# WINDMAR RENEWABLE ENERGY, PUNTA VENTANA, GUAYANILLA: COMMENTS AND CRITIQUE OF ENVIRONMENTAL IMPACT STATEMENT

## CASE NUMBER 2006-61-0536-JPU

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NOTE: References to EIS pages are in parentheses. Letters before page numbers indicate Appendix. In the case of Appendix C, the page numbers refer to the "final" HCP unless noted as CA#-page.

My first experience in Guánica Forest was in 1990 and since 1997 I have maintained an active research program on the structure, function, and effects of disturbance in Guánica Forest. I present my comments here today as my opinion as a <u>professional forest ecologist.</u> They do not represent the view of the University of Puerto Rico.

There are many emotional reasons for supporting or protesting a wind farm on Punta Ventana. These arguments will be made by others. I will present my objective scientific evaluation of the project's effects on the ecosystem and of the information contained within the environmental impact statement.

First, it is my overall impression that the Botanical Assessments presented in the Environmental Impact Statement refer primarily to Punta Verraco and Cerro Toro and not to Punta Ventana. However, it is not possible to fully evaluate the botanical work provided by Dr. Areces in the EIS because he does not document the locations of his sampling transects or plots. It is my opinion that these sites should be treated separately because Punta Ventana has a different land use history than Punta Verraco and Cerro Toro. This is evident from land use analysis performed by the USDA Forest Service based on aerial photos taken at various times since the 1930s. It is also clearly shown in the 1963 aerial photo included in Appendix C of the EIS (Figure 1). Punta Ventana is not degraded forest as the EIS states in multiple locations. With an emphasis on Punta Ventana, I will discuss:

1. the structure, diversity, and maturity of the forests in Punta Ventana
2. the condition of the forest, which is erroneously labeled a "tortured landscape." (Pg 68, C24)
3. The role and history of fire in Puerto Rican dry forest
4. Restoration and regeneration of dry forest
5. The relationship between birds and trees
6. General assessment of the science used to justify the EIS
7. Suggestions for alternatives

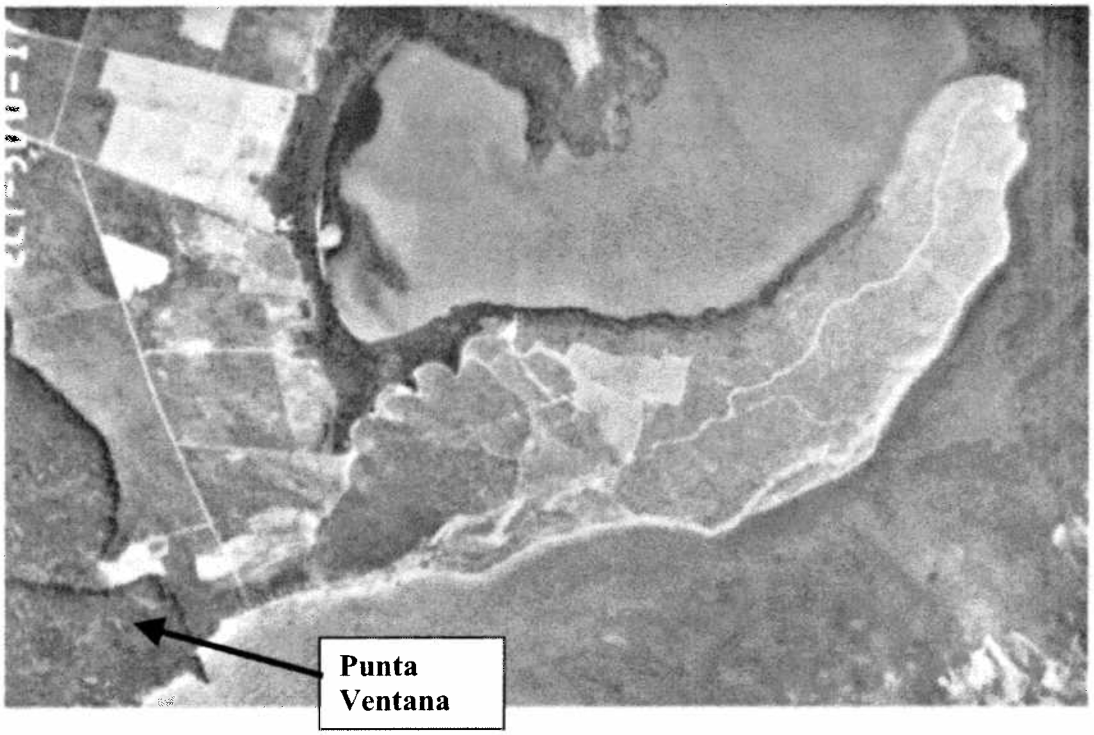



*Figure 2: 1963 photograph showing roads and trails used to exploit Punta Verraco and Cerro Toro*

Figure 1. Photo from WindMar EIS. Note that they are not illustrating roads in Punta Ventana because there aren't any. Also note the dense forest cover on Ventana. Label and arrow added.

## STRUCTURE AND DIVERSITY OF DRY FOREST IN THE AREA

The botanical information in the EIS does a good job listing the species present in the area. Unfortunately, the authors demonstrate, at best, only a rudimentary understanding of dry forest *ecology* and *restoration* in Puerto Rico. Their treatment of the plant community is filled with misunderstandings of disturbance ecology, forest structure, tree growth, and succession. This collection of misunderstandings is then used to misinterpret the quality of the forest.

In 1997, I established a 1-ha research plot within 100 feet of the eastern boundary of Guánica Forest. I will use data from this plot to illustrate some of the problems with the interpretation of the EIS. These data are published in 4 scientific journal articles and in my dissertation (see references at the end). Before establishing this plot, I also spent a significant amount of time surveying the forest adjacent to Guánica Forest – the area referred to as Punta Ventana and now owned by WindMar. In 1997 there were no roads in the area except a very overgrown extension of the Lluberas trail that leads out of Guánica Forest toward Media Quijada. My criteria for establishing research plots were that they had to be located in mature native forest that had closed canopy since the first aerial surveys in the 1930s. The easternmost section of Guánica Forest fit these criteria. I wanted to be certain that the adjacent lands did too, so there would be no edge effects in my studies. Also I was concerned that there may be incursion into the forest in general, and my plot specifically, from people entering the forest from the unpatrolled boundary on the east side. My conclusion was that the forest on either side of the old, rusted, barbed-wire fence was exactly the same. The forest had developed without regard to the artificial boundary drawn on the map. After 10 years of working in this plot, and walking to the plot using various routes, I can certify that the area is mature native forest and not "degraded tortured landscape" (pg 68; C24). The assessment of Paul Kerlinger, a consultant for WindMar, reached the same conclusion. He stated, "This forest borders the Guánica State Forest, and the vegetation is virtually identical to the forests within the state land." (CA3-6)

