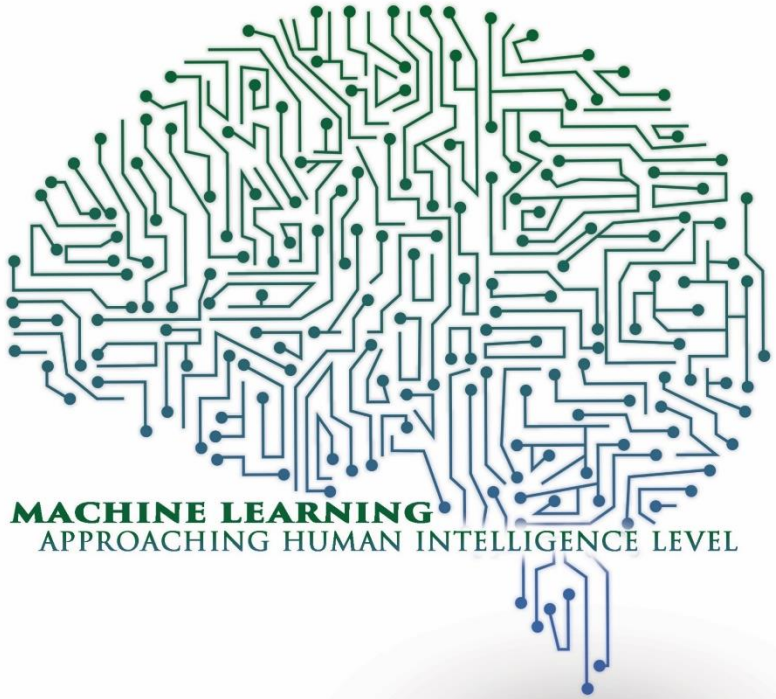
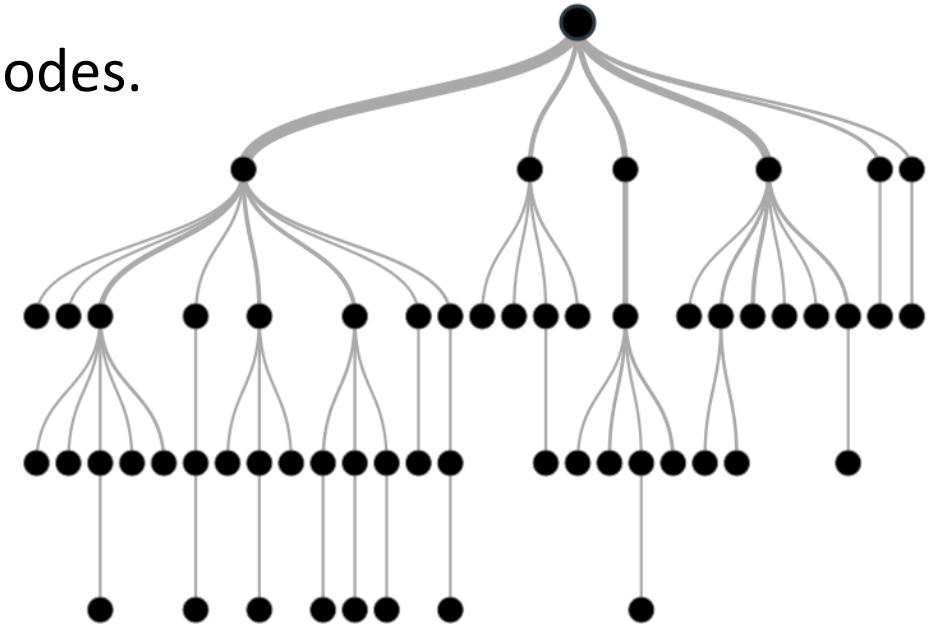


Decision Trees & Random Forest

Classification and Regression Trees

- Grow a binary tree.
- At each node, “split” the data into two “daughter” nodes.
  - Splits are chosen using a splitting criterion.



Bottom nodes are “terminal” nodes.

- For regression the predicted value at a node is the *average* response variable for all observations in the node.
- For classification the predicted class is the *most common class* in the node (majority vote).
- For classification trees, can also get estimated probability of membership in each of the classes

Splitting criterion

Regression: residual sum of squares

$$RSS = \sum_{left} (y_i - y_L^*)^2 + \sum_{right} (y_i - y_R^*)^2$$

where y_L^* = mean y-value for left node

y_R^* = mean y-value for right node

Classification: Gini criterion

$$Gini = N_L \sum_{k=1,\ldots,K} p_{kL} (1- p_{kL}) + N_R \sum_{k=1,\ldots,K} p_{kR} (1- p_{kR})$$

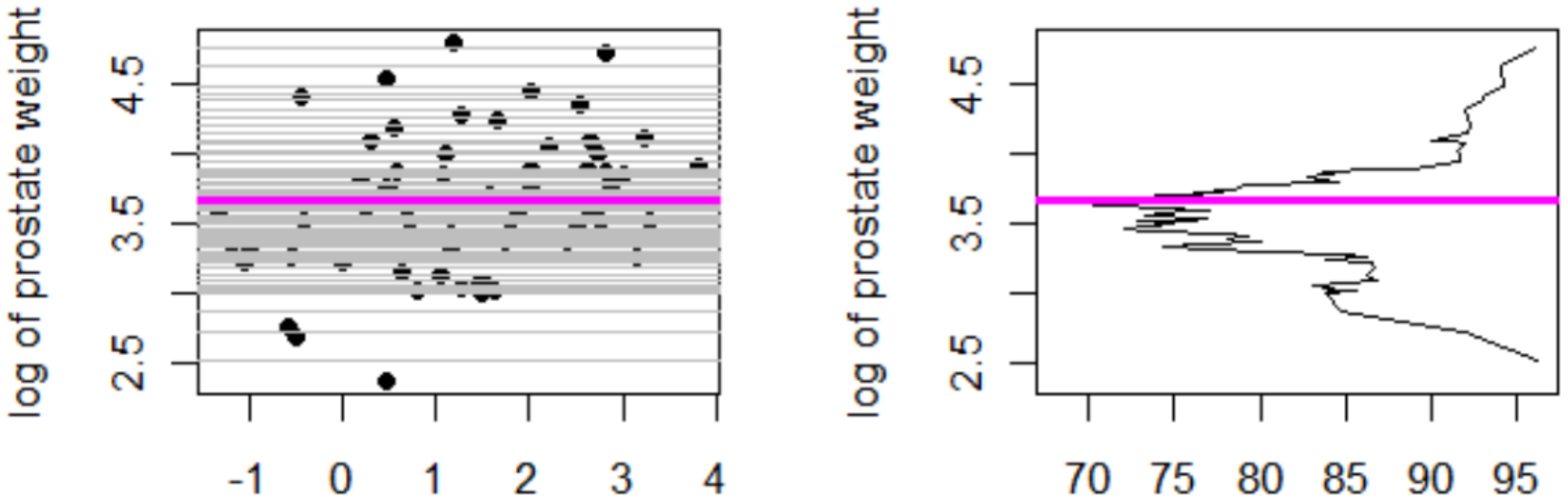
where p_{kL} = proportion of class k in left node

p_{kR} = proportion of class k in right node

Standard deviation

$$s_N = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \overline{x})^2}.$$

Cancer Example



Best horizontal split is at 3.67 with RSS = 68.09.

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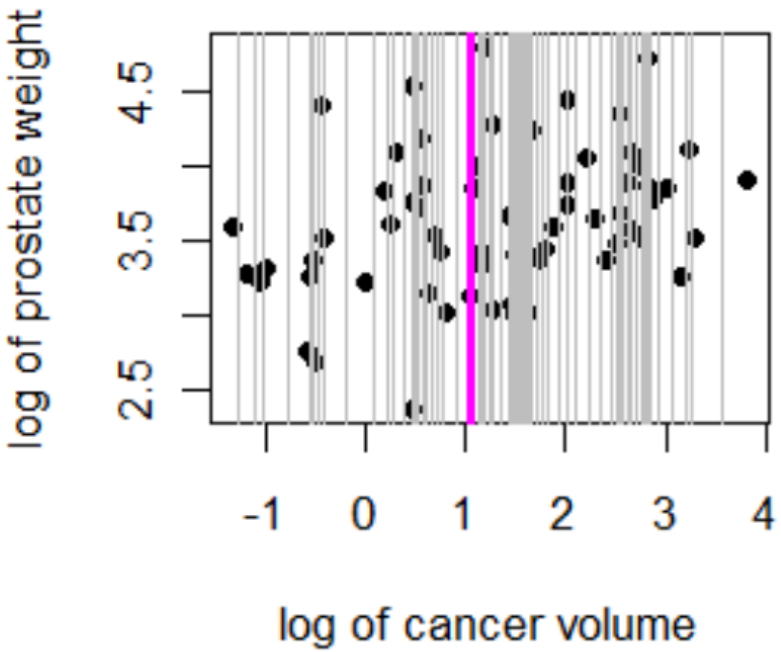

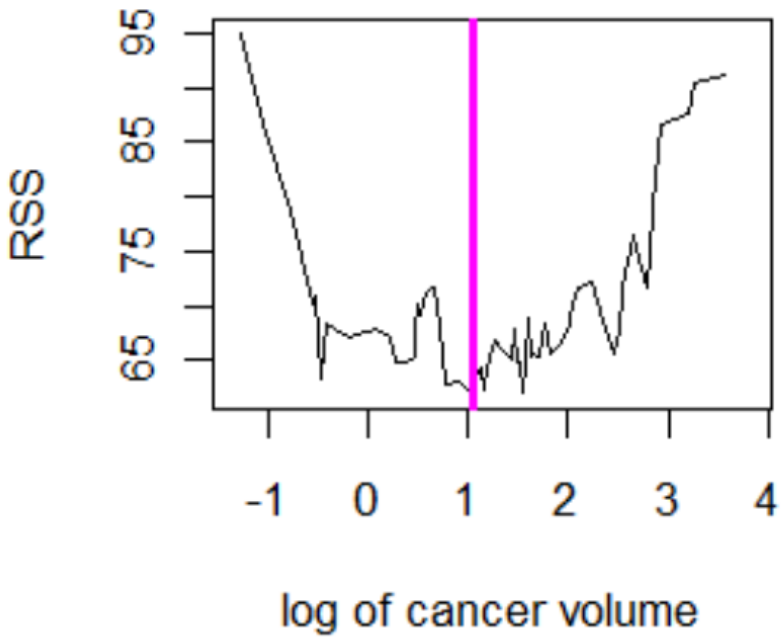

Best vertical split is at 1.05 with RSS = 61.76.

