Uncertainty in Decision Systems

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Sources of Uncertainty

- Geographical errors -- weather station is not located at farm of interest
- Representational errors -- weather station has different crop environment from weather station
- Prediction model itself is not completely accurate

Possible Solutions

- Models for interpolation
- Models for crop canopy
- Additional uncertainty from models

Pest Processes

- Non-linear systems
- *Phytophthora infestans*
  - water requirements
  - temperature requirements
  - population changes
- *Sclerotinia sclerotiorum*
  - apothecia and ascospore production

Measurement of Predictor Accuracy

- How often system predicts pest and pest is actually present
- How often system predicts absence of pest and pest is actually absent

True and False Positive

	Pest Occurs	Pest Absent
Predict Pest	A	B
Predict No Pest	C	D
	A/(A+C) True Positive Sensitivity	B/(B+D) False Positive D/(B+D) Specificity

Numerical Example

	Pest Occurs	Pest Absent
Predict Pest	27	4
Predict No Pest	3	16
	27/30 True Positive Sensitivity	4/20 False Positive 16/20 Specificity

Desirable Properties of Predictors

- High sensitivity
- High specificity -- low false positive rate

Continuous Predictor Variable

- Pest prediction systems often have a continuous variable derived from a number of other variables
- BLITECAST
- Sclerotinia predictor based on weather, cropping history and other variables
- Decision threshold

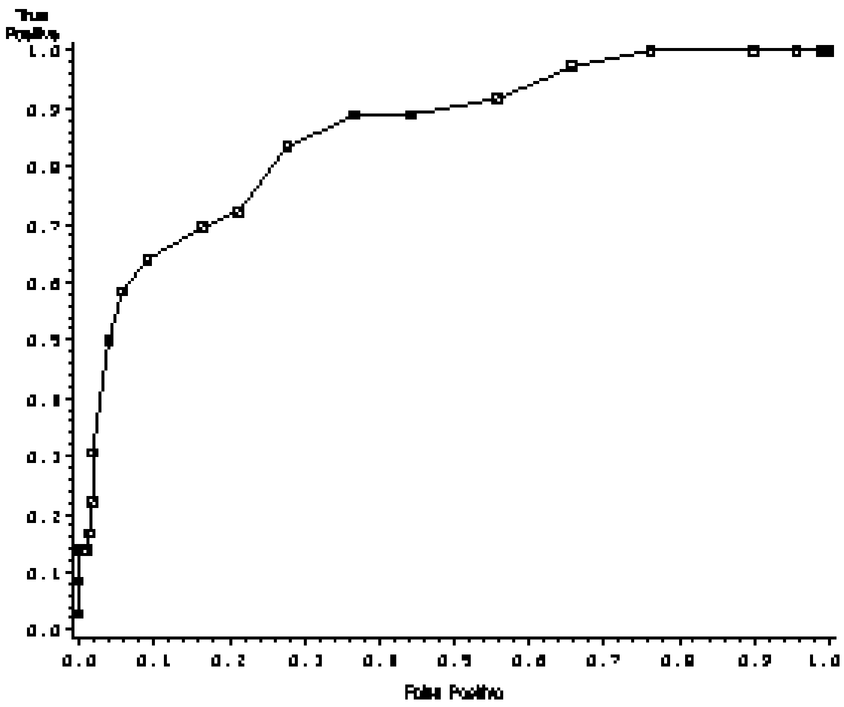
Effect of decision threshold on sensitivity and specificity

- Lower thresholds will increase the sensitivity of a our predictive system but will also increase the false positive rate (decrease specificity)
- Higher thresholds can reduce the false positive rate (increase specificity) at the expense of decreased sensitivity

