



# Modeling the distribution of eastern white pine in the 19th century in central Québec using land survey records

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Astronomical Course and Variation.	Range or Lot.	DISTANCE.		REMARKS.	
		Chains.	Links.	Intersection of Rivers, Lakes, Brooks, Mountains, Swamps, &c.	Soil and Timber.



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Sébastien Dupuis



Victor Kafka  
Raymond Quenneville



Nadyre Beaulieu

# *Pinus strobus* L.

G.R. Powell

- Relegated to **well-drained, coarse-textured** sites
- **Mineral** soil or **burned organic** horizon germination
- Sensitive to competition for **light**
- **Long-lasting pioneer**, favoured by surface fires

(Vlasiu et al. 2001; Wendel et Smith 1990)



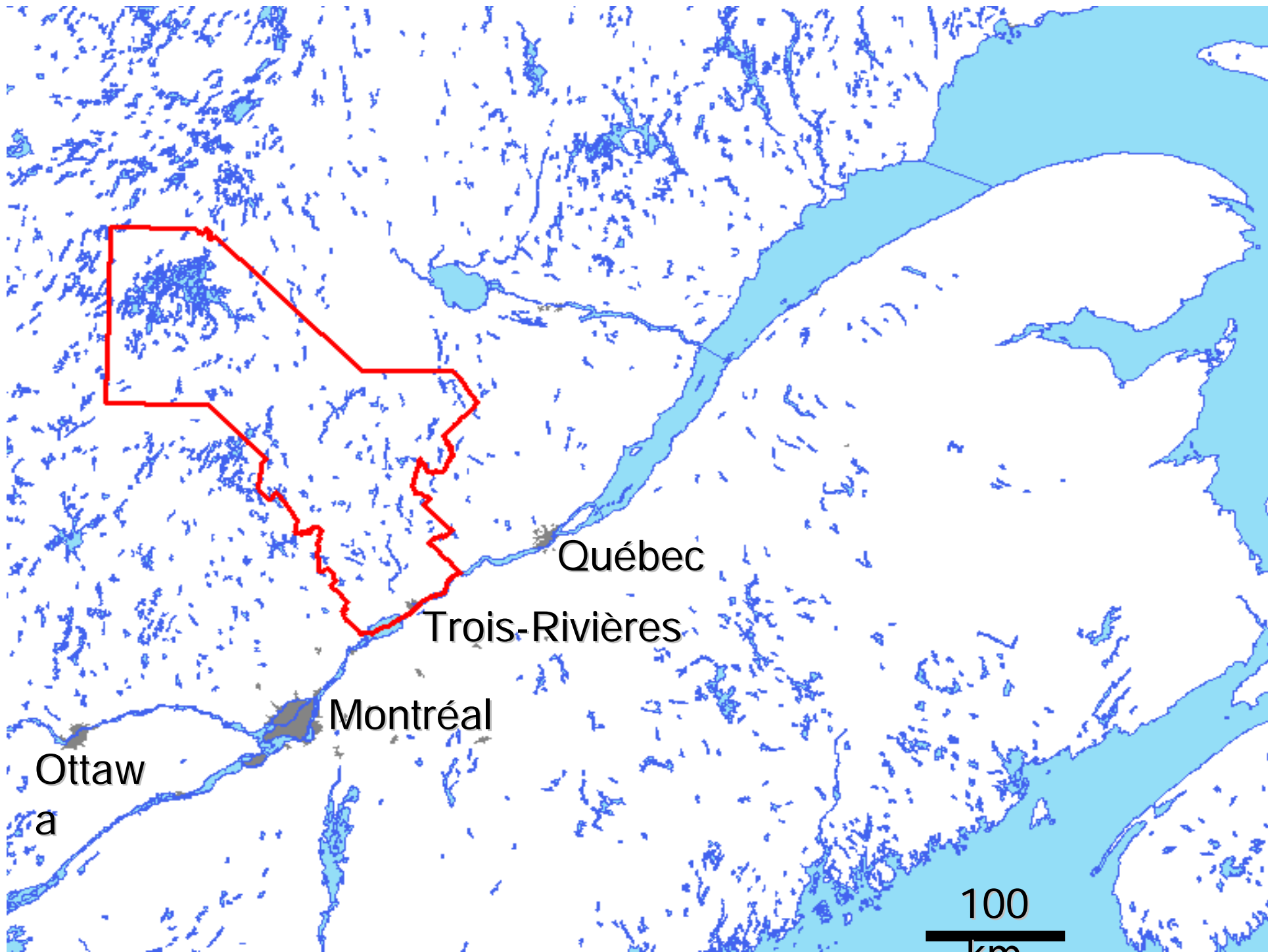
# Context

REMARKS.

Intersection of Rivers, Lakes, Brooks,  
Mountains, Swamps, &c.

Soil and Timber.

- Decrease of frequency and abundance
- Altered distribution (Bouchard 1999; Brisson et Bouchard 2003; Pelletier 1998)
- Historical changes in the Maurice region:
  - In La Mauricie national park, white pine **volume** decreased from **12.5 %** to **0.5 %** (Pelletier 1998)
  - Mature white pine prevalence decreased from **28 %** to **15 %** (Mauri Ortuno *et al.* unpublished)
- Limited tools to guide ecological restoration



