

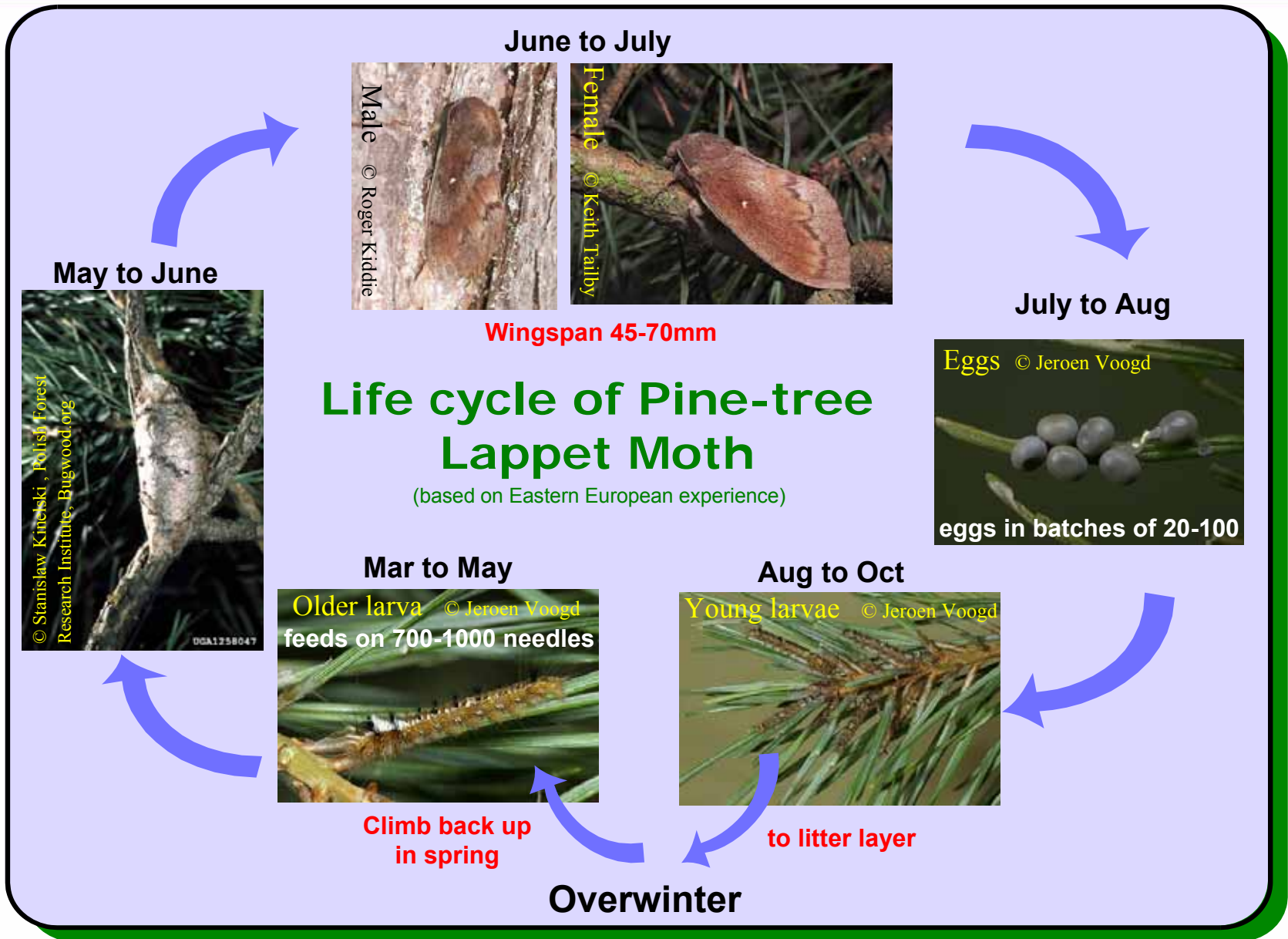
Pine-tree Lappet Moth- a new threat to Scottish Forests ?

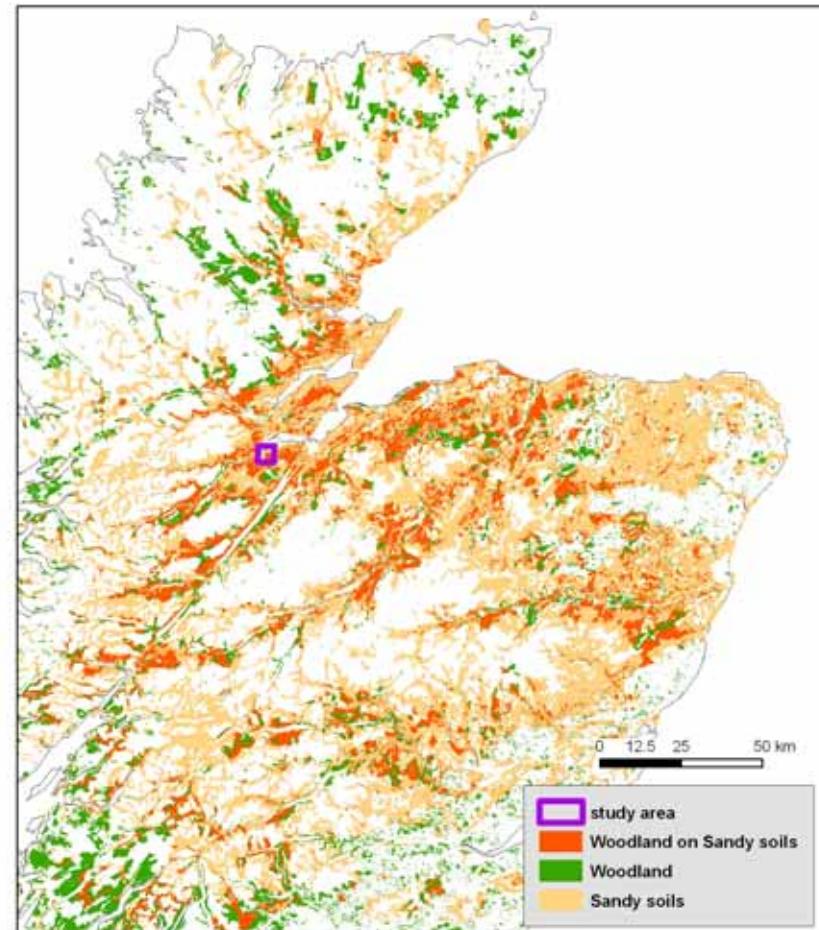
Research Update Seminar,
NRS - 17th Mar 2010

