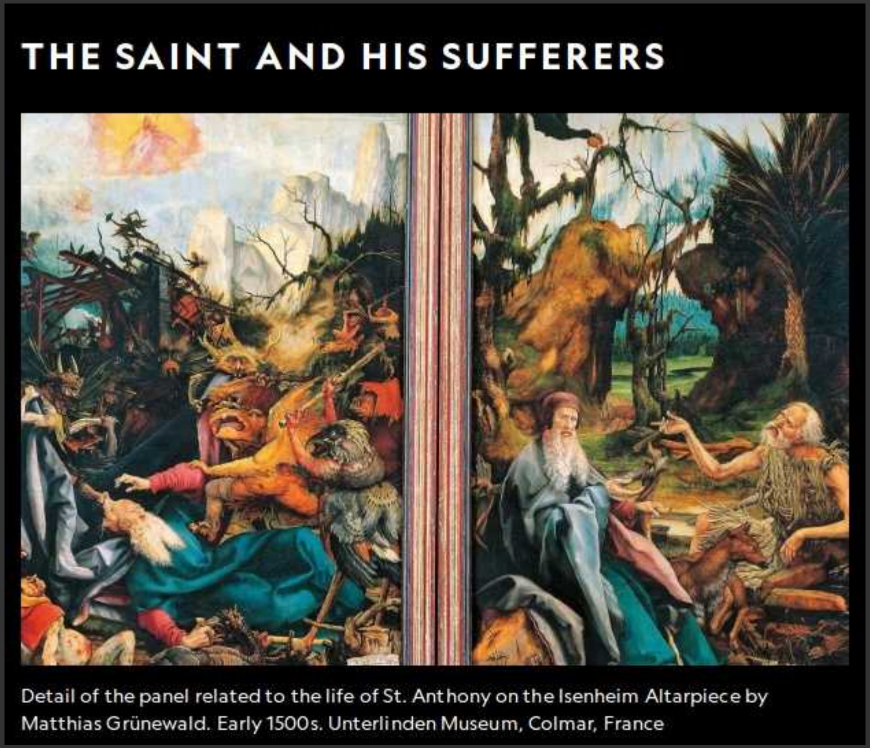

Asci in perithecia embedded in stroma
Ascospores in ascus
Germinating ascospore
Grain plant in bloom
Mycelium in ovary tissues
Immature sclerotium
Conidium
Droplets of conidia at honeydew stage
Conidiophores and conidia in ovary tissues
Mature sclerotium
Grain head with sclerotia
Overwintering sclerotium
Germinating sclerotium
Stroma
Stalk
Stalk
Perithecia at periphery of stroma

So maybe it’s a stretch to say that ergotism was responsible for starting the Salem witch scare. After all, those people were stone stupid to begin with.

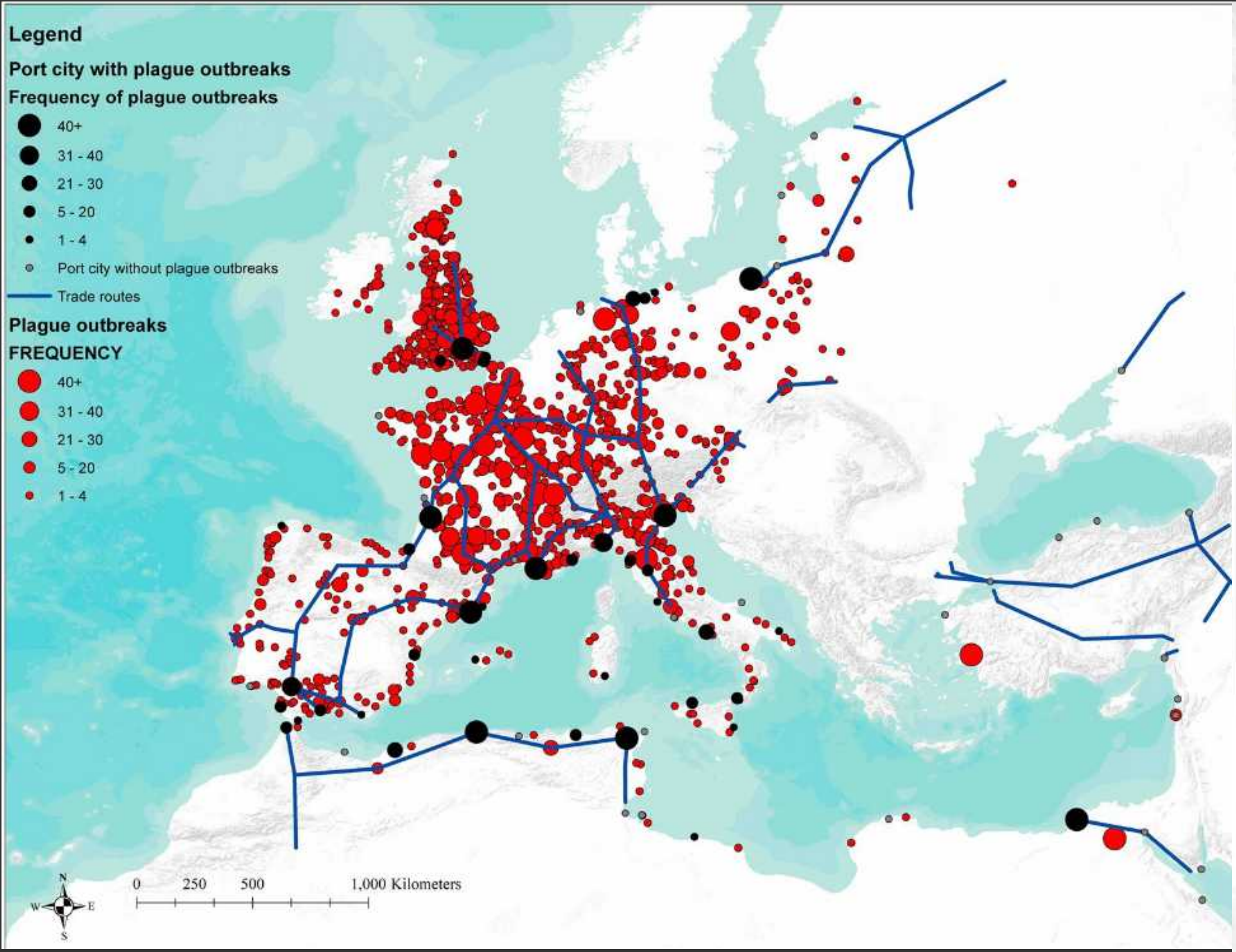
But that’s not to say that ergotism isn’t historically (and currently) important...

