Between-country collaboration and consideration of costs increase conservation planning efficiency in the Mediterranean Basin

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The importance of global and regional coordination in conservation is growing, although currently, the majority of conservation programs are applied at national and subnational scales. Nevertheless, multinational programs incur transaction costs and resources beyond what is required in national programs. Given the need to maximize returns on investment within limited conservation budgets, it is crucial to quantify how much more biodiversity can be protected by coordinating multinational conservation efforts when resources are fungible. Previous studies that compared different scales of conservation decision-making mostly ignored spatial variability in biodiversity threats and the cost of actions. Here, we developed a simple integrating metric, taking into account both the cost of conservation and threats to biodiversity. We examined the Mediterranean Basin biodiversity hotspot, which encompasses over 20 countries. We discovered that for vertebrates to achieve similar conservation benefits, one would need substantially more money and area if each country were to act independently as compared to fully coordinated action across the Basin. A fully coordinated conservation plan is expected to save approximately US$67 billion, 45% of total cost, compared with the uncoordinated plan; and if implemented over a 10-year period, the plan would cost ≈0.1% of the gross national income of all European Union (EU) countries annually. The initiative declared in the recent Paris Summit for the Mediterranean provides a political basis for such complex coordination. Surprisingly, because many conservation priority areas selected are located in EU countries, a partly coordinated solution incorporating only EU-Mediterranean countries is almost as efficient as the fully coordinated scenario.

biodiversity costs | complementarity | vertebrates

Currently, the majority of conservation programs are applied at national and subnational scales (1, 2), but global and regional coordination is becoming more common (3). Increasingly, both government and nongovernment organizations spend resources outside their country of origin, reflecting an internationalization of conservation efforts (1, 4). However, collaboration across countries can be costly, complicated, and often requires additional logistics and resources as compared to local programs. Therefore, given limited conservation budgets (5, 6), it is crucial to quantify how much more biodiversity can be protected by coordinating multinational conservation efforts than not. This quantification is especially crucial for parts of the world in which multiple countries belong to a single ecological biome and share many species.

While several studies have shown that spatial extent can affect conservation plans (7–10), little is known about the increased effectiveness of coordinated conservation plans across numerous countries. As far as we are aware, most of the previous studies have examined the effect over 2 countries at the most (7–10). Regional coordination can be especially important in places where a single biome is split between several geopolitical units that vary not only in their levels of biodiversity, but also in their conservation threats and the cost of conservation action. Hence, there is a need for efficient planning efforts that properly integrate at least 3 factors: biodiversity, its threats, and the cost of conservation actions (6, 11–13). Four of the 5 Mediterranean global biodiversity hotspots (14) consist of only 1 or 2 countries each (South Africa, Chile, United States-Mexico, and Australia). However, the Mediterranean Basin hotspot extends over 20 countries, with ≈250 million people and diverse socioeconomies, human history, cultures, and languages. This region has often been excluded from global conservation research, possibly because of its political and socioeconomic complexity.

The Mediterranean Basin has a long history of human land use (15) and any conservation plan or action must include people. The European Union (EU), which includes most countries along the northern rim of the Mediterranean Basin, forms an important political entity that currently coordinates various environmental decisions across countries. Recognizing the importance of the region for global conservation, the International Union for Conservation of Nature (IUCN) has recently begun generating distribution databases for several vertebrate groups for the entire Mediterranean Basin (16, 17) [supporting information (SI) Table S1]. Surprisingly, this region has one of the lowest levels of protection of the 5 Mediterranean regions of the world [i.e., the smallest area designated for biodiversity protection based on IUCN categories I–IV (18)]. Land conversion in the Mediterranean Basin exceeds protection by a factor of 22 (18). While the region is best known for its high plant endemism, it also holds large numbers of endemic vertebrates, many of which are currently threatened (16, 17). For example, of the 199 freshwater fish species endemic to the Mediterranean Basin, 69% are threatened or have already gone extinct (see Table S1).

Many spatial conservation prioritization techniques seek to meet predefined conservation objectives for the minimum total "cost," whereas traditionally the cost of a site for conservation is simply proportional to its area. Increasingly, researchers have recognized that an objective that minimizes a combination of real economic costs, and also less quantifiable social costs, is more appropriate than minimizing area or simple acquisition costs (5, 13, 19). We developed a metric for the relative cost of an area that is a combination of the cost of conservation action in different countries and human population density. We term this the "biodiversity-human impact metric" (BHM). The BHM is the multiplication of human population density (used as a surrogate of threat to biodiversity) with acquisition cost (used as a surrogate for biodiversity conservation cost) divided by the average population density over the entire Mediterranean Basin, so the units of the metric remain

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Table 1. Conservation costs using 90% selection frequency

Scenario	Spain	France	Greece	Morocco
Fully coordinated	100%($42.7)	100%($2.2)	100%($6.8)	100%($0.16)
Partly coordinated	104%	109%	113%	100%
Uncoordinated	114%	307%	118%	335%

The total calculated cost of conservation using the 90% selection frequency relative to the fully coordinated scenario for Spain, France, Greece, and Morocco when the planning is done following the fully coordinated scenario (whole Mediterranean Basin), partly coordinated scenario (only within EU or non-EU countries), and the uncoordinated scenario (single country). The value in parentheses in the first row gives the cost in billions of US$ under the fully coordinated scenario.

in cost (US$). Using this metric and the spatial prioritization algorithm Marxan (20), we found the highest priority places for achieving conservation objectives for the reptiles, amphibians, and freshwater fish of the region. We repeated this for vegetation (land cover) categories because, currently, as far as we are aware, no spatially explicit database for plant species is available across the whole region.

Results and Discussion

We discovered that planning for conservation in the Mediterranean Basin as a single integrated entity delivers a significantly more efficient conservation outcome than scenarios for separate plans for each country (Tables S2 and S3) . Fully coordinated whole Basin planning is also more efficient than partly coordinated planning, where EU and non-EU countries plan separately, although surprisingly, the difference is relatively small (Table 1, and see Tables S2 and S3). The number of high-priority planning units that are needed to meet the biodiversity targets (for all 3 taxa combined) increases from 1,566 in the fully coordinated scenario, to 1,808 in the partly coordinated scenario (an increase of 15%), to 2,887 in the uncoordinated scenario (an increase of 84%) (Fig. 1). In terms of our cost metric, the differences between the fully and partly coordinated scenarios are smaller (5%). When conservation planning is applied at the more traditional national level, the inefficiencies become much greater (see Tables S2 and S3). The coordinated plan, if fully implemented with the conservation targets used here, will cost US$148 billion, while the cost of a noncollaborative plan at US$215 billion, will be US$67 billion (45%) higher. The implementation of the coordinated plan over a 10-year period (for example) will require ≈0.1% of the gross national income (GNI) of all European Union countries each year (over the 10 years), or ≈0.19% of that of all Mediterranean Basin countries. These results are based on economic data currently available for the whole region and on the targets that we set. Thus, the absolute cost values should be treated as approximations.