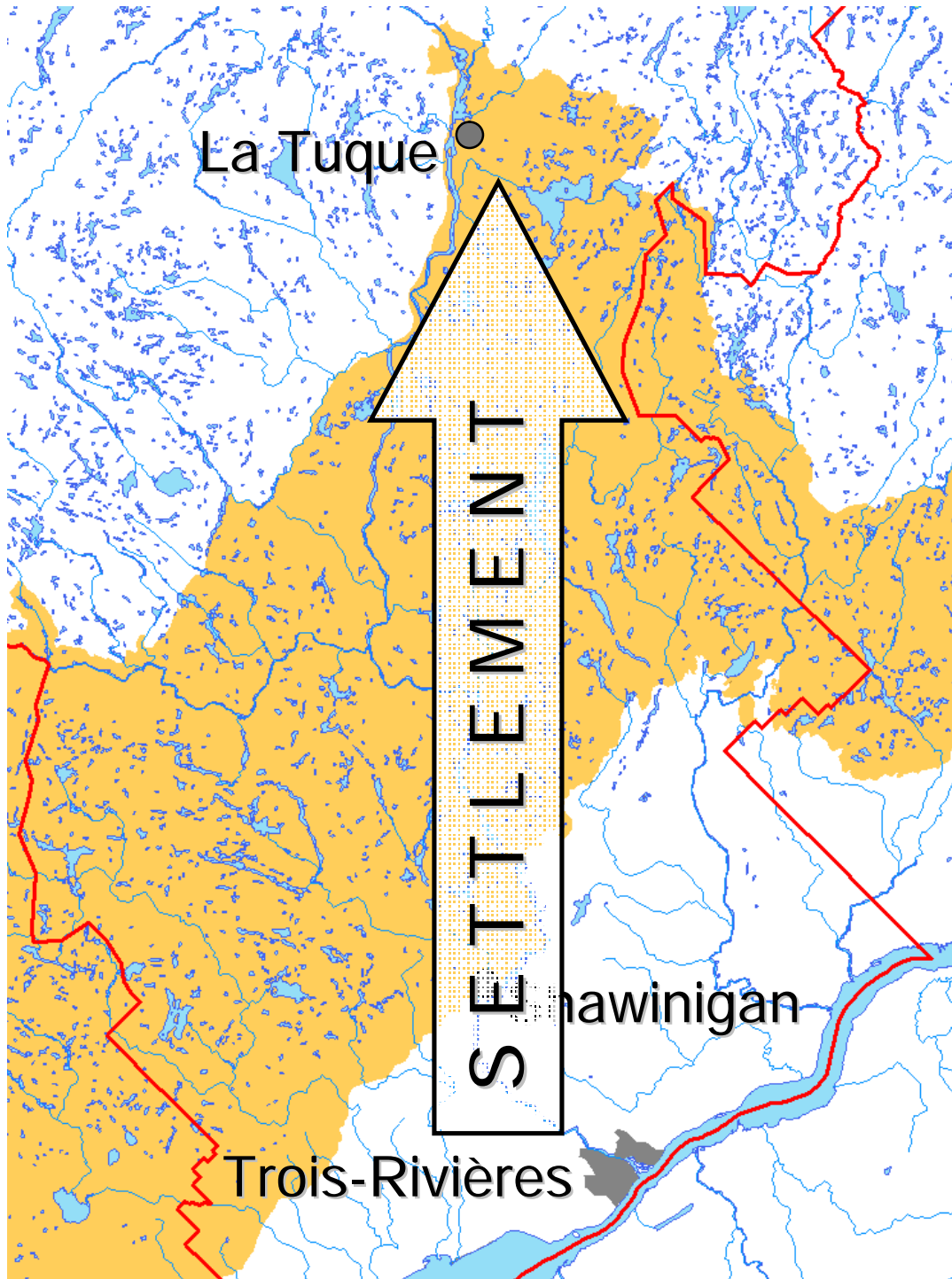


# Mid-Mauricie region

- Great Lakes-St. Lawrence forest:  
**Sugar maple-yellow birch**
- Hills and high-hills
- Glacial and fluvio-glacial deposits

(Gosselin 2001)

20 km



# Management history

- **1830 – 1850:** beginning of WP selective cuts
- **1850 – 1890:** WP pine still the most exploited species
- **1890:** depletion

(Boucher 1952; Gélinas 1984; Lafleur 1970)

20 km

# Causes of reduced abundance

## Successional trees



(Boucher 1952; Lafleur 1970; Quenneville et Thériault 2001)

# Objectives and Hypothesis

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Which sites did WP  
occupy in pre-  
settlement forests?

$$WP_{19} = f(\text{env})$$

**Create a tool to guide white**

**pine ecological restoration**

Are current WP traces  
reliable to describe past  
white pine distribution?

$$WP_{19} = f(\text{traces}_{20})$$

How much less WP  
is there in present  
forests?

$$WP_{19} \text{ vs. } WP_{20}$$

# Objectives and Hypothesis

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Which white occupied  
 with riparian  
 settlement forests?

$$WP_{19} = f(\text{env})$$

Are present white oak  
 with present of past  
 pine distribution?

$$WP_{19} = f(\text{traces}_{20})$$

Compare white oak  
 distribution against  
 forest? present observed

$$WP_{19} \text{ vs. } WP_{20}$$

$$WP_{19} = f(\text{env})$$

# What is *WP*<sub>19</sub>

REMARKS.	
Intersection of Rivers, Lakes, Brooks, Mountains, Swamps, &c.	Soil and Timber.



- 24 land survey logbooks:
  - **Mauricie** region
  - **Sugar maple-yellow birch** bioclimatic domain
  - before **1900**
- 21 logbooks with points
- 8 logbooks where pine already harvested
- **13 logbooks used**

What is *WP*<sub>19</sub>

REMARKS.

Intersection of Rivers, Lakes, Brooks,  
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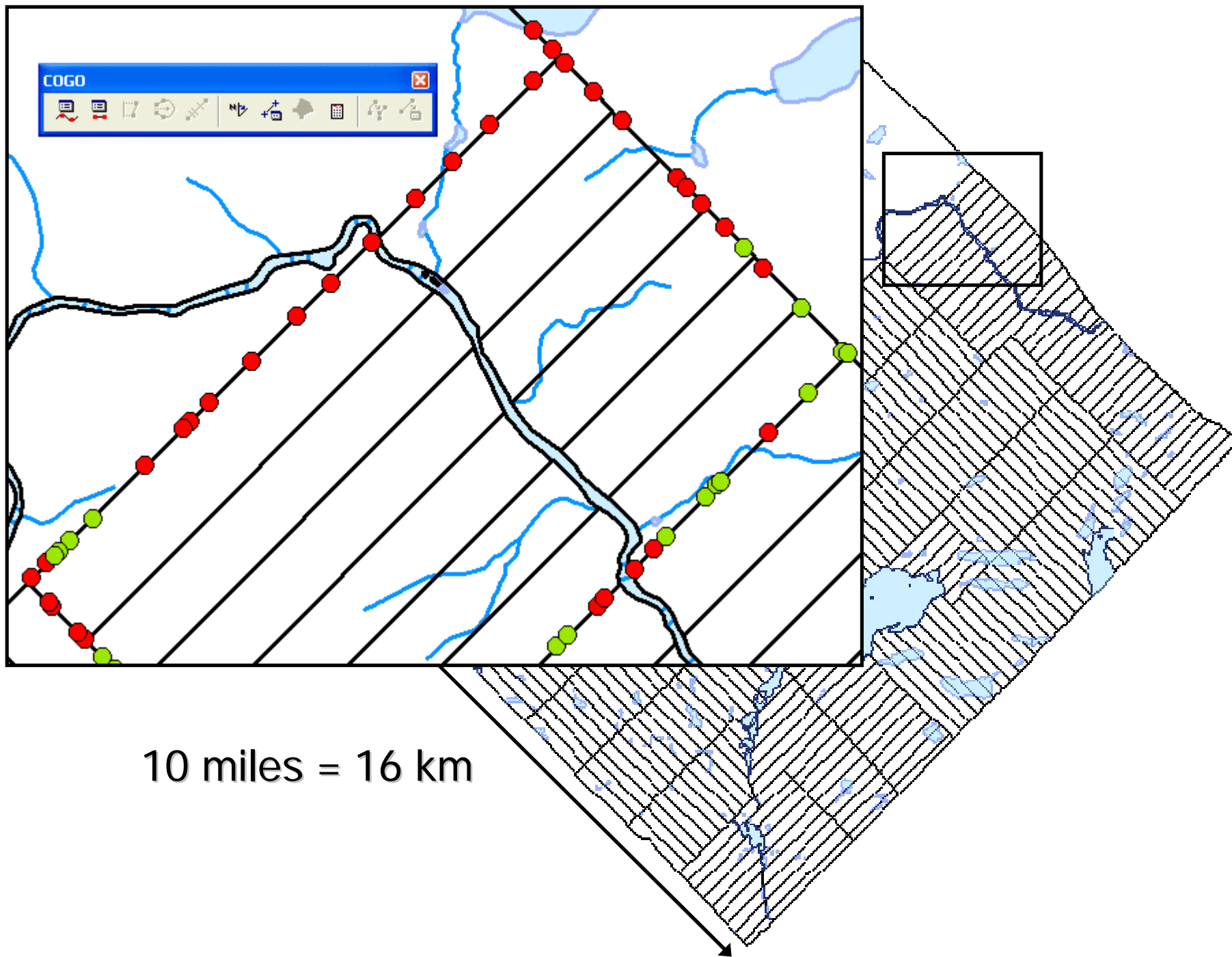
- Figure from  
Z:\maitrise\PROJET\hypothese\_1\resume  
\_des\_carnets.xls
- 90 % of the points, between 1960-1980.