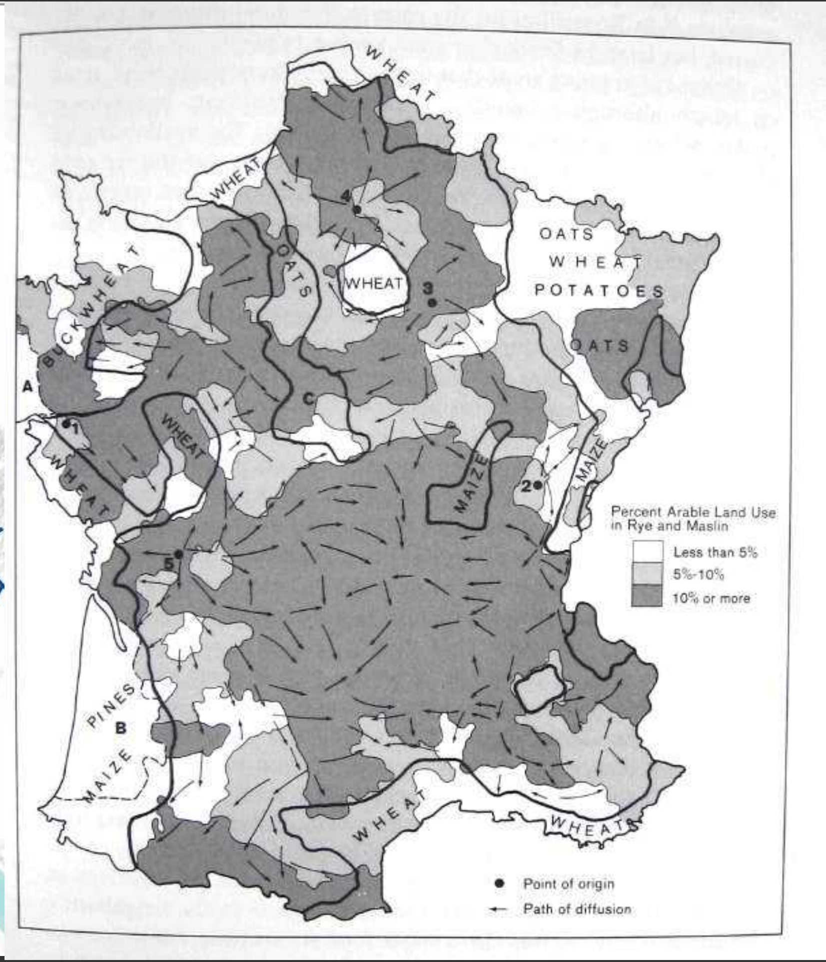
“The afflicted thronged to the churches and invoked the saints. The cries of those in pain and the shedding of burned-up limbs alike excited pity; the stench of rotten flesh was unbearable.”