Roger Moore, Dave Tracy (PH), Joan Cottrell,
Stuart A'Hara, Duncan Ray, Michal Petr

Forest Research

Northern Research Station





Map shows all woodland on:- freely draining podzols, sands, ironpans & podzolic brown earths

- One of most serious defoliators of pine forest in Europe- causes severe/ total defoliation & tree death (not native to British Isles)
- Feeds predominantly on Scots pine (also other *Pinus* and other conifer species)
- European work suggests PtLM prefers/ outbreaks on trees on:-
 - sandy freely draining soils
 - (warm summers)
 - (cold dry winters)

- Outbreaks can cover 000's ha of pine forests **esp. in Poland & Germany**
- 170,000ha damaged in N Germany (1782-92 & 1869-72)
- 83,700ha damaged in NE Germany (1993-96)

Pine-tree lappet moth outbreaks in Poland, 1791-1996

Source: Sierpiska 1988

Years	Region of Occurrence	Outbreak Duration	Between Outbreaks
1791-92	West Pomerania	2	
1863-72	From Saxony to Masuria	10	69
1905-09	Zagan Forest	5	31
1925-27	Pomerania and Mazovia	3	15
1936-37	Kurp Forest, Tuchola Coniferous Forest and Poznan province	2	9
1946-52	West Pomerania, Zagan Forest, Kurp Forest and White Forest	7	8
1956-57	Poznan and Tarnow provinces	2	3
1964-75	From Notec Forest to Augustow Forest and Solska Forest	12	6
1982-85	Pomerania and Zielona Gora province	4	6
1992-96	Zielona Gora prov, Tuchola Forest, White Forest & Green Forest	5	6

- Between 1946-95, 233,000ha of Polish forests required **direct control** to reduce damage
- Genus *Dendrolimus* (c 30 spp).....*many others v. damaging*

British Records (excl. Scotland)

Only rare ♂ migrants captured- south coast & Channel Islands (Jul/Aug)

- Surrey- 1748
- Norfolk- 1809
- Isle of White- 1996
- Essex- 1999 (♀ larva- on pine import)
- Cornwall- 2003
- Kent- 2004
- Guernsey- 1989 to 2004 (5 records)
- Jersey- 2005 to 2008 (3 records)

British Records (Scotland)

- Inverness- 2004
- Kiltarlity- 2007 (2 records)
- Kiltarlity- 2008 (6 records)

FC Outbreak Management Team Pheromone survey

- Kiltarlity- 2008 (3 records)
- Boblainy- 2008 (1 record)

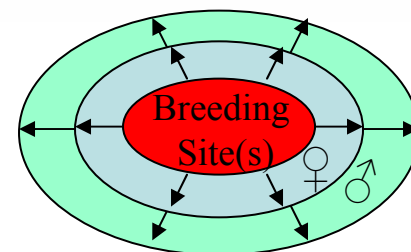


Surveys: to see if PtLM has established

Survey Objectives in 2009

IF PtLM is Established in Scotland it is Important to:-

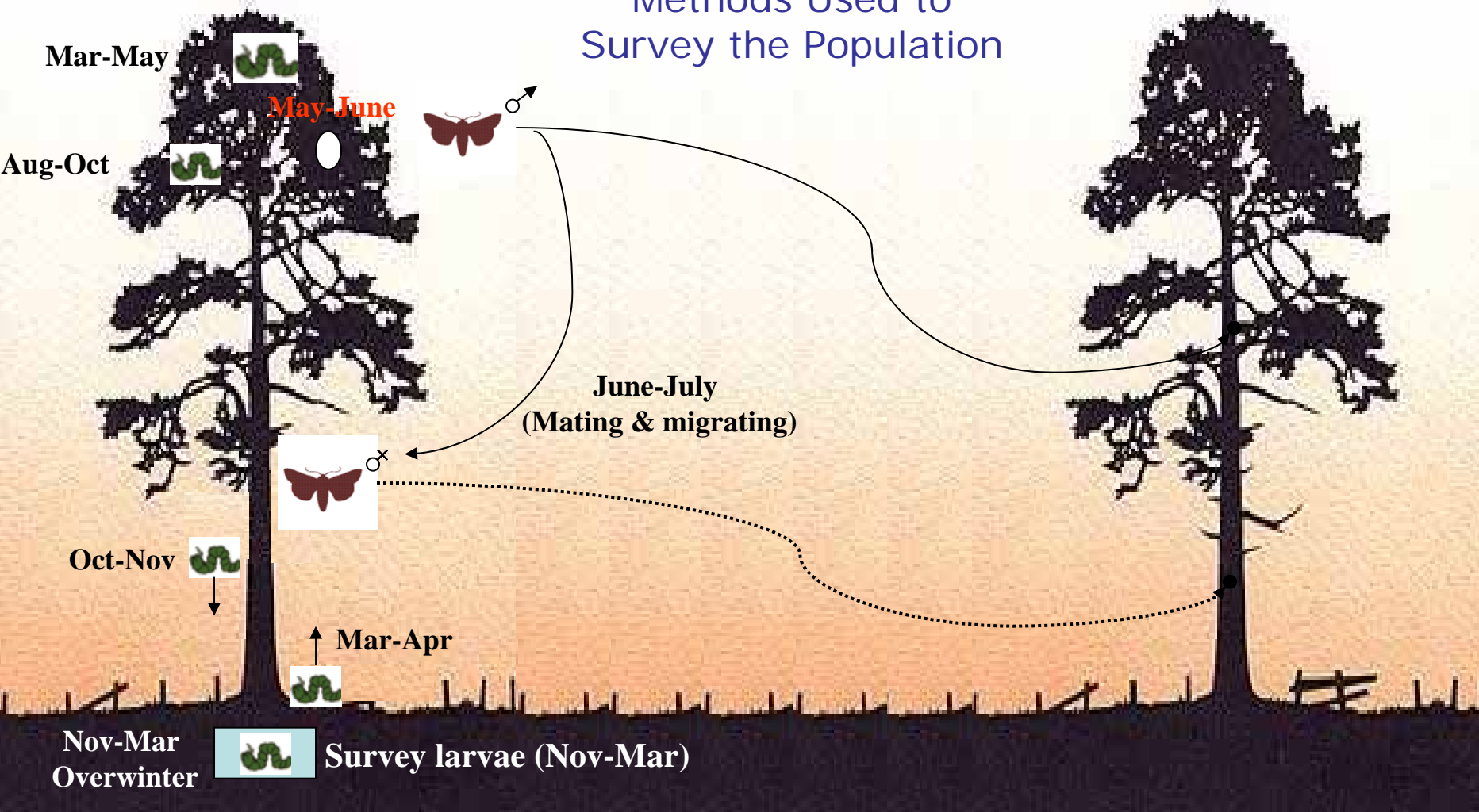
- Locate Breeding Site(s)
(*indicated by immature life stages esp. caterpillars*)
- Determine the Current Extent of PtLM's Distribution
(*moths disperse from breeding sites to **expand** range*)
- Determine if PtLM is Native or Non-native
- Determine if Climate is or will be Suitable for Outbreaks
- Determine PtLM's Potential Rate of Spread



