Evaluation of IAS in Macaronesia

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Methods

Lists of target or focal taxa

The basic definition of IAS, given above by IUCN, stresses that an invasive species is present in natural or semi-natural environments on one hand, and that it will cause change and threaten the native biodiversity, on the other hand. Thus, the focal taxa analysed in this book will only include those species that are not only naturalized, but also that are both present in natural or semi-natural habitats and are considered to have an impact or pose an evident threat to local biodiversity. In this sense, it was decided that exotic species that are present only in anthropic habitats would be excluded from the present analysis, even if they are considered as weeds or pests.

As an example, in the Azores, a list of terrestrial fauna and flora was used and only those taxa considered as alien and naturalized were selected. Afterwards, those species only occurring on anthropic habitats were excluded. Experts then elected those species with a known impact on biodiversity. In the Canaries this selection basically started with the analysis of those especies included as introduced in the Canary Islands Biodiversity Data Bank and of those species considered as invasive in the cited Bank, when their distribution was not limited to anthropogenic habitats. In the case of plant species, several lists, reports and publications were consulted, regarding invasive species in the archipelago (Sanz Elorza *et al*. 2004, 2005, Rodríguez & García 2002). Further, direct proposals from the experts that evaluated the existente of impacts on the natural and seminatural habitats and on biodiversity were also considered, all this leading to the definition of the list of focal species from the Canary islands.

Special attention should be given to the fact that the lists of focal species to be scored using the two sets of criteria in the present book, as detailed below, were based on the present knowledge about IAS in Macaronesia. In the future, other species should be added if pertinent information is made available. Furthermore, a species that is now only present in human disturbed habitats might, in the future, invade more pristine ecosystems. In fact, many alien species have not shown an invasive tendency immediately after introduction due to several reasons, including suboptimal habitat, lack of dispersal agents, or low number or quality of the founder population. This might change at any time in the future, due to unpredicted changes in the population or in the environment.

Criteria of noxiousness and viability of control

Lists of IAS from Azores, Madeira and the Canaries were assessed using two tables, evaluating different aspects of the invasion process and of the control strategy (Table 9). The analytical system was based on similar classification systems created for other regions, namely the system proposed by Morse *et al.* (2004). In Figure 3, the complete process of IAS evaluation is shown, and it will be described as follows.

Table 9. The two sets of criteria that were used to score IAS from Azores, Madeira and the Canaries.

Table I. Measures of noxiousness – known and potential effect of IAS on native biodiversity and on natural and semi-natural habitats.

i) Affected biodiversity values;
ii) Impact on the affected biodiversity values;
iii) Present status and trend of the invasion;
iv) Invasive potential.

Table II. Measures of feasibility of control – probability of successful control or eradication.

i) Invasion traits;
ii) Feasibility of control or eradication with available resources;
iii) Support for control or eradication actions;
iv) Impact of control or eradication actions.

The idea of using two complementary groups of criteria was based on the strategy suggested in a recent paper by Marsh *et al.* (2007), in which a systematic procedure allows the establishment of management priorities for endangered species. In the present case, a similar methodology was used in order to obtain management priorities for IAS in Macaronesia.

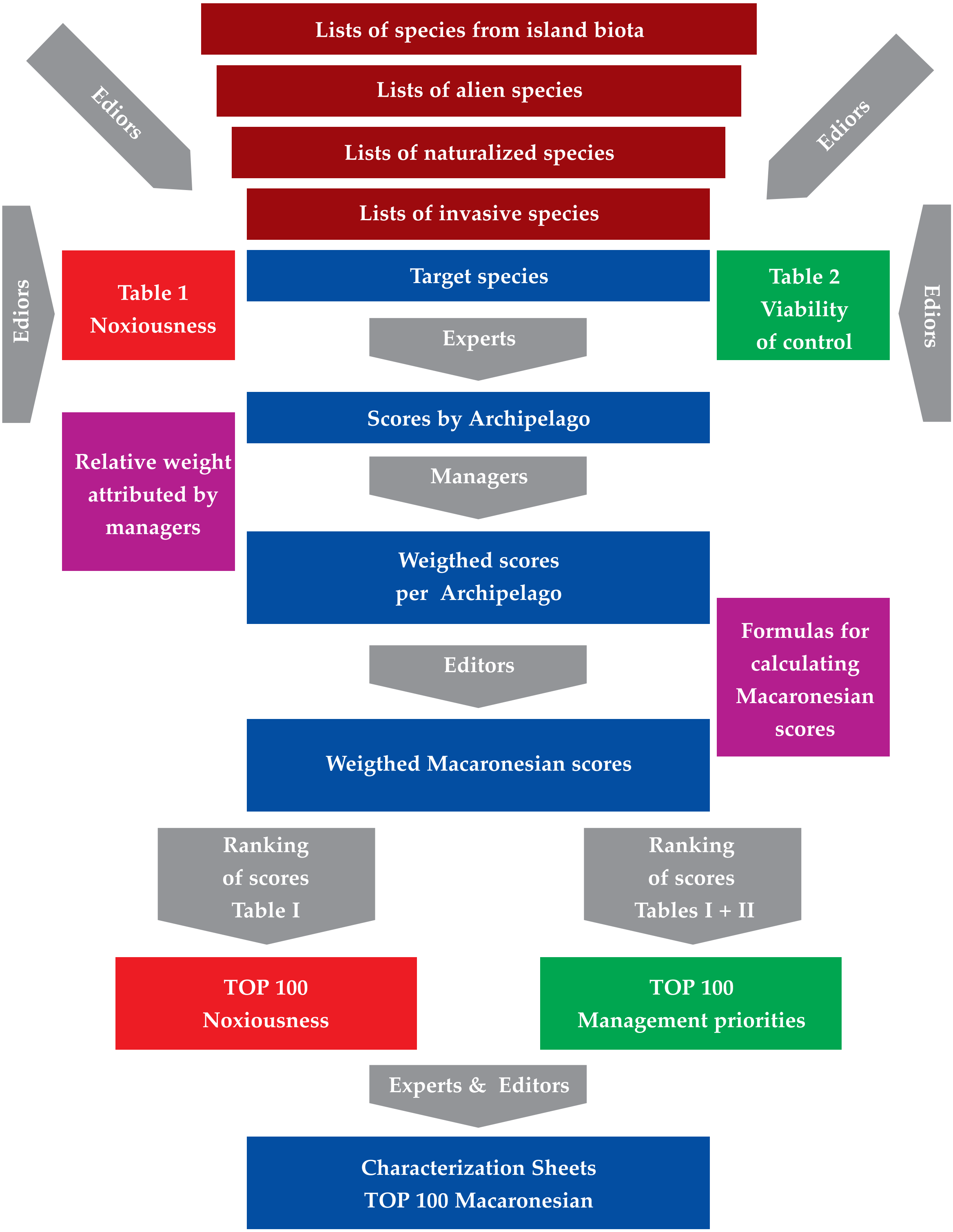

Figure 3. Process of analysis of IAS in European Macaronesia.

Each of the four topics from each set of criteria was evaluated using three different items or subcriteria, which resulted in a total of 12 items per table and a total of 24 items for each species (Appendix).

Scoring

Experts scored the target species according to the criteria of both sets, without knowing the relative weight of each item or subcriteria on the final score of each species.

Each item was scored from 1 to 4. In the case of **Table I**, a value of 1 corresponded to a low impact on biodiversity, while a value of 4 corresponded to a large impact on biodiversity. Regarding **Table II**, a value of 1 corresponded to a low probability of successful control or eradication, while a value of 4 corresponded to a high probability of successful control or eradication.

It should be stressed at this point that there was a need to organise several workshops, with all the archipelagos represented, aiming to standardize, as much as possible, the attribution of scores, not only among regions, but also among the several taxonomic groups analysed. Those meetings took place at each of the three archipelagos involved in the analysis.

On the other hand, environmental managers from the three regions weighted each item of both criteria sets, without knowing the scores attributed by experts. The relative weight attributed to each item was calculated as the average weight attributed by the different managers from the three regions.

On the basis of the score of each species for each archipelago, a "Macaronesian" score was calculated for each analysed species. This calculation followed different methods, depending on the type of item. For some of the items, larger weight was given to the presence of the taxa, according to the number of archielagos where it was present. In other cases, and depending on the type of question, the average, maximum or minimum value obtained from the three regions was used (Appendix). As an example, if one IAS is affecting endangered species in one of the archipelagos, it will score the maximum value for this item. On the other hand, in the case of the extension of the area to be treated, the score will depend on the number of invaded islands or archipelagos.

