Characterization of Phytophthora infestans populations in North America from the 2009-2011 late blight epidemics

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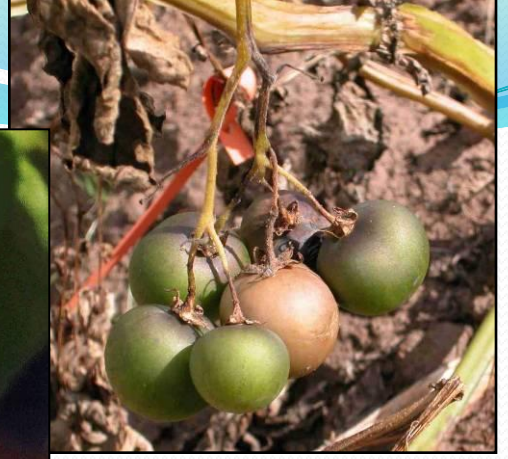
What does blight attack?



Tomato leaf sporulation

Tomato fruit infection

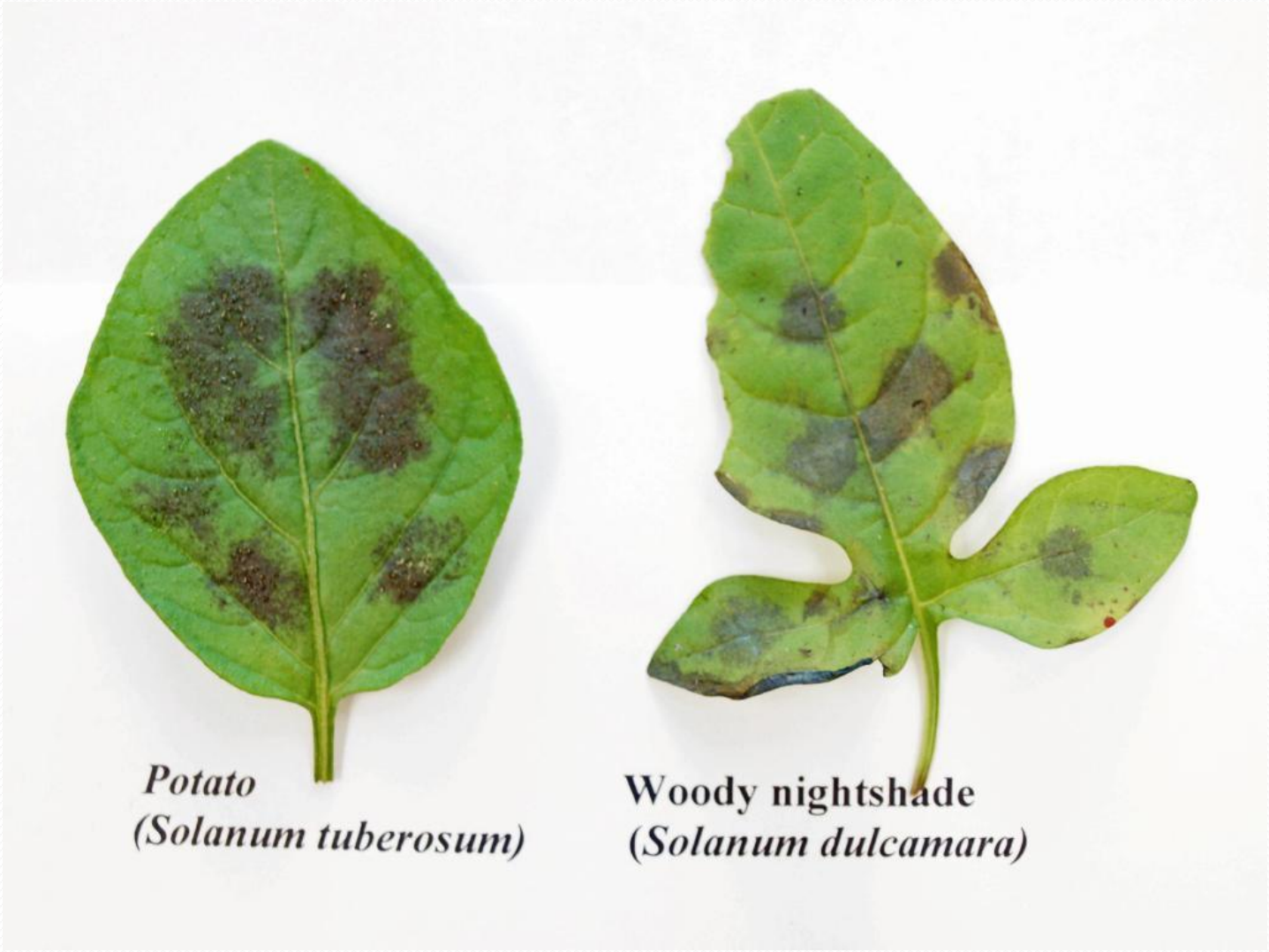
USDA-ARS Beltsville station tomato plants

Infected ripe tomato fruits

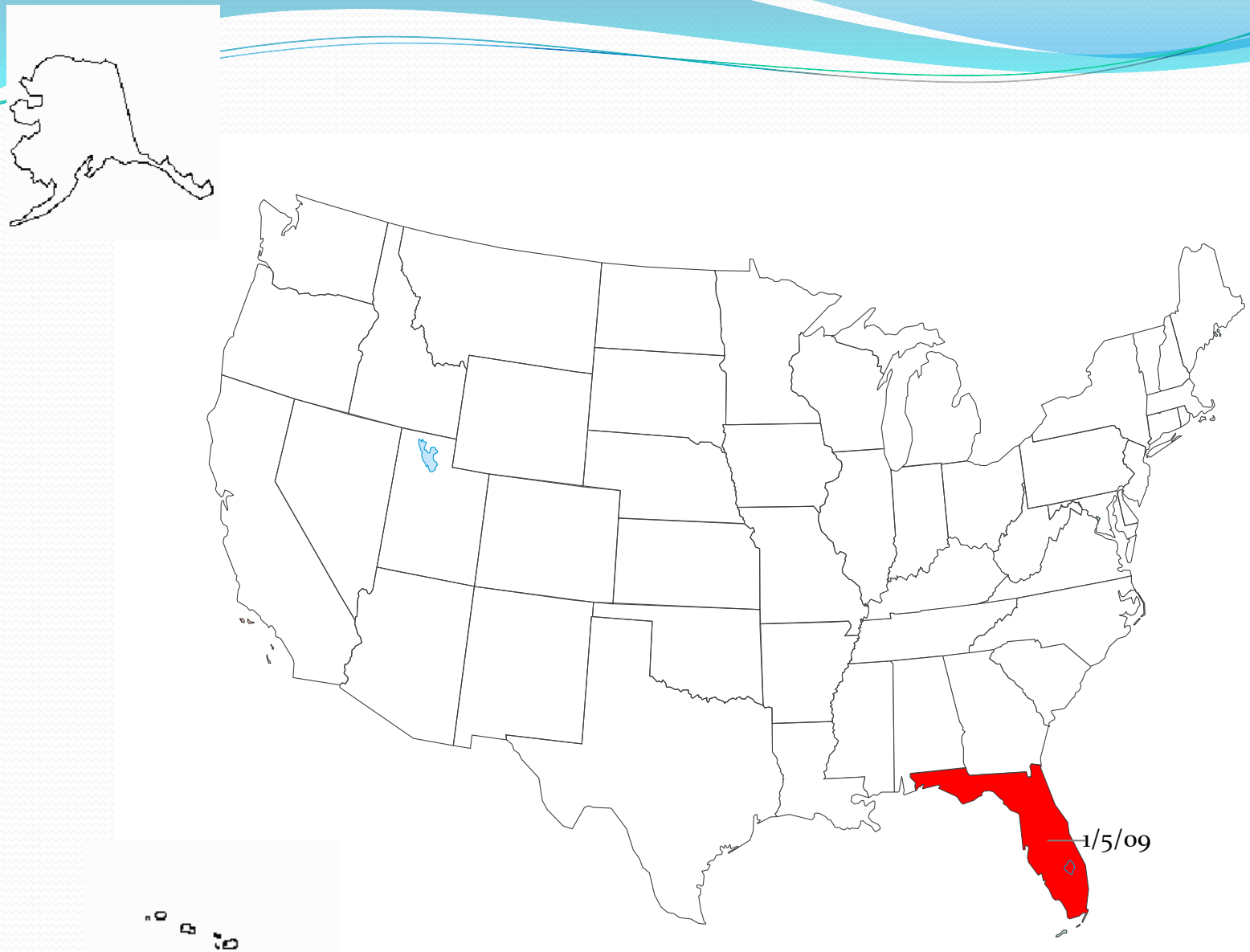
Infection in unripe/green tomato fruits

Late blight in tomato plants and not in potato plants

Woody nightshade


Potato
(Solanum tuberosum)
Woody nightshade
(Solanum dulcamara)