Compared with the uncoordinated plan, the savings in the conservation cost of the planning units selected in 90% of the Marxan runs in the fully coordinated scenario are 14% (US$5.96 billion) for Spain, 207% (US$4.5 billion) for France, 18% (US$1.26 billion) for Greece, and 235% (US$387 million) for Morocco (see Table 1, and Tables S2 and S3). These differences increase when selection frequencies greater than 50% are assumed to be high-priority areas for conservation, as can be seen for Spain (Fig. 2). This finding is consistent when the analysis is repeated for each taxon separately. In all cases, to achieve the same target one would need more money and a larger area if a single country acts alone compared with coordinated action across the region.

The location of the conservation priority areas differed between the 3 vertebrate taxa examined (Fig. 3). However, in all 3 cases, the majority (approximately 70%) of priority areas (hotspots) selected were in the EU, although the EU comprises only 45% of the total area of the Mediterranean Basin (Table S4). Results were similar when using vegetation (land cover) classification as the conservation target (see Fig. 3*D*). In general, the priority areas selected (for vertebrates) in the fully coordinated whole Mediterranean Basin scenario were concentrated in Europe (see Table S4, and locations in Figs. 3 and 4). Parts of the Levant (the eastern Mediterranean Basin) were priority areas for freshwater fish (see Fig. 3*A*, Table S5). Few conservation priority areas were selected in North Africa for at least 2 reasons: (*i*) lower species richness in North Africa (for freshwater fish and amphibians), as a consequence of drier habitats and lower primary productivity there, which we estimated using the Normalized Difference Vegetation Index (NDVI) (see *SI Text*, Fig. S1, and Tables S6 and S7,), and (*ii*) North African endemics (especially reptiles, which hold 58% of the species of all 3 taxa that are restricted to North Africa) are relatively widespread where conservation costs are lower, which leads to fewer high-priority areas in the region (see Fig. 4 and Table S8). This result may be partly related to less biodiversity data in some of this region (16, 17). The first step of the coordinated plan could be to refine this database. The Euro-Mediterranean Partnership could serve as a useful platform for further sampling, especially in North Africa. However, given the immediate threats to many of the species (16, 17) and an existing database that is reasonably comprehensive, any delay in conservation action in favor of further data collection should be short (21).

We found that the new BHM achieves an efficient compromise between minimizing acquisition costs and major threats to biodiversity while meeting biodiversity targets. The best Marxan solution for the fully coordinated scenario (Fig. S2*a*) using the BHM metric was 53% less expensive than when acquisition cost alone was

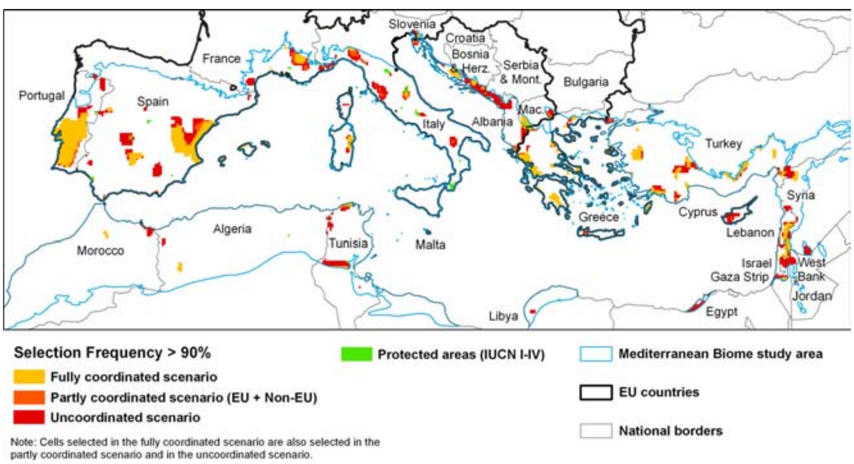

Fig. 1. Conservation priority areas in the Mediterranean Basin (selection frequency >90%) under the fully coordinated scenario (whole Mediterranean Basin), the partly coordinated scenario (EU and non-EU), and the uncoordinated scenario (individual countries), using the new cost metric, BHM.