Males disperse further than females- female dictates rate of range expansion

**How will our surveys fit into the
Pine-tree Lappet moths life cycle
& what have we
& what will we be doing?**

Methods Used to Survey the Population

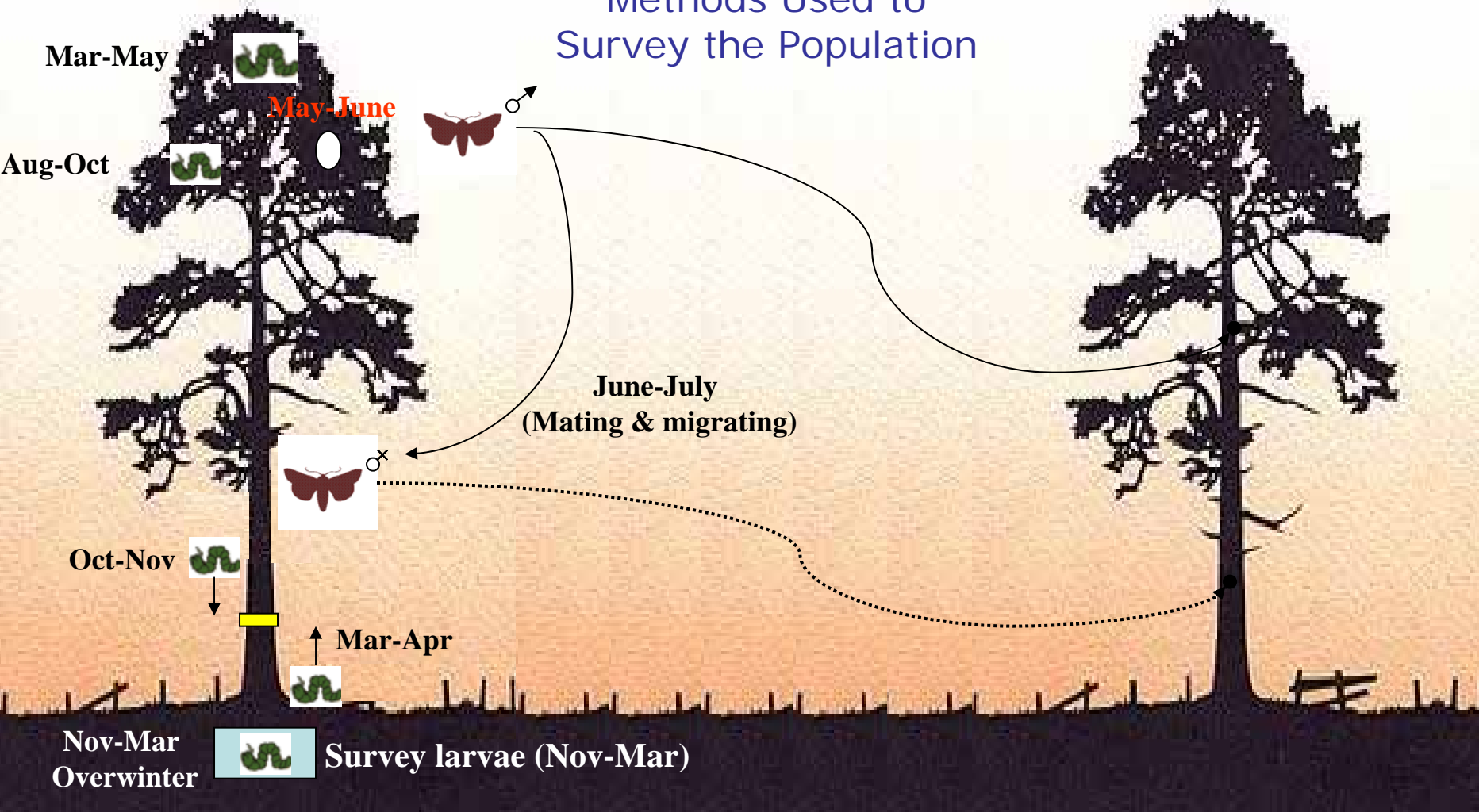


Surveys of 'Inactive' Larvae (Nov '08 - Mar '09)

A preliminary survey in winter '08-09 did NOT locate any over wintering larvae



Methods Used to Survey the Population



Surveys of 'Active' Larvae (Mar-May 2009)