Nightshade berries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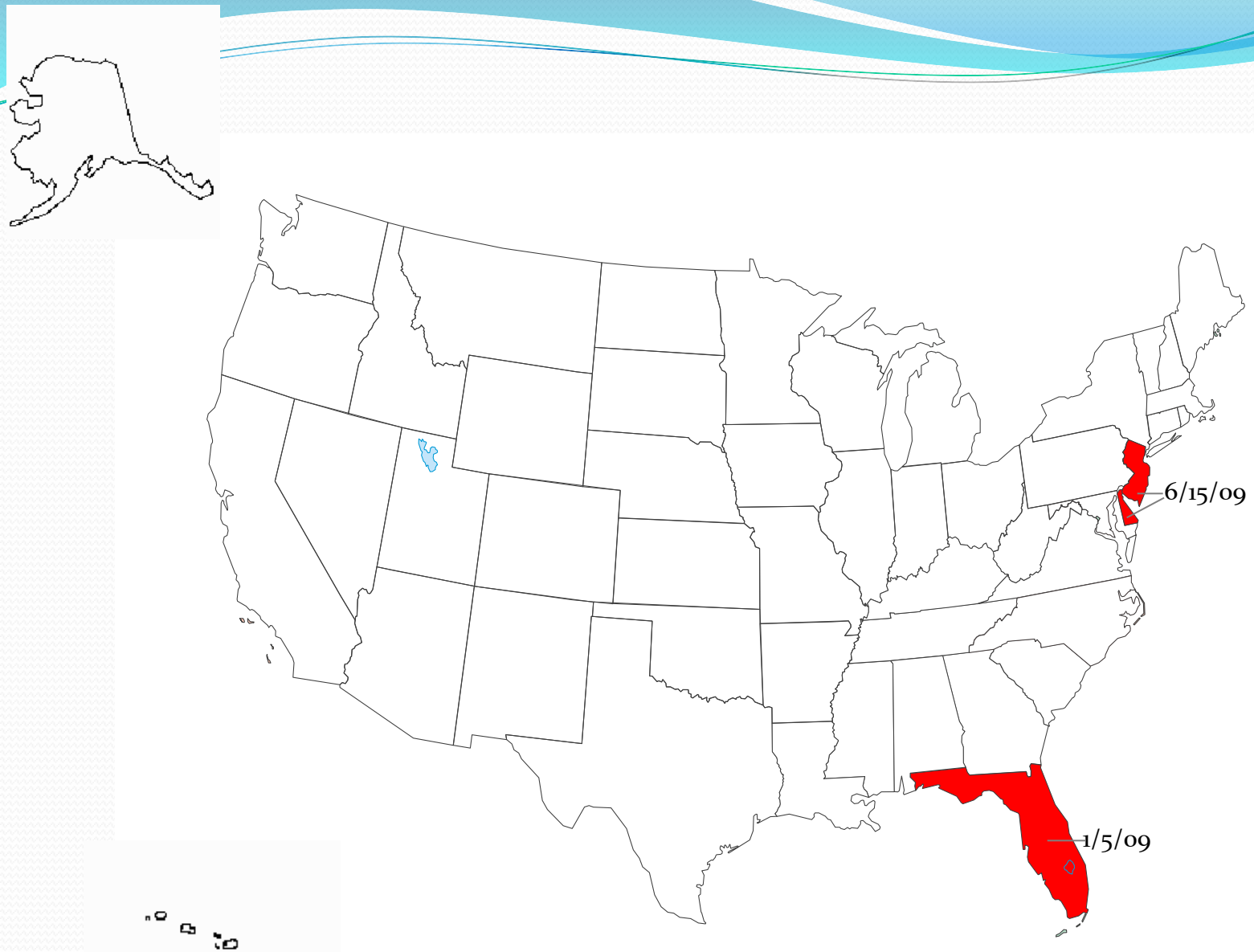
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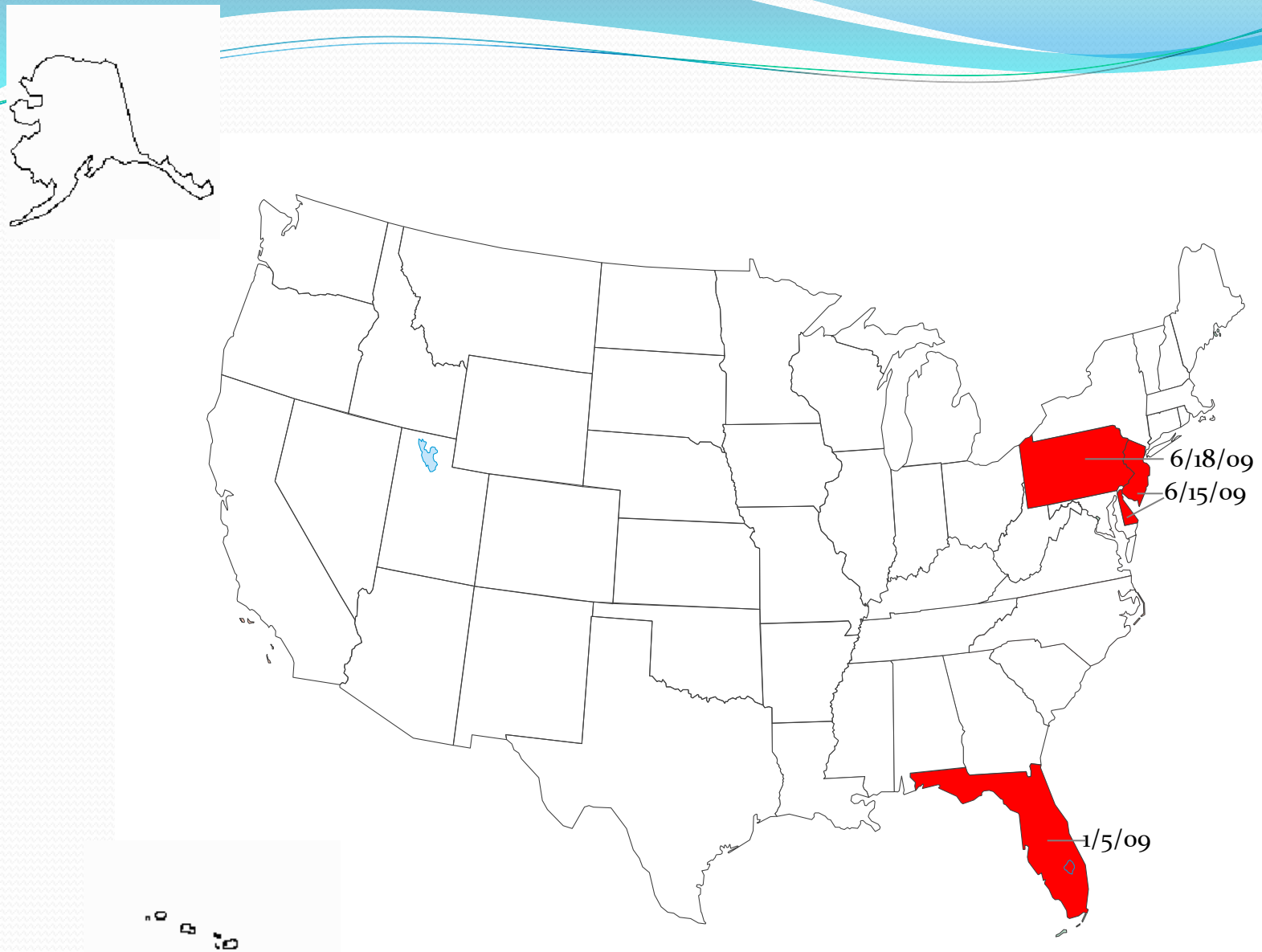
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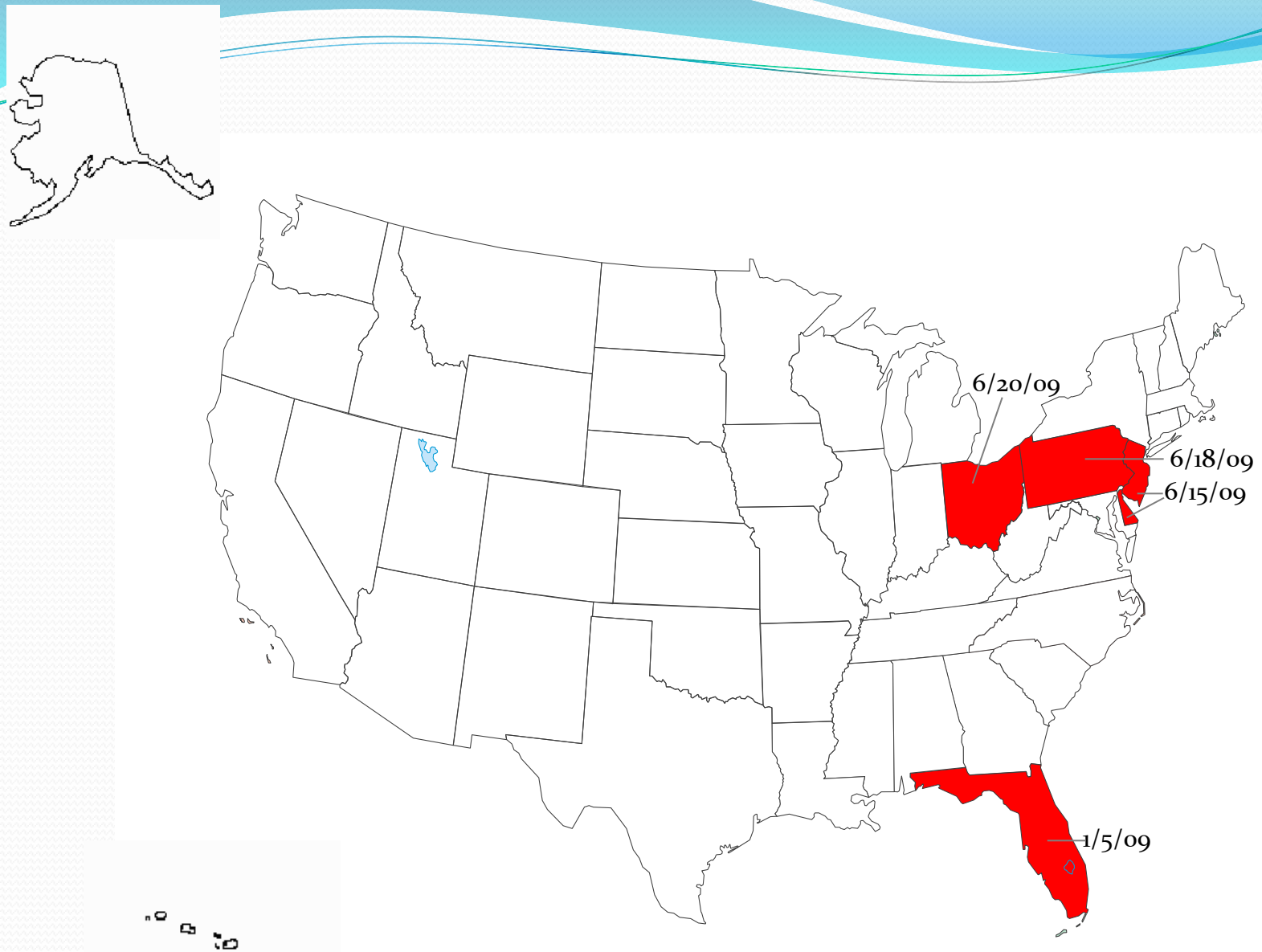
