

Machine Learning with WEKA

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- WEKA: A Machine Learning Toolkit
- The Explorer
 - Classification and Regression
 - Clustering
 - Association Rules
 - Attribute Selection
 - Data Visualization
- The Experimenter
- The Knowledge Flow GUI
- Conclusions

WEKA: the bird



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WEKA: the software

- Machine learning/data mining software written in Java (distributed under the GNU Public License)
- Used for research, education, and applications
- Complements “Data Mining” by Witten & Frank
- Main features:
 - ◆ Comprehensive set of data pre-processing tools, learning algorithms and evaluation methods
 - ◆ Graphical user interfaces (incl. data visualization)
 - ◆ Environment for comparing learning algorithms

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WEKA: versions

- There are several versions of WEKA:
 - ◆ WEKA 3.0: “book version” compatible with description in data mining book
 - ◆ WEKA 3.2: “GUI version” adds graphical user interfaces (book version is command-line only)
 - ◆ WEKA 3.3: “development version” with lots of improvements
- This talk is based on the latest snapshot of WEKA 3.3 (soon to be WEKA 3.4)

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WEKA only deals with “flat” files

```
@relation heart-disease-simplified
```

```
@attribute age numeric
```

```
@attribute sex { female, male}
```

```
@attribute chest_pain_type { typ_angina, asympt, non_anginal, atyp_angina}
```

```
@attribute cholesterol numeric
```

```
@attribute exercise_induced_angina { no, yes}
```

```
@attribute class { present, not_present}
```

```
@data
```

```
63,male,typ_angina,233,no,not_present
```

```
67,male,asympt,286,yes,present
```

```
67,male,asympt,229,yes,present
```

```
38,female,non_anginal,?,no,not_present
```

```
...
```

Flat file in
ARFF format



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```

```
38,female,non_anginal,?,no,not_present
```

```
...
```

numeric attribute
nominal attribute



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Weka GUI Chooser
Waikato Environment for Knowledge Analysis
(c) 1999 – 2003 University of Waikato New Zealand

GUI

- Simple CLI
- Explorer
- Experimenter
- KnowledgeFlow

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Weka GUI Chooser
Waikato Environment for Knowledge Analysis
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GUI

- Simple CLI
- Explorer
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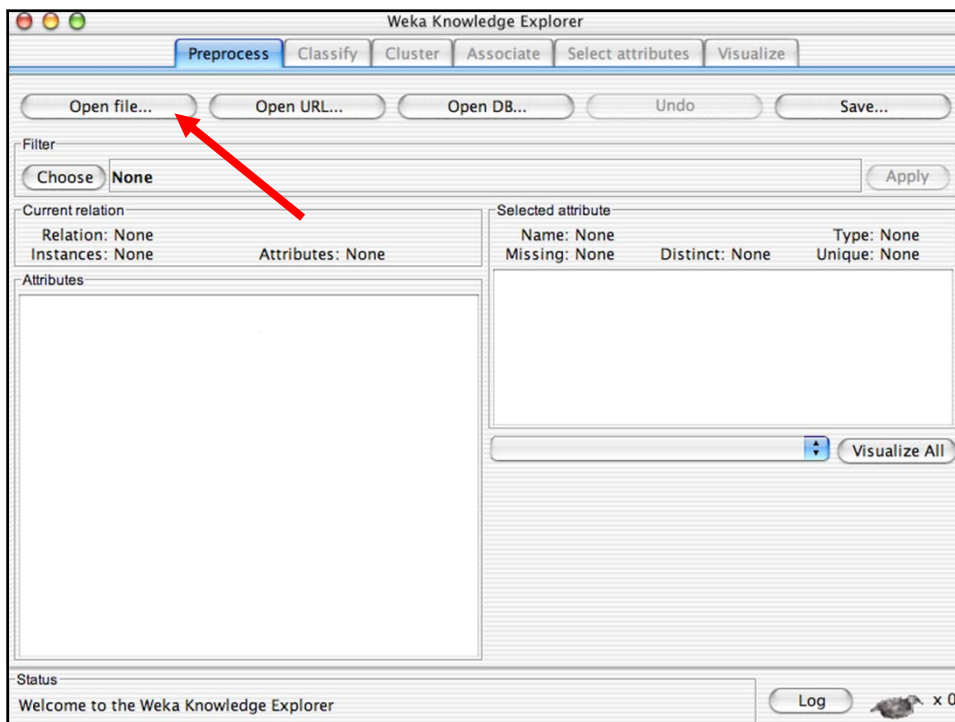
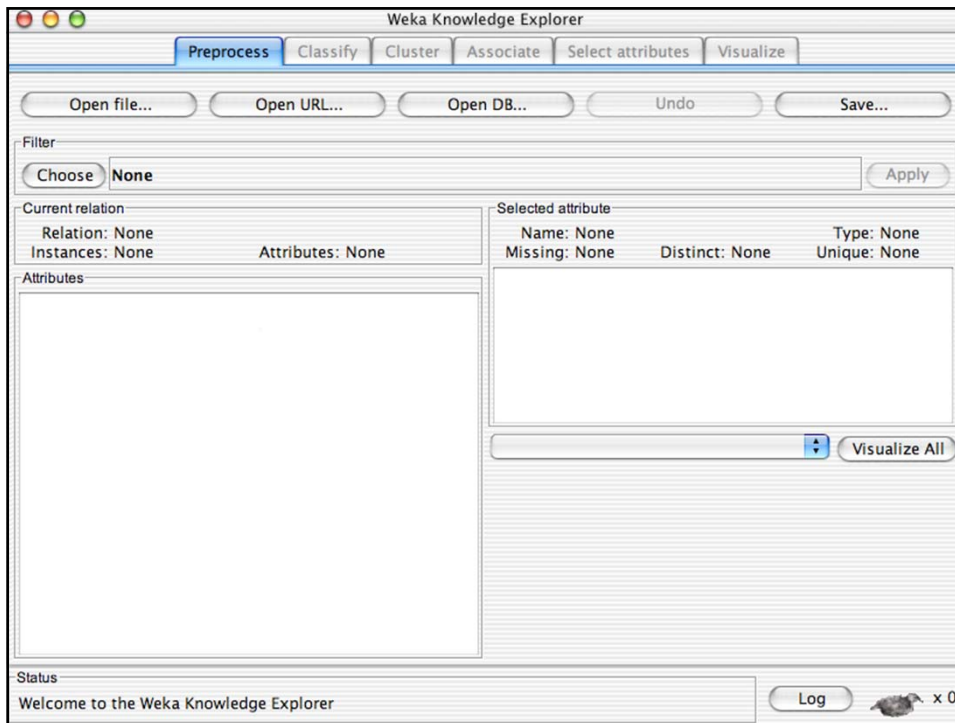
Explorer: pre-processing the data

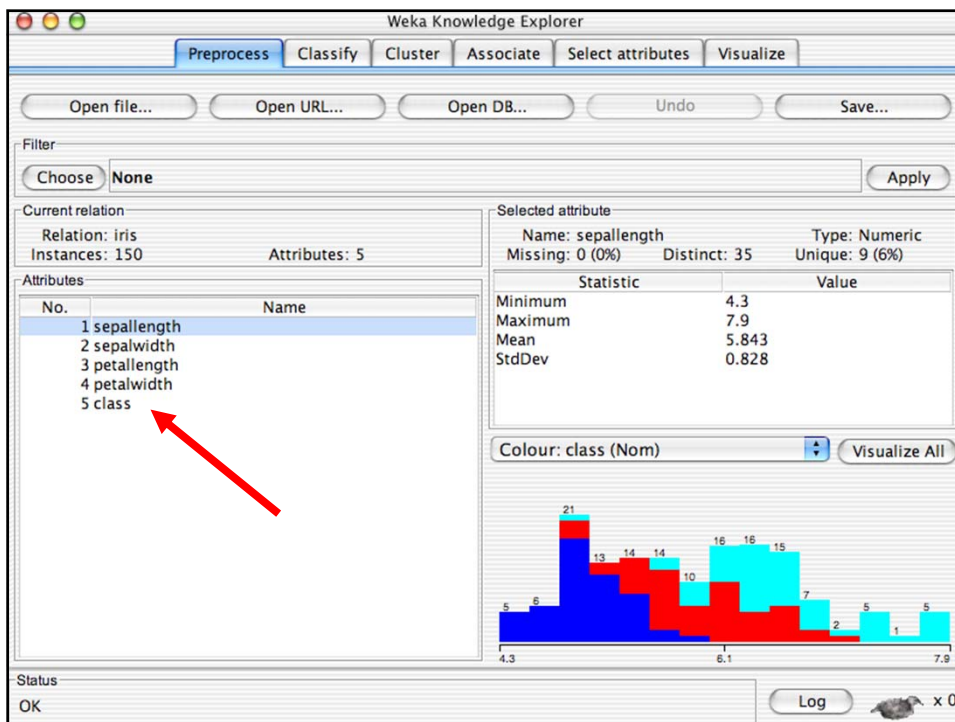
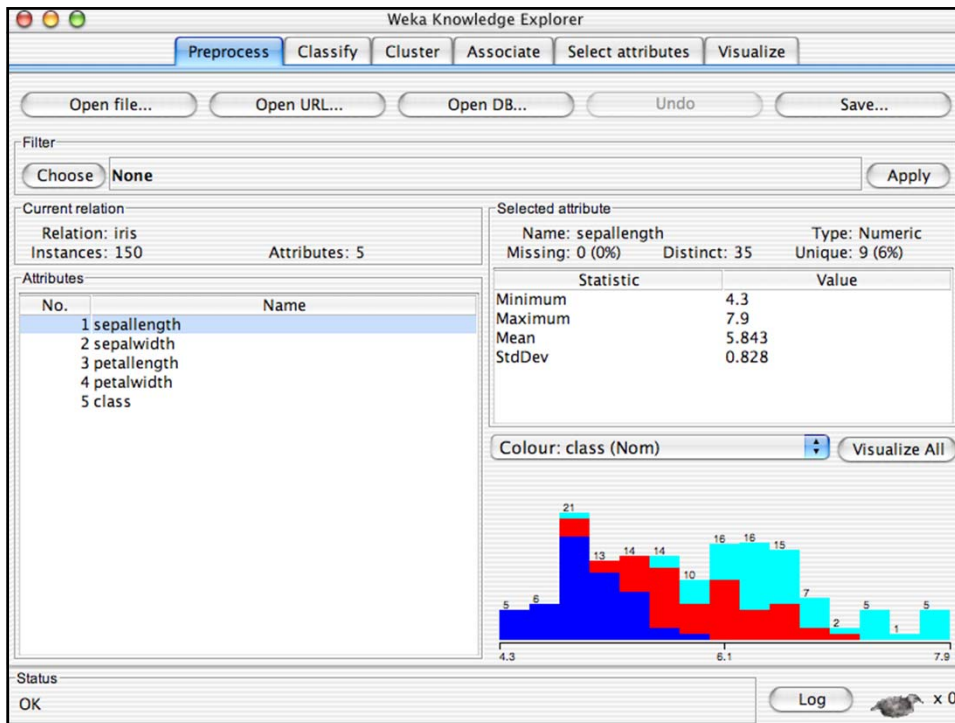
- Data can be imported from a file in various formats: ARFF, CSV, C4.5, binary
- Data can also be read from a URL or from an SQL database (using JDBC)
- Pre-processing tools in WEKA are called “filters”
- WEKA contains filters for:
 - ◆ Discretization, normalization, resampling, attribute selection, transforming and combining attributes, ...

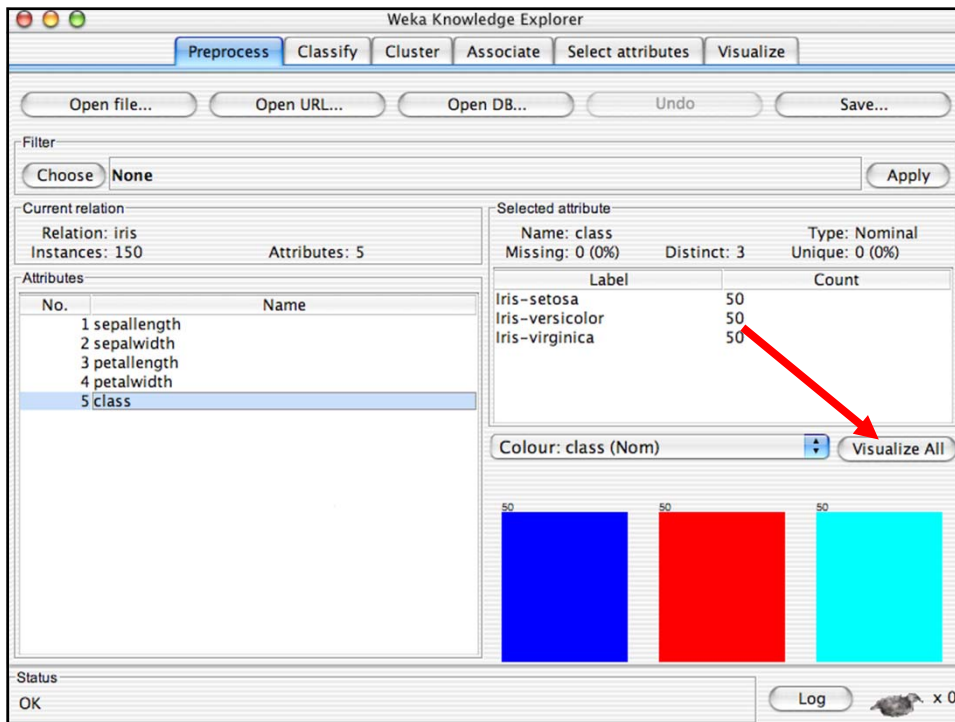
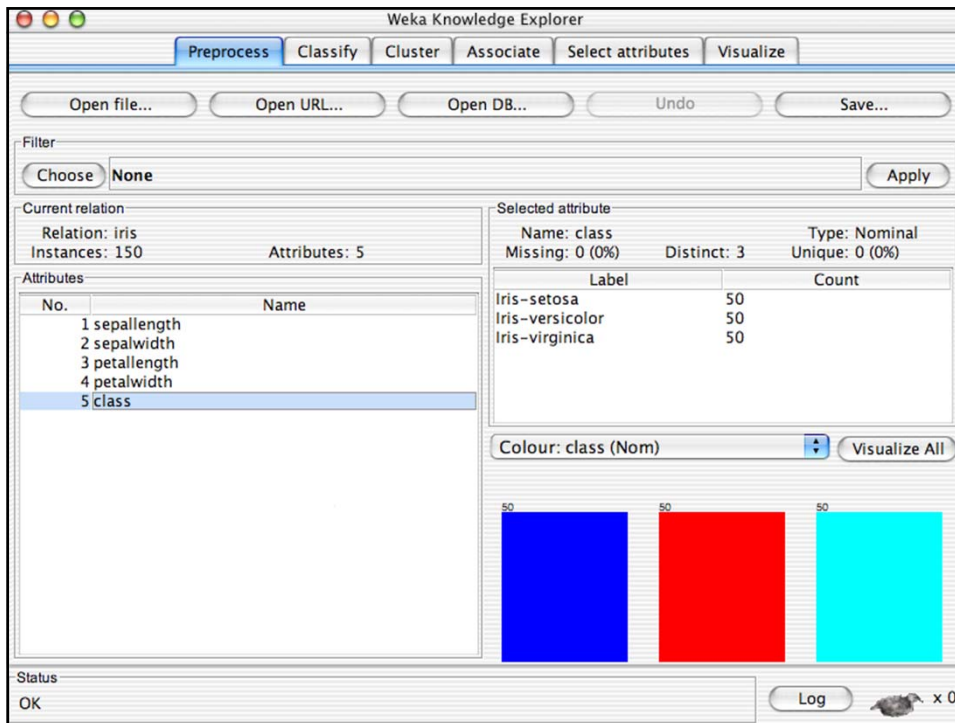
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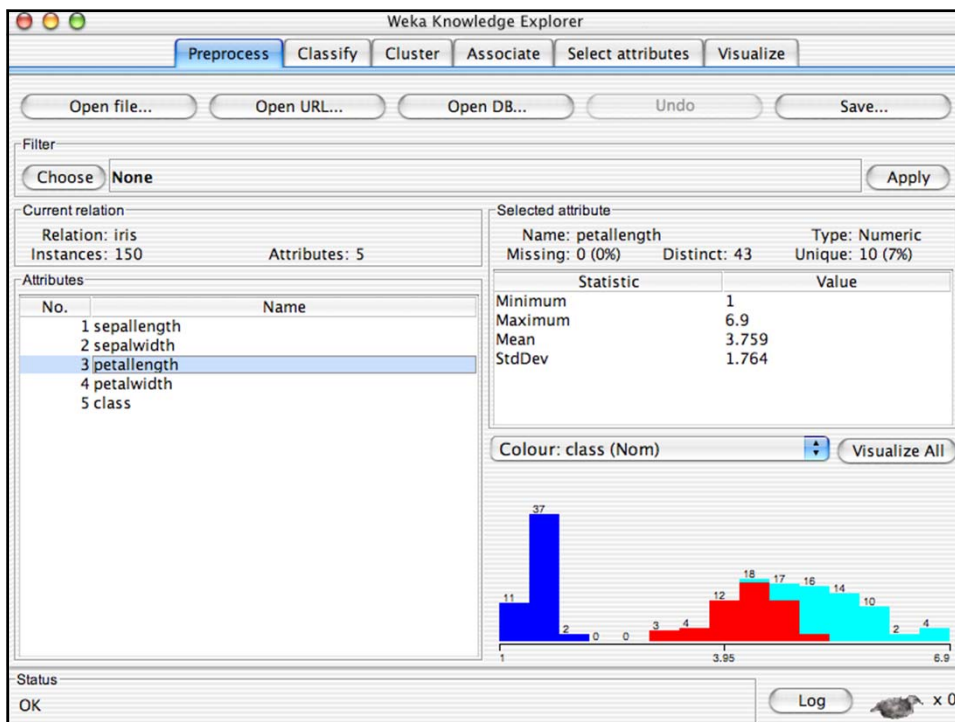
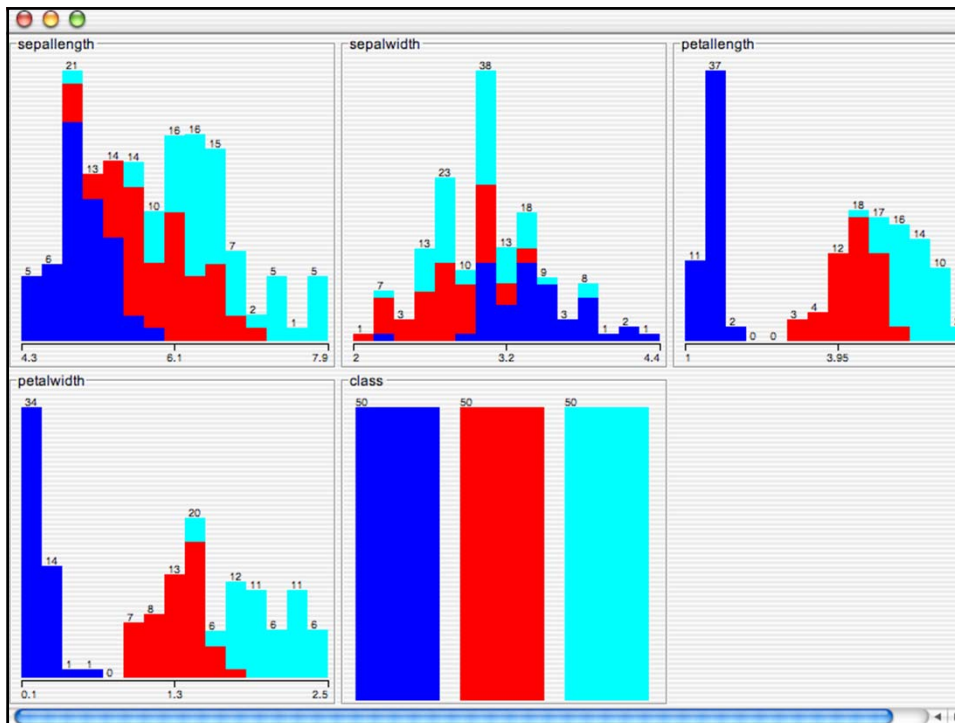
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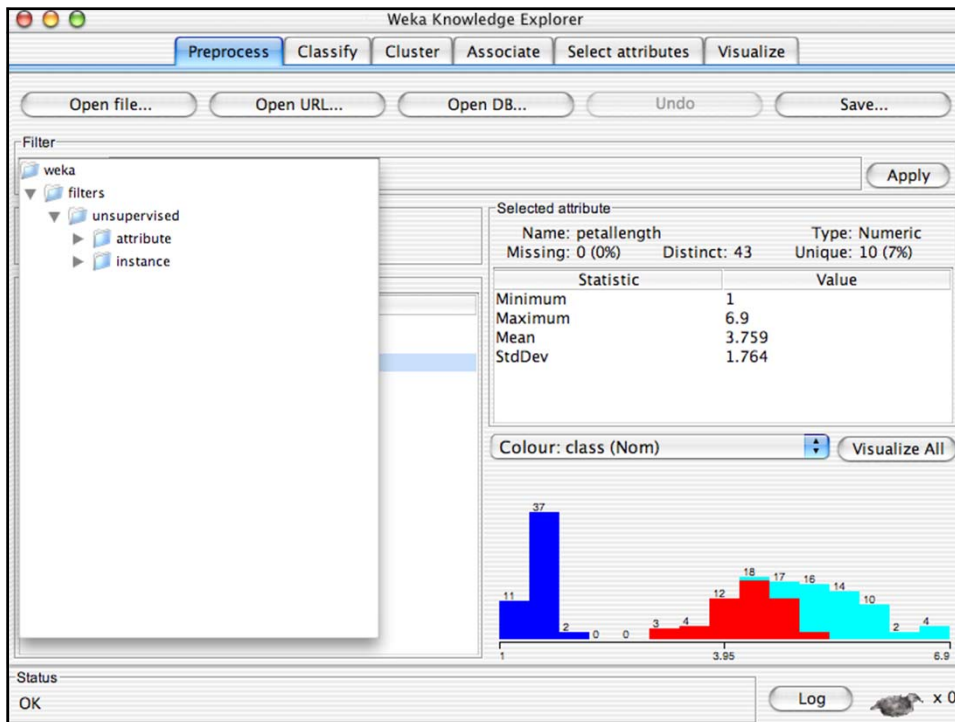
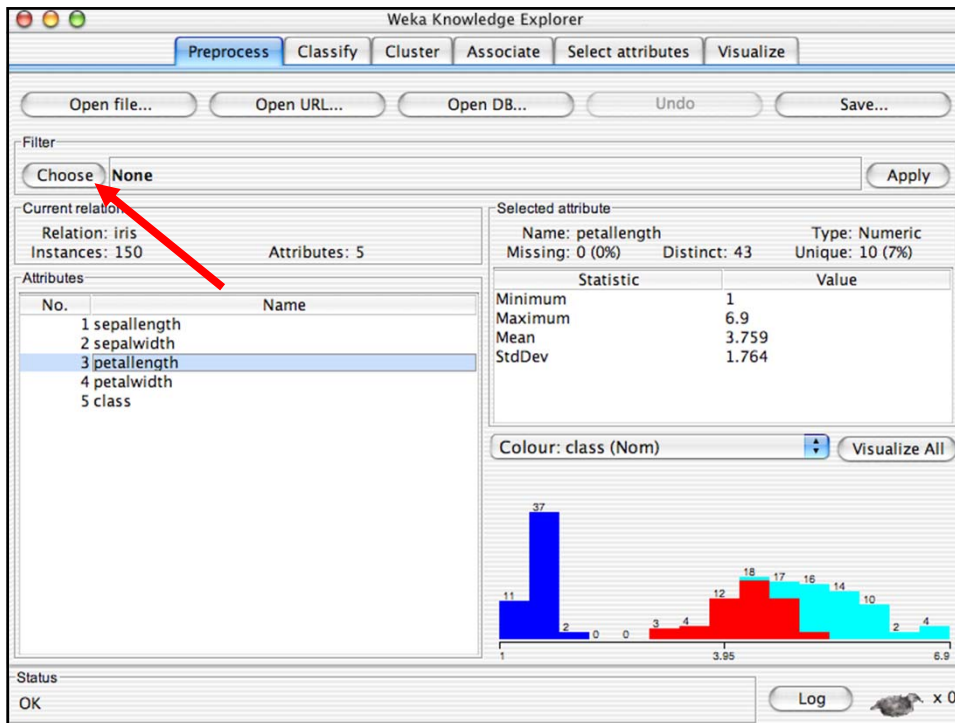
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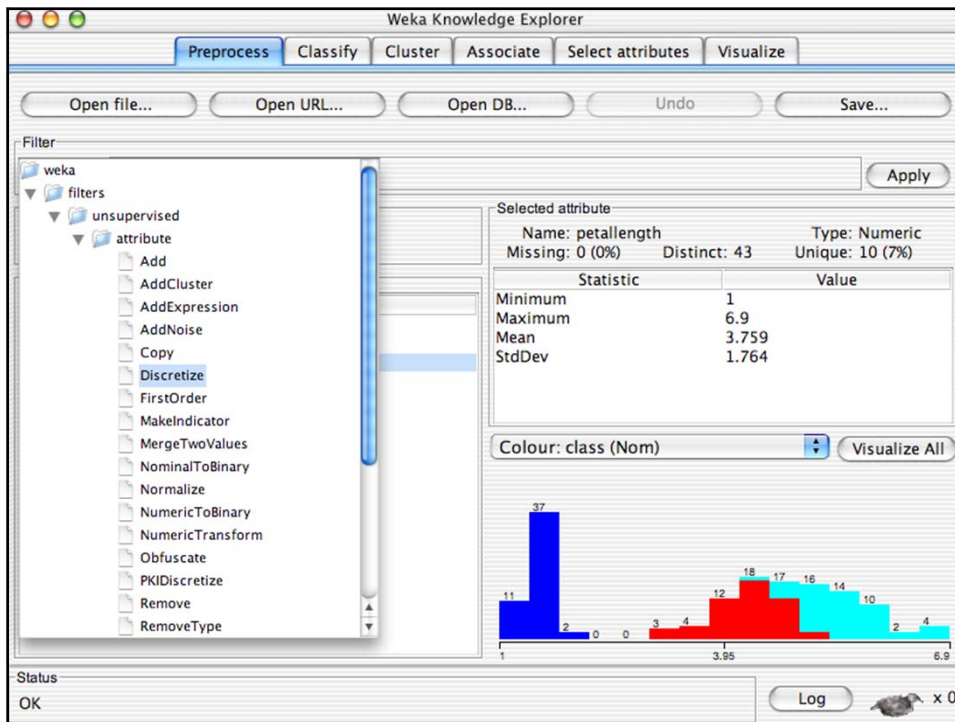
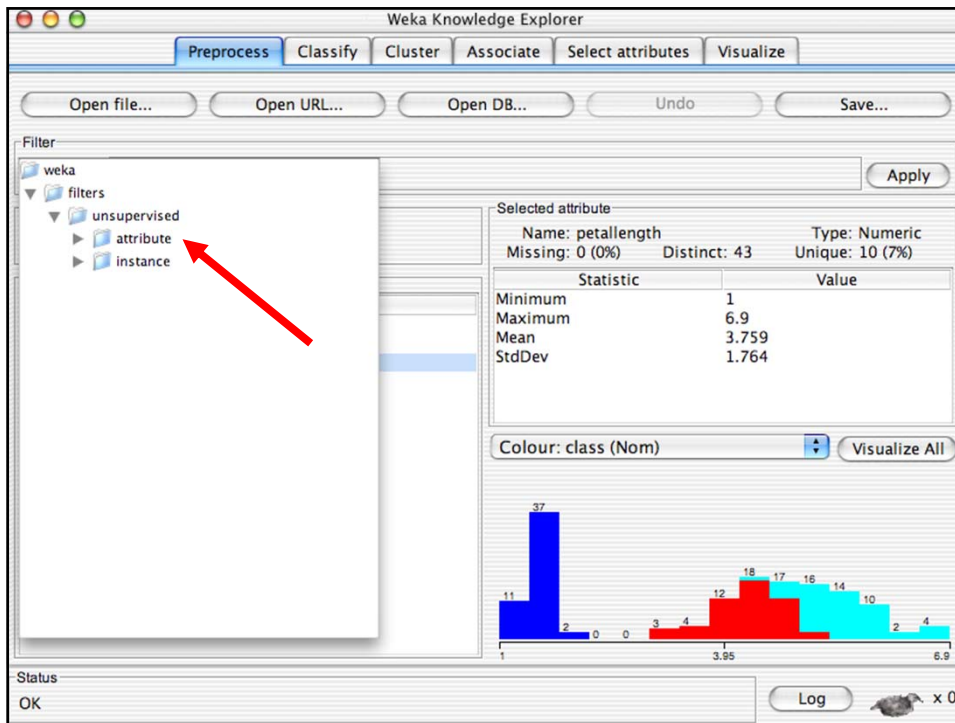


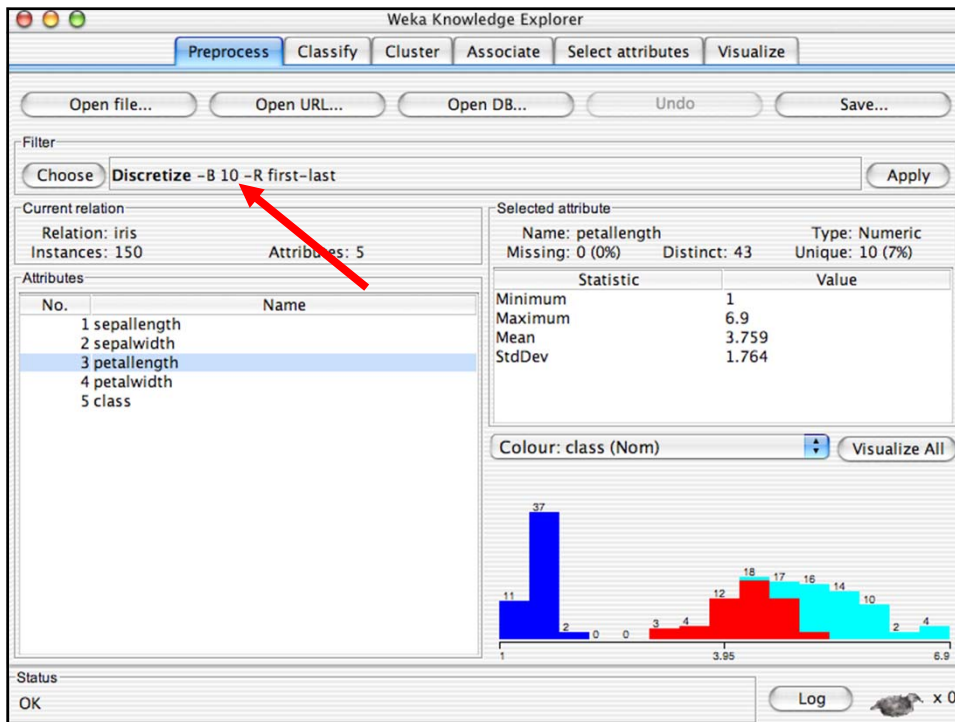
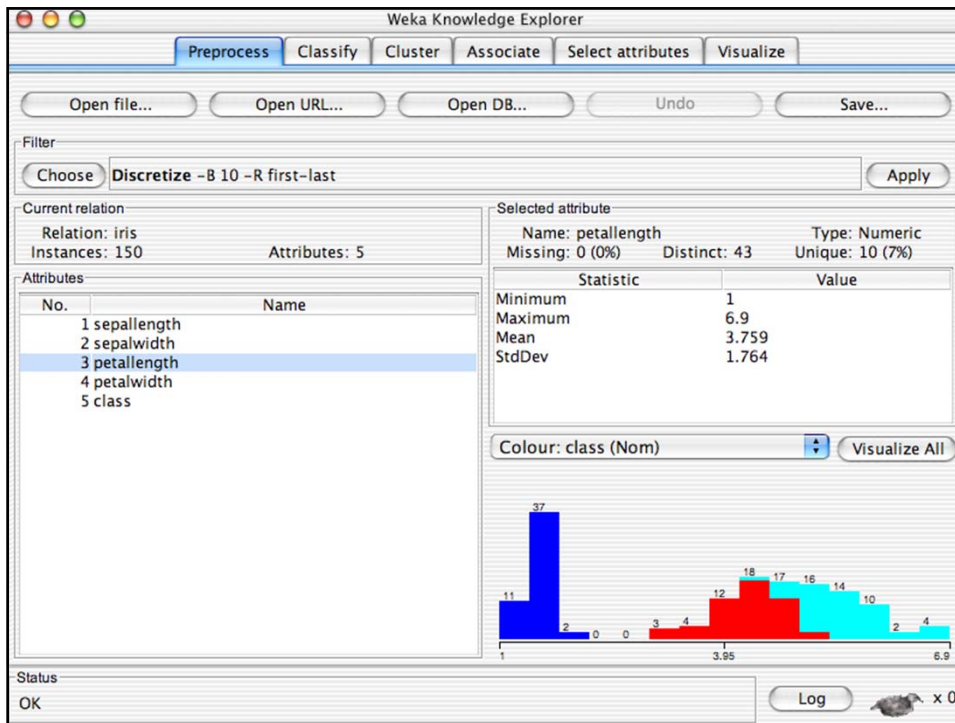


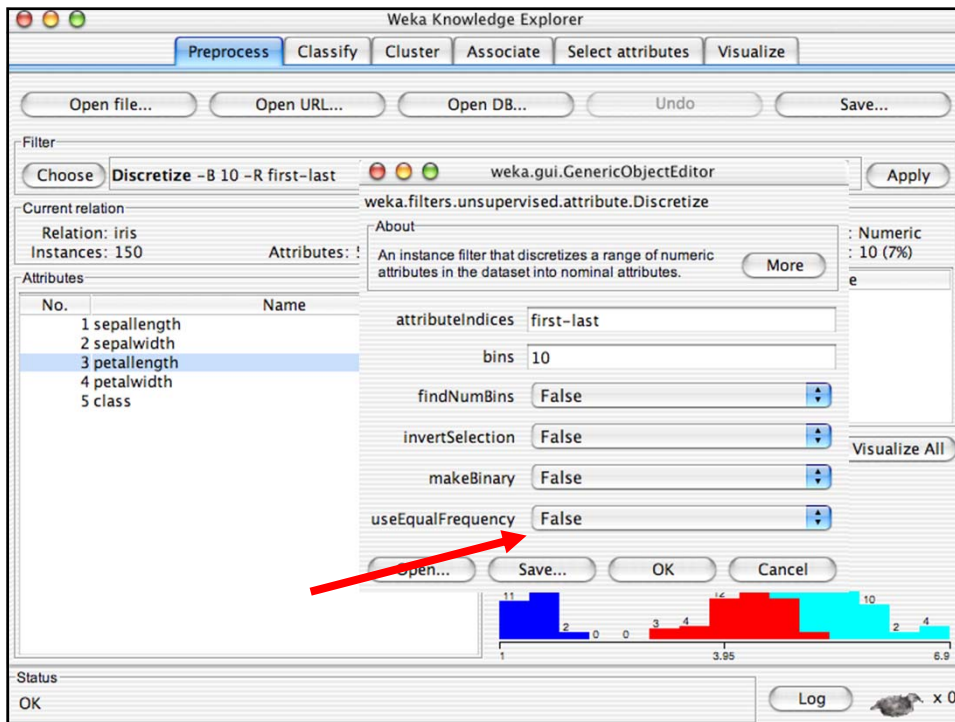
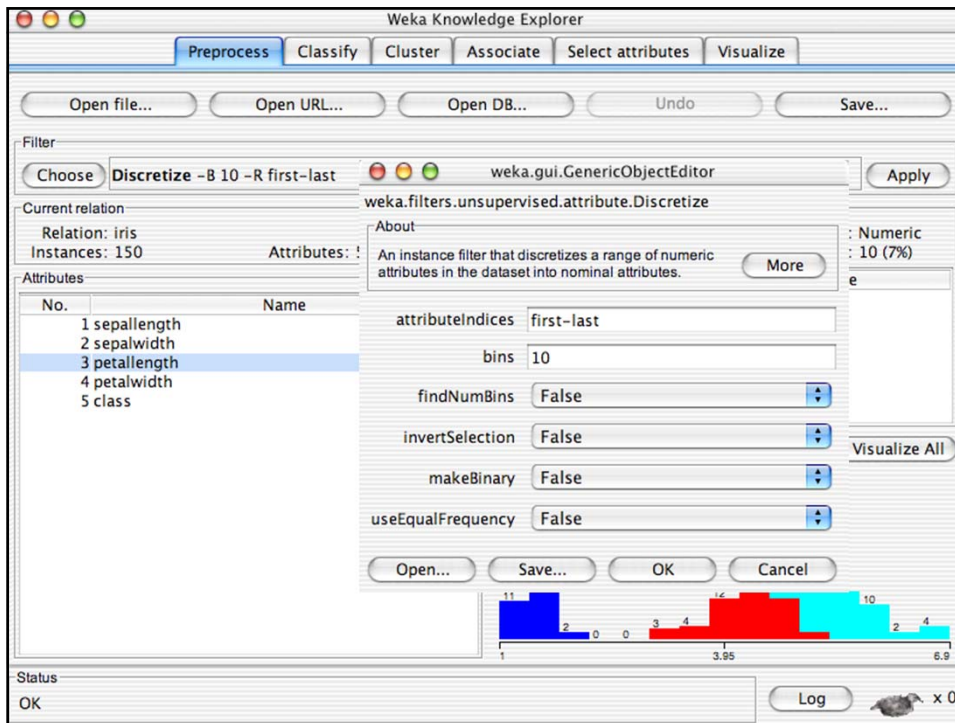


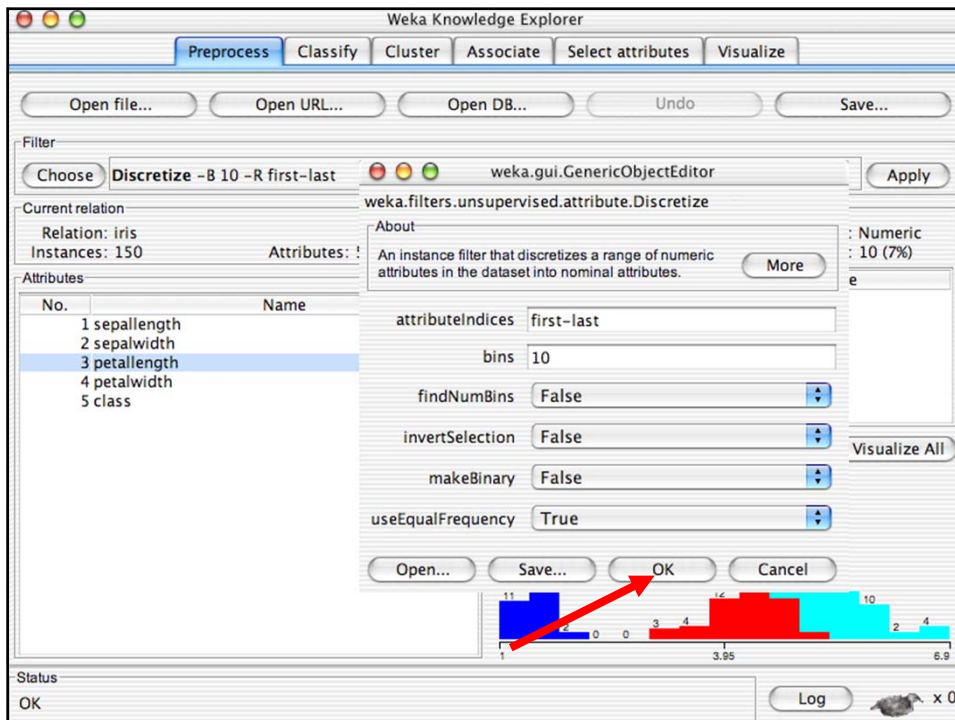
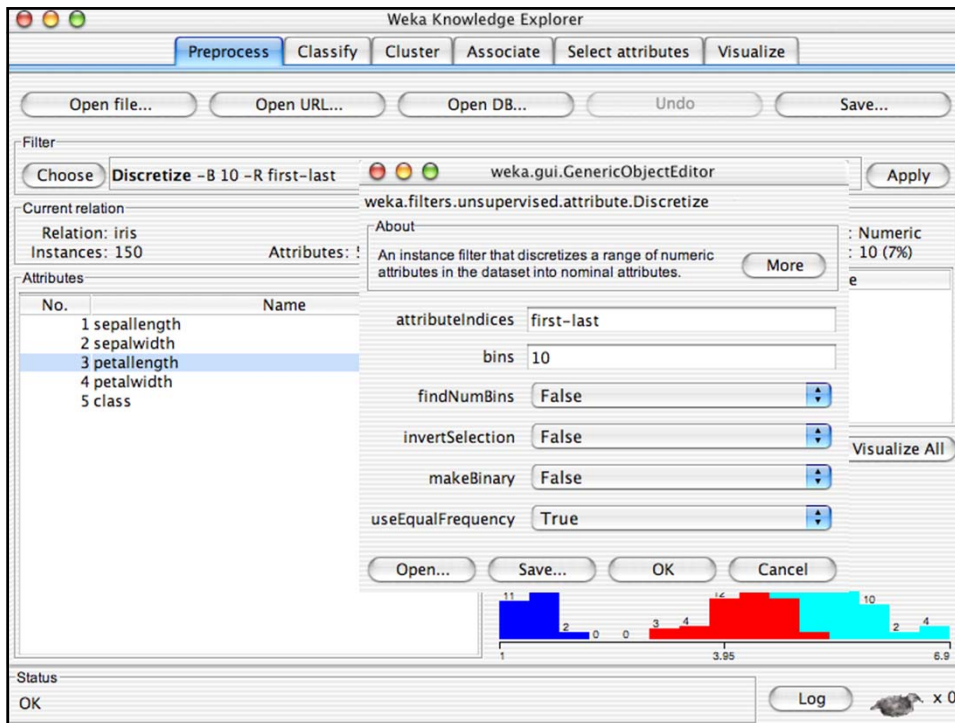


