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Habitat associations of wintering granivorous birds on the Canary Islands

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Farmland birds within arable land are of conservation concern in Europe, but little is known about their ecology in the oceanic islands of the Mediterranean Basin (Macaronesia). We report here that, during two consecutive winters and within the entire arable land area of the Canary Islands, increasing area of bare soil is associated with higher occurrences of the resident granivorous species Corn Bunting (*Emberiza calandra*), Atlantic Canary (*Serinus canaria*) and Linnet (*Carduelis cannabina meadowaldoi*). However, such a relationship was not found for wintering Skylarks (*Alauda arvensis*) probably because of its different diet. We recommend that local authorities, the Cabildo de Tenerife, purchase and manage these lands to improve conditions for granivorous farmland birds. We suggest that providing suitable foraging habitat will support the recovery of farmland birds on this island.

1. Introduction

Avian response to agricultural land-use has been a major topic in ecological research in Europe due to widespread declines of farmland birds and agri-environmental programmes aimed at halting and reversing these trends. The steep population declines of farmland birds is mostly due to agricultural intensification in Northern Europe, and due to land abandonment in the Mediterranean Basin (Pain & Pienkowski 1997, Preiss *et al.* 1997, Tucker & Evans 1997, Chamberlain *et al.* 2000, Donald *et al.* 2001, 2002, Súarez-Seoane *et al.* 2002, BirdLife International 2004, Wilson *et al.* 2005).

Within the Mediterranean Basin and at its south-western perimeter, three archipelagos belong to the European Community: Azores and Madeira belong to Portugal, and the Canary Islands belong to Spain. This region, often referred to as Macaronesia, also holds granivorous bird species of European conservation concern (Tucker & Heath 1994, BirdLife International 2004), and some of these are also taxonomically distinct, endemic species or subspecies (Bannerman 1963, Garcia-del-Rey 2001). These islands have experienced widespread land abandonment (Fernandez-Palacios *et al.* 2004, Arévalo *et al.* 2006). Consequently, some farmland bird species have disappeared from entire islands or from parts of these islands, such as the Rock Sparrow (*Petronia petronia madeirensis*) (Garcia-del-Rey 2010).

Arable land is rare within Macaronesia, and the Canary Islands are no exception. Their existence is currently threatened by building construction. The winter-season habitat associations of bird species

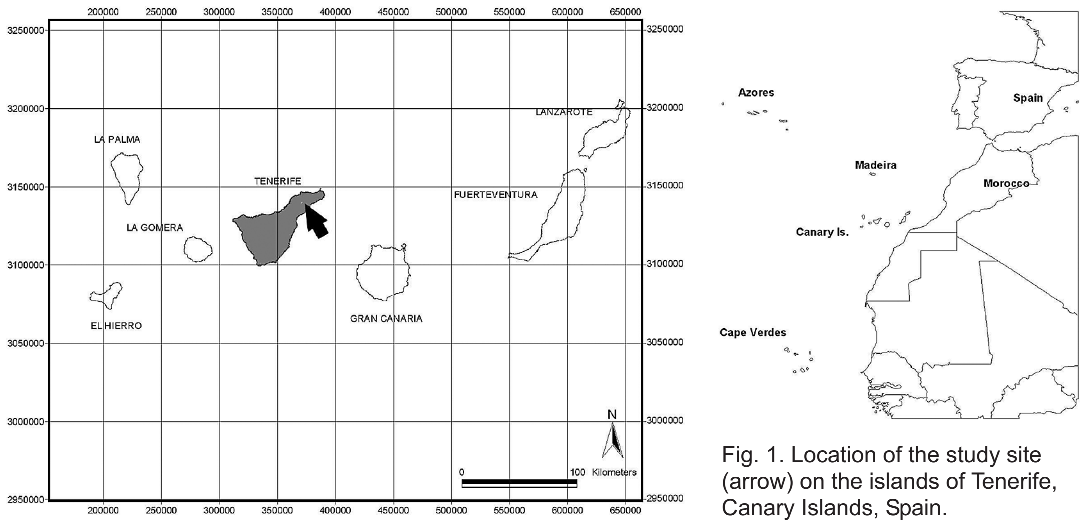

Fig. 1. Location of the study site (arrow) on the islands of Tenerife, Canary Islands, Spain.

of arable farmland are poorly understood within this oceanic Mediterranean system. Hence, we aimed at identifying habitat requirements of bird species occupying these areas. Our results will be applicable for setting priorities for conservation action in the arable ecosystem.