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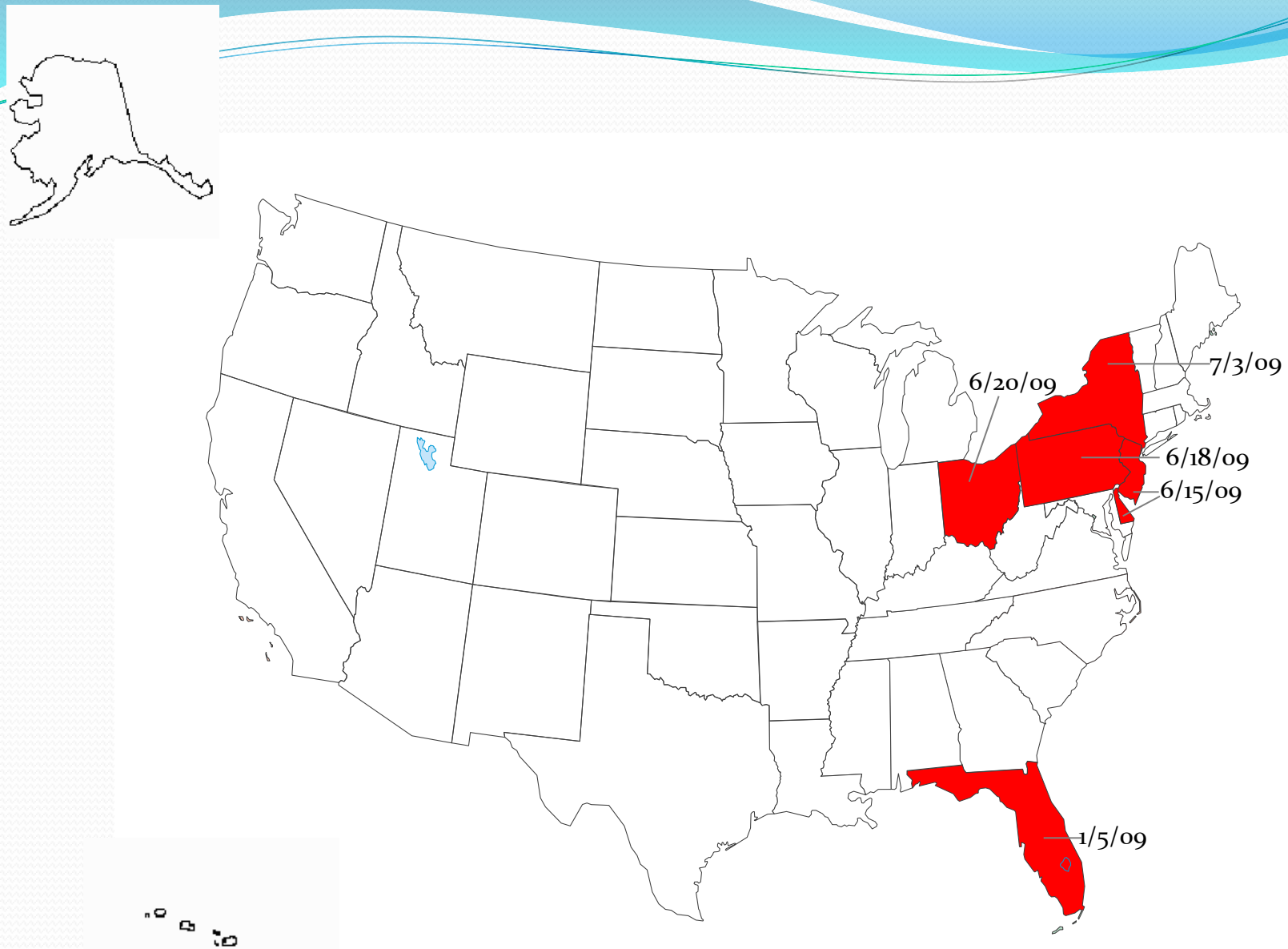
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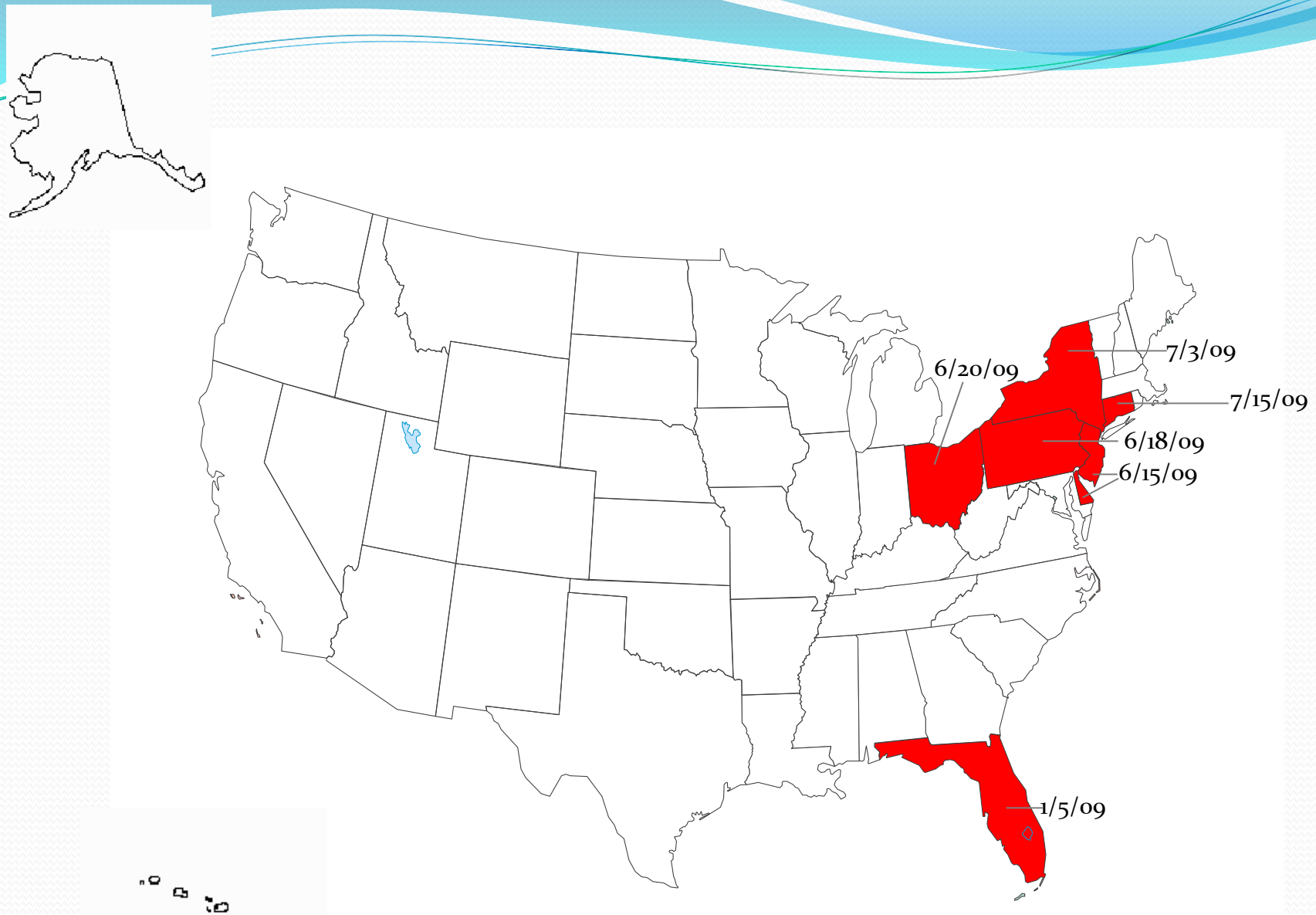
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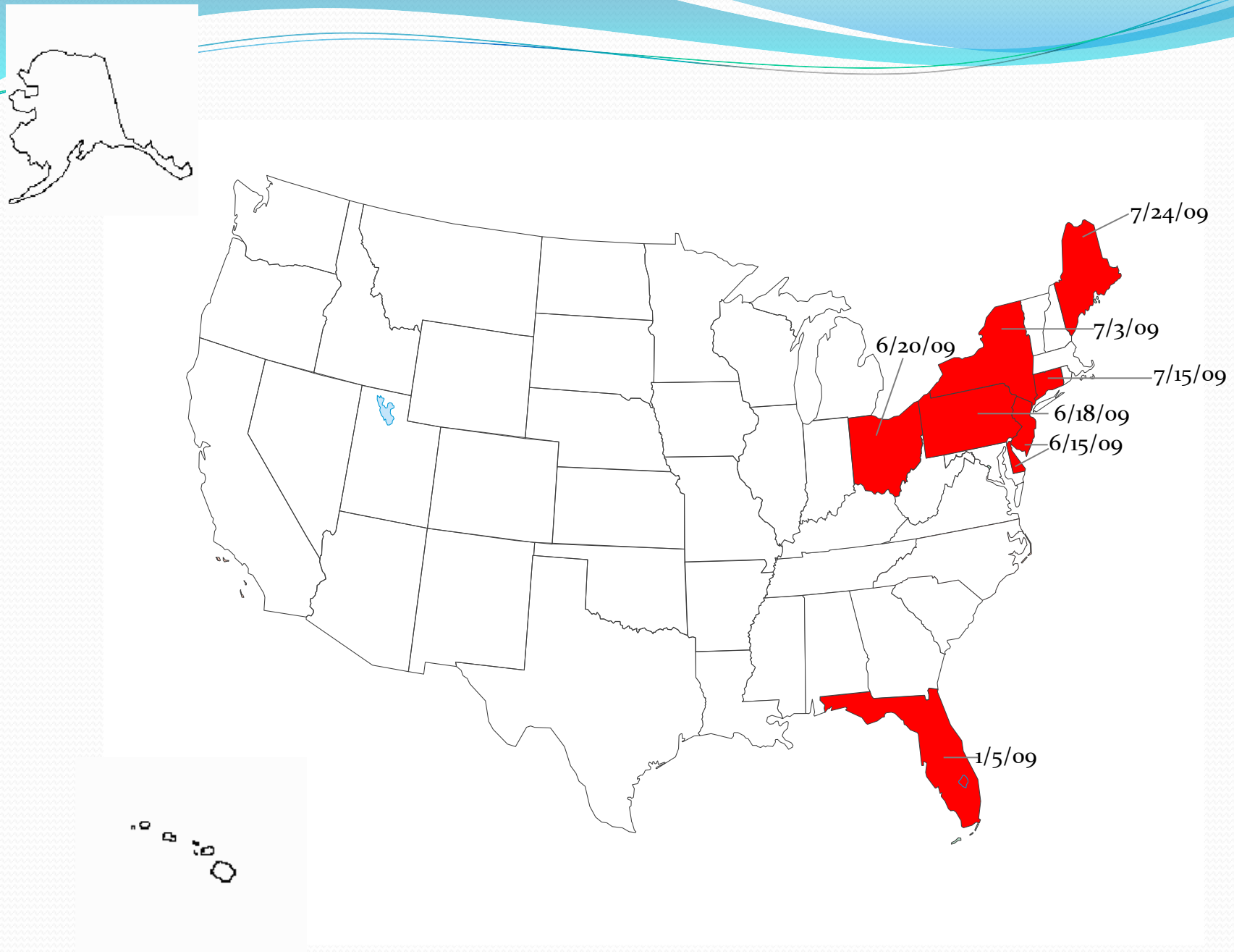