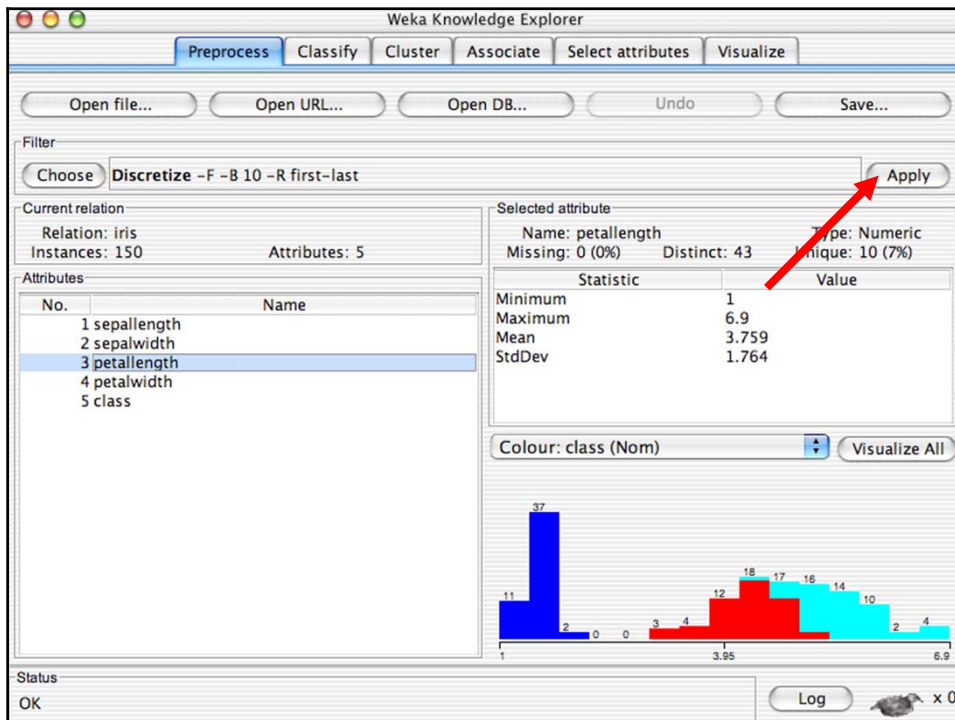
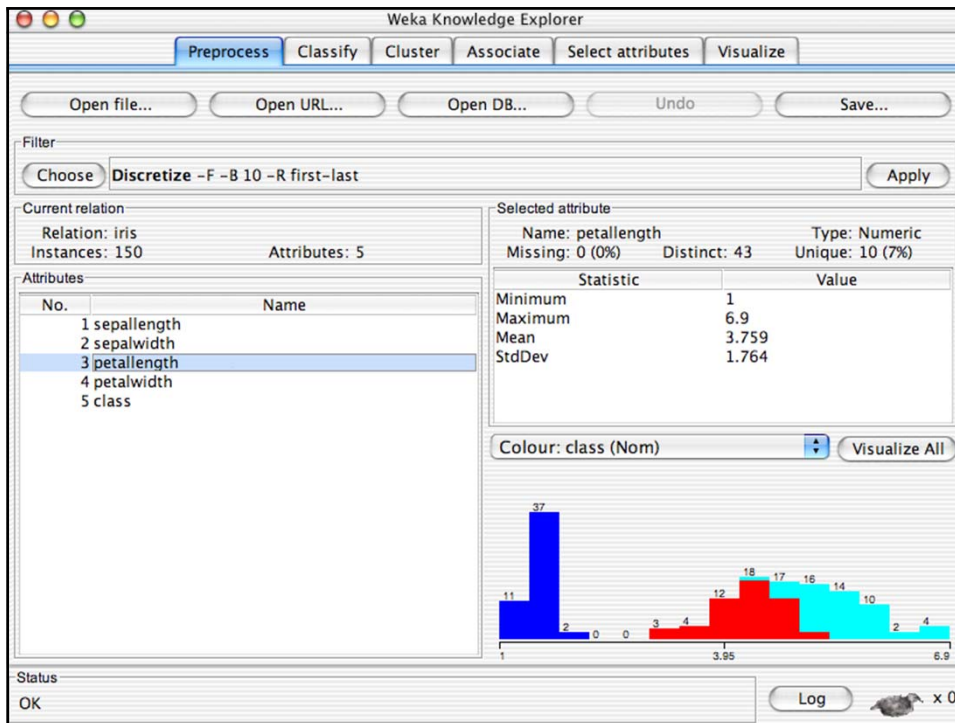


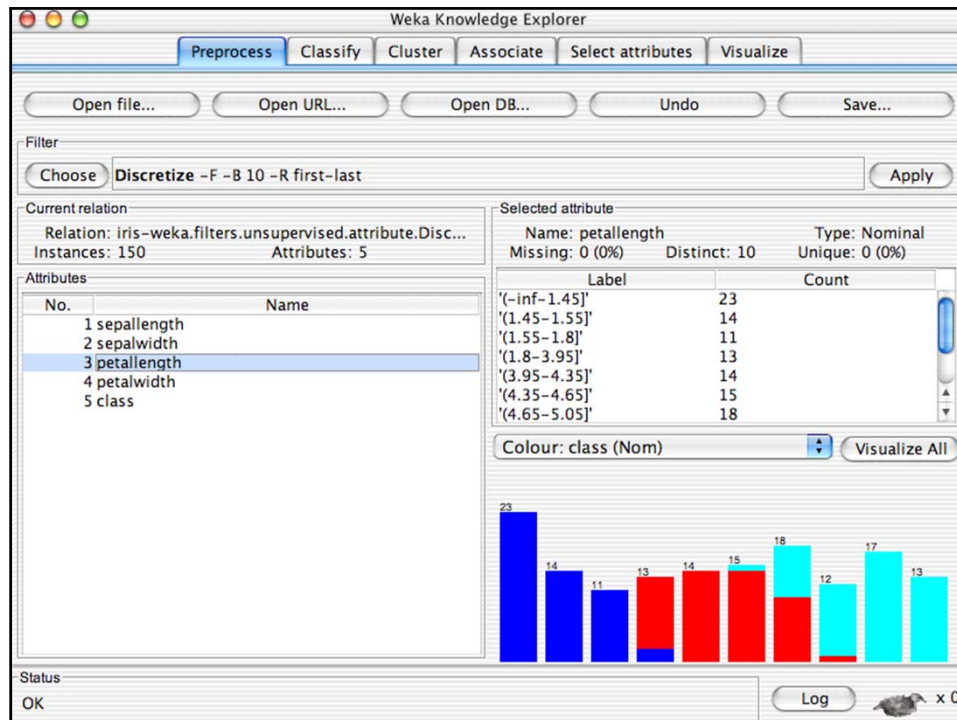






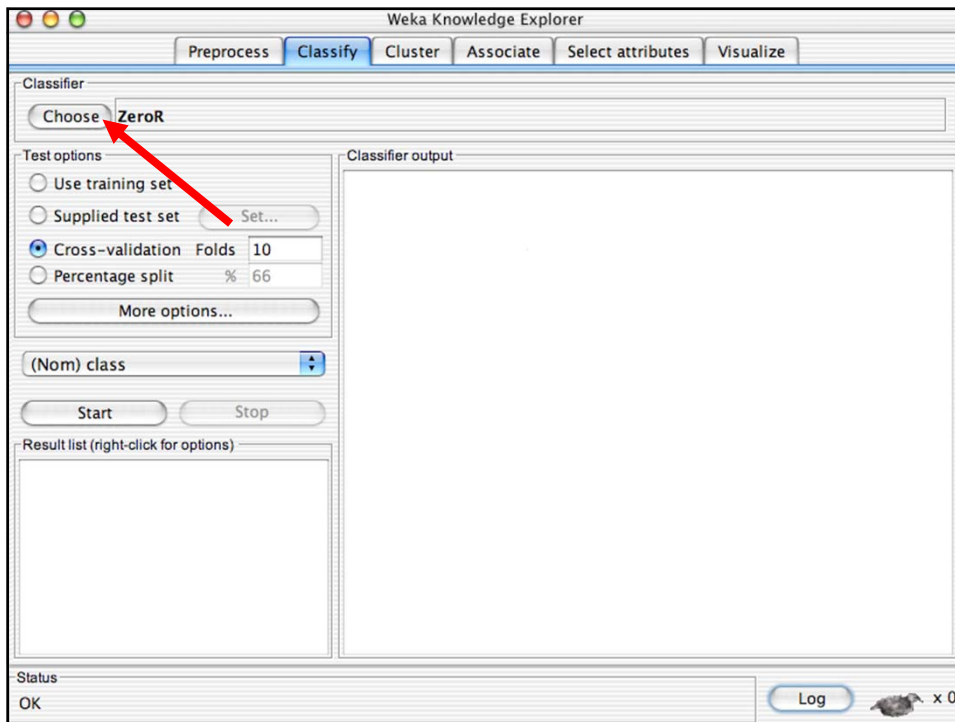
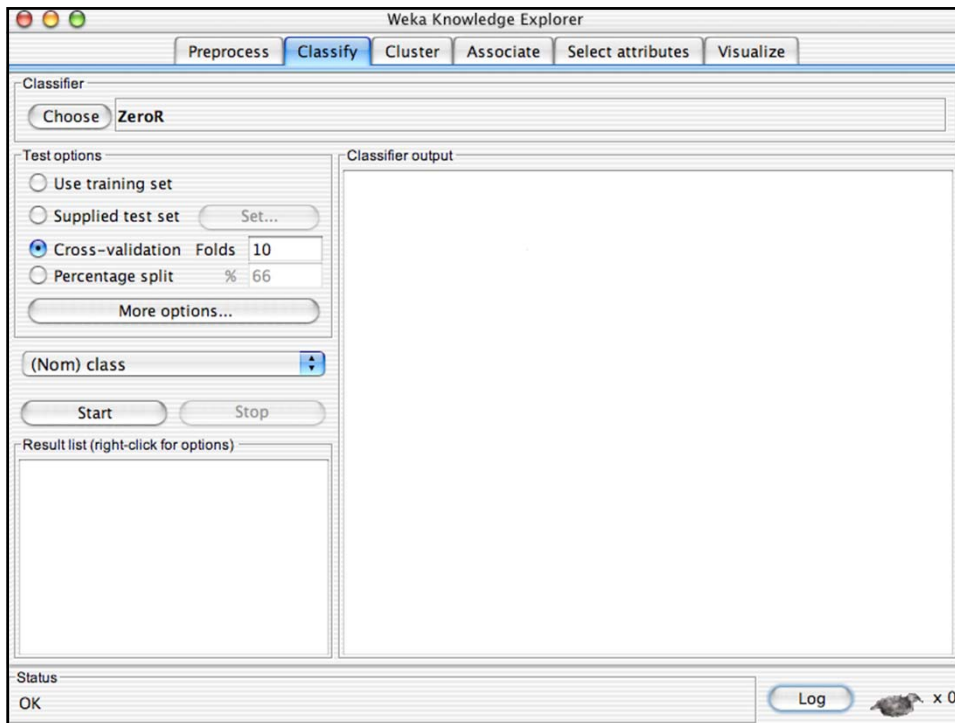


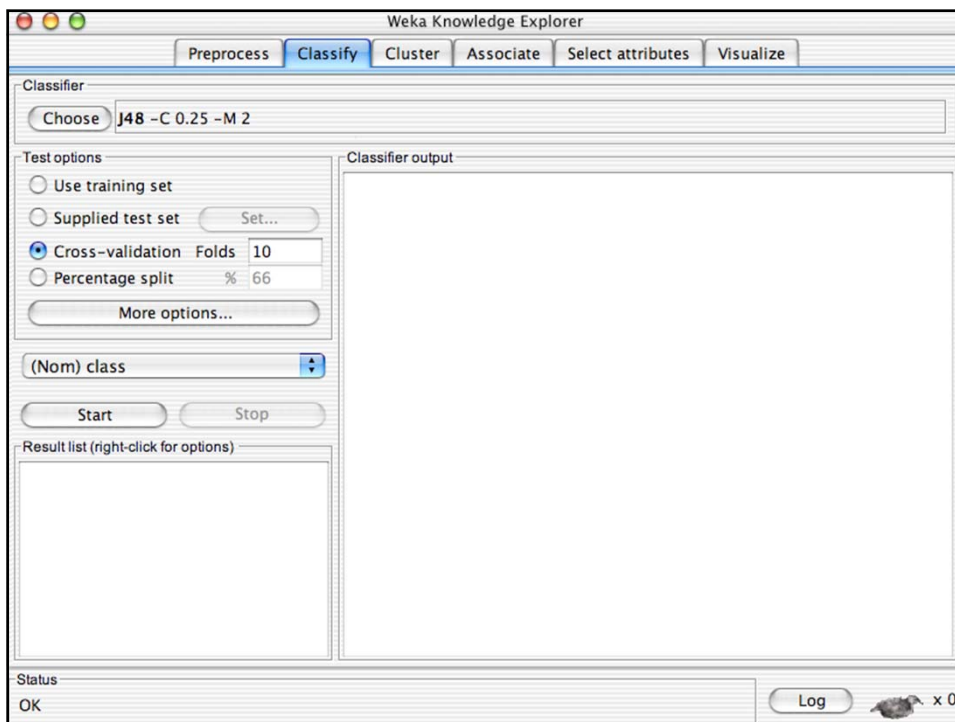
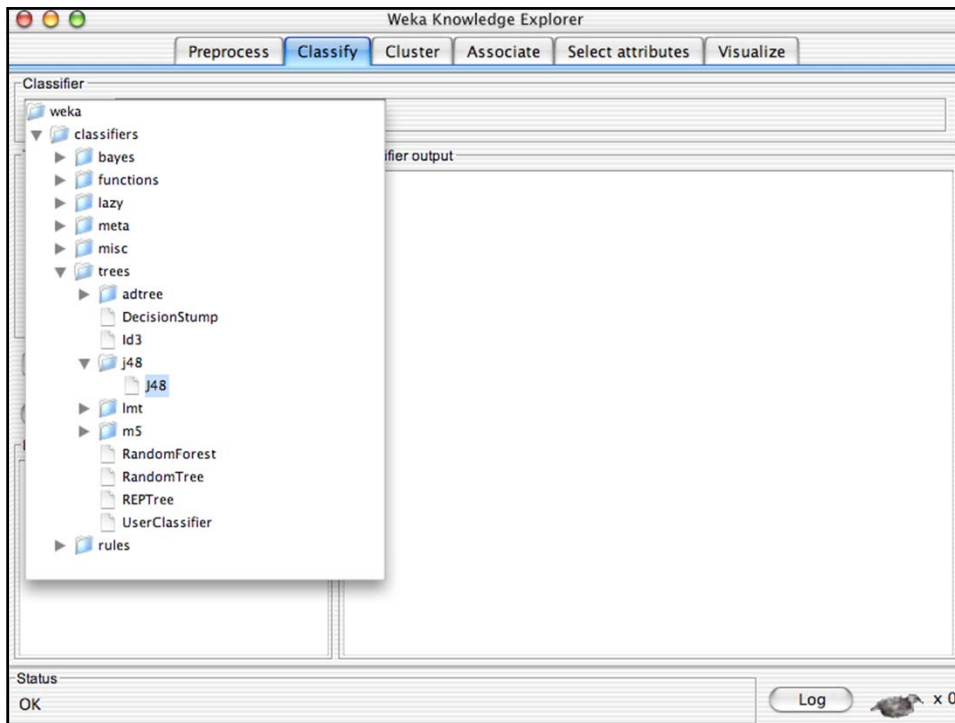


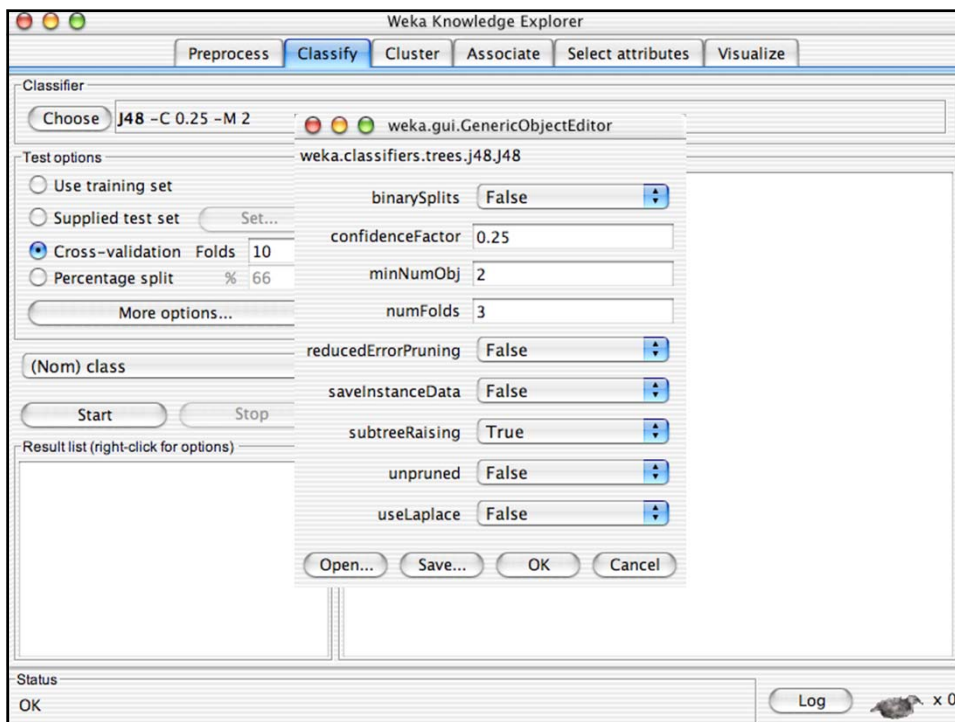
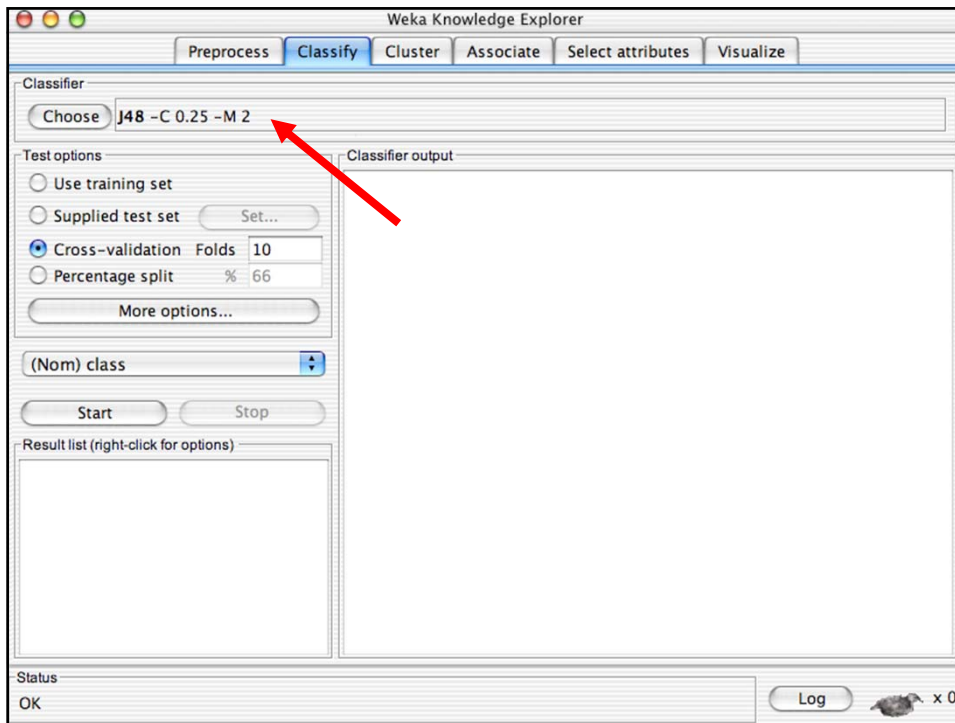


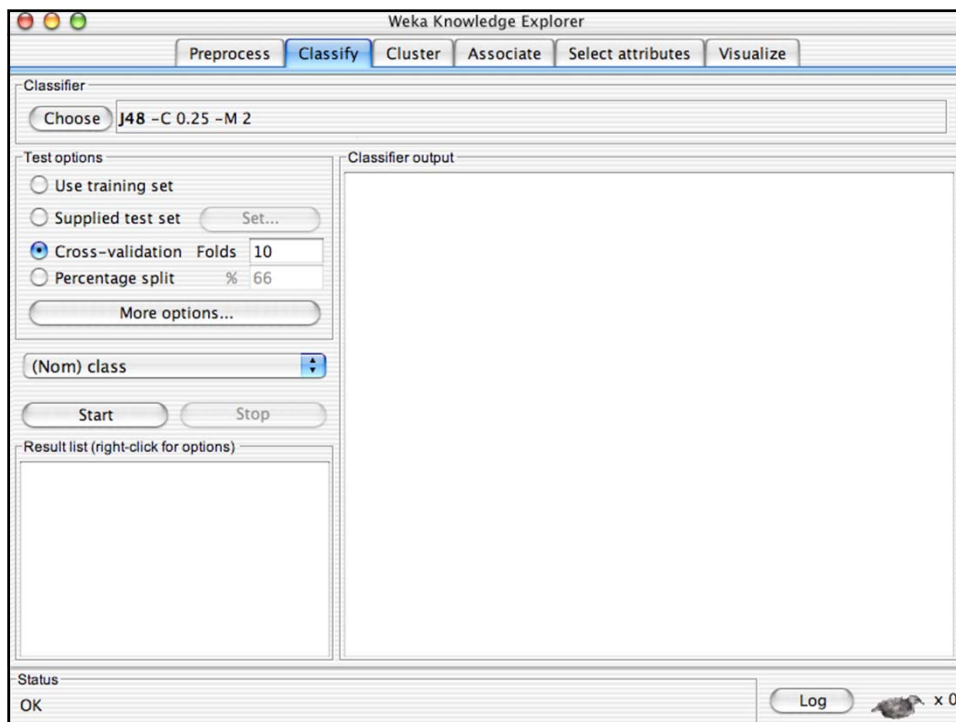
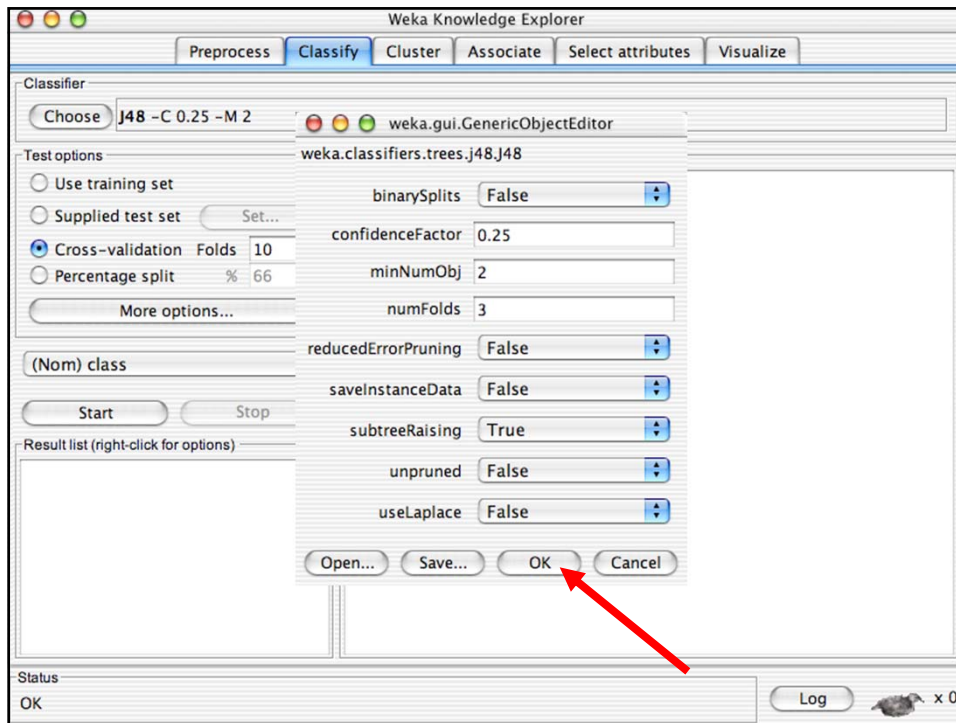
Explorer: building “classifiers”

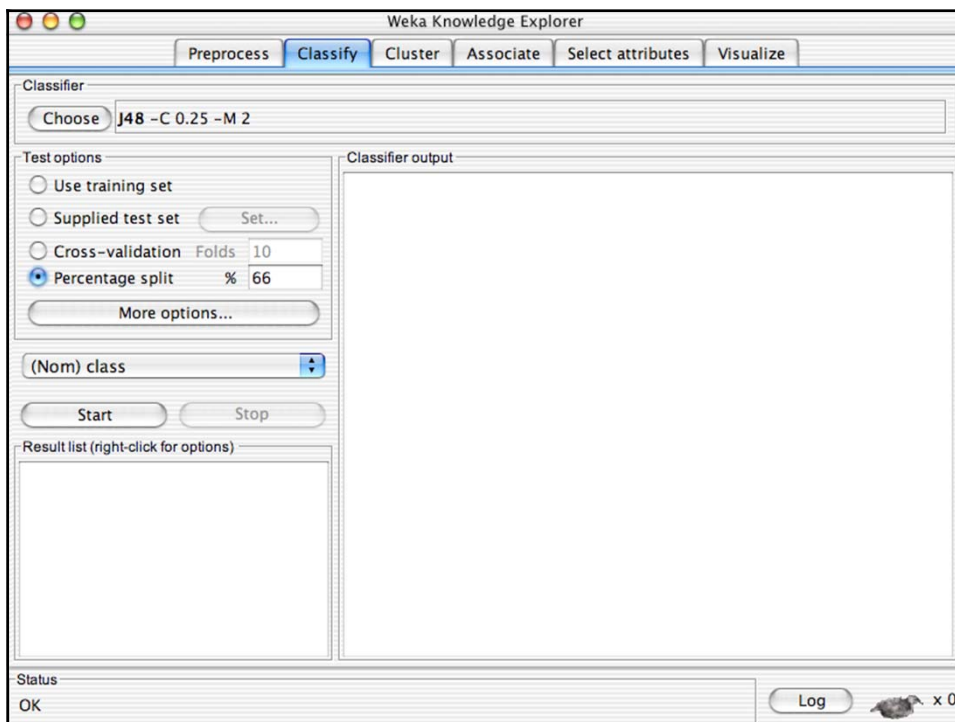
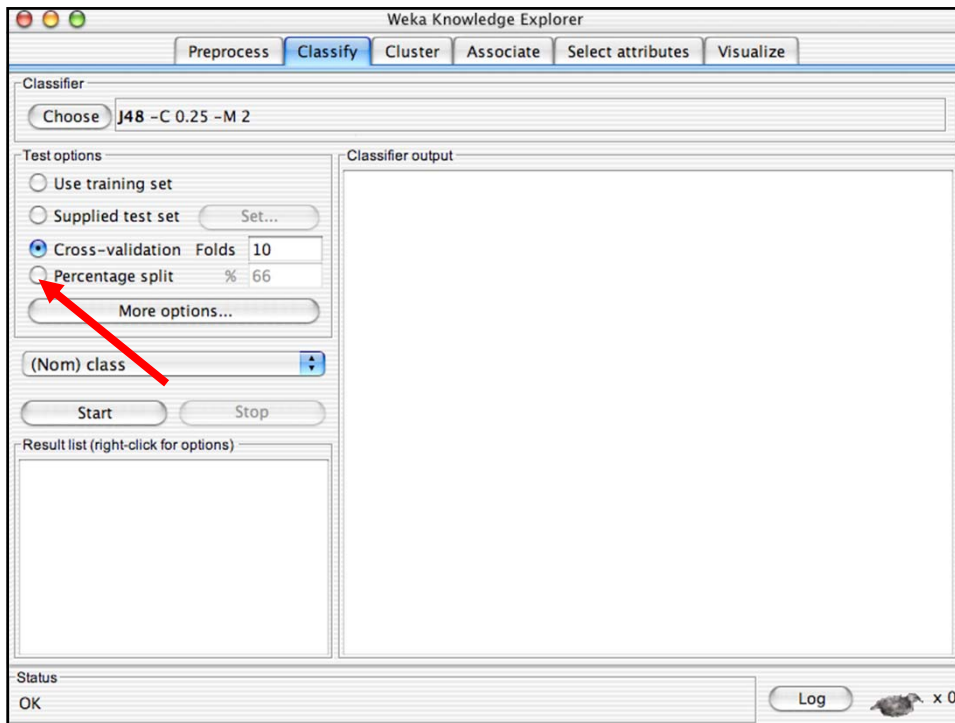
- Classifiers in WEKA are models for predicting nominal or numeric quantities
- Implemented learning schemes include:
 - ◆ Decision trees and lists, instance-based classifiers, support vector machines, multi-layer perceptrons, logistic regression, Bayes’ nets, ...
- “Meta”-classifiers include:
 - ◆ Bagging, boosting, stacking, error-correcting output codes, locally weighted learning, ...

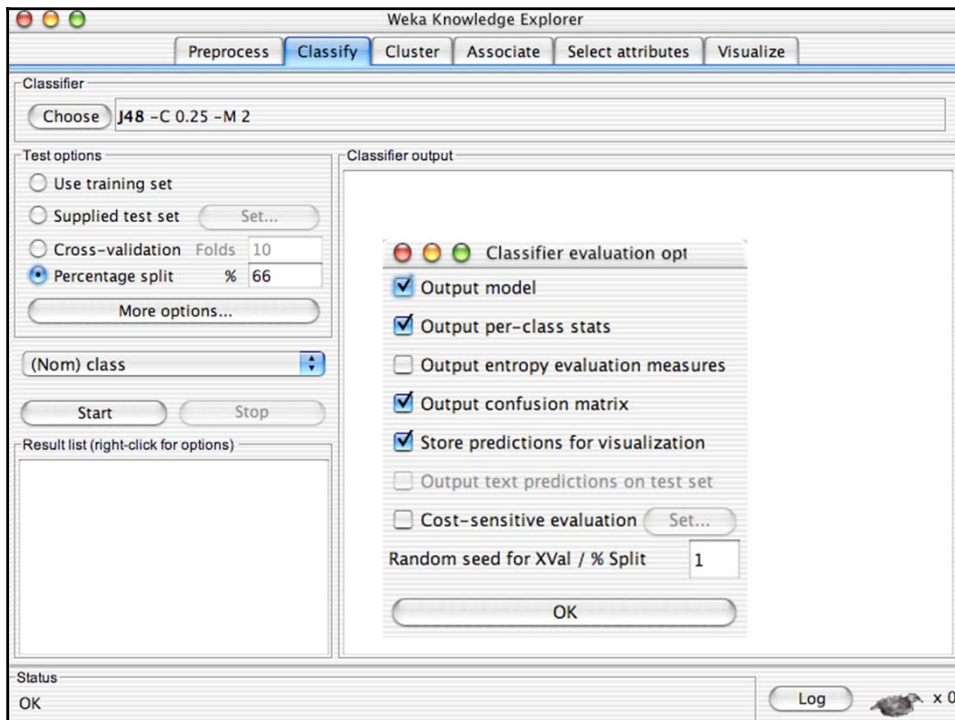
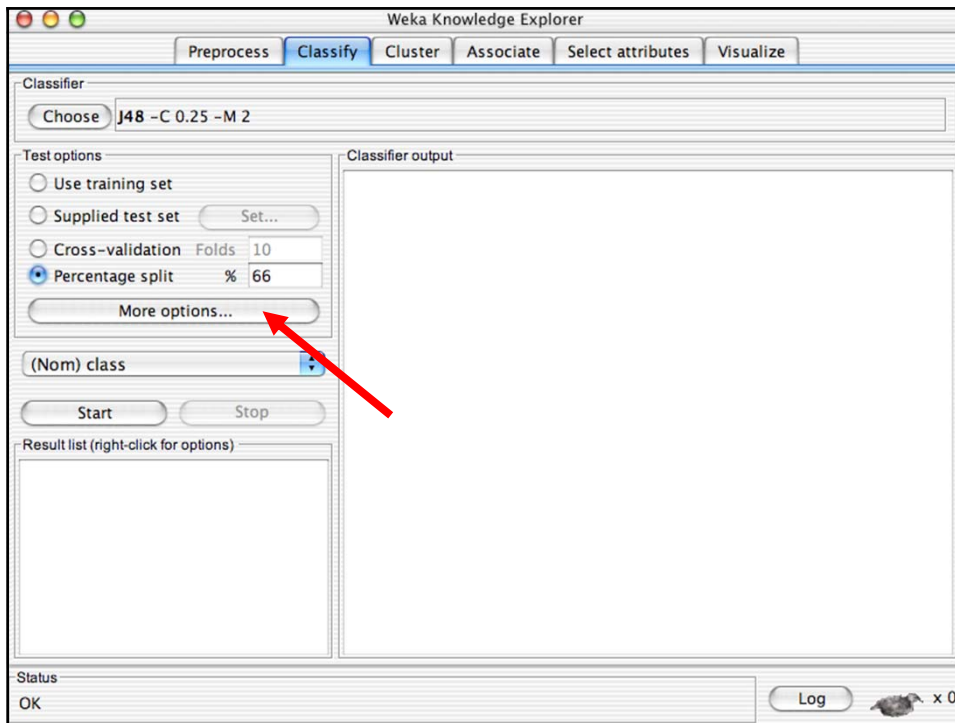


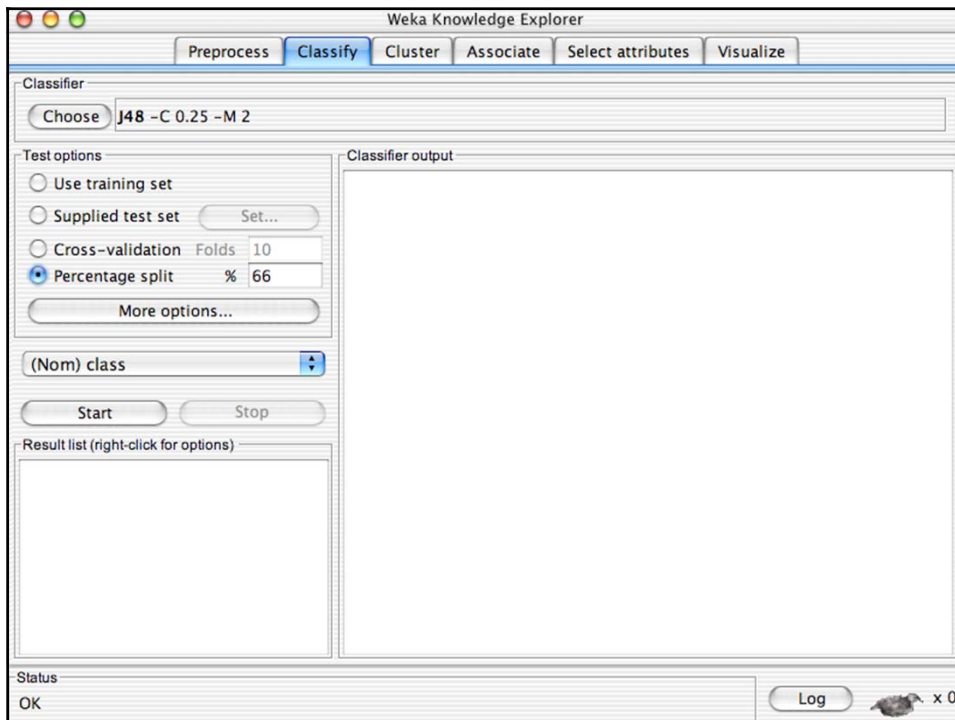
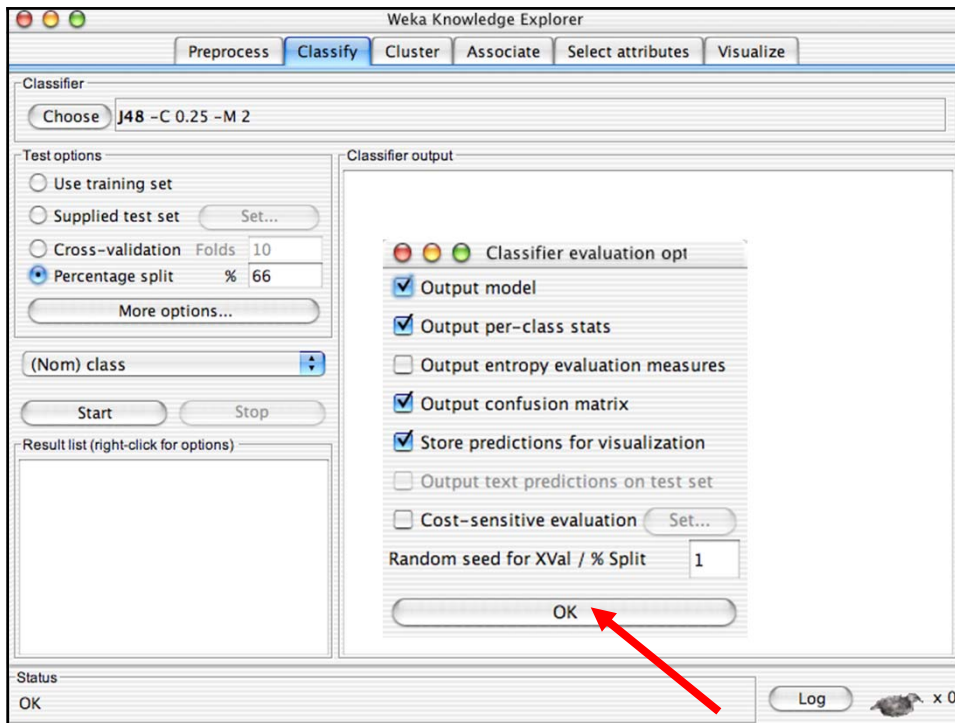


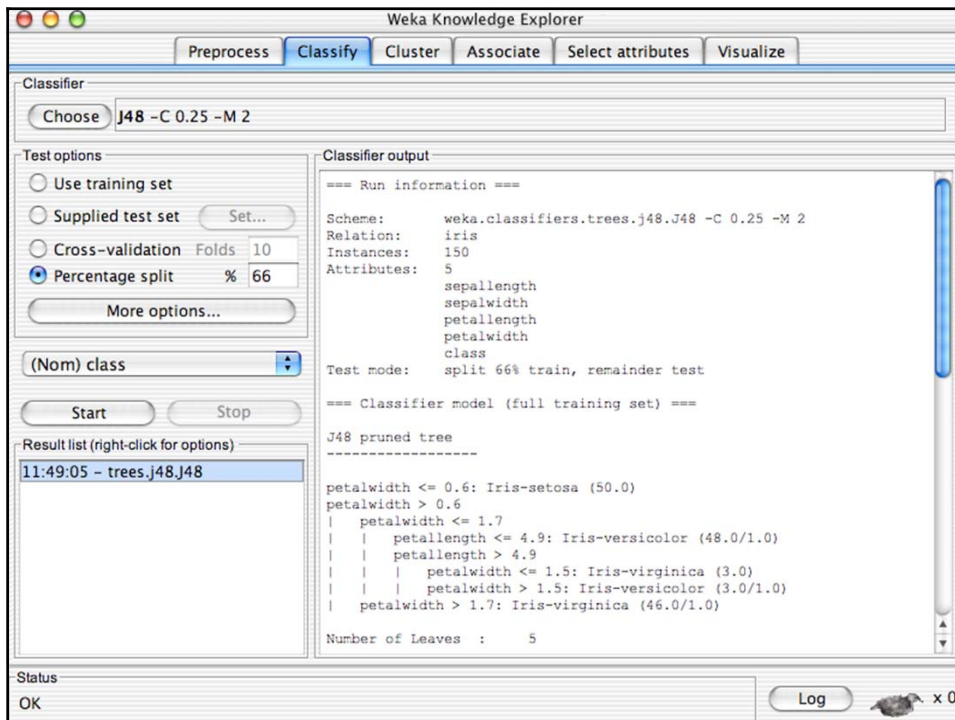
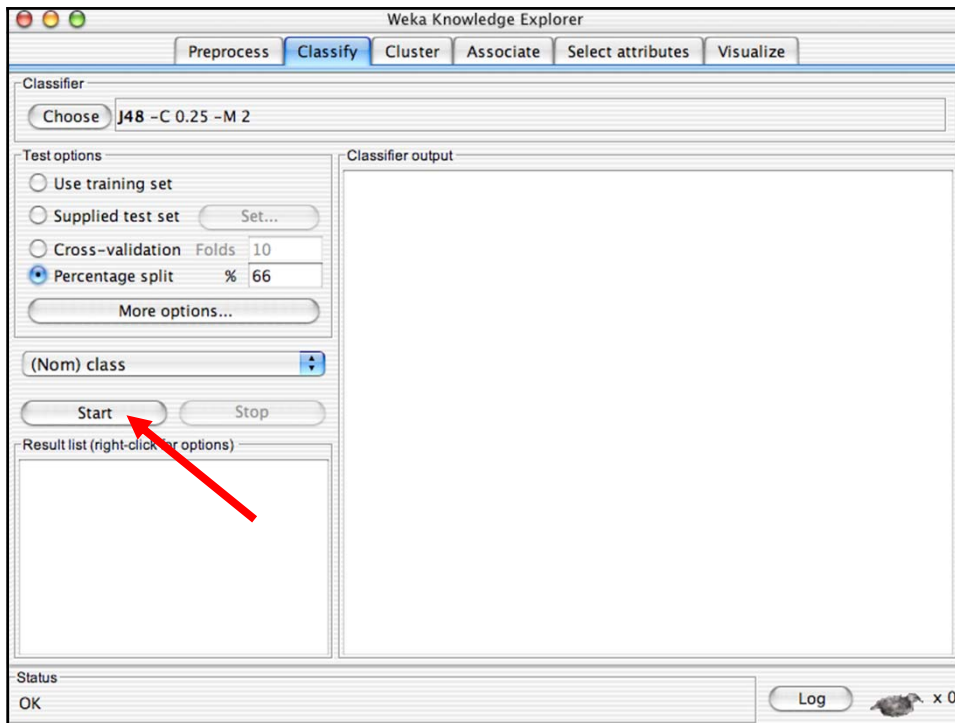