2. Material and methods

2.1. The focal species

Three resident granivorous bird species comprise the avian community in the arable land of the Canary Islands: Corn Bunting (*Emberiza calandra*), Linnet (*Carduelis cannabina meadowaldoi*) and the Atlantic Canary (*Serinus canaria*). Certain species or subspecies are of particular conservation concern on the arable lands of the Canary Islands: the Rock Sparrow *Petronia petronia madeirensis* has gone locally extinct during the last twenty years (Lorenzo 2007, Martín 1987), and the Skylark (*Alauda arvensis*) is a scarce but regular winter visitor (Garcia-del-Rey 2010).

2.2. Study area

We carried out the field work between mid-November and mid-January during the winters of 2007–2008 and 2009–2010, covering all of the arable land of Tenerife, Canary Islands (28°15' N, 16°45' W; Fig. 1). Tenerife occupies a total area of 2,034 km^2 of which a total of ca. 10 km^2 is arable land. No other pieces of arable land occur on the rest of the Canary Islands archipelago. However, abandoned grasslands can be found at the relative flat, uniform and low-altitude areas (550 m a.s.l.) near the Los Rodeos airport (28°28' N, 16°21' W). Our study area was dominated by cereal crops (mainly wheat and rye) with some set-aside fields where annual plants grow freely. Some fields are planted with leguminous shrubs to increase the nitrogen content of the soil. Thin hedges of *Spartocitysus supranubius* divide some fields.

2.3. Bird and habitat surveys

We visited each field once on two consecutive winters. We assigned parallel systematic transects 62.5 m apart within each field, and walked these at 1 km/h speed while making observations (Wilson *et al.* 2005). We identified birds seen on the ground or flushed by the observer were identified to species using binoculars or a telescope. At steep sites we made observations at standard points with the aid of a telescope, and spent approximately the same time at each field. We carried out the surveys during days free of precipitation and no or only light wind, between 7:30 (dawn) and 10:30 AM.

Each time birds were observed we recorded nine environmental variables (Table 1) within a 25-m radius around the bird's location. We paired

Table 1. Descriptive statistics for environmental (model predictor) variables for plots occupied by observed bird individuals (n = 33) and random, i.e., non-occupied, plots (n = 33). The values are mean ± SE.

Variable description	Occupied plots	Unoccupied plots
Response variables		
Bird occurrence*	8.61±1.67	0.0
Species richness	1.20±0.10	0.0
Bird diversity (Shannon-Wiener index)	1.58±0.33	0.0
Number of *Emberiza calandra*	16.26±5.32	0.0
Number of *Serinus canaria*	3.09±1.33	0.0
Number of *C. cannabina meadowaldoi*	11.56±3.30	0.0
Number of *Alauda arvensis*	3.53±1.13	0.0
Predictor variables		
Nominal variable (Winter; 2007/08 or 2008/09)	–	–
Tree cover (TC;%)	0.0	0.47±0.35
Tree height (MTH; m)	0.0	0.75±0.63
Shrub cover (SH;%)	0.15±0.11	12.38±4.67
Shrub height (MSH; m)	0.15±0.11	0.57±0.17
Grass cover (G;%)	39.43±5.44	67.66±6.33
Grass height (MGH; cm)	19.52±4.47	25.31±5.42
Bare-soil cover (BS;%)	59.69±5.44	14.81±5.09
Rock cover (R;%)	0.74±0.72	4.69±2.89
Slope (SL; degrees)	1.09±0.08	2.13±0.37

* Total number of birds counted in each sampling unit.

each of these plots with a randomly-selected, unoccupied plot, and measured the same variables. These variables were percentages of tree, shrub, grass, bare-soil and rock cover, measured visually, slope, tree height which were measured using a Haglöf Vertex IV dendrometer, and mean grass height which was measured with a tape at 1 m x 1 m plots located at 12.5 m from the centre of each observation point (coinciding N, S, E and W; 20 measurements per each 500-m transect).