Claims that the forest is low in diversity (DIA 43 and App B)
In a collection of subplots equaling .09 ha, I found 32 tree species (Table 1). This is equivalent to the number of species found in similar plots in **mature, native forest** elsewhere in Guanica Forest (Lugo et al, 1978; Murphy and Lugo 1986; Molina 2006). The more important species in the plot included some species that are clearly indicative of mature native forests with little disturbance and other species that are labeled "opportunistic" (C26). Two of the opportunistic species identified by the EIS are corcho (*Pisonia albida*) and palo de vaca (aka paleto, *Bourreria succulenta*). Rather than being opportunistic, these species are more correctly considered pioneers and they are frequently found wherever there are openings in the forest canopy. With frequent hurricane disturbance and rocky soils that make rooting difficult, Puerto Rican dry forest is a patchwork of open and closed points in the canopy and therefore these pioneer species are frequently found mixed in with later successional native species. The third opportunist in the EIS is zarcilla (*Leucaena leucocephala*). Zarcilla is native to Mexico but was brought to PR some 300 years ago. It grows in areas that were previously used for agriculture or cleared for housing (Molina Colon and Lugo 2006; Molina Colon 1998). Of the 320 trees in the subplots, only 3 of them – or less than 1% – were *Leucaena leucocephala* (zarcilla), making it a very uncommon species in mature dry forest areas.

The EIS claims that "the Minimal Area (the area where 95% of the plant community's species can be found) for the dry forest on Punta Verraco is significantly small, only 200 $m^2$." (C27) Yet the graph provided on B20 suggests that much more than 200 $m^2$ will be necessary to contain approximately 162 species, or 95% of the total number of species found on WindMar property. (Figure 2).

In 2004 Ian Ramjohn (2004) completed a study of the conservation value of forest fragments in SW PR. Among his findings he identified 6 indicator species of conservation value for a fragment. These species provide a "flag" or tool by which to identify fragments that have a high species richness and are representative of the reference community, which is Guánica Forest. The species list in the EIS includes 4 of these species, indicating that the windmill area is also of high priority for conservation.

Table 1. Importance values for plant species having dbh ≥2.5 cm in nine 10 x 10 m blocks in the Ventana site in 1998. I.V. is the sum of relative frequency (RF), relative density (RD), and relative dominance (RBA; basal area).

| Rank | Species | I.V. | % of total I.V. | RF | RD | RBA |
|---|---|---|---|---|---|---|
| 1 | *Gymnanthes lucida* | 35.84 | 11.95 | 7.09 | 22.50 | 6.25 |
| 2 | *Amyris elemifera* | 34.51 | 11.50 | 7.09 | 18.44 | 8.99 |
| 3 | *Coccoloba diversifolia* | 26.55 | 8.85 | 6.30 | 7.81 | 12.44 |
| 4 | *Bursera simarouba* | 24.20 | 8.07 | 7.09 | 5.00 | 12.11 |
| 5 | *Tabebouia heterophylla* | 19.35 | 6.45 | 5.51 | 5.63 | 8.21 |
| 6 | *Bucida bucerus* | 19.23 | 6.41 | 4.72 | 2.19 | 12.32 |
| 7 | *Pilosocereus royeni* | 17.08 | 5.69 | 3.15 | 2.19 | 11.74 |
| 8 | *Pisonia albida* | 16.45 | 5.48 | 5.51 | 2.50 | 8.44 |
| 9 | *Pictetia aculeata* | 15.52 | 5.17 | 7.09 | 6.25 | 2.18 |
| 10 | *Coccoloba microstachya* | 13.97 | 4.66 | 4.72 | 3.75 | 5.49 |
| 11 | *Exostema caribaeum* | 10.03 | 3.34 | 4.72 | 4.06 | 1.25 |
| 12 | *Thouinia portoricensis* | 7.13 | 2.38 | 3.94 | 2.50 | 0.70 |
| 13 | *Guettarda krugii* | 7.09 | 2.36 | 3.94 | 2.19 | 0.96 |
| 14 | *Krugiodendron ferreum* | 5.82 | 1.94 | 3.15 | 2.19 | 0.48 |
| 15 | *Erythroxylon rotundifolium* | 5.11 | 1.70 | 2.36 | 1.25 | 1.49 |
| 16 | *Eugenia xerophytica* | 4.42 | 1.47 | 2.36 | 1.25 | 0.81 |
| 17 | *Bourreria succulenta* | 4.08 | 1.36 | 2.36 | 0.94 | 0.78 |
| 18 | *Guettarda elliptica* | 3.85 | 1.28 | 2.36 | 0.94 | 0.55 |
| 19 | Unknown species | 3.45 | 1.15 | 0.79 | 0.31 | 2.35 |
| 20 | *Comocladia dodonaea* | 3.45 | 1.15 | 2.36 | 0.94 | 0.15 |
| 21 | *Bourreria virgata* | 3.43 | 1.14 | 2.36 | 0.94 | 0.13 |
| 22 | *Eugenia foetida* | 2.95 | 0.98 | 1.57 | 1.25 | 0.13 |
| 23 | *Coccoloba krugii* | 2.90 | 0.97 | 1.57 | 0.94 | 0.39 |
| 24 | *Leucaena leucocephala* | 2.66 | 0.89 | 1.57 | 0.94 | 0.15 |
| 25 | *Jacquinia berterii* | 2.36 | 0.79 | 0.79 | 0.94 | 0.63 |
| 26 | *Pithecellobium ungis-cati* | 1.61 | 0.54 | 0.79 | 0.31 | 0.51 |
| 27 | *Ximenia americana* | 1.25 | 0.42 | 0.79 | 0.31 | 0.15 |
| 28 | *Securinega acidoton* | 1.19 | 0.40 | 0.79 | 0.31 | 0.09 |
| 29 | *Canella winterana* | 1.14 | 0.38 | 0.79 | 0.31 | 0.04 |
| 30 | *Crossopetalum rhacoma* | 1.13 | 0.38 | 0.79 | 0.31 | 0.03 |
| 31 | *Plumeria alba* | 1.13 | 0.38 | 0.79 | 0.31 | 0.03 |
| 32 | *Erithroxylon areolatum* | 1.13 | 0.38 | 0.79 | 0.31 | 0.03 |