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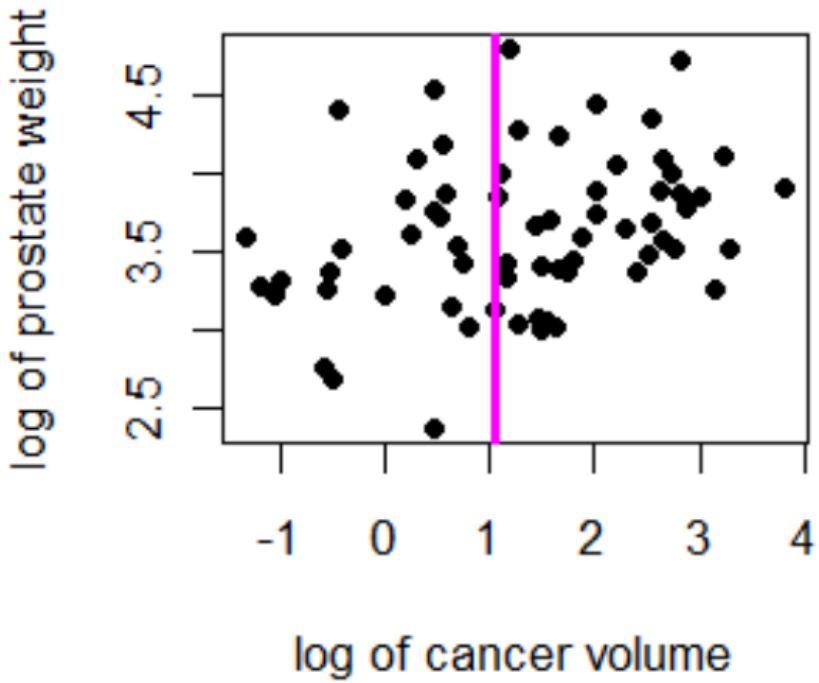

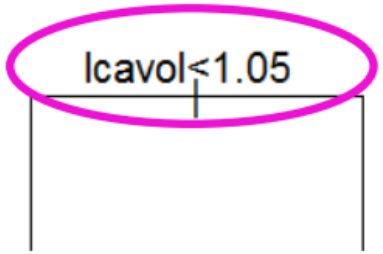

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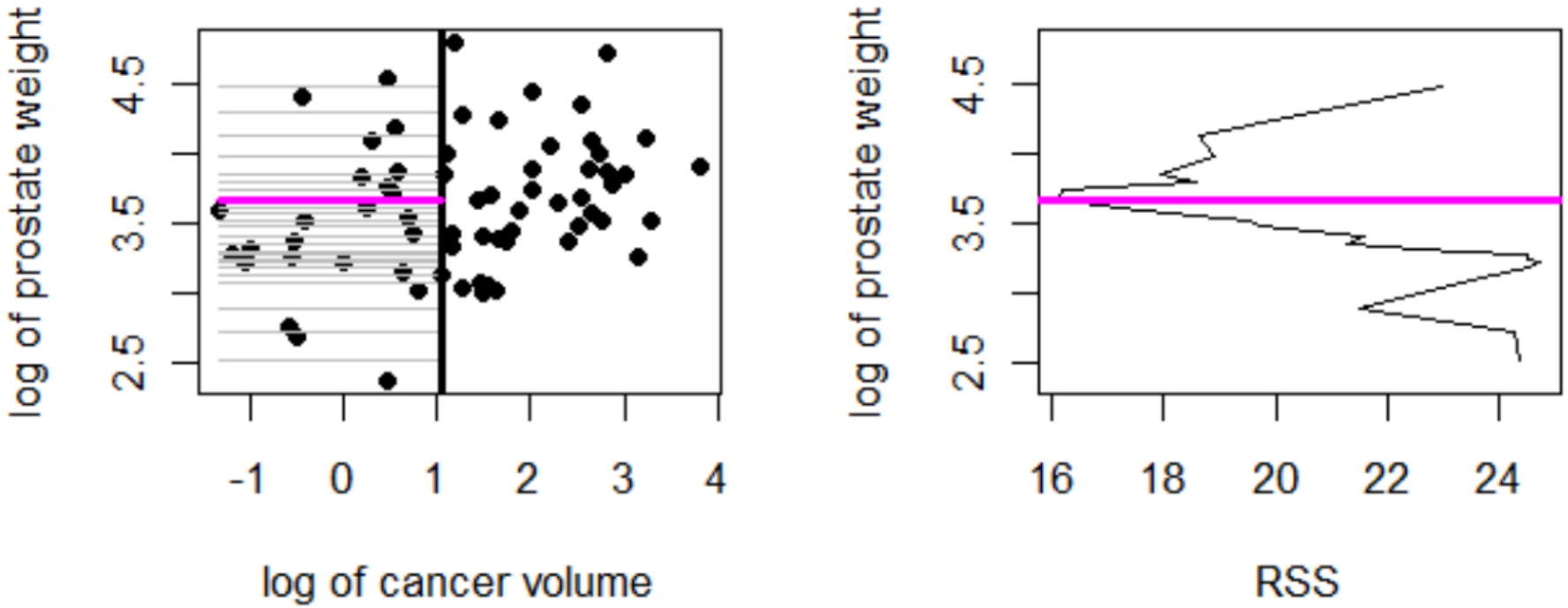

Best horizontal split is at 3.66 with RSS = 16.11.

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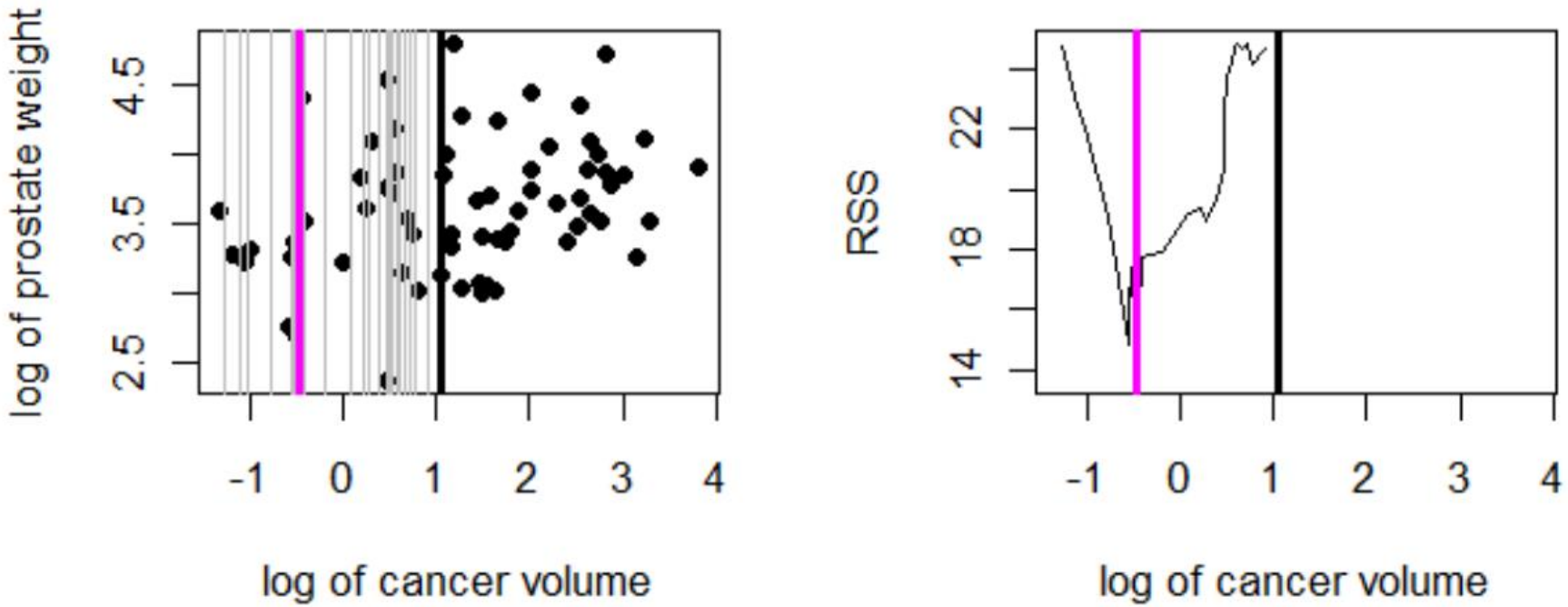

Best vertical split is at -.48 with RSS = 13.61.