Next, the species were ordered according to their total score on **Table I**. This allowed defining the 100 most noxious species for Macaronesia, the **TOP 100**. To obtain the species scores on **Table II,** the same method was applied, which originated a list of taxa ranked according to the feasibility of their control or eradication. However, the management priority of each species results, according to the concept of the model proposed by Marsh *et al.* (2007), from the combination of the noxiousness of the taxa and the viability of its control or eradication. Thus, the 100 species from the TOP were ranked again, now according to the sum of the scores from both tables, which defined their management priority. In this way the **TOP 100** IAS with management priority in the European Macaronesia were defined. The complete list of evaluated taxa and all the scores can be obtained at the Azorean Biodiversity Portal (www.azoresbioportal.angra.uac.pt/publicacoes.php?lang=en) or at the Invasion Biology Regional Observatory (www.orbi.uac.pt).

Results and discussion

Environmental manager's relative weights

Environmental managers attributed somewhat different relative weights or importance to the different items or subcriteria on both tables (Figure 4). High relative weight was given to the level of threat of the affected species; the dispersal ability; the extent of the area to be treated; the availability of human and technical resources. In contrast, low weight or importance was given to the classification as IAS in other regions; the existence of a legal mandate for control or eradication; the interaction between IAS. An unexpected result was the low weight attributed to the existence of a specific legal mandate to control or eradicate the IAS, since it would be expected that managers would give considerable importance to regulation and legislation.

Global analysis of the scores

In total, 195 IAS from European Macaronesia were scored. There were no pronounced "leaps" on IAS scores (Figure 5). This might imply that the selection of the first 100 species is arbitrary, mainly with public information aims, and not with an objective meaning.

In fact, the value obtained in **Table I**, corresponding to the 100th species (225.4) is somewhat below the mean value for the scale that corresponds to 250. The minimum and maximum values that might be obtained for each table, by the analysed species vary between 100 and 400. In reality, the scores ranged from minima of 148.9 and 140.1 to maxima of 352.2 and 377.7 for **Tables I** and **II**, respectively. That is, a wide range of socres was obtained, including from very noxious and difficult to control IAS to much less noxious and less hard to control species. There was a slightly negative correlation between the scores of both tables, that is, the more noxious is a species, the more difficult it will be to eradicate (Figure 6). However, the **TOP 100** IAS showed considerable variation regarding their probability of successful control.

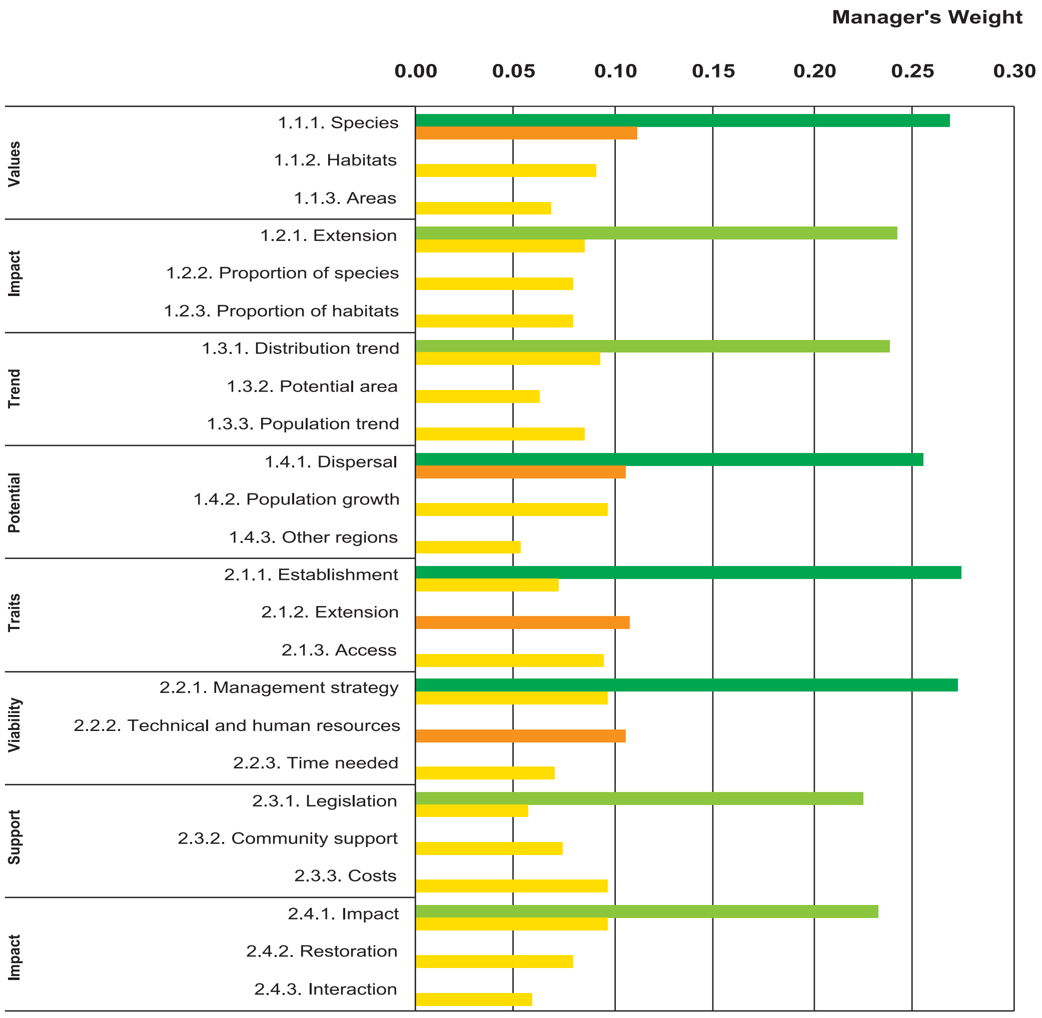

Figure 4. Relative weight attributed by environmental managers from the three regions to subcriteria and to the items in both tables. Green bars, weight of the subcriteria - dark above 0.25, light below de 0.25. Orange bars, weight of individual items – dark above 0.10, light below 0.10.

The analysis of the results also showed a positive correlation (Figure 7) between the score from **Table I** (noxiousness) and the sum of scores from **Tables I** and **II** (noxiousness + probability of control or eradication). This allowed ranking the **TOP 100** IAS, according to their management priority, which results from considering the degree of noxiousness of a taxon and the viability of implementing effective control measures.

It was thus possible to produce a list of management priorities for IAS in Macaronesia, not ignoring those species considered as highly noxious, but which also assumes the real possibility of their control or eradication.

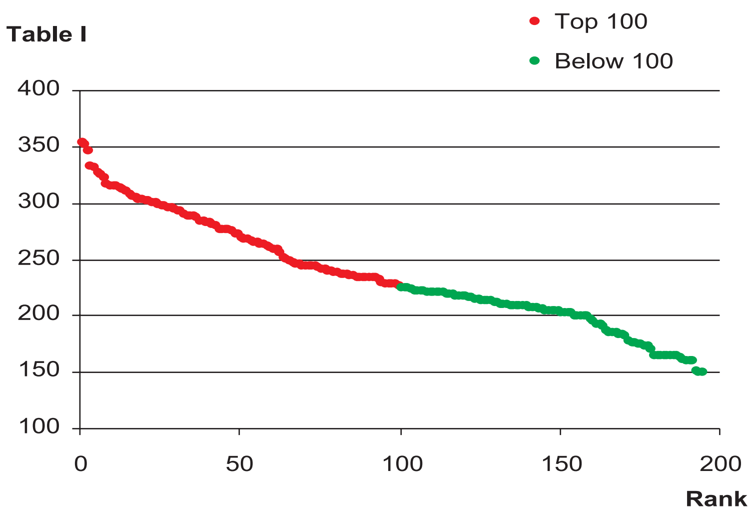

Figure 5. Scores obtained for the 195 IAS in European Macaronesia, based on Table I (noxiousness), as a function of their ranking. In red the species on the TOP 100, in green those species below TOP 100.