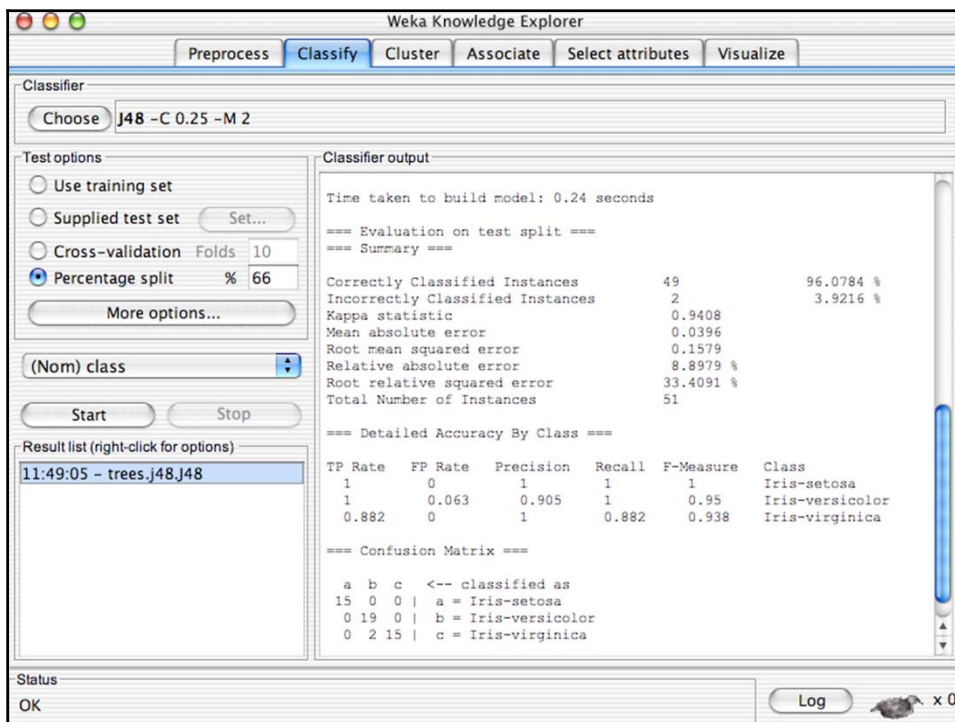
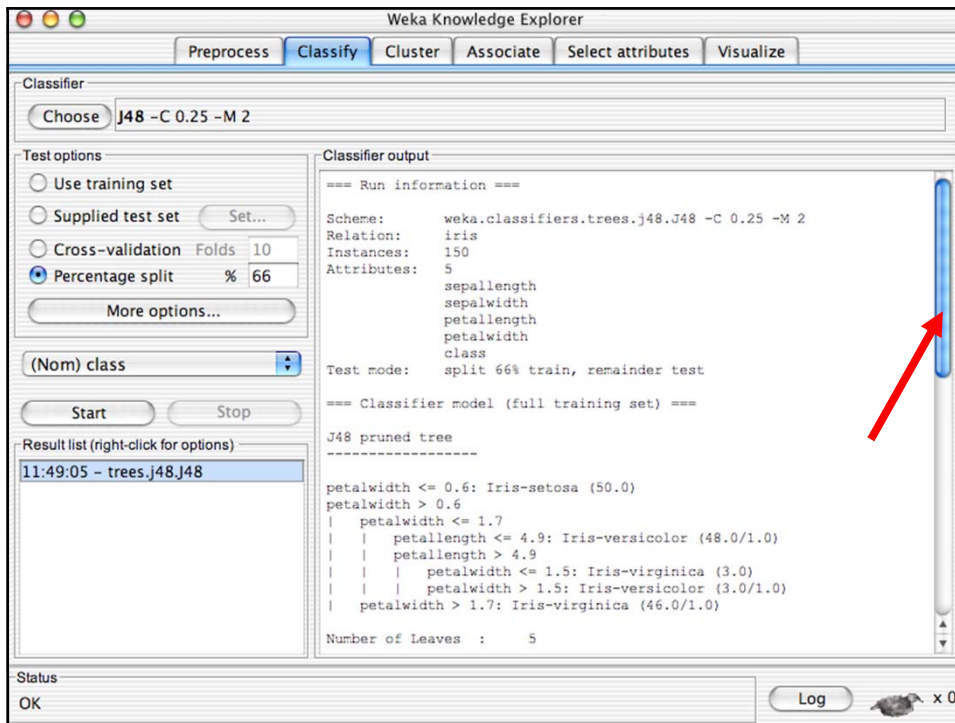


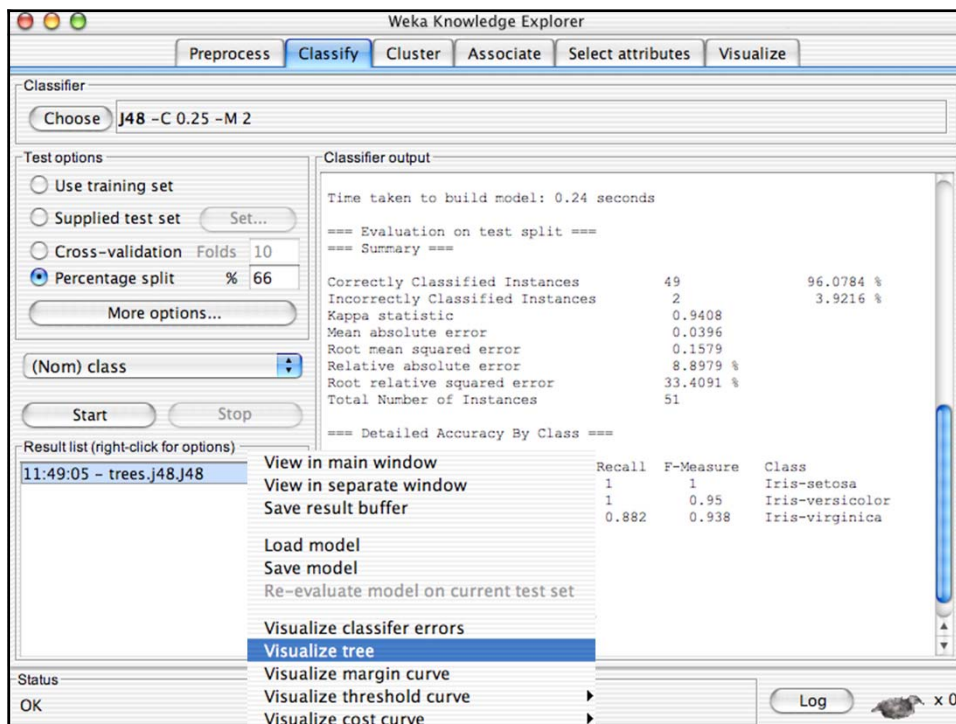
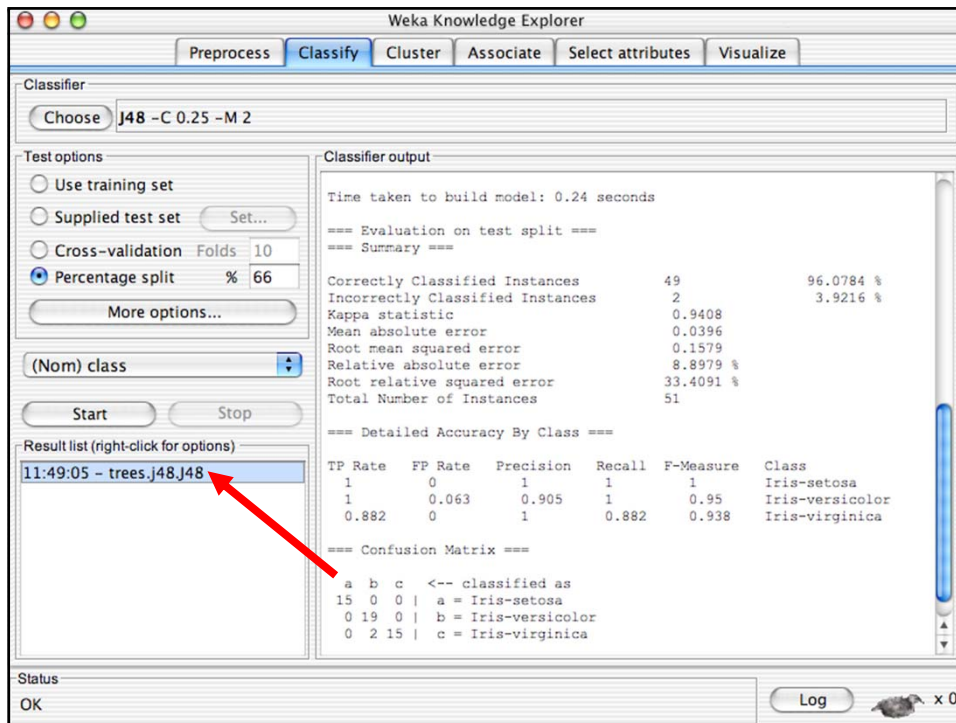


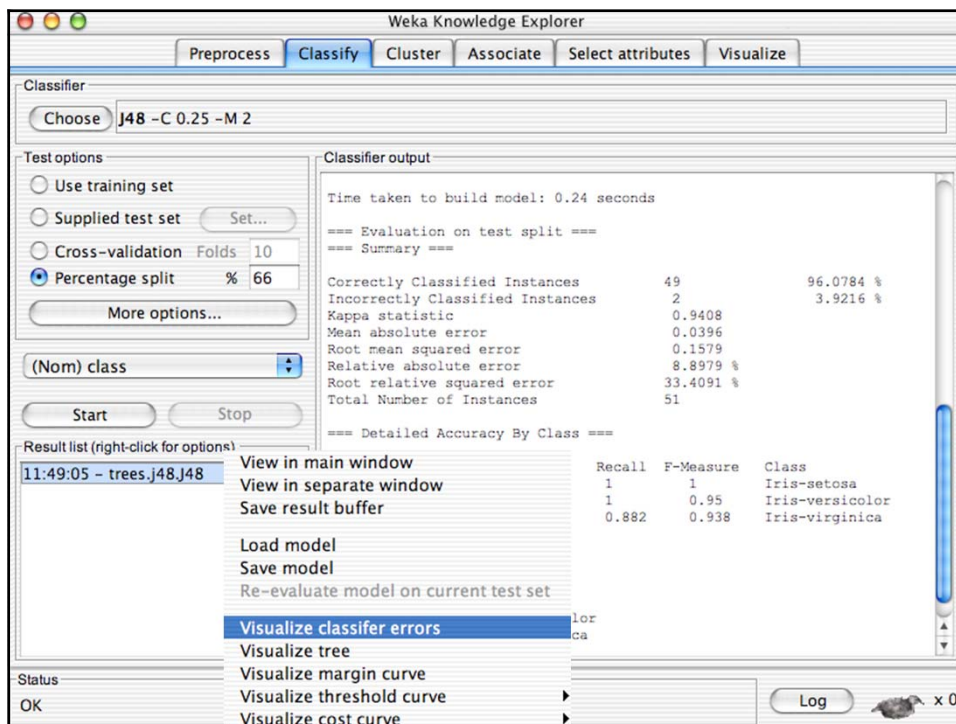
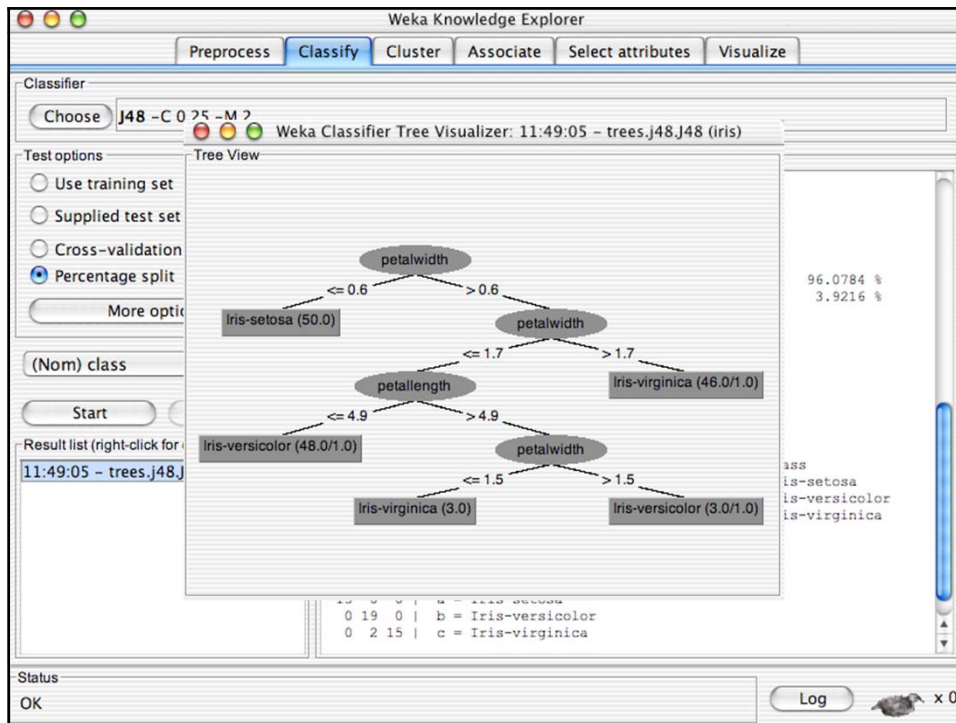


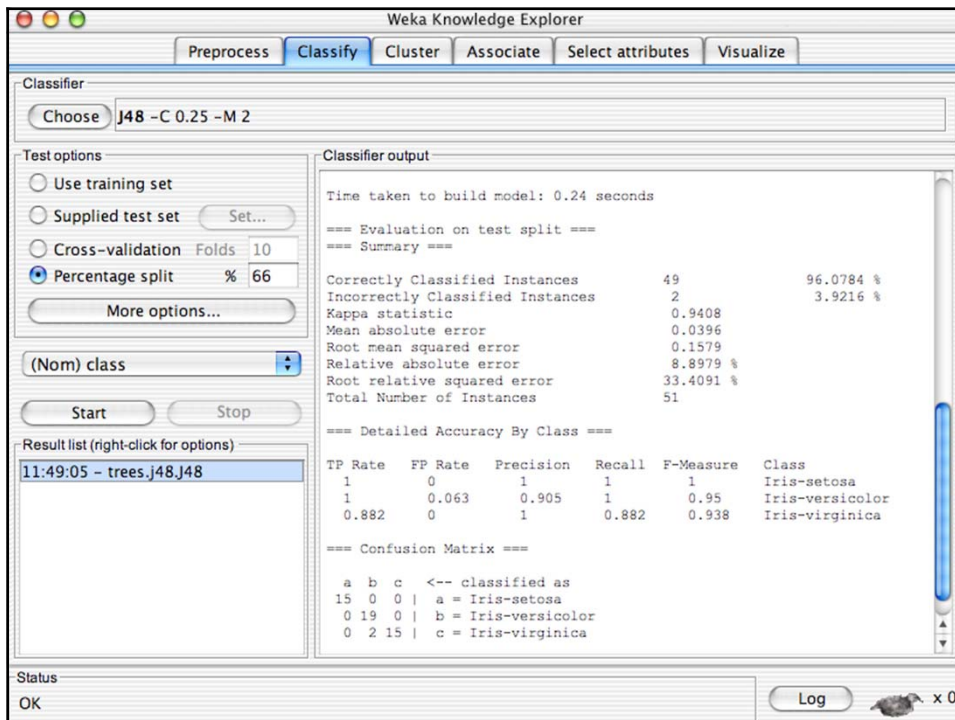
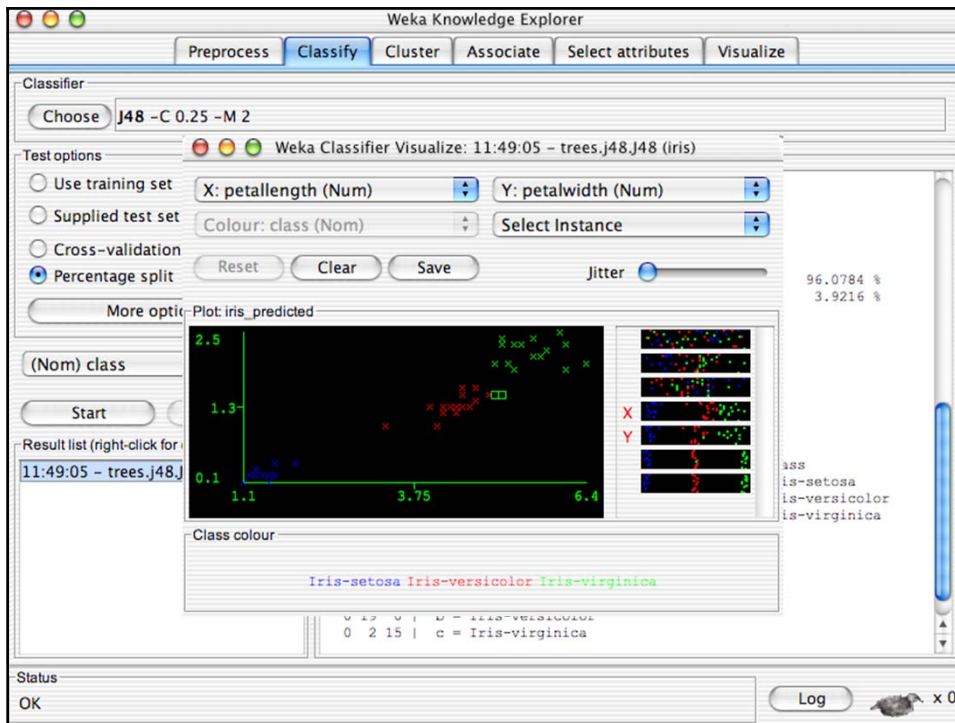


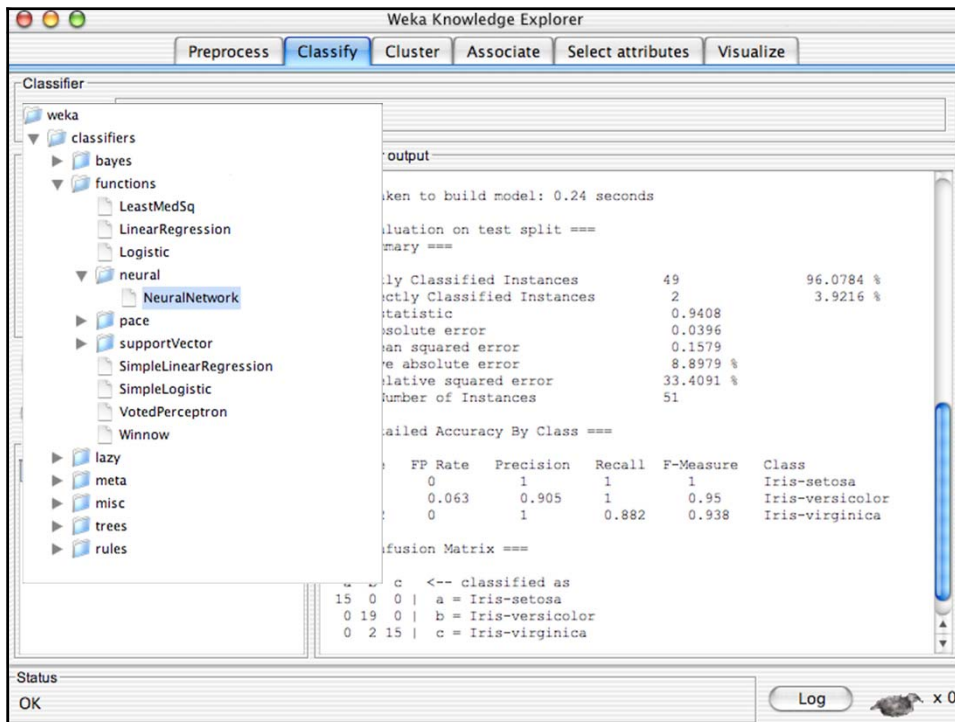
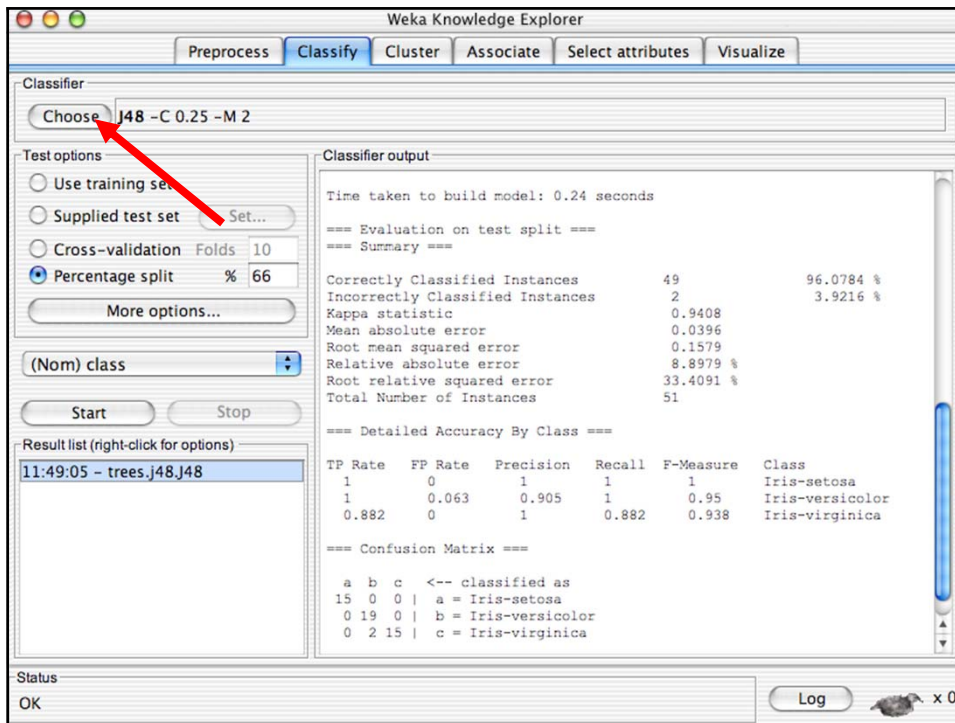


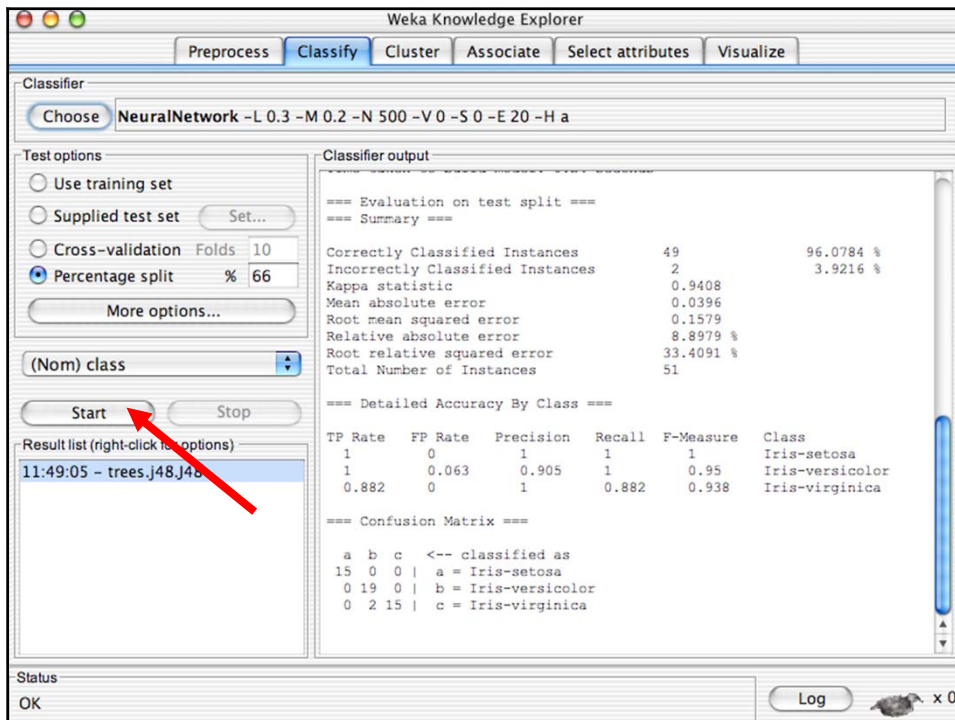
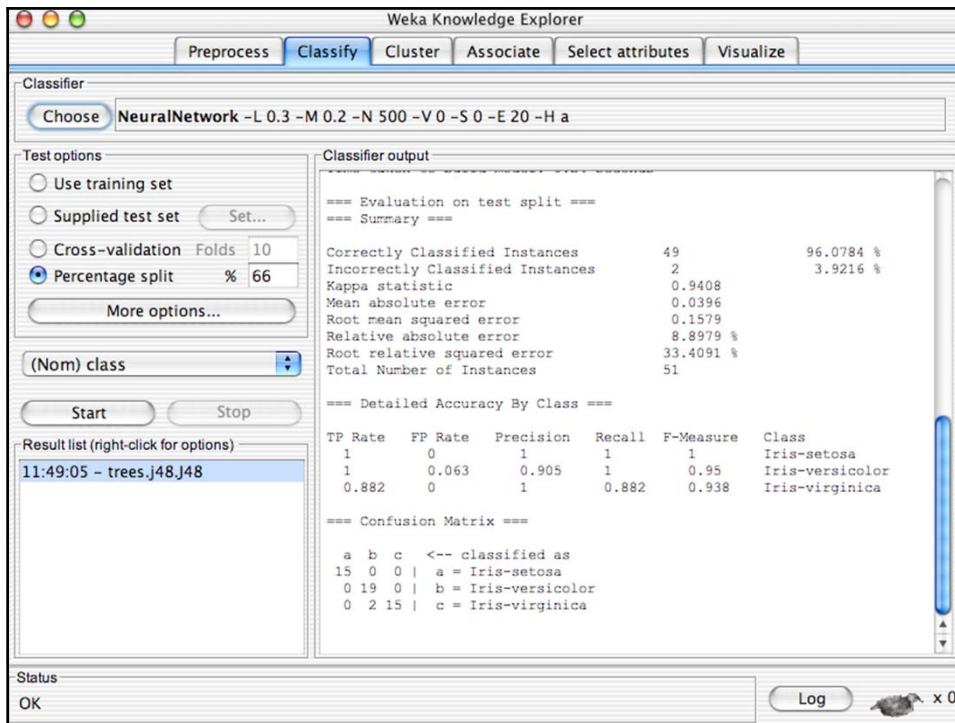


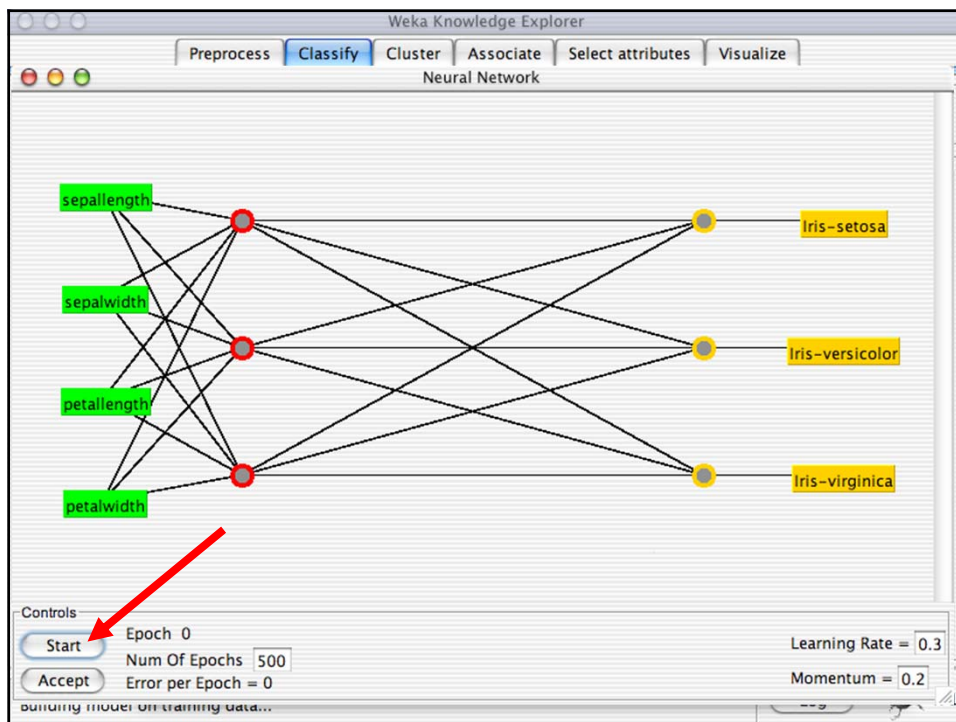
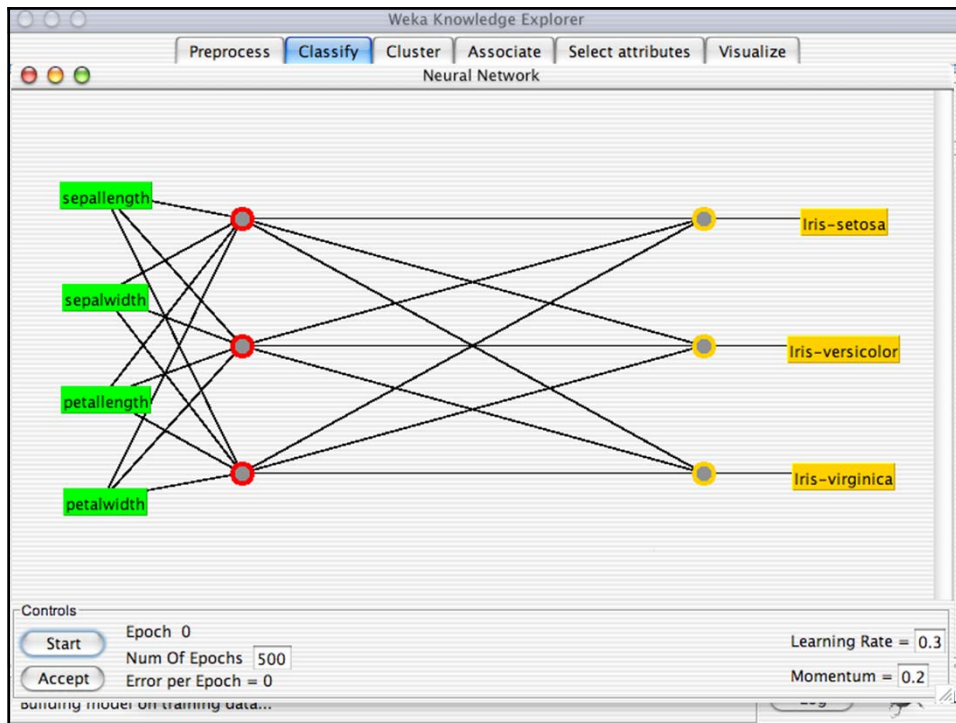


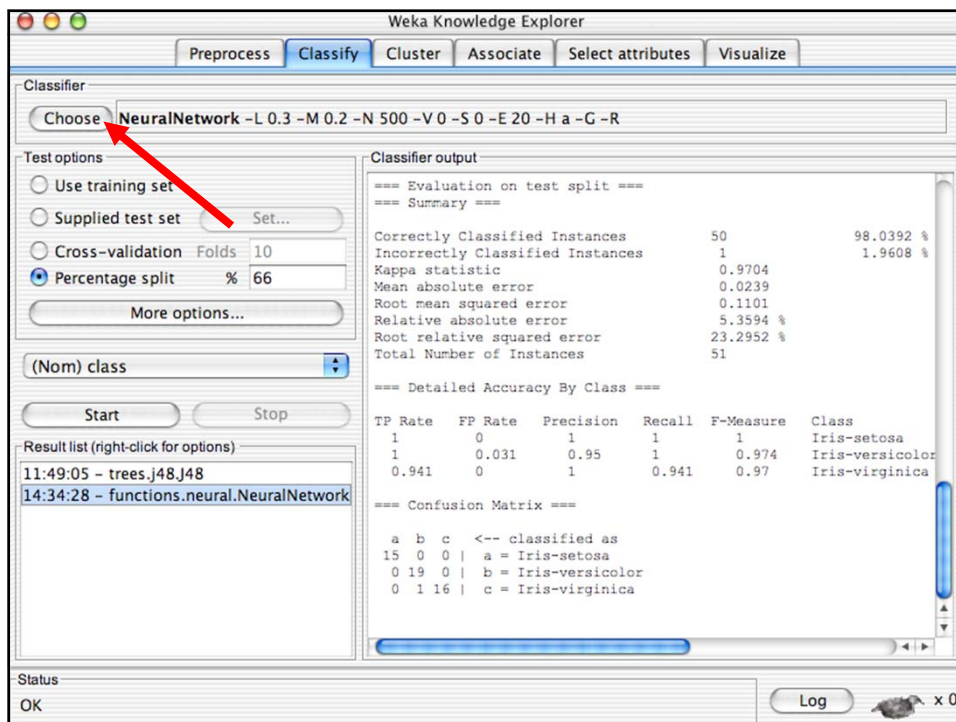
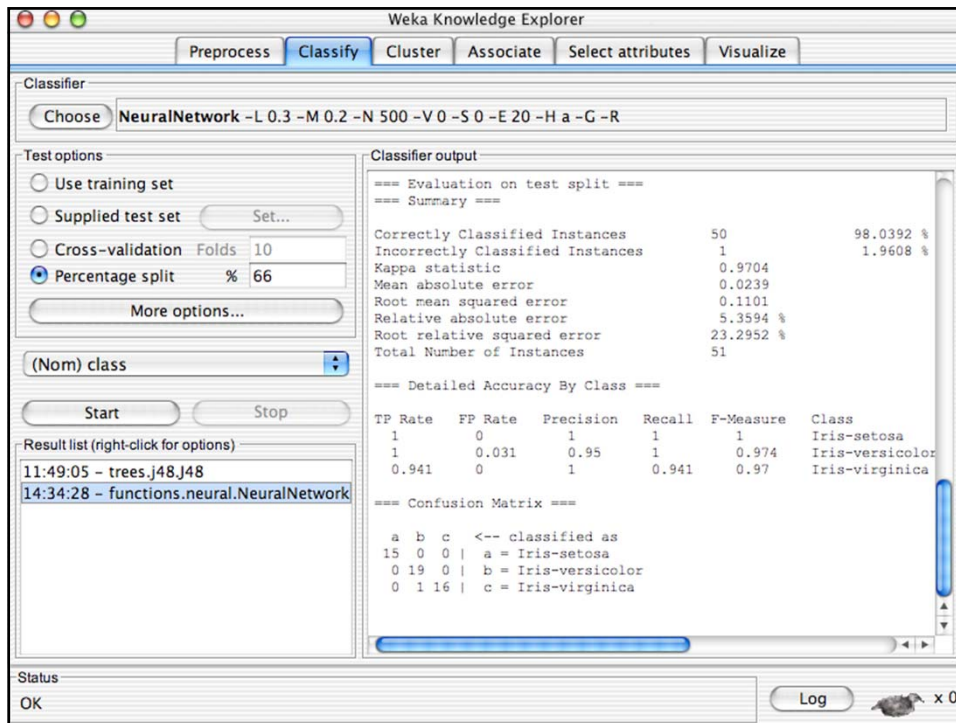


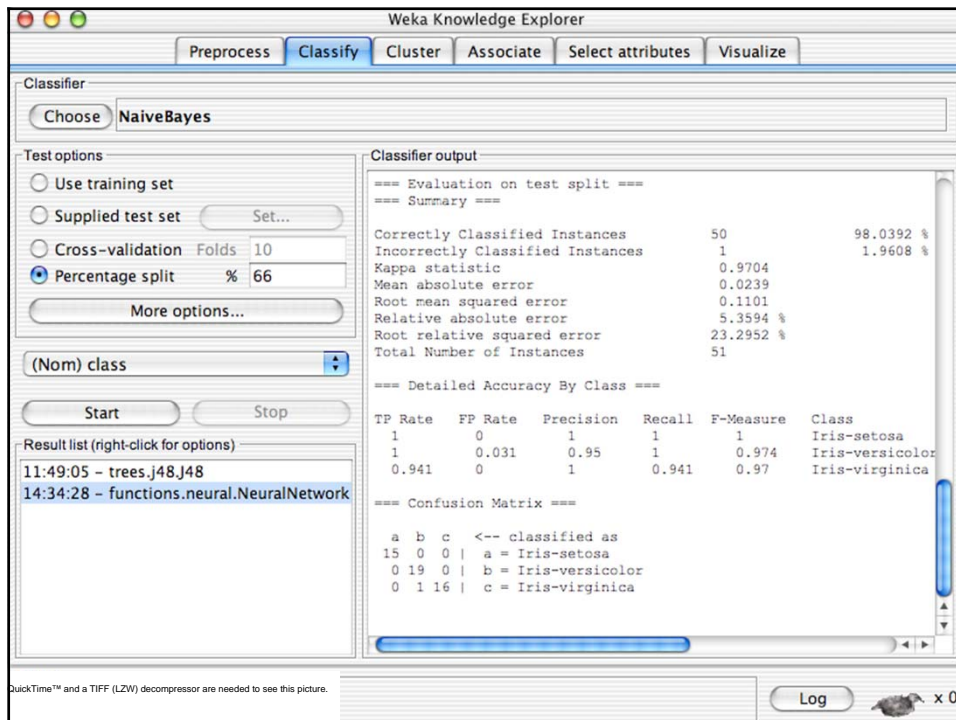
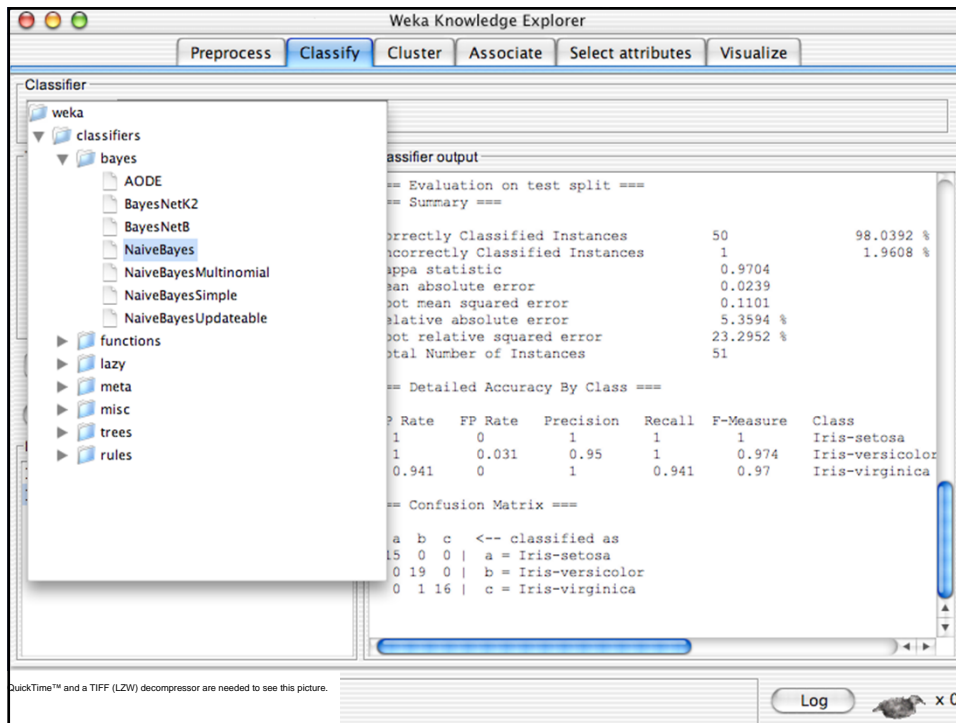


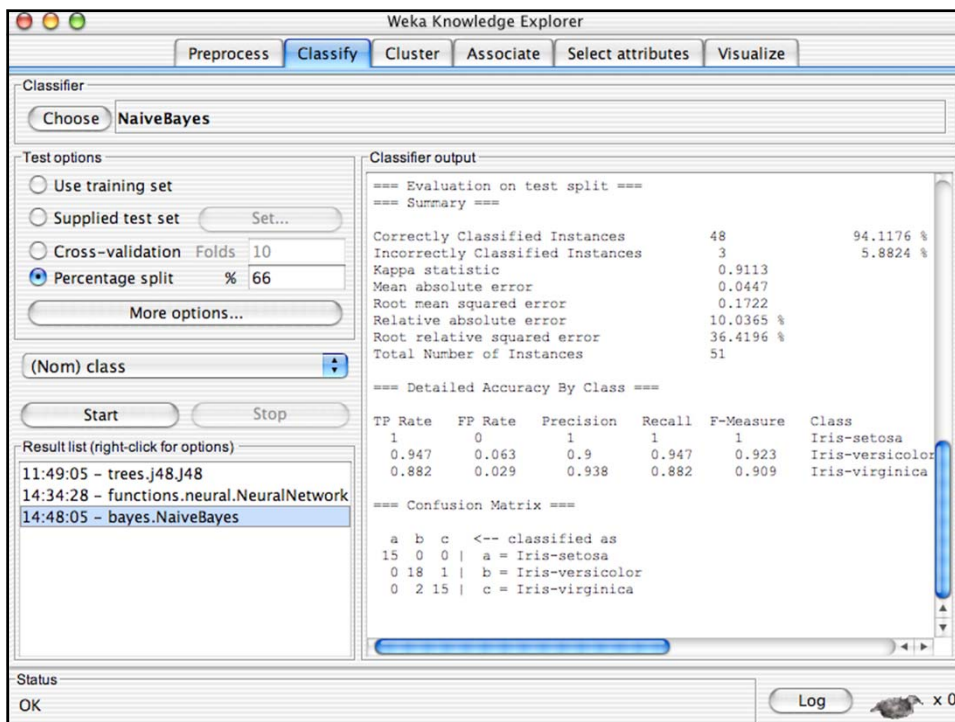
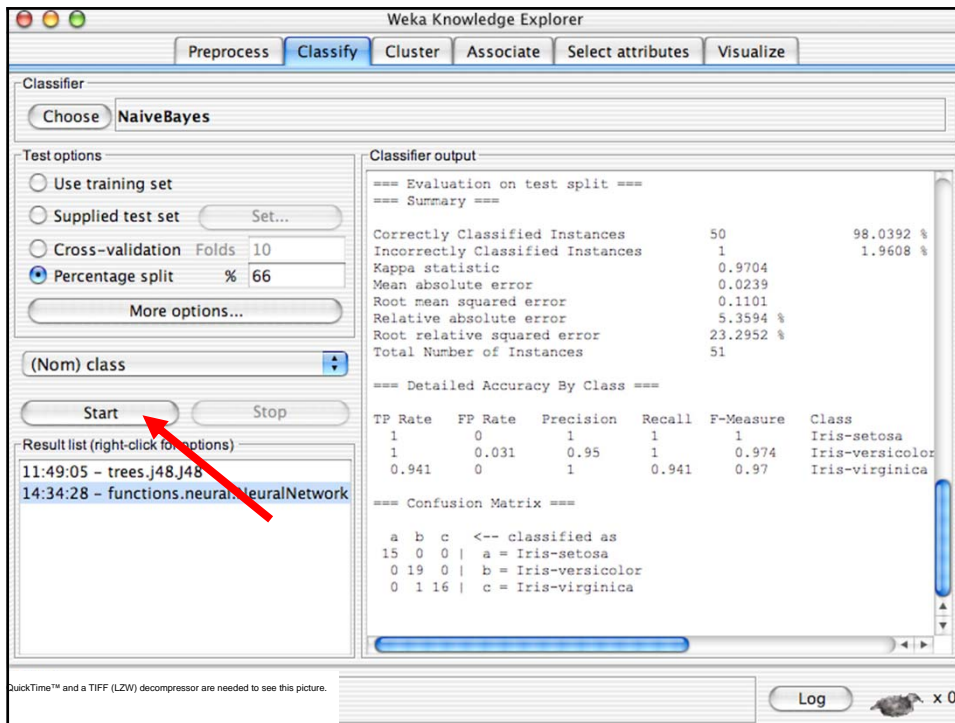