-François Eudes de Mézeray 10th century historian



St Anthony’s Fire

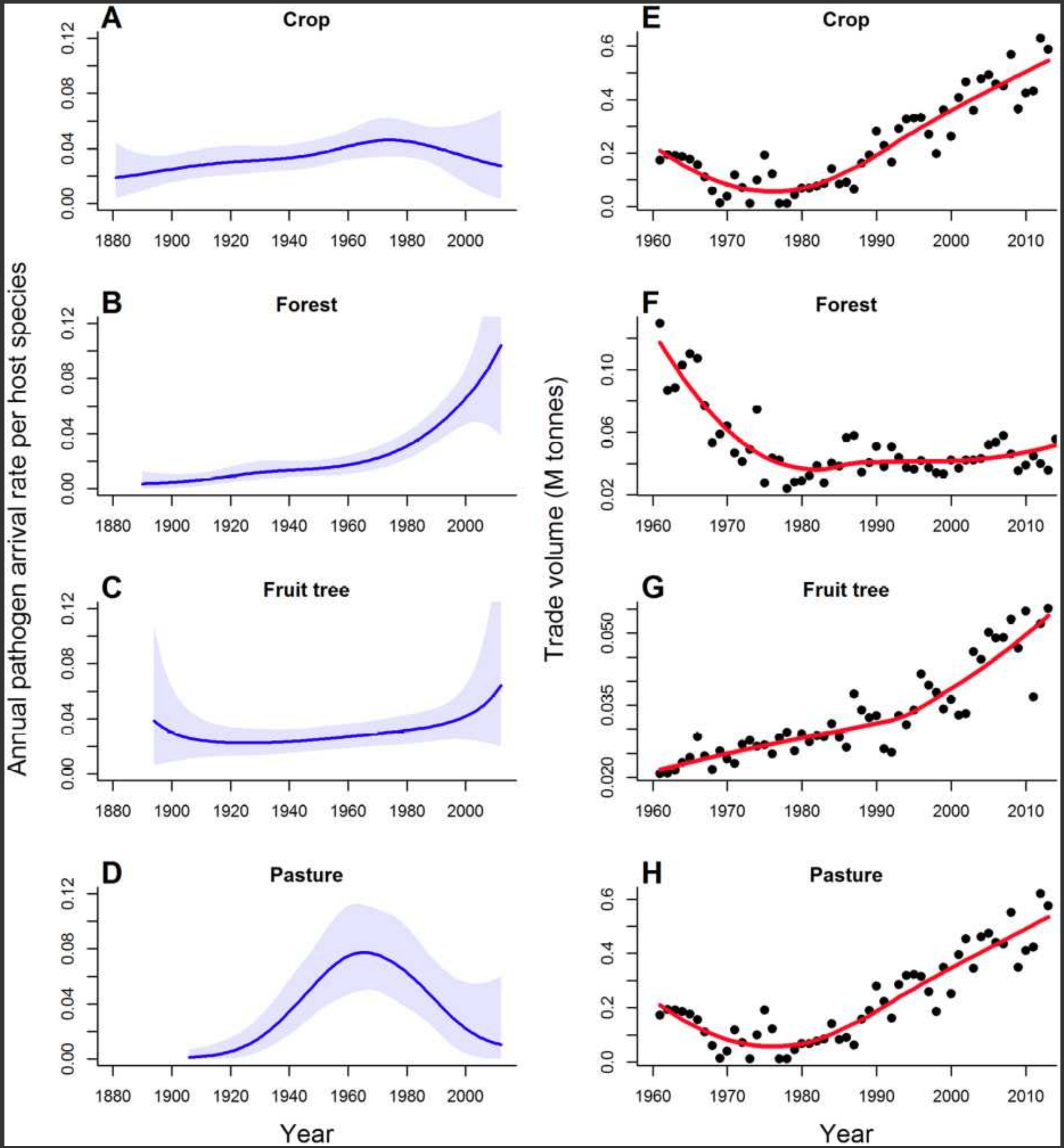




Severity of black plague outbreaks was worse in communities with more rye production.

Ergotism still affects human communities today

Plant pathogens are becoming a *global* economic concern



New Zealand imports of plant products (and pathogens)

Rapid ʻŌhiʻa death

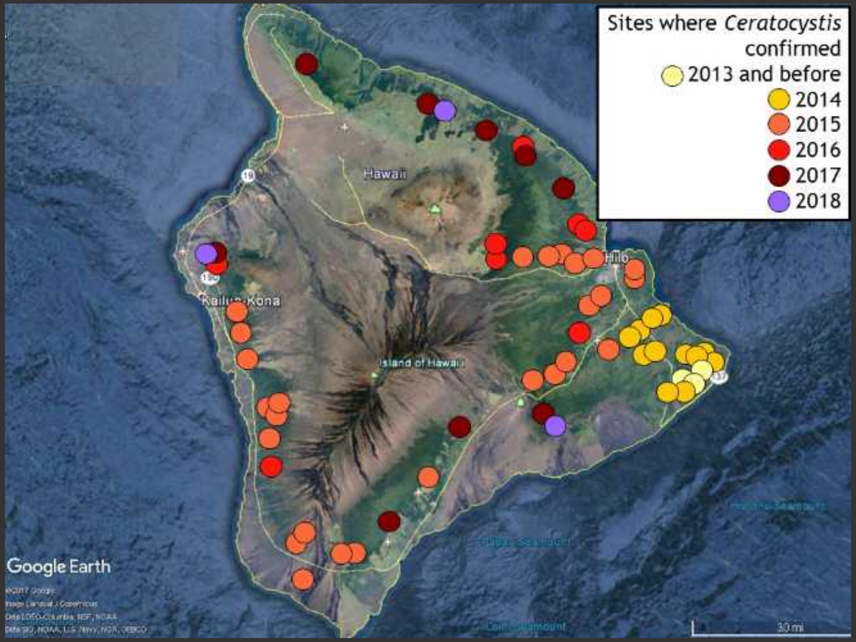
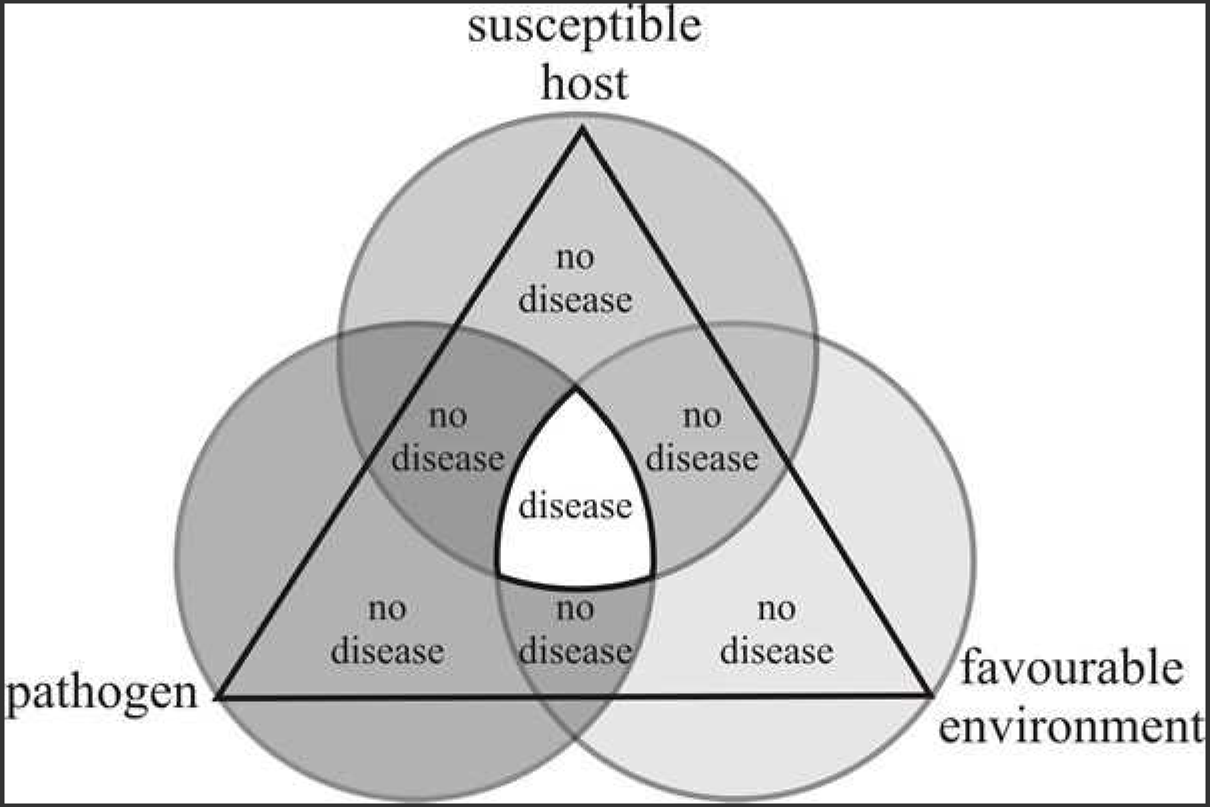