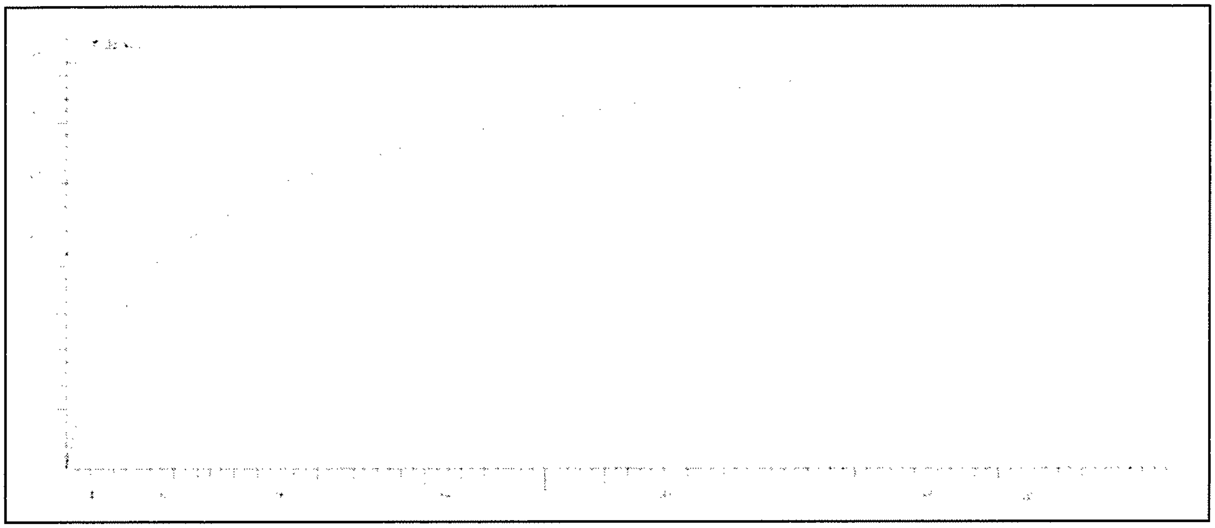


Figure 2. Species Area Curve from WindMar EIS (CB-20). WindMar claims that 95% of the area's 170 species can be found in 200 $m^2$. However, their species area curve shows that in about 150 $m^2$ they have only accumulated about 35 species. Furthermore, the slope of the curve is not increasing fast enough to reach 162 species in anywhere near 200$m^2$. This figure demonstrates two things: 1. Much, much more land at the site will need to be conserved to capture the diversity of the area, and 2. Whoever prepared the EIS does not understand a fundamental concept of ecology – species area relationships.

Lack of rare species.

The EIS concludes that the absence of Bariaco (*Trichilia triacantha*), Palo de Rosa (*Ottoschulzia rhodoxylon*), or *Mitracarpus maxwelliae* indicates that the forest is "notably poor floristically." (C25) The total area covered by these three species in all of Guánica Forest is probably less than 1000 $m^2$, or less than 1/100$^{th}$ of 1% of the forest. To not find these species in an area less than 6% of the total size of Guánica Forest is not surprising. This conclusion is analogous to going to New York City, surveying 100,000 people and learning that they came from 170 different places, but determining that the city is notably poor culturally because there was no one from Vieques or Culebra.

Growth form and size of trees

The EIS claims that the trees in the area are of small size and have a high frequency of multiple-stemmed trees (multicaule or rebrotado). This is true, relative to other forests. In fact, 42% of the trees in Guánica Forest are multiple-stemmed (Murphy and Lugo 1986; Van Bloem et al. 2004, 2005). Of the 12,000 stems/ha commonly found in mature areas of Guánica Forest, 57% of them are in clumps (Murphy and Lugo 1986). The EIS indicates that this form means that the forest is severely degraded and implies that any future disturbance would not be serious (B2, C26, CA12). This conclusion is completely inaccurate and it illustrates that the authors did very little research into the ecology of dry forest. Multistemmed trees can be the result of cutting, but in an article specifically focused on multi-stemmed trees, 8 of 11 species studied (e.g. *Guettarda elliptica, Coccoloba krugii*) had multiple-stemmed individuals in the absence of human disturbance before they were 3 cm in diameter (Dunphy et al 2000). My own research has shown that hurricanes can snap, uproot, or bend over trees, resulting in resprouting that is similar to that found from cutting (Table 2). More importantly, hurricanes can cause trees to resprout from the base even without physically damaging the stems (Van Bloem 2004, Van Bloem et al. 2003, 2005, 2006, 2007).

**Table 2. Sprouting in Guánica Forest, Puerto Rico. Pre-hurricane sprouts were counted on 451 stems. Post-hurricane sprouts were counted on 1407 stems pooled from five plots. Only sprouts developing below breast height (1.4 m) were counted. A sprout was defined as any woody twig with an orientation greater than 45° relative to the ground. Post hurricane sprouts compared against pre-hurricane sprouts using z or t tests as appropriate.**

| | Total number of stems | % of stems with sprouts | Sprouts per sprouting stem (se) |
|---|---|---|---|
| Pre-Hurricane Sprouts | 451 | 3.5 | 1.7 (0.3) |
| Post-Hurricane Sprouts | | | |
| Major structural damage | 205 | 48.3*** | 21.3 (3.3)** |
| Defoliated stems† | 1153 | 31.8*** | 10.1 (1.0)** |
| No visible stem damage | 49 | 28.6*** | 5.8 (1.6)* |

†Stems with defoliation but without major structural damage.
***$p < 0.0002$; **$p < 0.0005$; *$p < 0.01$

The EIS also states that: *(C26)*

> *The size of the trees is also telling. With the exception of the fast-growing, opportunistic species, whose trunks reach a foot in diameter in the study area, the large majority of hardwood trees do not reach a basal diameter of 6-7 cm. .... It is as if, about a half century ago, the WindMar property was deforested to a high degree, and only since then has this dry forest had a chance to recover.*

The 1963 aerial photo in the EIS clearly refutes this finding for Punta Ventana (Figure 1). In addition, small stature does not indicate young age in Puerto Rican dry forest. One of the consequences of living in a windy environment is that rainfall, when it comes, evaporates quickly. The rocky limestone soils increase run off, further decreasing the ability of trees to access water. Average tree growth in Guánica forest is 0.03 to 0.06 cm/yr for hardwoods such as Gymnanthes, Krugiodendron, Pictetia, and Coccoloba (Van Bloem et al., in prep. Murphy et al., 1995; Weaver 1970). Typically, smaller trees grow faster in diameter than large trees, but this is not the case in Guánica Forest as all size classes have similar growth rates (Figure 3). Thus, a 6 cm diameter tree, indicated as small in the EIS, could represent 100 to 200 years of growth. Guánica has lower average annual growth than most other dry forests, this is likely due to harsher conditions and poorer soils in Guánica Forest than elsewhere. In addition, one common response of trees to living in a windy environment is to have a small stature (Vogel 1994).