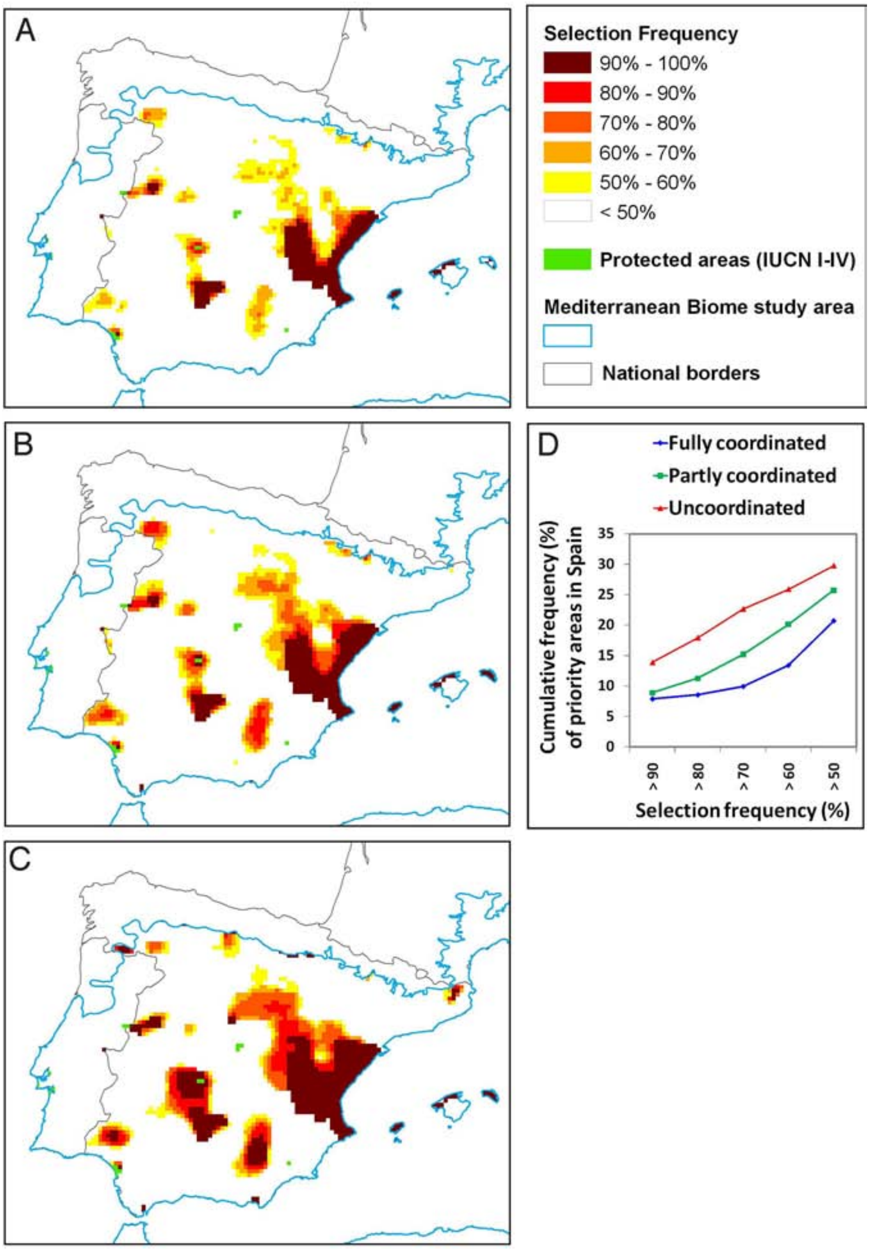

Fig. 2. Conservation priority areas based on selection frequency of planning units (summed solutions within Marxan runs) in Spain for amphibians, reptiles, and freshwater fish under 3 coordination scenarios when the spatial extent considered is: (*A*) the entire Mediterranean Basin (fully coordinated), (*B*) the European Union (partly coordinated), (*C*) Spain (uncoordinated), and (*D*) the cumulative frequency of priority areas (planning units) at varying selection frequencies in Spain under the different coordination scenarios.

included, and 64% less than when only area was included (results in Table S9). The location and extent of the highest priority areas did not change much when we assumed that high-priority planning units are those that are selected in 90% or more of the near-optimal solutions. However, the differences between the metrics became apparent as this selection threshold was lowered. The BHM incorporates population-density data, which is globally available at high spatial resolutions of 1 km and can be examined over time. As better data on cost at a more detailed resolution becomes available, this can be incorporated into the metric and reanalyzed. Because management is a more realistic conservation action in parts of the Mediterranean Basin (compared with acquisition), we propose that to better prioritize conservation actions, further data on biodiversity management costs should be collected across the region. This collection can be done as part of the Euro-Mediterranean partnership.

Here, as our goal was to compare the different coordination scenarios rather than to provide a detailed conservation work plan, we did not place limits on the budgetary outlay. In our analyses it is the relative, not the absolute, economic costs that determine conservation priorities. If the goal, however, is to build an applied conservation plan for biodiversity hotspots in the region—or parts of it—within a specific limited budget framework, one would need to collect more detailed economic data of management and acquisition costs and take into account discounting, market fluctuations, and other political and economic factors. Including such factors, however, is not expected to largely affect the uncoordinated finding that the coordinated plan is more efficient than the noncoordinated one.

While we have shown that international conservation planning is theoretically more efficient, coordination has disadvantages that need to be traded-off against this increased efficiency. These disadvantages include socioeconomic, political, and biological factors. From the socioeconomic and political perspective, many of the practical decisions on feasibility and cost-effectiveness of conservation projects and their application are eventually made at the within-country scale by local agencies, institutions, and people (22). Some of the factors that make the coordinated planning efficient may be disadvantageous for conservation. Because less area is

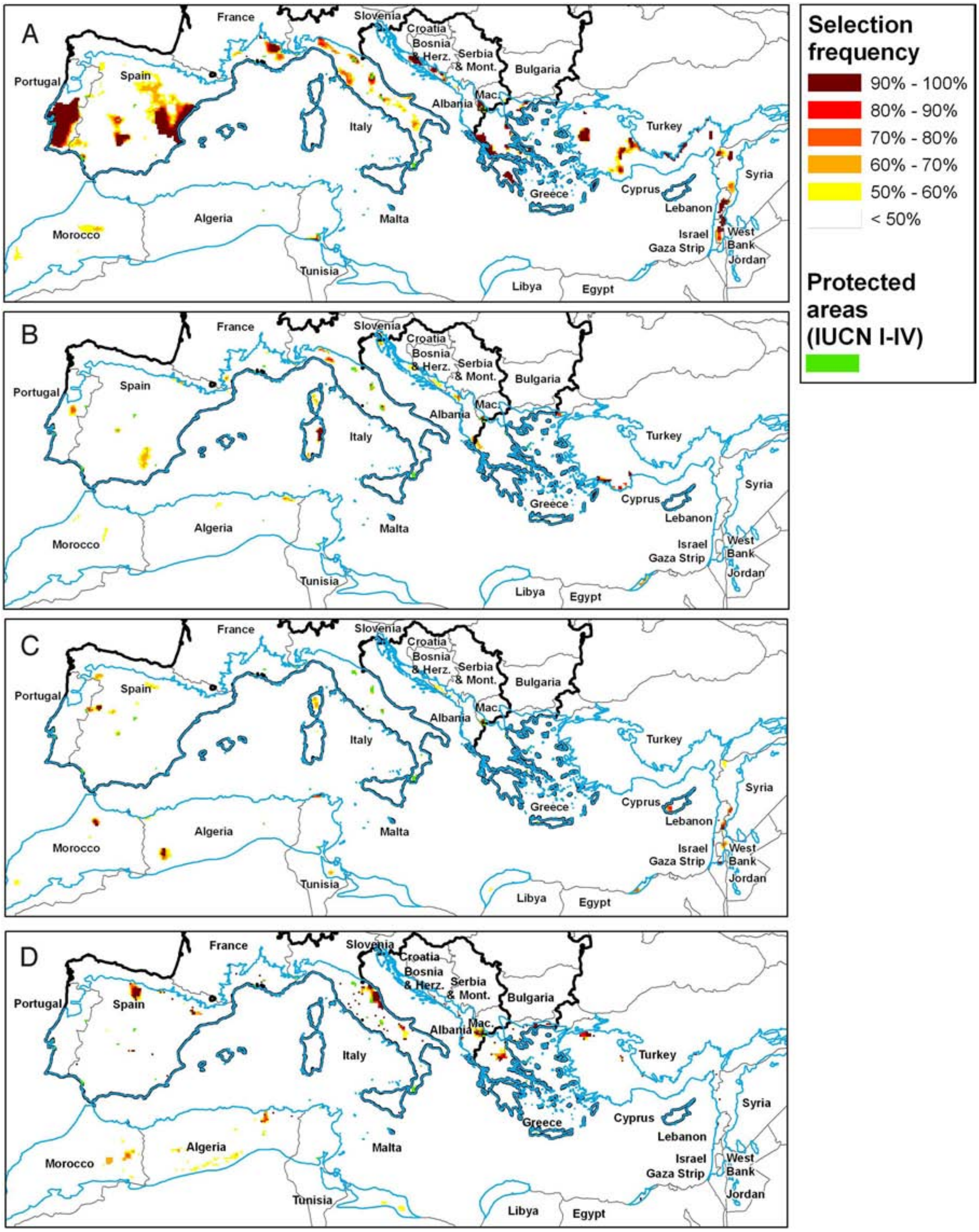

Fig. 3. Conservation priority areas (of high-selection frequency) in the Mediterranean Basin under the fully coordinated scenario based on the new cost metric (BHM) for (*A*) freshwater fish, (*B*) amphibians, (*C*) reptiles, and (*D*) vegetation classes (categories).