Table 14. The Production and Economic Impacts of Bt Corn, 1996-2001: Bushels of Corn Yield Loss Avoided, Value of Increased Yield, the Bt Corn Premium, and Impact on Farm-level Profits, 1996-2001

State	1996	1997	1998	1999	2000	2001	1996-2001 Totals
Colorado	369,200	2,246,149	5,477,784	6,811,740	6,240,780	6,027,840	27,173,493
Illinois	2,549,583	3,806,569	4,165,384	4,053,672	6,013,907	24,301,408	44,890,523
Indiana	276,438	820,573	995,390	5,230,579	3,016,440	5,056,819	15,396,240
Iowa	1,402,080	3,275,005	3,533,718	3,042,394	3,567,000	13,742,001	28,562,198
Kansas	283,227	888,071	1,035,368	923,832	932,880	3,881,196	7,944,574
Kentucky	139,707	355,056	306,811	900,900	484,120	1,146,880	3,333,474
Michigan	103,626	355,680	100,596	188,760	178,957	364,320	1,291,939
Minnesota	1,140,000	2,497,970	3,091,663	2,111,576	2,926,663	12,854,824	24,622,695
Missouri	739,555	1,218,781	1,344,871	1,393,982	317,950	1,468,800	6,483,940
Nebraska	1,685,493	4,974,442	2,723,418	3,108,040	5,569,200	14,710,800	32,771,393
New York	32,218	110,854	125,841	177,710	129,654	277,970	854,246
Ohio	93,240	409,106	295,849	1,147,608	614,739	2,275,416	4,835,958
Pennsylvania	13,114	46,178	59,319	56,700	97,441	133,950	406,701
South Dakota	897,867	1,416,606	1,719,979	2,107,224	3,385,648	8,873,304	18,400,628
Texas	611,520	3,895,545	7,683,624	9,810,450	9,478,560	6,697,600	38,177,299
Wisconsin	305,454	880,610	262,152	1,045,044	944,328	2,120,294	5,557,882
Other States	746,435	1,648,085	2,357,586	1,636,252	2,698,088	6,339,178	15,425,624
U.S. Total (Bushels)	11,388,756	28,845,280	35,279,353	43,746,462	46,596,356	110,272,601	276,128,808
Dollar Value Added Yield*	$ 30,863,529	$ 70,094,030	$ 68,441,944	$ 79,618,561	$ 86,203,258	$ 231,572,461	$ 566,793,785
Bt Corn Price Premium*	$ 11,690,000	$ 62,730,000	$ 144,720,000	$ 147,180,000	$ 154,250,000	$ 138,560,000	$ 659,130,000
Net Profit (Loss) from Bt Corn	$ 19,173,529	$ 7,364,030	$ (76,278,056)	$ (67,561,439)	$ (68,046,742)	$ 93,012,461	$ (92,336,215)

Source: Benbrook Consulting Services, 2001.