Years of the 8 rejected logs:

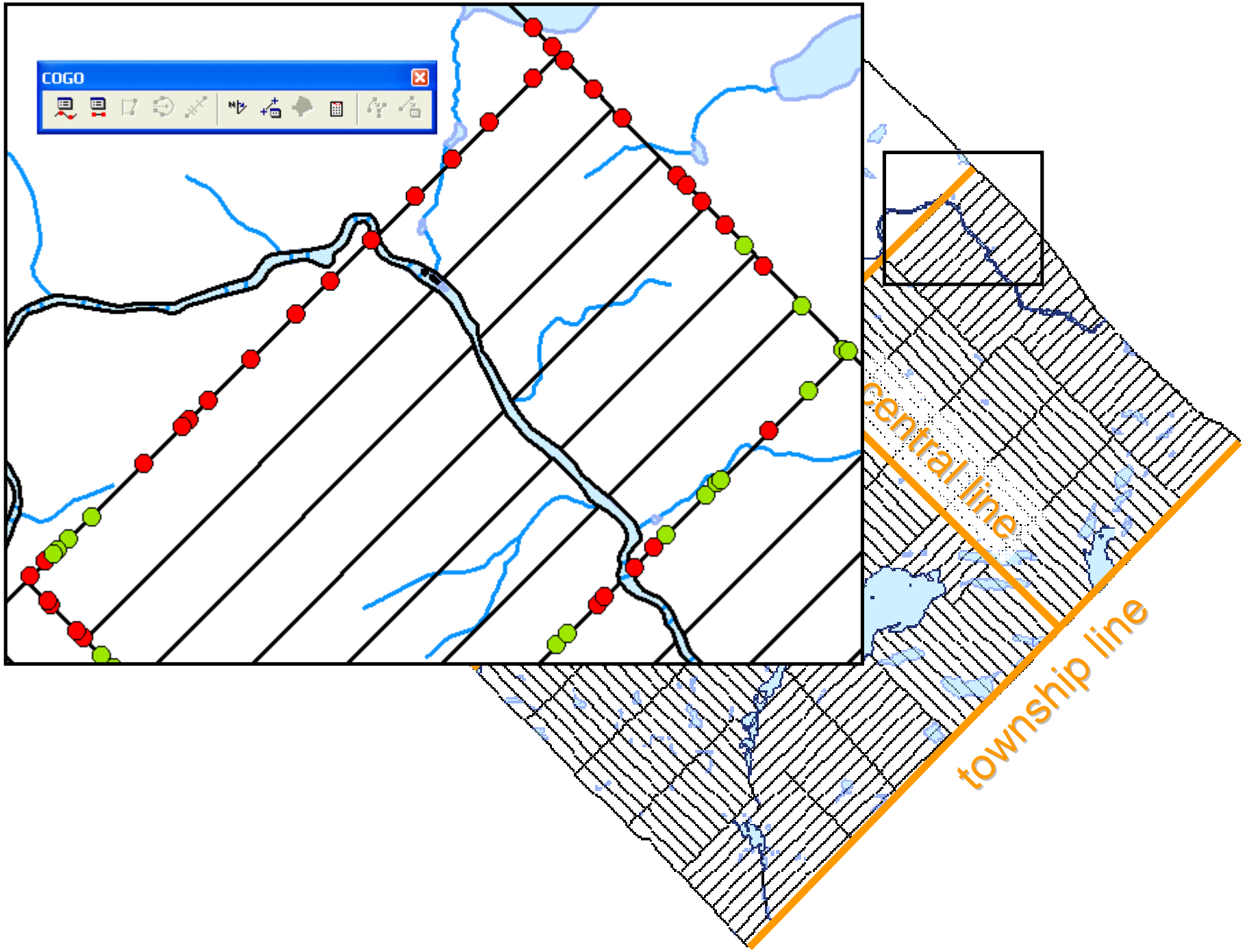
29, 53, 58, 70, 70, 76, 80, 80

(de la Chevrotière 1875)

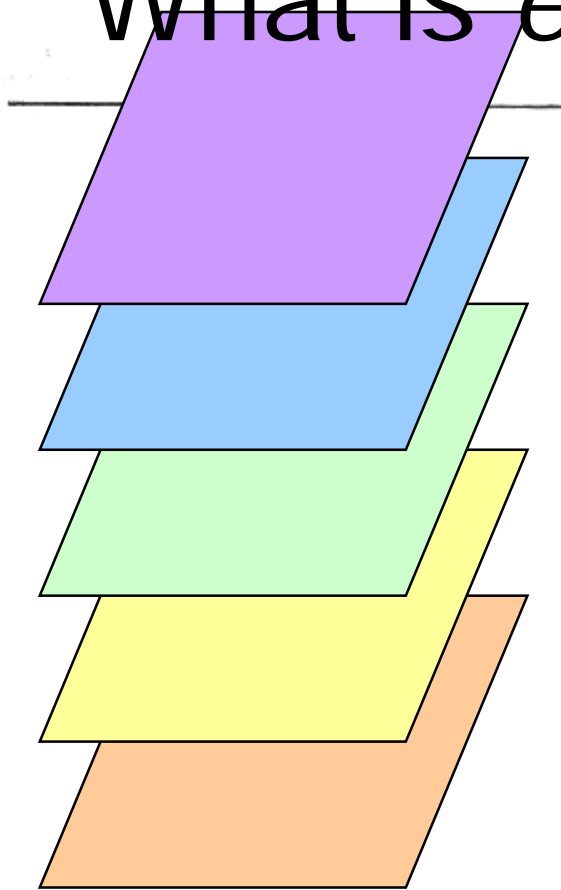
Astronomical Course and Variation.	Range or Lot.	DISTANCE.		REMARKS.	
		Chains.	Links.	Intersection of Rivers, Lakes, Brooks, Mountains, Swamps, &c.	Soil and Timber.
N 45° E		31		on commence à monter une	
Var.				montagne, épinette, sapin, <b>merisier</b> .	
12 1/2° -		40		on monte en core la même mon-	
ouest,					
N = 2614					
		WP = <b>yes</b>		WP = <b>no</b>	
		737 <b>28%</b>		1877 <b>72%</b>	
		50		on monte, encore,	
		54		Sommet de la montagne.	
				pruche, épinette sapin terrain	
				rochers.	
		60		Terrain plan, épinette, cèdre	
				et sapin	