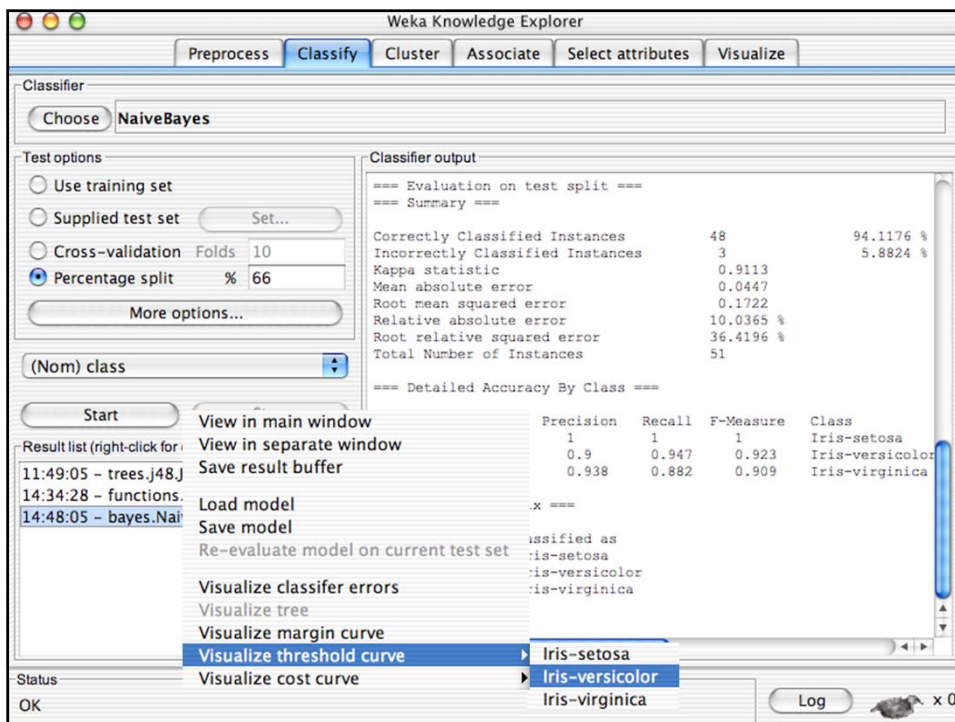
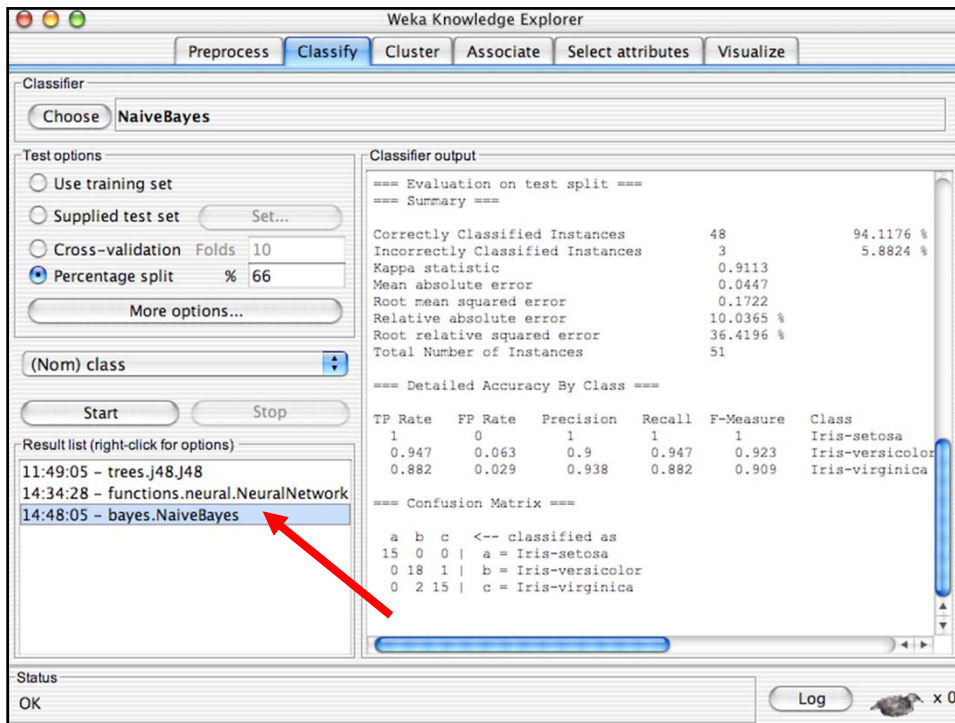


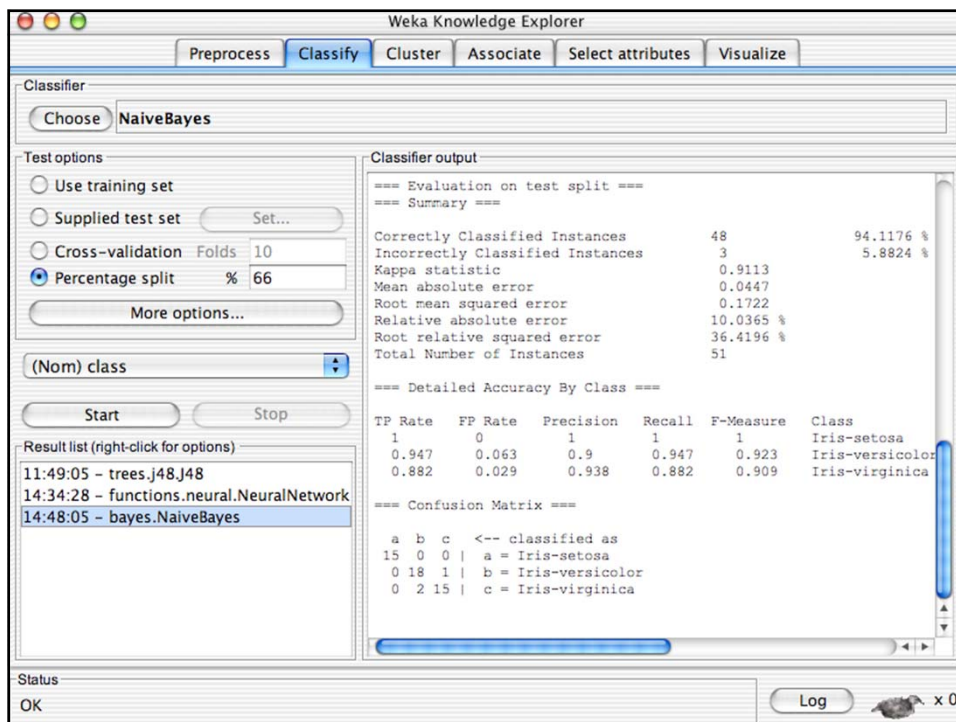
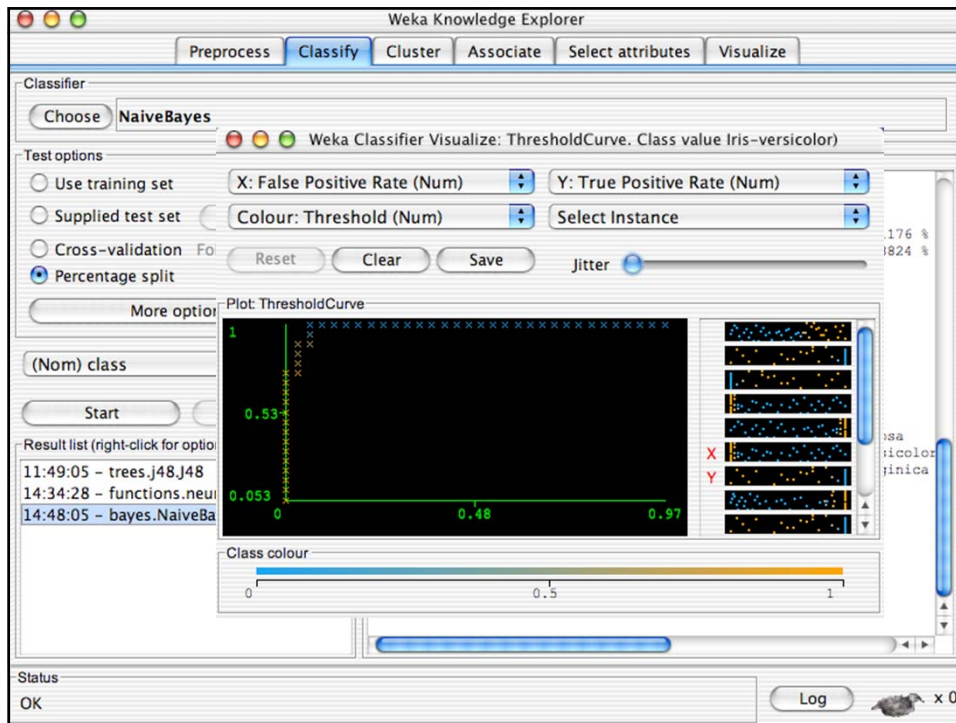


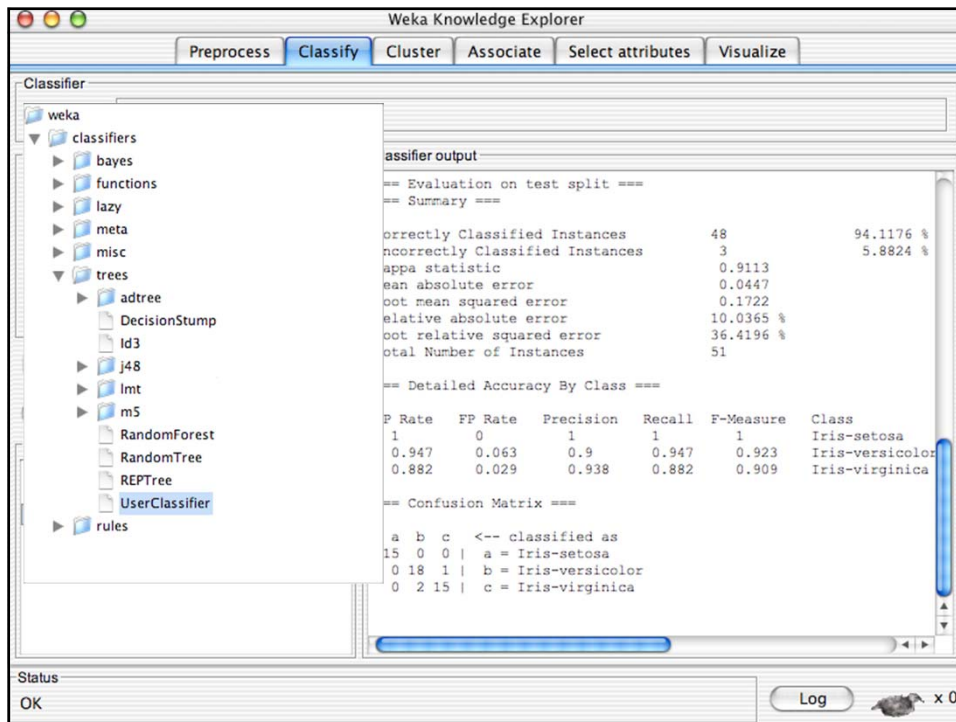
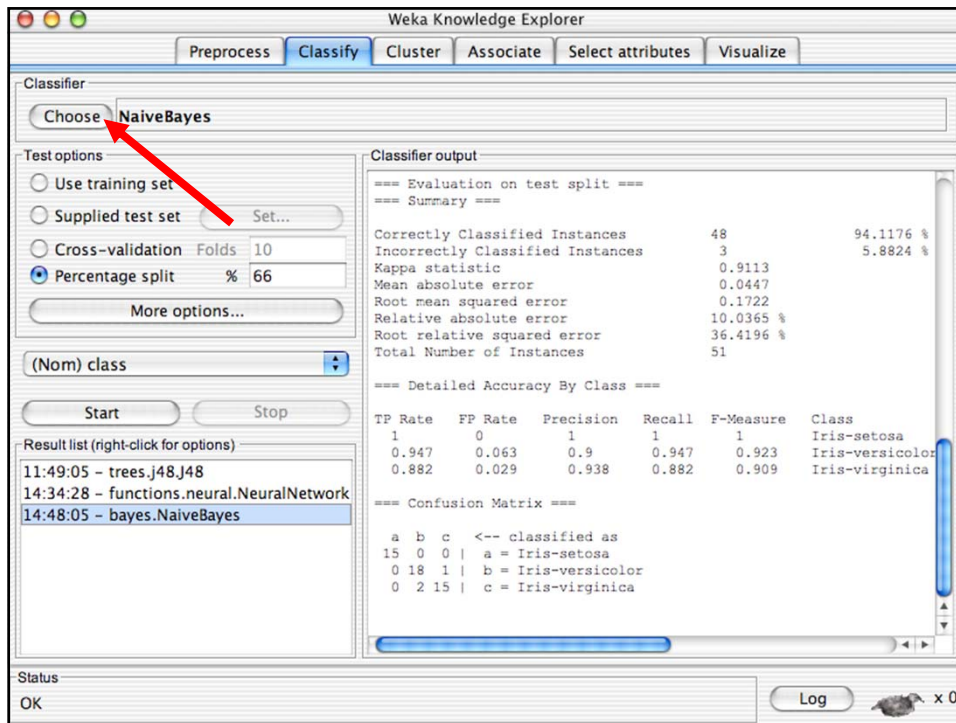


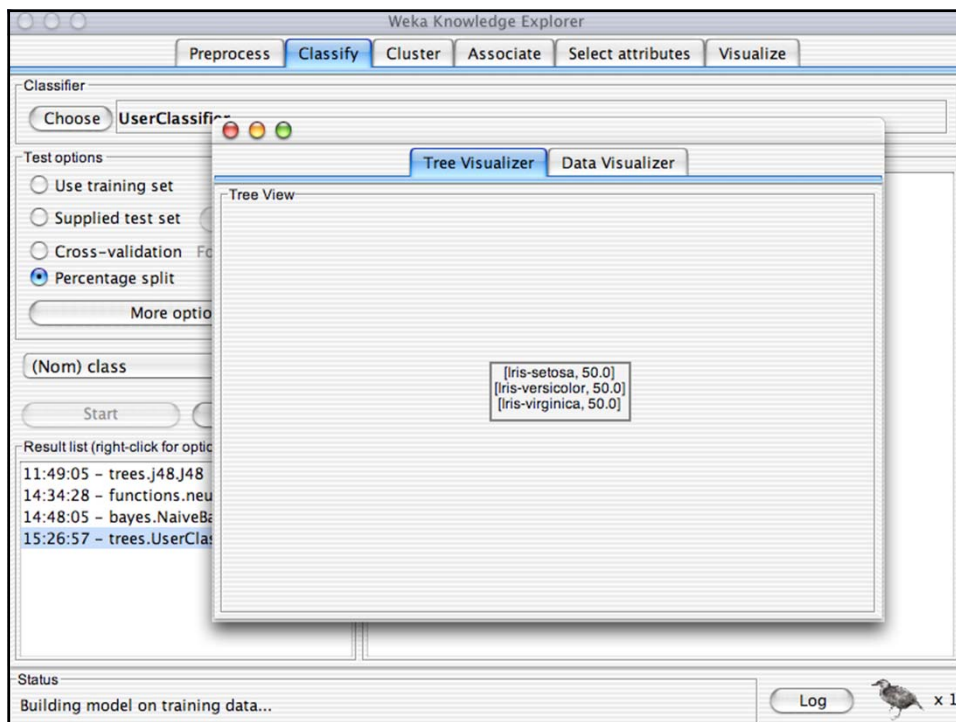
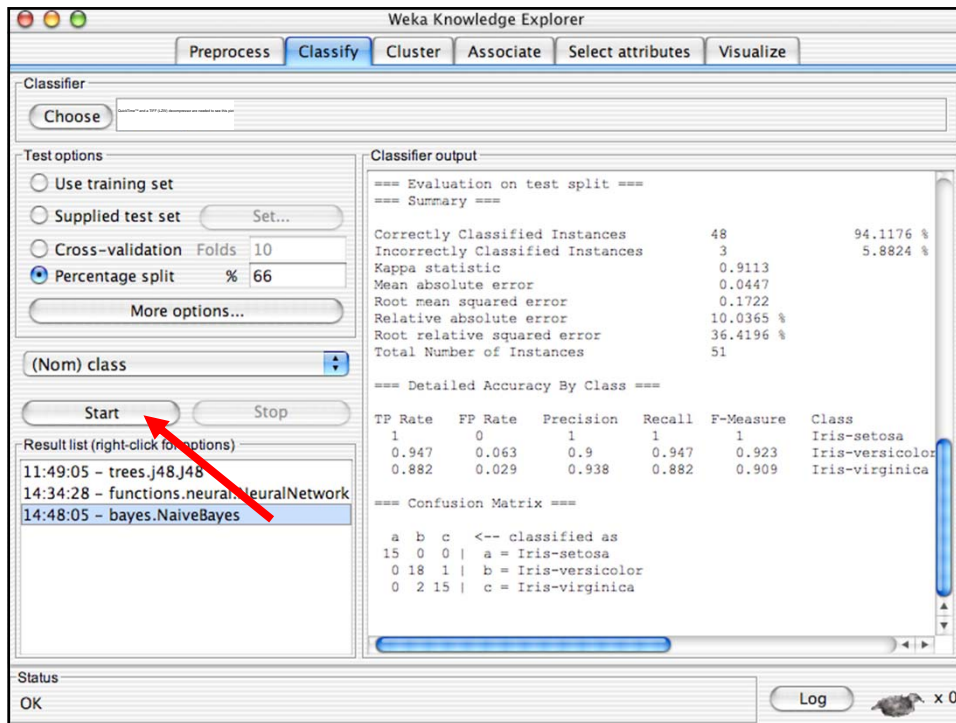


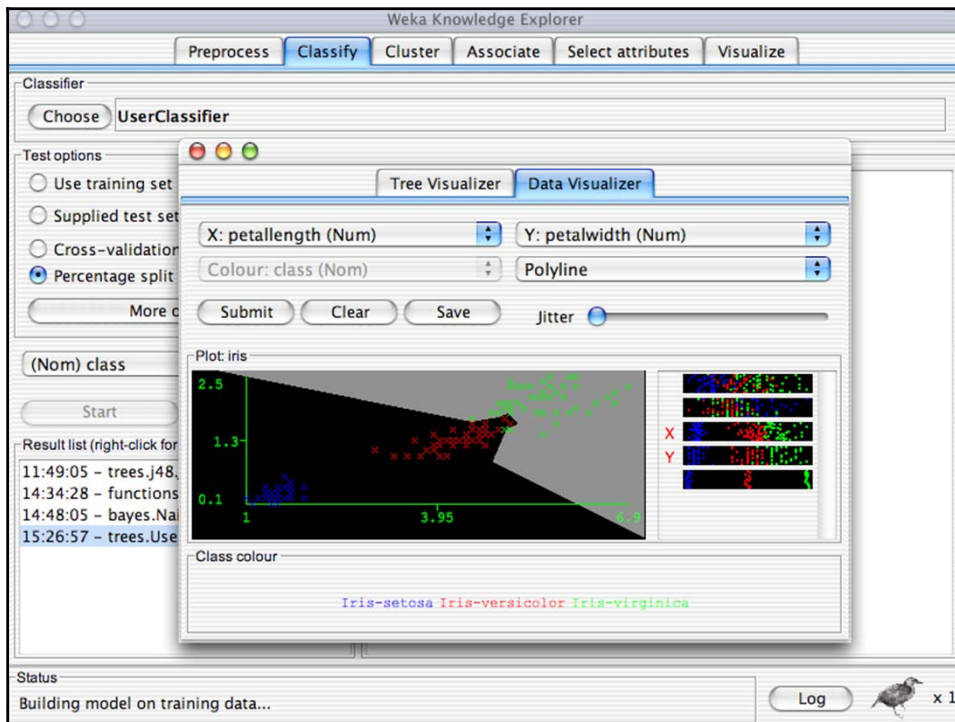
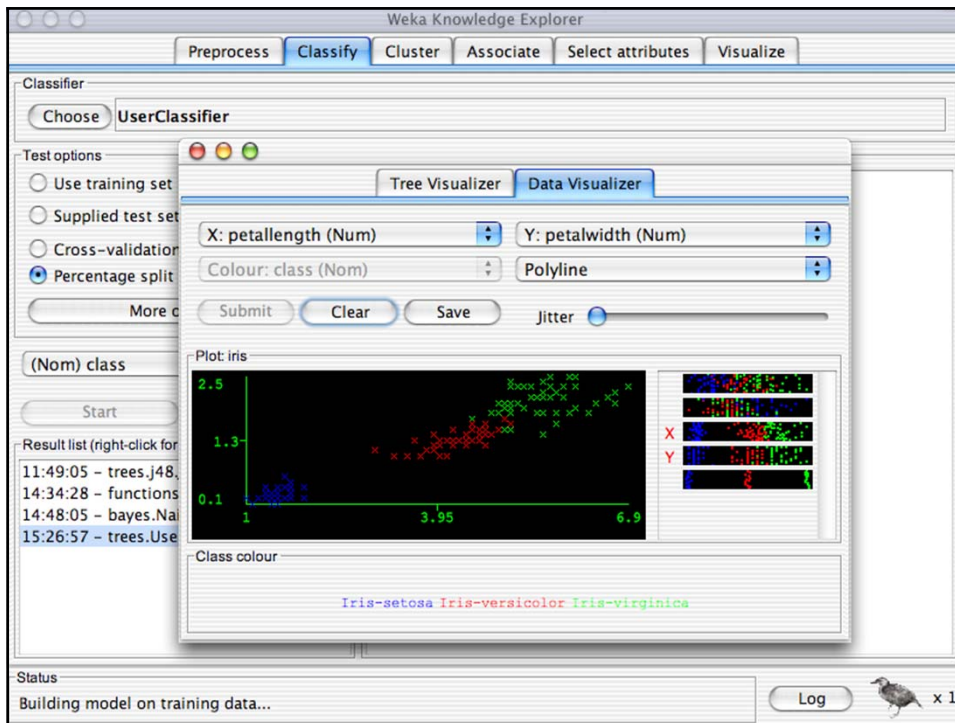


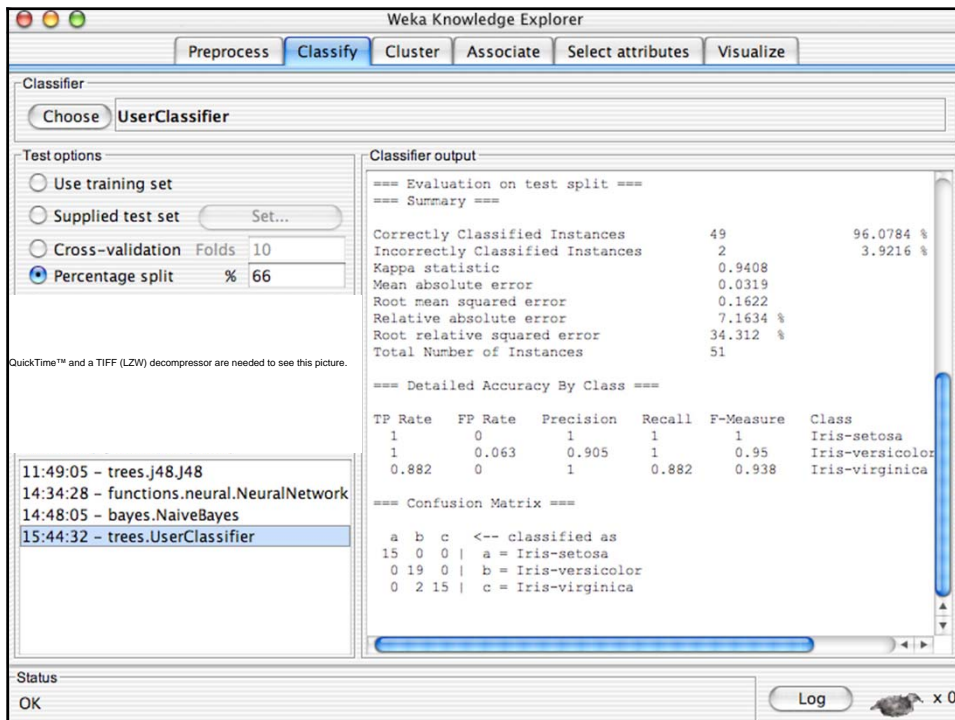
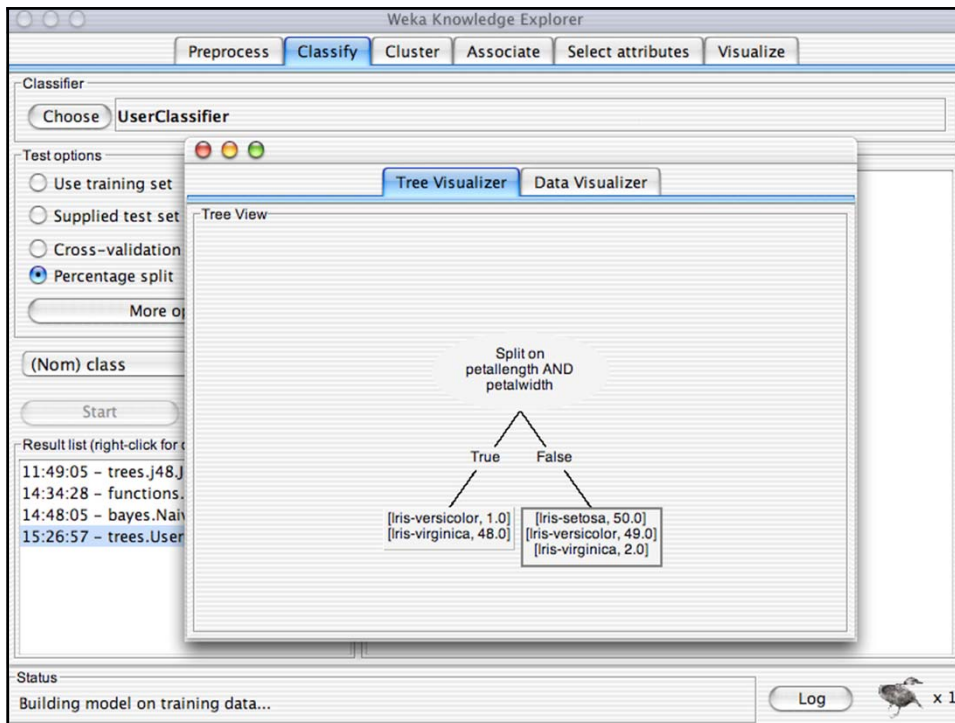


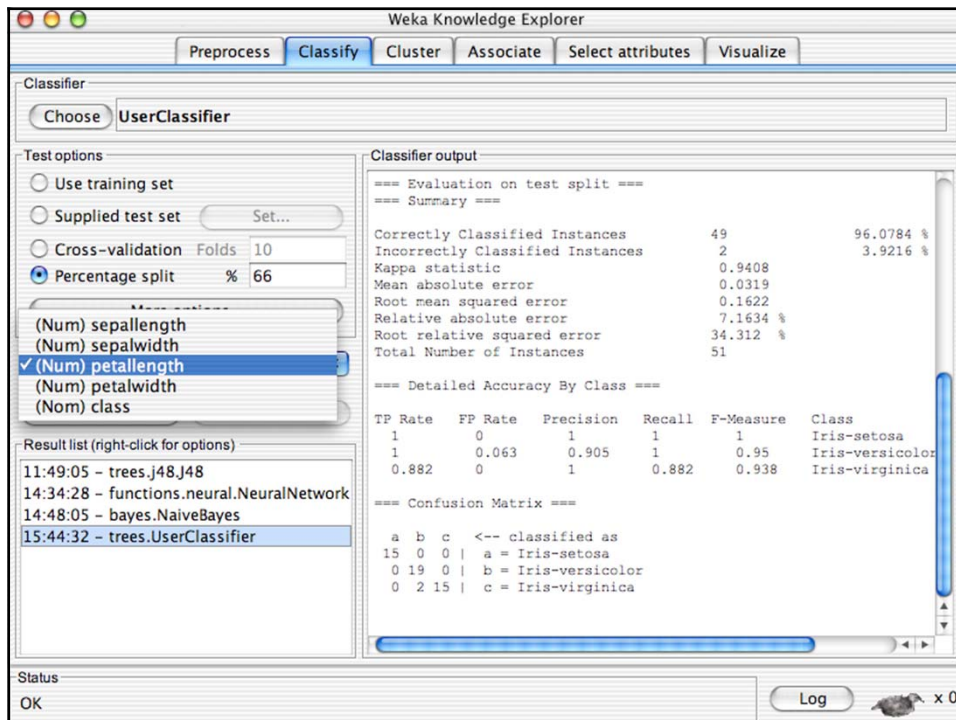
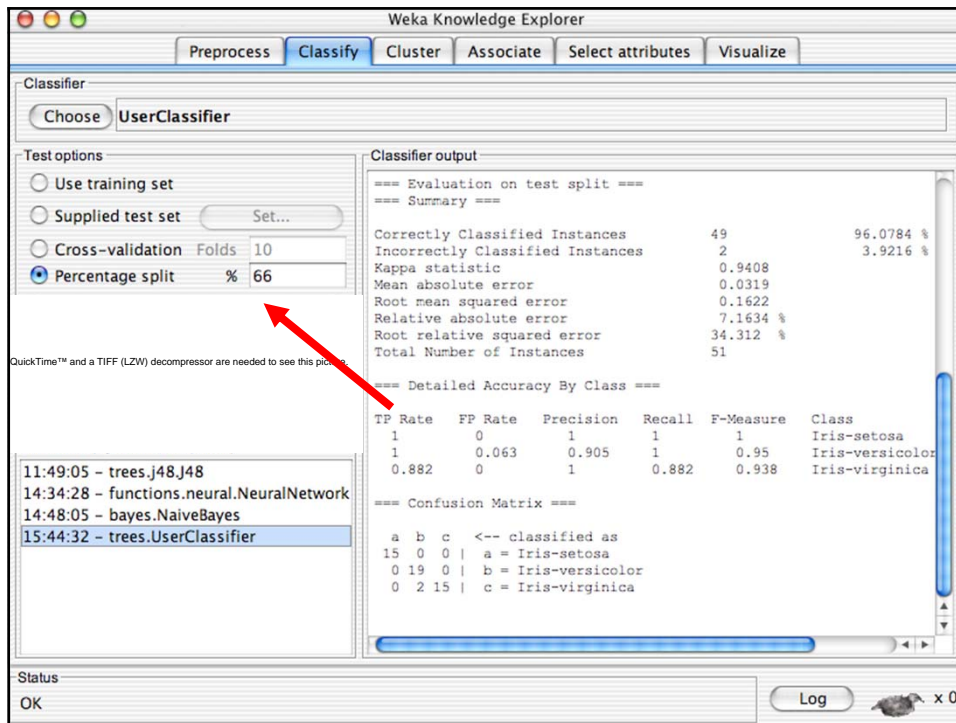


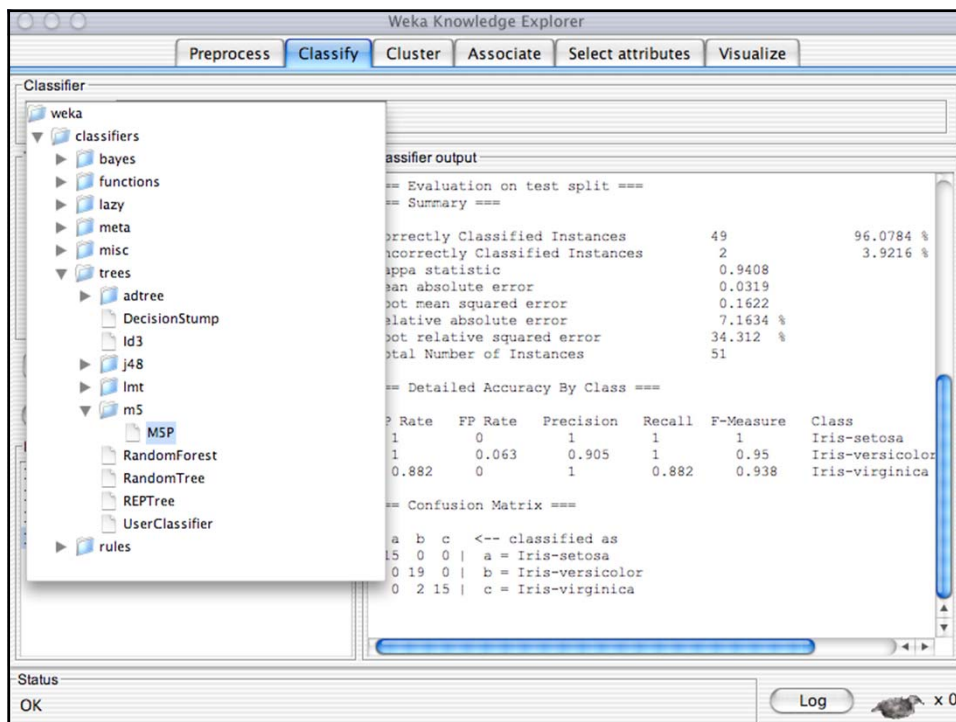
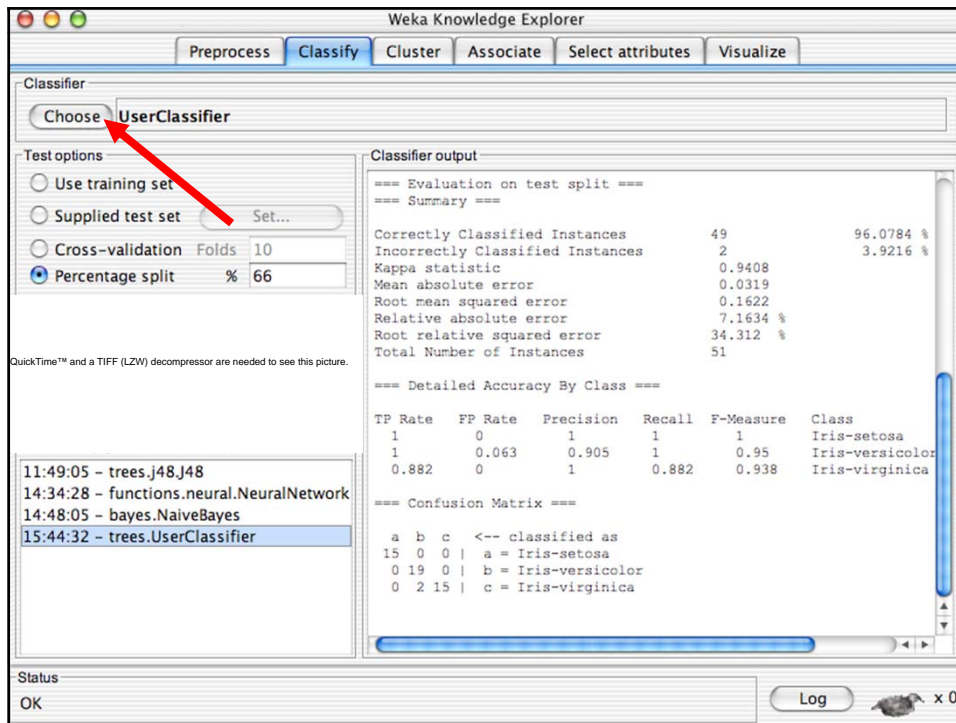


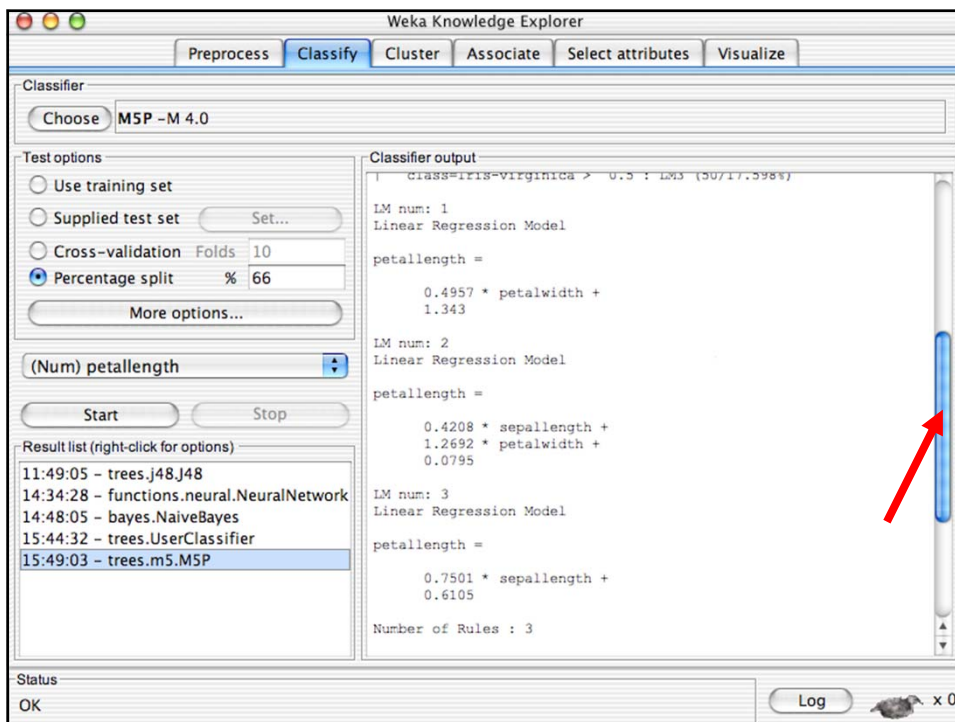
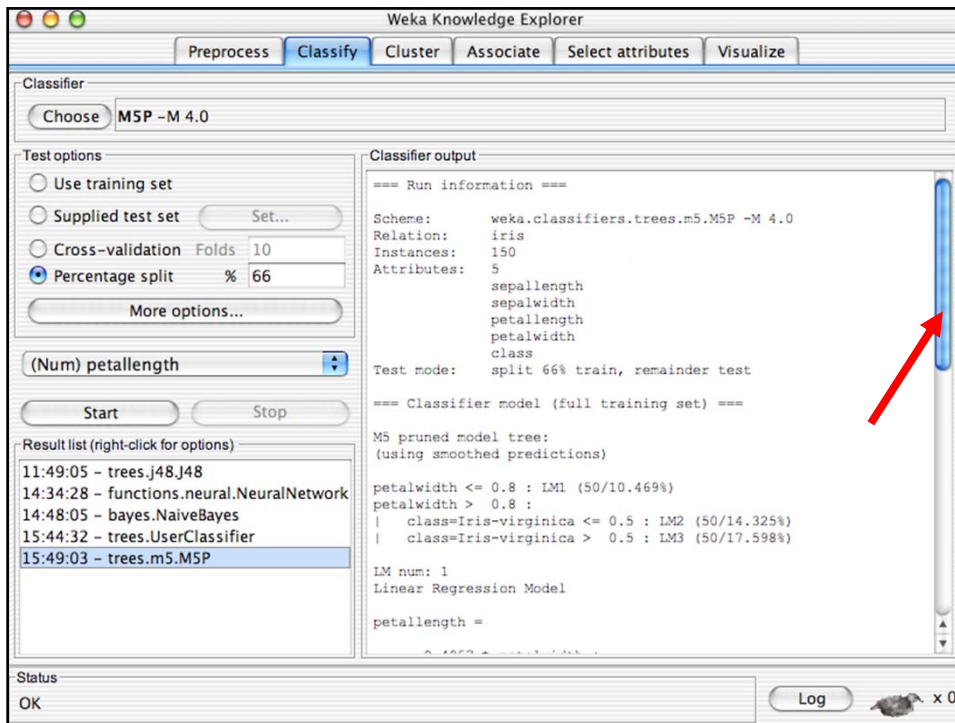