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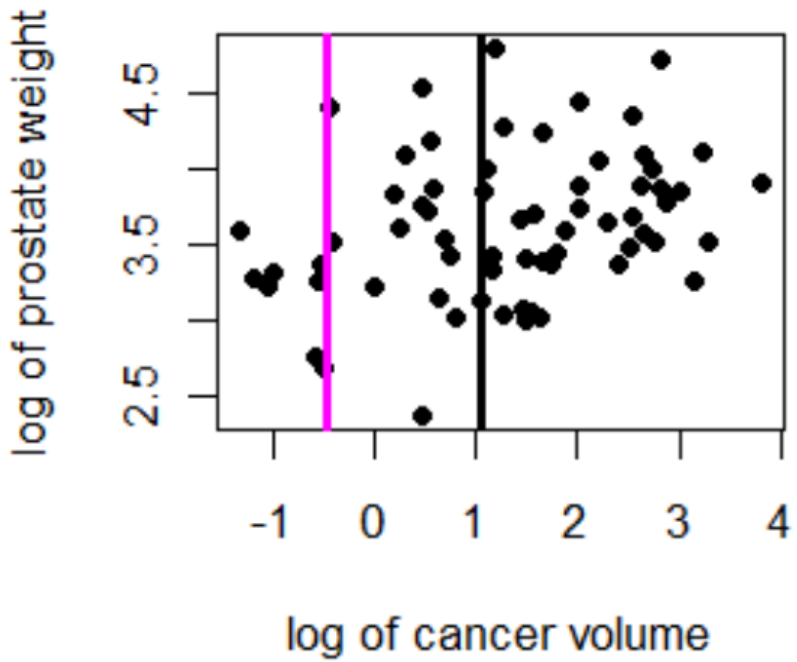

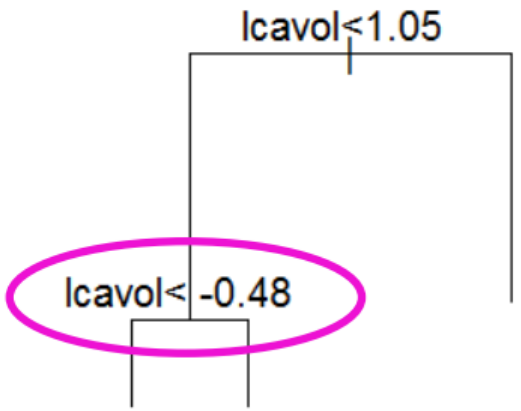

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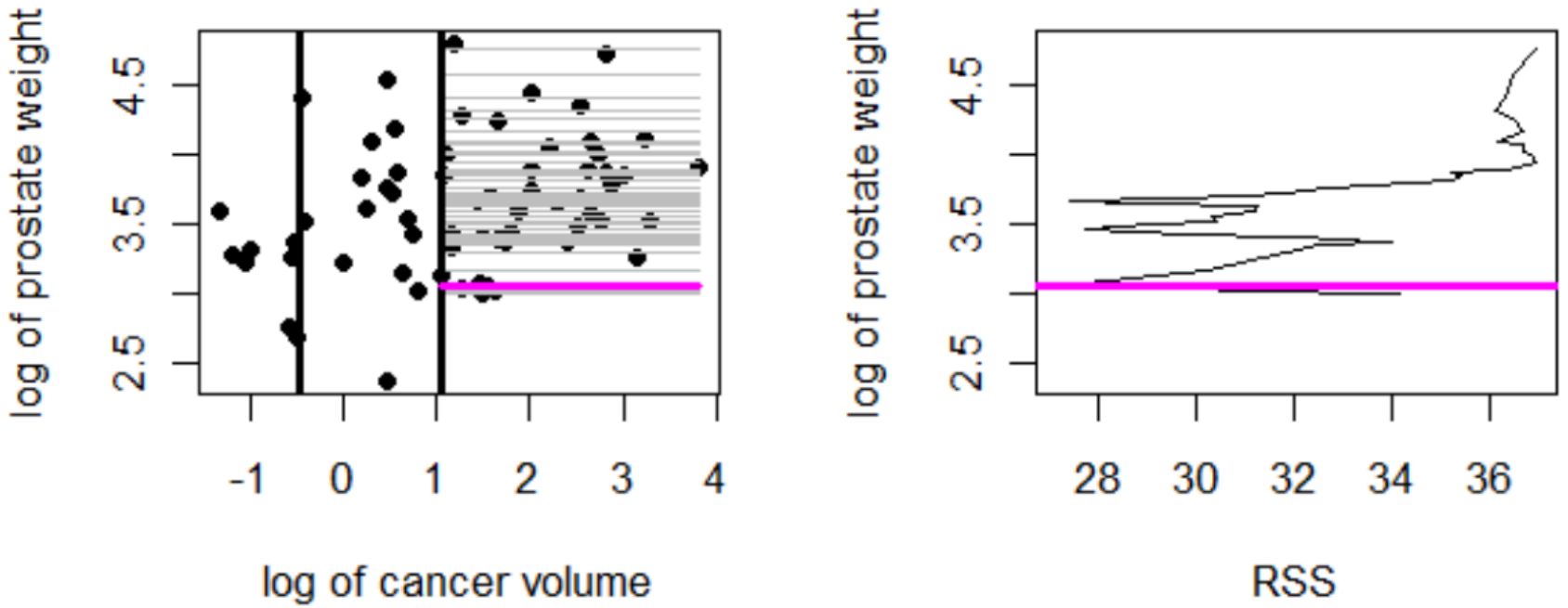

Best horizontal split is at 3.07 with RSS = 27.15.

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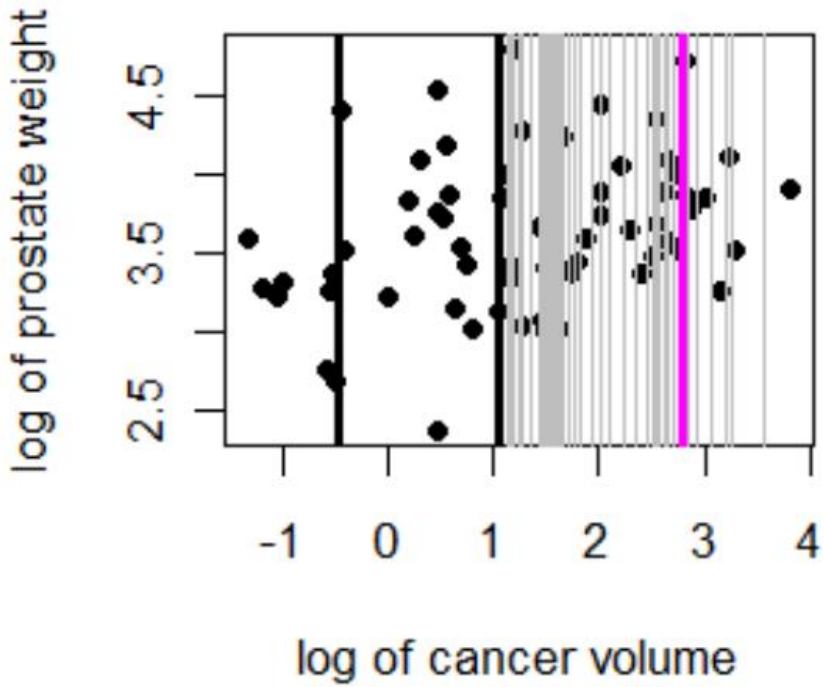

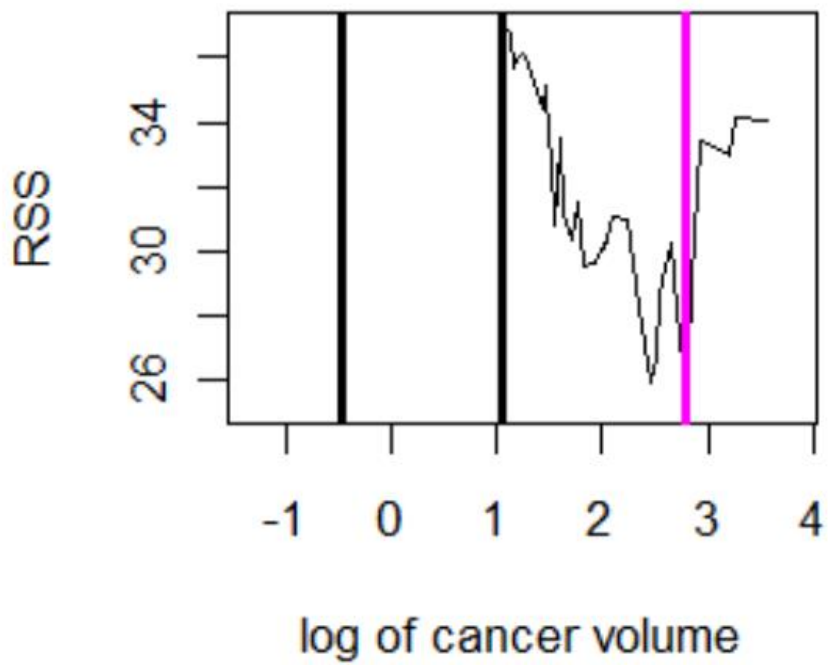

Best vertical split is at 2.79 with RSS = 25.11.