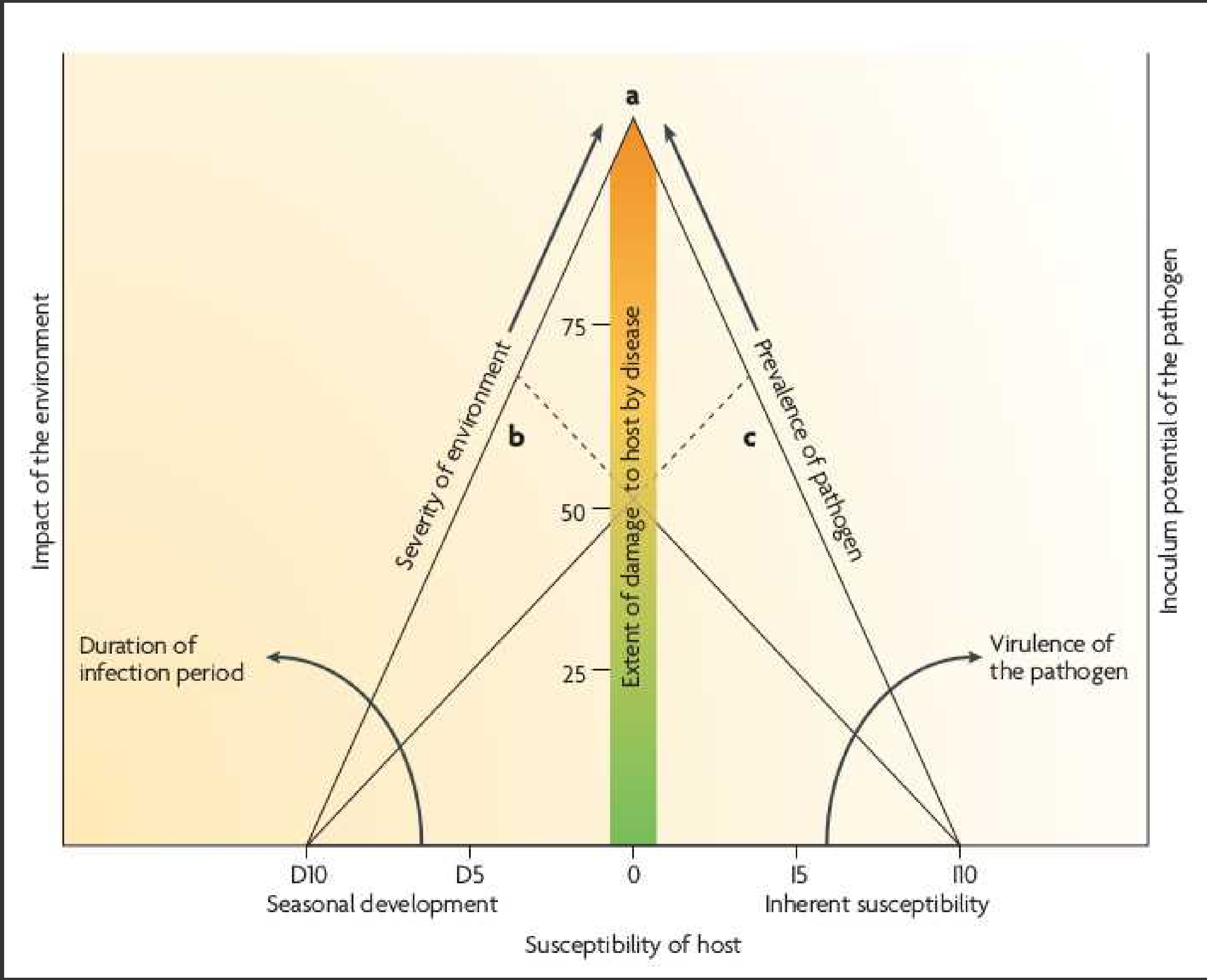
The disease triangle



Three interlocking participants — host, pathogen and environment — determine disease outcome during the life-history of the host

What is the host susceptibility?
Does the environment favor pathogenicity?
Is the pathogen present, and able to infect?

Which corner do you take out to prevent/stop a disease?



Mathematical versions of this concept that incorporate time are used in epiphytotics (plant epidemiology)

Special Report

Potato Late Blight in the Columbia Basin:
An Economic Analysis of the 1995 Epidemic

D. A. Johnson and **T. F. Cummings,** Department of Plant Pathology, Washington State University, Pullman 99164-6430; **P. B. Hamm,** Department of Botany and Plant Pathology, Hermiston Agricultural Research and Extension Center, Oregon State University, Hermiston 97838; **R. C. Rowe,** Department of Plant Pathology, Ohio State University, Wooster 44691; **J. S. Miller,** Department of Plant Pathology, Washington State University; **R. E. Thornton,** Department of Horticulture, Washington State University; **G. Q. Pelter,** Washington State University, Ephrata 98823; and **E. J. Sorensen,** Washington State University, Pasco 99301

Economic impact of one plant disease in one place in one single year....

$30,000,000 !

This is why plant pathology can be a lucrative science to study

Fig. 1. Map of the potato production area in the Columbia Basin of Washington and Oregon (insert) showing the north and south basin of Washington and the basin of Oregon.

Table 1. Number of fungicide applications and cost of applications and materials for management of late blight on early- to midseason potatoes in three areas in the Columbia Basin of Washington and Oregon in 1995