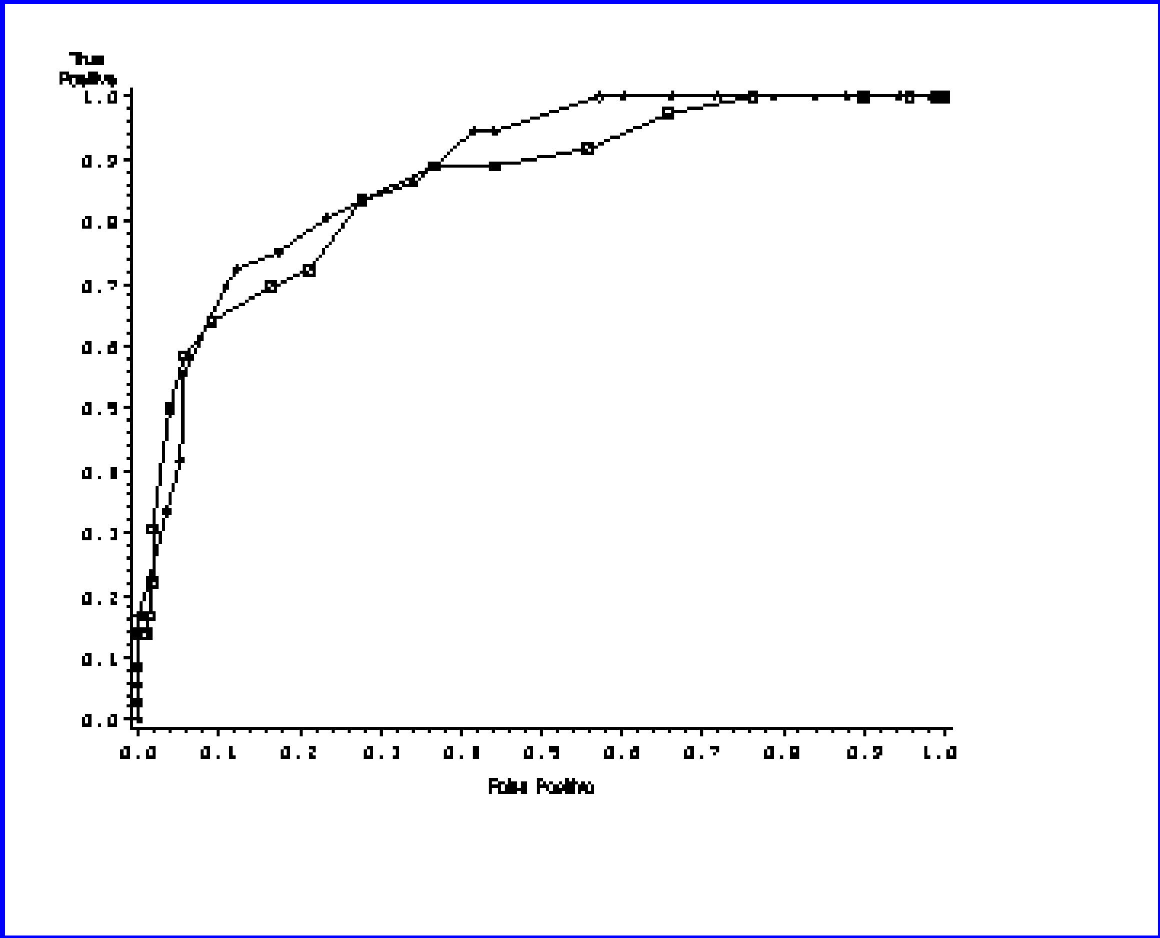
What is a ROC curve?

- A graph of the true positive rate as a function of the false positive rate at varying decision thresholds is called a Receiver Operating Characteristic curve (ROC curve)
- An alternative used by some authors is a graph of the sensitivity as a function of specificity

ROC curve example



Comparing Predictors with ROC curves



Assumptions

- Single control measure (often fungicide application)
- Single time point when the decision has to be made.
- Time point often determined by crop development stage (flowering in oilseed rape example)

Evaluation of Predictors

- Probability of pest occurrence before predictor
- What is the probability of the pest occurring after the predictor?
- Use of Baye’s Theorem

Bayes' Theorem

Sens

FP

$$\Pr(A|B) = \frac{\Pr(B|A)\Pr(A)}{\Pr(B|A)\Pr(A) + \Pr(B|\overline{A})\Pr(\overline{A})}$$

Bayes' Theorem

- Probability of pest presence if predictor is positive
- Sensitivity * prior prob of pest present
- divided by sum of sens * prob pest present and false positive and prob pest not present

More on Bayes' Theorem

- Use odds instead of probabilities
- use sensitivity and specificity in likelihood ratios
- LR for positive test is sens/(1-spec)
- LR for negative test is (1-sens)/spec
- New odds = old odds * LR