Thus, one should not conclude that the presence of small, multi-stemmed trees indicates a long, severe history of cutting, only that there has been disturbance by either humans or wind. Considering that the whole reason for building a wind farm in this area is because of the presence of winds, it is therefore just as likely that the multi-stemmed growth form of the trees is caused by wind, not by widespread cutting.

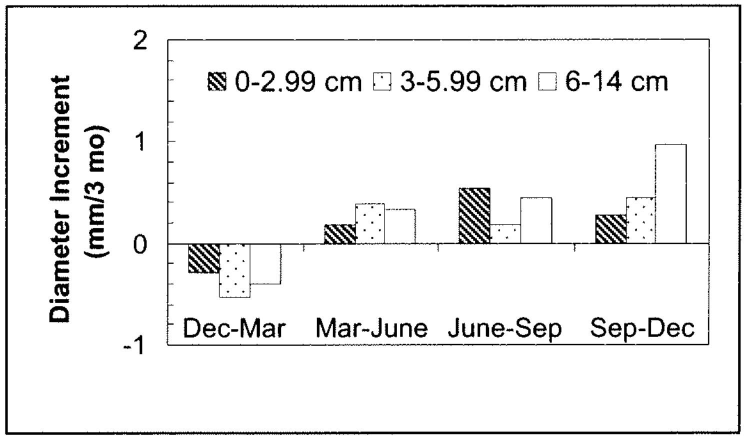



Figure 3. Seasonality in the diameter growth of trees of three diameter size classes in the deciduous forest of Guánica Forest. The values shown are the means of 18 years of measurements of 305 trees.

Murphy and Lugo (1986b) reviewed the structure of mature, native stands in Guánica Forest and concluded that among dry forests of the same age and disturbance worldwide, Guánica Forest had less biomass, shorter canopy, and smaller diameter stems. Despite its small stature, Guánica Forest has just been chosen by the National Science Foundation to be one of only 20 sites nationwide included in the National Ecological Observatory Network. As the forests in Punta Ventana are indistinguishable from those in Guánica Forest, they would appear to have the same value. To demean their value, and those in the *bosques enanos,* because of their size is like saying that Ivan Rodriguez could never be a good baseball player because he is only 5'9".

**CHARACTERISTICS OF DEGRADED FOREST**

Considering that the EIS erroneously labels the forests in Punta Ventana as degraded, it would be worthwhile to describe some characteristics of degraded forest. A satellite image of Puerto Rico shows a curious concentration of forest cover in a strip that leads from Guánica to Susua to Maricao. In fact, the Spanish crown protected these forests before the US Government established them as reserves (M. Pizzini, UPRM, personal communication). While this did not eliminate all human intrusion into the forests, it did minimize what could have been. While the EIS summarizes the forest as a "tortured landscape," in fact the assessment done by Kerlinger (CA3-7) says there are only 3 degraded areas, and none of these are on Punta Ventana.

Degraded forest arises from lands that have had severe soil disturbance, grazing, or recent history of fire. In the first case, the subsequent plant community is dominated by Leucaena. After grazing, Prosopis dominates. Fires result in rapid invasion by non-native grasses. A great deal of soil is **not** necessary for grass, even Guinea grass, to establish. This is clearly illustrated when you drive down Rt. 333 past Copa Marina to Playa Tamarindo. Cutting trees for firewood or charcoal was an activity that had largely ceased in the area by 1950, but because the roots of these trees are left intact, the trees can resprout and survive. In these cases, the main roots may be much older than the stems. Degraded forest also has lower species richness and a higher percentage of introduced species in its understory. The EIS suggests that the land will be cleared by bulldozing in such a way to encourage resprouting, but bulldozing will not leave a stump aboveground and will likely remove the top few inches of soil. Elsewhere in PR, bulldozing was found to be the disturbance that caused the slowest regeneration and the tree species that returned were invasive exotic species (Chinea 2002).

In a study comparing 9 pairs of mature and degraded forests in SW PR, we found that the percentage of saplings from exotic tree species decreases with forest age (Figure 4) (Pérez 2007). The proportion of exotic saplings in Punta Ventana is very low, indicating that it is mature, native forest. Further we found a number of tree species that occurred only in mature native forests and not in degraded forest dominated by Leucaena or Prosopis. Among these species the following are also found on the WindMar site: *Pictetia aculeata, Tabebuia heterophylla, Erithalis fruticosum, Canella winterana, Antirrhea acutata, Colubrina elliptica, Zanthoxylum flavum, Conocarpus erectus, Coccoloba krugii, Eugenia xerophytica* (though not on the species list, it occurs near west boundary post 92, if not elsewhere), *Polygala cowellii, Reynosia guama,* and *Laguncularia racemosa.* Thus, according to the species list presented in the EIS, it appears that there are many species present on the WindMar property that are characteristic of mature, native dry forest.

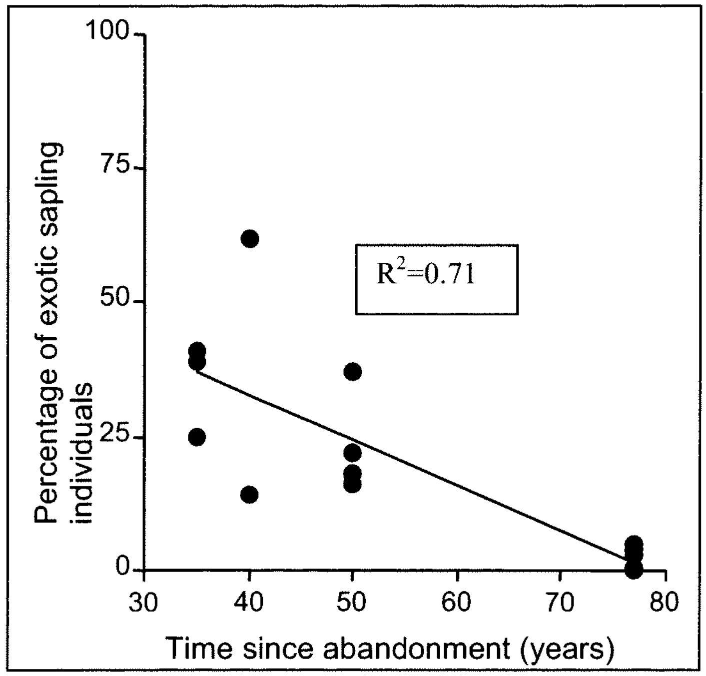



Figure 4. Relationship between age of forest and the proportion of individuals from exotic species in 9 secondary forests and 9 nearby stands of mature forest. (Perez Martinez 2007)