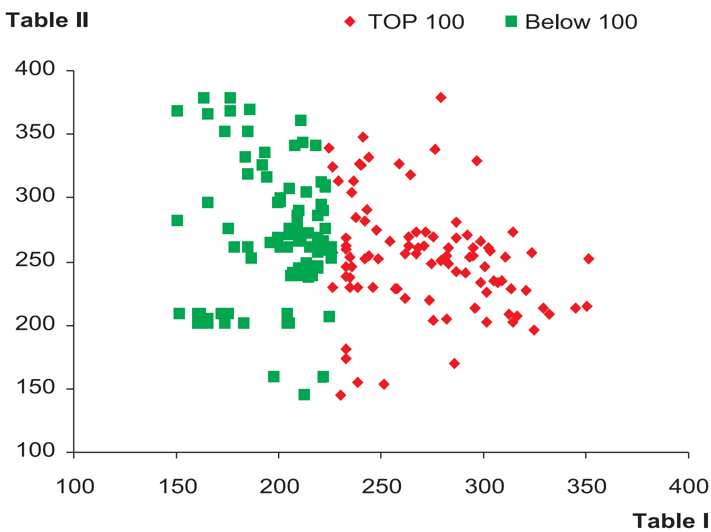

Figure 6. Relationship between noxiousness (Table I) and viability of control (Table II), based on the scores obtained for all the evaluated species on both criteria sets. In red the species of the TOP 100, in green the species below TOP 100.

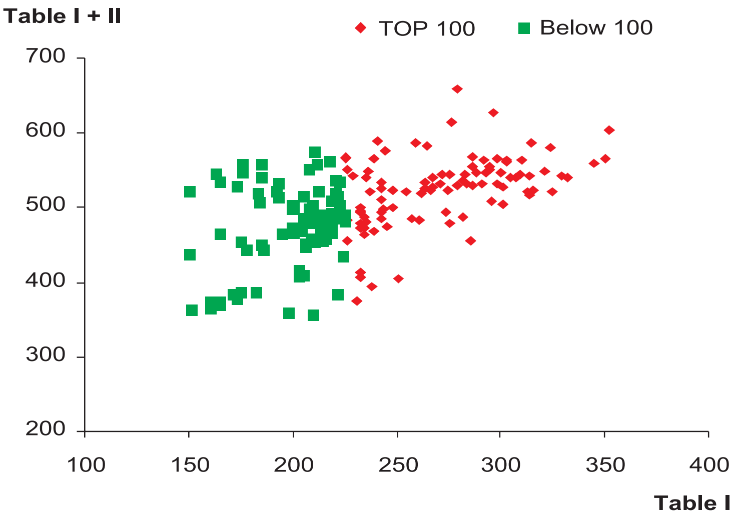

Figure 7. Relationship between noxiousness (Table I) and management priority (Tables I + II), based on the scores obtained for all species evaluated. In red the species of the TOP 100, in green the species below TOP 100.

Characterization of the Top 100 IAS

The **TOP 100** IAS, were mainly vascular plants, with some invertebrate and vertebrate species (Figure 8).

It should be noted that the first twenty positions of the **TOP 100** generally include several very problematic invasive plants. These include species with more or less significant impacts on the three archipelagos (*Carpobrotus edulis, Ageratina adenophora, Ulex europaeus, Agave americana, Arundo donax*), or species which are only present in one or two regions but with a very significant impact (*Hedychium gardnerianum, Cyrtomium falcatum, Pittosporum undulatum, Opuntia ficus-indica, Hydrangea macrophylla, Nicotiana glauca*, etc.).

In fact, species like sweet pittosporum (*Pittosporum undulatum*) and yellow ginger (*Hedychium gardnerianum*) or common reed (*Arundo donax*) pose real threats to the conservation of biodiversity in the Azores and Madeira, due to their effect in terms of a drastic limitation of native species regeneration. The common reed acts in a similar way in the Canaries, and we should also add species such as century plant (*Agave americana*) or the prickly pears (*Opuntia ficus-indica* and *O. stricta*) that pose important threats to biodiversity in this archipelago.

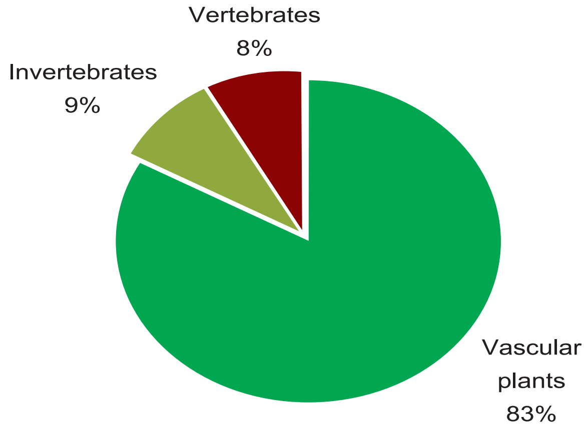

Figure 8. Characterization of the TOP 100 IAS in Macaronesia. Percentage of IAS belonging to different groups of living organisms.

Regarding vertebrates, it should be mentioned that the three species of rodents are included in the top 21 positions, the black rat (*Rattus rattus*) being the first of those species, in the 11th place. In particular, regarding the brown rat (*Rattus norvegicus*) the knowledge of its impact is, apparently, reduced. Regarding the rabbit (*Oryctolagus cuniculus*), although its negative effects on the native flora have been well documented in the Canaries, it is possible that some lack of knowledge about its real effects on the native flora in the Azores, might have led to a relatively lower position at Macaronesian level. On the other hand, it is an important game species in the Azores, and thus there will be social sectors interested in its use. Regarding the cat (*Felis silvestris catus*), its score was lower because, although it has serious impacts in Madeira and the Canaries, in the Azores it is present but not considered as feral, being closely associated to human settlements. It is a considerable difference that sould be investigated in the future, moreover considering that there are evidences that show its ability to predate upon native bird siblings, namely of the blackbird (*Turdus merula azorensis*).

From the analys of figures 9 to 20, regarding the scores obtained by the **TOP 100** in **Table I**, the conclusions summarized in Table 9 were derived. Likewise, from the analys of figures 21 to 32, regarding the scores obtained by the **TOP 100** in **Table II**, the conclusions summarized in Table 10 were derived.

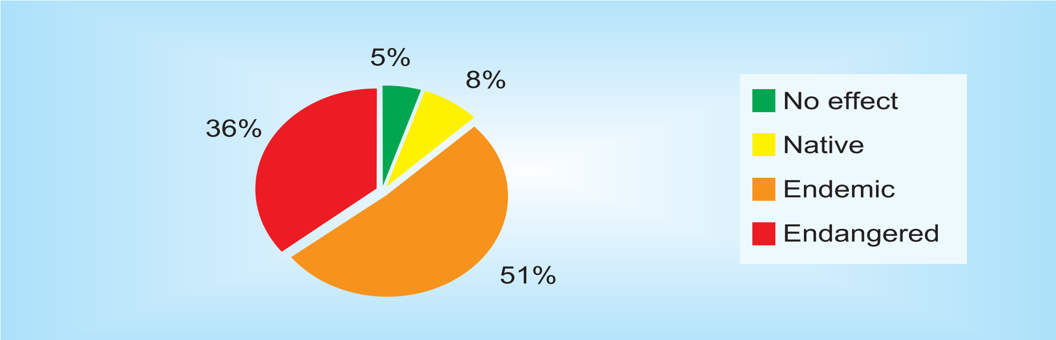

Figure 9. Results obtained for criteria 1.1.1. Affected species. The majority of the IAS affects endemic, non-endangered species. However, more than one third affects endangered species.

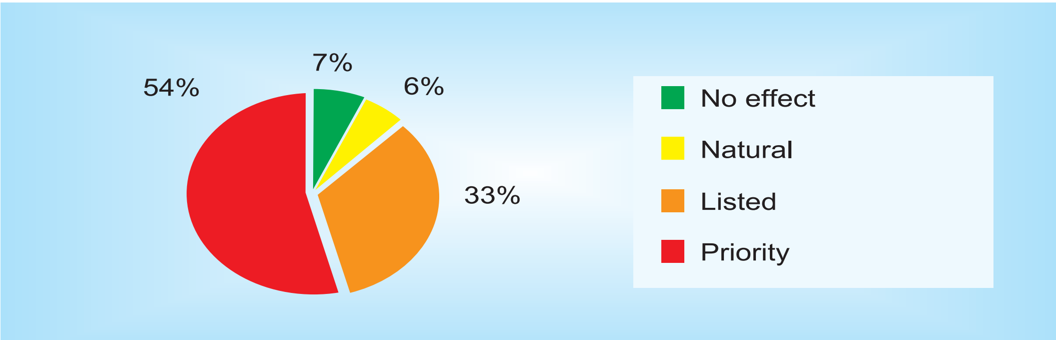

Figure 10. Results obtained for criteria 1.1.2. Affected habitats. The large majority of the IAS affects priority habitats or habitats listed on the Habitats Directive.