required per country to reach the same conservation targets for a given cost, the coordinated strategy, if misinterpreted, may actually encourage countries to spend less conservation dollars locally or to devote less area for conservation. Local involvement is crucial to the success of conservation programs (4, 23). Large-scale, top-down, and centralized decisions generate, in some cases, antagonism and apathy in local groups and individuals (4). For example, people may not be comforted by the fact that an interesting threatened species is going to be conserved in another country (24). In essence, most nations give higher priority to retaining their local repertoire of species for multiple reasons, such as national pride, parochialism, and ethical responsibility (24). Factors other than biodiversity, such as ecosystem services, often determine which areas are eventually given conservation priority. Regional coordinated plans require explicitly stating the reasons underlying protection of certain areas, which is often not trivial and may lead to delays in conservation

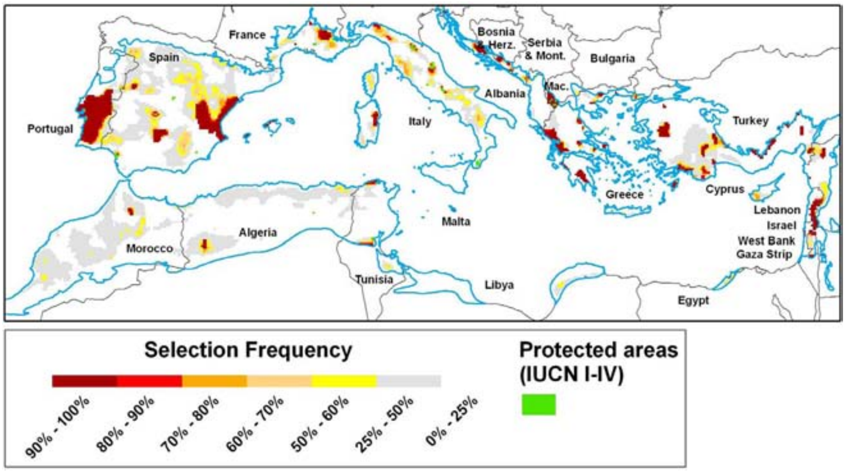

Fig. 4. Conservation priority areas based on selection frequency in the whole Mediterranean Basin (fully coordinated scenario) for all taxa combined, using the BHM.

actions. Large-scale plans and actions are often clumsy, costly, and involve substantial politics (22). International plans and treaties take time and resources and have additional transaction costs related to large-scale planning and communication that are difficult to quantify and incorporate into conservation planning. This difficulty may be especially emphasized in the Mediterranean Basin, with its many diverse languages, cultures, religions, political agendas, governance, and institutions (25).

From a biological perspective, separate rather than coordinated decision making can actually be useful in some cases. For example, given uncertainty about the importance of biodiversity conservation in many countries in the future, spreading the "political" risk for a species across different countries may be an objective in itself. Furthermore, large-scale conservation actions may miss out on some locally important populations [e.g., with unique genetic diversity (7)] and tend to give higher priority to the species level (such as to threatened species). However, if done well, a coordinated plan can take genetic variation and political risk spreading explicitly into account (e.g., by setting targets for each genetically distinct population or populations across sociopolitical boundaries). Coordination can also enable sharing of different views, agendas, and learning from one another, especially if local knowledge is shared and used wisely and fairly (4). Given that most of the species in this study are endemic to the Mediterranean Basin (all fish and reptiles and 64% of the amphibians), such coordination may be crucial in enabling their persistence over time.

We suggest that a strategy that brings together the advantages of coordinated conservation planning across the whole region, with the advantages resulting from local planning, involvement, and leadership, may be useful, cost efficient, and successful. In the case of the Mediterranean Basin, for the taxa studied, because a high portion of the conservation priority areas were located in the EU, the partial coordination option may currently be a useful and practical conservation compromise. This results from the fact that the EU already has much of the institutional and legislation basis that enables coordination more easily among countries within the EU, compared with other parts of the Basin. Coordination of biodiversity conservation efforts across the whole region could provide an excellent key initiative for the new directions in the Euro-Mediterranean Partnership launched in July 2008 in the Paris Summit by Heads of State from the whole Basin, aimed at bringing the Mediterranean countries closer politically, economically, and culturally.

Given that the Mediterranean is well known for its diversity of endemic plants, it would be useful to repeat our analyses for plants, in addition to vertebrates. There have been various initiatives aimed at generating a large-scale and much needed plant-species distribution database, but because most of the data are localized, this requires large-scale coordinated regional collaboration. We propose that one of the first initiatives of the Euro-Mediterranean Partnership established should be to establish such a database for plants and other taxa.

Materials and Methods

Spatial Extent. Our study area included ecoregions within the Mediterranean Basin that belong to the Mediterranean biome as defined by the World Wildlife Fund (26) (see Fig. 1). We used distribution range data compiled by the IUCN for 106 amphibian species, 162 reptile species endemic to the Mediterranean countries, and 251 endemic freshwater fish species (16, 17) (see Table S1). In addition, we used a classification of 13 land-cover categories generated at a spatial resolution of 1 km, using satellite imagery (27), and analyzed its results separately. We projected all data into the Albers Equal Area Projection at a spatial resolution of 10×10 km, forming 24,171 grid cells (planning units). This resolution was chosen as a compromise between the relatively detailed resolution of the population-density data and the less detailed resolution of the cost data and some of the biodiversity data. However, it provides a useful baseline at a detailed enough resolution to serve in conservation plans, and the results can be easily adjusted as more detailed and more accurate data become available on species ranges and local conservation costs.

We compared the conservation planning scenarios at 3 spatial extents, ranging from the entire Mediterranean Basin to individual countries: (*i*) across the whole Mediterranean Basin region (i.e., fully coordinated); (*ii*) across subregions within the Basin based on different political extents (i.e., partly coordinated), which included only EU Mediterranean countries (France, Spain, Italy, Greece, Bulgaria, Portugal, Slovakia, Slovenia, Cyprus, and Malta), only non-EU Mediterranean countries, and only North African Mediterranean countries (including Western Sahara, Morocco, Algeria, Tunisia, Libya and Egypt); and (*iii*) separately for each country in the Mediterranean Basin (i.e., uncoordinated).