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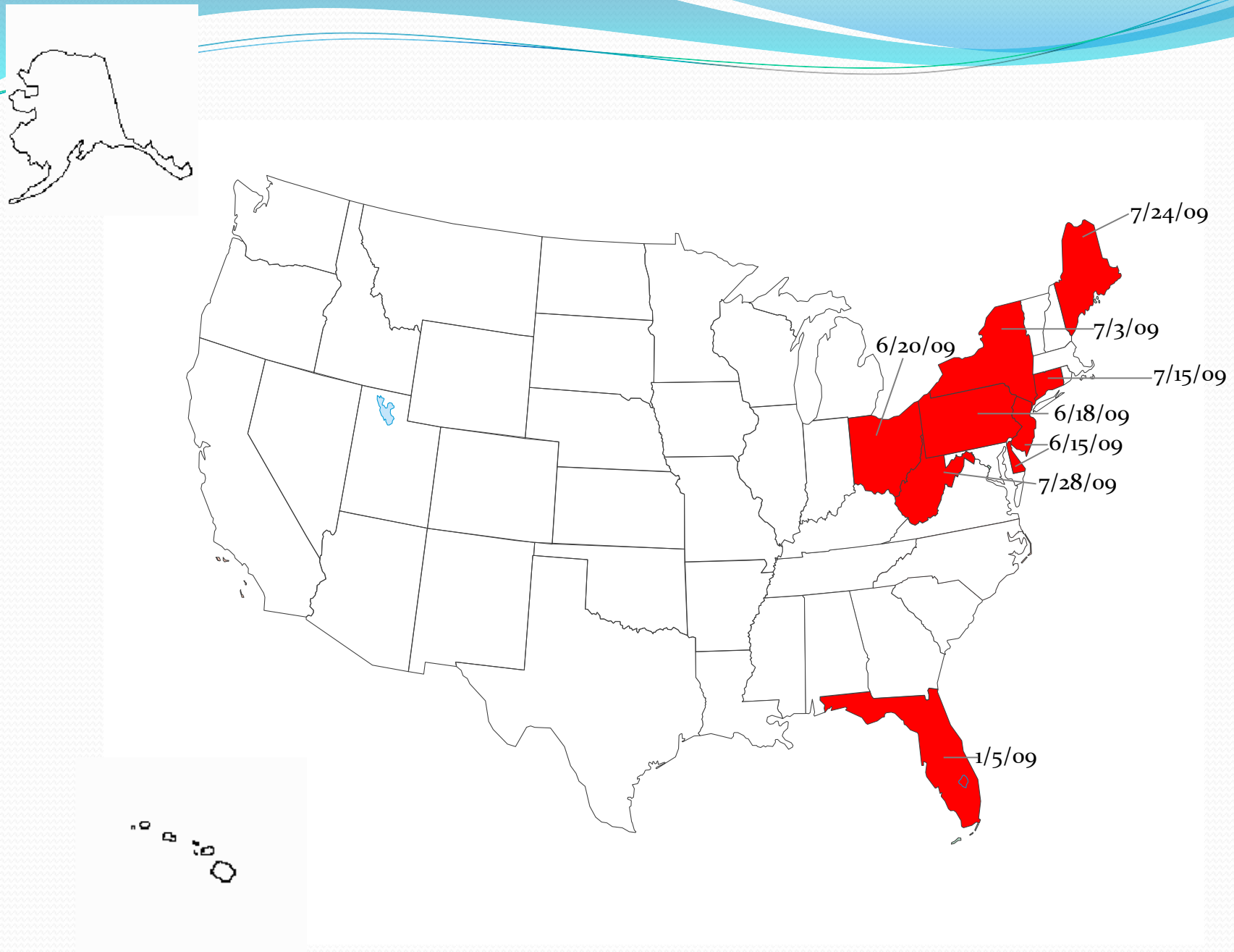
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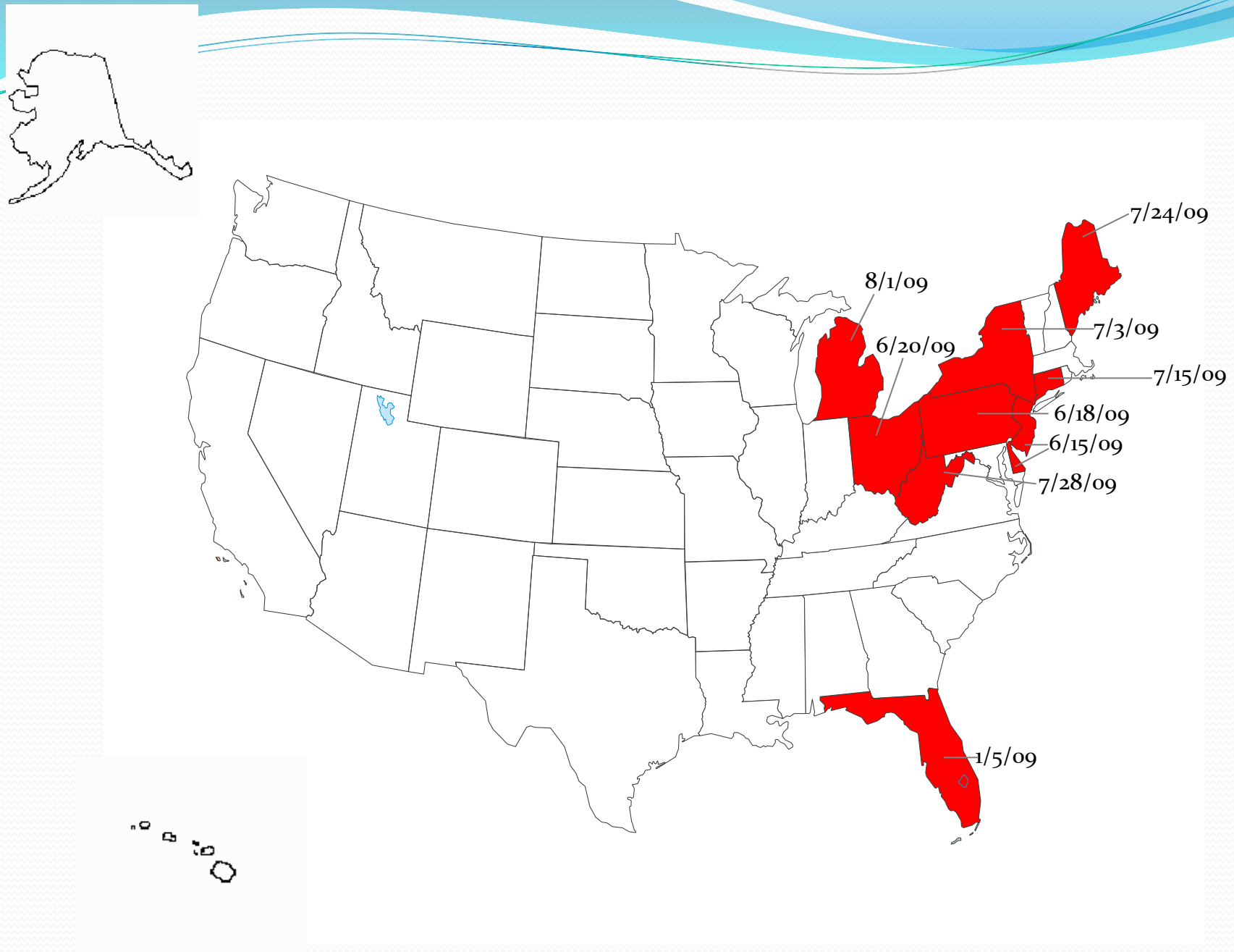
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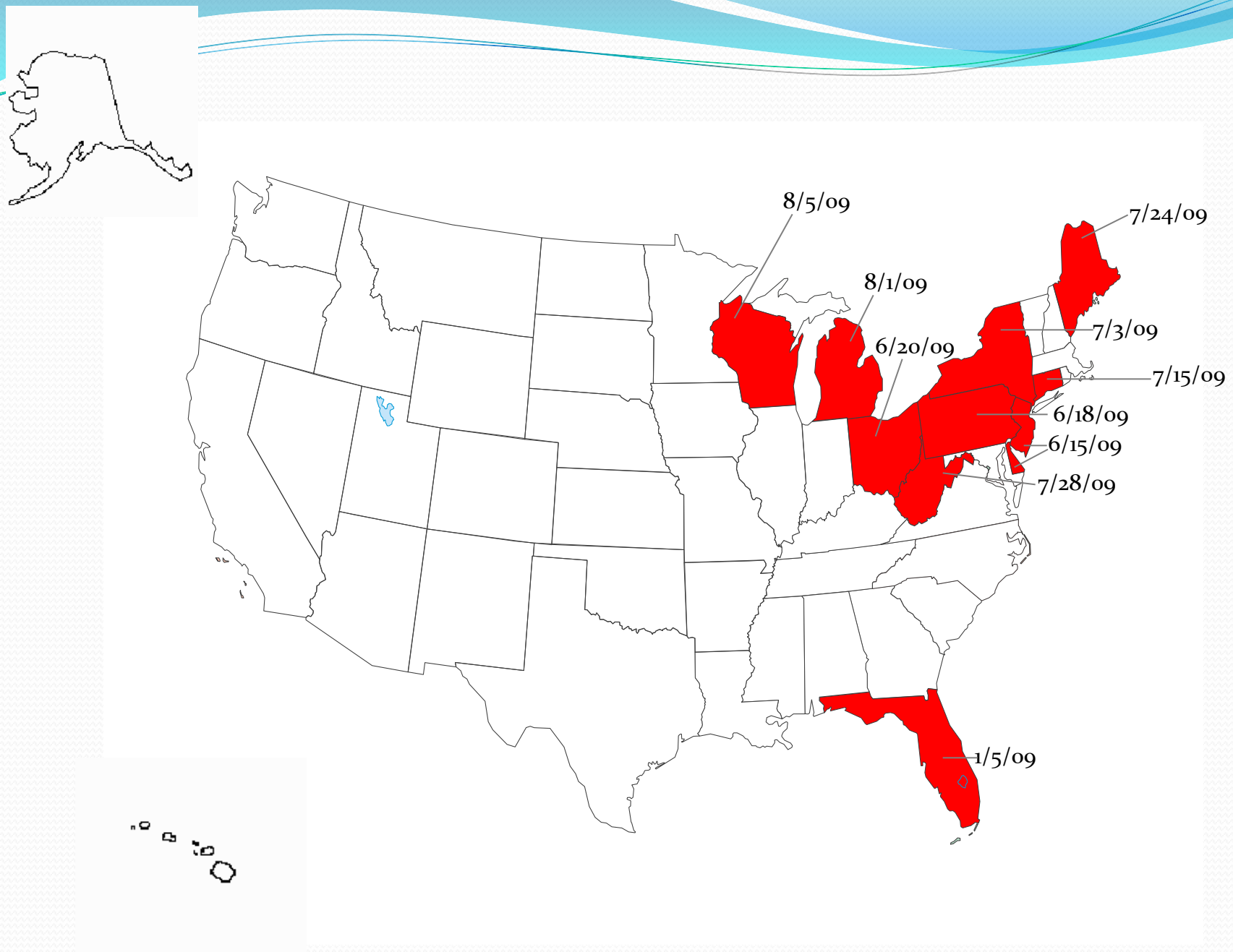