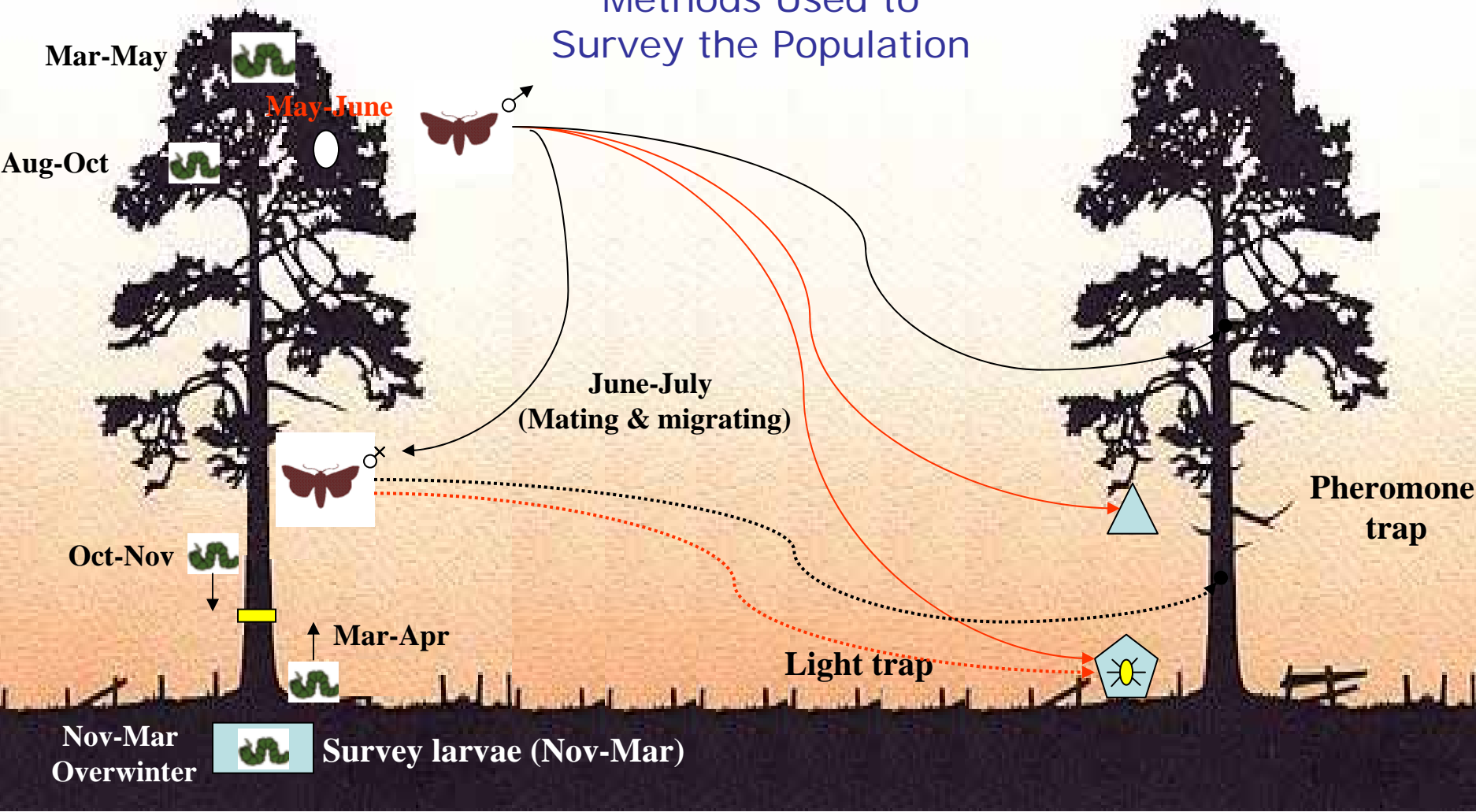
Glue bands to detect larvae moving back *up* into the canopy

1000 glue bands put out at 3 sites where moths previously caught



No caterpillars were found

Methods Used to Survey the Population



Surveys of Adult Moths (late Jun- early Aug 2009)



- An extensive FC pheromone trap network to catch male moths (47 sites & 282 traps)
continuous monitoring- 22 Jun to 7 Aug



- Light traps- put out by amateur entomologists, co-ordinated by FR & Plant Health (8 sites)
2 short monitoring periods- 22 to 26 Jun & 11 Jul

Pheromone Trap Locations

Light Trap Locations

47 sites- up to 50km from suspected area of infestation

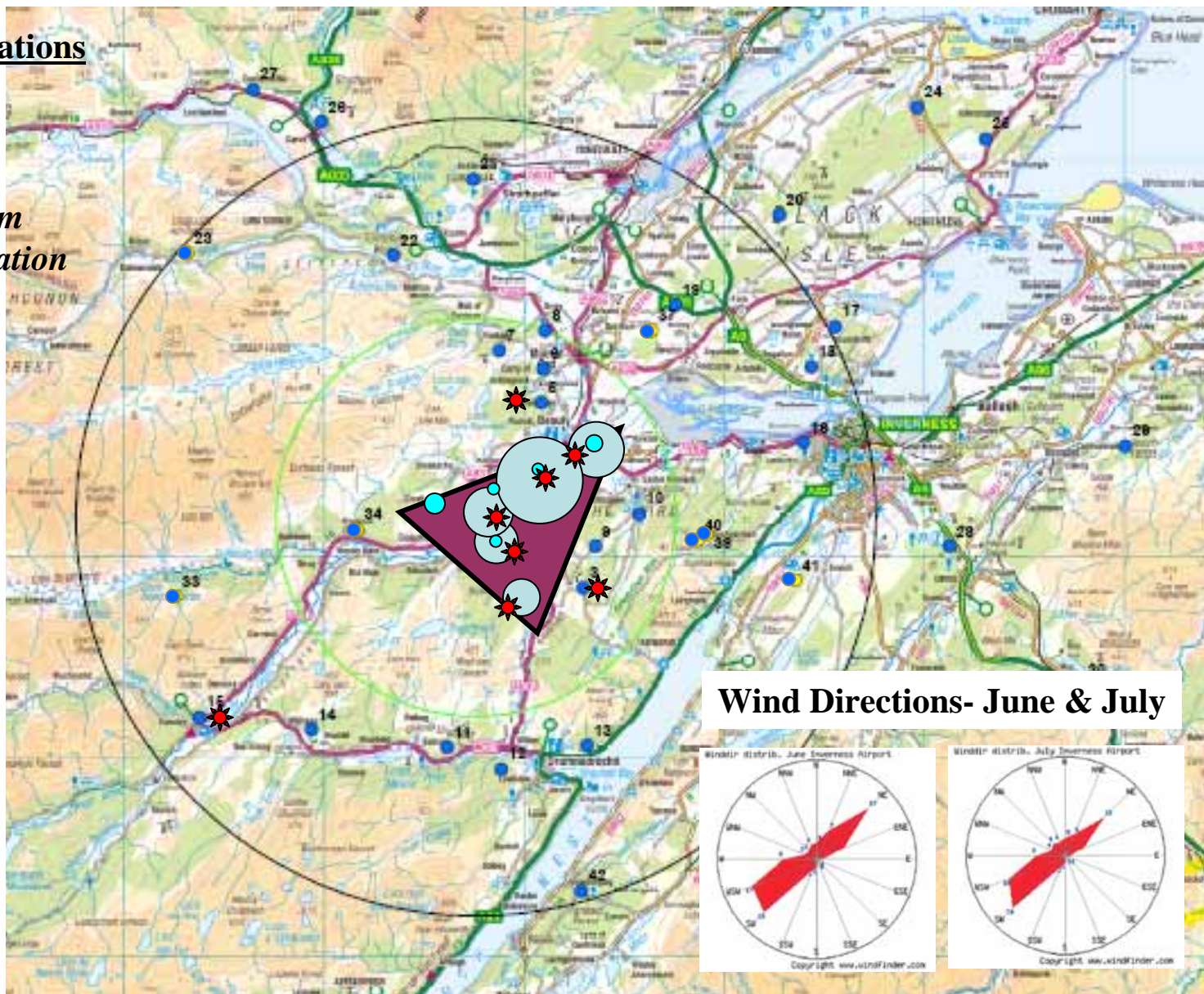
▲ *Male captures-
8 in pheromones
90 in light traps*