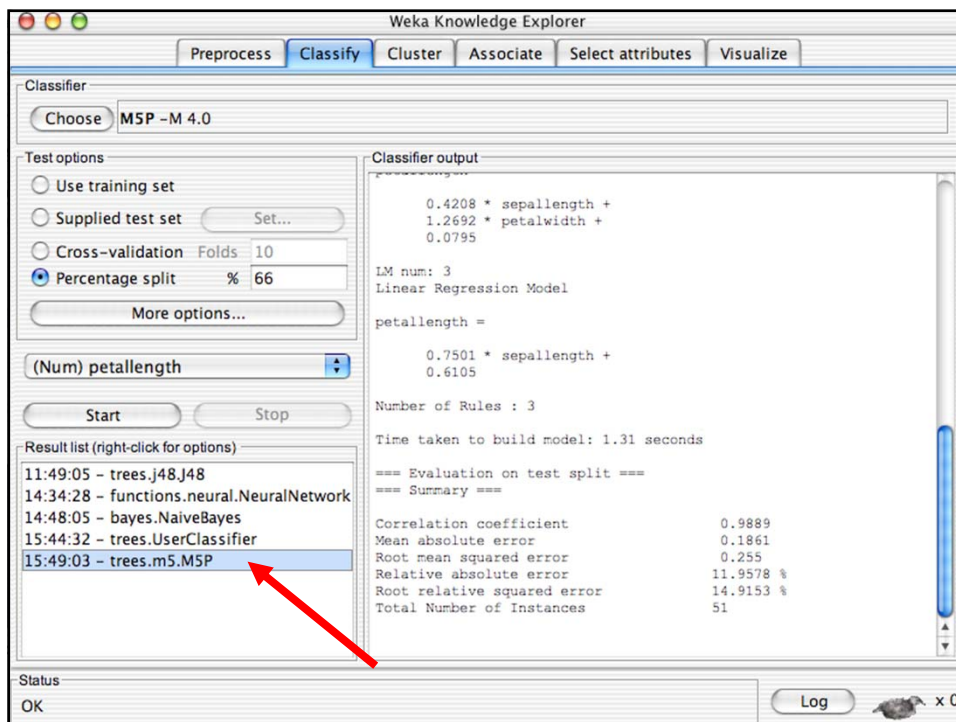
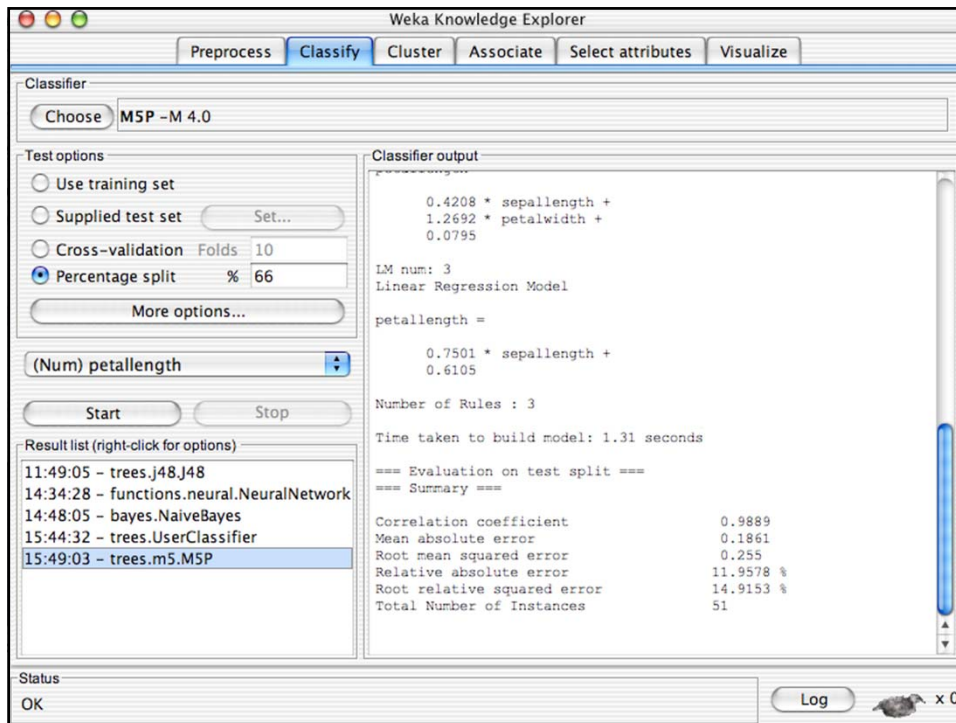


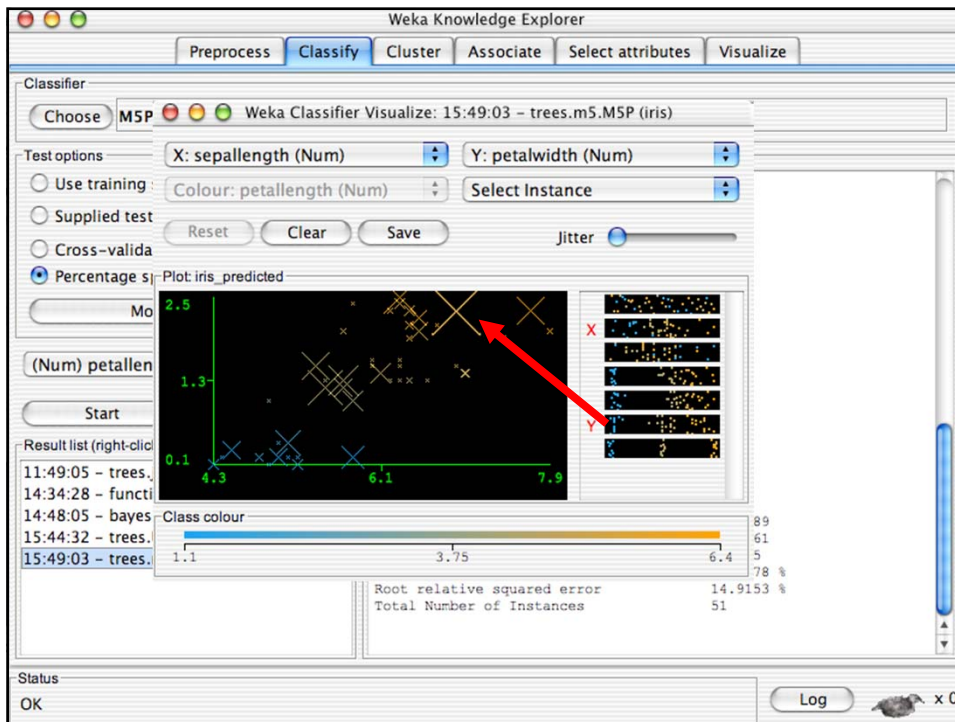
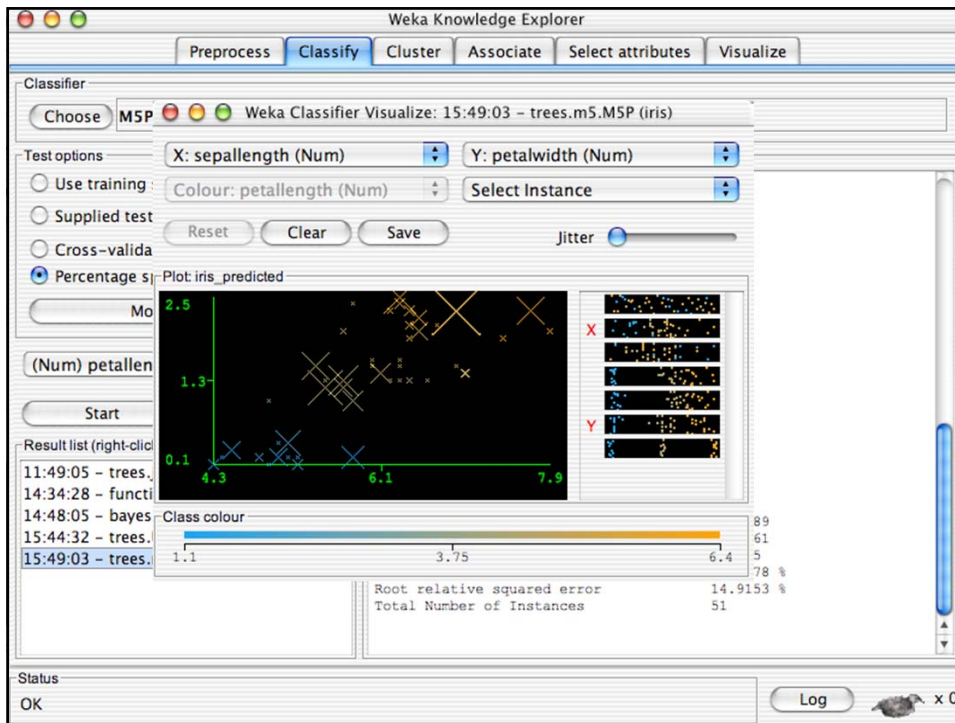


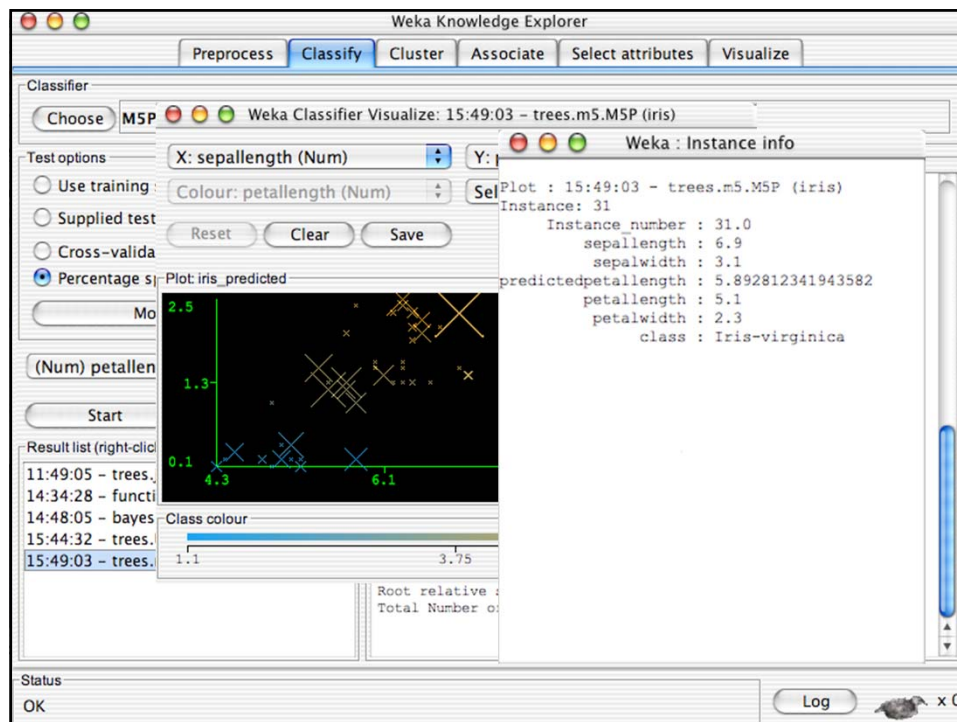






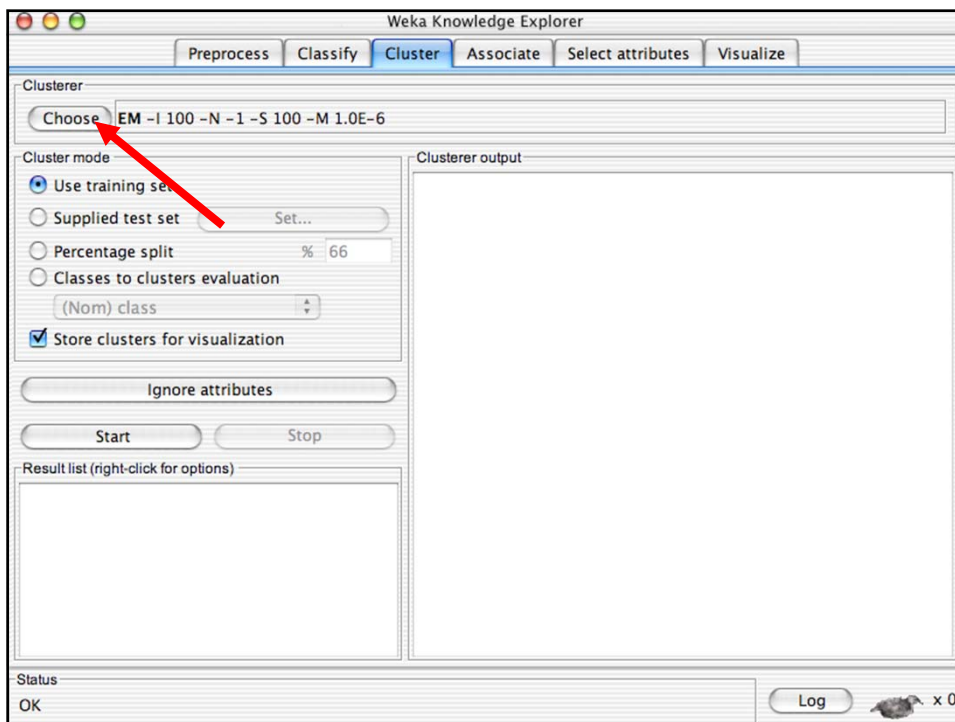
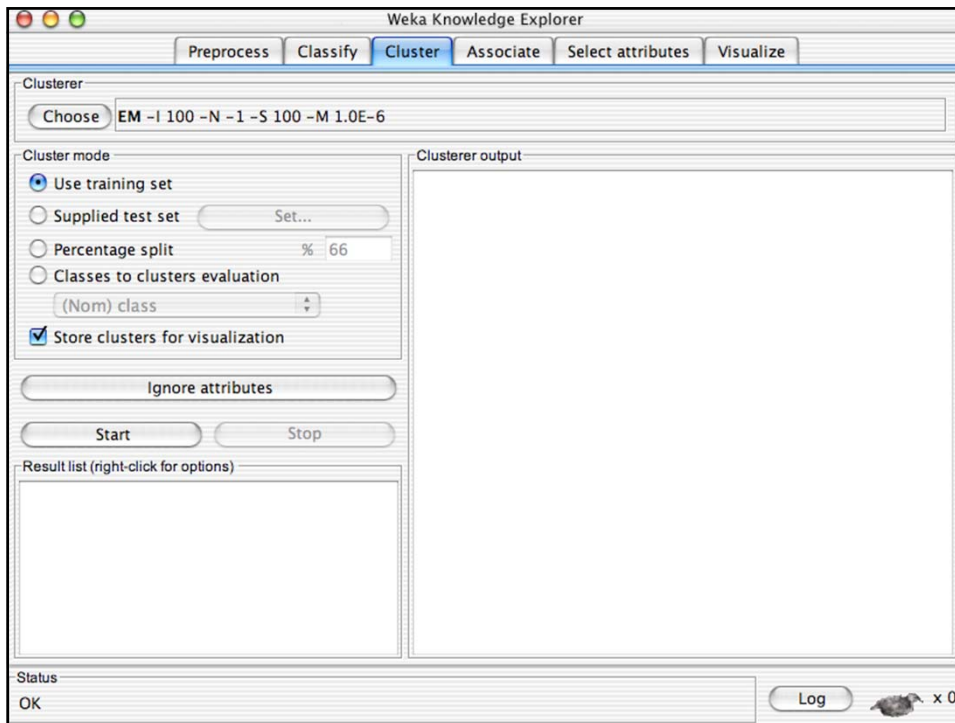


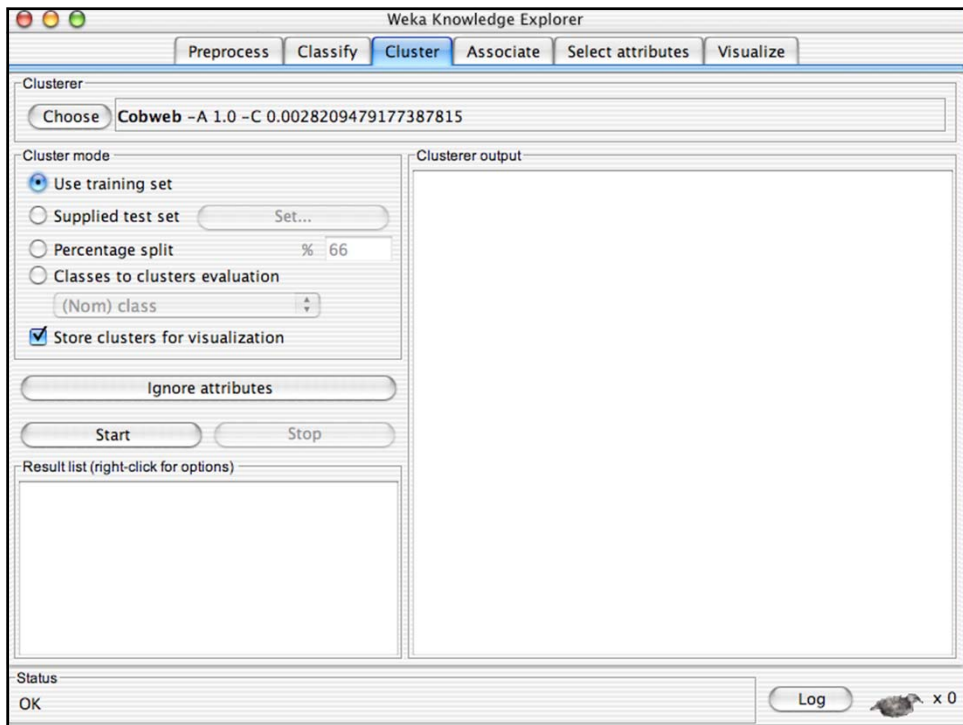
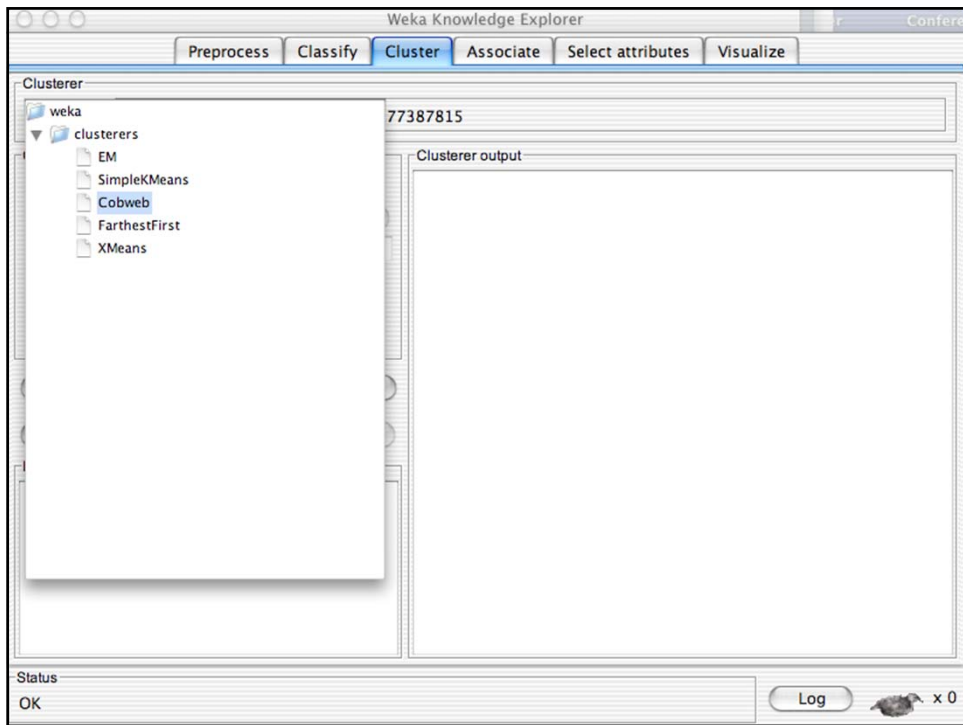


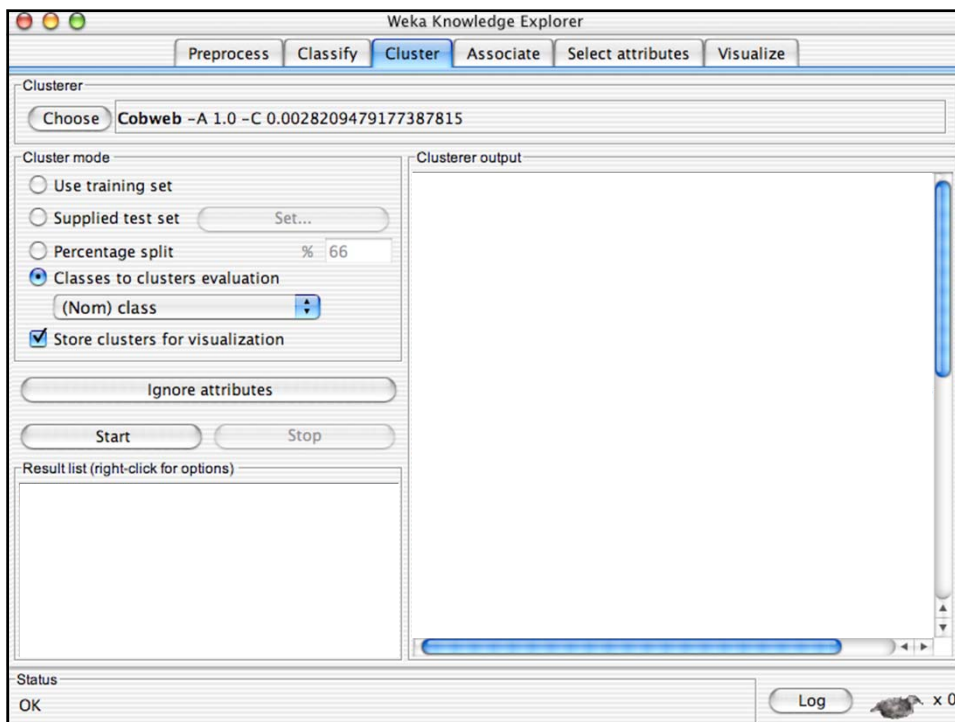
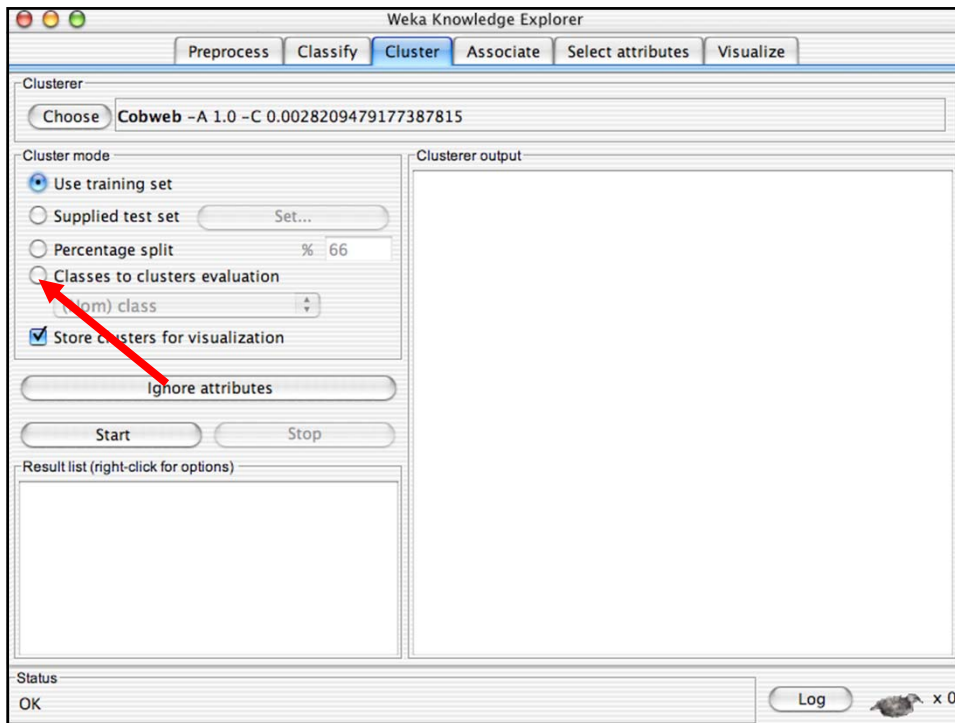


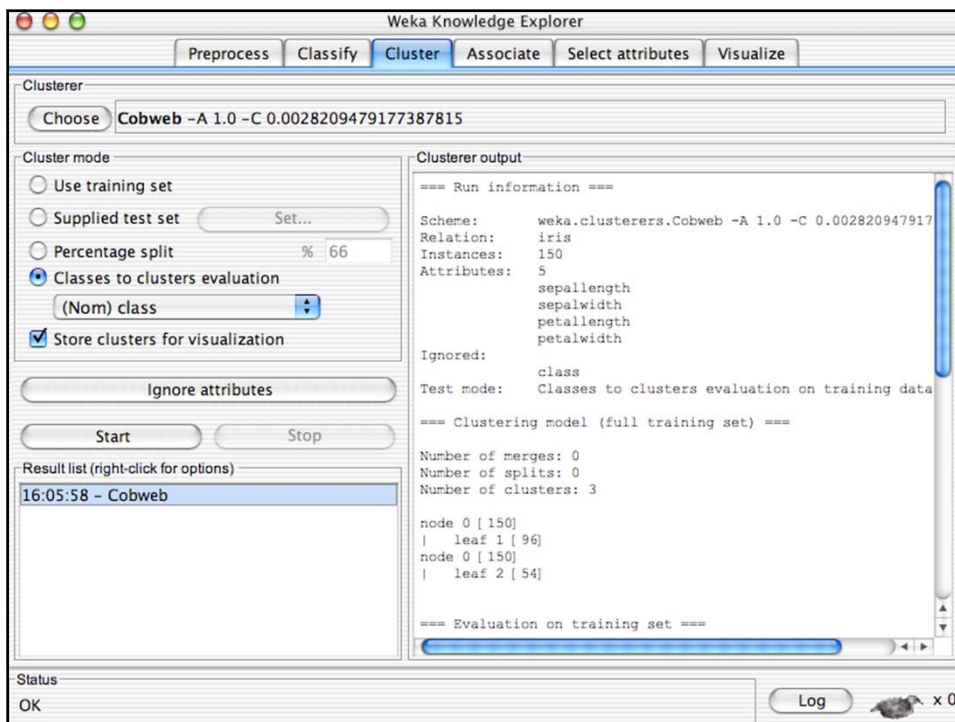
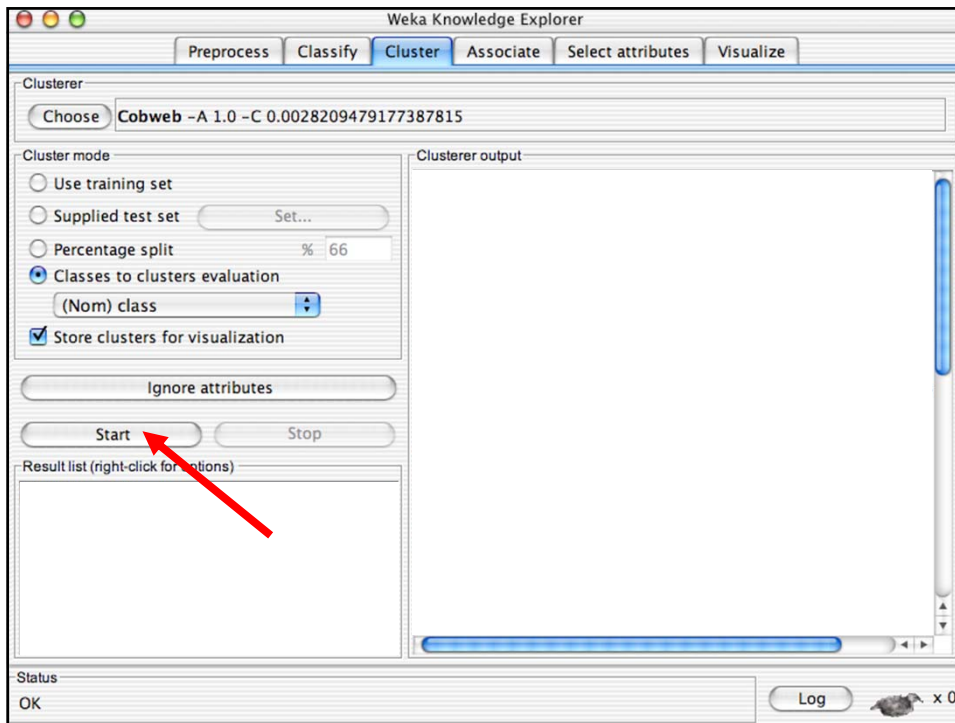
Explorer: clustering data

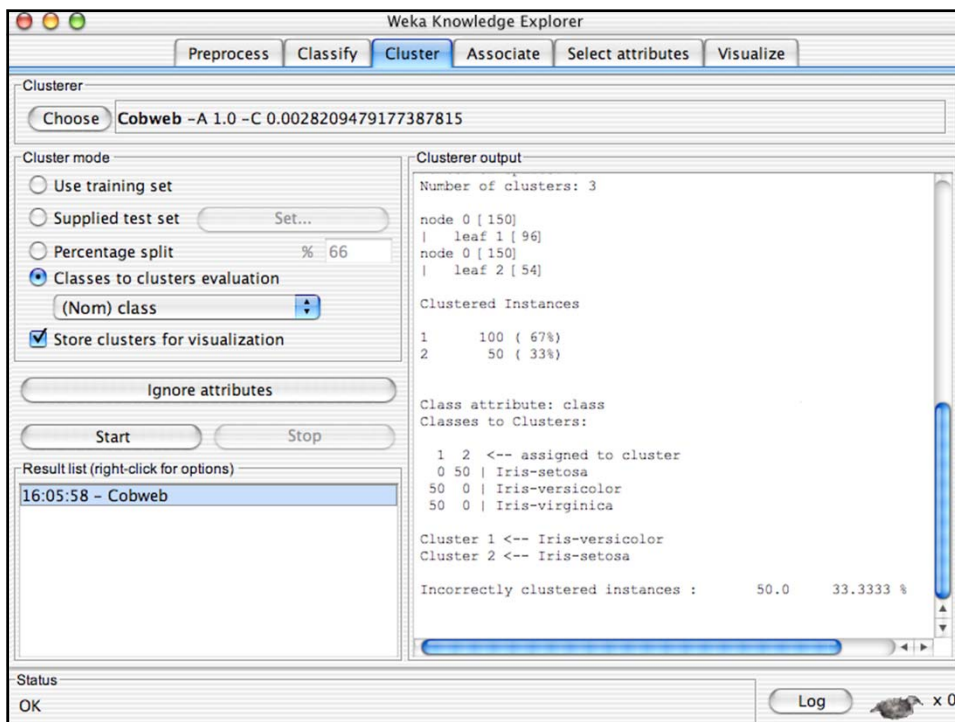
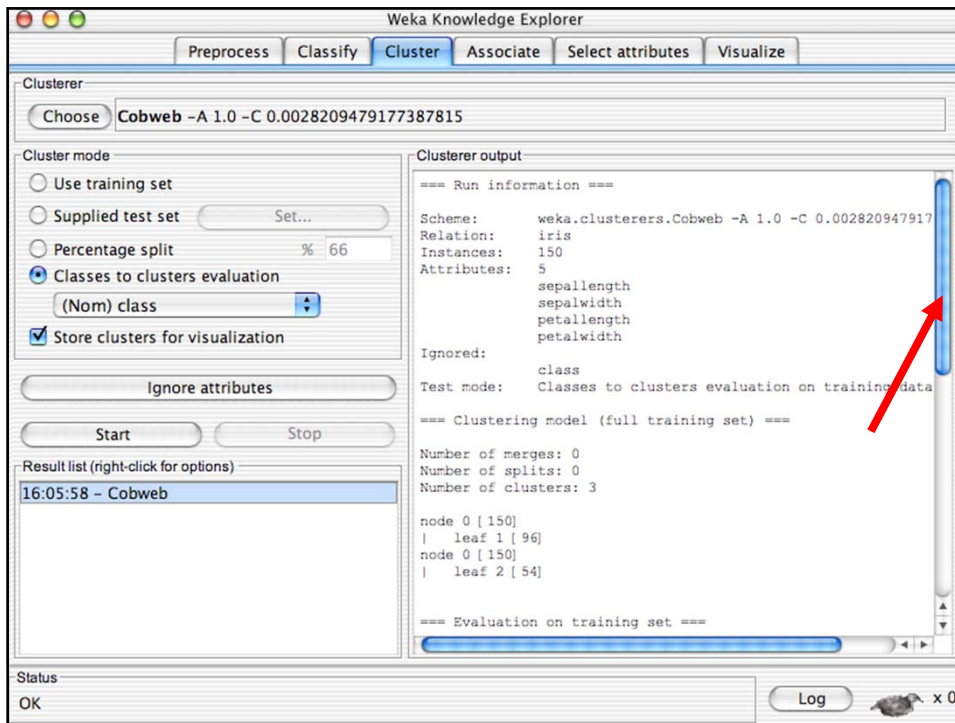
- WEKA contains “clusterers” for finding groups of similar instances in a dataset
- Implemented schemes are:
 - ◆ k -Means, EM, Cobweb, X-means, FarthestFirst
- Clusters can be visualized and compared to “true” clusters (if given)
- Evaluation based on loglikelihood if clustering scheme produces a probability distribution

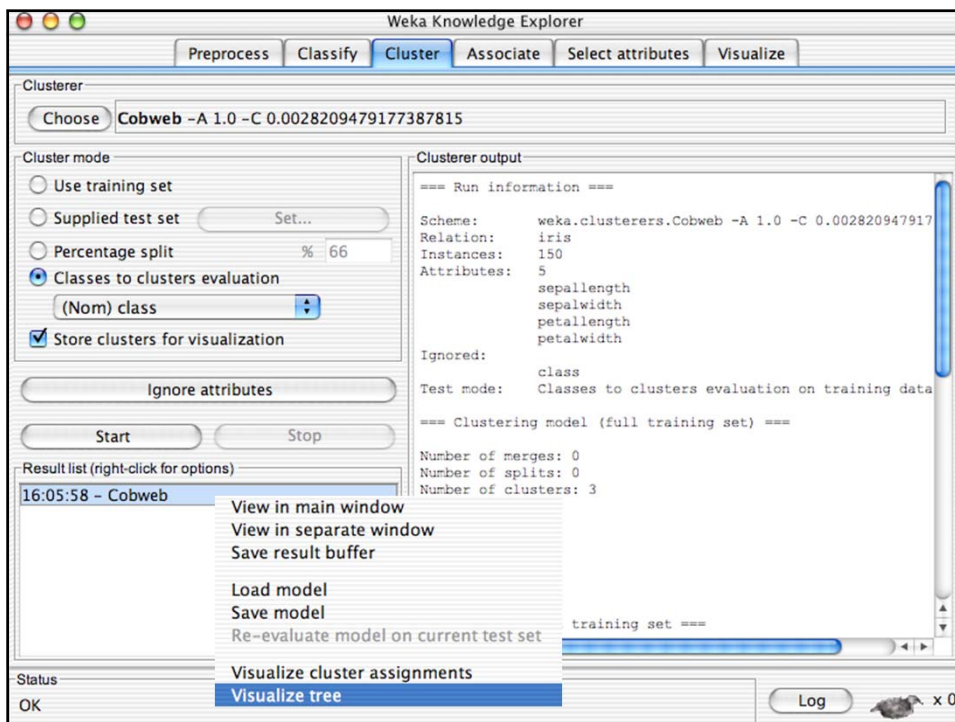
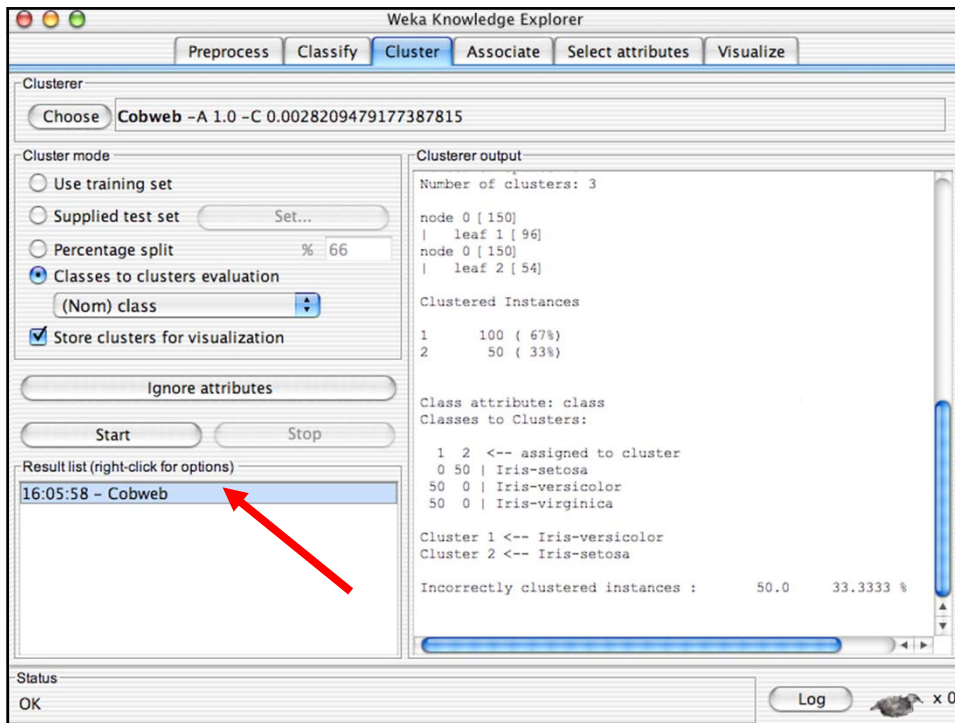


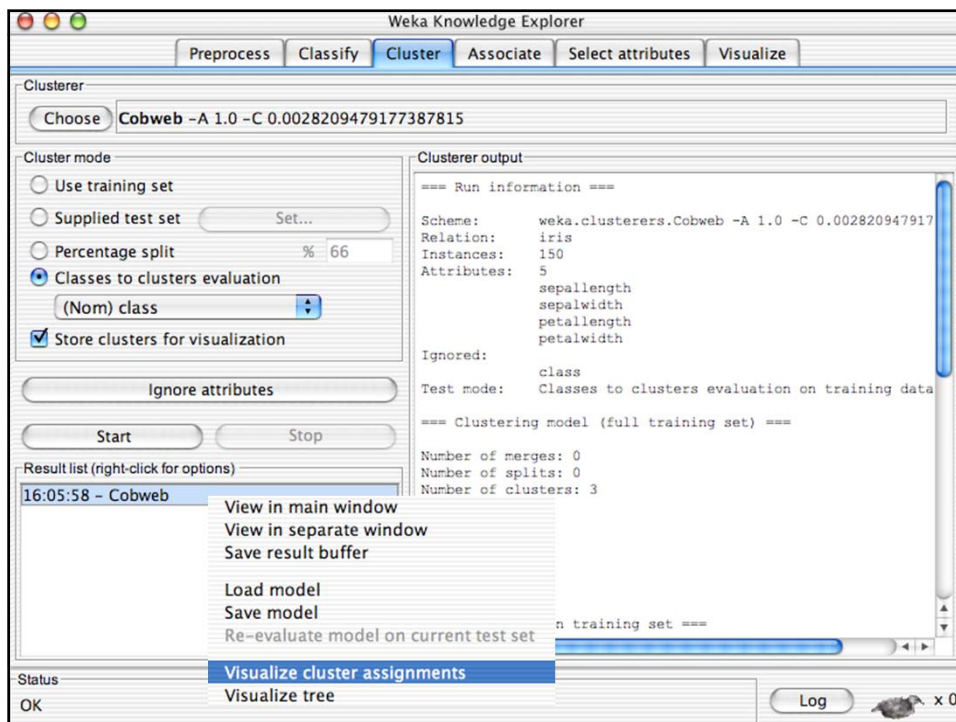
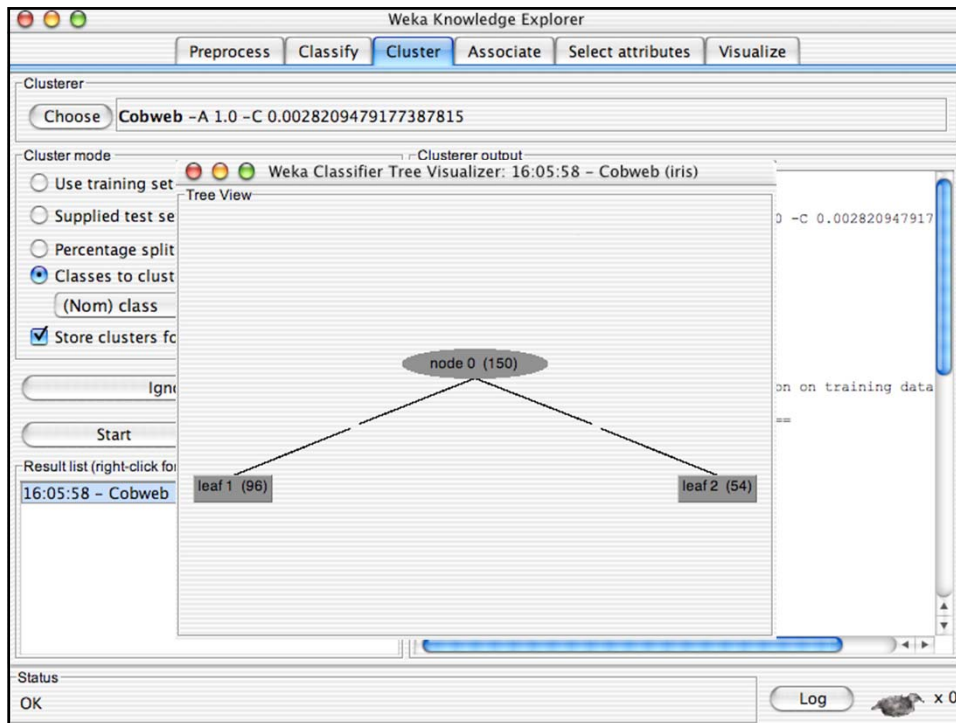