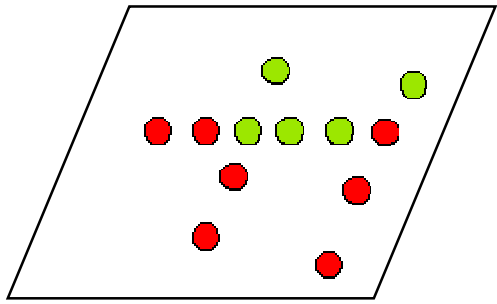
10 miles = 16 km



# What is env



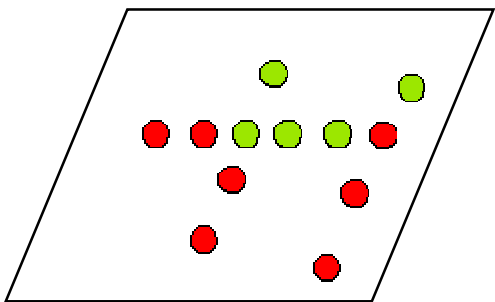
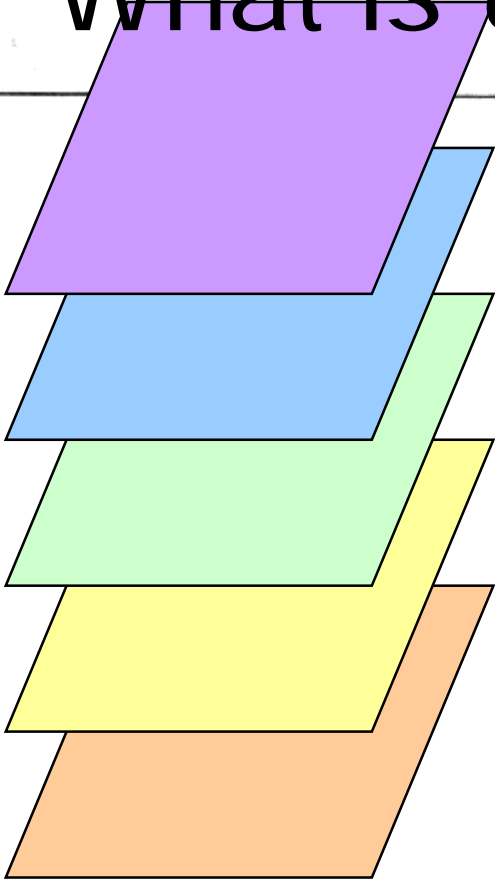
- Deposit
- Drainage
- Slope
- Aspect
- Slope position



<b>DV</b>	<b>Type</b>	<b>N</b>
WP <sub>19</sub>	Dicot.	2614

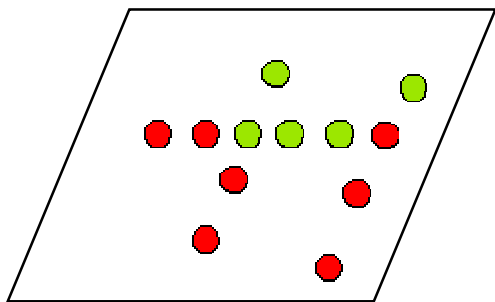
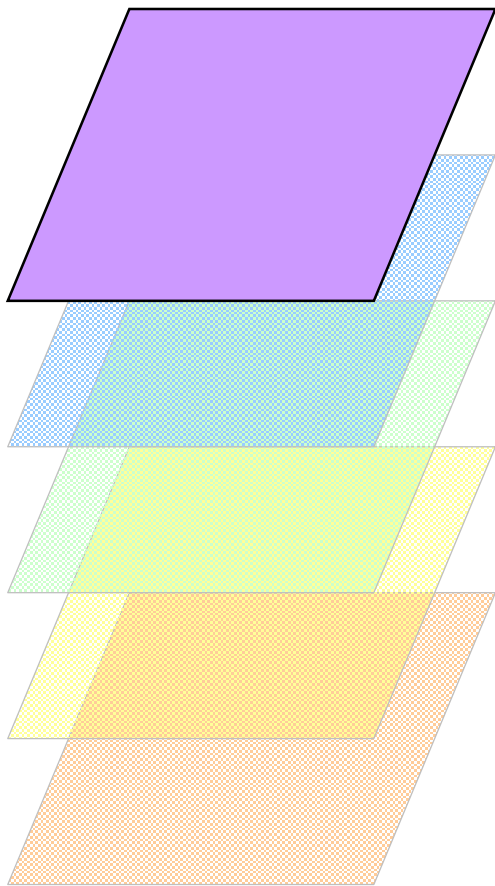
REMARKS.	
ers, Lakes, Brooks, Swamps. &c.	Soil and Timber.

What is  $e_{WV}$



	REMARKS.		
$e_{WV}$	Type	N. cat.	
Deposit	Nom.	18	6
Drainage	Ord.	7	7
Slope	Cont.		
Aspect	Nom.	9	3
Slope positon	Nom.	6	3

DV	Type	N	
WP <sub>19</sub>	Dicot.	2614	



**IV**

**Categories**

Deposit

Glacial

Drainage

Thin glacial – Rocky

Slope

Ice-marginal

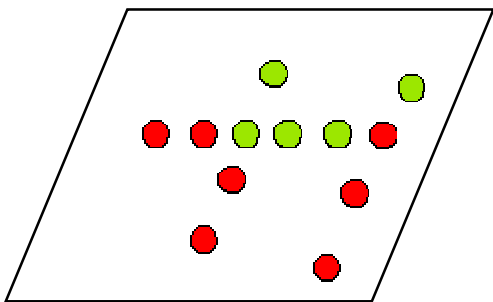
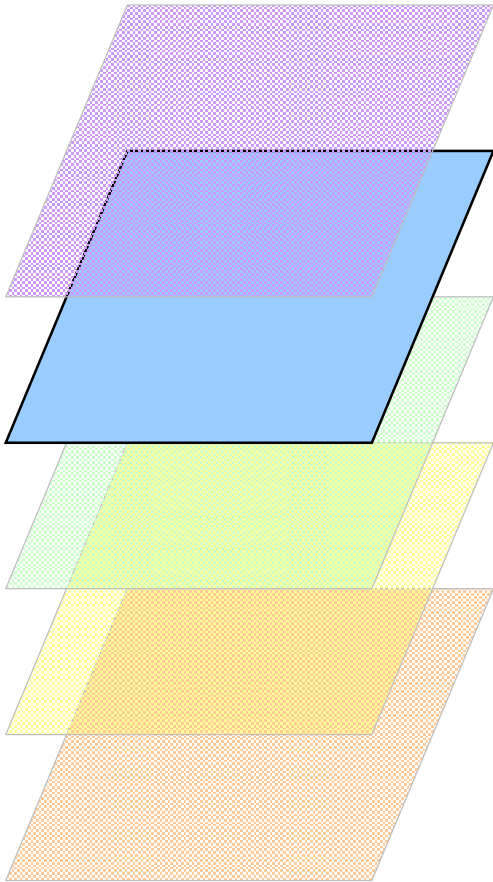
Aspect