c. 1400ha forest

● *Total no. caught
in pheromone traps*

○ *Nos. caught/ light
trap/ night*

Captures at 7 Sites



**The adult male Pine-tree Lappet moth captures
led to a concentration of monitoring effort
on the 7 sites where moths caught:
to locate breeding sites**

Tree Felling (Sept '09)

6 SP felled at each of 7 sites where adult moths caught from 10th-21st Sept
 A Breakthrough- Detection of Breeding Populations of PtLM



A caterpillar at 1 site
 +
 pupal cocoon at another



Surveys of 'Active' Larvae (Sept-Nov 09)

Glue bands to detect larvae moving *down* trunks to overwinter

1900 glue bands on 7 sites where adult moths caught- set up 14th-24th Sept




Glue bands also had thick glue added to them


33 caterpillars caught (+70), 4 confirmed breeding sites


Highest density- 1 caterpillar in every 4 trees (min)

Pheromone Trap Locations

*** Light Trap Locations**


 *Male captures-
8 in pheromones
90 in light traps*

 *Total no. caught
in pheromone traps*

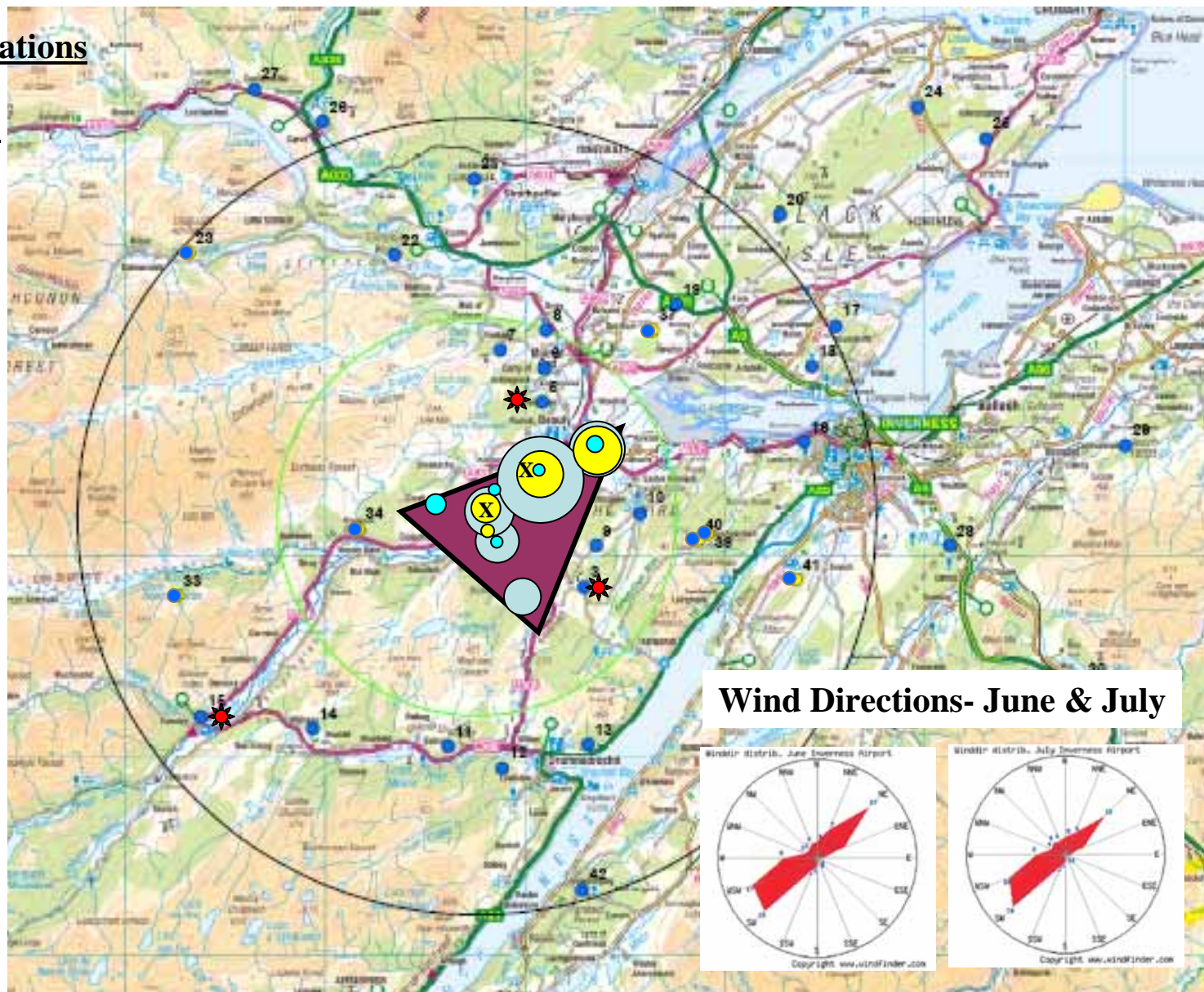
 *Nos. caught/ light
trap/ night*

Captures at 7 Sites

X *Tree Felling-
caterpillar &
pupa captures*

 *Total no. caught
by glue bands*

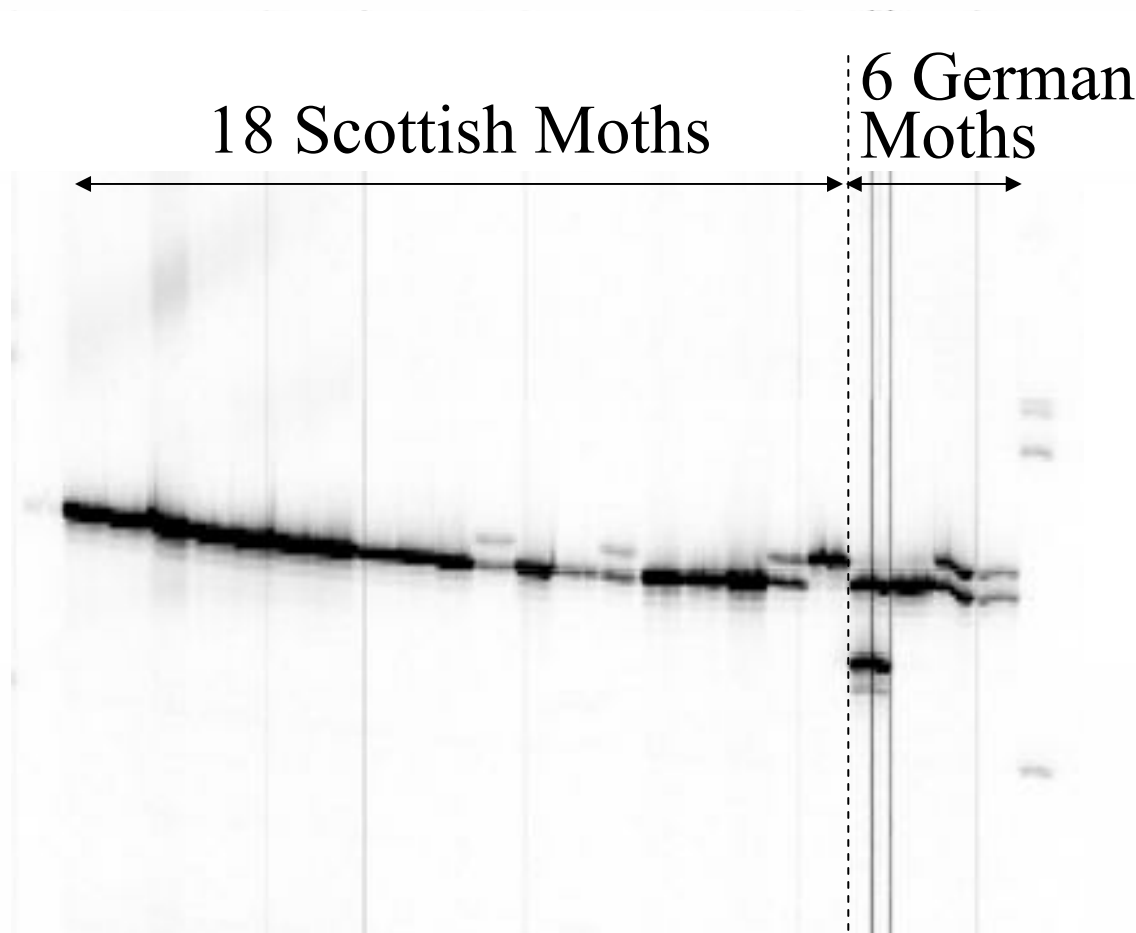
Breeding at 4 Sites