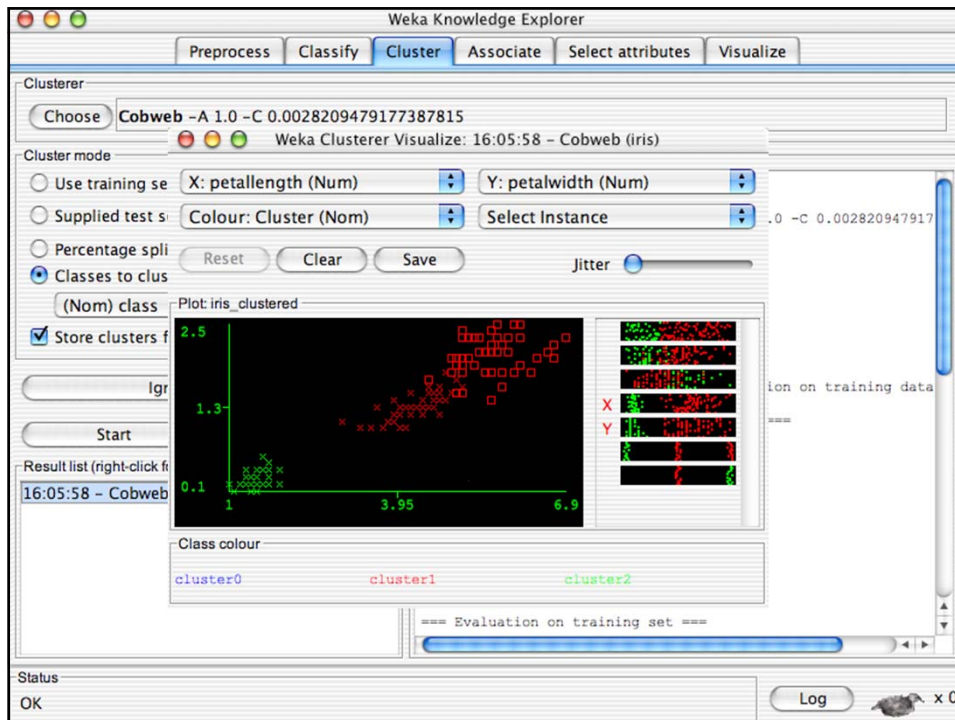






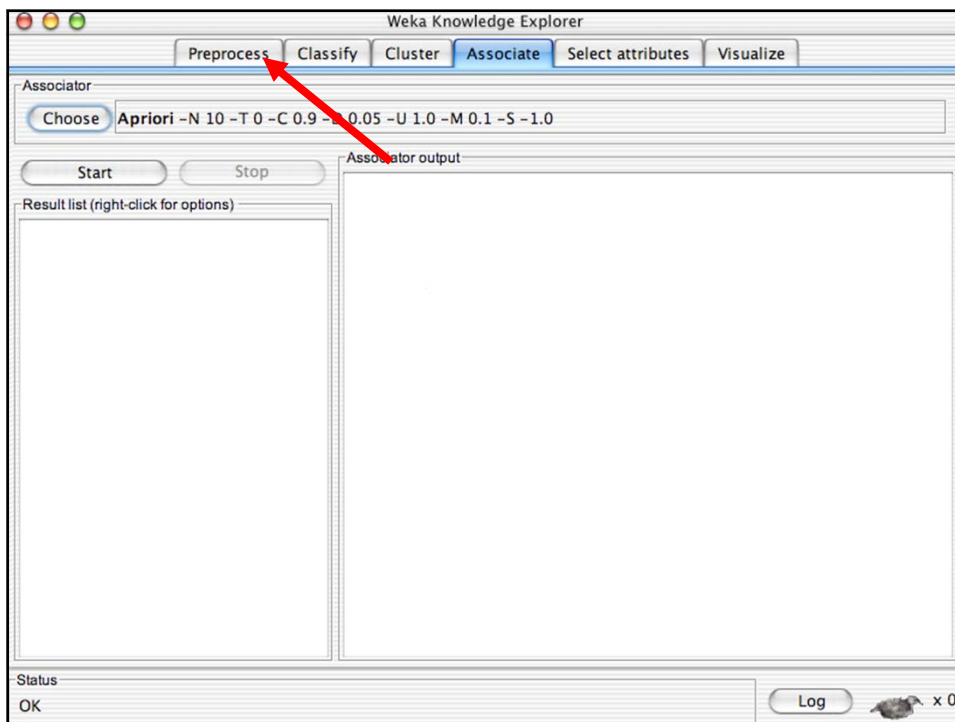
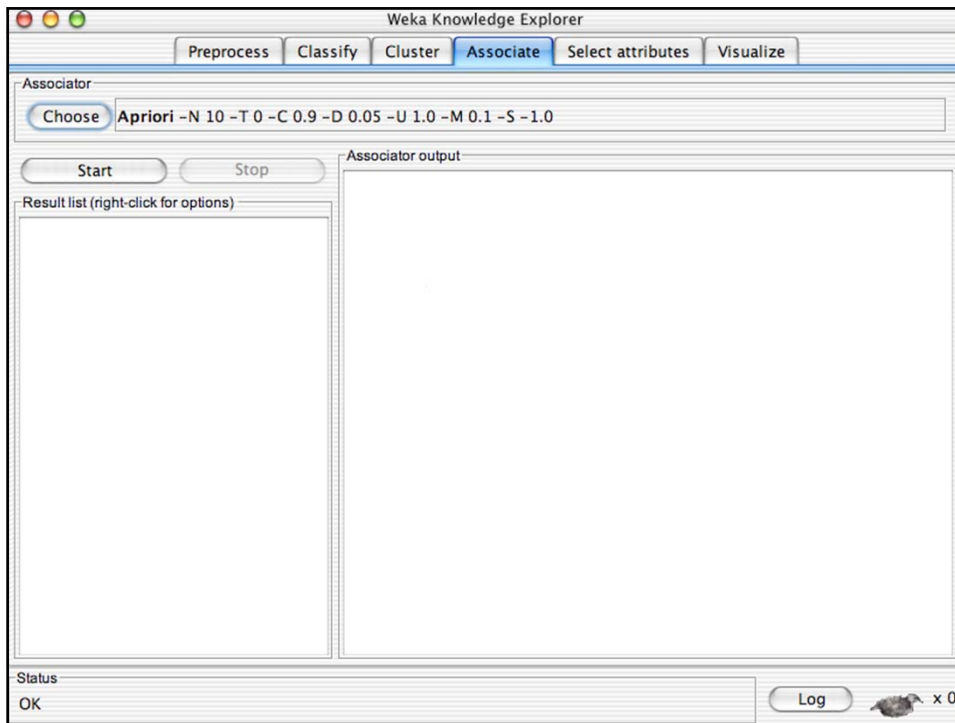


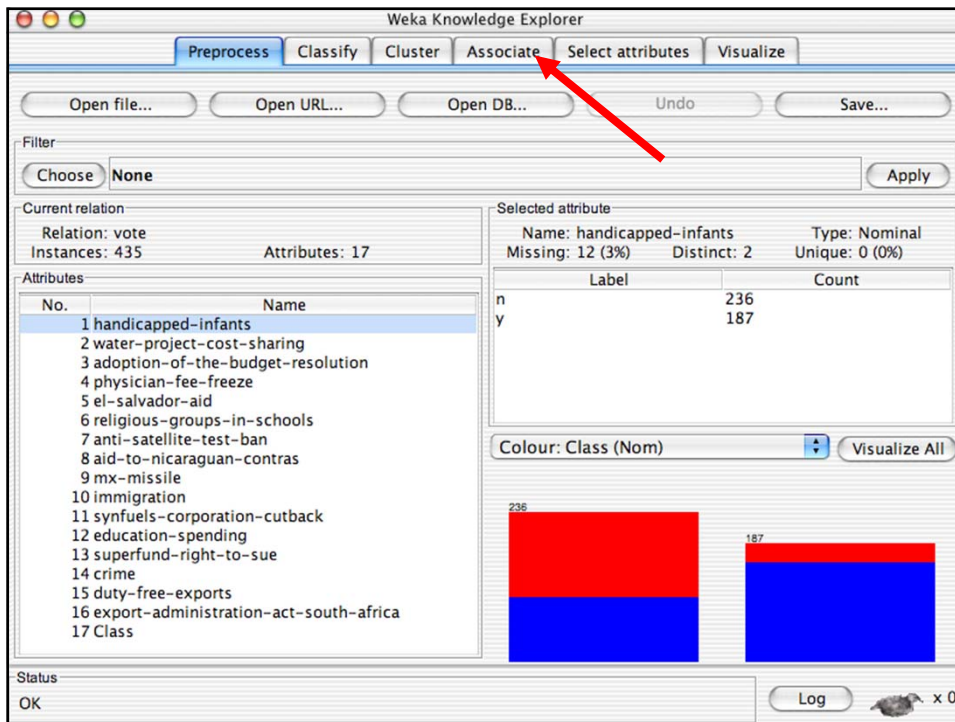
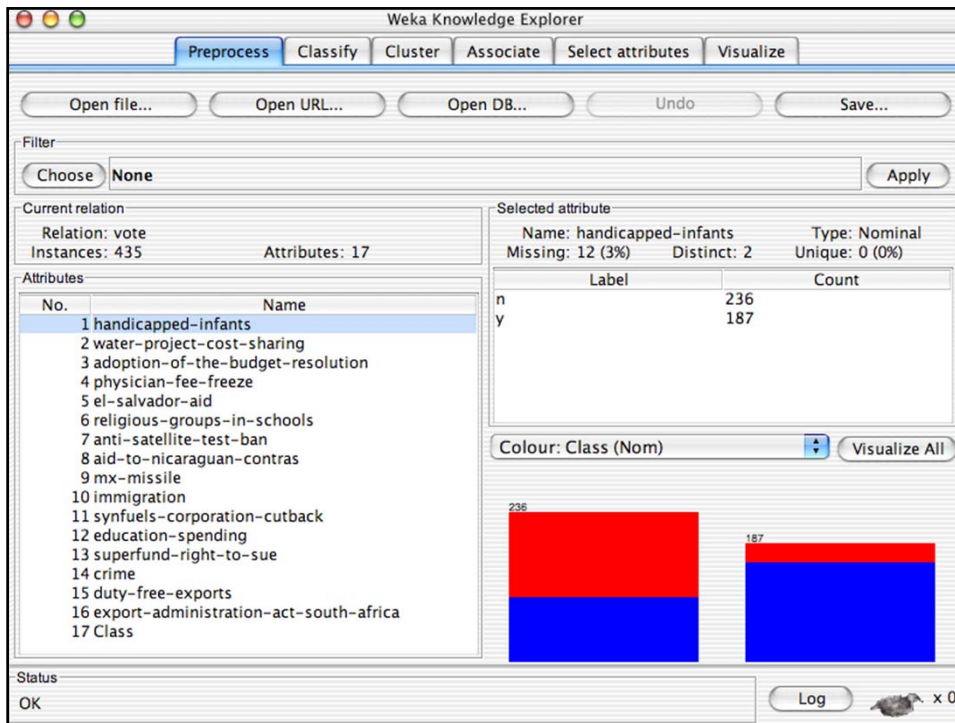


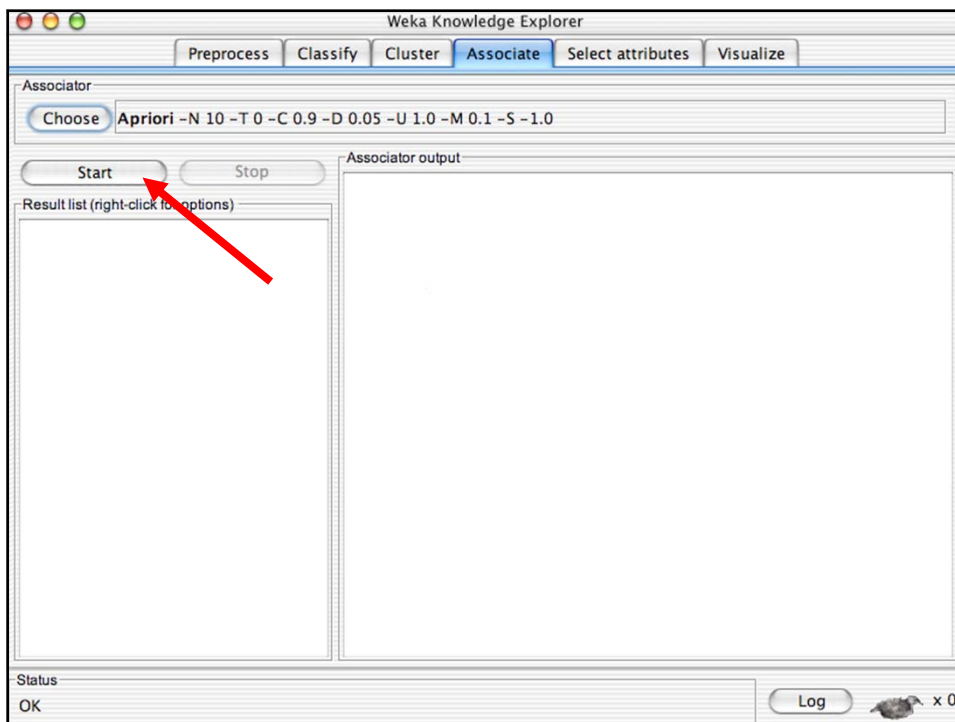
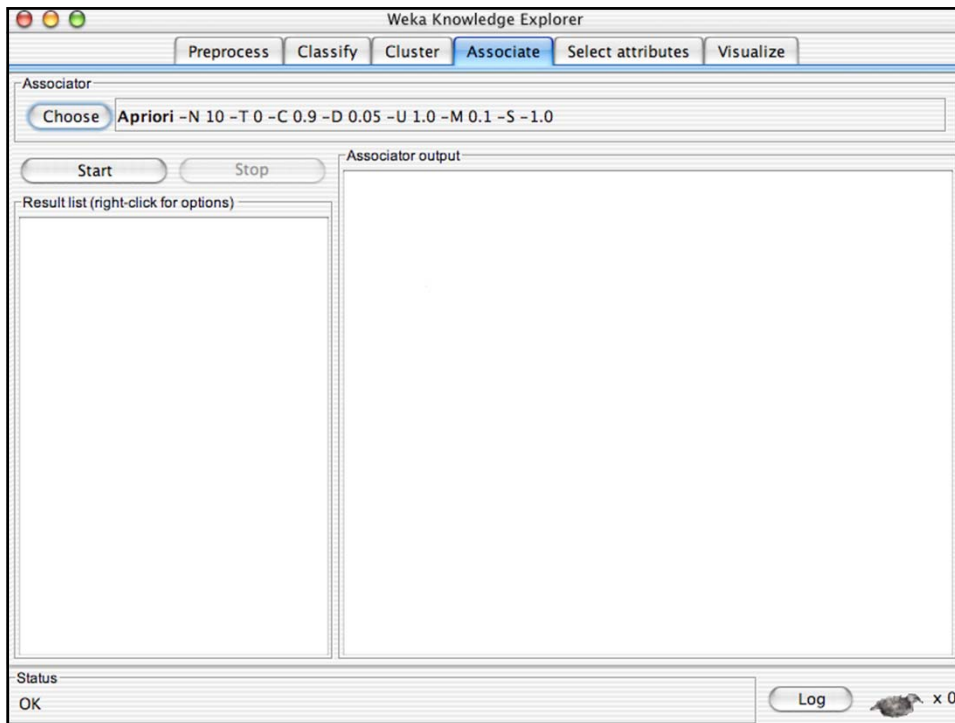


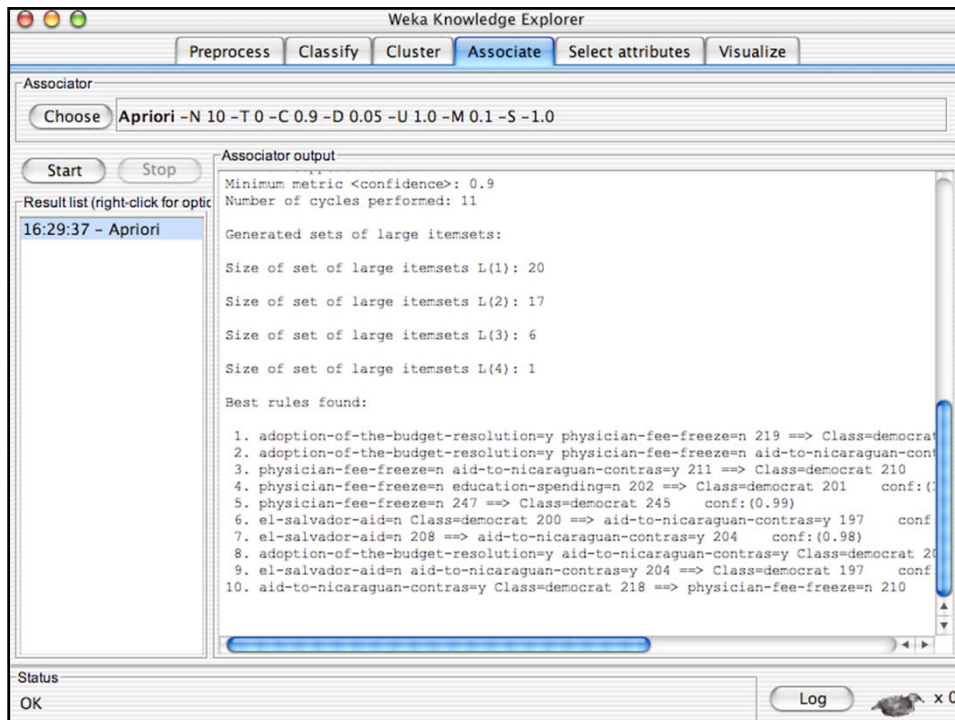
Explorer: finding associations

- WEKA contains an implementation of the Apriori algorithm for learning association rules
 - ◆ Works only with discrete data
- Can identify statistical dependencies between groups of attributes:
 - ◆ milk, butter \Rightarrow bread, eggs (with confidence 0.9 and support 2000)
- Apriori can compute all rules that have a given minimum support and exceed a given confidence



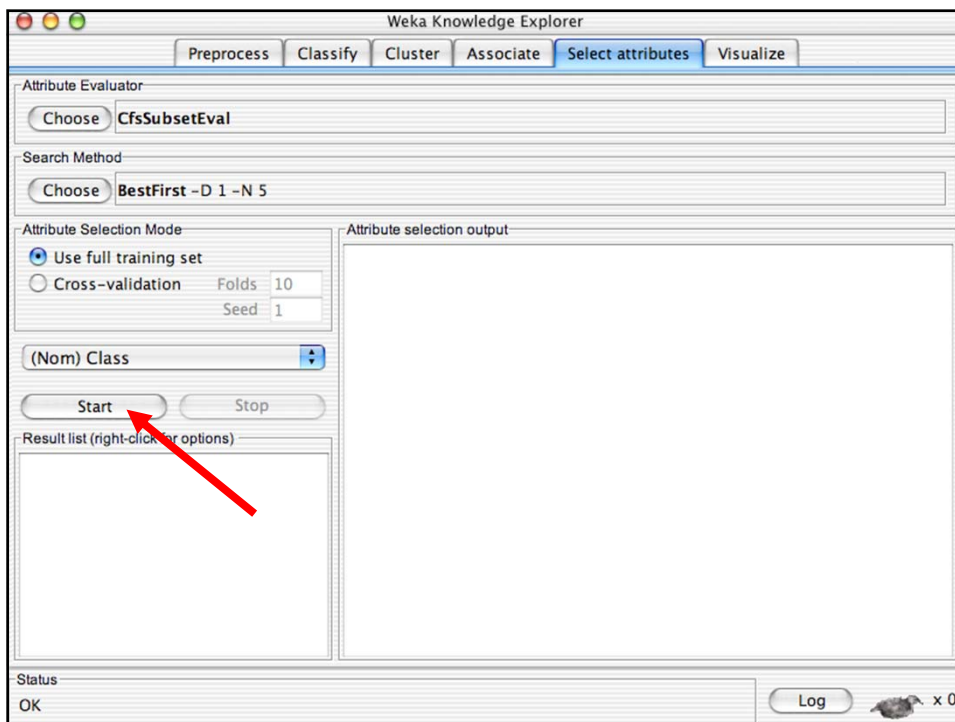
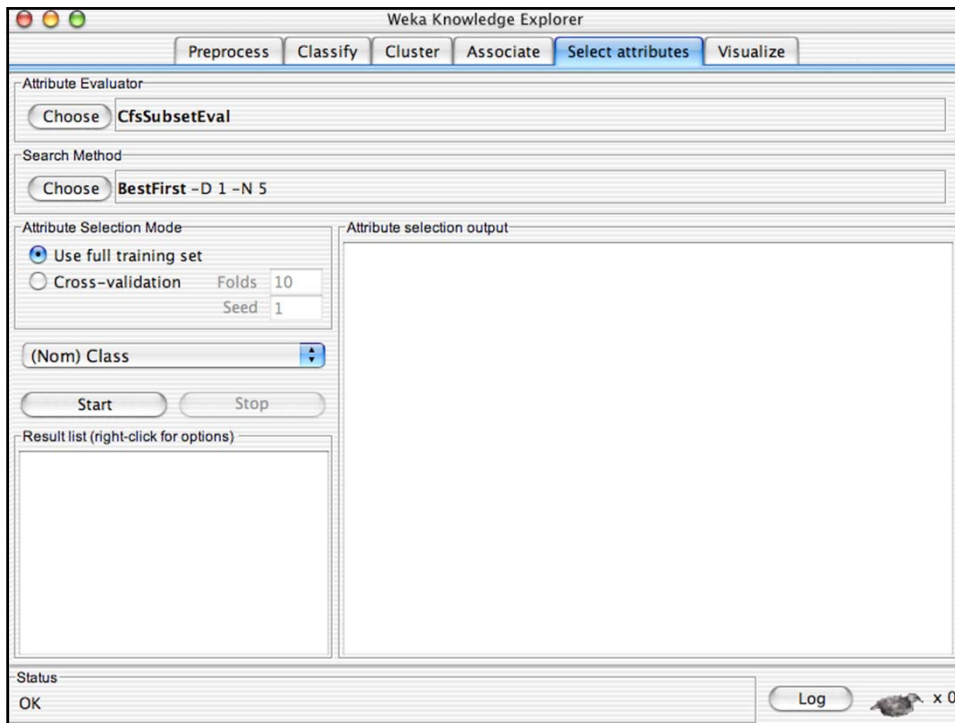


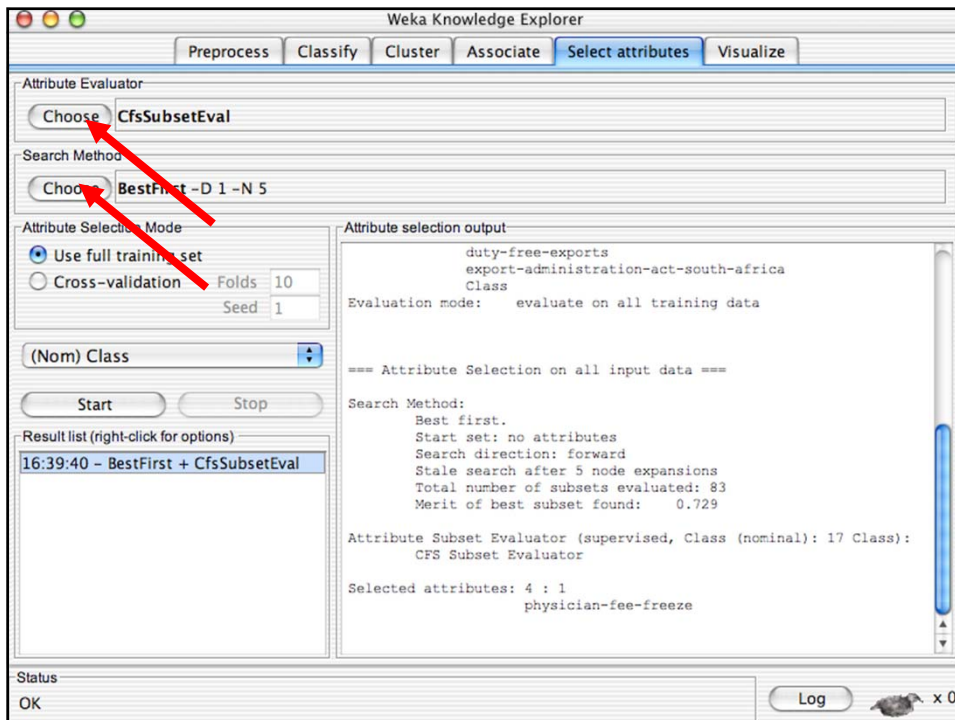
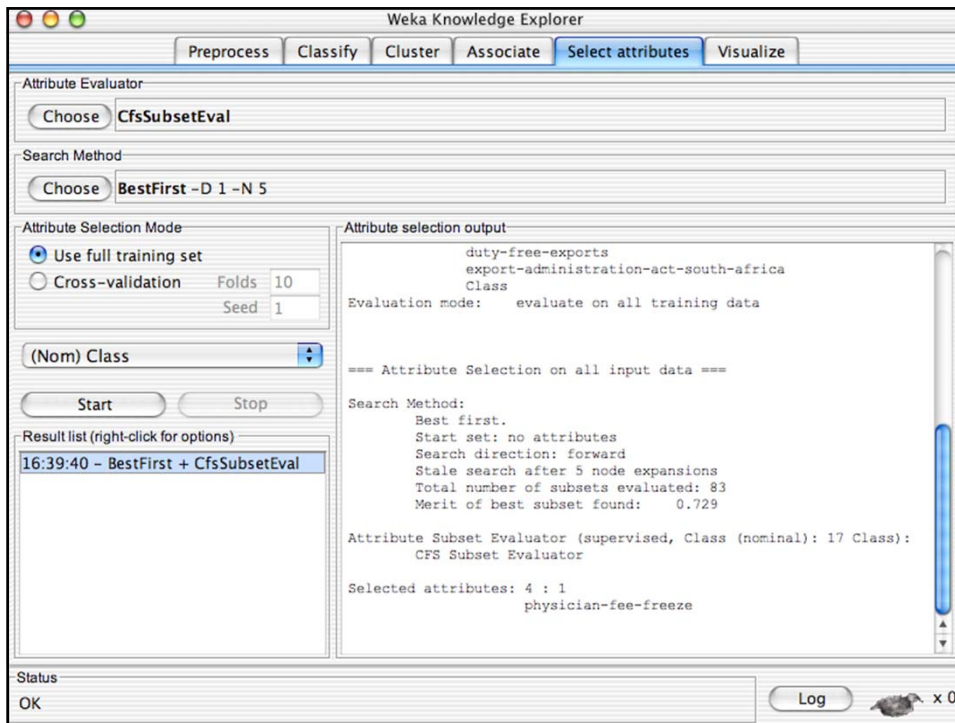


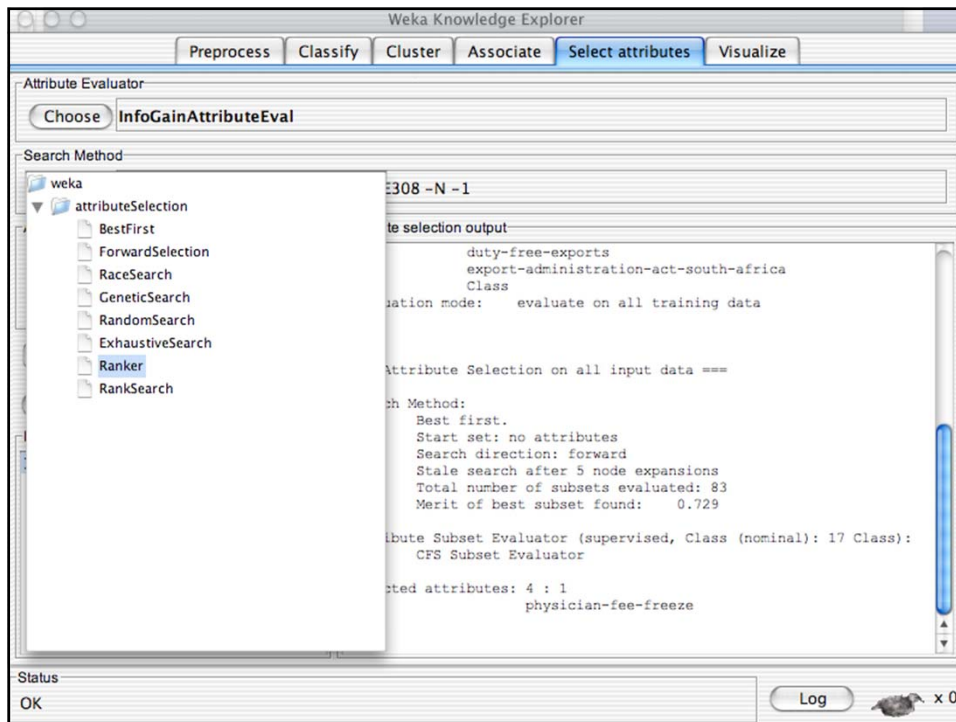
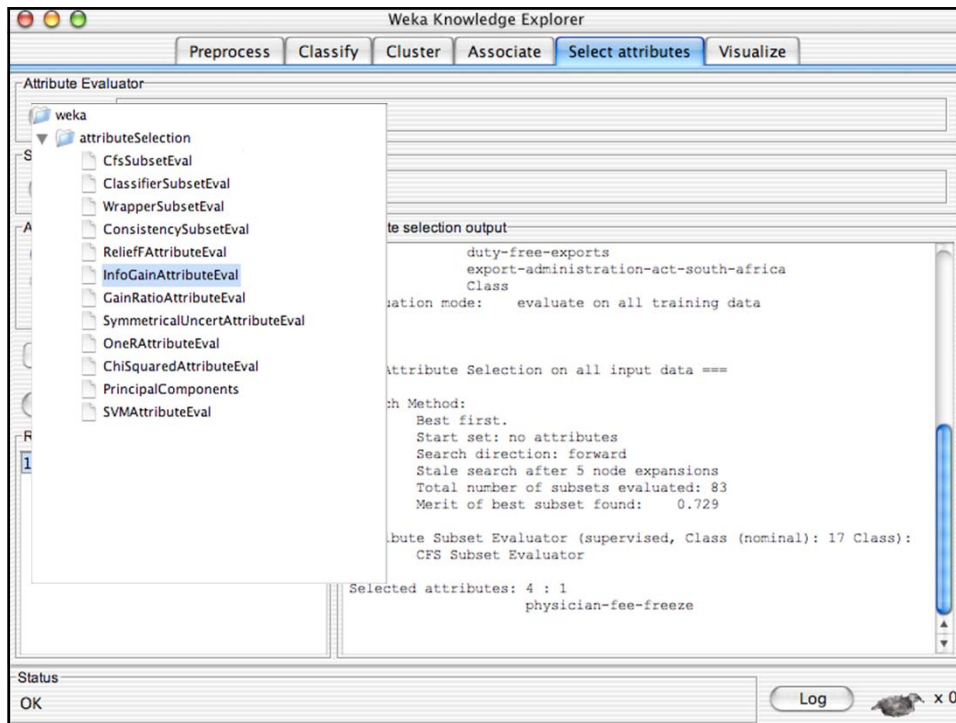


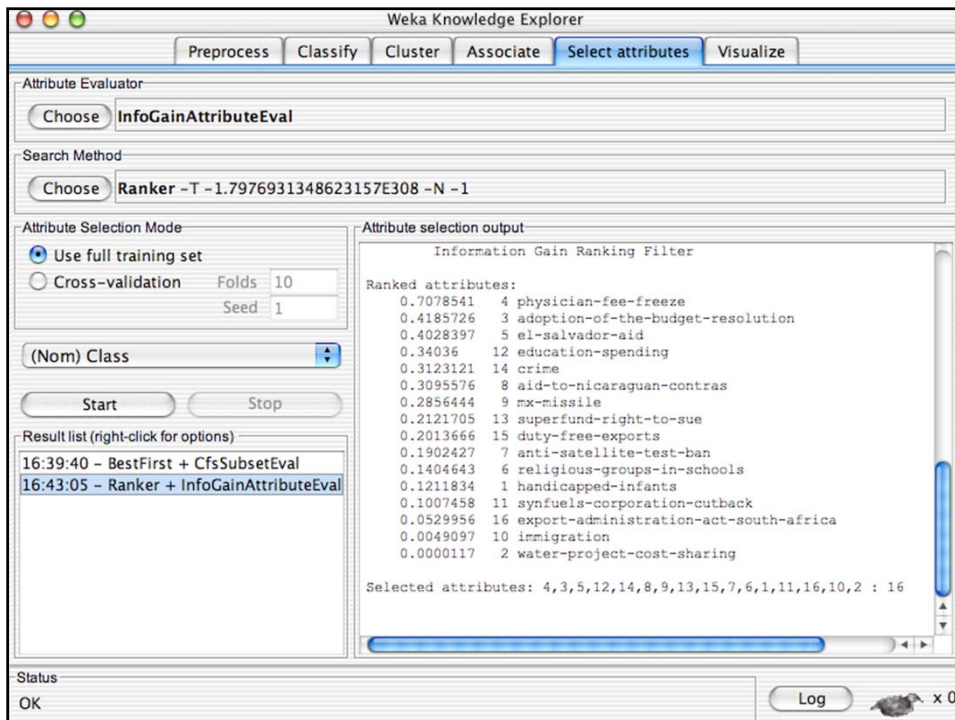
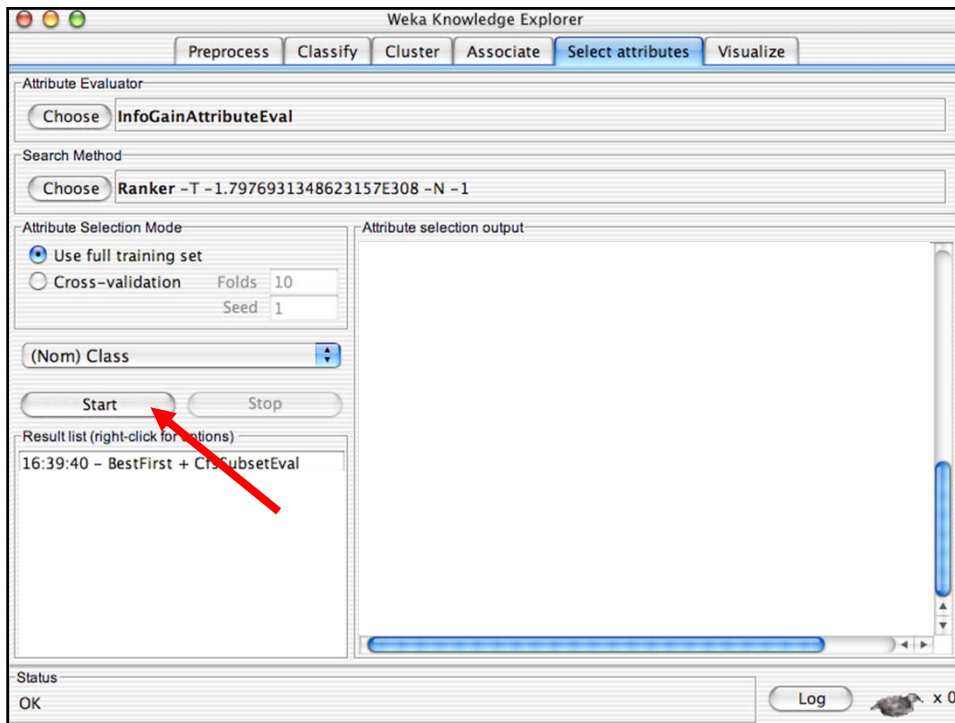
Explorer: attribute selection

- Panel that can be used to investigate which (subsets of) attributes are the most predictive ones
- Attribute selection methods contain two parts:
 - ◆ A search method: best-first, forward selection, random, exhaustive, genetic algorithm, ranking
 - ◆ An evaluation method: correlation-based, wrapper, information gain, chi-squared, ...
- Very flexible: WEKA allows (almost) arbitrary combinations of these two









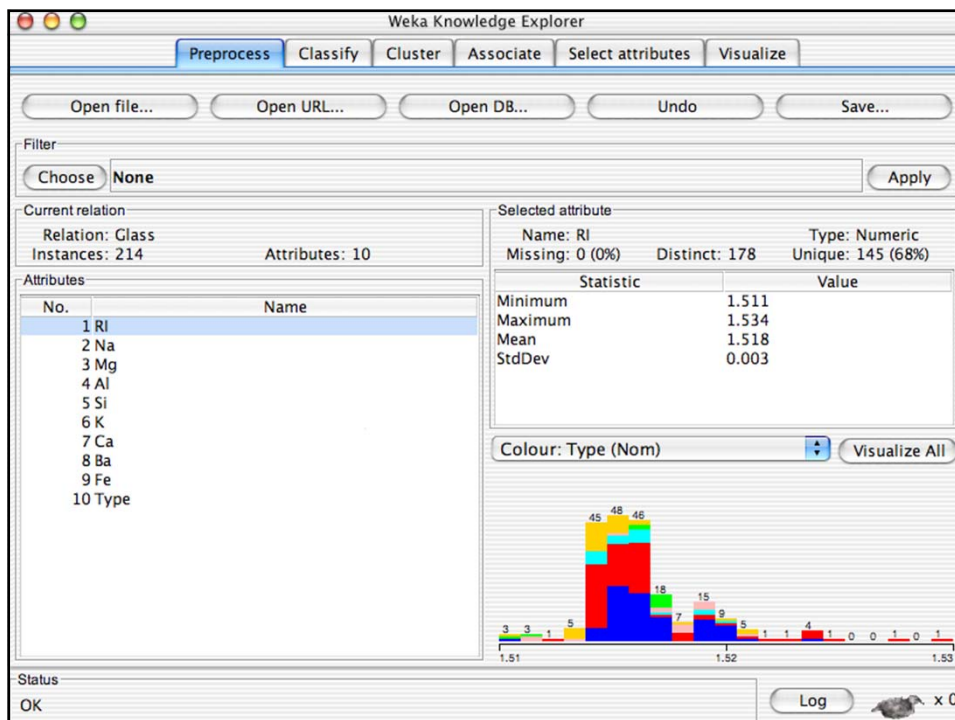
Explorer: data visualization

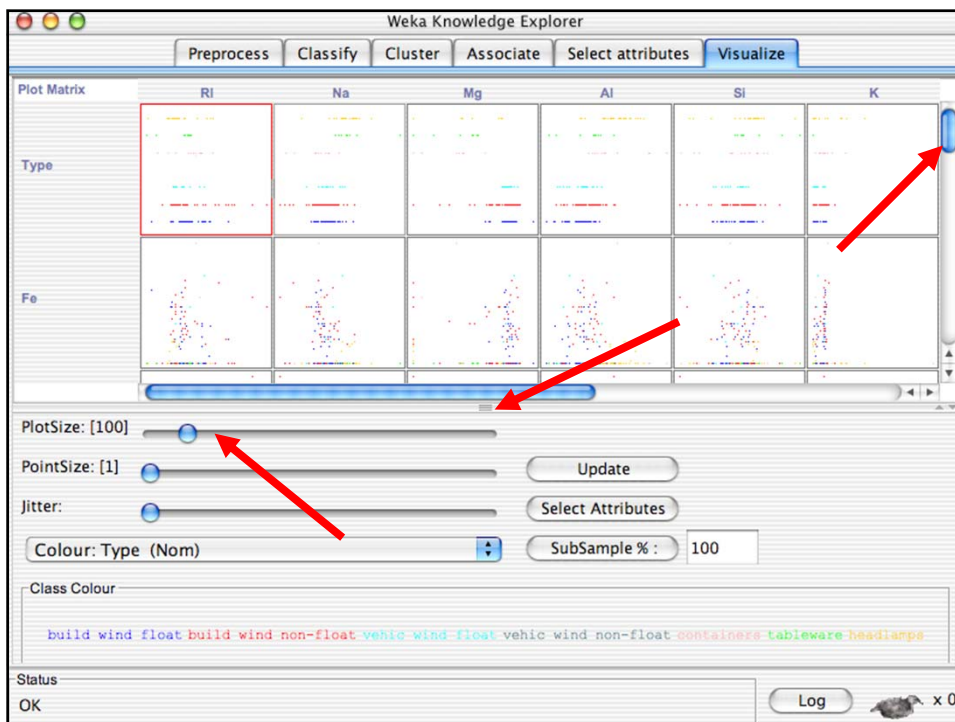
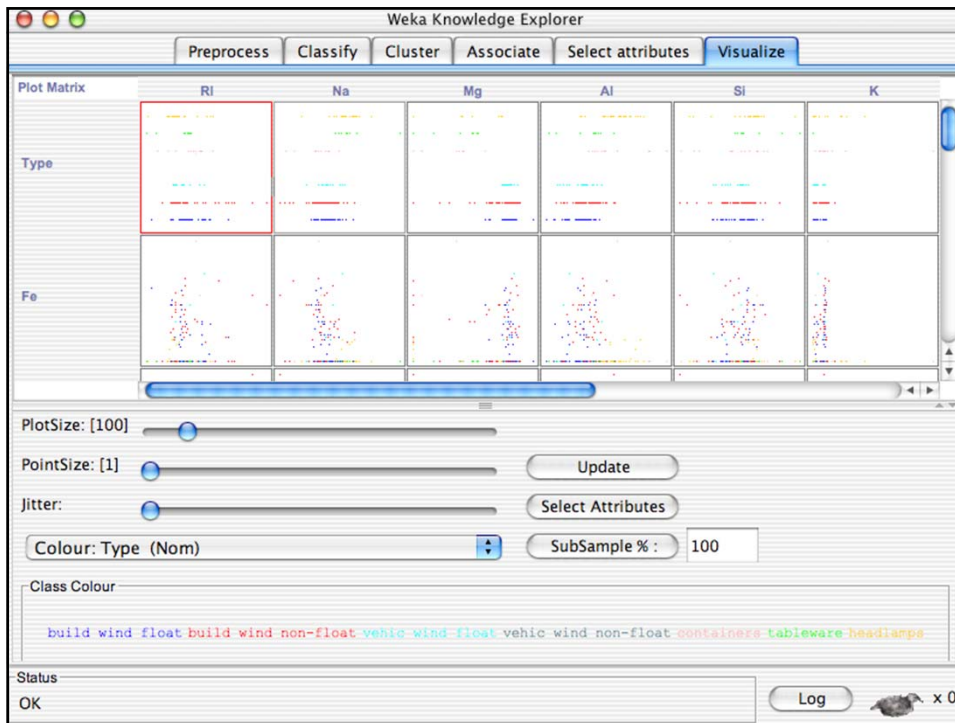
- Visualization very useful in practice: e.g. helps to determine difficulty of the learning problem
- WEKA can visualize single attributes (1-d) and pairs of attributes (2-d)
 - ◆ To do: rotating 3-d visualizations (Xgobi-style)
- Color-coded class values
- “Jitter” option to deal with nominal attributes (and to detect “hidden” data points)
- “Zoom-in” function