2.4. Statistical analyses

Descriptive statistics follow Zar (1998) and were obtained using SPSS 13 (SPSS 1986). Regression tree models follow Zuur *et al.* (2007) and were constructed to explore the relationship between single response variable (occurrence; one or more birds recorded) and multiple explanatory variables (Chambers & Hastie 1992, De'Ath & Fabricius 2000), but they also provide thresholds for explanatory variables, which can be used to guide management operations. 'Pruning' was done aiming at detecting the tree (variables) with the highest predictive power, because in ecological data multi-branch trees usually have a relatively high cross-validated error (Breiman *et al.* 1984). The predictive power is a cross-validated estimate of the predictive accuracy of the tree (i.e., variables included in the tree in that particular order). The predictive accuracy of a tree, expressed as cross-validation error, varies from 0 for a perfect predictor to 1 for a poor predictor, and can be expressed as a percentage of the root-node error. The power of the obtained regression tree was evaluated by means of cross-validation procedure using 10 random-sampling iterations, and the process of pruning the tree was done by applying the 1-SE rule (Breiman *et al.* 1984, Zuur *et al.* 2007). The deviance explained by the tree is presented for every model (De'Ath & Fabricius 2000). ArcView 3.2 was used to create the map.

3. Results

Descriptive statistics for response and explanatory variables of the regression trees are shown in Table 1, the regression-tree models are summarized in Table 2, and Appendix 1 shows the analysis details (deviance [D] = 44%, CV error = 0.59). At the

Table 2. MRT summary results of every cross-validation after applying the 1–SE rule on every tree; cross-validated error (CV error) is shown. Response variables, explanatory variables along with the detected threshold value, cross-validated error and total variation explained by the model are shown. BS = bare soil, G = Grass cover, and MGH= mean grass height. The regression-tree model shows the path to obtain the highest occurrence for each particular case, with the most important predictor shown first in each path. For details, see Appendix 1.

Response variable	Expl. var., threshold	CV error	Variation (%)
Total bird occurrence	BS, >15.5%	0.59	44
Total species richness	BS, >15.5%	0.71	36
Total bird diversity	BS, >23.5%; G, >48.5%; MGH, ≤31.5cm	1.20	33
Emberiza calandra	BS, >15.5%	0.95	5
Serinus canaria	BS, >23.5	1.80	31
C. cannabina meadowaldoi	BS, >23.5	0.66	34
Alauda arvensis	G, <2.5	0.63	37

community level, the total bird occurrence and the total species richness were most strongly influenced by bare soil, with a threshold at 15.5% cover (D = 36%, CV error = 0.71). The highest bird diversity was observed in plots with bare soil greater than 23.5%, grass cover greater than 48.5%, and grass height less than 31.5 cm (D = 33%, CV error = 1.2). At the species level, *Emberiza calandra* was more common at plots with bare-soil cover greater than 15.5% (D = 5%, CV error = 0.95). Both *Serinus canaria* and *Carduelis cannabina meadowaldoi* were positively associated with bare-soil cover greater than 23.5% (D = 31%, CV error= 1.8 and D = 34%, CV error = 0.66, respectively). *Alauda arvenis* was influenced by grass cover, with a threshold at 2.5% (note that grass cover was negatively correlated with bare soil; D = 37%, CV error = 0.63).

4. Discussion

The key predictor influencing winter farmland bird occurrence in the arable system of Tenerife was bare soil, at both the community (total occurrence, richness and diversity) and species levels (except for the winter visitor *Alauda arvensis*, which feeds on seeds but also on plant parts). In Tenerife, bare soil is created through ploughing the stubble fields left after mowing during the first fortnight of October, which coincides with the onset of the rainy season in the Canaries (Marzol-Jaén 1984). In years of abundant rainfall, the fields are sown from mid-October onwards and immediately after the heavy rains. This is the time when the bare-soil resource becomes most abundant in most fields.