Outwash – Alluvion

Slope position

Glaciolacustrine – marine

Organic



**IV**

**Categories**

Deposit

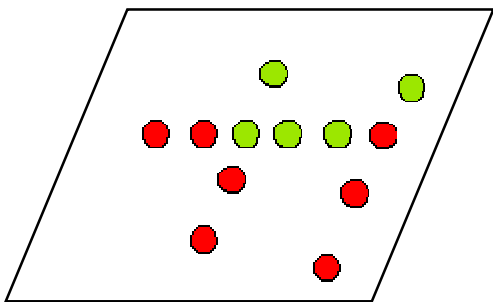
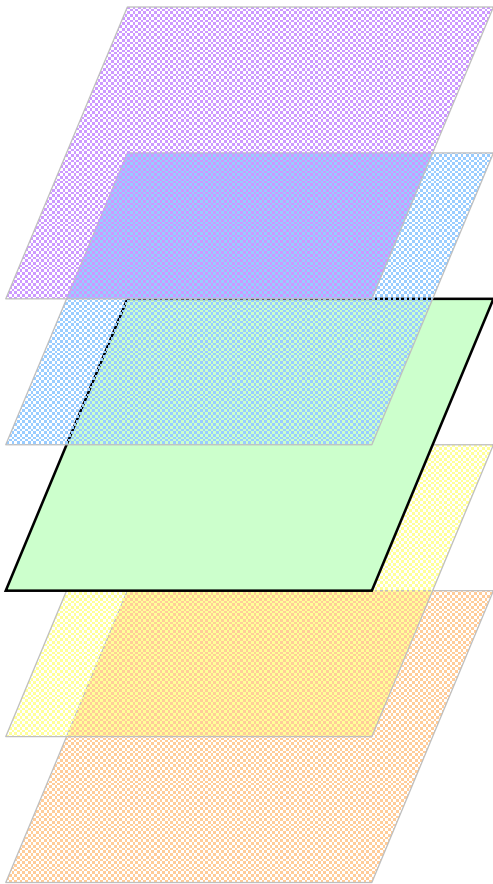
Drainage

0 to 6

Slope

Aspect

Slope positon



**IV**

**Categories**

Deposit

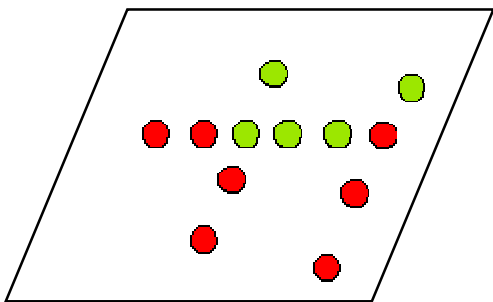
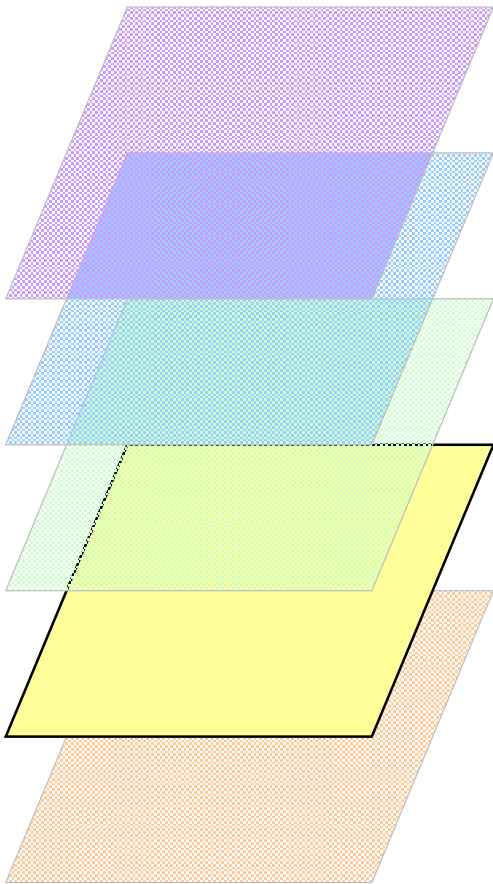
Drainage

Slope

percentage

Aspect

Slope positon



**IV**

**Categories**

Deposit

Drainage

Slope

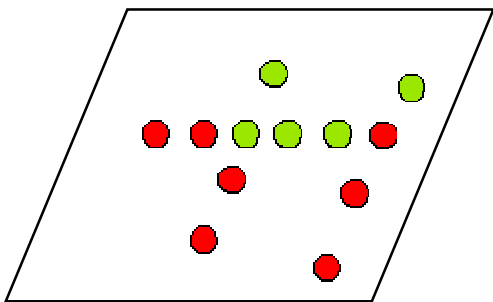
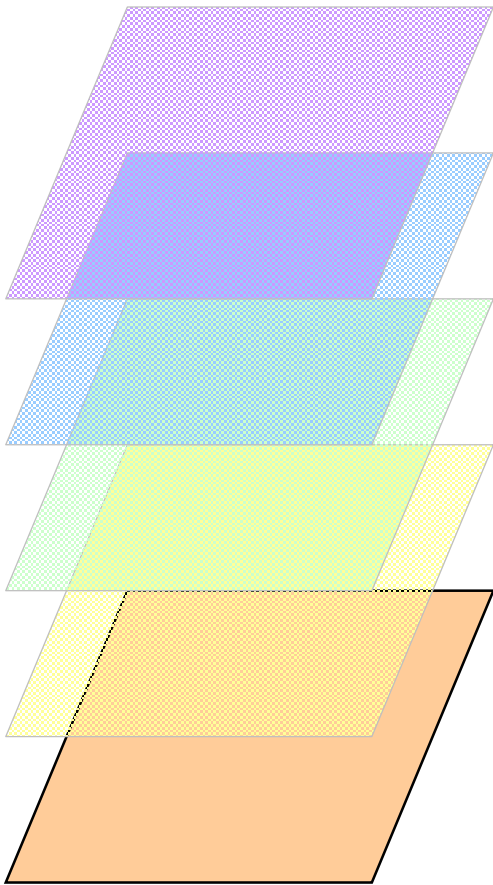
Aspect