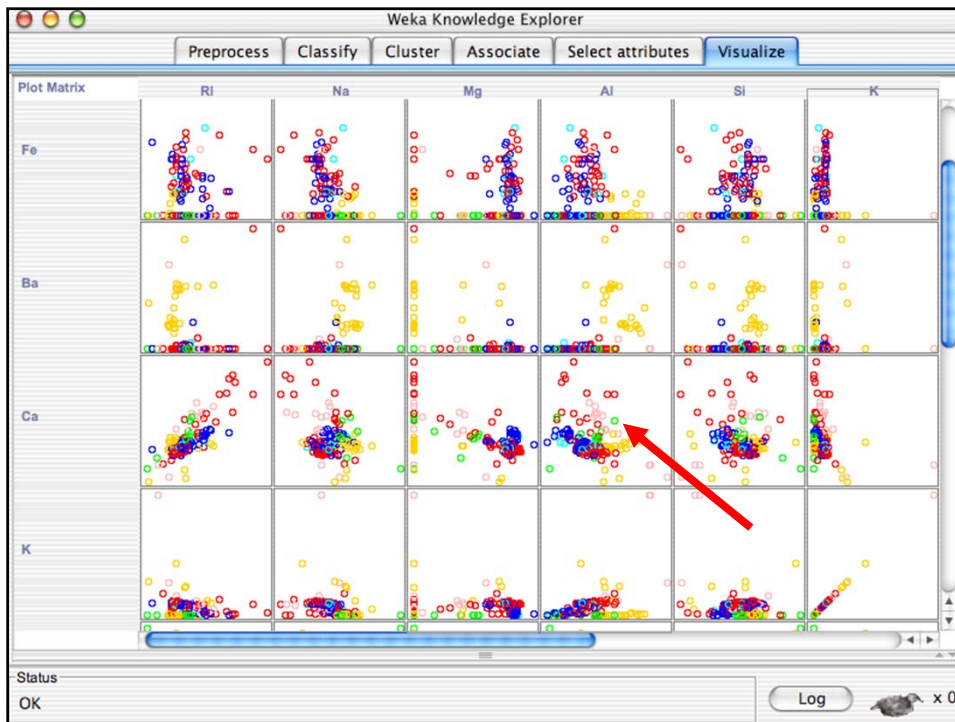
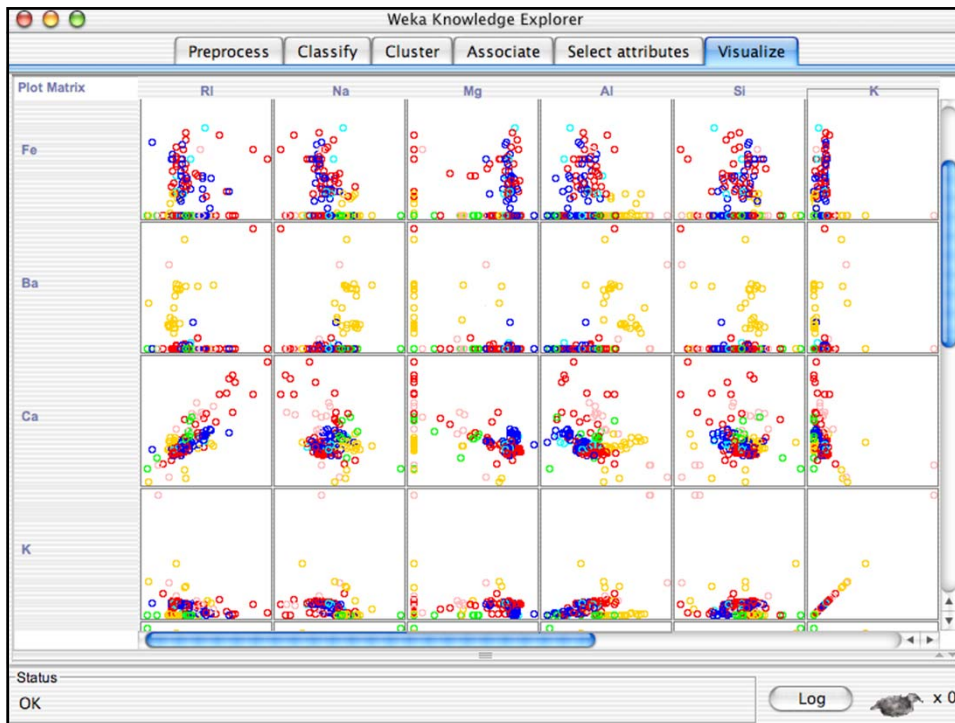
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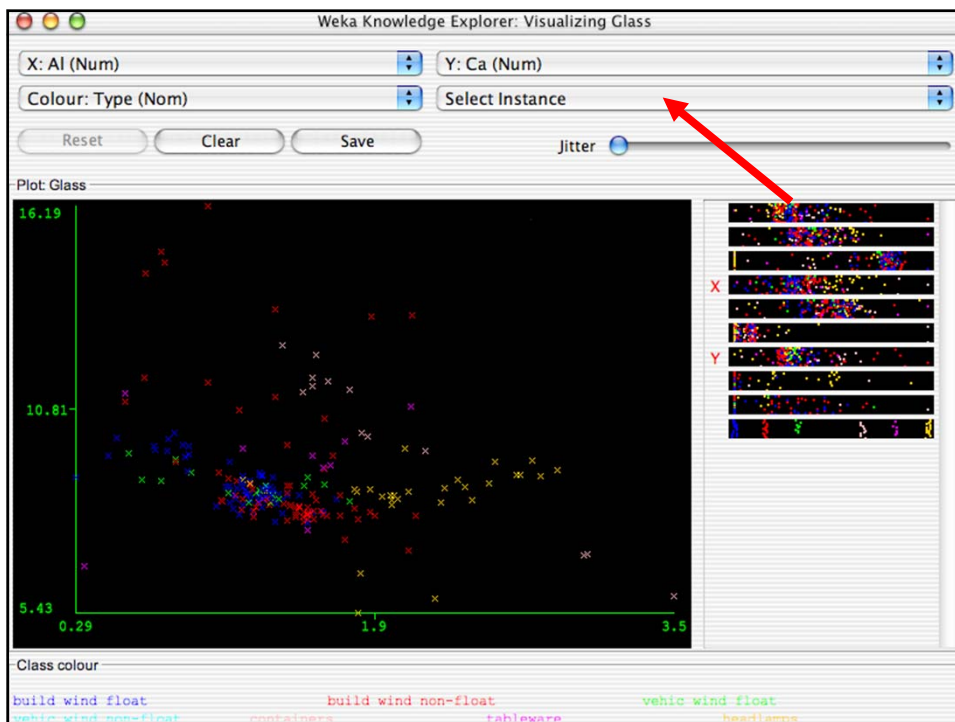
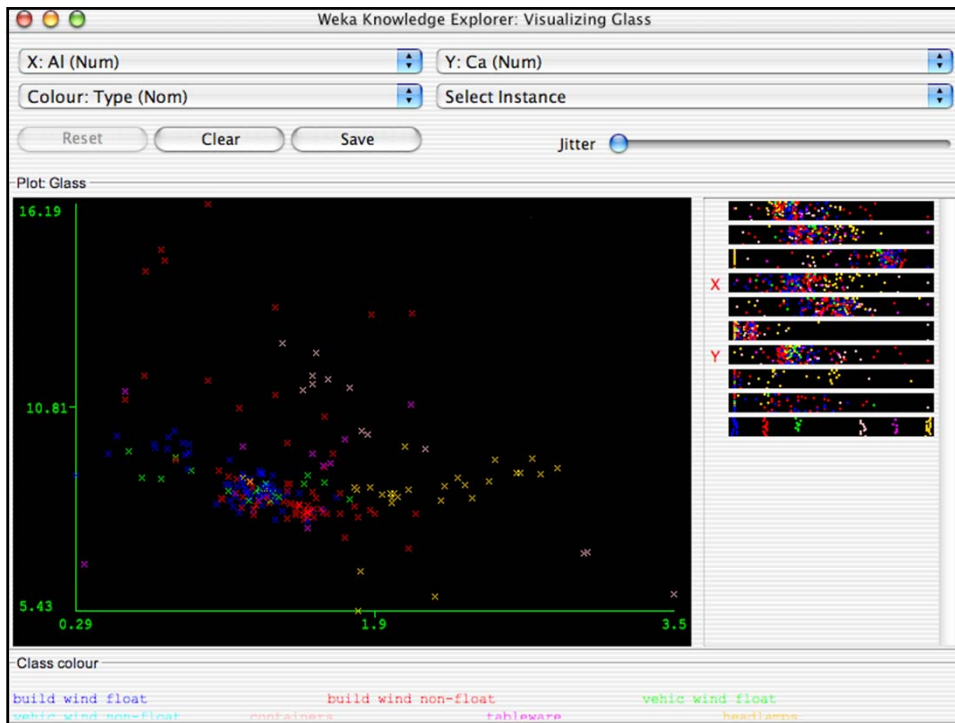
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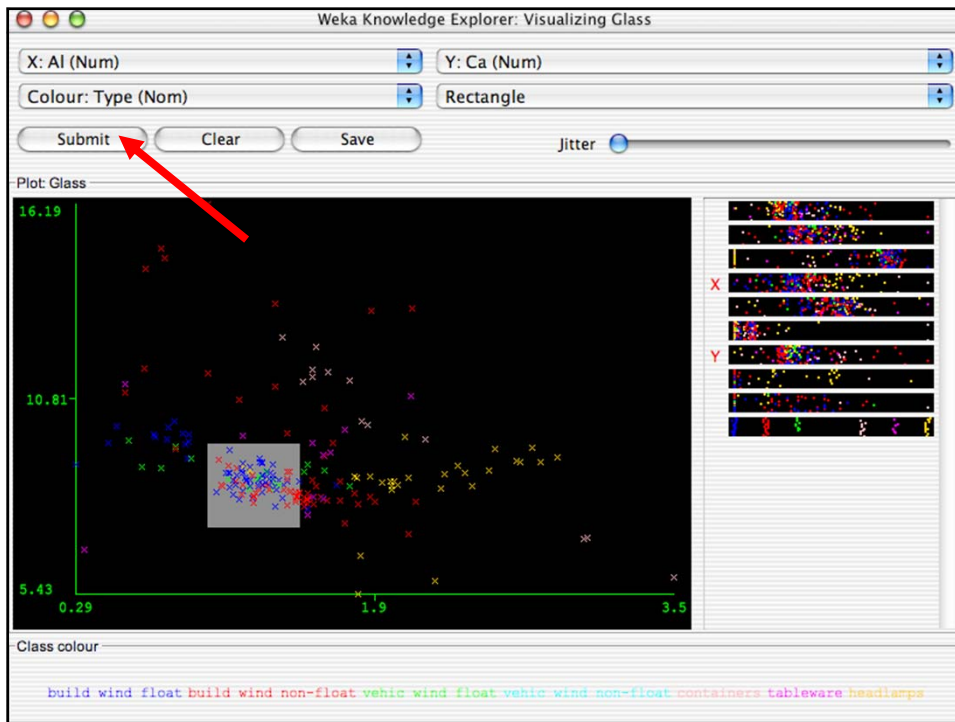
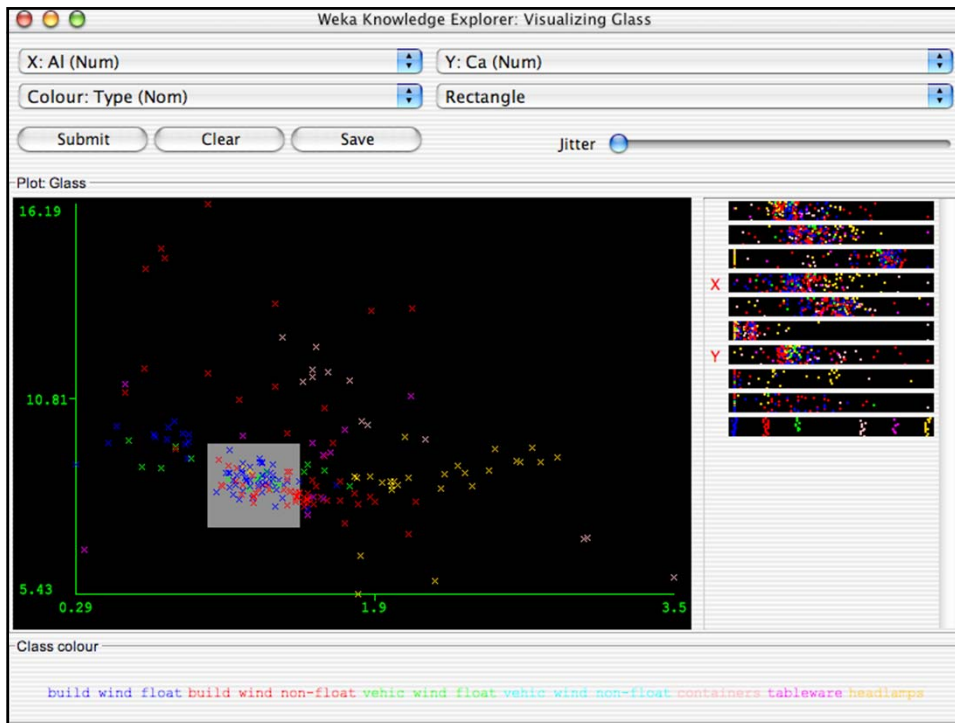
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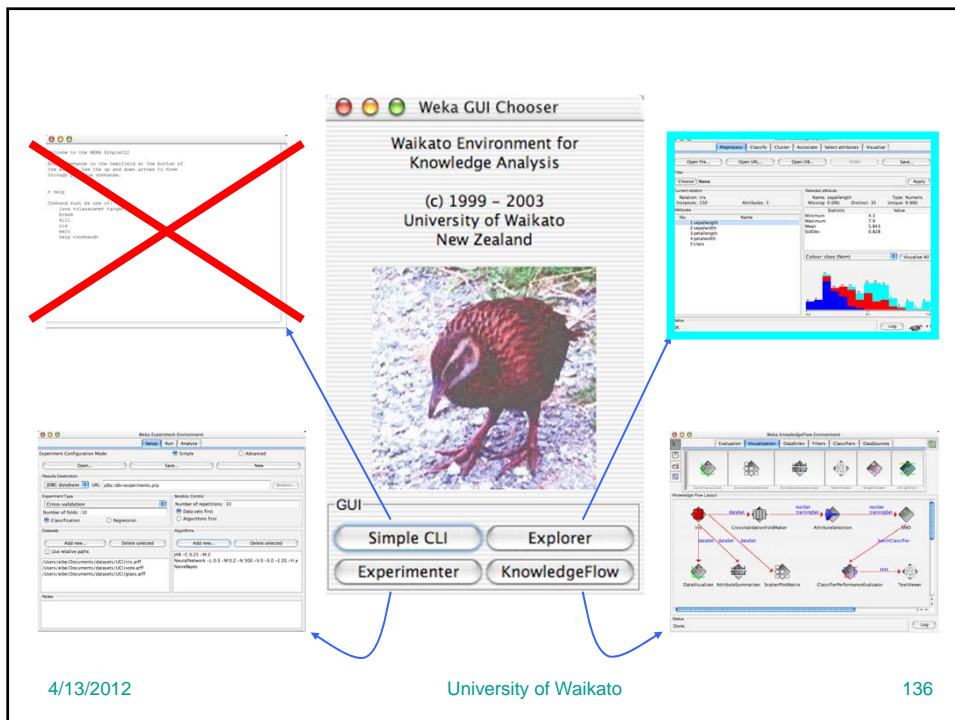
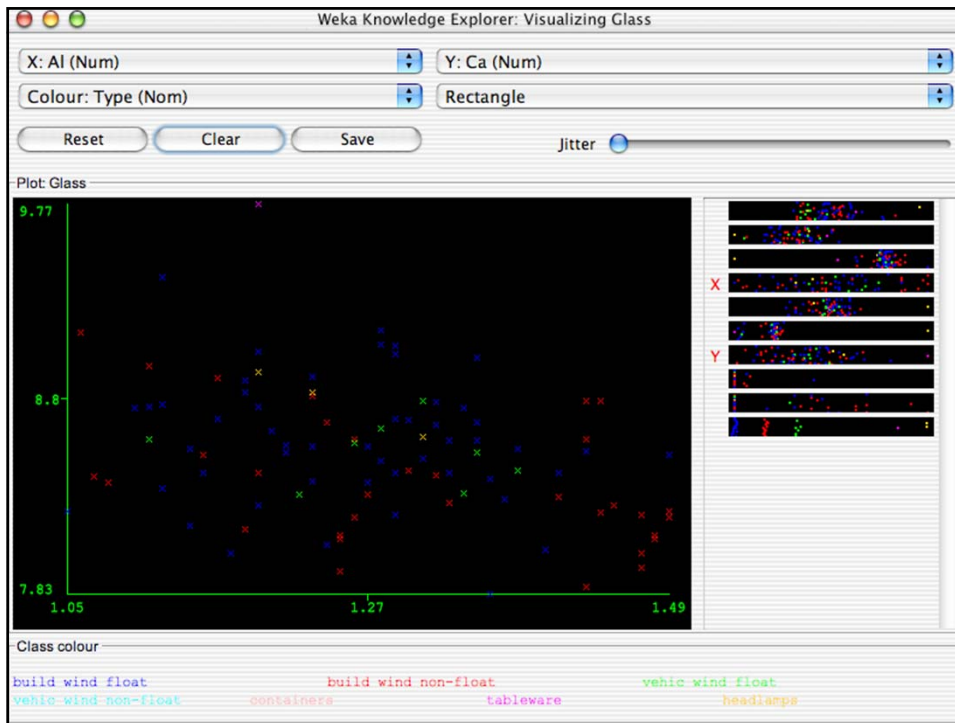












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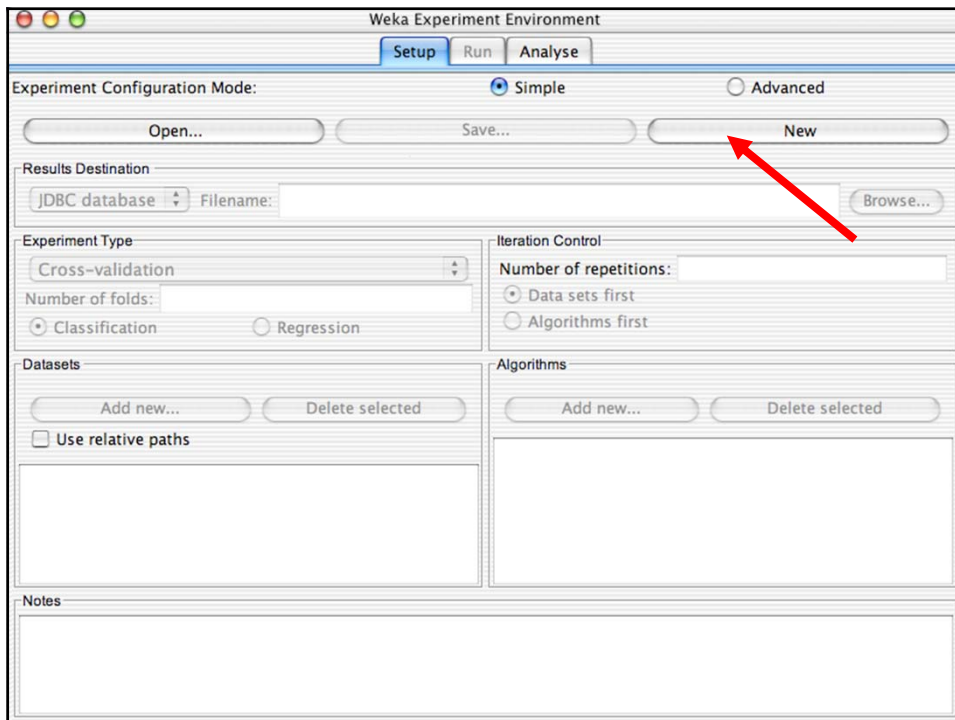
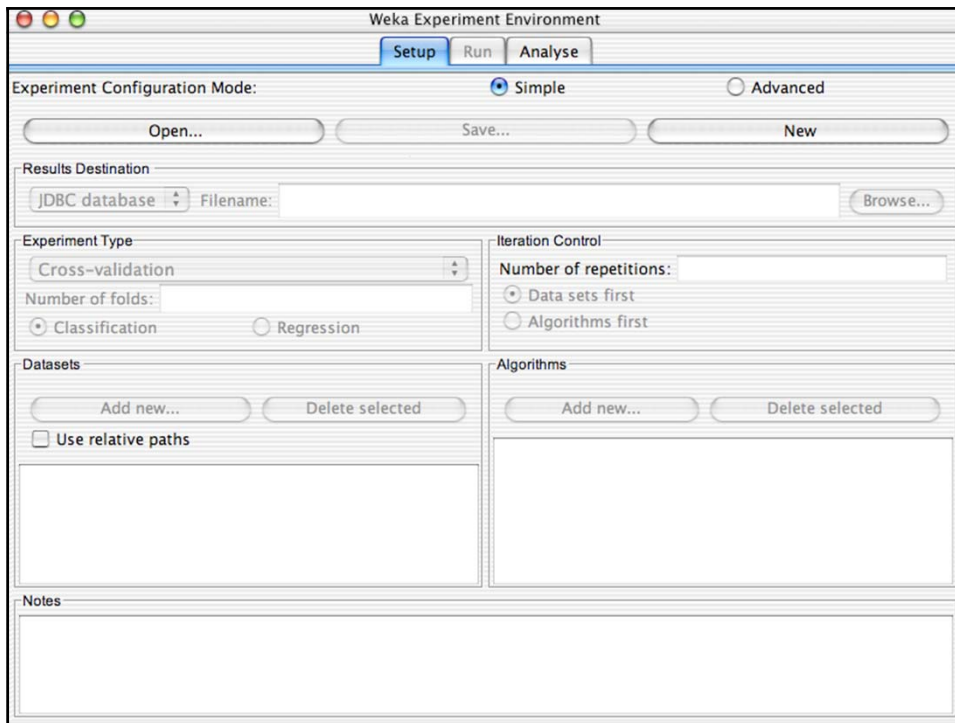
Performing experiments

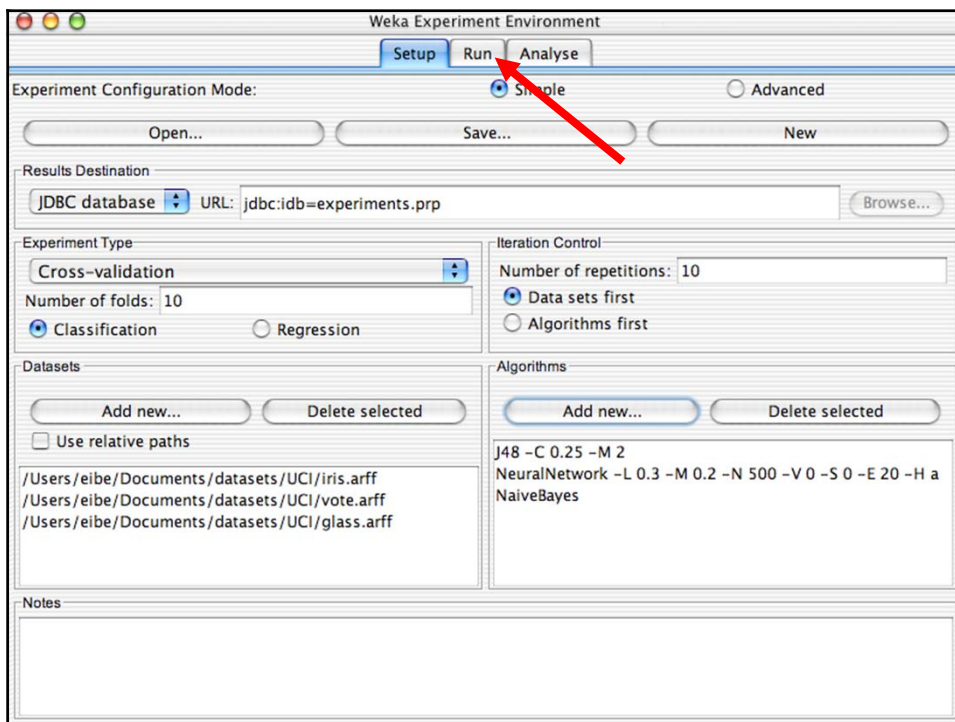
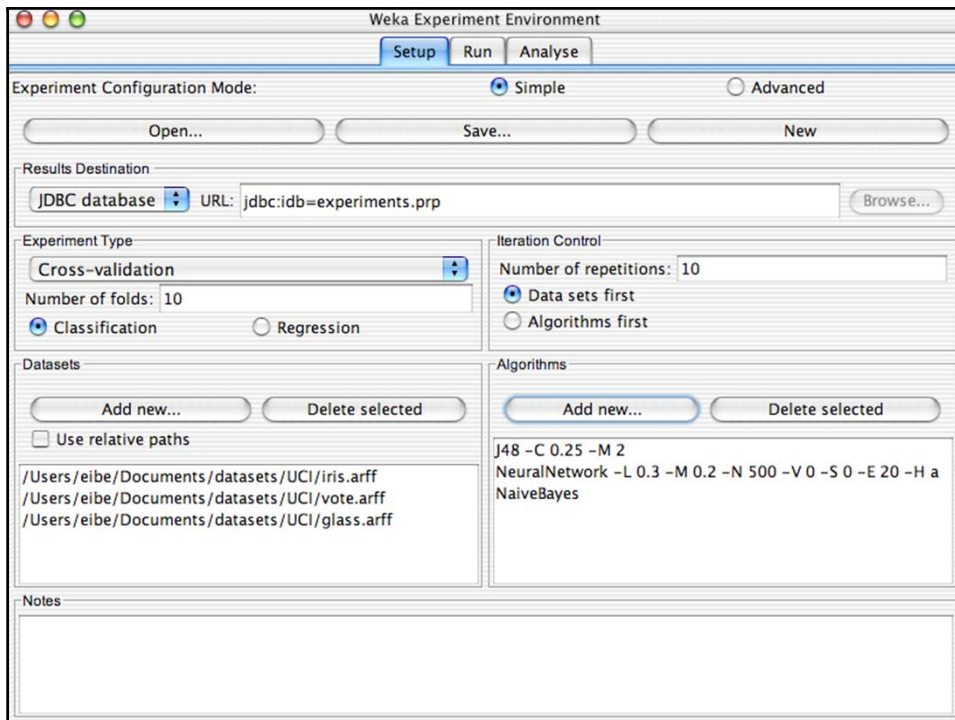
- Experimenter makes it easy to compare the performance of different learning schemes
- For classification and regression problems
- Results can be written into file or database
- Evaluation options: cross-validation, learning curve, hold-out
- Can also iterate over different parameter settings
- Significance-testing built in!

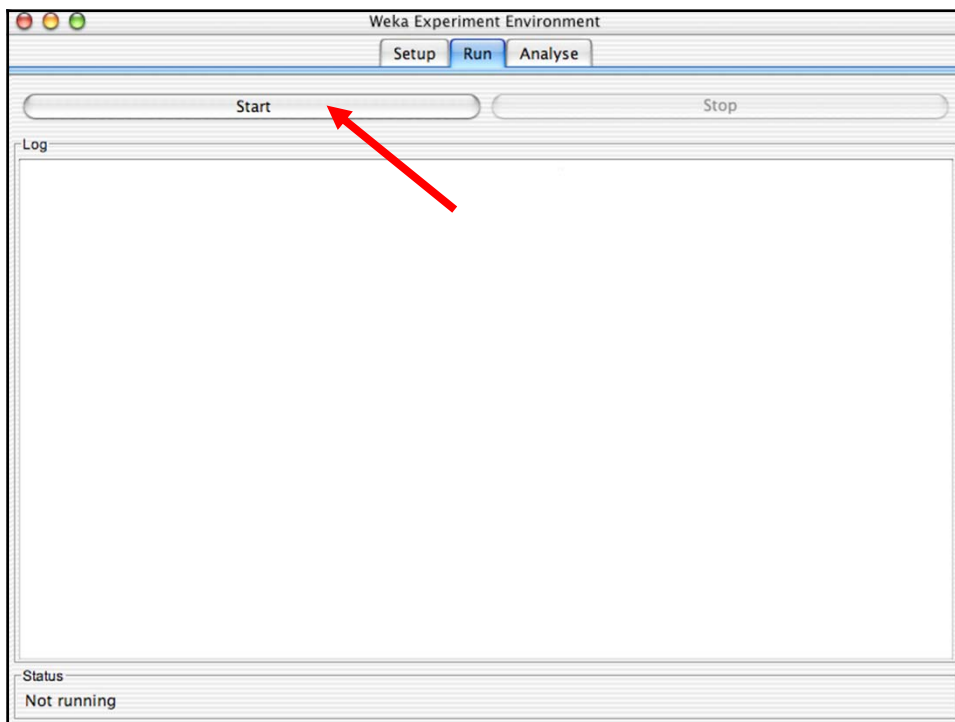
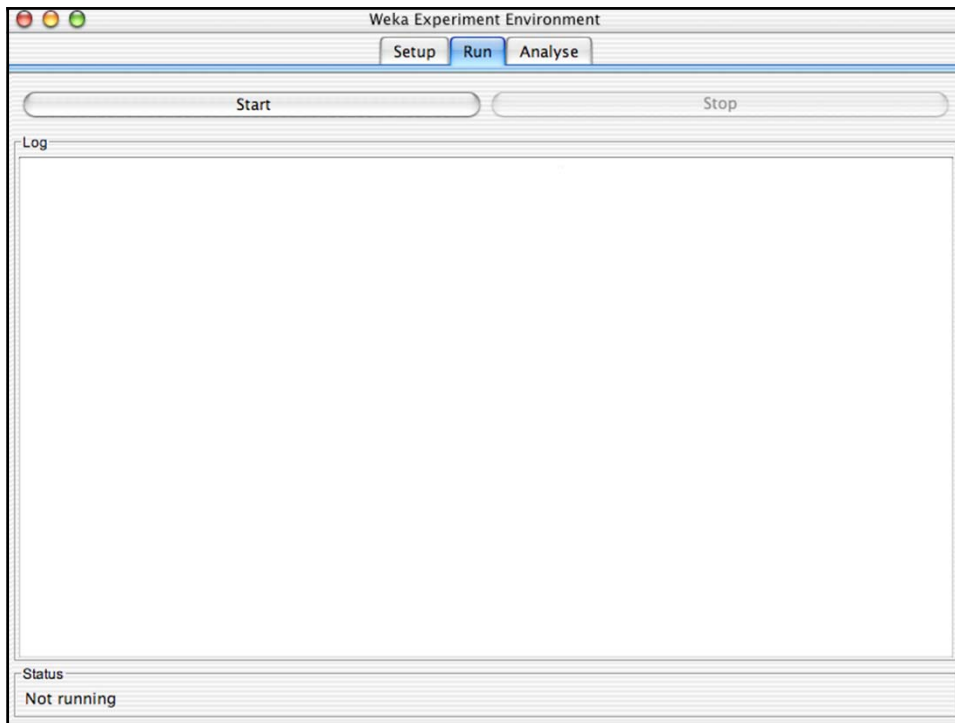
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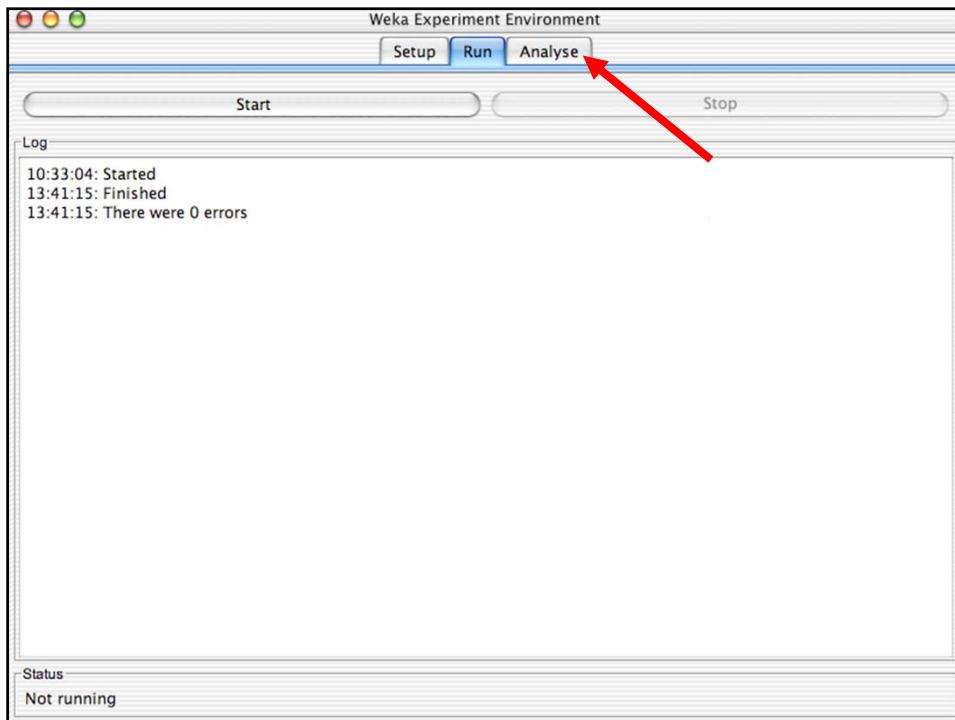
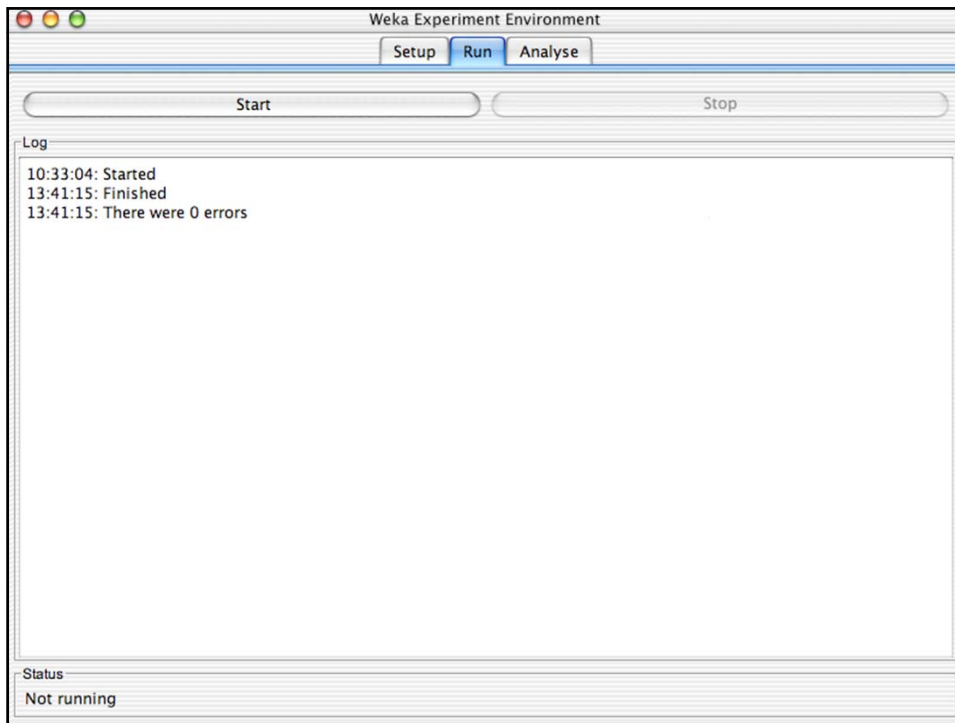
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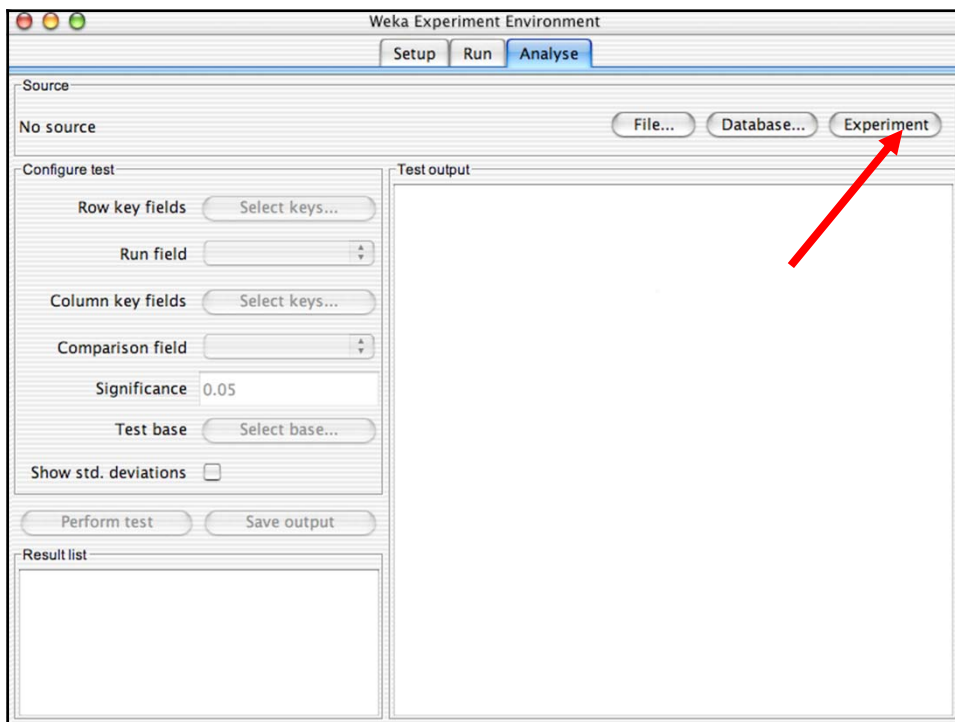
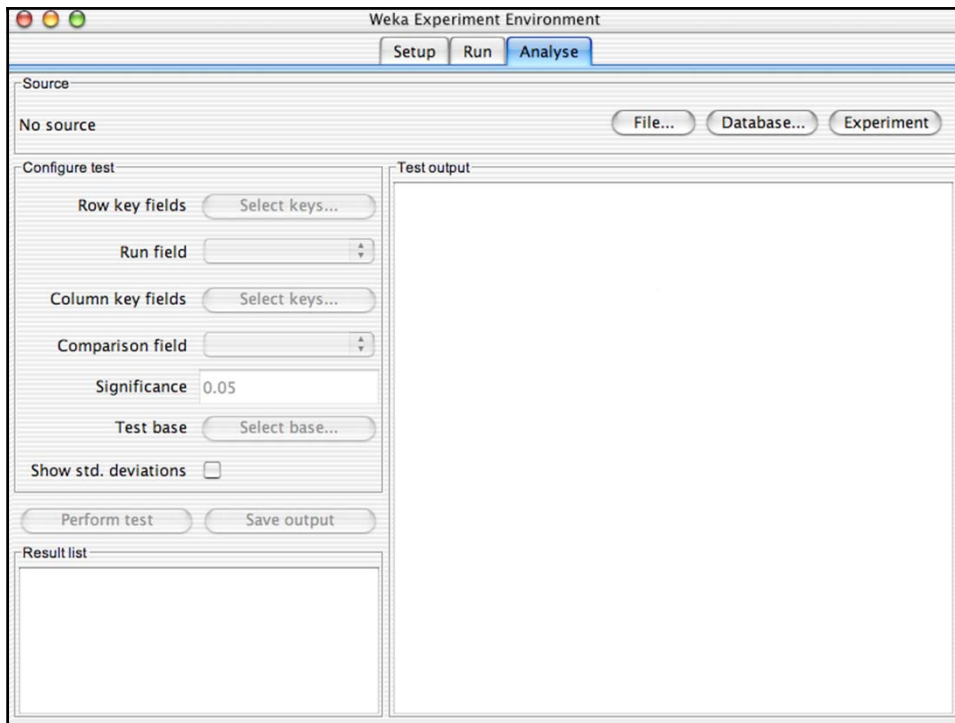
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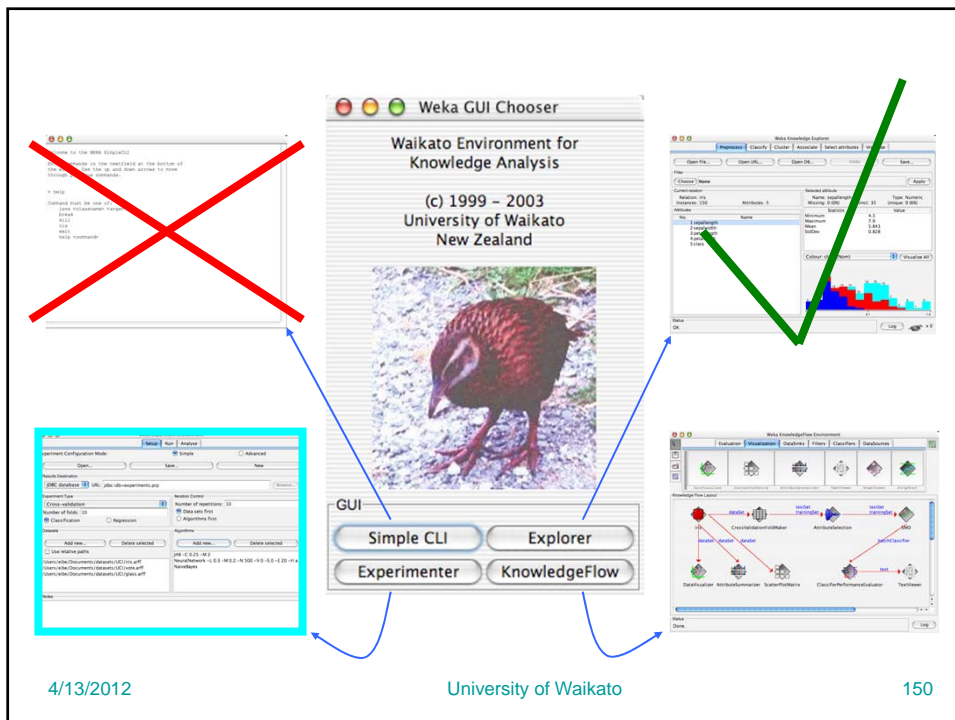
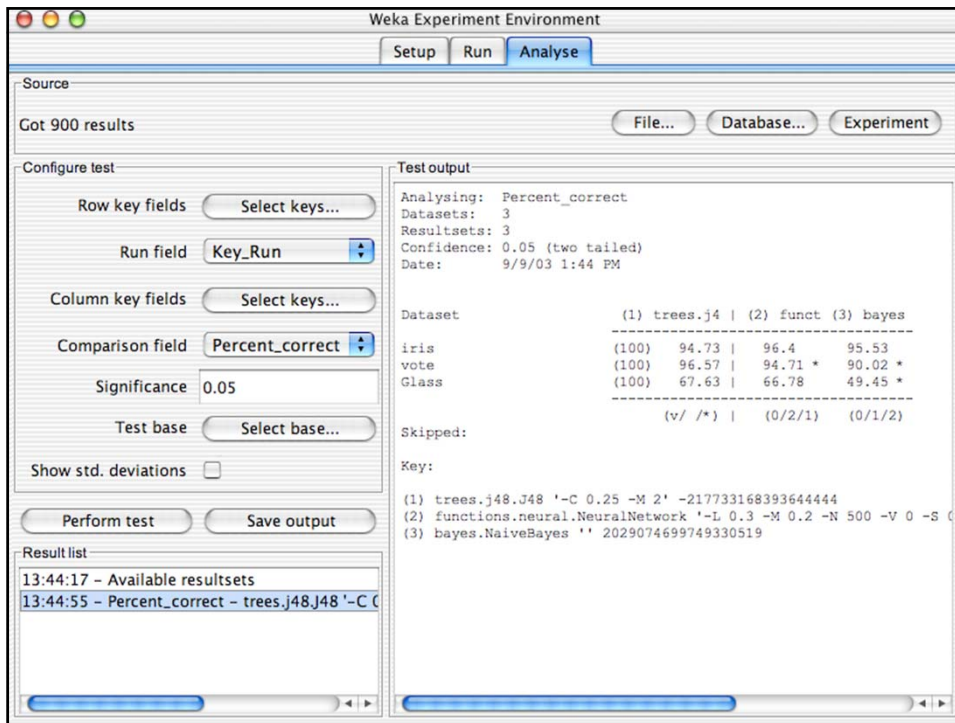