Survey Objective Progress . ..and Next Steps

- Locate Breeding Site(s) ✓
(indicated by immature life stages esp. caterpillars)
- Determine the Current Extent of PtLM's Distribution ✓
*(moths disperse from breeding sites to **expand** range)*
- Determine if PtLM is Native or Non-native **..... Progress**

Microsatellite markers- show variation within population



Scottish moths- fewer alleles & lower heterozygosity (low genetic base)
 Indicates small population (recent introduction or genetic bottleneck)

Mitochondrial DNA sequence- (cytochrome oxidase region)

Maternally inherited & best for showing historical colonisation routes

Sequencing the CO region has generated very interesting results

- 1) Scottish sequences
- 2) Scottish vs European sequences

Scottish Moths- Results for CO region 1 sequence

Site No.	SNP1	SNP2	SNP3	SNP4	SNP5	SNP6		SNP7	SNP8	SNP9	SNP10	SNP11	SNP12	SNP13	SNP14	SNP16	SNP17	SNP18	SNP19	SNP20
	114	153	164	319	369	375	510	573	664	816	867	879	900	954	990	1062	1086	1127	1155	1179
38	A	T	T	T	A	C	A	C	C	G	A	C	T	G	A	G	G	G	C	C
36
2
2
No tag
No tag
43
4
1
43

• Dots in the same column indicates the same

All Scottish sequences are identical.

Comparison of Scottish & European Moths- Results for CO region 1 seq.