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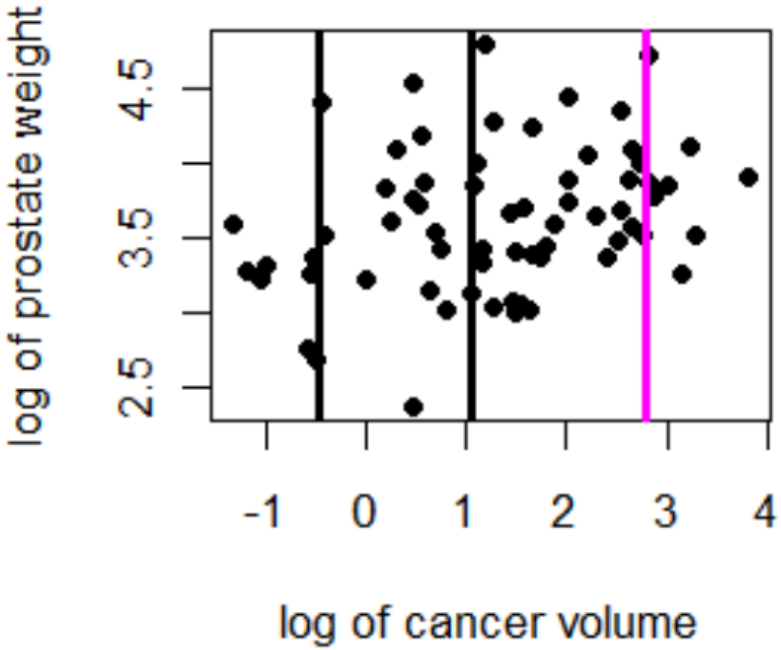

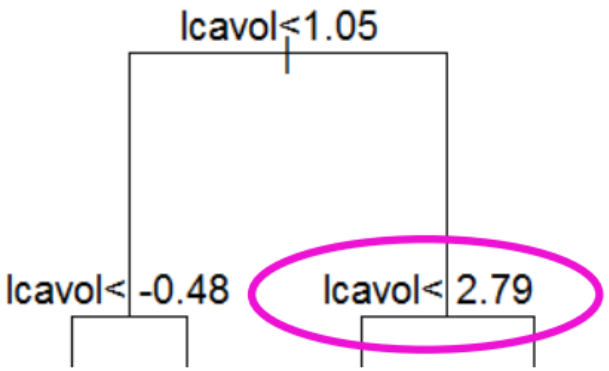

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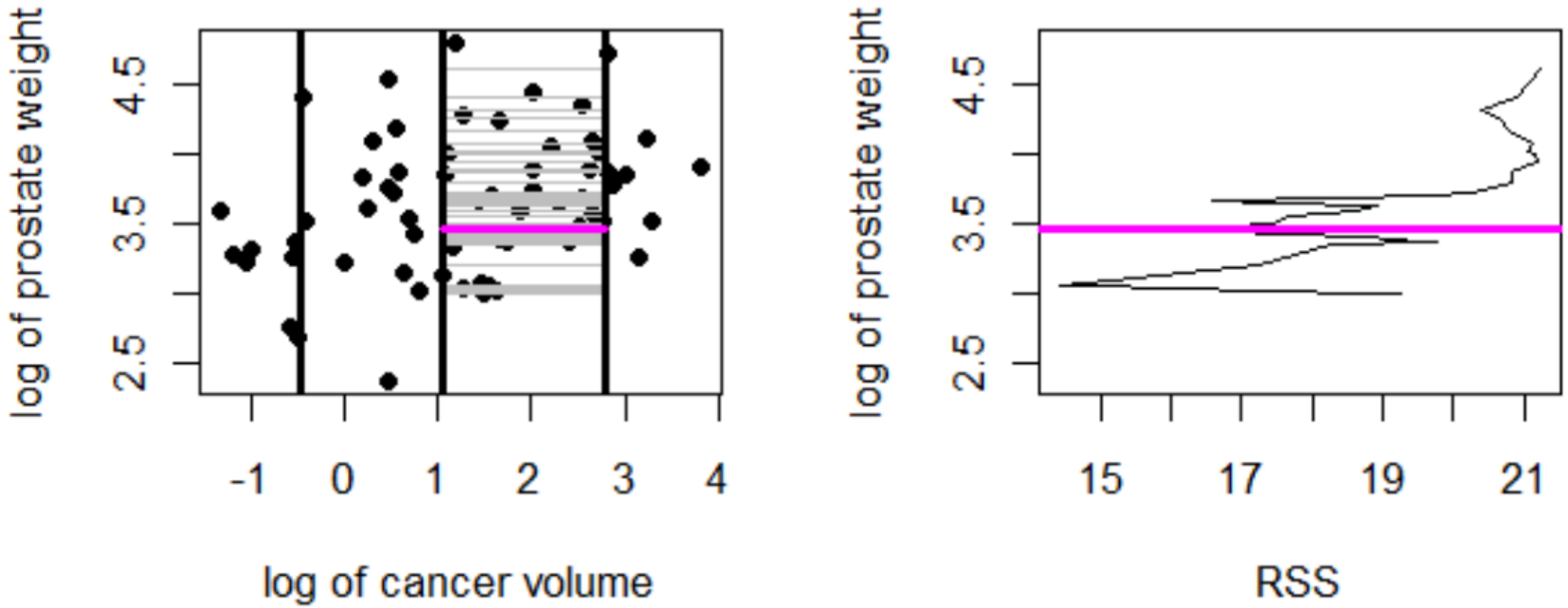

Best horizontal split is at 3.07 with RSS = 14.42, but this is too close to the edge. Use 3.46 with RSS = 16.14.

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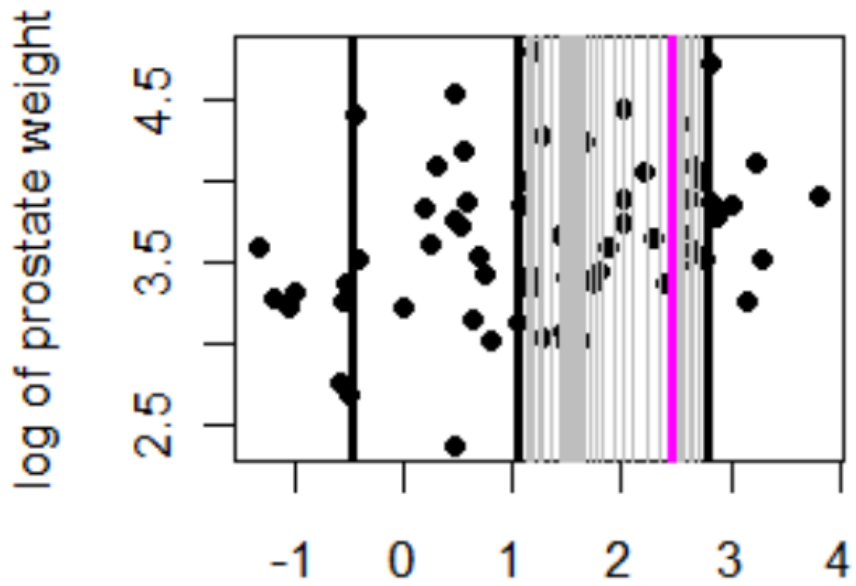

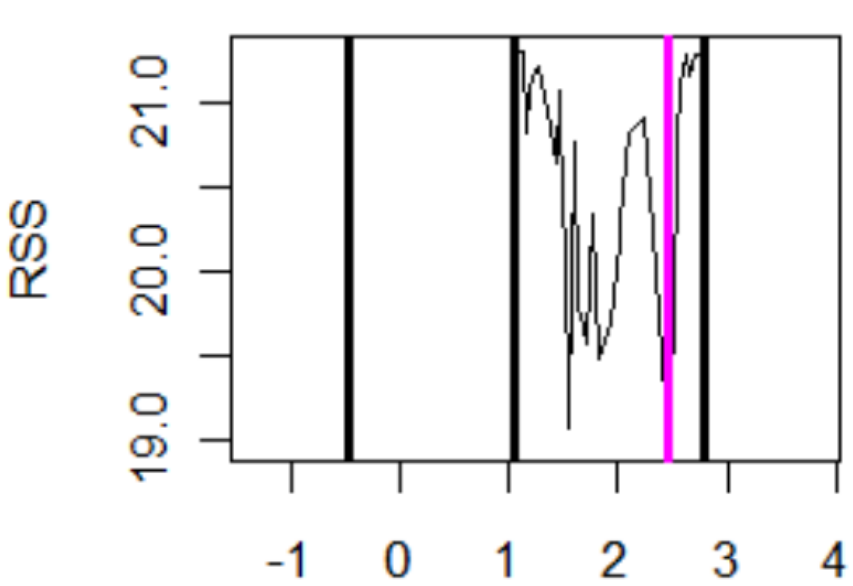

Best vertical split is at 2.46 with RSS = 18.97.

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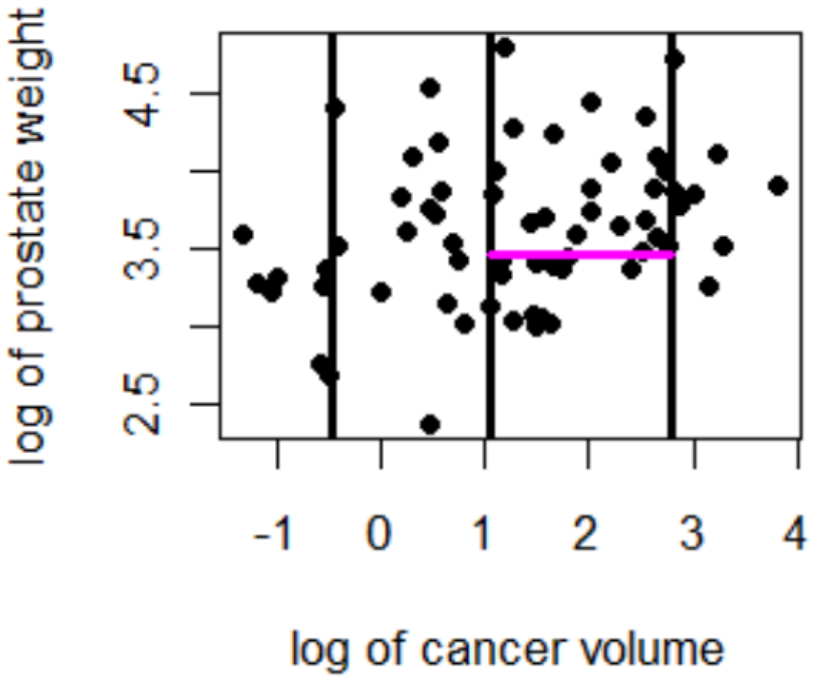