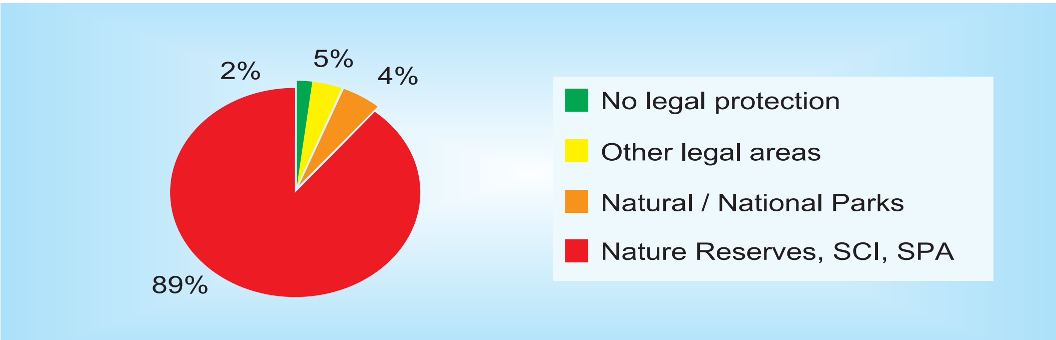

Figure 11. Results obtained for criteria 1.1.3. Affected areas. The large majority of the IAS affects legally protected areas with considerable interest for consevation.

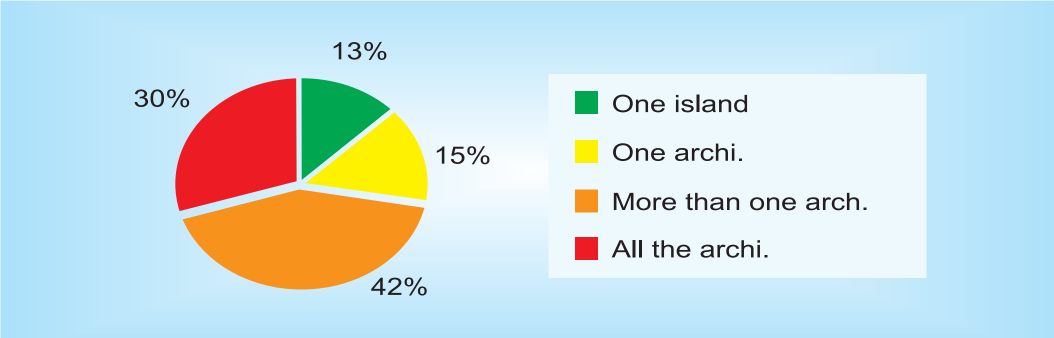

Figure 12. Results obtained for criteria 1.2.1. Extension of the invasion. The large majority of the IAS affects more than one archipelago.

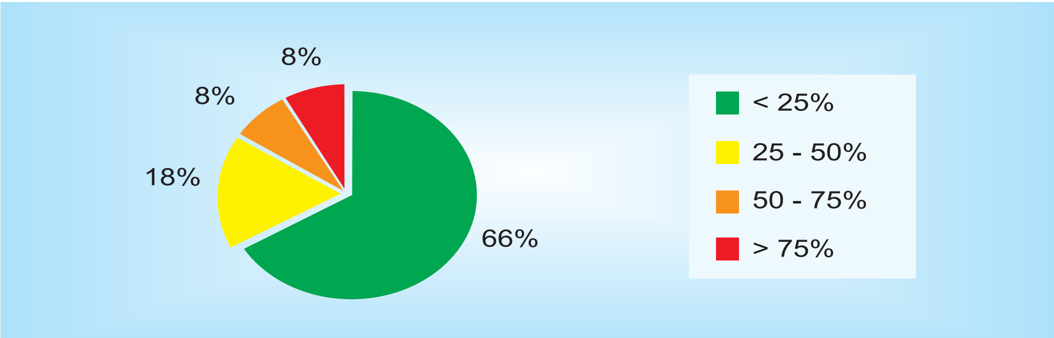

Figure 13. Results obtained for criteria 1.2.2. Portion of the population/distribution of affected species impacted by IAS. The majority of the IAS affects only a small portion of the population/distribution of the impacted species.

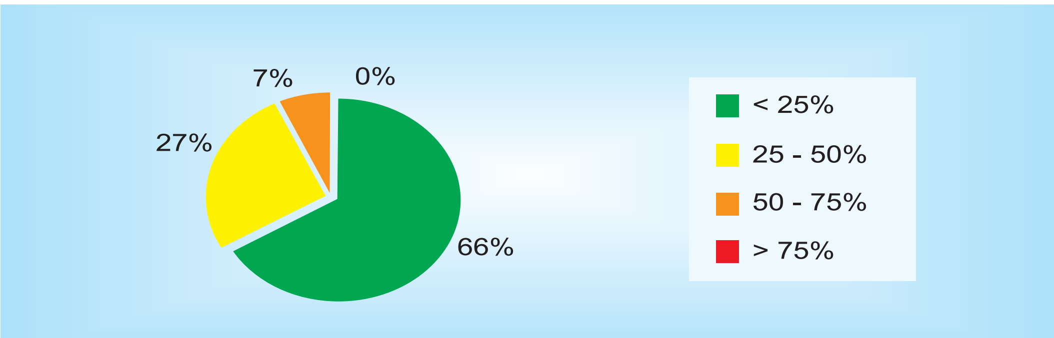

Figure 14. Results obtained for criteria 1.2.3. Portion of the distribution affecting natural or semi-natural habitats. The distribution of the IAS is only partly located in natural and semi-natural habitats.

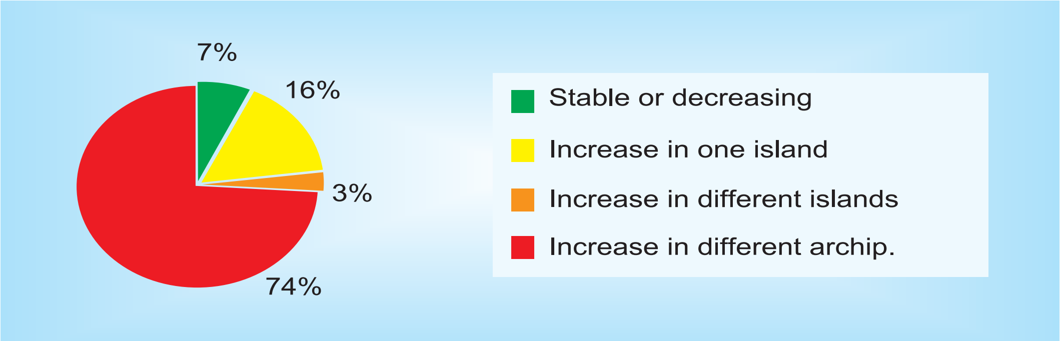

Figure 15. Results obtained for criteria 1.3.1. Present tendency of the invasion. The large majority of the IAS were considered to be expanding in different archipelagos.

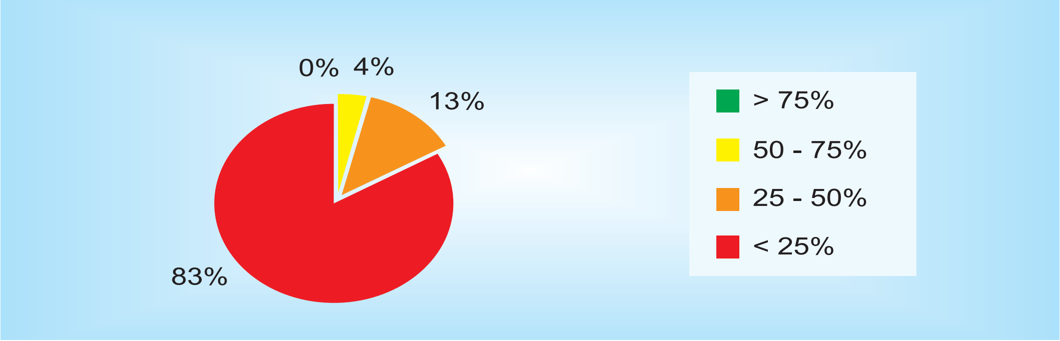

Figure 16. Results obtained for criteria 1.3.2. Portion of the potencial area already occupied. The large majority of the IAS will still be able to increase their distribution areas.