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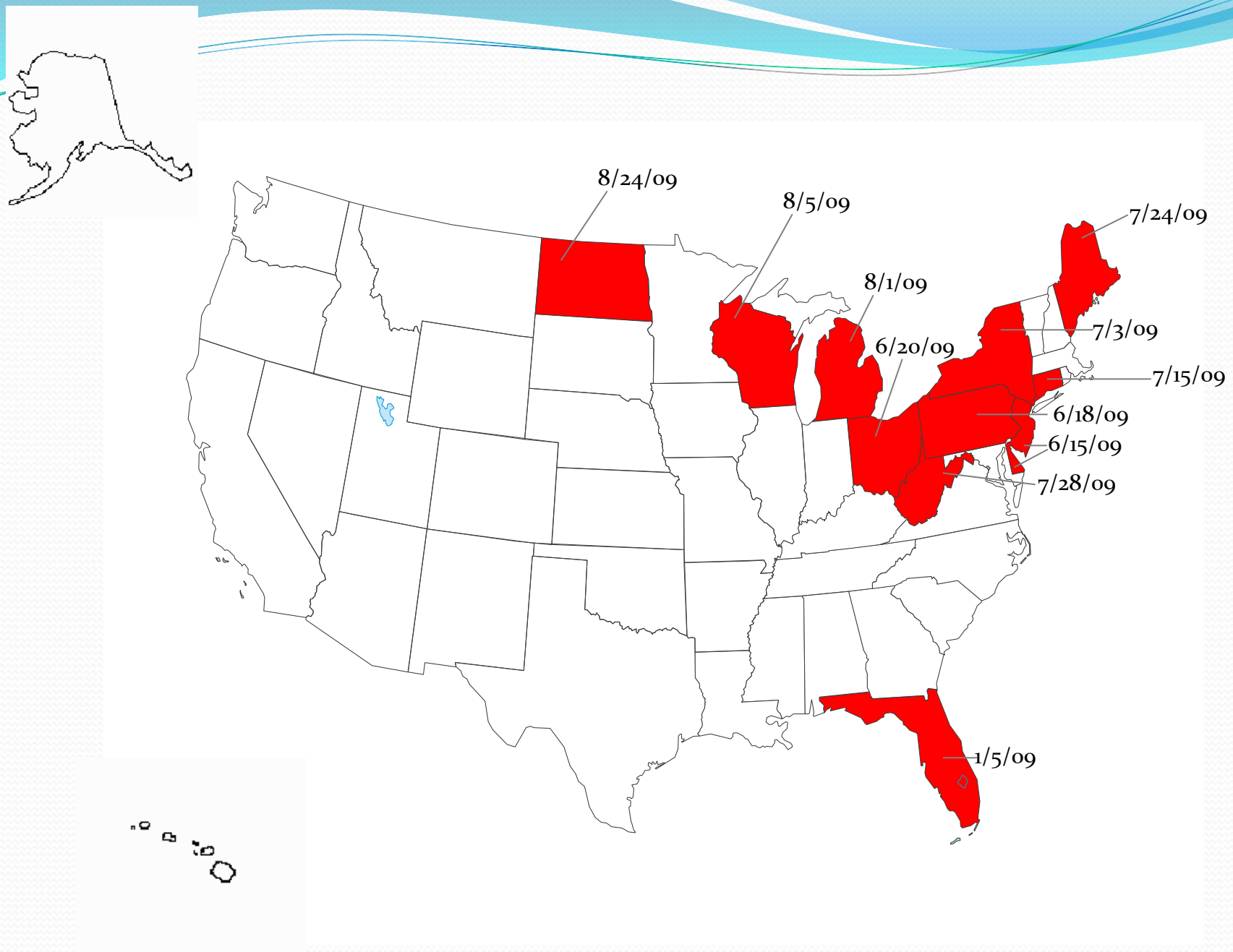
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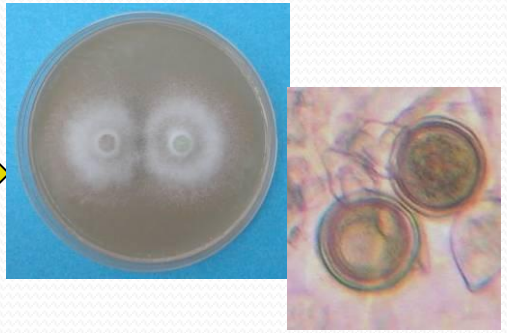
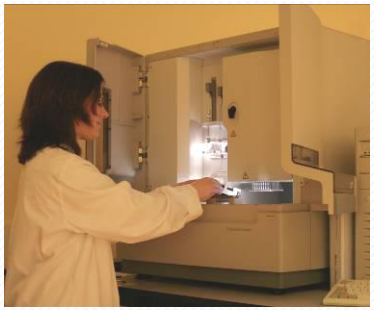
Results to date