These areas then decrease as grasses grow and the winter progresses from mid-October to mid-January, through an increase in cereal size and density. Cereals typically reach 25–30 cm in height by mid-February, but they vary and depends on the year. During years of poor rainfall, some fields are not sown until early in December, which delays the availability of bare-soil sites by 1.5 months. Habitats can offer both protective and obstructive cover for nesting birds (Lazarus & Symonds 1992). Bare soil also probably allows a simultaneous maximization of efficient foraging and predator detection (Cresswell *et al.* 2003). Our study suggests that there was a generally positive relationship between the amount of bare soil and farmland birds, which agrees with findings by Moorcroft *et al.* (2002) who reported wintering birds to prefer areas with greater amount of bare soil. Open areas minimize the perception of predation that a flock of birds might experience, as they rely on early detection of predators to retreat to protective cover (Whittingham & Evans 2004), but it also increases the foraging efficiency by minimizing the time allocated to find seeds compared to the more visually complicated environments with higher and denser vegetation (Whittingham & Markland 2002).

However, not simply bare soil but a mosaic of crop types or habitats appear crucial to farmland biodiversity (Benton *et al.* 2003). This premise is less important in the simplistic system of Tenerife where both crop types and bird communities vary little and are relatively species poor compared to continental areas.

The total bird diversity was positively associated with bare soil greater than 23.5%, grass cover greater than 48.5% and grass height lower or equal to 31.5 cm. Birds have been shown to alter their foraging behaviour in response to vegetation-height manipulation, and the ultimate factor explaining why granivorous birds avoid long grass may be perceived predation risk (Whittingham & Evans 2004, Whittingham *et al.* 2006, Devereux *et al.* 2006). Our results for the total bird diversity support this view. As the winter progresses in the arable lands of Tenerife, the fields will shift from open bare ground – as a result of tillage – to tall grass or cereal early in spring. Midway between this process birds may benefit on the short swards, as they can monitor the environment for predators simultaneously while feeding, allowing them to capture more seeds over the same period of time (Devereux *et al.* 2006).

Habitat choice for non-breeding birds is driven by the starvation-predation risk trade-off: in this oceanic system perceived predation risk, food occurrence and availability, and overall availability of safe foraging options are all possibly determining habitat choice. This study suggests that providing suitable foraging habitat is fundamental for the conservation and possibly the recovery of farmland birds on this island.

For the conservation of the remaining arable lands in the Canary Islands, we propose that local authorities (Gobierno de Canarias and Excmo. Cabildo Insualar de Tenerife) purchase these lands to create nature reserves for a diverse bird fauna, and make sure that the EU agri-environmental actions are effectively applied on this island. A reintroduction of the locally extinct *madeirensis* subspecies of the Rock Sparrow should take place at the present study areas after determining the causes of the extinction.

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Talvehtivien siemensyöjälintujen elinympäristövaatimukset Kanarian Saarilla

Viljelymaiden linnut ovat luonnonsuojelullinen huolenaihe Euroopassa, mutta näiden lajien ekologiasta Välimeren valtamerisaarilla (Makaronesia) tiedetään vain vähän. Tässä tutkimuksessa, joka tehtiin kahden vuoden aikana koko Kanarian Saarten viljelymaa-alueella, havaitsimme että paljaan maan kasvava osuus oli positiivisessa suhteessa siemeniä syövien paikkalintujen harmaasirkun (*Emberiza calandra*), kanarianhempon (*Serinus canaria*) ja hempon (*Carduelis cannabina meadowaldoi*) esiintymiseen. Tällaista riippuvuutta ei kuitenkaan havaittu talvehtivilla kiuruilla (*Alauda arvensis*) luultavasti lajin erilaisen ravinnonkäytön vuoksi.