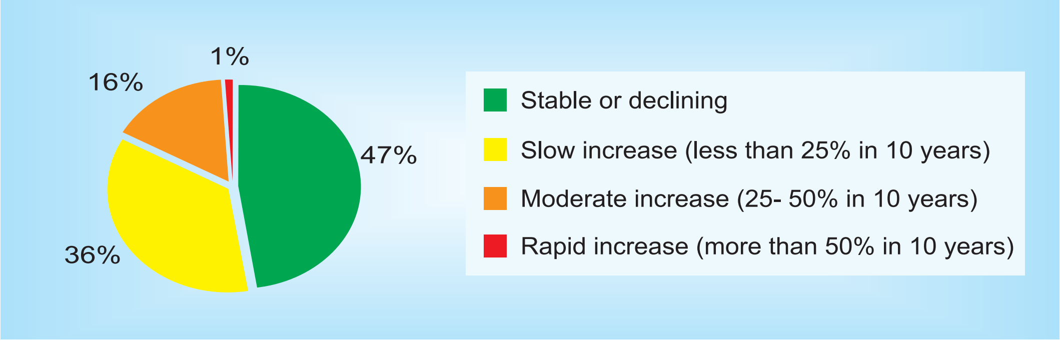

Figure 17. Results obtained for criteria 1.3.3. Population growth. In general, the IAS were not considered as showing a very fast population increase.

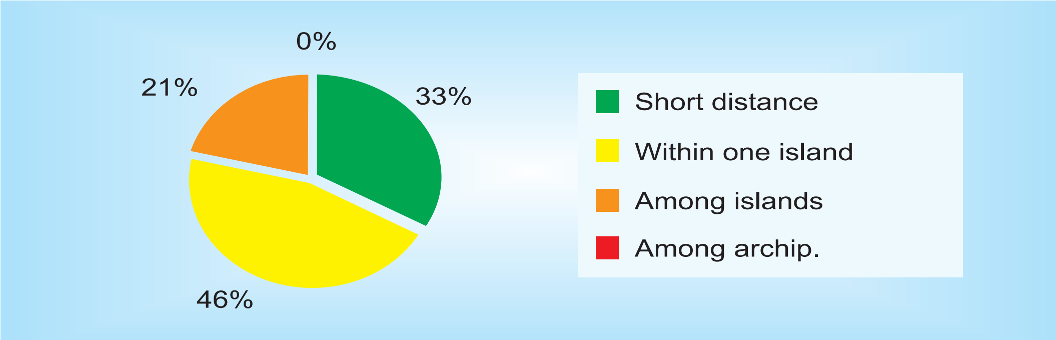

Figure 18. Results obtained for criteria 1.4.1. Dispersal ability. The majority of the IAS will not be able to disperse between islands by natural means.

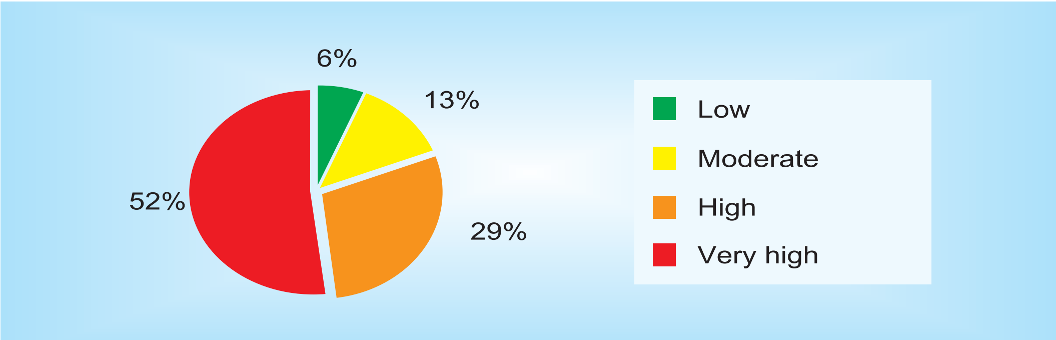

Figure 19. Results obtained for criteria 1.4.2. Reproduction potential. The large majority of the IAS was considered as having a high reproduction potential.

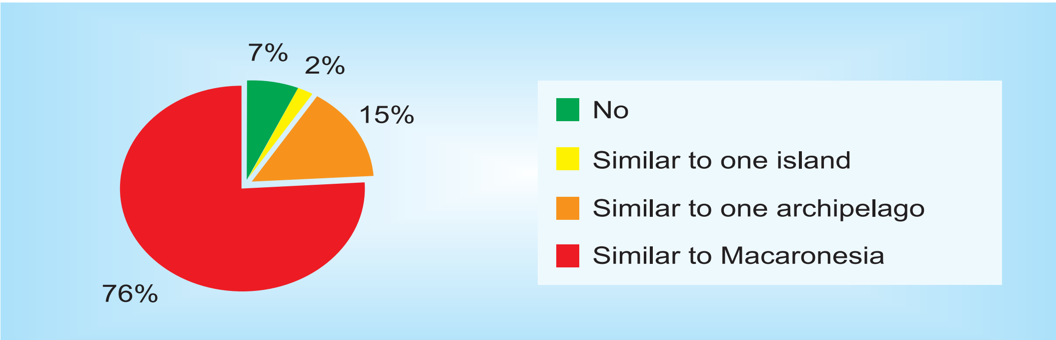

Figure 20. Results obtained for criteria 1.4.3. The large majority of the IAS was considered as invasive in other biogeographical regions, with ecological conditions similar to Macaronesia.

Table 9. Summary of the conclusions derived from analysis of the previous figures, regarding the scores obtained by the species in the TOP 100 in Table I.

• The majority of the IAS affected endemic, non-endangered species. However, more than one third affected endangered species. • The large majority of the IAS affected high priority or listed habitats. • The large majority of the IAS affected legally protected areas with a high conservation value.
• The large majority of the IAS affected more than one archipelago. • The majority of the IAS affected only a small portion of the area/population of the impacted species • The distribution of the IAS was only partially located in natural habitats.
• The large majority of the IAS were considered to be expanding in different archipelagos. • The large majority of the IAS still has the possibility to further expand their distribution. • However, in general IAS are not considered to be having a rapid population increase.
• The majority of the IAS is not capable of dispersal between islands by natural means. • The large majority of the IAS was considered to have a considerable potential for population increase. • The large majority of the IAS was also considered as such in other biogeographic regions.

The fact that the majority of the IAS affects endemic species and more than one third affects endangered species, is in agreement with the recent results that showed the importance of IAS as a threat to the conservation of priority species in Macaronesia (Martin Esquivel *et al.* 2008). Further, this result implies that the recovery plans designed for endangered species will have to take into account the need to monitor and eventually control the IAS.

In the same sense, the fact that the majority of the IAS affects high priority habitats or habitats listed in the Habitats Directive, implies the need to continuously monitor the evolution of this situation and also demands taking concrete management actions in the invaded areas, particularly regarding high priority habitats. This situation, however, extends to the protected areas in general, since the large majority of the IAS affects legally protected areas with high importance in conservation, namely National Parks, Natural Parks, Nature Reserves as well as areas included in Natura 2000 network.

Regarding extension of the invasion, the large majority of the IAS affects more than one region, thus it will be appropriate to conjugate efforts and to transfer knowledge regarding control methods. On the other hand, it is probable that a species already considered as invasive in one archipelago, being only introduced or naturlalized in another, will change its status in the future. Thus, special attention should be devoted to these cases in terms of monitoring and of an eventual early eradication. This guideline should also be applied at each of the archipelagos, in those cases where a species is presently invading a limited number of islands. Some examples are the cases of *Leycesteria formosa* in the Azores, where it is only present in one island, and the species of *Pennisetum* which have not yet invaded the Azores.

The fact that the majority of the IAS only affects a small portion of the distribution/population of the impacted species and also that they are only partly located in natural or semi-natural habitats, suggests that in many cases it will be a priority to take action in areas with high value for conservation. However, this situation also suggests that those species that essentially invade anthropogenic habitats, in certain situations, might become established in natural areas. This might occur, for instance, with the openning of pedestrian trails and other access to the protected areas and with an increase in the number of visitors to those areas. Again, it will be necessary to monitor the spread of IAS populations along trails, access roads, and adjacent areas surrounding nature reserves. This is also related to the fact that many of the IAS still occupy a relatively small area, being able to further increase their distribution range. This phenomenon might be further potentiated in the future, due to climate change, allowing, as an example, the establishment of IAS at higher elevations. Also associated is the fact that experts considered that the **TOP 100** IAS showed a tendecy to increase their range of the invasion as well as a high potential in terms of population growth. In the case of plants, this situation is associated with the existence of short sexual maturation periods and/or the possibility of asexual reproduction. In the case of animal species, this situation is associated with the possibility of producing a high number of offspring per generation (invertebrates) or to the existence of several reproductive cycles throughout the year (rodents, rabbits).