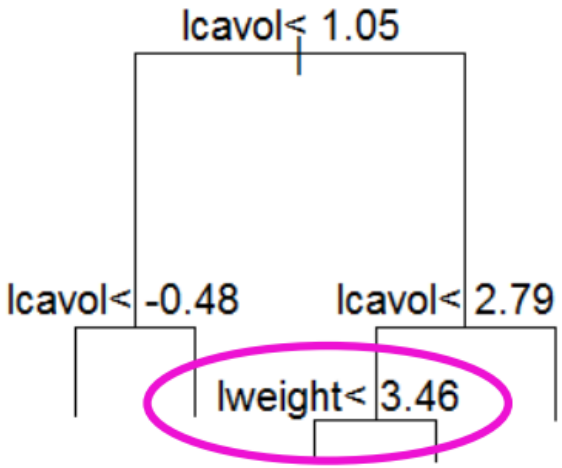

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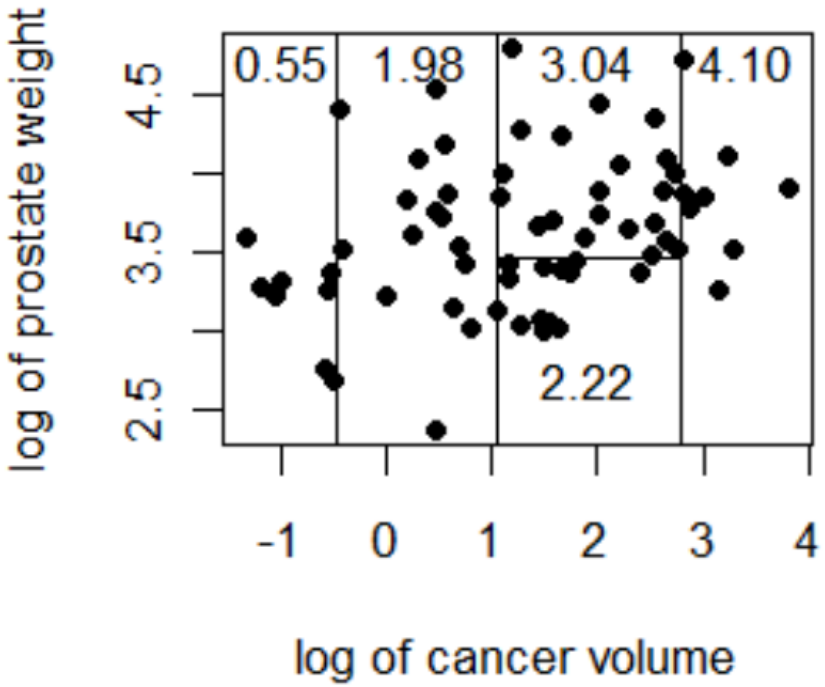
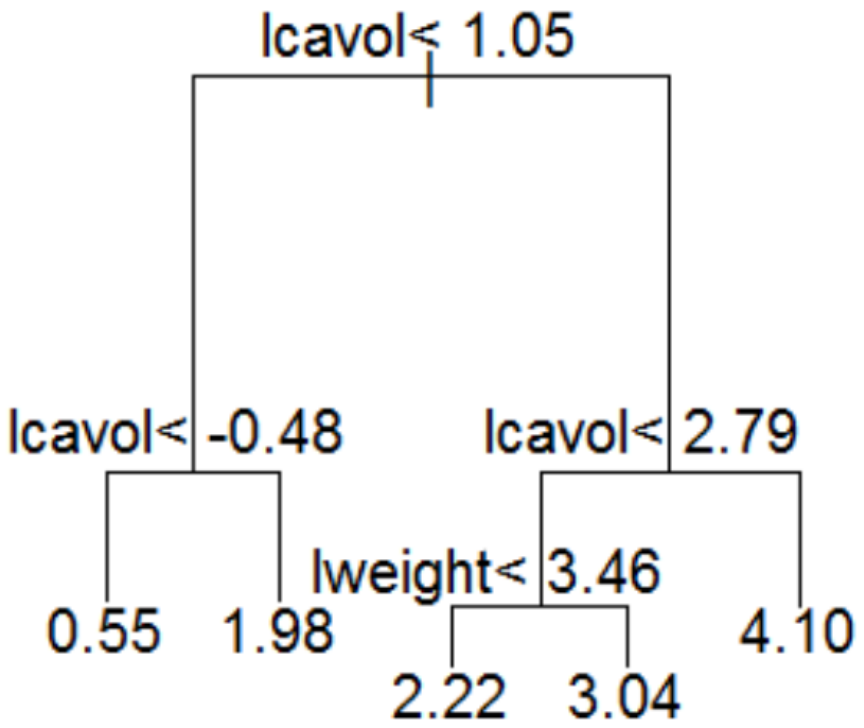
Final Tree





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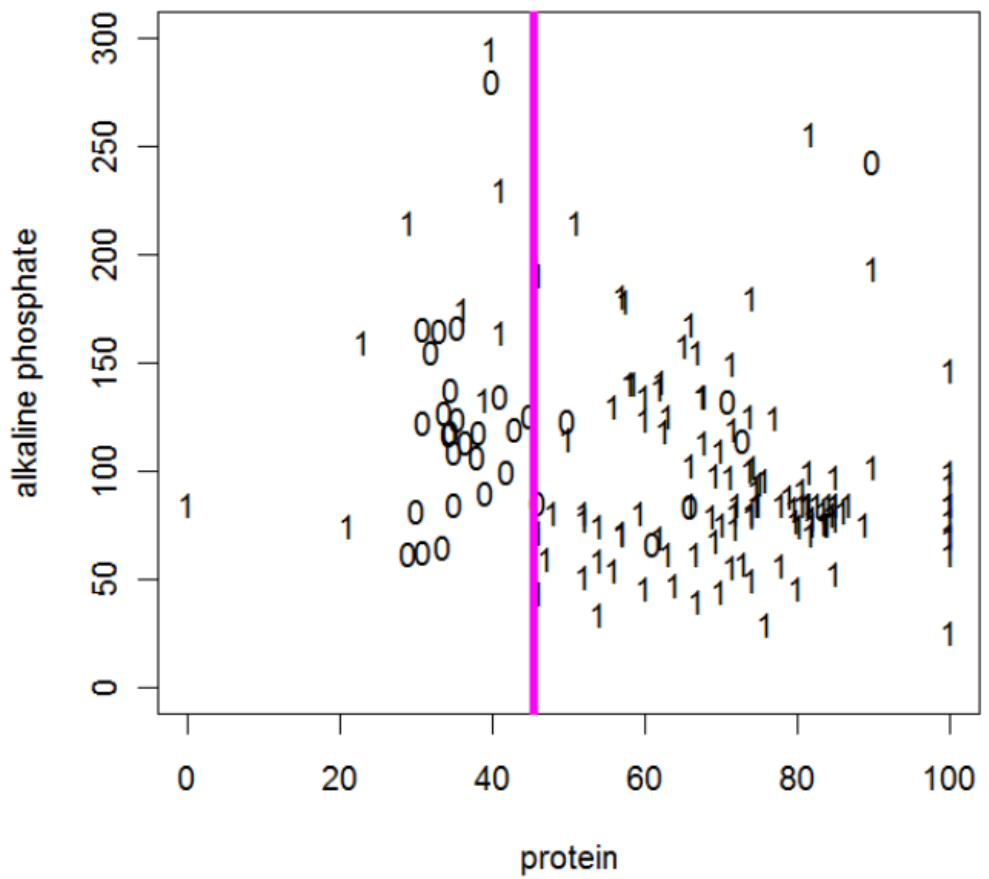
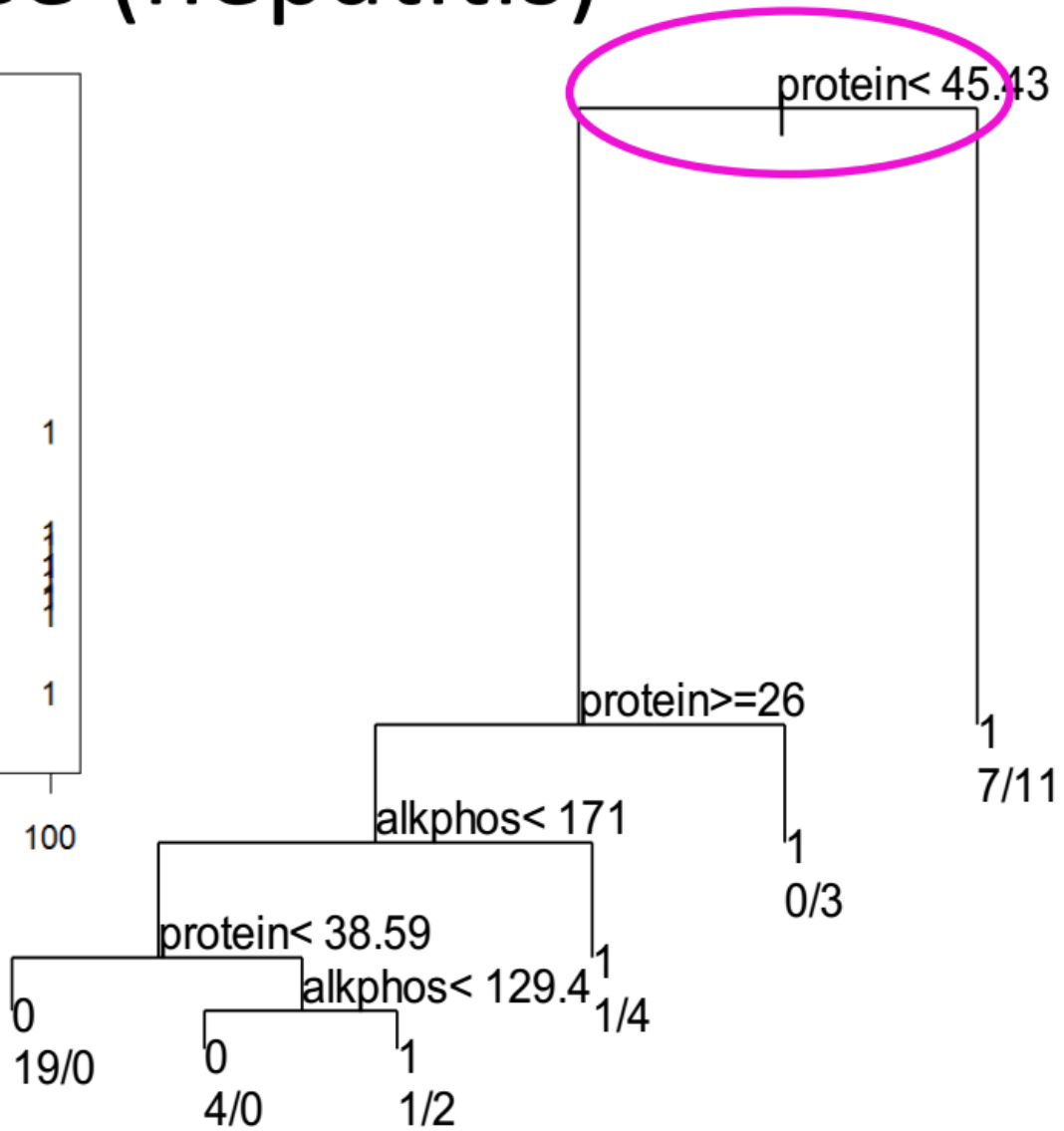
Classification tree (hepatitis)