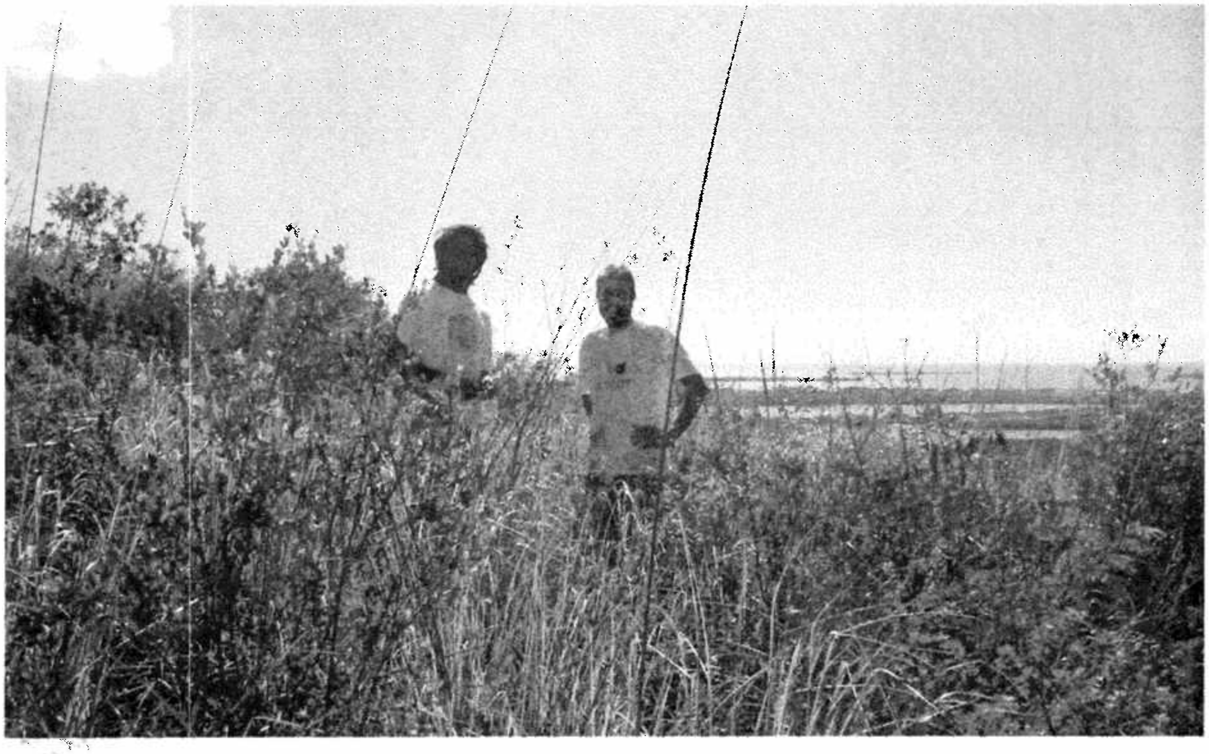
## THE ROLE OF FIRE IN PUERTO RICAN DRY FOREST

The EIS correctly states that native dry forest species are not well adapted to fire. Fire is an introduced phenomenon in the dry forests of Puerto Rico. There is no ecological long-term history of fire here because there is no natural ignition source. Lightning is accompanied by rainfall and spontaneous fires do not exist. Despite what you hear on the radio, our air is too humid for spontaneous fires to ignite. However, there are ample human causes of fire, and these are causing the spread of invasive grasses and decreasing the coverage of native woody species. Once a fire occurs in PR dry forest, the area does not return to forest, but remains grassy, perhaps with a few trees entering. The grass cover increases the chances of subsequent fires. Because the grass provides fuel for future fires, it has been called the Grass-Fire Cycle. The construction of the roads into the forest will provide a new avenue for the grass species to invade the interior of the forest, increasing fuel load and resulting in more severe fires if they are ignited. This same phenomenon of introduced fire is also found in Hawaii. Fires need not happen only because of turbine malfunctions. Sparks, hot catalytic converters from cars parked in grass, and employees and others who carelessly discard cigarettes start fires along the roadsides. Once started, fires are hard to put out in dry forest and can easily jump a 5-m wide road in high winds (the same high winds that make the site good for wind power). Guánica Forest is downwind and so would be imperiled by fires started in the Punta Ventana sector of the WindMar property. The roads that WindMar has constructed in the forest already will eventually be lined with grasses that will help the fire spread and provide a hotter, more uniform fuel distribution than would undisturbed, mature dry forest.

## RESTORATION AND REGERATION

One common response in development projects is to state that forests will be "restored." This is also a goal for the mitigation of construction and use effects for the WindMar project. However, there is typically little thought put into what restoration means. Restoration is the act of returning a disturbed ecosystem back to its original conditions, but this begs a number of questions: Restore to what type of forest? With what species and to what level of diversity? How much biomass and how many species will be added and by when? While restoration is an admirable goal, it is not a panacea. If the quality of the ecosystem being disturbed is so high that it will take 100 years or more to return to a similar state, it is truly possible to restore the area? How will WindMar guarantee that restoration efforts will continue for even 40 years? One would expect to find the answers to these questions in the Habitat Conservation Plan, but they are not there. There is a lot of details on the production of energy, and the construction of the site, but very, very little specific information on the owners plans for ecological restoration. The plans that they do set forth, in Appendix C12 are amazingly unrealistic and incomplete. For example:

- Specific restoration plans are only provided for 2.6 ha of the site, the majority of the old quarry on Punta Verraco. No specific plans are discussed for the balance of the impacted area, except for some "regeneration" that will be allowed on the roadsides and construction zones (see regeneration discussion below).
- Water is to be provided by drilled wells. Considering the proximity to the ocean and former land use by a refinery nearby, is it certain that water will not be saline or polluted? How will the grass that will inevitably grow in the watered areas be eliminated?