Meanwhile, the majority of the IAS are not capable of natural dispersal between islands. This is of particular importance, meaning that transpor mechanisms within and particularly among islands will largely depend on human actions, either direct or indirect. That is, the reduction of the number of new introductions will largely depend on the implementation of efficacious quarantine systems, of fiscalization measures based on systematic and statistically sound sampling, and on the adoption of codes of good practice in transportation of people and goods. This situation is also related to the fact that the large majority of the **TOP 100** IAS are also considered as such in other biogeographic regions. That is, the mechanisms used to minimize the entrance of IAS form other islands in the same archipelago or form a neighbour archipelago should also miminize the entrance of species considered as invasive in other biogeographic regions and that will have a high probability of invading Macaronesia also.

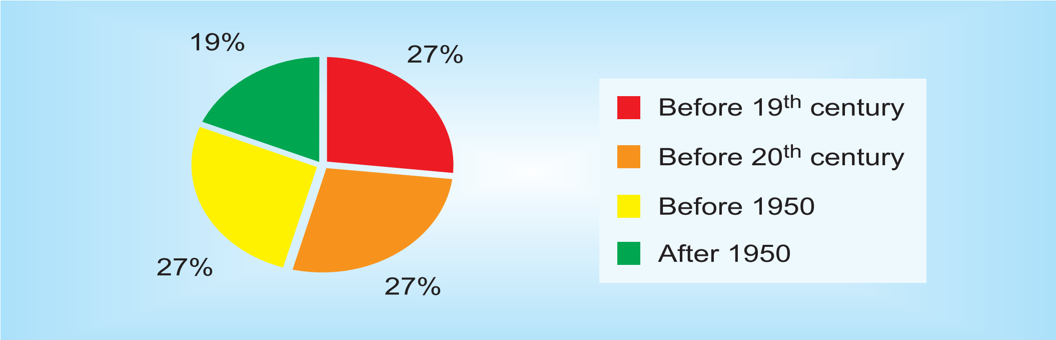

Figure 21. Results obtained for criteria 2.1.1. Time of introduction. The large majority of the IAS was introduced after the 19th century.

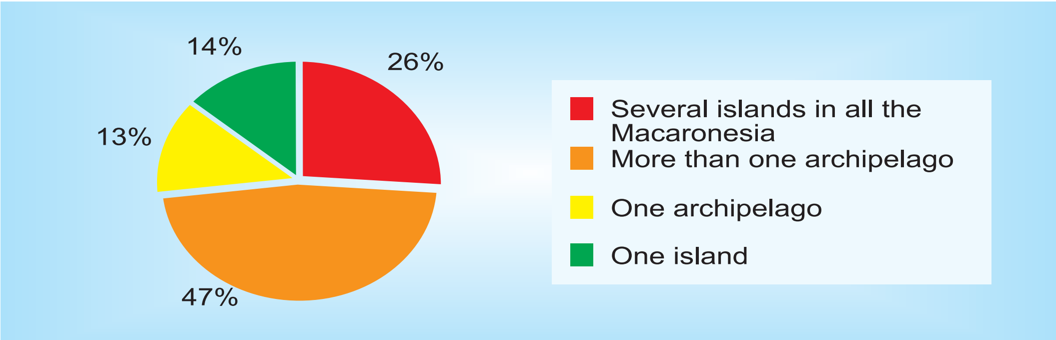

Figure 22. Results obtained for criteria 2.1.2. Area to be treated. The majority of the IAS will have to be controlled in more than one region.

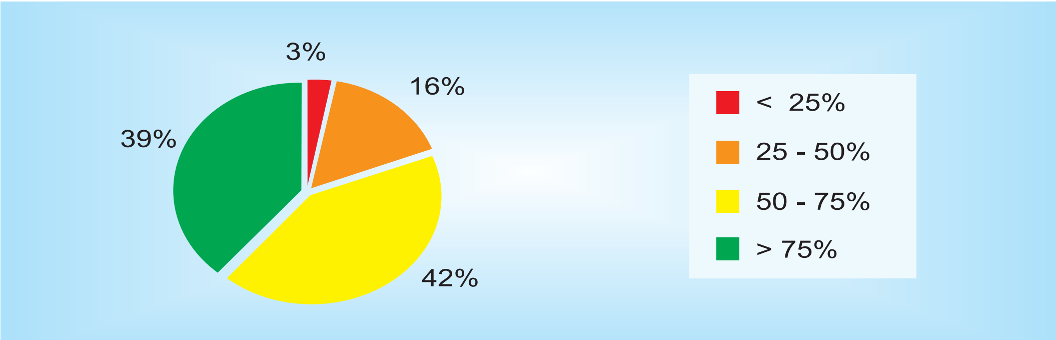

Figure 23. Results obtained for criteria 2.1.3. Accessibility. The large majority of the IAS was considered has being localised in areas accessible to control measures.

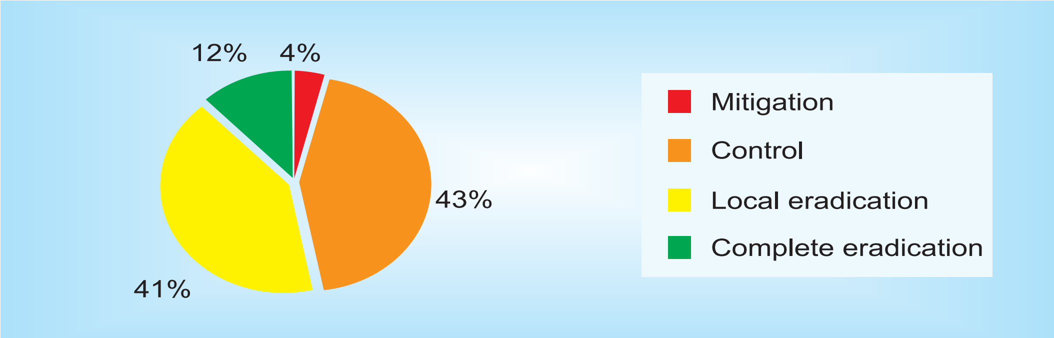

Figure 24. Results obtained for criteria 2.2.1. Possible strategy. The majority of the IAS was only considered to be susceptible to local eradication or control.

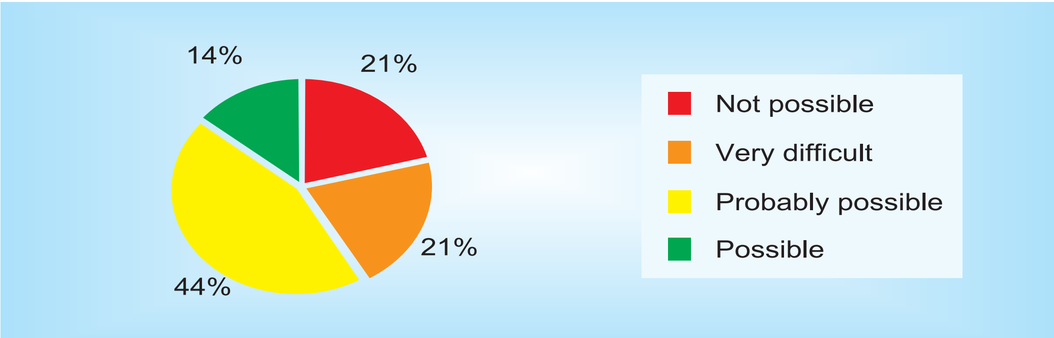

Figure 25. Results obtained for criteria 2.2.2. Feasibility of control with the available means. It will be difficult or impossible to control 42% of the IASI, with the available human and technical resources.

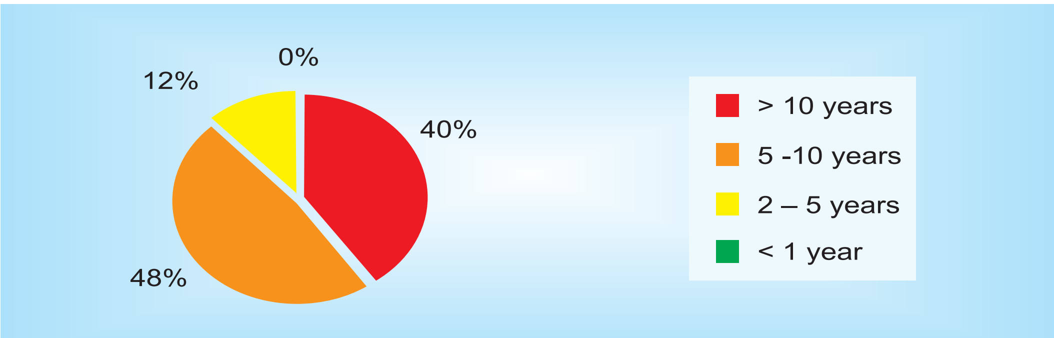

Figure 26. Results obtained for criteria 2.2.3. Duration of the projects. The control of the large majority of the IAS will demand medium to long duration projects.