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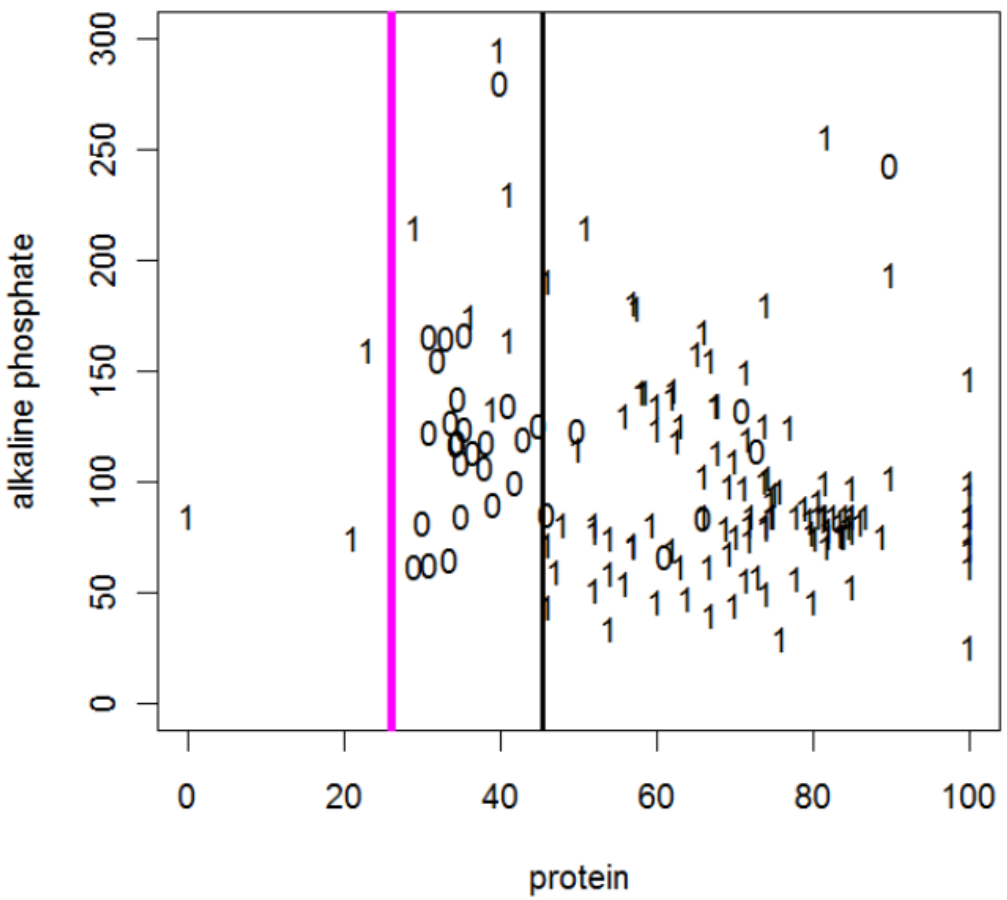
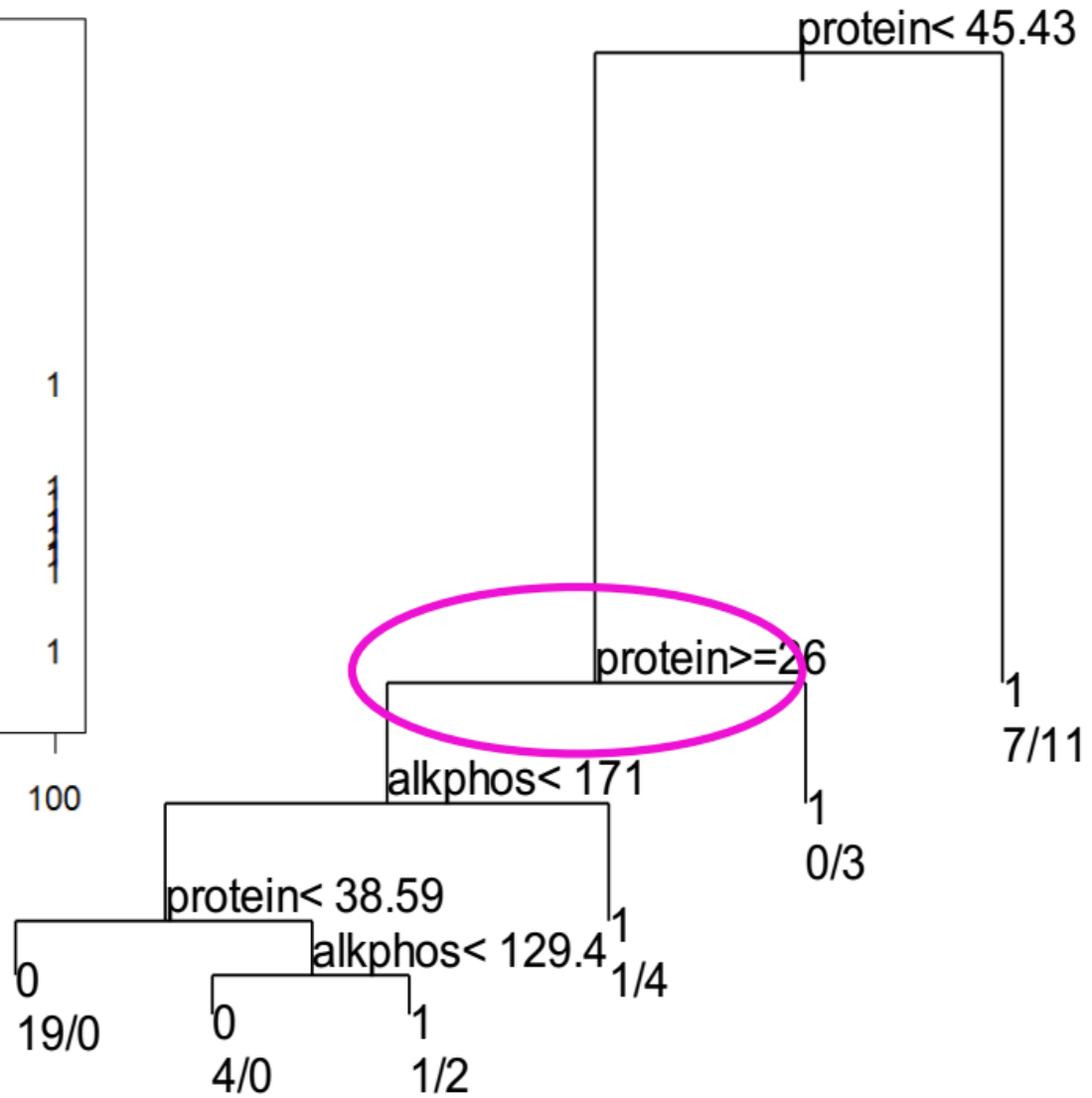
Classification tree (hepatitis)