Sample Analysis

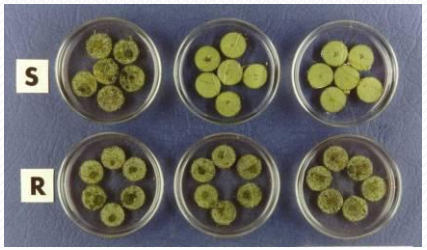
Sample isolation



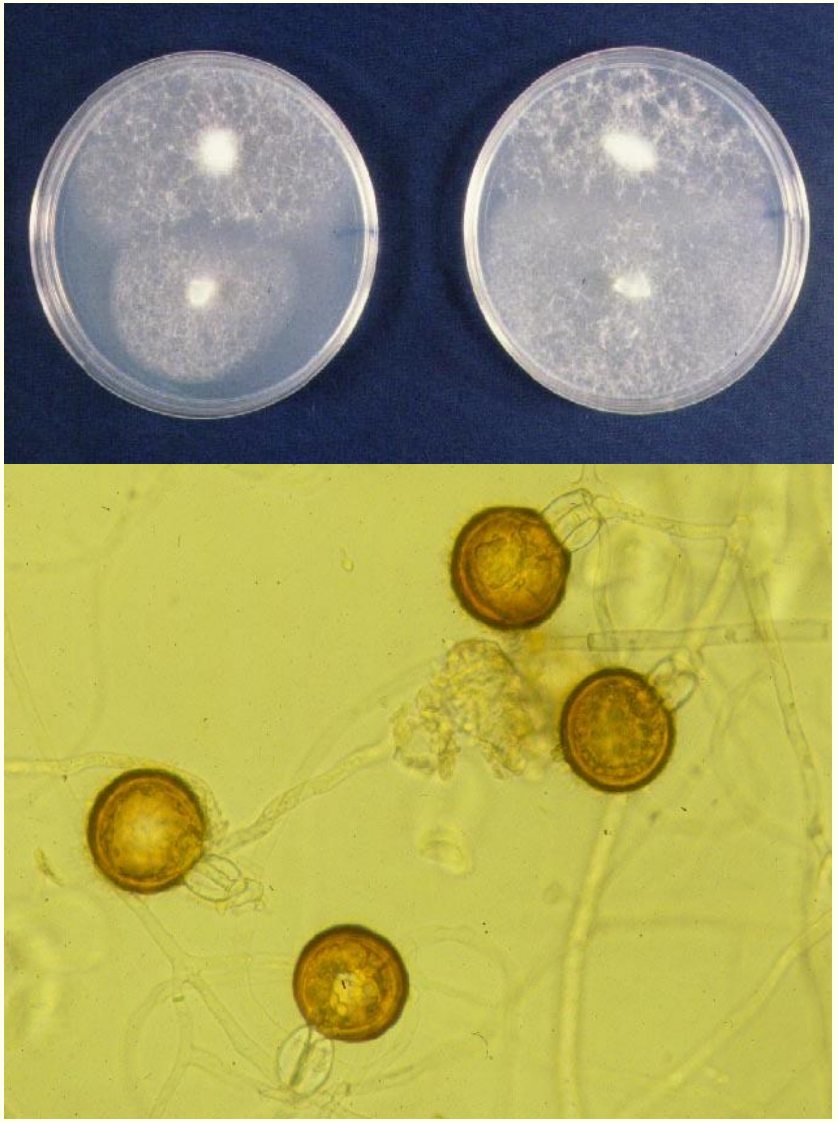
Mating type



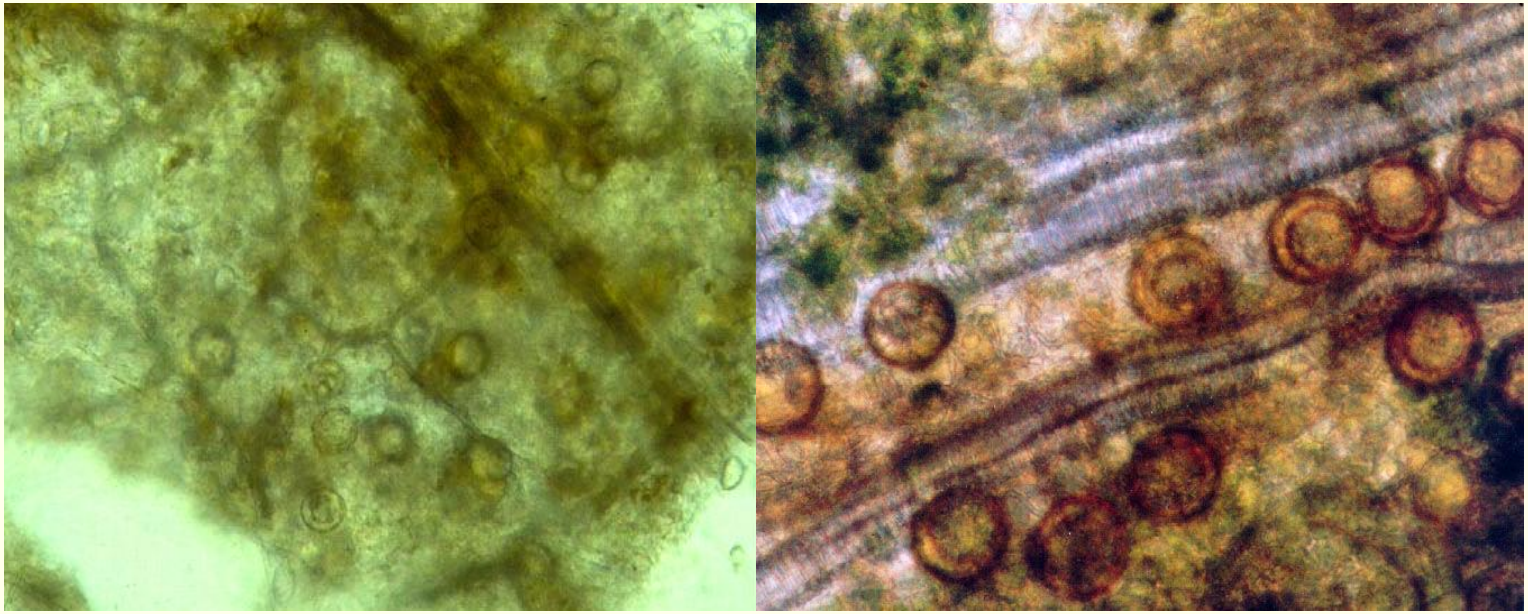
DNA Fingerprinting



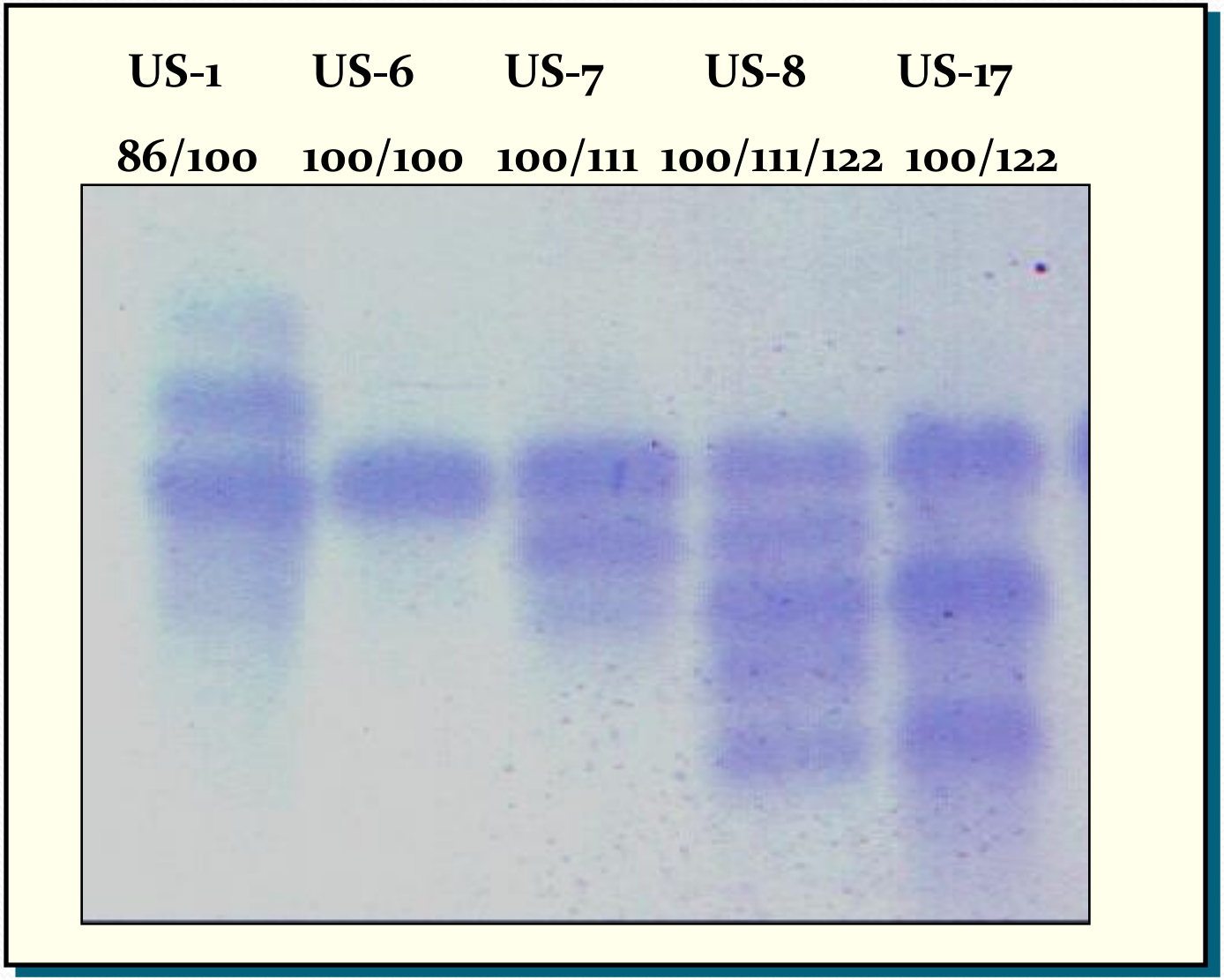
Metalaxyl sensitivity

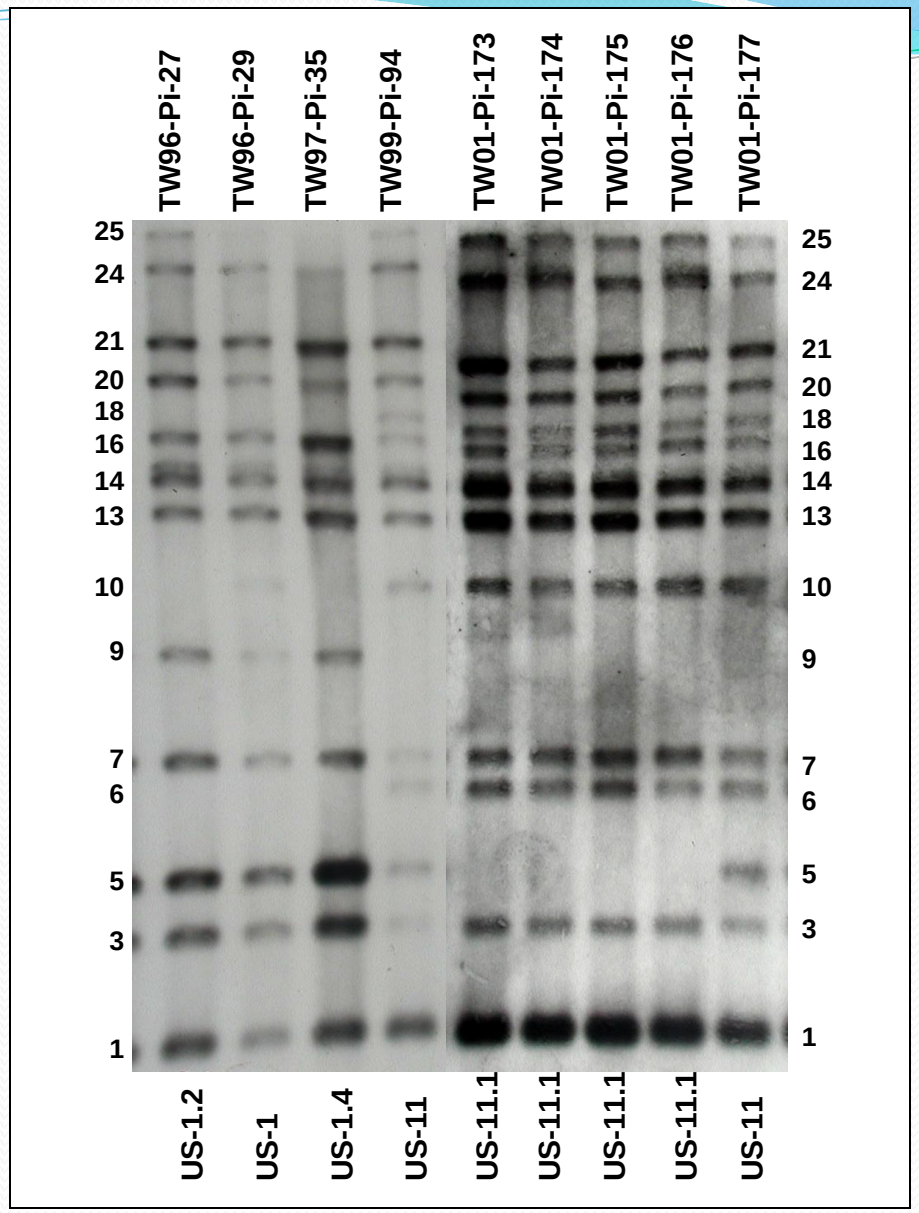