Cost Metrics. We applied the software Marxan to examine and compare different scenarios of conservation planning (20). Marxan is a decision support tool for conservation planning (2), which finds relatively efficient solutions to the problem of selecting a system of spatially cohesive areas that meet a suite of biodiversity targets (20). Because the complete data on the constraints of all conservation actions is unavailable for this region, and because the database is large, it is unrealistic to search for a single optimal solution here. Marxan provides flexibility in where actions can occur and is therefore a decision support tool rather than a single answer (20). Using a simulated annealing algorithm (20), a widely used industry standard optimization method, Marxan provides a range of good (near-optimal) solutions rather than a single solution (the latter could be quite incorrect when data are incomplete). As each Marxan run provides a slightly different solution, we used the metric "selection frequency" to compare scenarios. Selection frequency is the number of times each planning unit is selected in good solutions to the overall problem (28, 29). Planning units that are selected above a certain threshold-percentage of runs are considered as high-priority conservation areas. For each of the coordination scenarios, we examined the number and the cost of the planning units that were selected in at least 90% of the Marxan runs (representing high-conservation priority areas). For the fully coordinated scenario (whole Mediterranean Basin) we compared 4 metrics for cost:

(1) AREA: aiming to minimize the total area selected by the Marxan runs.

(2) DENSITY: This was taken as the population density in 2005 based on the Gridded Population of the World database (http://sedac.ciesin.org/gpw/), which is available at a spatial resolution of 2.5′ (≈5 km). We chose to use population density rather than other proxies, such as the human footprint (30) or night lights (31, 32), because density is not as strongly correlated with the gross domestic product as the latter. Population density is an important driver of many threats to biodiversity and is one of the only variables currently available for the whole Basin at the within-country spatial scale. As data on other threats becomes available, they can be incorporated into the new metric.

(3) ACQUISITION: To estimate the cost of purchasing land in each country we used a modified (13) version of Balmford et al. (19). Following this approach, the recurrent cost of annual management in US$ per square kilometer was:

$$\log(\text{Cost US\$}) = 1.61 + 0.57 \times \log(\text{GNI US\$ km}^{-2}) - 0.7 \times \log(\text{PPP}) - 0.46 \log(\text{Area, km}^2).$$

The GNI was compiled from the International Monetary Fund's International Financial Statistics (2004) and Purchasing Power Parity (PPP; the local buying power of a United States dollar in 2004 divided by the exchange rate) (13) and gross domestic product deflators were acquired from the World Bank (http://devdata.worldbank.org/wdi2006/contents/Section4.htm). Balmford et al. (19) suggested that land purchase costs are reasonably closely related to recurrent annual management costs at this scale of analysis. For 19 countries examined, the ratio between the national mean land purchase cost per square kilometer and the annual recurrent management costs was 50.6 (±13.5) (19). Following Wilson et al. (13), we used this ratio to estimate the cost of land purchase in each country based on the management costs. PPP data to calculate Balmford's cost metric was unavailable for the Gaza Strip, Gibraltar, Iraq, Malta, Monaco, San Marino, Serbia and Montenegro, Vatican City, the West Bank, and Western Sahara. In these cases we used data from countries that are in close geographic proximity and have similar sociopolitical attributes. As more accurate and higher resolution management cost data become available, this can easily be added to the analysis and converted to acquisition costs, if required.

(4) The biodiversity-human impact metric: A new metric we developed for this work, which combines population density (*DENSITY*) and Balmford's (19) acquisition cost (*ACQUISITION*). The BHM was calculated as follows:

$$BHM = \frac{DENSITY \times ACQUISITION}{DENSITY_{\text{MedBasin}}}$$

where $DENSITY_{\text{MedBasin}}$ is the average population density over the entire Mediterranean Basin in 2005 (127 people/km^2). The BHM was also applied in the subregional analyses. This metric combines the monetary costs of acquisition (metric 3, ACQUISITION) with population density (metric 2, DENSITY). The spatial distribution of BHM is shown in Fig. S2. Because data on the actual costs of conservation actions is currently unavailable for the whole region (or for most parts of it), we use this index as a surrogate for cost. Some actions, and especially off-reserve initiatives that are not based on acquisition, which are important components in this region, are very difficult to estimate and only little data exists for them.

Conservation Targets. We set quantitative conservation targets for each species for the Marxan runs, incorporating both its current range size (33, 34) in the Mediterranean Basin and the level of global threat to the species based on its IUCN 2006 Red List category (35). For species that were defined by the IUCN as critically endangered or had a total distribution of less than 1,000 km^2 in the study region, we applied a target of the entire (100%) present-day distribution range (34). For species that are vulnerable or endangered based on the IUCN (Red List) (35) or had a distribution of less than 10,000 km^2 in the study region, we applied a target of the larger value among these 2 options: 30% of the distribution or 1,000 km^2. For any other species with a range greater than 10,000 km^2 in the study region, we applied a conservation target of 10% of its distribution. While using both percentages and range size has its disadvantages, we chose it as a compromise, following ref. 34, because using only percentages would lead to selection of very small ranges for rare species that could have important consequences in our database, which consists mainly of species endemic to the region. Because our goal was to examine the importance of coordination across the region, we did not impose a per country coverage area for each species. This could easily be done by each country, if within-country conservation is the target.

Marxan Runs. We classified each planning unit as protected if over 50% of if its extent contained a protected area (defined as IUCN category I–IV) based on the World Database of Protected Areas (http://www.unep-wcmc.org/wdpa/). Each Marxan run had 10^6 iterations, and we repeated the runs for each scenario 1,000 times to find the summed solution. Using the technique developed by Stewart and Possingham (36), we chose to use a boundary length modifier value of 100 for ACQUISITION and BHM, which was found to increase the compactness of the solutions (i.e., decrease the total boundary length of the selected planning units) with only a small increment of cost. Because DENSITY and AREA are not in US$ units, following the same principle, we selected boundary length modifier values of 0.01 and 5,000 for these metrics, respectively.