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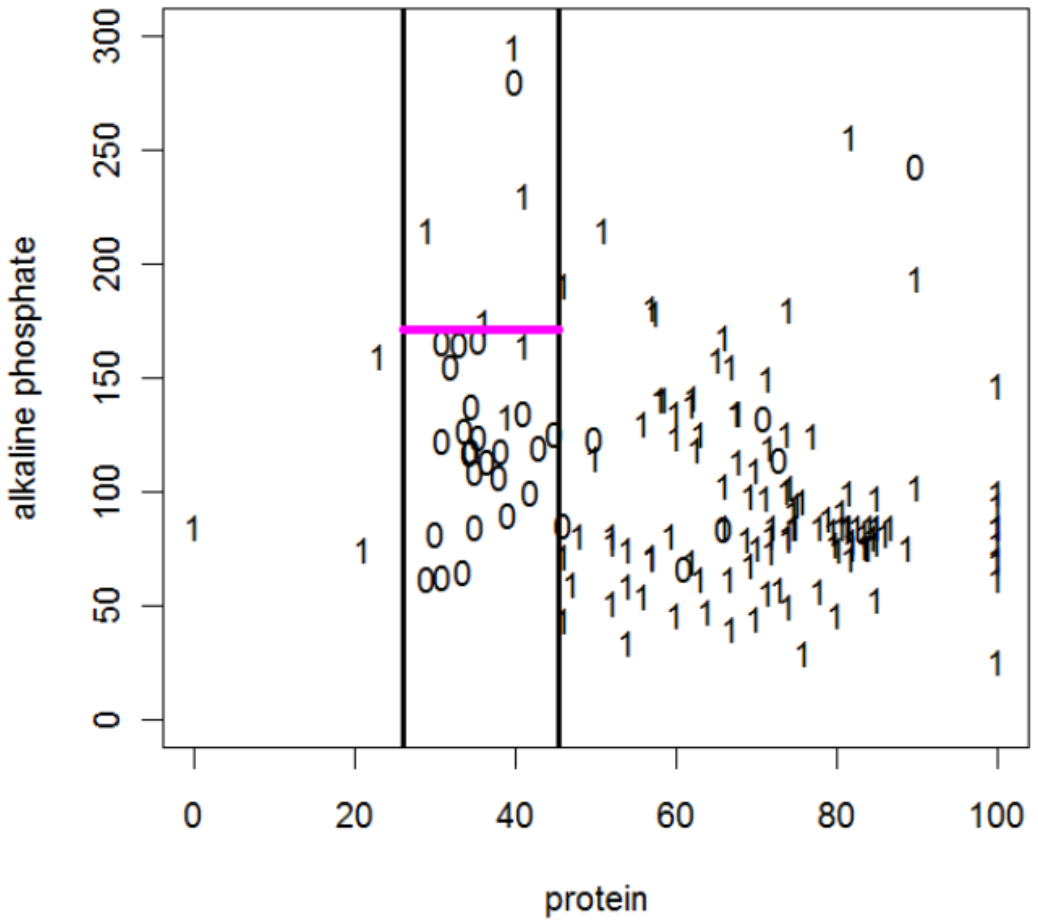
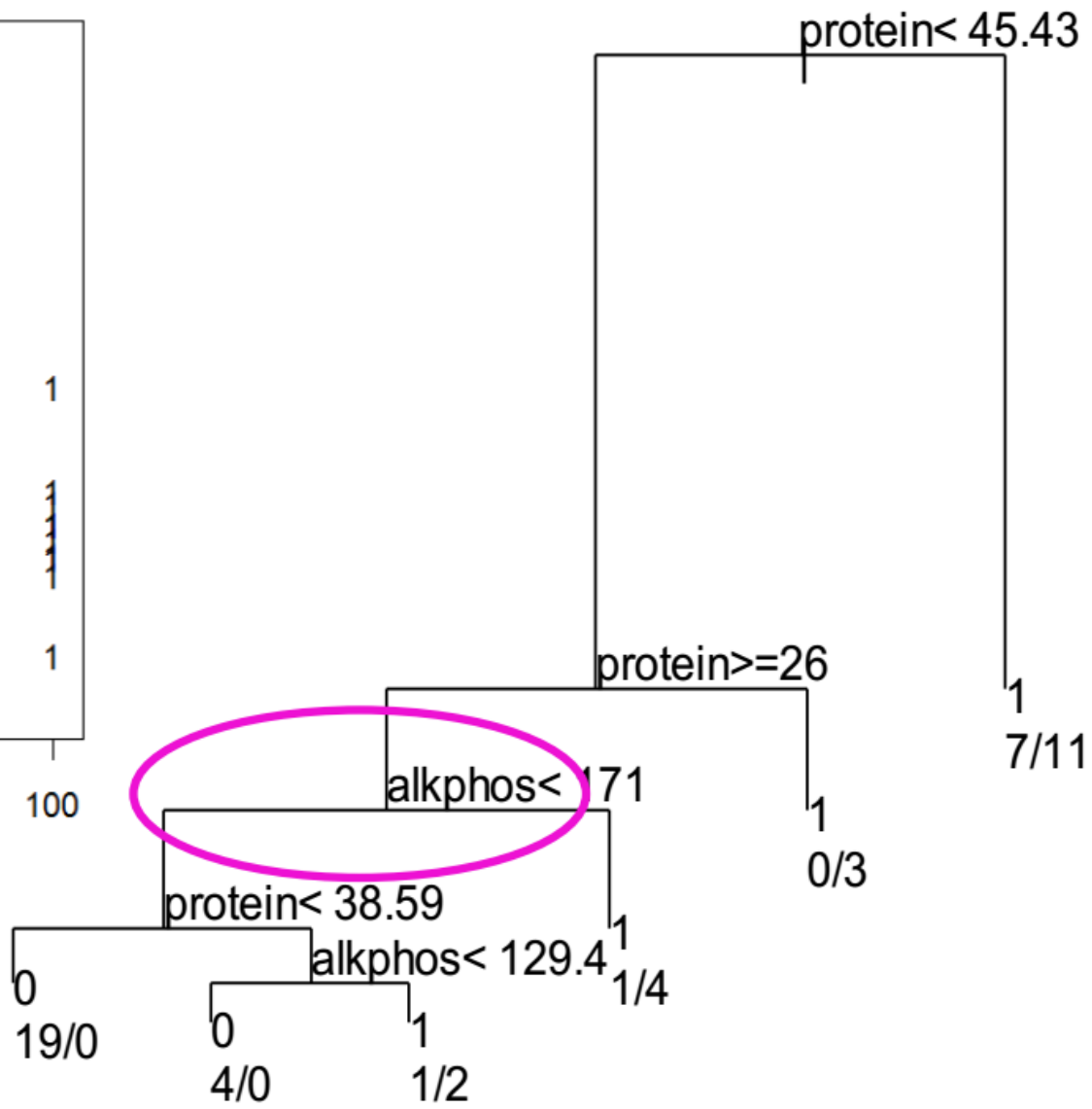
Classification tree (hepatitis)





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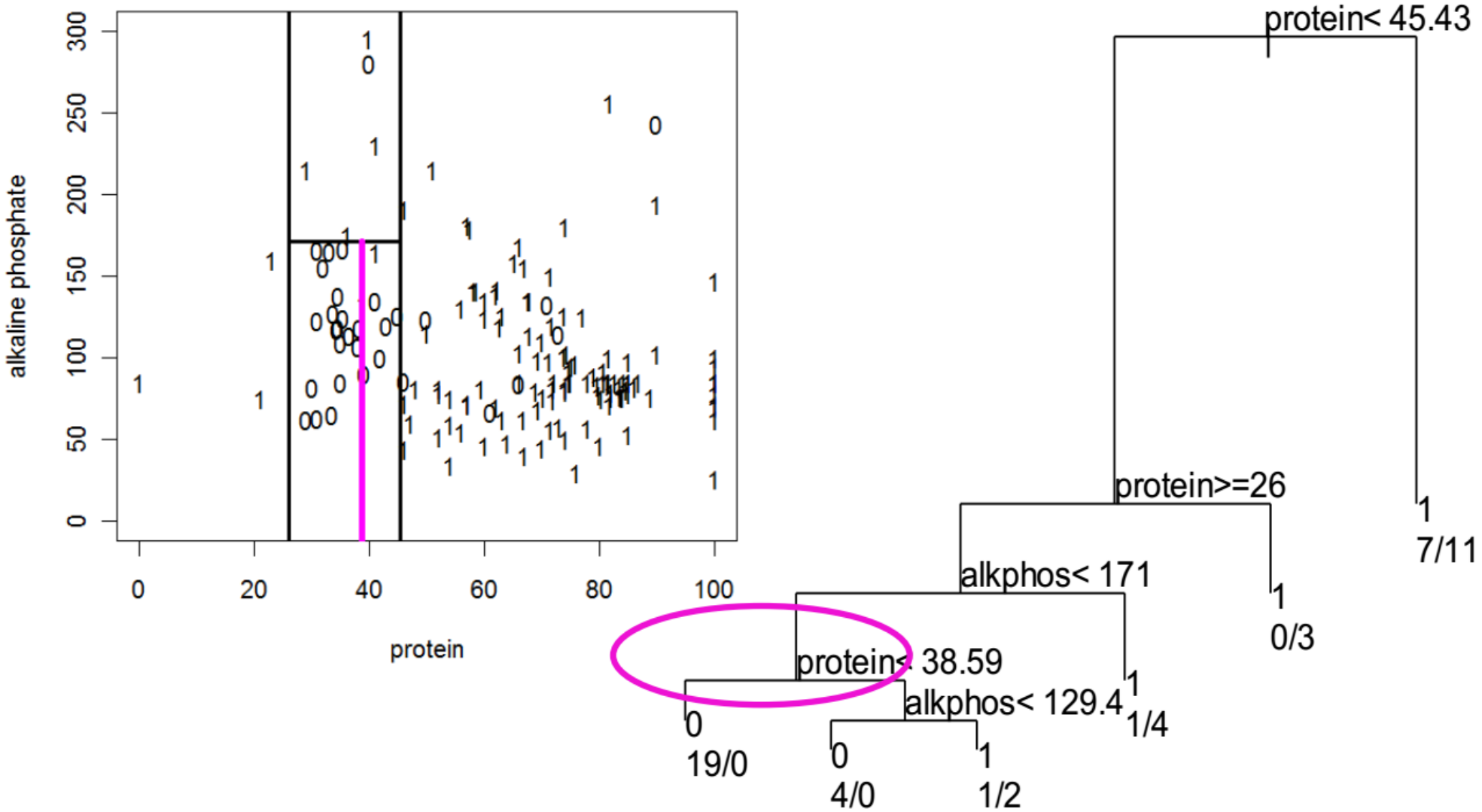
Classification tree (hepatitis)