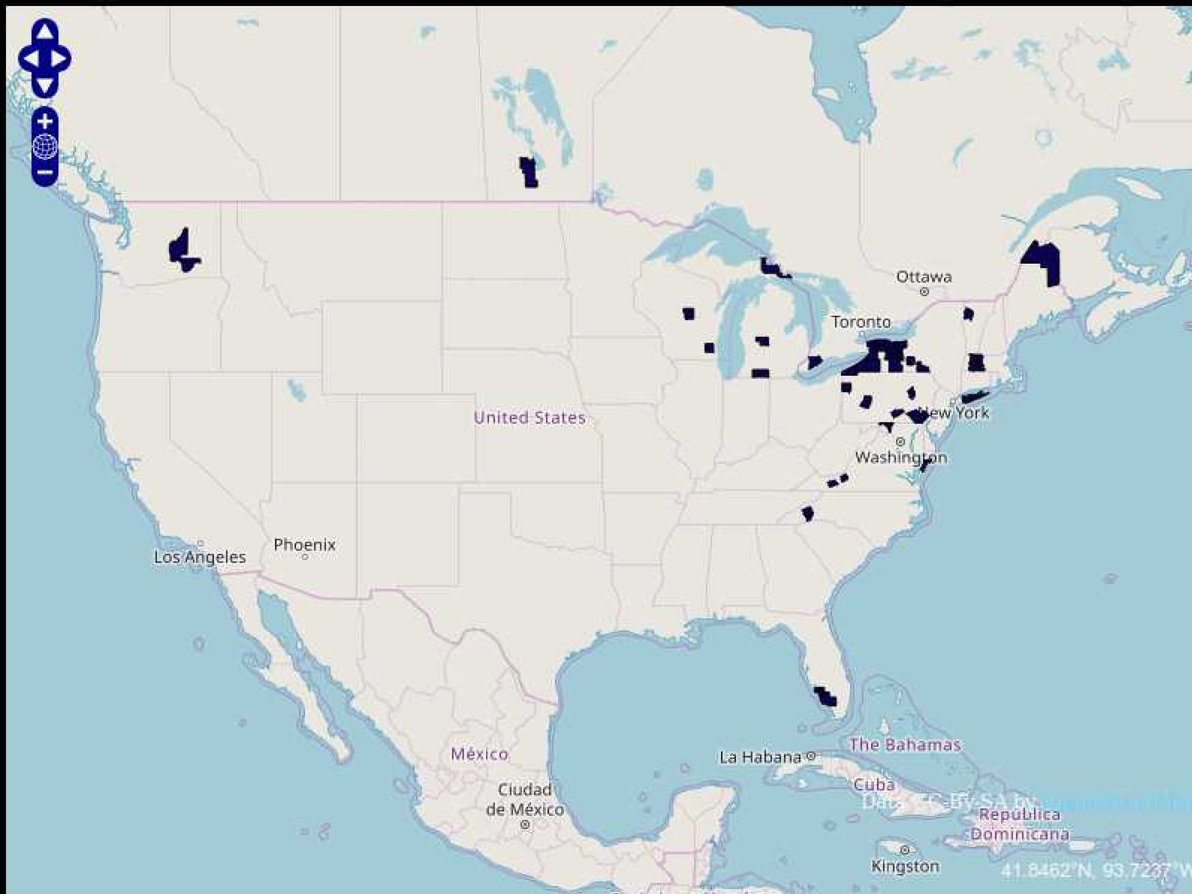
	Washington			Oregon
	North basin	South basin	Avg.	south basin
Number of fungicide applications per field[a]				
Mean	5.1	5.2	5.2	6.3
Standard error	0.69	0.97	0.54	0.50
Range	3-9	2-7	2-9	4-10
Sample size	8	5	13	15
Total application cost per acre ($)[b]				
Mean	35.50	32.20	34.23	37.98
Standard error	4.61	5.75	3.48	...
Range	21-63	14-46	14-63	...
Sample size	8	5	13	...
Fungicide cost per acre ($)				
Mean	71.77	74.57	72.85	72.10
Standard error	12.97	29.37	13.08	...
Range	23-133	18-169	18-169	...
Sample size	8	5	13	...
Application and total fungicide cost per acre ($)				
Mean	107.27	106.77	107.08	110.08
Standard error	14.96	34.67	15.31	...
Range	44-175	32-215	32-215	...
Sample size	8	5	13	...

[a] More than one fungicide may be present in an application.

Late Blight Map

Note: Not all states/regions currently report late blight to our web site. We encourage you to ask your local extension agent to report the disease.

Click on a county below for more report information.



Confirmed Reports 2017-01-01 to 2017-12-31

Group by state

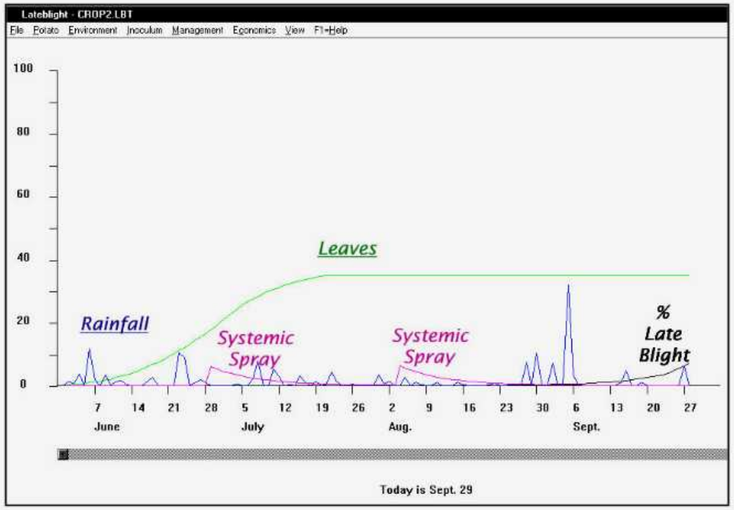
1	Hartford County, CT
4	Collier County, FL
2	Lee County, FL
1	Franklin County, MA
3	Hampshire County, MA
1	Division No. 8, MB
1	Aroostook County, ME
1	Branch County, MI
1	Chippewa County, MI
14	Montcalm County, MI
2	St Joseph County, MI
1	Buncombe County, NC
1	Henderson County, NC
1	Transylvania County, NC
1	Broome County, NY
2	Cattaraugus County, NY
1	Chautauqua County, NY
2	Erie County, NY
1	Genesee County, NY
1	Livingston County, NY
1	Monroe County, NY

Legend: Observed in the last 7 days | Observed over 7 days ago

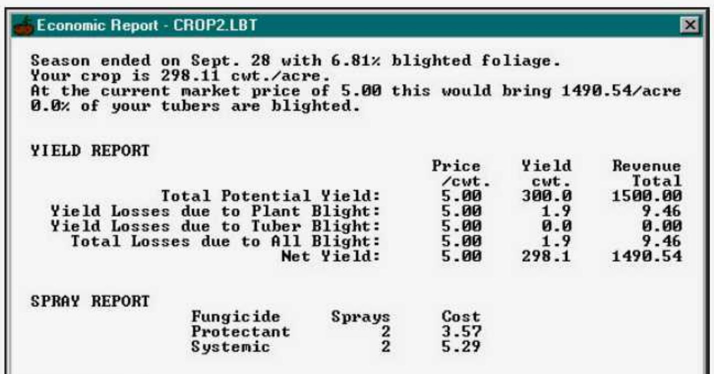
2017

Models incorporating: weather, nearby outbreaks, pesticide applications, potato variety, crop density, etc.