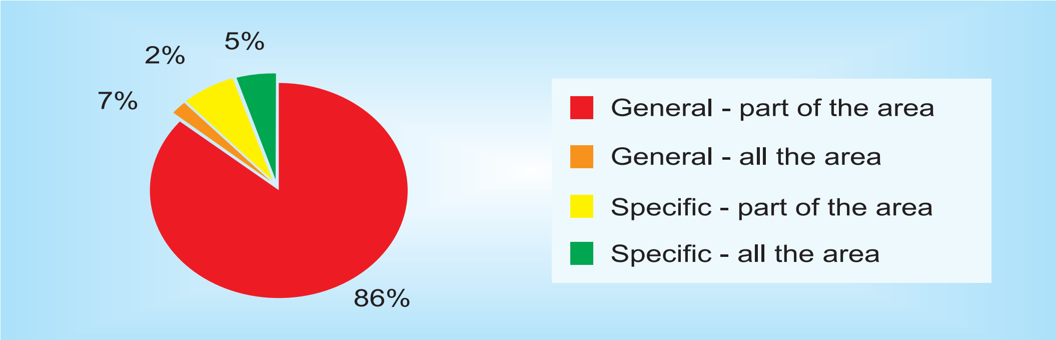

Figure 27. Results obtained for criteria 2.3.1. Legislation. For almost all the IAS, control actions would have to be based on general legislation devoted to protected areas and biodivesity.

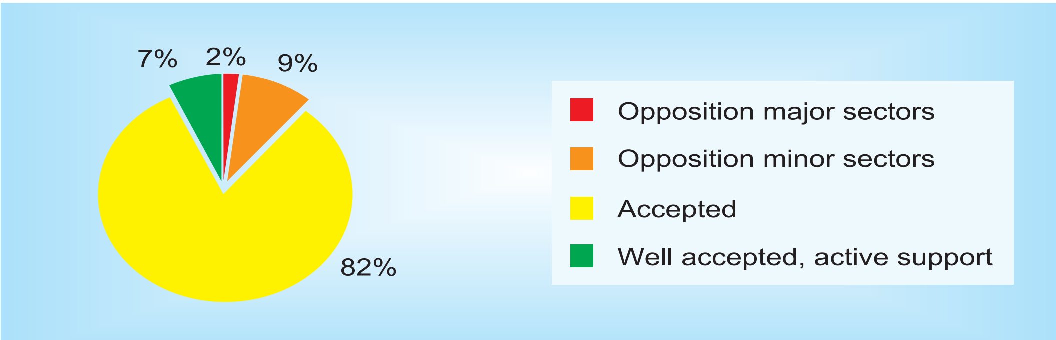

Figure 28. Results obtained for criteria 2.3.2. Support from society. For almost all the IAS, the control actions would be accepted by the public.

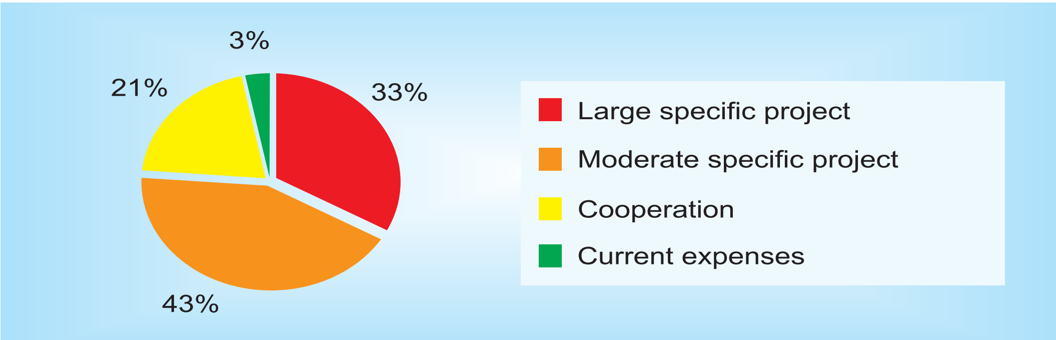

Figure 29. Results obtained for criteria 2.3.3. Costs. The control of the large majority of IAS will demand specific projects with a moderate to large investment.

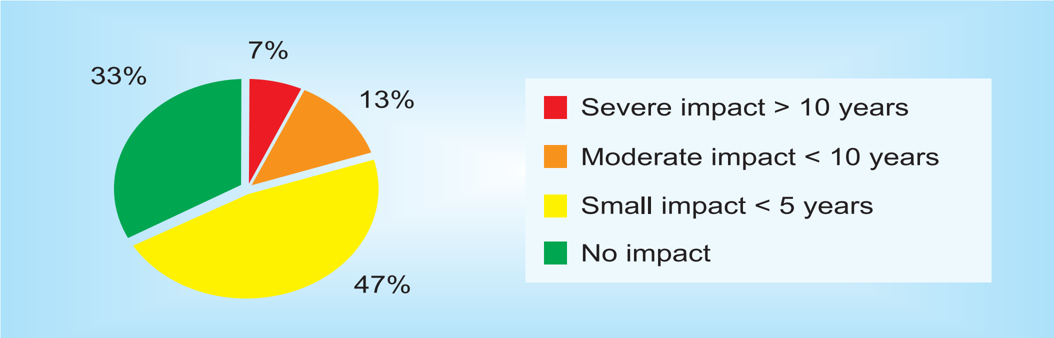

Figure 30. Results obtained for criteria 2.4.1. Impact resulting from control actions. For the large majority of the IAS the control actions were considered as having only small non-target impacts.

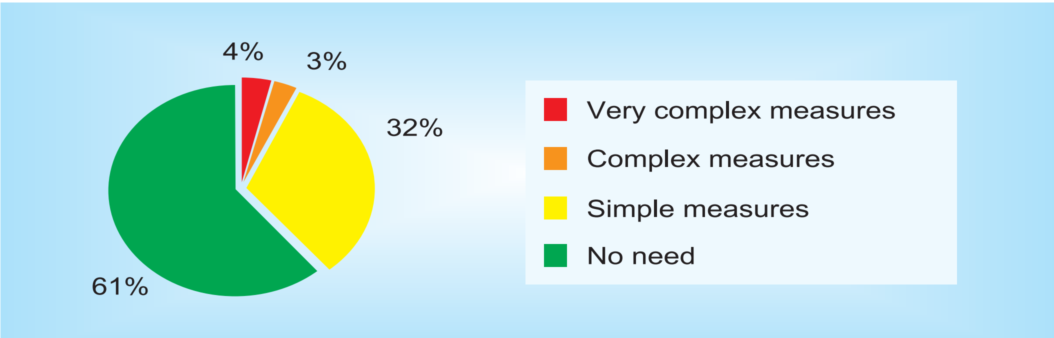

Figure 31. Results obtained for criteria 2.4.2. Habitat restoration. For the majority of the IAS it was considered that habitat restoration measures would not be necessary after control actions.

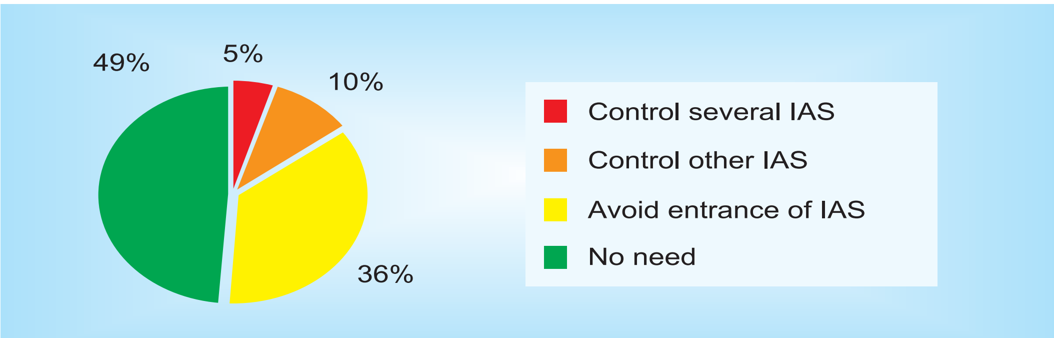

Figure 32. Results obtained for criteria 2.4.3. Interaction between IAS. For the majority of the IAS it was considered that there would be no need to control several IAS simultaneously.