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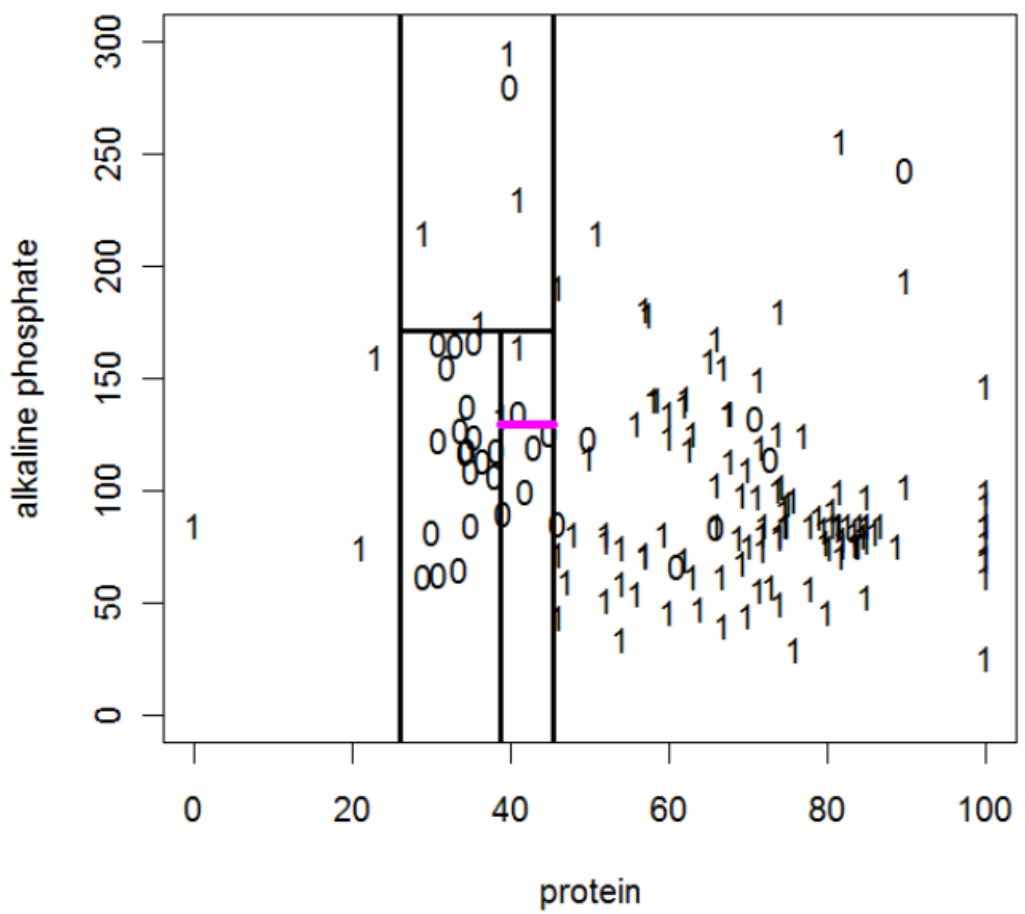
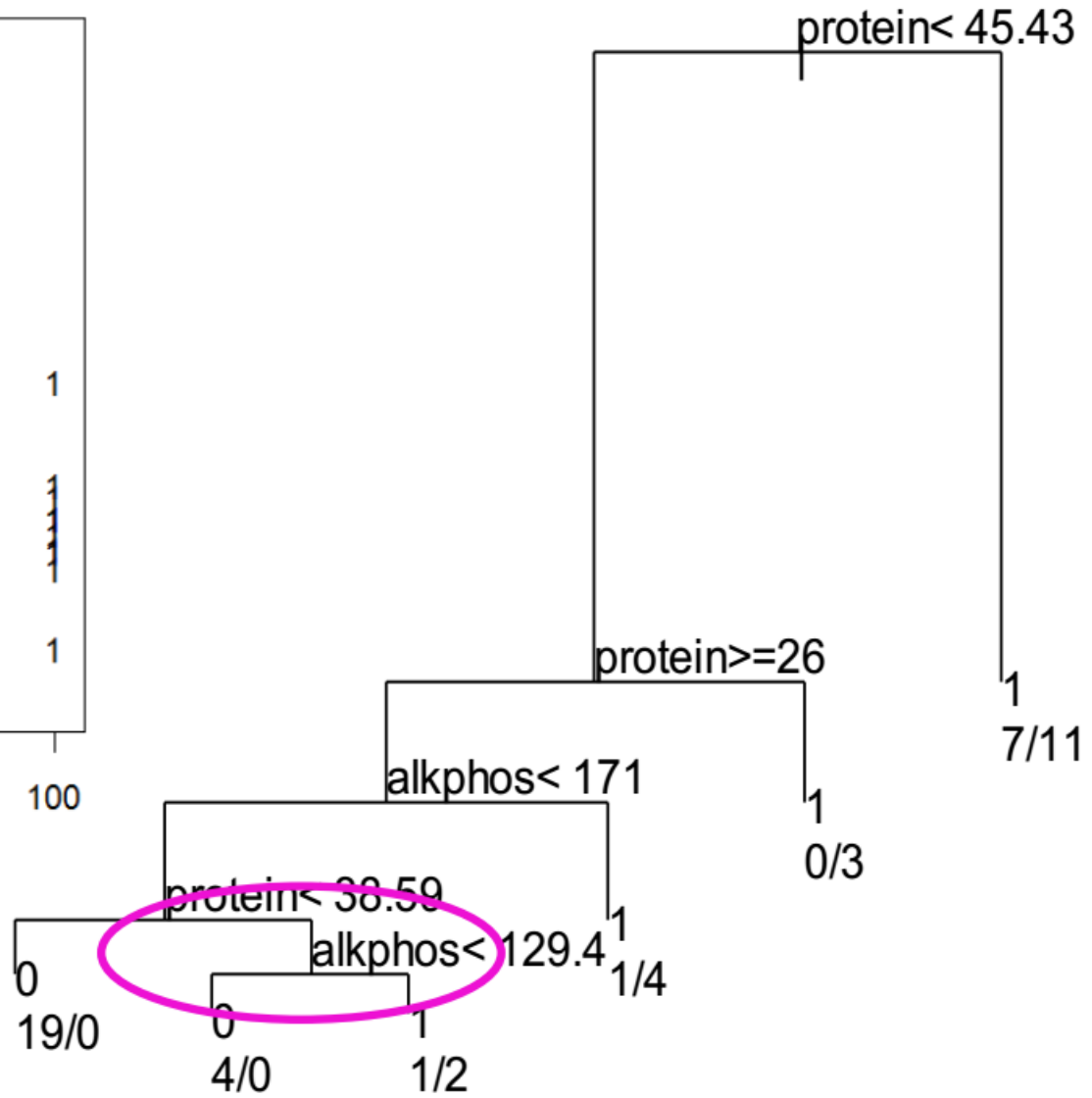
Classification tree (hepatitis)





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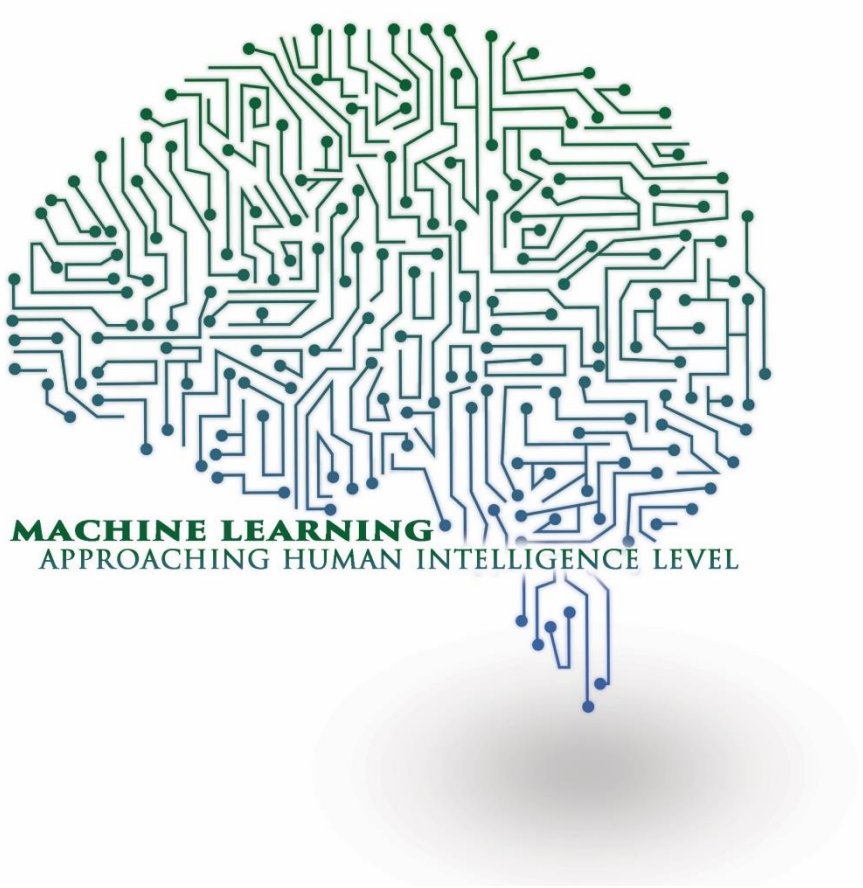

Random forest

Random forest