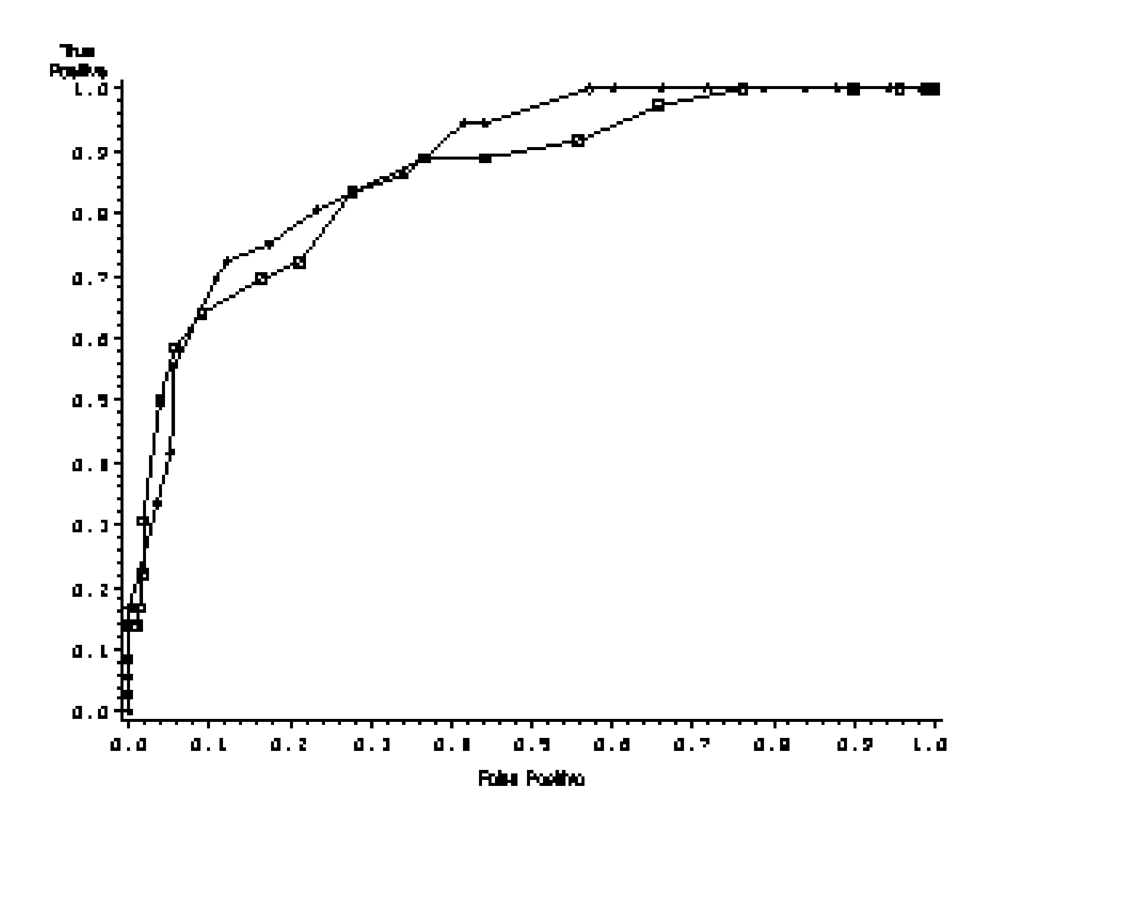
Numerical Example

- Sensitivity is 80%
- Specificity 75%
- LR for positive prediction 0.80/(1-.75) or 3.2
- LR for negative prediction (1-0.80)/0.75 or 0.267

Numerical Example

- If old (prior) odds is 1 to 10 (1 year of 11)
- After positive prediction, posterior odds is 0.1 * 3.2 = 0.32 or about 24%
- After negative prediction, posterior odds is 0.1 * 0.267 = 0.0267

Sclerotinia predictor



Increases in probability after a positive prediction

	LR	prior 0.19	prior 1.56	prior 0.30	prior 1.78
35	3.9	0.75	6.12	1.17	6.96
40	4.8	0.92	7.53	1.44	8.56
50	7	1.33	10.95	2.09	12.44

Decreases in probability after a negative prediction

	LR	prior 0.19	prior 1.56	prior 0.30	prior 1.78
35	0.130	0.02	0.20	0.04	0.23
40	0.274	0.05	0.43	0.08	0.49
50	0.684	0.13	1.07	0.20	1.22

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