S – SW – W

Slope position

NW – N – flat

NE – E – SE



**IV**

**Categories**

Deposit

Drainage

Slope

Aspect

Slope position

Top – High-slope

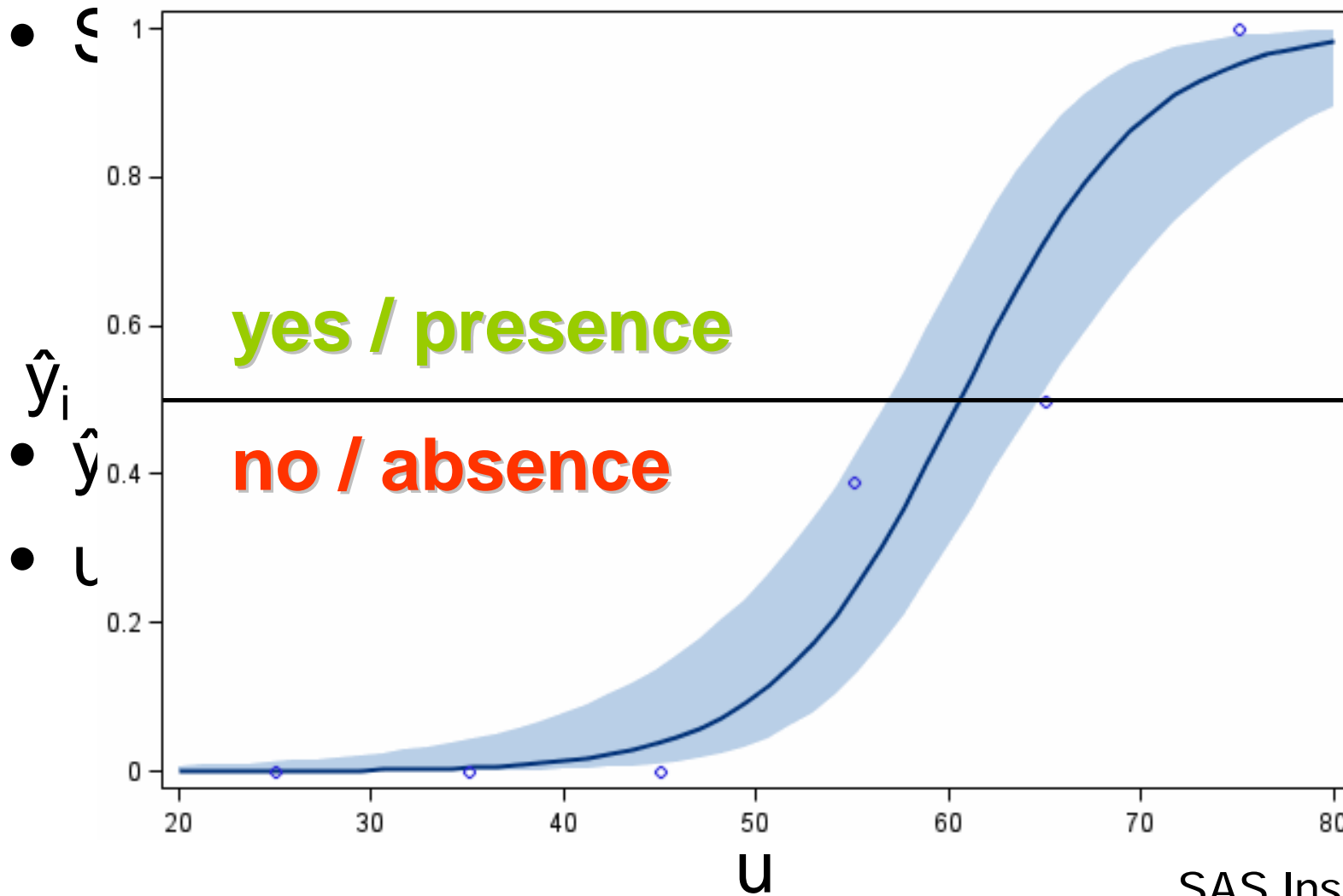
Mid- – Bottom-slope

Valley – Flat

REMARKS.

Soil and Timber.

$$WP_{19} = f(\text{env})$$



$WP_{19} = f(\text{deposit})$

aspect

slope position

Nagelkerke  $R^2$  .047

AIC constant only 3111

AIC constant & VI 3043 ✓

4-fold cross validation ✓

REMARKS.

$$WP_{19} = f(\text{env})$$

Reference =  
Glacial

IV & cat.	est.	odds ratio	
Outwash – Alluvion	++	2.5	146 %
Thin glacial – Rocky	+	1.5	48 %
Glaciolacustrine – marine	--	0.4	-145 %
Ice-marginal	not significant		
Organic	not significant		

REMARKS.

$$WP_{19} = f(\text{env})$$

Reference =  
NW – N – flat

IV & cat.	est.	odds ratio	
Outwash – Alluvion	++	2.5	146 %
Thin glacial – Rocky	+	1.5	48 %
Glaciolacustrine – marine	--	0.4	-145 %
S – SW – W	+	1.3	31 %
NE – E – SE	-	0.9	-17 %

REMARKS.

$$WP_{19} = f(\text{env})$$

Reference =  
Mid- – Bottom-slope

IV & cat.	est.	odds ratio	
Outwash – Alluvion	++	2.5	146 %
Thin glacial – Rocky	+	1.5	48 %
Glaciolacustrine – marine	--	0.4	-145 %
S – SW – W	+	1.3	31 %
NE – E – SE	-	0.9	-17 %
Top – High-slope	+	1.5	46 %
Valley – Flat	-	0.9	-12 %

# Classification assessment

Threshold = 0.28

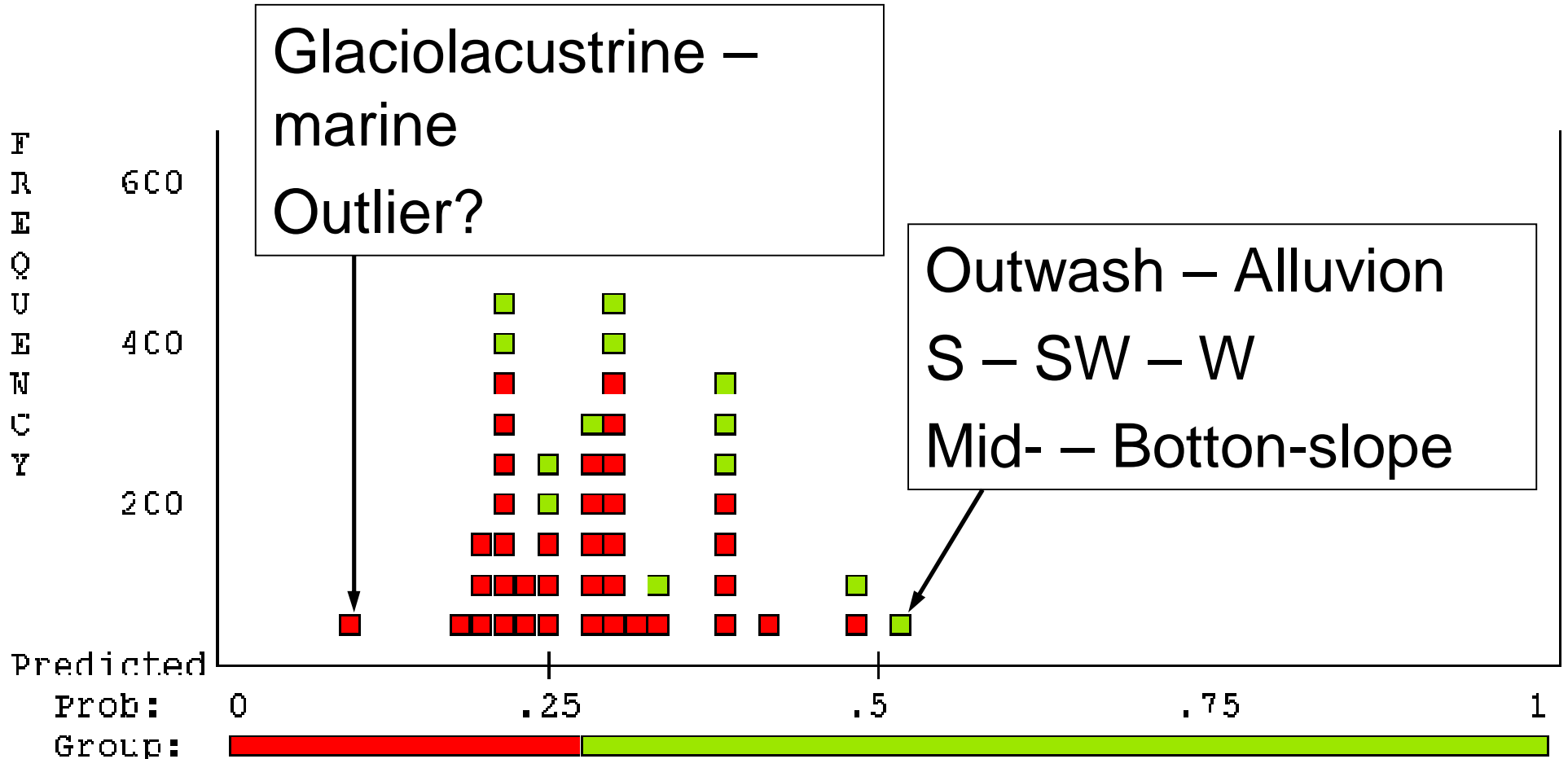
		Predicted		Total
		no	yes	
Observed	no	954	923	1877
	yes	266	471	737
	total	1220	1394	2614