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Supporting Information

Kark et al. 10.1073/pnas.0901001106

SI Text

To investigate whether the low number of priority areas selected in North Africa is a result of low sampling effort, we analyzed the relationships between area, the normalized difference vegetation index used as a surrogate for primary productivity (1, 2) and species richness per country using Pearson's r and a multiple regression. This was done for each vertebrate taxon separately and for the 3 taxa combined. A multiple regression analysis showed that 75% of the total variation in species richness is explained by area and NDVI alone ($P < 0.001$). Species richness at the country level was positively correlated with area in all cases (Table S7). The strongest correlation between area and richness was found for reptiles ($r = 0.90$) (see Table S7). Species richness was positively correlated with NDVI for all taxa combined (see Table S7); this correlation was strongest in amphibians ($r = 0.64$). The observed species richness in North African countries was lower than expected based on area alone when examined for all 3 taxa combined (Fig. S1*a*). We calculated the residuals from the regression between area and country-based species richness. These residuals were used as the dependent variable in a regression, with the mean NDVI for the years 1981–2000 used as the independent variable. The residuals were positively and significantly correlated with the NDVI (see Tables S6 and S7 and Fig. S1*b*). Thus, the lower species richness found in North Africa is related to the lower primary productivity there. Amphibian and freshwater fish richness in North Africa was lower than expected based on area. However, reptile richness was not lower than expected in North Africa, based on area alone. This is likely explained by the habitat requirements of amphibians and freshwater fish, as compared with those of reptiles, namely the association of the prior with water sources (3, 4).

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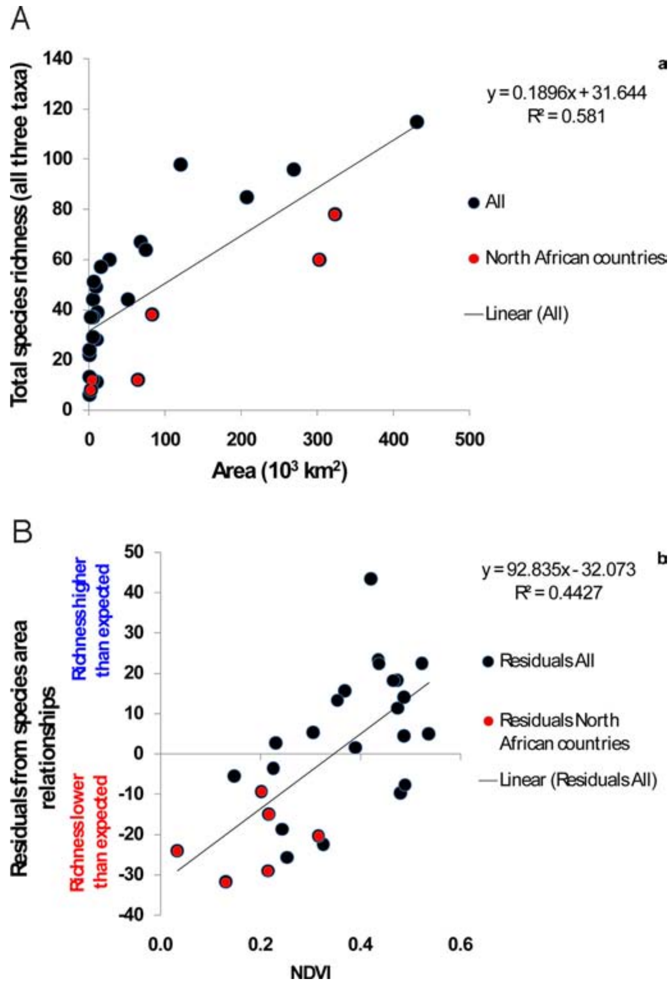

Fig. S1. (*a*) The relationship between area and species richness for all taxa combined at the country level. North African countries are marked with red circles. (*b*) The relationship between NDVI and the residuals from a regression between species richness at the country level and area. North African countries are marked with red circles.

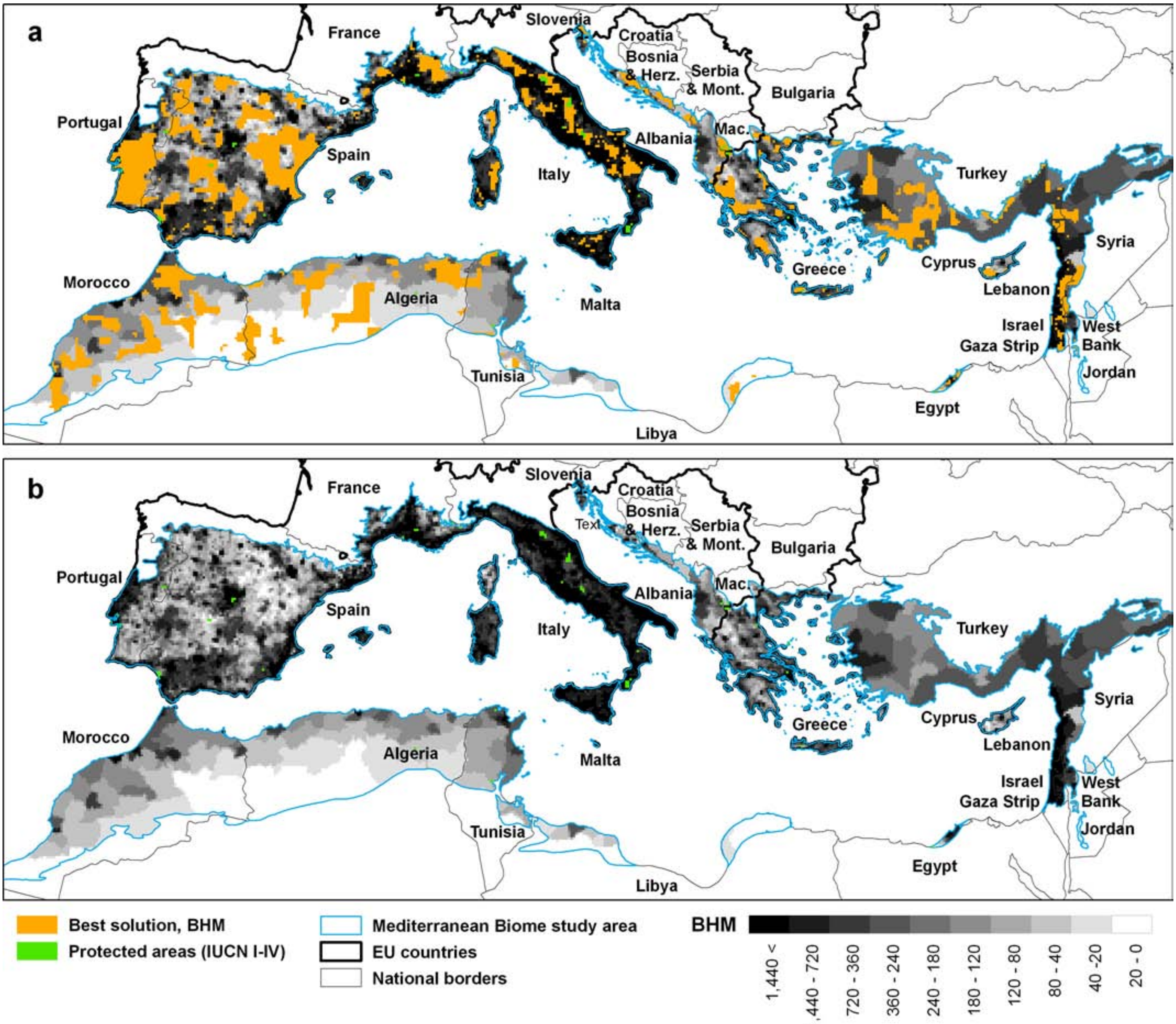

Fig. S2. (*a*) The best Marxan solution achieved for all taxa combined under the fully coordinated scenario (the whole Mediterranean Basin) using the BHM cost metric. Costs are per square kilometer. (*b*) The spatial distribution of the BHM.