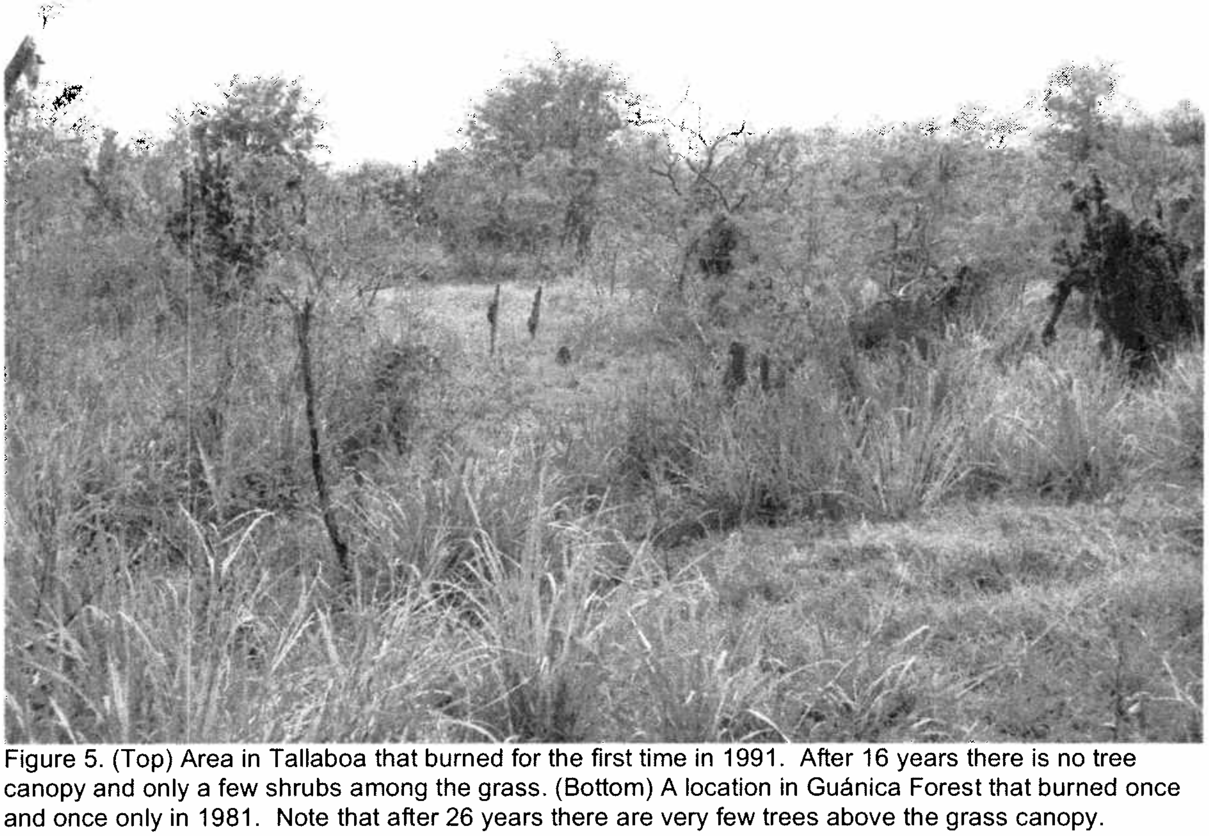


Figure 5. (Top) Area in Tallaboa that burned for the first time in 1991. After 16 years there is no tree canopy and only a few shrubs among the grass. (Bottom) A location in Guánica Forest that burned once and once only in 1981. Note that after 26 years there are very few trees above the grass canopy.

- Soil will be trucked in. Wow! From where? Will it be sterile so as not to introduce invasive grasses or diseases? Will it have the appropriate mycorrhizae to help the trees establish? How will they keep the soil in place after putting in on top of rock or compacted subsoils of a quarry?
- Planting density is projected to be 1,375 seedlings/ha (Murphy and Lugo 1986). This is about 25% the density of mature native forest. Apparently restoring a forest with the same tree density of Guánica Forest is not an objective of this plan. At this density, after 5 years, the saplings will cover less than 20% of the surface area of the quarry site, assuming they can grow as well there as elsewhere. Thus the restored forest will be very open.
- Mortality. How much mortality do they expect in their planted trees?
- Growth rates. As mentioned above, trees in Guánica Forest grow very slowly, as do saplings. It is extremely unlikely that they will have a 3 m canopy in only five years. A few Bursera will certainly be 3 m, but they will not provide much crown-cover. Average height growth of small trees is only 0.1 cm/year. (Figure 6) Murphy et al. (1995) report on cut plot experiments and they did not obtain 5 m trees after 13 years as WindMar projects they will have in 10 years.
- Shade. Many species grow better with partial shade, including many on the list of "pioneer" species. This has been demonstrated by Castilleja and Ray and Brown. How will they provide shade when their initially planted trees will not be big enough?
- Nursery stock. WindMar projects collecting seed from Guánica Forest and using tissue culture techniques for very rare species such as bariaco. What are the germination rates of the species they intend to plant? How many seeds will be needed? How will they ensure genetic variability? How long will the seedlings remain in the nursery before being transplanted to the field? (To get saplings large enough to compete against grasses, it will take at least two years.)
- Species. Many of their pioneer species on their list are not pioneers but are mid-successional species that will require some shade to survive and grow. They should cite a reference for this list, because many of the "pioneers" do not have pioneer life history traits (i.e. high fecundity, fast growth, etc.). Leucaena is an