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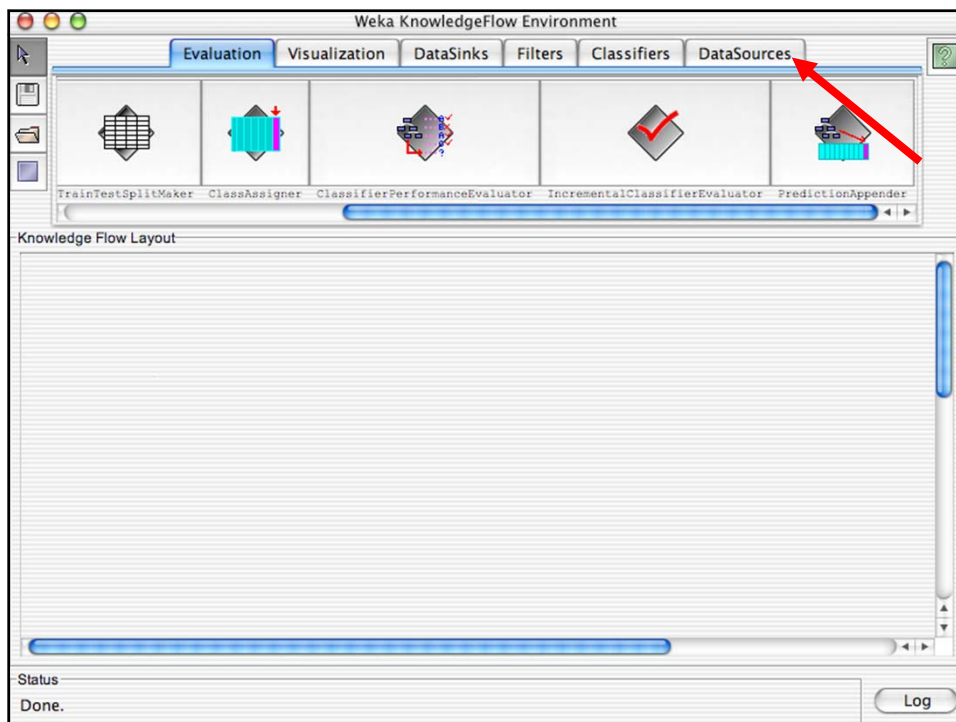
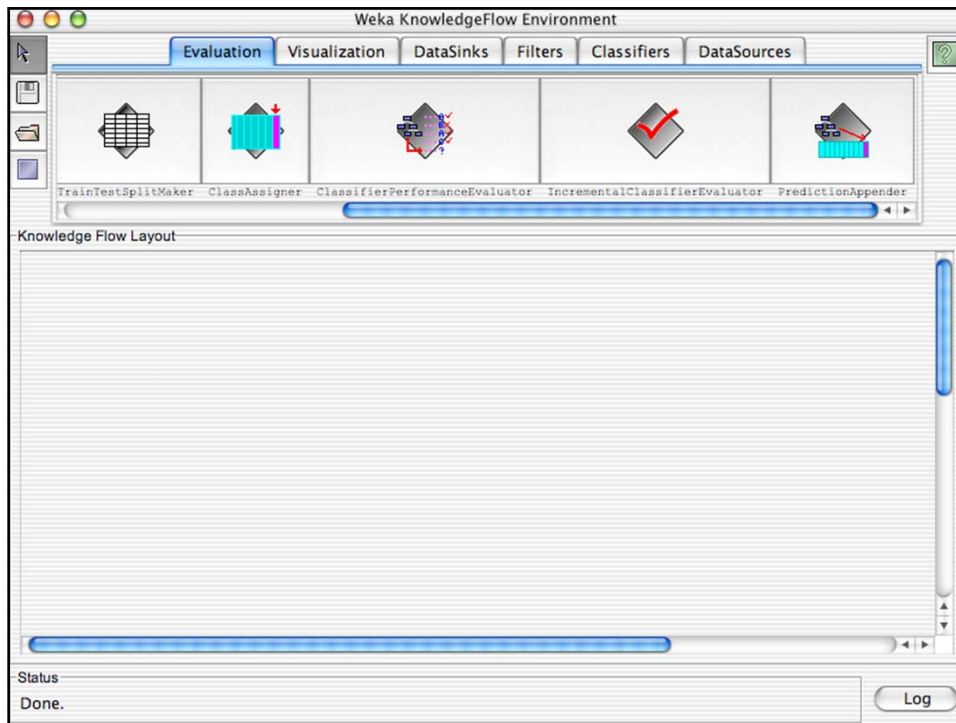
The Knowledge Flow GUI

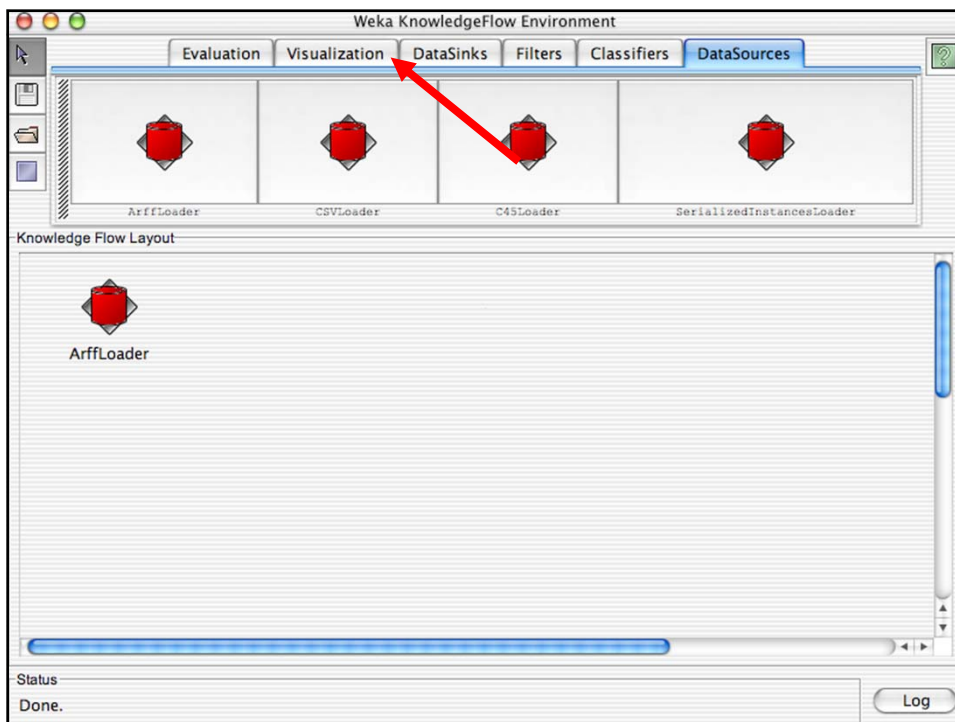
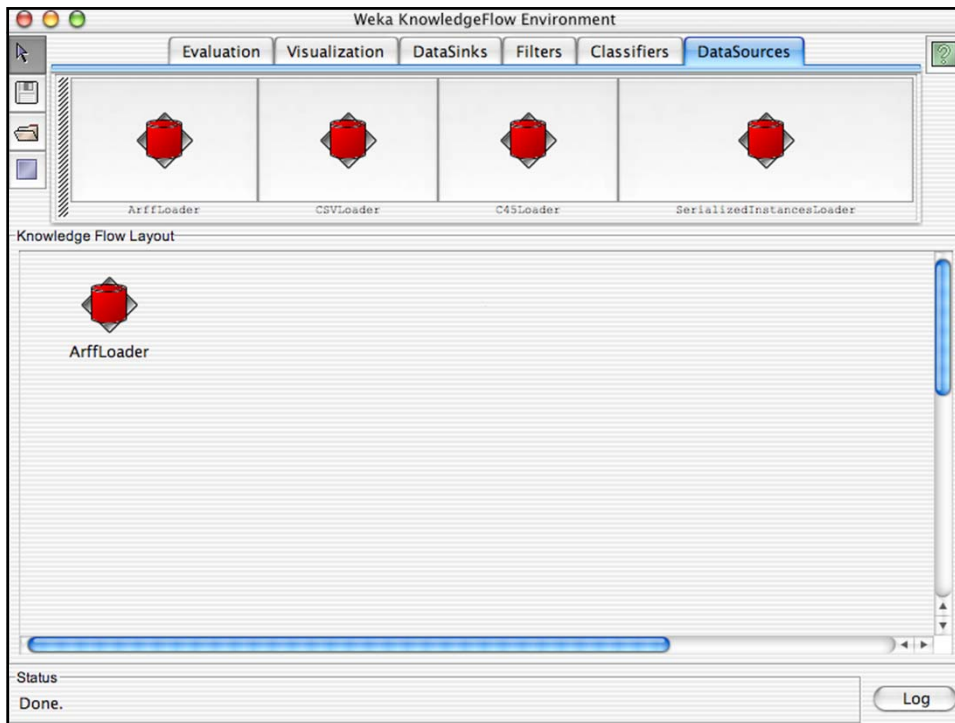
- New graphical user interface for WEKA
- Java-Beans-based interface for setting up and running machine learning experiments
- Data sources, classifiers, etc. are beans and can be connected graphically
- Data “flows” through components: e.g., “data source” -> “filter” -> “classifier” -> “evaluator”
- Layouts can be saved and loaded again later

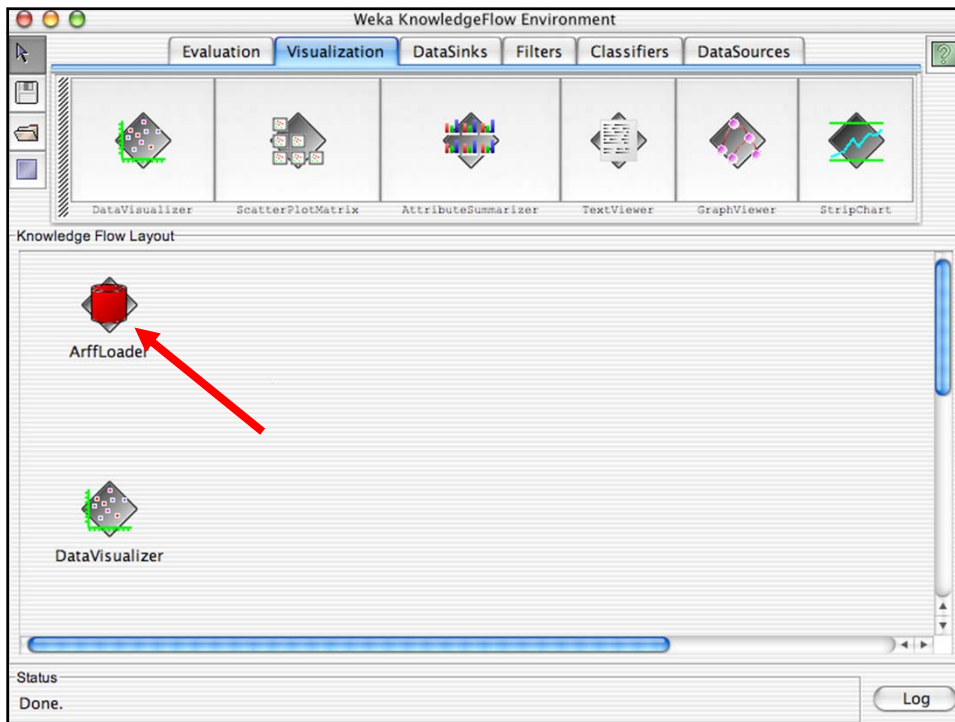
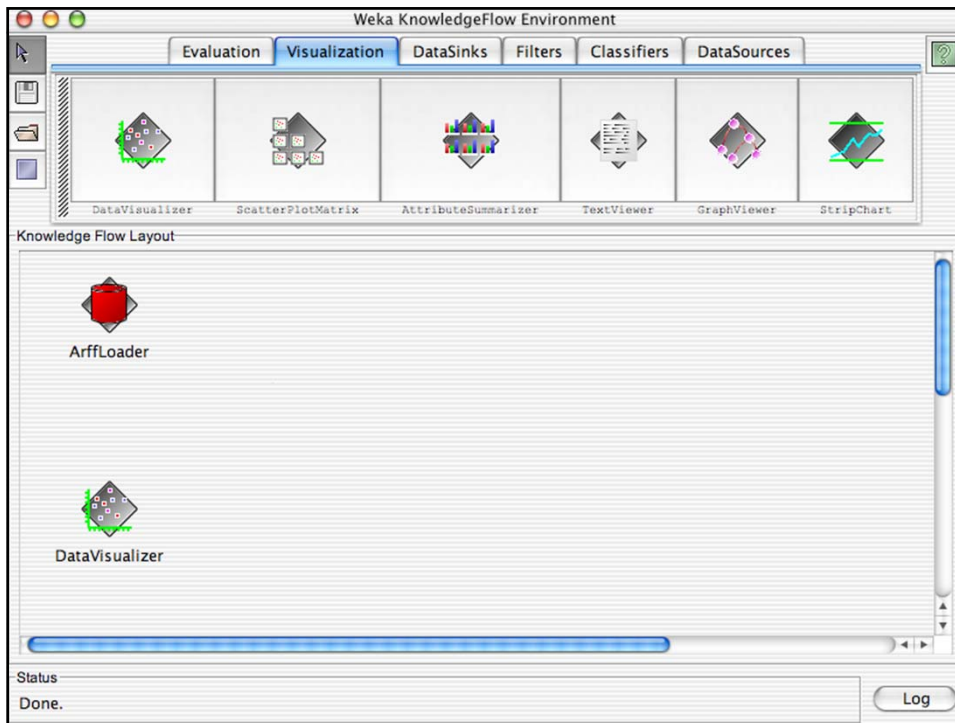
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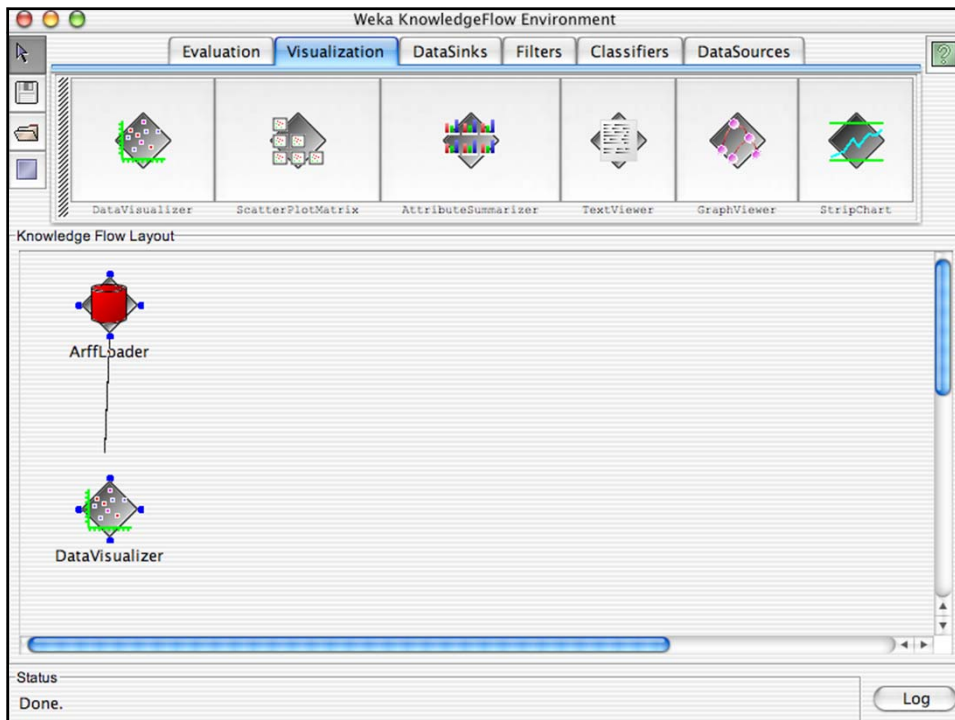
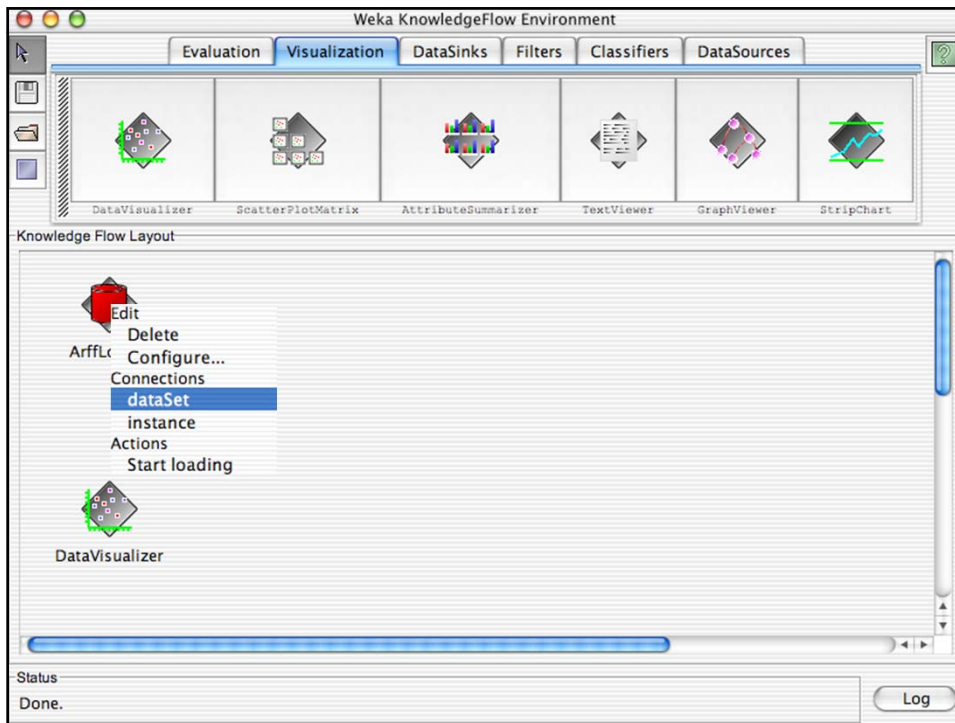
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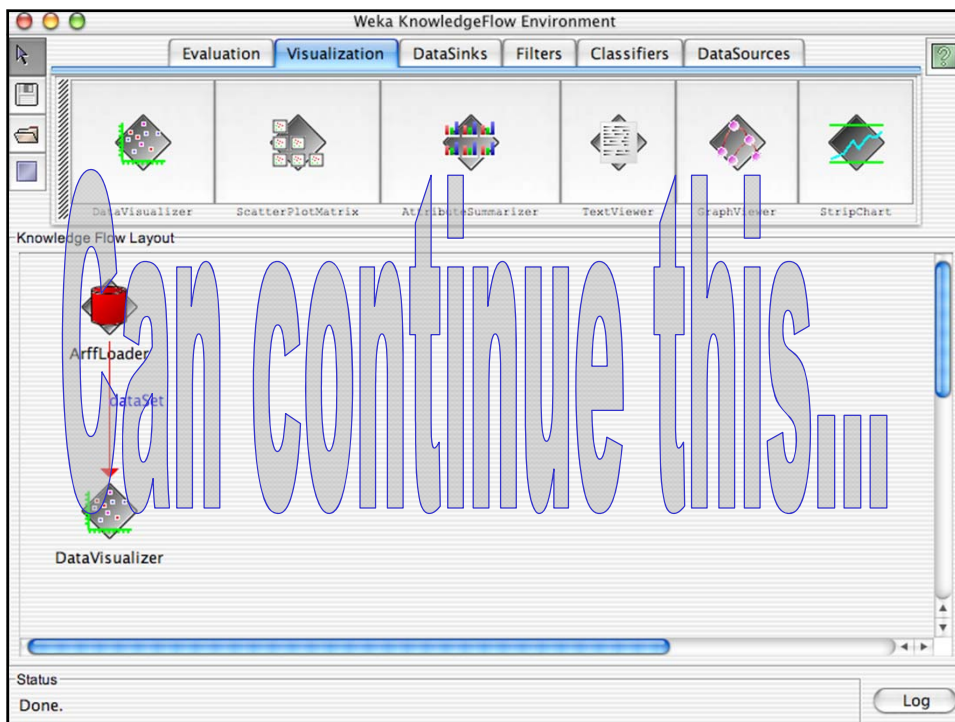
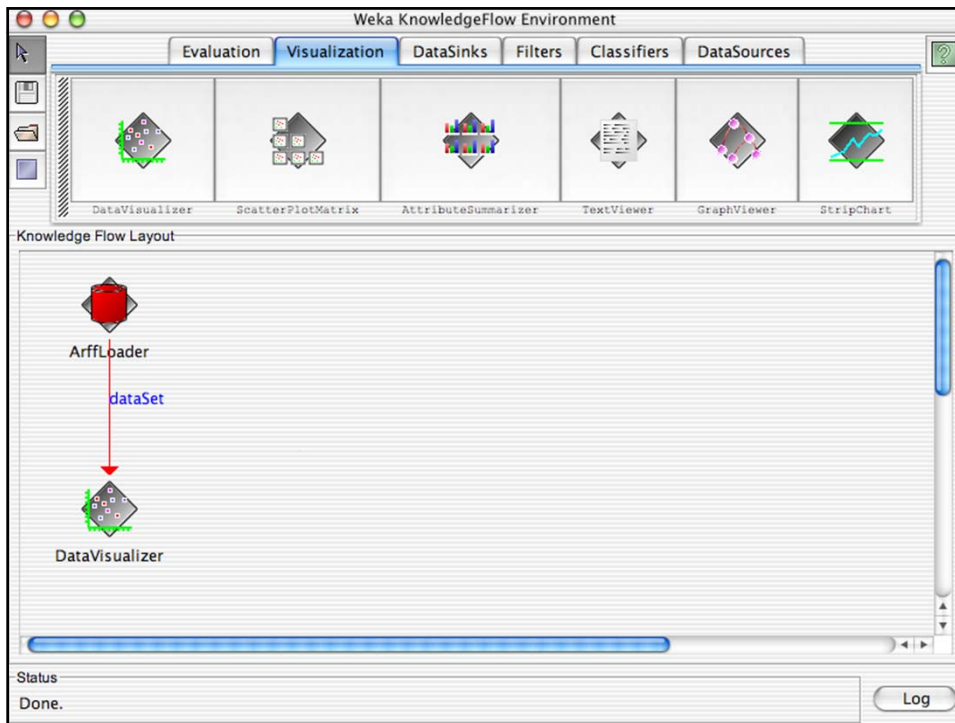
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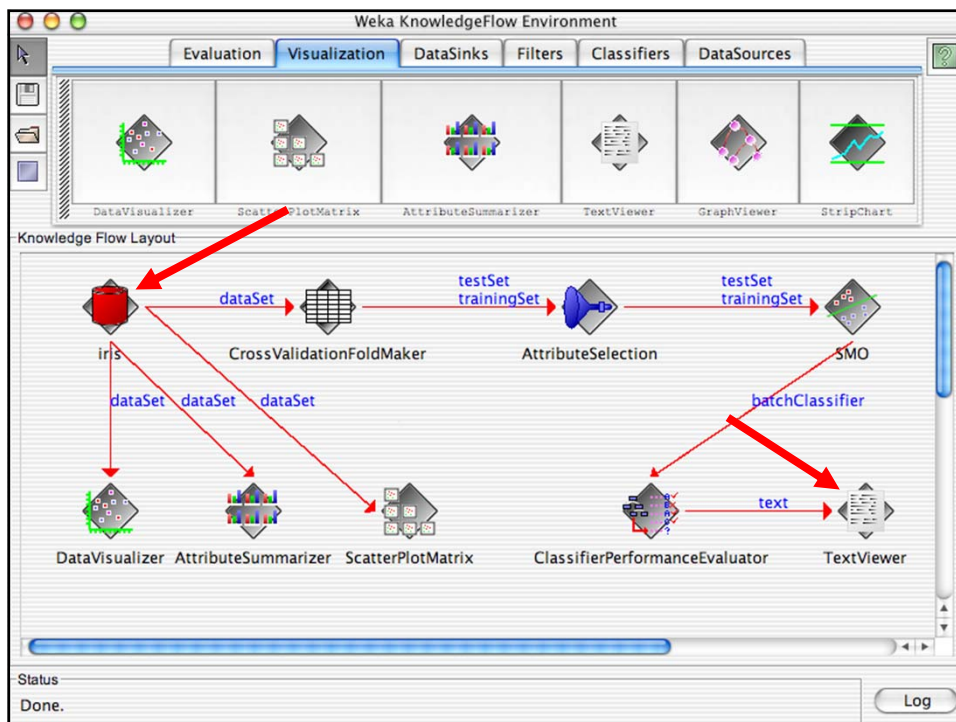
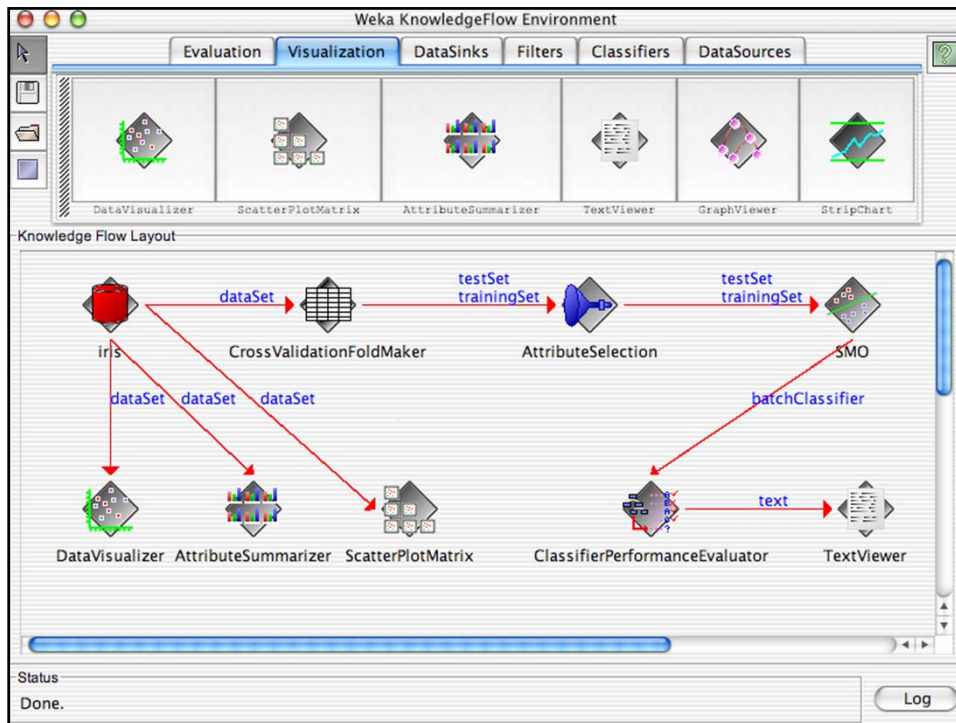


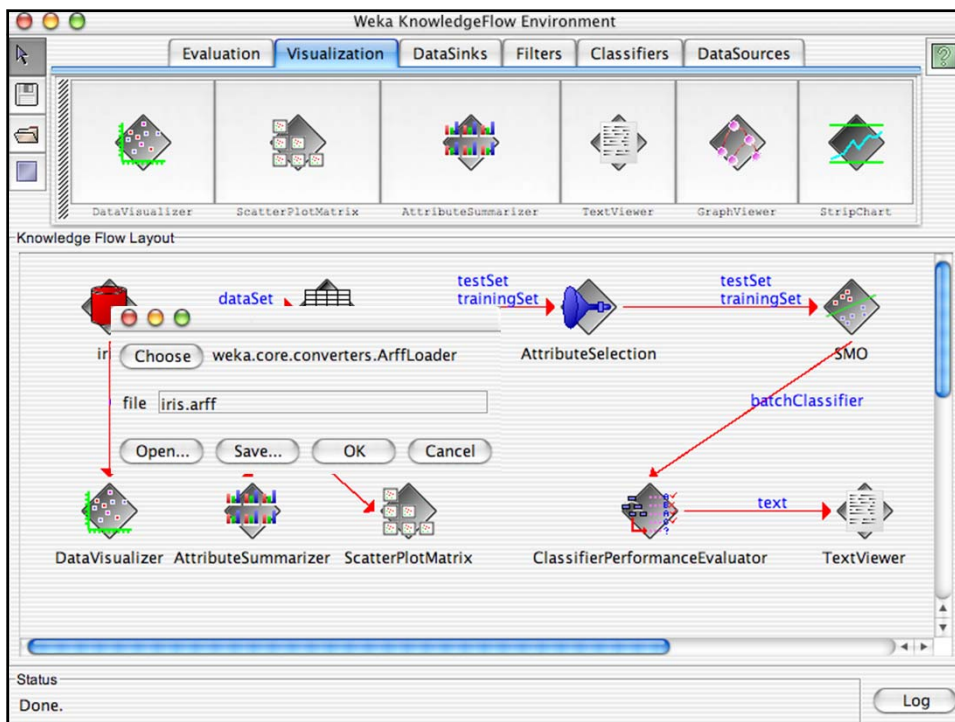
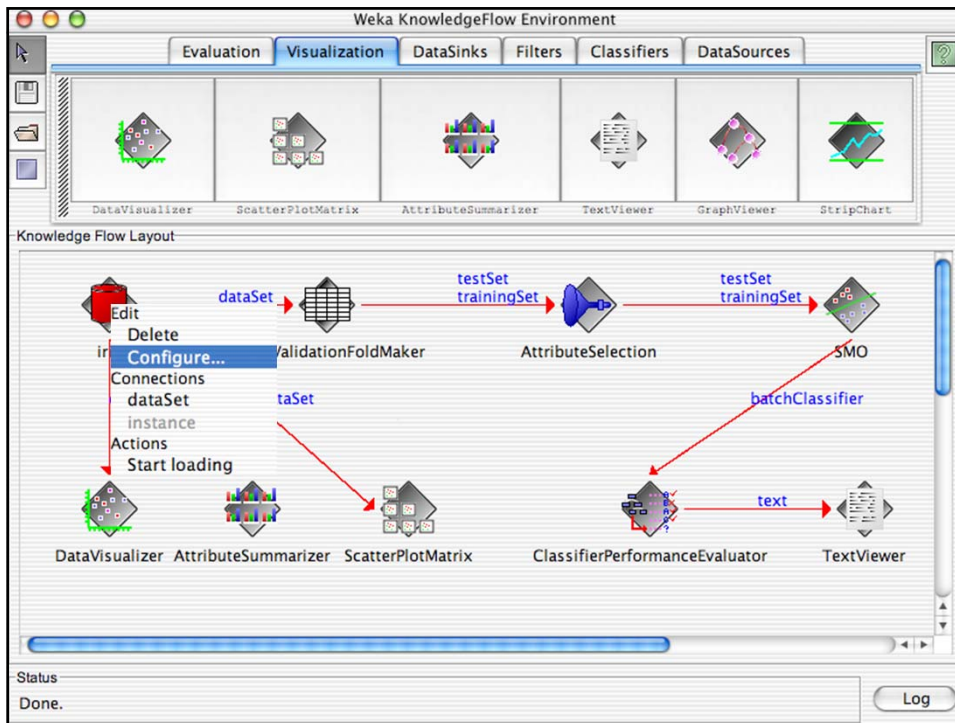


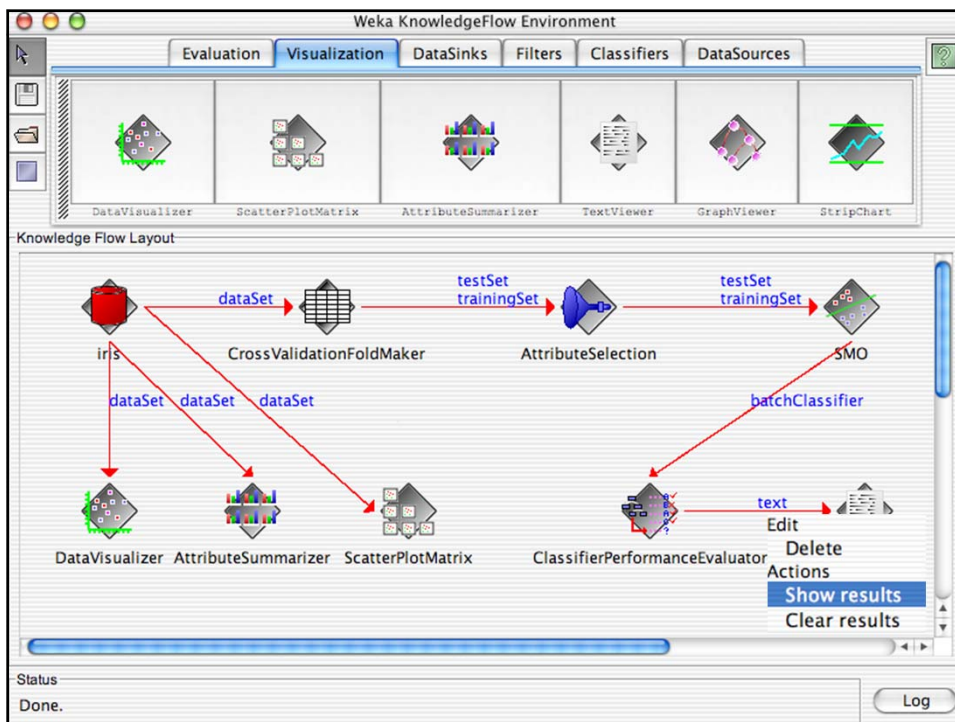
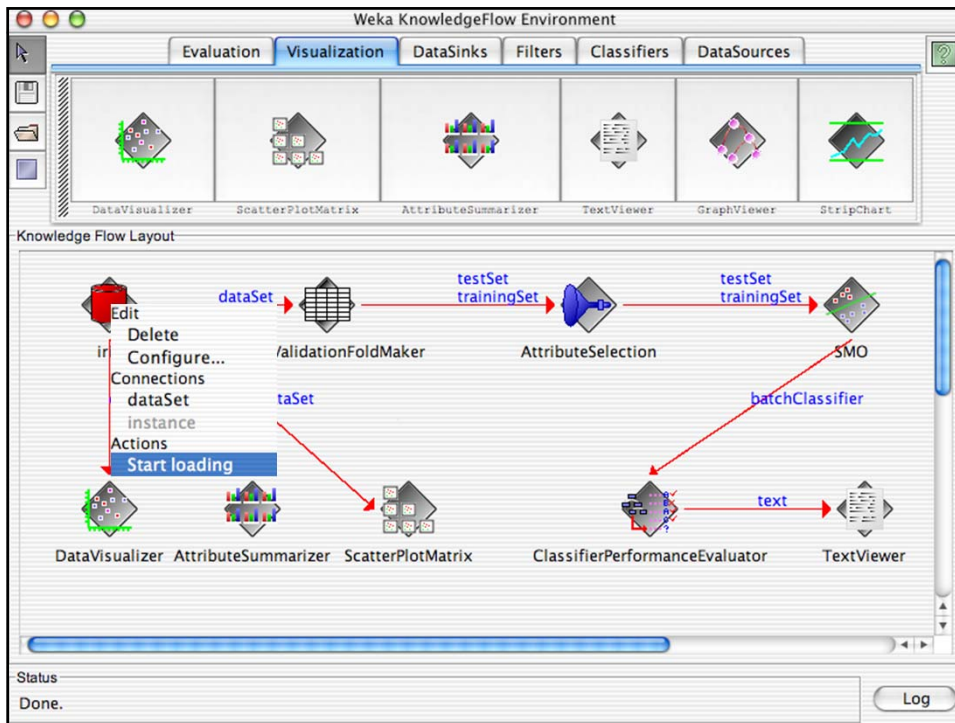


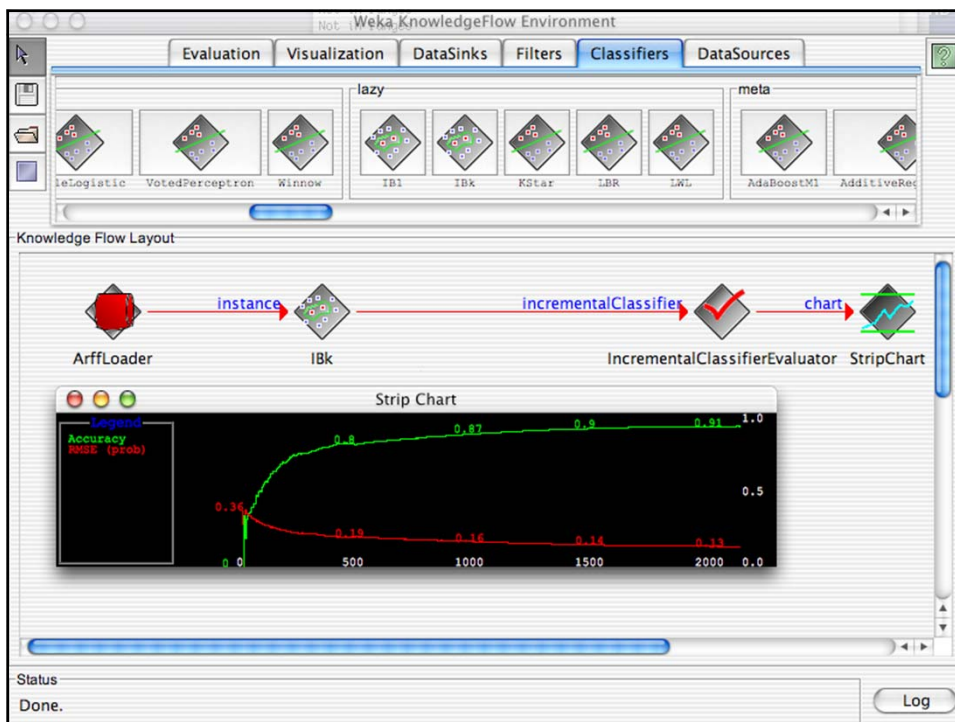
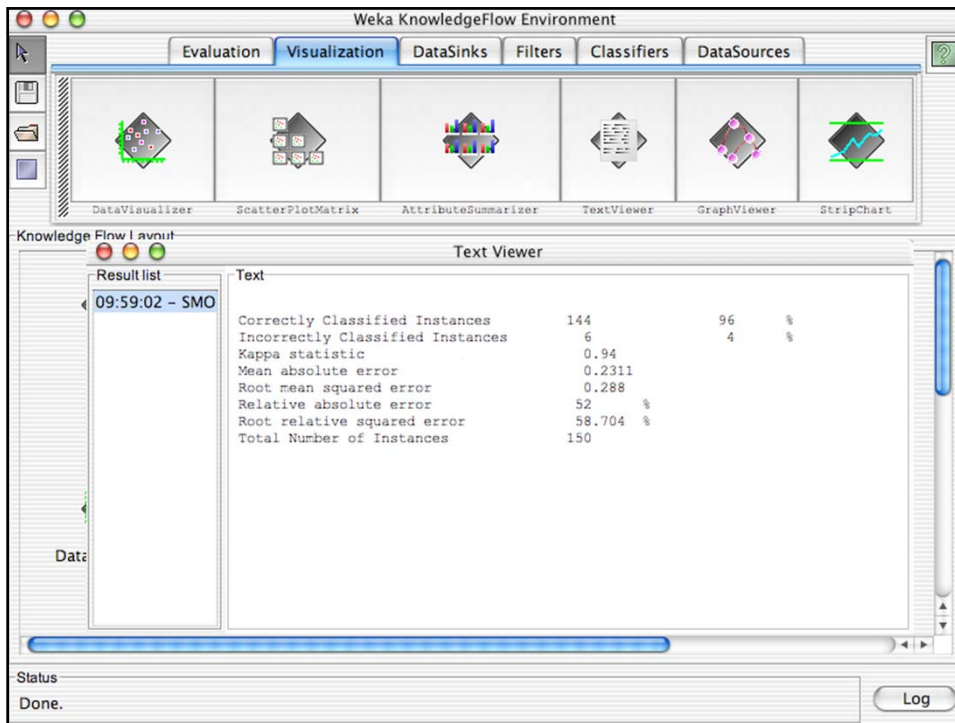












Weka GUI Chooser
Waikato Environment for Knowledge Analysis
(c) 1999 – 2003
University of Waikato
New Zealand

GUI
Simple CLI Explorer
Experimenter KnowledgeFlow

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Detailed description: This screenshot shows the Weka GUI Chooser interface. At the top, it displays the title 'Weka GUI Chooser' and the organization 'Waikato Environment for Knowledge Analysis (c) 1999 – 2003 University of Waikato New Zealand'. Below this is a central image of a kiwi bird. Underneath the image are four buttons: 'Simple CLI', 'Explorer', 'Experimenter', and 'KnowledgeFlow'. To the left of the central window is a terminal window with a large red 'X' over it. To the right is a 'Weka Knowledge Explorer' window showing a data table and a bar chart, with a green checkmark over it. Below the central window are two more windows: 'Weka Environment Environments' on the left and 'Weka KnowledgeFlow Environment' on the right. The 'Weka Environment Environments' window has a green checkmark, while the 'Weka KnowledgeFlow Environment' window has a red 'X' over it. Blue arrows point from the central window to the 'Weka Environment Environments' and 'Weka KnowledgeFlow Environment' windows. The date '4/13/2012' is at the bottom left, 'University of Waikato' is at the bottom center, and '171' is at the bottom right.

Weka GUI Chooser
Waikato Environment for Knowledge Analysis
(c) 1999 – 2003
University of Waikato
New Zealand

GUI
Simple CLI Explorer
Experimenter KnowledgeFlow

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Detailed description: This screenshot is identical to the one above, showing the Weka GUI Chooser interface. It features the same central window with the kiwi bird image and four buttons: 'Simple CLI', 'Explorer', 'Experimenter', and 'KnowledgeFlow'. The layout of surrounding windows and their status (terminal with red 'X', Knowledge Explorer with green checkmark, Environment Environments with green checkmark, and KnowledgeFlow Environment with red 'X') is the same. Blue arrows point from the central window to the 'Weka Environment Environments' and 'Weka KnowledgeFlow Environment' windows. The date '4/13/2012' is at the bottom left, 'University of Waikato' is at the bottom center, and '172' is at the bottom right.

Conclusion: try it yourself!

- WEKA is available at
<http://www.cs.waikato.ac.nz/ml/weka>
- Also has a list of projects based on WEKA
- WEKA contributors:

Abdelaziz Mahoui, Alexander K. Seewald, Ashraf M. Kibriya, Bernhard Pfahringer , Brent Martin, Peter Flach, Eibe Frank ,Gabi Schmidberger ,Ian H. Witten , J. Lindgren, Janice Boughton, Jason Wells, Len Trigg, Lucio de Souza Coelho, Malcolm Ware, Mark Hall ,Remco Bouckaert , Richard Kirkby, Shane Butler, Shane Legg, Stuart Inglis, Sylvain Roy, Tony Voyle, Xin Xu, Yong Wang, Zhihai Wang