Table S1. The number (and percentage) of amphibian, reptile and freshwater fish species belonging to each of the IUCN red-list categories in the Mediterranean Basin

IUCN category	Amphibians	Reptiles	Freshwater fish
Extinct	1 (1%)	2 (1%)	8 (4%)
Threatened	25 (26%)	35 (23%)	130 (65%)
Near threatened	16 (17%)	23 (15%)	9 (5%)
Least concern	54 (56%)	89 (60%)	52 (26%)
Total	96 (100%)	149 (100%)	199 (100%)

The species defined by IUCN as data deficient are not included in this table.

Table S2. Cost in millions of US$ of conservation priority areas (cells) chosen in at least 90% of the 1,000 Marxan runs under different coordination scenarios for the whole Mediterranean Basin and several single-country cases

Row	Spatial extent scenario	All taxa	Amphibians	Freshwater fish	Reptiles
1	To be protected in MedBasin (fully coordinated)	148,244	10,449	110,593	50,795
2	To be protected in MedBasin (partly coordinated)	155,519	13,878	115,665	54,037
3	Increase in US$ (row 2–row 1)	7,274	3,429	5,072	3,242
4	Percent increase (row 3 / row 1) × 100	5%	33%	5%	6%
5					
6	To be protected in Spain (fully coordinated)	42,699	5,220	35,962	10,109
7	To be protected in Spain (partly coordinated)	44,319	6,574	36,447	11,380
8	To be protected in Spain (uncoordinated)	48,655	7,284	38,664	13,122
9	Increase in US$ (row 8–row 6)	5,957	2,064	2,702	3,014
10	Percent increase (row 9 / row 6) × 100	14%	40%	8%	30%
11					
12	To be protected in France (fully coordinated)	2,194	370	2,181	370
13	To be protected in France (partly coordinated)	2,396	370	2,364	370
14	To be protected in France (uncoordinated)	6,733	2,324	6,223	619
15	Increase in US$ (row 14–row 12)	4,540	1,954	4,041	249
16	Percent increase (row 15 / row 12) × 100	207%	529%	185%	67%
17					
18	To be protected in Greece (fully coordinated)	6,836	688	6,660	602
19	To be protected in Greece (partly coordinated)	7,743	750	7,178	1,017
20	To be protected in Greece (uncoordinated)	8,098	1,247	7,428	1,066
21	Increase in US$ (row 20–row 18)	1,262	559	768	464
22	Percent increase (row 21 / row 18) × 100	18%	81%	12%	77%
23					
24	To be protected in Morocco (fully coordinated)	165	3	3	165
25	To be protected in Morocco (partly coordinated: Non-EU)	165	3	3	182
26	To be protected in Morocco (partly coordinated: North Africa)	165	3	3	182
27	To be protected in Morocco (uncoordinated)	552	54	123	516
28	Increase in US$ (row 27–row 24)	387	51	119	352
29	Percent increase (row 28 / row 24) × 100	235%	1522%	3581%	213%

The "All taxa" column represents the outcome when combining in the runs all 3 vertebrate taxa (amphibians, freshwater fish, and reptiles). The following 3 columns (for each taxon) do not sum to the "All taxa" column because some of the planning units are chosen for more than a single taxon.

Table S3. The number of planning units (cells) chosen in at least 90% of the 1,000 Marxan runs under different spatial extent scenarios for the whole Mediterranean Basin and several single-country cases

Row	Spatial extent scenario	All taxa	Amphibians	Freshwater fish	Reptiles
1	To be protected in MedBasin (fully coordinated)	1,566	192	1,286	304
2	To be protected in MedBasin (partly coordinated)	1,808	252	1,493	352
3	Increase in planning units (row 2–row 1)	242	60	207	48
4	Percent increase (row 3 / row 1) × 100	15%	31%	16%	16%
5					
6	To be protected in Spain (fully coordinated)	363	26	294	77
7	To be protected in Spain (partly coordinated)	411	37	344	92
8	To be protected in Spain (uncoordinated)	641	80	572	115
9	Increase in planning units (row 8–row 6)	278	54	278	38
10	Percent increase (row 9 / row 6) × 100	77%	208%	95%	49%
11					
12	To be protected in France (fully coordinated)	42	11	41	11
13	To be protected in France (partly coordinated)	61	11	60	11
14	To be protected in France (uncoordinated)	138	63	126	25
15	Increase in planning units (row 14–row 12)	96	52	85	14
16	Percent increase (row 15 / row 12) × 100	229%	473%	207%	127%
17					
18	To be protected in Greece (fully coordinated)	219	38	189	36
19	To be protected in Greece (partly coordinated)	261	41	216	54
20	To be protected in Greece (uncoordinated)	279	72	227	56
21	Increase in planning units (row 20–row 18)	60	34	38	20
22	Percent increase (row 21 / row 18) × 100	27%	89%	20%	56%
23					
24	To be protected in Morocco (fully coordinated)	9	1	1	9
25	To be protected in Morocco (partly coordinated: Non-EU)	9	1	1	10
26	To be protected in Morocco (partly coordinated: North Africa)	9	1	1	10
27	To be protected in Morocco (uncoordinated)	31	3	9	29
28	Increase in planning units (row 27–row 24)	22	2	8	20
29	Percent increase (row 28 / row 24) × 100	244%	200%	800%	222%

The last 3 columns (for each taxon) do not sum up to the "All taxa" column sum because some of the planning units are chosen for more than a single taxon.

Table S4. Regional distribution of conservation priority areas in the Mediterranean Basin using each of the 4 cost metrics and total number of cells in each of the subregions (i.e., subregion size)

		Total # of planning units	% in rows			
Taxon	Cost metric	Entire Med. Basin	European Union	Levant	North Africa	Non-EU countries in eastern Europe
All taxa	AREA	1,433	69%	21%	4%	6%
	DENSITY	1,802	70%	20%	4%	6%
	ACQUISITION	1,490	68%	21%	4%	7%
	BHM	1,566	69%	20%	4%	7%
Amphibians	BHM	192	73%	13%	4%	9%
Freshwater fish	BHM	1,286	72%	20%	2%	6%
Reptiles	BHM	304	66%	12%	13%	9%
Vegetation categories	BHM	408	70%	15%	5%	10%
	Total number of cells	24,171	45%	17%	35%	3%

Four cost metrics: AREA (area of planning units), DENSITY (population density, 2005), AQCUISITION (acquisition cost), BHM (the combined metric of populations density and acquisition cost). Selection frequency threshold was 90%. Total for each row is 100%. The Levant includes Turkey, Lebanon, Syria, Israel, Jordan, the West Bank ,and Gaza Strip.