Suosittelemme tuloksiemme perusteella, että paikalliset viranomaiset (Cabildo de Tenerife) lunastavat ja hoitavat näitä maita siemensyöjälintujen elinolojen parantamiseksi. Uskomme, että hyvien ruokailumaiden tarjoaminen kohentaa viljelymaiden lintujen palautumista alueella.

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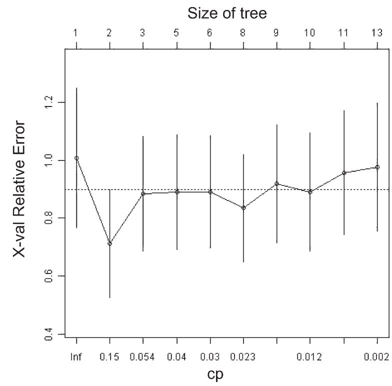
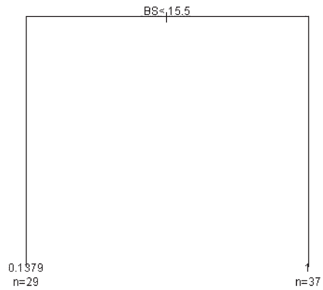
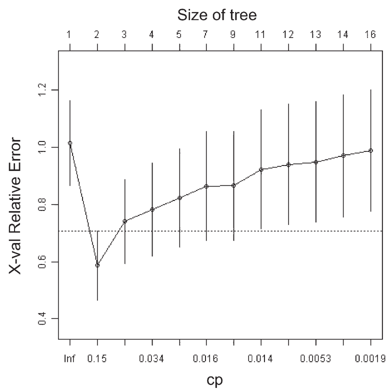
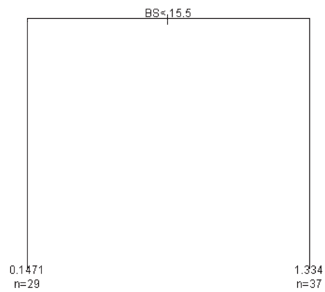
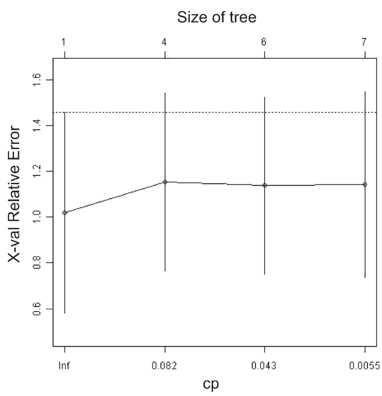
Appendix 1. MRT cross-validation (left) and the pruned tree (right) for each response variable within occupied (n = 33) and unoccupied 25-m radius plots (n = 33). The response variables were (from top to bottom) total bird occurrence, total species richness, total bird diversity, *Emberiza calandra*, *Serinus canaria*, *Carduelis cannabina meadowaldoi* and *Alauda arvensis*. Branch length is proportional to the improvement of model fit, and left-hand branches of the pruned trees show the true statement. Left-hand graphs show the pruning process: the horizontal axis shows the complexity parameter (*cp*) and the vertical axis shows the corresponding tree size (default *cp* = 0.001; deviance *cp* is similar to AIC). The vertical axis shows the cross-validated relative error obtained by the cross-validation process. Dots are averages of ten cross-validations, and vertical lines around these dots show standard deviation of cross-validations. Right-hand figures show the optimal tree size after cross-validation and applying the 1-SE rule. The variable appearing in the top of each tree is the most important predictor. Numbers at each terminal leaf show mean values (highest mean value = highest occurrence) and the number of observations (n) in that particular group.