Table 10. Summary of the conclusions derived from analysis of the previous figures, regarding the scores obtained by the species in the TOP 100 in Table II.

• The large majority of the IAS was introduced after the 19th century. • The large majority of the IAS will have to be controlled in more than one archipelago. • The large majority of the IAS was considered to be located in areas accessible to control actions.
• Most of the IAS were only considered as susceptible to local eradication or control. • It was considered that it will be difficult or impossible to control 42% of the IAS with the presently available human and technical resources. • The control of the large majority of the IAS was considered to demand medium to long duration projects.
• For almost all of the IAS possible control actions would only rely on general legislation for protected areas and biodiversity and not on specific legal mandates. • For almost all of the IAS possible control actions would be accepted by the public. Active support or opposition would not be frequent. • The control of the large majority of the IAS will demand specific projects requiring moderate to large financial investment.
• For the large majority of the IAS control actions were considered to cause only minor non-target impacts. • For the majority of the IAS it was considered that no restoration measures would be needed after control actions. • For the large majority of the IAS it was considered that it would not be needed to control other IAS, simultaneously.

The large majority of the **TOP 100** IAS was introduced after the 19th century. This means that human activities potentiated the occurrence of new introductions from that period onwards, due to an intensification of trade flows but also due to the development of a botanic garden network beginning in the 18th century that allowed an intense exchange of plant species between islands and mainlands.

As already mentioned the large majority of the **TOP 100** wil have to be controlled in more than one region, although experts considered that the majority of the IAS are located in areas accecible to control actions. However, due to the extension of the invasion, the majority of the IAS was only considered as susceptible to local control or eradication. Moreover, it was considered as difficult or impossible to control 42% of the IAS with the presently available human and technical resources, since the majority of the IAS will demand specific medium to long duration projects with a moderate to large investment. Another difficulty is the fact that control actions for the majority of the IAS would have to be supported only on general legislation devoted to nature reserves and biodiversity and not in specific legal mandates. This apparent lack of legislation might be related to the reduced importance attributed by environmental managers to the existence of regulations. However, law making is not the responsibility of managers, not even the top decisions. Thus, an apparent lack of specific legislation should be addressed in more detail by a group of intervenients with different roles, law makers, governing bodies, environmental managers, and experts in order to objectively evaluate if, in reality, there are legislative or regulamentary gaps that should be adequately filled.

Regarding acceptance of control actions by the society, this would be a reality for almost all the IAS, while active participation in control or active opposition to control would not be frequent. Meanwhile, these results are based on the general knowledge of experts about the situation, and not on data resulting from direct sampling of the different social groups. Thus, it would be important to develop at Macaronesian level a consultation of the general society towards its perception of the impacts caused by IAS and the acceptance of more restrictive measures in terms of the control of alien species importation.

Finally, it should be recognised that, according to the experts, and for the majority of the IAS, control actions were considered to have reduced impacts on native biodiversity, implying that in the majority of the cases complex restoration measures would not be needed, after the application of control actions. In fact, for instance Silva (2001), demonstrated the ability of controling *Clethra arborea* in São Miguel island, without causing significant impacts on the native flora. And the same was found during Project LIFE Priolo, regarding the control of several invasive plant species. Moreover, for the large majority of the IAS, it was considered that control of several species simultaneously would not be needed. However, for some major invasive species in the Azores, like *Gunnera tinctoria*, *Clethra arborea* and *Hedychium gardnerianum*, their simultaneous occurrence at some sites might demand such an effort.

Limitations of the scoring system

Some limitations were recognized during the application of the classification system. Namely, several species considered as IAS in the Azores were not included in the analysis because this book folows a global vision of Macaronesia and those species are considered as native in Madeira or in the Canaries. This fact is particularly relevant for the lilly of the valley tree (*Clethra arborea*) and for blackberry (*Rubus ulmifolius*) which are included in Regional Plan for Eradication and Control of Invasive Plants in Sensible Areas (PRECEFIAS). This limitation also occurs for somes species introduced in Madeira or in Canaries, due to the existence of different criteria in those archipelagos when deciding the origin of certain species, particularly in the case of plant taxa.

Moreover, this effect might also occur within an archipelago, that is, the endemic flora might act as an invasive agent if through unsafe ornamental purposes it is introduced in islands or locations that are not part of their original distribution, since in those cases hibridization phenomena might occur which would not naturaly happen (Ojeda 2007). As an example, only in Tenerife island there are 823 taxa which are island endemics (Martín Esquivel *et al*. 2005), many of which might act as invasives in the remaning islands of the Canary archipelago. In plants this negative effect is particularly noted with the transfer betwen islands of species with ornamental use from very diverse genera, like *Limonium* spp., *Cheirolophus* spp., and *Echium* spp., etc.

On the other hand, certain taxa considered as highly invasive in some of the archipelagos, namely the squirrel (*Atlantoxerus getulus*), a species of beetle (*Rhynchophorus ferrugineus*), or the date palm (*Phoenix dactylifera*) in the Canaries, were not selected to the Top 100 fundamentally due to the fact that their distribution is limited to one archipelago, and to other factors which led to lower scores as a consequence of the application of global criteria.

The above mentioned limitations imply the need of using, besides Macaronesian lists, lists regarding each of the archipelagos, where the different species are ranked according to the scores obtained on both tables, independently of the fact of whether the species is native in a part of Macaronesia.

It is also important to comment on some particular cases like those of the goat (*Capra hircus*) and of sheep (*Ovis aries*) in the Canaries. Since the arrival of pre-hispanic human settlers, cattle has been exerting a strong negative impact in the conservation of the endemic flora, which presently is reduced to the effect of individual animals or different sized groups at certain sites. Since this is related to domesticated and not to feral species, they are not included in the Canary Islands Biodiversity Data Bank and thus were not considered in the present analysis, not whithstanding their negative effects on native biodiversity at some locations.

Regarding some alien vertebrates in the Azores like the least weasel (*Mustela nivalis*) and the ferret (*Mustela furo*) there is an inverse situation, since they are considered as naturalized but the possible associated impacts to native biodiversity are unknown. On the other hand, the impacts associated with the action of rodents and rabbits on native biodiversity were not evaluated in a satisfactory way.

As for the invertebrates, although this group corresponds to an important part of the alien species, and they are frequently considered as pests in agriculture and in stored products, the present knowledge about their impact on native biodiversity didn't revealed considerable impacts. This situation might be altered in the future if more research is dedicated to this subject. As an example, in the Azores several agricultural pests (scale insects, trips) use endemic plant species as hosts, particularly at low altitude.

Guidelines for the future

Although with the above mentioned limitations, this system allows the identification of the majority of the most important IAS in Macaronesia. Since it is not possible to control all these species in one region, the use of hierarchic systems helps to define management priorities. The aplication of this method makes available a more objective criterium when selecting the more important species in each archipelago. Undoubtedly, this also facilitates the identification of gaps in knowledge about particular groups of IAS.

This method should be used in a dynamic way, thus it would be appropriate for the results and the lists of species to be revised every three years to include new introductions which might have been converted to biological invasions, but also to evaluate the possible effects derived from control or eradication actions meanwhile undertaken.

On the other hand, regarding methodology, and as a result of the experience gained during the development of this task, it should be mentioned that the IAS characterization sheets used in this book should be the first step of the risk analysis. In reality, their use at an early stage of the evaluation process will make scoring more easy and objective. We thus propose that the present sheets should be officially used to characterize the situation of IAS in Macaronesia. Furthermore, the present system of analysis should be complemented with the creation of an early detection system which might alert about new introductions, before they become problematic.

Considering the large portion of IAS common to the three archipelagos, and also the fact that they constitute one of the main threats to high priority species in conservation (Martín Esquivel *et al.* 2008) it would be pertinent to suggest the institution of a Macaronesian Observatory for Biological Invasions. This initiative would involve different entities working or related to this phenomenon, at local, archipelagic, and Macaronesian levels. The observatory would be responsible for integrating the information related to the occurrence of biological invasions in Macaronesia and would maintain a communications network between the archipelagos, quickly delivering the available information to the decision makers and to the general public.

Regarding biological invasions, there are some accepted truths. The number of new introductions has been growing exponentially. Besides that, from the moment when the establishment of an invasive species occurs onwards, the problem will tend to aggravate, if nothing is done. That is, the costs of a later action will always be larger than those associated with a good prevention strategy or a rapid response. Undoubtedly, biological invasions, presently, are directly dependent on economic activities, culture and the way our human society, as a whole, faces environmental management. Thus, the future role of alien species will largely depend on our collective decisions or indecisions, not only with regard to the sustainability of human activities but also regarding the preservation of global biodiversity.