All Scottish	A	T	T	T	A	C	A	C	C	G	A	C	T	G	A	G	G	G	C	C
Russian							G	T	.	.	.	.	.	.	.	.	A	A	.	.
Russian							G	T	.	.	.	.	.	.	.	.	A	A	.	.
Russian							G	T	.	.	.	.	.	.	.	.	A	A	.	.
Russian							G	T	.	.	.	.	.	.	.	.	A	A	.	.
German	G	.	.	C	.	T	.	T	T	A	G	T	C	A	.	A	A	A	.	T
German	G	.	C	C	.	.	.	T	T	A	G	T	C	A	.	A	A	A	.	T
German	G	C	.	C	G	T	.	T	T	A	G	T	C	A	.	A	A	A	T	.
German	G	.	C	C	.	.	.	T	T	A	G	T	C	A	.	A	A	A	.	T
German	G	.	.			T	.	T	T	A	G	T	C	A	.	A	A	A	.	T
German	G	.	.	C	.	T	.	T	T	A	G	T	C	A	.	A	A	A	.	T
Finnish							.	T	T	A	G	T	C	A	.	A	A	A	.	T
Finnish							.	T	T	A	G	T	C	A	.	A	A	A	.	T
Finnish							.	T	T	A	G	T	C	A	G	A	A	A	.	T

The Scottish sequence was unique.

It was very different from the German & Finnish Moths.

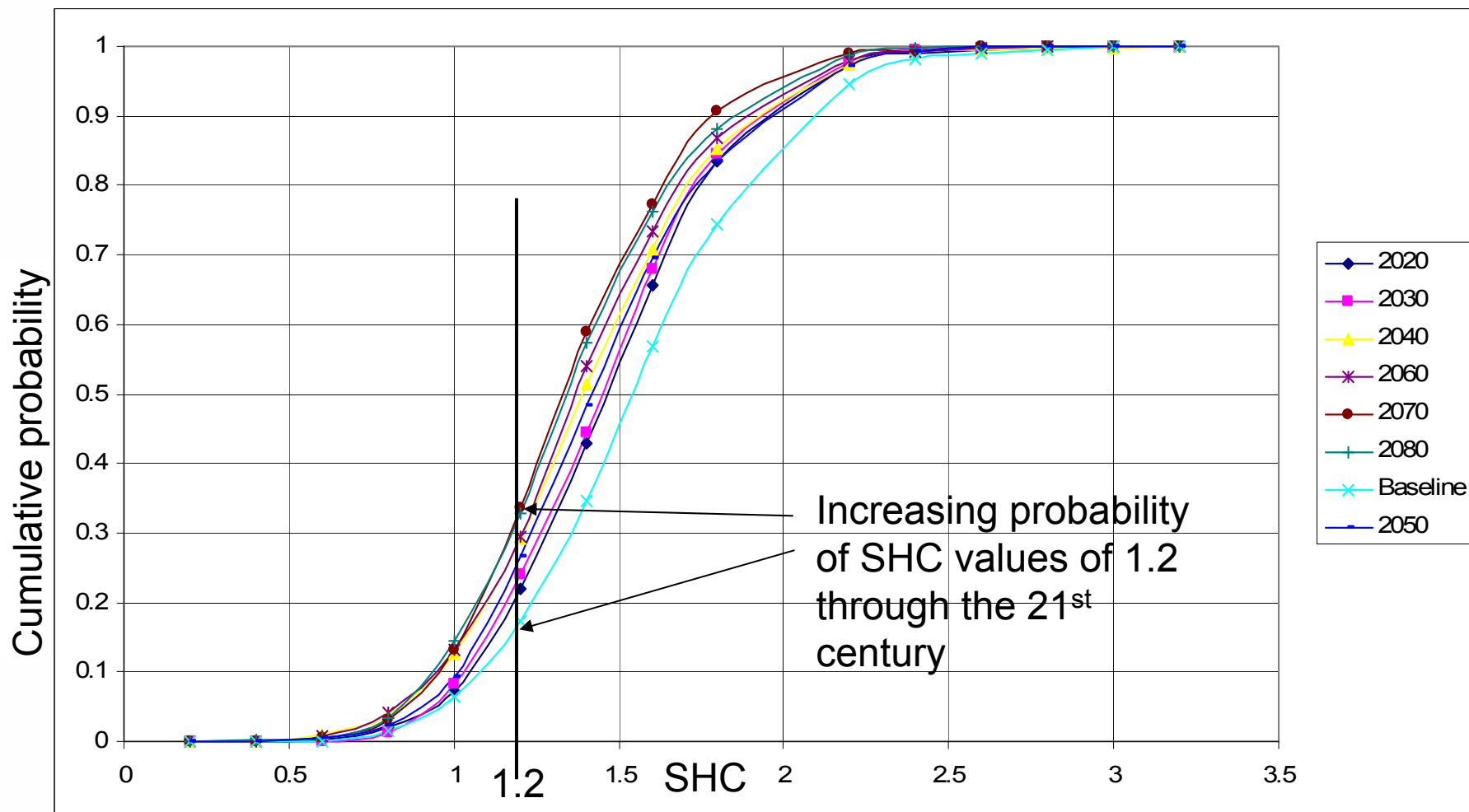
But a very close match to the Russian sequences (Mikkola, 2008) from the Southern Urals.