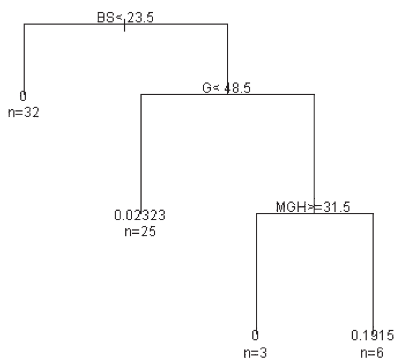












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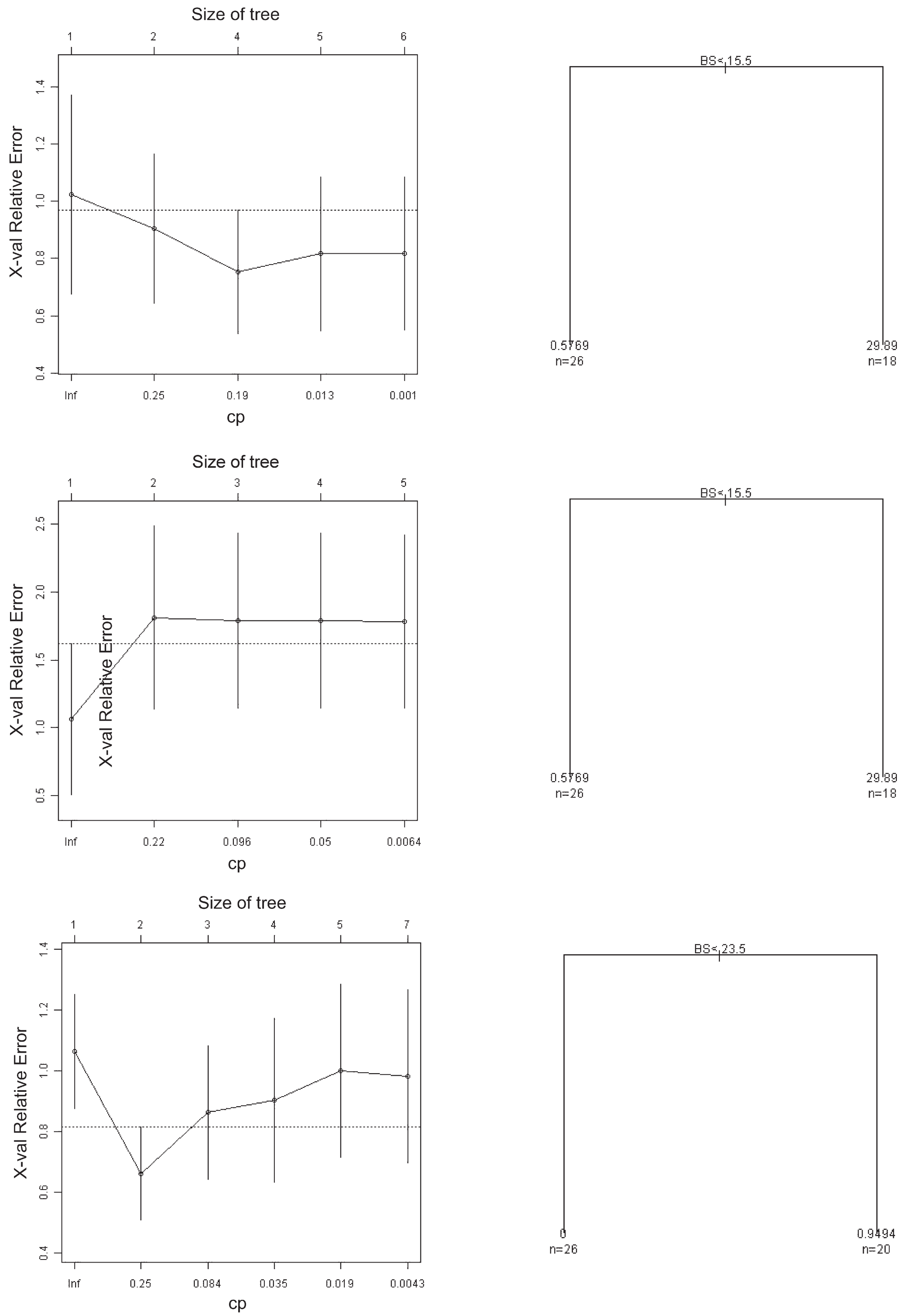

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