- Sensitivity = 64 %
- Specificity = 51 %
- Correctly classified = 55 %

REMARKS.

Soil and Timber.

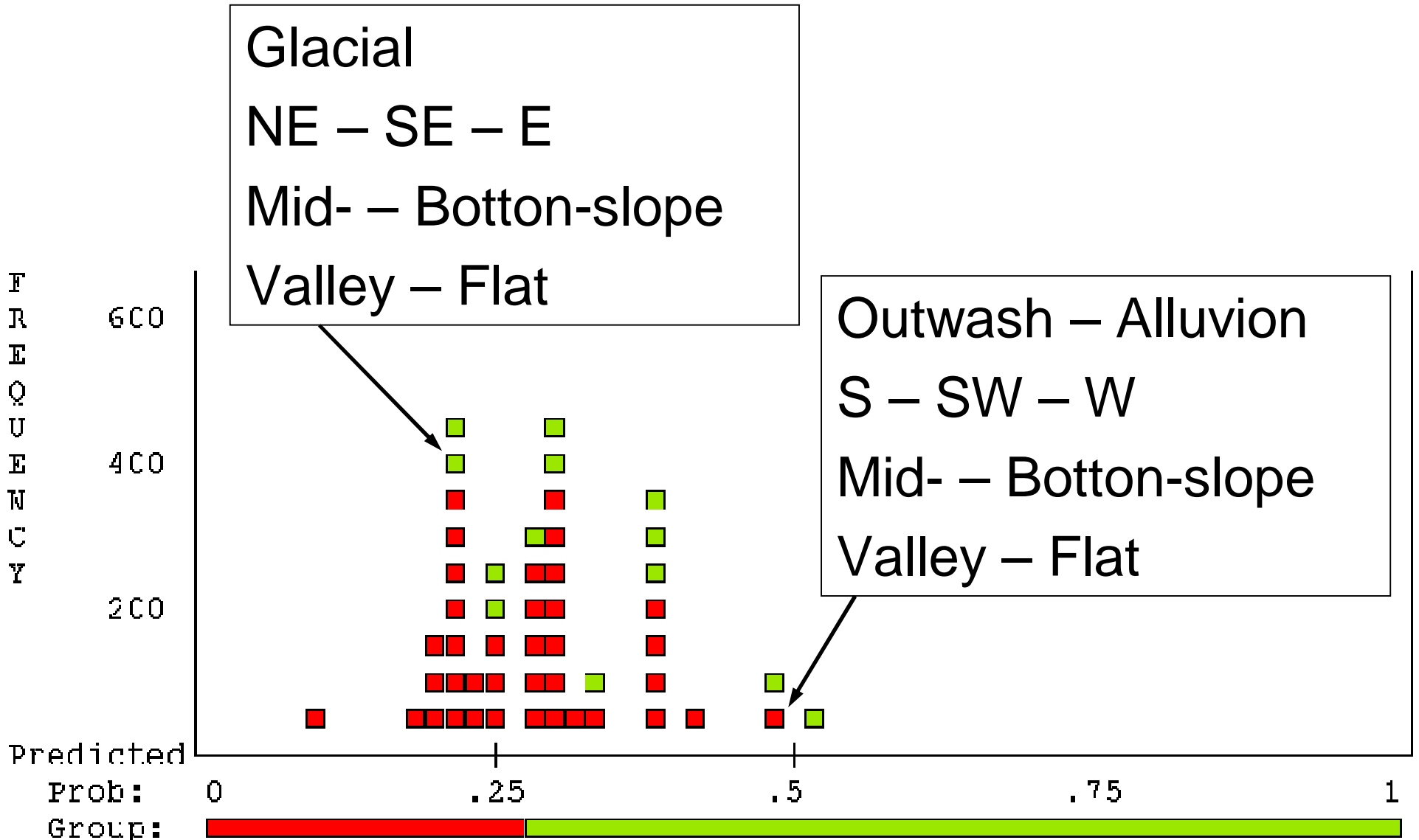
$$WP_{19} = f(\text{env})$$



threshold = 0.28

■ 50 cases with WP

■ 50 cases without WP



$$WP_{19} = f(\text{env})$$

- 4-fold cross validation

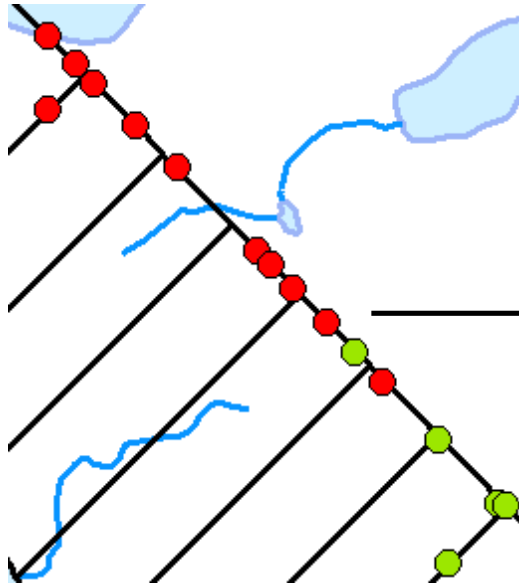
	model		tests
sensitivity	64 %	✓	60 %
specificity	51 %	✓	54 %
correctly classified	55 %	✓	56 %
Kappa	0.116	✓	0.111

$$WP_{19} = f(\text{traces}_{20})$$

REMARKS.

$$WP_{19} = f(\text{traces}_{20})$$

Soil and Timber.



421 plots

GPS located

● 222

● 199



20 m radius

$\text{traces}_{20}$

REMARKS.