***P. infestans* oospores**

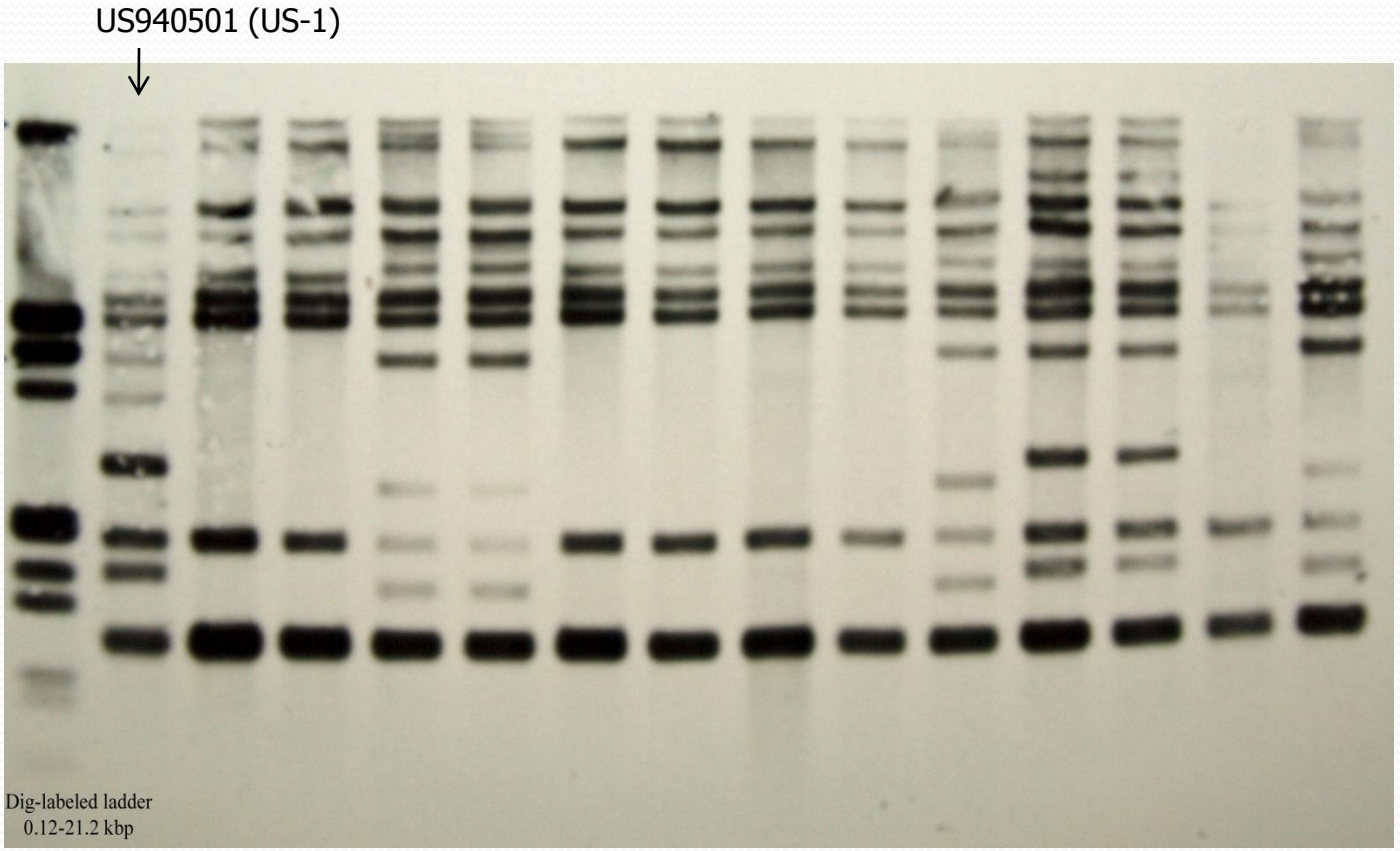


Cellulase acetate electrophoresis (CAE) of US Gpi genotypes of Phytophthora infestans





DNA fingerprinting using RG57 probe



DNA fingerprints of 13 P*. infestans* isolates from the N.E. epidemic collection.