Sound familiar?



If you open your Economic Report, you can see that spraying with a systemic has resulted in a net profit under otherwise identical conditions.


Economic Report - CROP2.LBT

Season ended on Sept. 28 with 6.81% blighted foliage.
Your crop is 298.11 cwt./acre.
At the current market price of 5.00 this would bring 1490.54/acre
0.0% of your tubers are blighted.

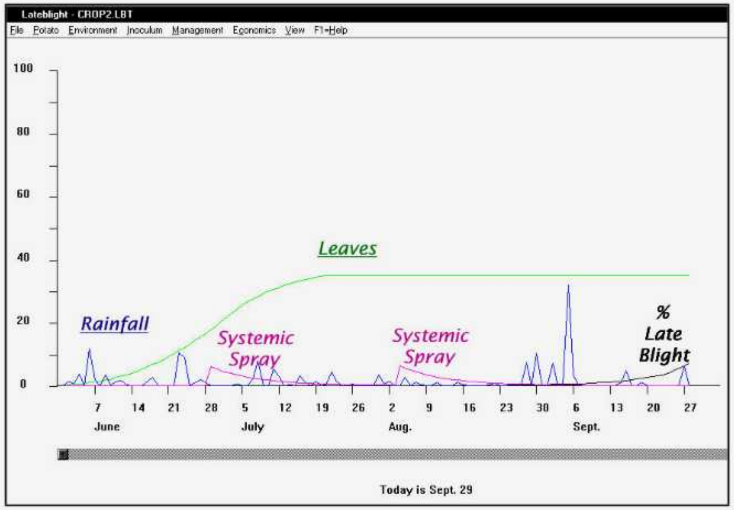
YIELD REPORT

	Price /cwt.	Yield cwt.	Revenue Total
Total Potential Yield:	5.00	300.0	1500.00
Yield Losses due to Plant Blight:	5.00	1.9	9.46
Yield Losses due to Tuber Blight:	5.00	0.0	0.00
Total Losses due to All Blight:	5.00	1.9	9.46
Net Yield:	5.00	298.1	1490.54

SPRAY REPORT

Fungicide	Sprays	Cost
Protectant	2	3.57
Systemic	2	5.29

LATEBLIGHT Software



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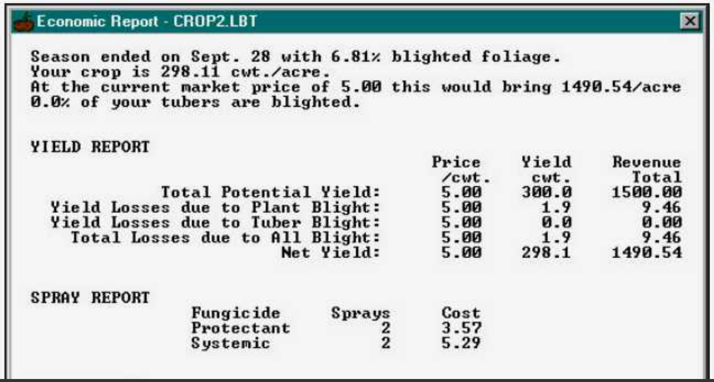

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LATEBLIGHT Software

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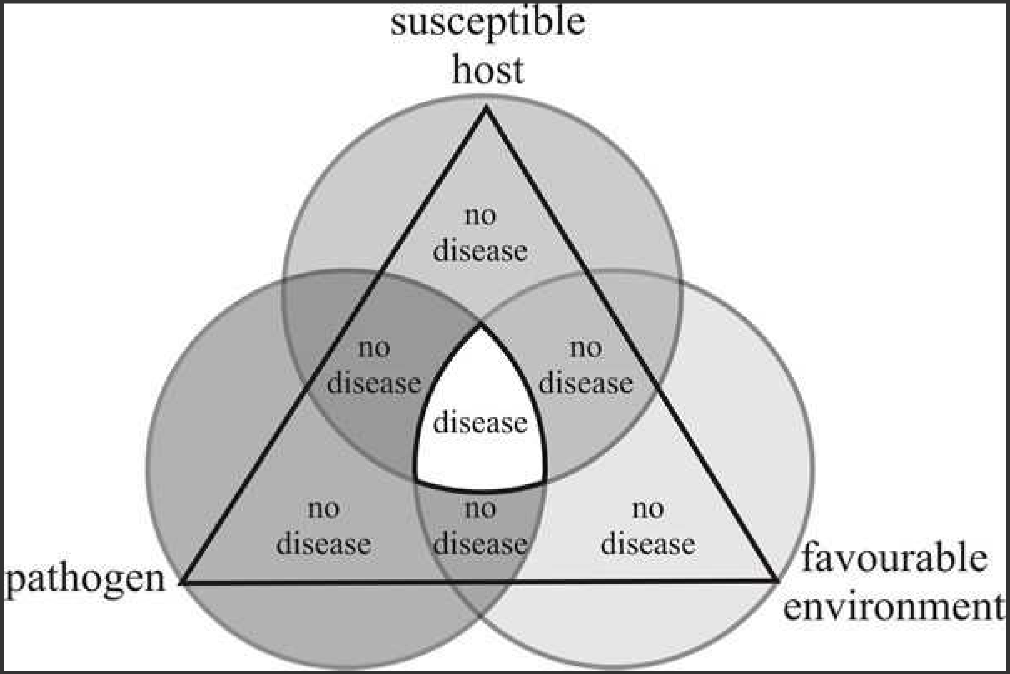