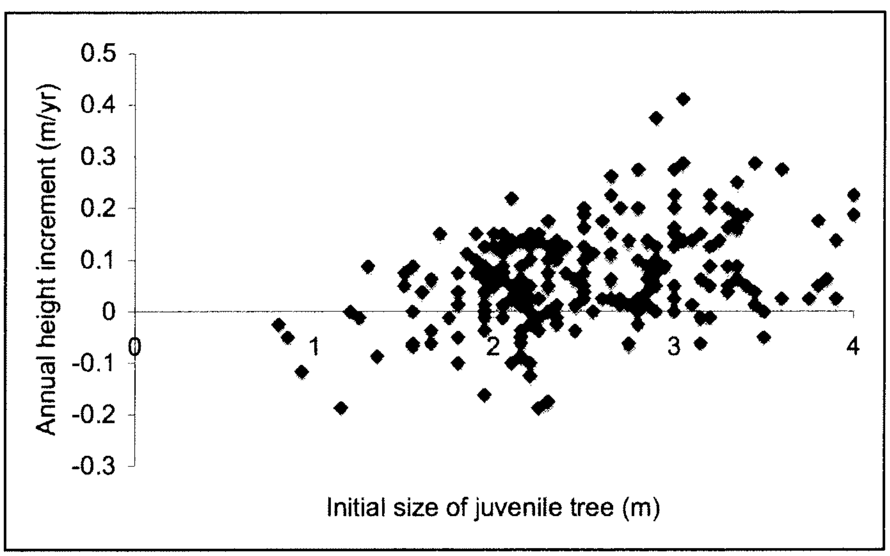



Figure 6. Annual height increment of 240 saplings and small trees in Guánica Forest. Measurements taken from 1998-2002. Negative increments come from herbivory and beetle damage, particularly on Eugenia species, and from drought killing terminal leaders. Average increment was 0.1 m per year. It will take an average of 50 years to restore a 5 m canopy, based on these trends, assuming no future disturbance (Van Bloem et al, in prep).

exotic species. Their second list – rare and uncommon species – show up on their species list for the site. If these species are rare or uncommon, this argues even more for preserving the entire site, rather than bulldozing it and hoping it regenerates.

In my opinion, and with my experience in forest restoration projects throughout SW PR, I believe that it will be impossible for WindMar to restore a forest similar to the one they have already begun to disturb in Punta Ventana. Trying to restore a forest on an old quarry is a laudable goal, but it will be very difficult and there is no indication that Dr. Areces or WindMar will have any success with this. Restoring quarry lands is much different than planting trees on a university campus.

Regeneration is the natural process of an ecosystem returning itself to a pre-disturbance state. The EIS indicates that 88% of the disturbed areas will be able and allowed to naturally regenerate from root sprouts (pg. 78). However, with a 40 yr replacement cycle for each windmill and the extremely slow growth rates of the native hardwood trees in the area, it is unlikely that the forest will regenerate as well. We know that the understory community will not have returned to a mature state in that time (Figure 4). Even moist and wet forests in PR do not regenerate to mature states in less than 40 years, and they have the advantage of longer growing seasons (Chinea 2001, Aide 1996, 2000). Much of the area is likely to be invaded by non-native grasses and exotics tree and shrub species. WindMar suggests that these can be controlled with Round-Up (DIA 91), but Round-Up will also kill native species in the process of trying to regenerate in grass-dominated areas. This will create a never-ending need to continually use Round-Up as grasses will then reestablish in the herbicided areas.

In addition, the EIS documents introduce some serious uncertainties as to the total amount of area that will be impacted. The EIS states that roads will be sufficiently wide at 5 m. However, while the roads they have already cleared in Punta Ventana may only be about 5 m wide, there impact is much greater because the cleared wood has been pushed to the side. Furthermore, trees off the sides of the roads, but leaning over the road will need to be trimmed back. Vestas documentation indicates that there needs to be a 2.5-m easement on either side of a 5-m wide road, thus doubling the impacted area of the roads.

The EIS states that assembly at each tower site will only take 840 $m^2$ each, or 2.1 ha total. The Vestas documents (C2) indicate that the assembly sites will need to be 65.5 X 71 m or about 4500 $m^2$, totaling 11.5 ha, plus road width on one side (Figure 7). WindMar states that they can reduce the size of the footprint by cutting in 40 x 3.5 m paths for the blades, but it seems unlikely that they can reduce the assembly footprint to only 18% of that suggested by Vestas. In addition the blades are 3.2 m wide and the suggestion that they will cut paths in the forest that are only 30 cm (12 inches) wider than the blades is *highly unrealistic*.

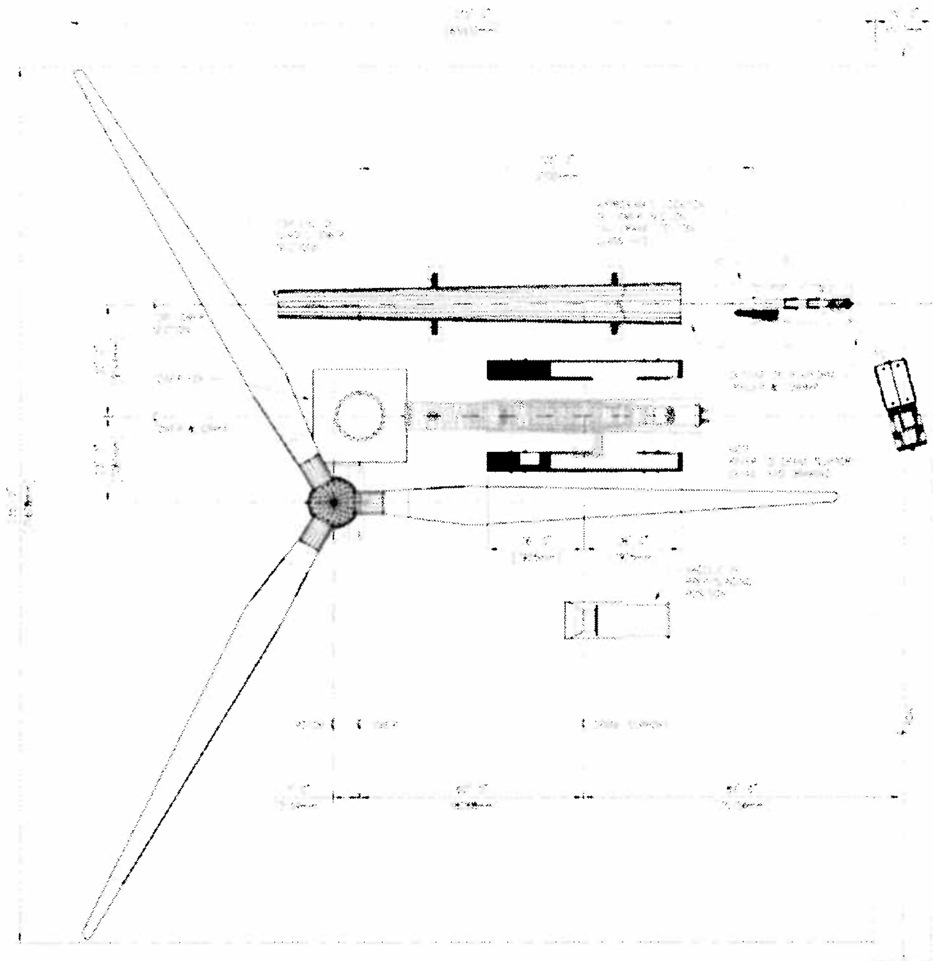



Figure 7. Assembly site diagram from Vestas Inc. literature provided in WindMar EIS. This site is about 4500 $m^2$ without the road, but WindMar claims they can assemble each windmill in only 18% of this area.