Summary of Isolates from 2009 Epidemic

Host	Mating Type Type	Metalaxyl Sensitivity	Gpi	Pep	Haplo-type	Genotype	RG57 Fingerprint
tomato	A1	MI	100/100	100/100	Ia	??	1,3,5,6,10,13,14,16,20,21,24,25
tomato	A1	MS	100/100	100/100	Ia	??	1,3,5,6,10,13,14,16,20,21,24,25
potato	A1	MI	100/100	100/100	Ia	??	1,3,5,6,10,13,14,16,20,21,24,25
potato	A2	MR	100/111/122	100/100	Ia	US-8	1,5,10,13,14,16,20,21,23,24,25
potato	A2	MR	100/111/122	100/100	Ia	US-8	1,5,10,13,14,16,20,21,23,24,25
tomato	A1	MI	100/100	100/100	Ia	??	1,3,5,6,10,13,14,16,20,21,24,25
potato	A1	MI	100/100	100/100	Ia	??	1,3,5,6,10,13,14,16,20,21,24,25
potato	A2	MI	100/122	100/100	Ia	??	1,5,13,14,16,20,21,24,25
potato	A2	MS	100/122	100/100	Ia	??	1,5,13,14,16,20,21,24,25
std	A2	MR	100/122	100/100	Ia	US-14	1,5,10,13,14,16,20,21,23,24,25
std	A1	MR	100/122	100/100	Ia	US-17	1,3,7,13,14,16,18,20,21,24,25

?? = unknown

Deahl KL, Jones RW, Perez FG, Shaw DS & Cooke LR. 2006. Characterization of isolates of *Phytophthora infestans* from four solanaceous hosts growing in association with late-blighted potatoes. Hortscience 41(7):1-6.

TABLE 2-- *Evaluation of the mitochondrial DNA (mtDNA) haplotype, mating type, metalaxyl resistance, allozymes of glucose-6-phosphate isomerase and peptidase, and DNA fingerprint with the RG57 probe of isolates of Phytophthora infestans, collected from potatoes and weed hosts in four USA locations and one UK location.*

Host	MtDNA haplotype	Allozyme genotype		Metalaxyl sensitivity[2]	Mating Type	Genotype	RG57 fingerprint
		Gpi	*Pep*				
Black nightshade	IIa	*100/100*	*100/100*	S	A1	n/a	1,5,9,10,13,14,16,20,21,24,25
Potato[1]	IIa	*100/100*	*100/100*	S	A1	n/a	1,5,9,10,13,14,16,20,21,24,25
Petunia	Ia	*100/111/122*	*100/100*	R	A2	US-8	1,5,10,13,14,16,20,21,23,24,25
Potato[1]	Ia	*100/111/122*	*100/100*	R	A2	US-8	1,5,10,13,14,15,20,21,23,24,25
Hairy nightshade	Ia	*100/111/122*	*100/100*	R	A2	US-8	1,5,10,13,14,15,20,21,23,24,25
Potato[1]	Ia	*100/111/122*	*100/100*	I/R	A2	US-8	1,5,10,13,14,15,20,21,23,24,25
Tomato	Ia	*122/122*	*100/100*	R	A2	n/d	1,3,5,7,10,13,14,18,20,21,24,25
Potato[1]	Ia	*100/111/122*	*100/100*	R	A2	US-8	1,5,10,13,14,16,20,21,23,24,25
Tomato	Ia	*100/122*	*100/100*	S	A2	n/d	1,5,13,14,18,20,21,24,25
Potato[1]	Ia	*100/111/122*	*100/100*	R	A2	US-8	1,5,10,14,16,20,21,23,24,25

[1] Late blighted potato hosts that were located in bordering, neighboring or close-by plantings

Schultz, D., Donahoo, R., Perez, F., Tejeda, S., Roberts, P., and Deahl, K. A Survey of Tomato and Potato Fields in Florida Reveals Unique Genotypes of Phytophthora infestans between 2005 and 2007.2010. HortScience 45:1064-1068

4 genotypes of *P infestans*, 2009 from different sources -

Table 1. Summary of genotypes of *Phytophthora infestans* collected in the US and Canada, 2002-2009.

Genotype[a]	Host	Mating Type	Allozyme genotype[b]		Sensitivity to metalaxyl[c]	mtDNA haplotype[d]	RG57 RFLP[a]	Year(s)	State
			Gpi	Pep					
US-8[e,f]	Potato	A2	100-111-122	100/100	R/I	Ia	1,4,5,10,13,14,16,20,21,23,24,25	2009	NC, VA, PA, NY, ME
US-20	Tomato	A2	100/100	100/100	R/I	Ia	1,3,5,7,10,13,14,16,18,20,21,24,25	2002-2007	FL, NC
US-21	Tomato	A2	100/122	100/100	R/I/S	Ia	1,5,10,13,14,18,20,21,24,25	2006-2007	FL, NC
US-22[f]	Potato & Tomato	A2	100/122	100/100	S/I	Ia	1,5,13,14,16,20,21,24,25	2007-2008	TN, NY, FL
								2009	12 states & Canada
US-23	Potato & Tomato	A1	100/100	100/100	S/I	Ia	1,2,5,6,10,13,14,17,20,21,24,24a,25	2009	MD, VA, DE*, PA
US-24	Potato	A1	100/100/111	100/100	I	Ia	1,3,5,7,10,13,14,16,20,21,23,24,25	2009	ND*

[a]DNA fingerprinting by RFLP (Goodwin et al. 1992) and genotype name assigned.
[b]Allozyme genotyping (Goodwin et al. 1995).
[c]R = metalaxyl resistant, I= intermediate, S=sensitive.
[d]mtDNA haplotype (Griffith and Shaw 1998).
[e]US-8 has been found on potato since 1990's.
*Only one genotype was found in the state.
[f]The SSR alleles for the US-8 genotype are: 163/165, 176/179, 213/226, 155/155, 166/170, 190/190, 257/257, 280/280, 106/110,173/177, 202/202 and for the US-22 genotype were: 163/165, 176/179, 213/213, 131/155, 166/170, 190/193, 257/257,280/280, -/-, 177/177, 202/205 for the Pi02, Pi89, Pi4B, PiG11, Pi04, Pi70, Pi56, Pi63, D13, Pi16 and Pi33 loci, respectively (Lees et al. 2006)

- US- 8 - Potato tubers NC, VA, PA, NY, ME
- US-21 infects tomato and not potato
- US-22 –Present in 2007, 2008 . Move from tomato to potato
- US-23 – MD, VA, DE into PA - DELMARVA
- US-24 – ND
- Note US-23 and US-24 are A1 mating type – rest A2

US-22 spread on tomato transplants

- 61% of isolates genotyped were US-22
- Occurred on potato and tomato
- 12 states - FL, NC,TN, MD, VA, NJ, PA, NY, ME, WVA, IN, WI,
- A2 mating type
- Ia mtDNA Haplotype
- Mostly sensitive to mefenoxam (few isolates intermediate)
- Allozyme genotype *Gpi* 100/122, *Pep* 100/100
- RFLP genotype 1,4,5,13,14,16,20,21,24,25
- The SSR alleles for the US-22 genotype were: 163/165, 176/179, 213/213, 131/155, 166/170, 190/193, 257/257,280/280, -/-, 177/177, 202/205 for the Pi02, Pi89, Pi4B, PiG11, Pi04, Pi70, Pi56, Pi63, D13, Pi16 and Pi33 loci, respectively.

Genotype	Host	Mating type	Allozyme genotype		Sensitivity to mefenoxam	RG57 RFLP
			Gpi	Pep		
US-8	Potato	A2	100/111/122	100/100	R/I	1,5,10,13,14,16,20,21,23,24,25
		2010 ISOLATES				
US-21	Tomato	A2	100/122	100/100	R/I/S	1,5,10,13,14,18,20,21,24,25
US-22	Tom/Potato	A2	100/122	100/100	S/I	1,5,13,14,16,20,21,24,25
US-23	Tom/Potato	A1	100/100	100/100	S/I	1,2,5,6,10,13,14,17,20,21,24,24a,25
US-24	Tom/Potato	A1	100/100/111	100/100	I	1,3,5,7,10,13,14,16,20,21,23,24,25
		2011 ISOLATES				
US-22	Tom/Potato	A2	100/122	100/100	S/I	1,5,13,14,16,20,21,24,25
US-8	Potato	A2	100/111/122	100/100	R/I	1,5,10,13,14,16,20,21,23,24,25
US-23	Tom/Potato	A1	100/100	100/100	S/I	1,2,5,6,10,13,14,17,20,21,24,24a,25
US-24	Tom/Potato	A1	100/100/111	100/100	I	1,3,5,7,10,13,14,16,20,21,23,24,25