Survey Objective Progress . . .and Next Steps

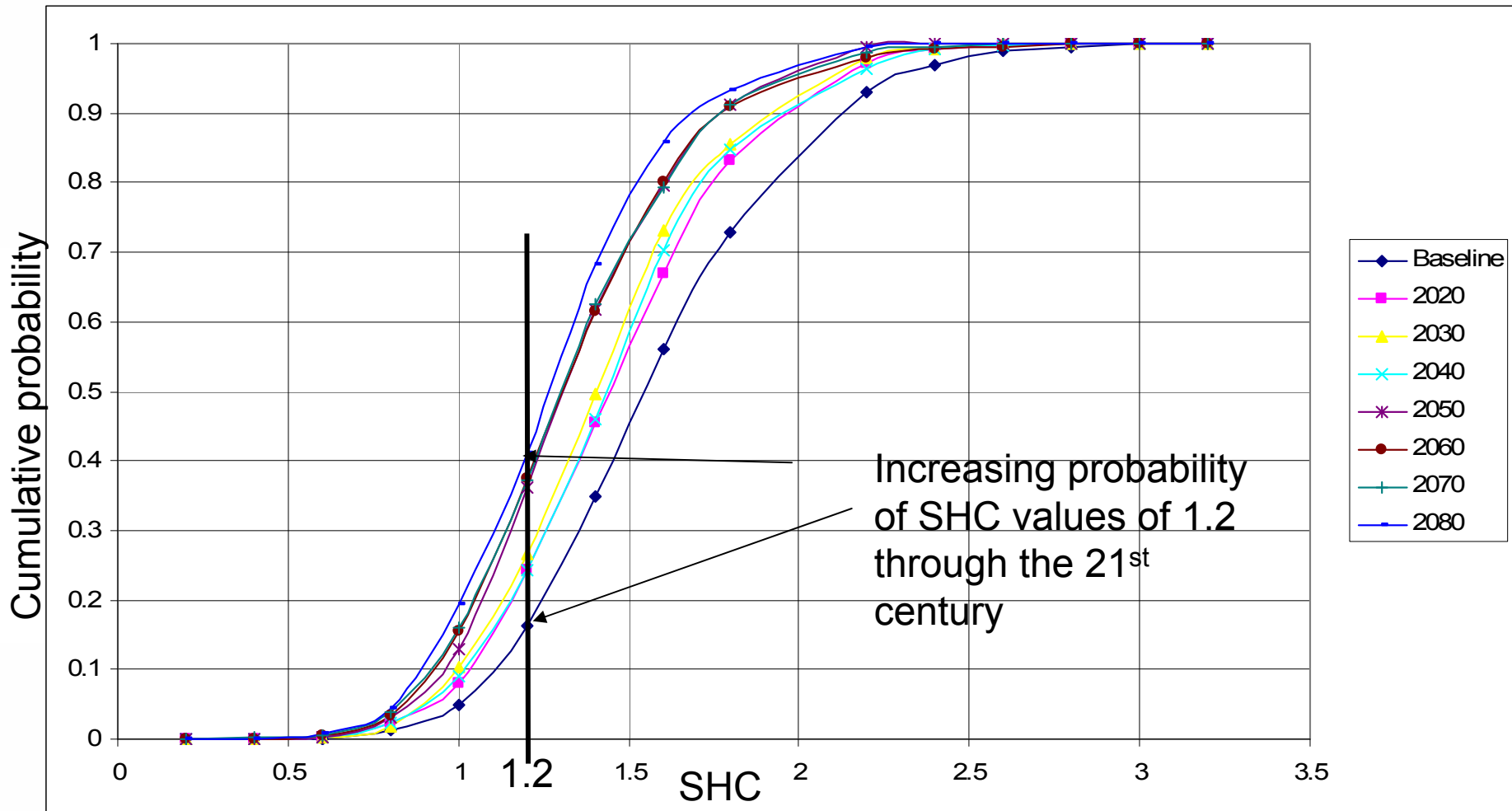
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- Determine if PtLM is Native or Non-native Progress
- Determine if Climate is Suitable for Outbreaks Progress

- In Poland- *Seljaninov's hydrothermal coefficient* (SHC) is used to indicate ideal climatic conditions for outbreaks of PtLM
- Polish outbreaks can occur for values between 1.0 and 1.5. A value of **1.2** identifies the best conditions for outbreak (Prescott 2009)
- UKCP09 Climate Weather Generator sampled for a 5x5km square of the Beauly catchment to predict current & future values of SHC (for both *low* & *high emissions* scenarios)
- This was done to help us predict whether or not the climate in this area is suitable for PtLM outbreaks now or in the future





Probability of ideal value of 1.2 changes from 0.15 (1 or 2 yrs in every 10 yrs) in the baseline climate to a probability of 0.3 (3 yrs in 10) by 2080 for low emissions scenario.



Increasing probability of SHC values of 1.2 through the 21st century

Probability of ideal values of 1.2 changes from 0.15 (1 or 2 years in every 10 years) in the baseline climate to a probability of 0.4 (4 years in 10) by 2080 in the high emissions scenario (worst case scenario).

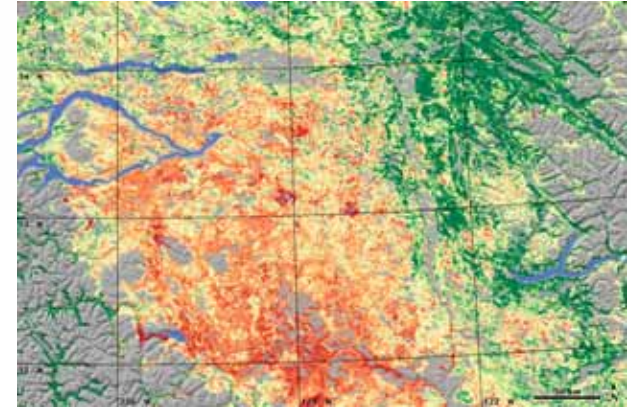
Survey Objective Progress . ..and Next Steps

- Locate Breeding Site(s) ✓
(indicated by immature life stages esp. caterpillars)
- Determine the Current Extent of PtLM's Distribution ✓
*(moths disperse from breeding sites to **expand** range)*
- Determine if PtLM is Native or Non-native Progress
- Determine if Climate is Suitable for Outbreaks Progress
- Determine PtLM's Potential Rate of Spread Ongoing
(including: in relation to climate change)

- PtLM is breeding in Scotland
- PtLM's current spatial distribution is typical of a recent introduction
- DNA analysis shows a low genetic base- ALL Scottish sequences are identical
- Scottish DNA most similar but not identical to Russian DNA sequences
- Large areas of plantation and Caledonian pine woods exist in Scotland on infertile, sandy textured soils known to favour PtLM outbreak.
- Climate analysis indicates that the climatic conditions will become warmer & drier in this part of NE Scotland and ideal climatic conditions- which occur 1-2 years in every 10 years for our current climate will increase to 3 or 4 years in every 10 by 2080.
- Increase in the likelihood that ideal climatic conditions for outbreak occur in consecutive years. This could make outbreaks even more serious & damaging.

Next Steps

- Delimit Breeding Area (even more accurately)
- Further DNA analysis (more samples from Europe)
- Further Climate Analysis
- Remote Sensing (to spot damage/stressed pine)
- OMT decisions: Control, Eradication or No Action?



Control- Insecticide Application



Eradiation- Sanitation Felling