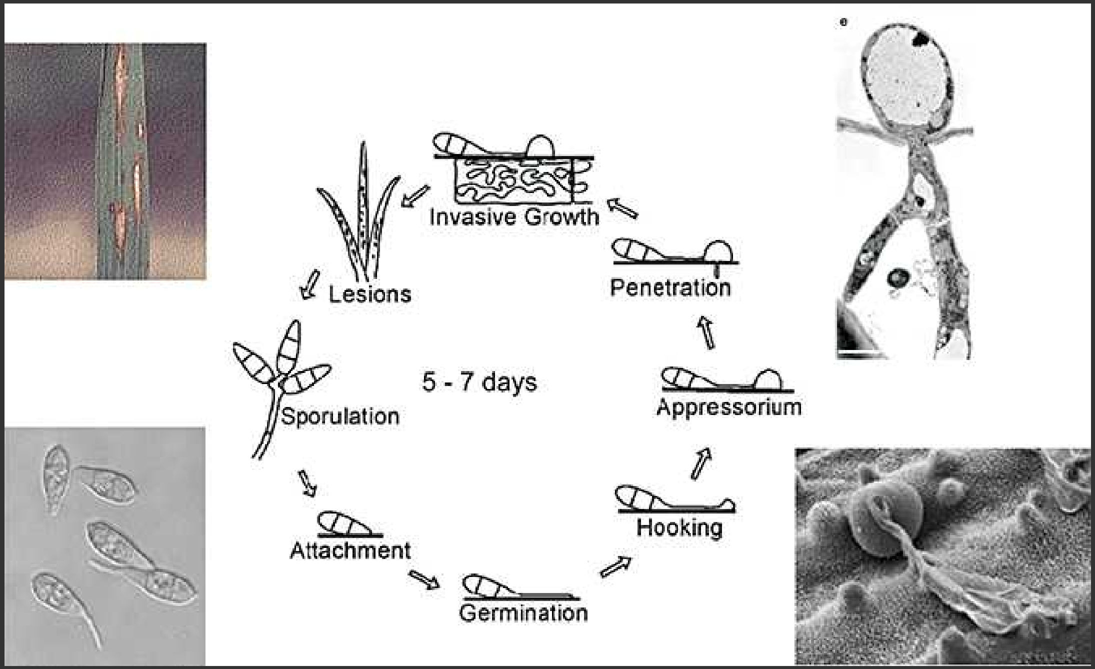
Top 10 most-wanted plant pathogenic fungi

Rank	Fungal pathogen	Author of fungal description
1	*Magnaporthe oryzae*	Ralph Dean
2	*Botrytis cinerea*	Jan A. L. van Kan
3	*Puccinia* spp.	Zacharias A. Pretorius
4	*Fusarium graminearum*	Kim Hammond-Kosack
5	*Fusarium oxysporum*	Antonio Di Pietro
6	*Blumeria graminis*	Pietro Spanu
7	*Mycosphaerella graminicola*	Jason J. Rudd
8	*Colletotrichum* spp.	Marty Dickman
9	*Ustilago maydis*	Regine Kahmann
10	*Melampsora lini*	Jeff Ellis

The table represents the ranked list of fungi as voted for by plant mycologists associated with the journal *Molecular Plant Pathology*.

Magnaporthe oryzae, a filamentous ascomycete fungus, is the causal agent of rice blast disease, the most destructive disease of rice worldwide

Disease resulting from the infection of rice and wheat with Magnaporthe oryzae. (A) Classical symptoms of panicle blast on rice, although the fungus can cause disease on all foliar tissues. (B) Head blast on wheat.



Botrytis cinerea, known as grey mould, can infect more than 200 plant species. The fungus is considered as a typical necrotroph, which co-opts programmed cell death pathways in the host to achieve infection

Anamorph

Teliomorph

Altogether, global expenses of Botrytis control (cultural measures, botryticides, broad-spectrum fungicides, biocontrol) easily surmount €1 billion a year.

Puccinia spp. Three rust diseases occur on wheat, namely stem (black) rust (caused by *Puccinia graminis f. sp. tritici*), stripe rust (*P. striiformis f. sp. tritici*), and leaf rust (*P. triticina*)

P. graminis

P. striiformis

Obligate biotrophs (Urediniomycotina) - Aecial host is Barberry (*Berberis vulgaris)*
USA and UK began barberry eradication programs in 1918 - major acheivement in plant disease management!

Plant pathology research is a very rich field with a degree of maturity:

- mechanistic hypotheses about how fungi enter and subvert plant denfeses
- molecular pathways for plant responses to disease
- evolutionary theories for co-evolved "zig-zag" responses

Small taste from a Plant Path. textbook table of contents...

It's a goal-oriented, applied field of biology. Lots of work goes into finding ways to control disease (disease triangle).

Foliar microbiome transplants confer disease resistance in a critically-endangered plant

Geoffrey Zahn[1] and Anthony S. Amend[2]

[1] Biology Department, Utah Valley University, Orem, UT, United States of America
[2] Botany Department, University of Hawaii at Manoa, Honolulu, HI, United States of America

<- One of my main research areas.

(manipulating microbiome to prevent disease)

Assignments

1. Read Roy, 1993
- This is a look at flower mimicry in plant pathogenic fungi

2. You will have a Canvas quiz on the assigned reading and will also have to participate in a Slack discussion about it.

3. Keep working on your lab assignments