## BIRDS AND TREES

The EIS correctly focuses its efforts on endangered bird species and says that the other bird species found on the site are common. In our study of tree species found in the understory of degraded forest, we determined that over 80% were dispersed by birds (Pérez Martinez 2007). If the turbines affect the behavior of the common birds, it could have a large impact on forest regeneration.

The nightjar surveys showed a surprising increase in nightjar populations after the road construction in 2003. This is attributed to the roads opening foraging corridors for the nightjar (C 36). Let me suggest an alternate explanation for this result. Clearing the roads made it easier for the scientists and their technicians to walk though the forest. Mature dry forest such as found on Punta Ventana is quite dense and difficult to walk through, particularly at night. Walking through the forest in 2003 would have been a noisy occurrence, and likely to make the nightjars stay quiet. In 2004, the scientists would have been able to walk the roads, make less noise, and use their flashlights less. This pattern (more birds if doing road surveys, less if off road but parallel) has been documented in Guánica Forest with nightjar (R. Gonzalez, Mississippi State U, personal communication). According to the maps, the 2004 transects were performed along the roads and not through the forest. So the construction of the roads may not lead to more guabairo, but instead make listening for singing guabairos a less disturbing experience for them.

Finally, WindMar misquotes Vilella and Zwank (1993) in their EIS (C36). They state:

> *Kerlinger favors the explanation that the new access roads cut through the forest at the WindMar site provided better foraging habitat such that more singing birds could occupy the site, particularly in new areas. He believes it is possible that these openings in the forest make foraging easier. North American nightjars forage in openings and edges of the forest (Paul Kerlinger, personal observation). Orlando Garrido, the Cuban ornithologist, has told WindMar that the closely related Greater Antillean Nightjar (Caprimulgus cubanensis) has become more common in areas of dense forest where roads have been cut, such as in the Zapata Swamp (Orlando Garrido, personal communication). Vilella's own research appears to support this hypothesis as well.*

The implication is that Vilella thinks that roads are good for nightjars. Elsewhere in the EIS WindMar suggests that mongoose does not prey upon nightjar. Of course, the issue is not whether mongoose eat adult nightjars, but whether they will eat the eggs. **Regardless, this is a very selective reading of Vilella and Zwank's article**, because on page 28 of the article, they state:

> *The inverse relationship between Nightjar and mongoose numbers has implications for conservation of the endangered Puerto Rican Nightjar. Proposals to establish paved roads through the forest and development of adjacent private land threaten Guanica Forest, a UNESCO Biosphere Reserve.* ***Such development would increase habitat for mongooses by providing non-forested roadway corridors,*** *as well as supplemental food and water sources. Future management of arid forested uplands in Guanica Forest and adjacent private lands should not reduce forest canopy closure, nor increase water and/or food sources which would favor mongooses.* (emphasis added)

The logic of WindMar's nightjar assessment continues to unravel when they suggest that nightjars prefer open understories of plantations to the "scrubby" forest that "may not be good to forage in." (C 37) Yet, they are proposing to bulldoze much of the land on Punta Ventana and let it regenerate by stump sprouts, resulting in a more "scrubby" forest than is currently there.

## EVALUATION OF THE BOTANICAL SCIENCE WITHIN THE EIS

Publication is the currency of scientists. A stockbroker may be rated based on how his investments grow, a lawyer based on how many cases he wins, and a doctor on the number of lives he saves. Scientists are rated based on the quality of their publications. This quality is assured by a system of peer review, where other scientists in the field evaluate the quality of data and its interpretation. We are expected to be up-to-date with the current literature and include important findings from others when publishing our research. It is particularly curious that neither of the 1986 Murphy and Lugo references were cited, considering that they directly address Guánica Forest and have been cited over 300 times by other scientists (Web of Science search result). The botanical assessment for this EIS provided a nice long list of plant species present at the site, but the interpretation of the forest structure, history, and growth patterns was all wrong. If I were to receive this as a manuscript from a journal, I would recommend that the editor reject the paper outright. Dr. Areces has excellent credentials as a taxonomist, but the ecology that he reported in this document is weak.

**SUGGESTIONS AND CONCLUSIONS**

Despite my evaluation of the ecology of this EIS, I think that investing in wind power is essential for the future of Puerto Rico. Let me be clear, my objection is not to the project, but to the location, particularly on Punta Ventana.

Of course, WindMar owns the site in question and not other sites, which puts the company in a bit of an awkward position. Part of the problem is certainly that there is a serious lack of guidance on the part of the Junta de Calidad Ambiental and the Junta de Planificacion on how our lands should be used. Perhaps the new Land Use Plan will be able to rectify this. In terms of wind power, it would not be difficult to model the geography of the entire island in relation to the prevailing winds and determine the best sites for wind power. These could then be overlaid on land cover in a GIS data base to eliminate sites like Punta Ventana that have high ecological value.

WindMar's stated intentions in their EIS as to conservation easements, environmental education, invasive species control, and scientific research and monitoring are admirable. Since I have no direct knowledge of any of the personnel in the company, I will assume that this reflects a genuine concern for the environment, rather than lip service. However, the fundamental lack of ecological understanding demonstrated in the EIS suggests either that WindMar associates are not competent in the area or that they have been deliberately understating the value of the forest and the effects of the construction. In any project of this type, regardless of the reputation of the company involved, I believe that the government regulators should insist on some concrete guarantees for mitigation, and should hold the funding for the environmental efforts in escrow and ensuring that there is proper oversight. The 88% of the land that will be left for conservation should be turned over to an appropriate non-profit group like the Conservation Trust *at the beginning of the project.* It should not be turned over to a group with close ties to the WindMar owners in order to decrease the chances of malfeasance and because, in my opinion, the have not demonstrated sufficient scientific understanding of dry forest ecology to be able to manage the natural biological resources on the site.

There are plenty of truly degraded lands around Guayanilla, Tallaboa, and elsewhere in southern PR. These should be used instead, and the native forests on Punta Ventana, Punta Verraco, and Cerro Toro could be purchased and set aside for conservation as part of a mitigation program for development elsewhere. It would be preferable for Pridco to exchange some lands, probably brownfields, with WindMar and then turn over the current WindMar property to DRNA to be managed with Guánica Forest.

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