Soil and Timber.

$$WP_{19} = f(\text{traces}_{20})$$



- Stumps
- Mature WP
- Saplings
- Seedlings

traces<sub>20</sub>

$WP_{19} = f(\text{stumps})$   
 $\text{seedlings}$   
 $\text{saplings}$

Nagelkerke  $R^2$  .243

AIC constant only 584

AIC constant & VI 505 ✓

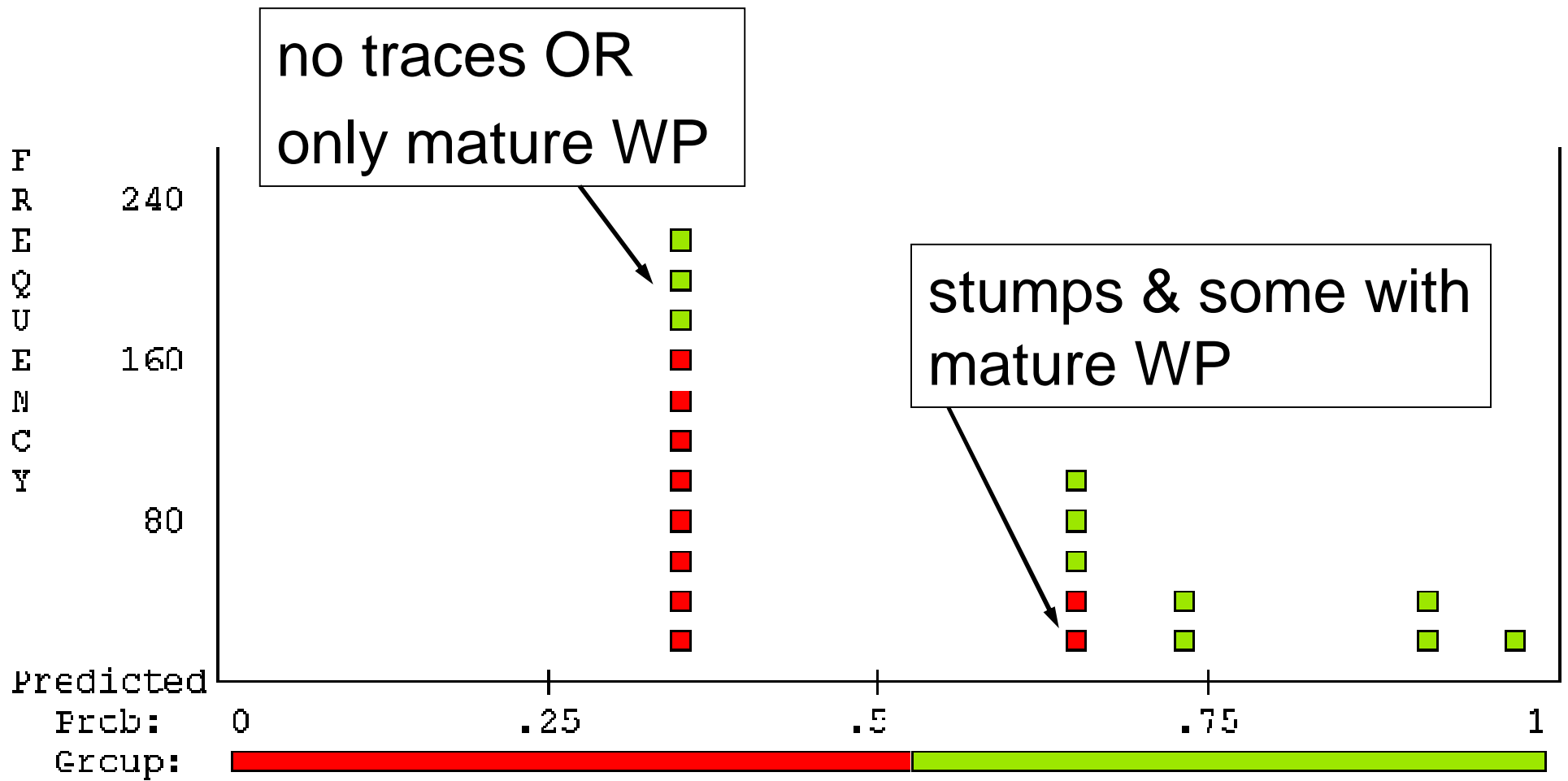
# Classification assessment

Threshold = 0.53

		Predicted		Total
		no	yes	
Observed	no	150	49	199
	yes	75	147	222
	total	225	196	421

- Sensitivity = 66 %
- Specificity = 75 %
- Correctly classified = 71 %





threshold = 0.53

■ 20 cases with WP

■ 20 cases without WP

$$\text{WP}_{19} = f(\text{env}, \text{traces}_{20})$$

Not significantly different of

$$\text{WP}_{19} = f(\text{traces}_{20})$$

# Discussion

REMARKS.

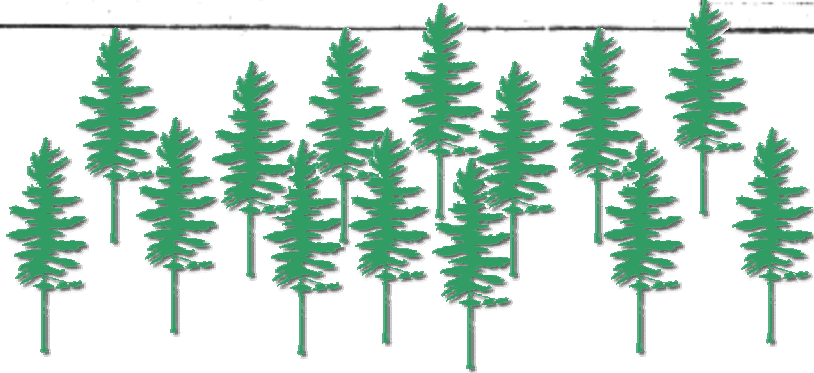
Intersection of Rivers, Lakes, Brooks,  
Mountains, Swamps, &c.

Soil and Timber.

- **First** study in Québec to build an autoecological model from pre-settlement forest using land survey records
- $WP_{19} = f(\mathbf{env})$  is similar to known autoecology, but weak prediction
- The best model is  $WP_{19} = f(\mathbf{traces}_{20})$  but:
  - no remote sensing for  $\mathbf{traces}_{20}$ ,
  - stump decomposition
- Using **abundance** of  $WP_{19}$  and  $\mathbf{traces}_{20}$  did not improve the prediction

# Discussion

REMARKS.	
Intersection of Rivers, Lakes, Brooks, Mountains, Swamps, &c.	Soil and Timber.



- Mature WP distribution halved: **28 %** to **15 %**

- Reduced abundance should be even more notable in the Saint Lawrence valley

- 



t.  
n:  
of

H. Lemay

# Conclusion

REMARKS.

Intersection of Rivers, Lakes, Brooks,  
Mountains, Swamps, &c.

Soil and Timber.

- Achieved objectives ✓
- Could be carried out for **other species** and **regions** (largely used in the USA)
- It guides and quantifies the required **restoration** effort
- In the study area:
  - forest ecosystem management: Projet Triade,
  - WP restoration program: La Mauricie national park

# Conclusion: next steps

2009 traces  
campaign planned  
from  $WP_{19} = f(\text{env})$

**is  $WP_{19} = f(\text{env})$  valid  
for all the study area?**

Compare  $WP_{19} =$   
 $f(\text{env})$  vs. present WP  
from forest survey

**$WP_{19}$  vs.  $WP_{20}$**

Vegetation  
associations in WP  
presence

**Which species  
accompanied WP?**