Table S5. Country-based species richness in the Mediterranean Basin (only including species distributed in the area falling within the Mediterranean biome of the country)

	Freshwater fish		Amphibians		Reptiles		All taxa	
	Richness	Endemic species richness	Richness	Endemic species richness	Richness	Endemic species richness	Richness	Endemic species richness
Albania	32	0	17	0	11	0	60	0
Algeria	14	1	9	1	37	3	60	5
Bosnia and Herzegovina	20	1	13	0	11	0	44	1
Bulgaria	3	0	12	0	7	0	22	0
Croatia	26	3	16	0	15	0	57	3
Cyprus	2	0	3	0	6	1	11	1
Egypt	1	0	5	3	6	0	12	3
France	18	3	31	4	18	0	67	7
Gaza Strip	3	0	4	0	6	0	13	0
Greece	55	29	22	3	21	7	98	39
Israel	22	9	6	0	21	0	49	9
Italy	23	9	37	11	25	2	85	22
Jordan	11	1	5	0	13	1	29	2
Lebanon	15	0	7	0	17	0	39	0
Libya	1	0	2	0	9	0	12	0
Macedonia	28	0	15	0	8	0	51	0
Malta	0	0	2	0	4	0	6	0
Morocco	21	11	11	3	46	18	78	32
Portugal	22	2	19	0	23	1	64	3
San Marino	8	0	9	0	7	0	24	0
Serbia and Montenegro	11	0	15	0	11	0	37	0
Slovenia	9	0	17	0	11	0	37	0
Spain	32	11	35	4	48	20	115	35
Syria	20	3	8	0	16	0	44	3
Tunisia	6	1	7	0	27	2	40	3
Turkey	52	35	23	7	21	0	96	42
West Bank	10	0	5	0	14	0	29	0
Western Sahara	0	0	3	0	5	0	8	0
Total		119		36		55		210

Endemic richness refers to endemism in a single country among all Mediterranean Basin countries.

Table S6. Mean NDVI between 1981 and 2000, area at the country level, and residuals from a regression between area and richness (the difference between the observed and the expected species richness based on area as the independent variable)

Country	Mean NDVI	Area (km^2)	Residuals amphibians	Residuals freshwater fish	Residuals reptiles	Residuals all taxa
Albania	0.436	26,146	6.4	18.2	−1.2	23.4
Algeria	0.215	302,725	−13.9	−15.7	0.6	−29.0
Bosnia and Herzegovina	0.475	4,919	3.3	7.4	0.7	11.4
Bulgaria	0.480	228	2.5	−9.3	−2.9	−9.7
Croatia	0.437	15,373	5.9	12.8	3.8	22.4
Cyprus	0.326	9,272	−6.9	−10.8	−4.7	−22.4
Egypt	0.316	3,663	−4.6	−11.5	−4.2	−20.3
France	0.523	67,558	18.5	1.8	2.2	22.6
Gaza Strip	0.243	221	−5.5	−9.3	−3.9	−18.7
Greece	0.421	120,169	7.2	35.8	0.6	43.6
Israel	0.369	8,917	−3.9	9.2	10.3	15.7
Italy	0.487	206,808	18.4	−1.2	−3.0	14.2
Jordan	0.148	9,712	−4.9	−1.9	1.3	−5.5
Lebanon	0.305	10,308	−2.9	2.1	6.2	5.4
Libya	0.131	63,906	−10.3	−15.0	−6.5	−31.8
Macedonia	0.474	5,507	5.3	15.4	−2.4	18.3
Malta	0.254	351	−7.5	−12.3	−5.9	−25.7
Morocco	0.217	323,134	−12.8	−9.9	7.8	−14.9
Portugal	0.466	74,248	6.2	5.4	6.6	18.3
San Marino	0.489	100	−0.5	−4.3	−2.9	−7.7
Serbia and Montenegro	0.487	4,467	5.3	−1.5	0.7	4.5
Slovenia	0.537	1,536	7.5	−3.4	1.0	5.1
Spain	0.390	431,158	6.4	−5.1	0.3	1.6
Syria	0.231	50,690	−3.7	4.8	1.7	2.7
Tunisia	0.202	82,434	−6.1	−11.0	7.9	−9.3
Turkey	0.354	269,251	1.6	24.2	−12.5	13.3
West Bank	0.226	4,711	−4.7	−2.6	3.7	−3.5
Western Sahara	0.034	2,014	−6.5	−12.4	−5.1	−24.0

Table S7. Correlation coefficients (Pearson's at the country level

	Amphibian	Freshwater fish	Reptiles	All taxa
Correlation between area and richness	0.54	0.48	0.90	0.76
Correlation between NDVI and richness	0.64	0.37	−0.03	0.38
Correlation between NDVI and richness residuals	0.80	0.46	0.07	0.67

*The residuals derive from a regression between area and richness (the difference between the observed and the expected species richness based on area as the independent variable) are plotted in Fig. S1.

Table S8. The differences between the total number of North African endemics (species restricted to North Africa) and nonendemics (species not restricted to North Africa) in their richness, median area of occupancy, and the median area of the conservation targets

		Amphibians	Freshwater fish	Reptiles	All taxa
Species richness	Species restricted to North Africa	10	24	47	81
	Species not restricted to North Africa	96	227	115	438
Area of occupancy (median, km^2)	Species restricted to North Africa	7,987	58,672	49,478	48,725
	Species not restricted to North Africa	32,411	3,296	19,273	7,211
Area size required to achieve our targets (median, km^2) (see *Materials and Methods*)	Species restricted to North Africa	2,396	6,578	5,947	6,174
	Species not restricted to North Africa	4,287	1,181	2,288	1,881

Table S9. Total median cost of the priority areas (planning units) chosen in 1,000 Marxan runs using each of the 4 cost metrics

Cost Metric	AREA	DENSITY	ACQUISITION	BHM
AREA (km^2)	436,563	455,312	451,699	486,005
DENSITY (people/km^2)	130	83	122	84
ACQUISITION (10^9 US$)	472	489	474	491
BHM (10^9 US$)	429	254	414	251

The columns designate the metrics used in order to determine the priority areas. The rows show the total cost as calculated based on: AREA (row 2), DENSITY (row 3), ACQUISITION (row 4), and BHM (row 5).