# Does *Baccharis conferta* Shrub Act as a Nurse Plant to the *Abies religiosa* Seedling?

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**Abstract:** The role played by nurse plants represents a common ecological process in nature; this being an interaction where a particular species benefits from the presence of another species. Nurse plant species offer an efficient aid for the survival and growth of other species, including some which are of economic importance or interest for conservation. *Baccharis conferta* Kunth (shrub) and *Abies religiosa* (tree) are two common species which cohabit in the mountains of Mexico. It is general a practice, when establishing plantations to clear the mountainside, which involves cutting down and removing all shrubs. In order to discover whether *B. conferta* acts as a nurse plant when *Abies religiosa* seedlings are becoming established, this research evaluated the effect of this plant on the survival and growth of *Abies religiosa* seedlings. After taking records for two years, we found that the survival of *A. religiosa* did not vary significantly under the two contrasting conditions (65% with *B. conferta* and 55 % without *B. conferta*, nor was there significant interaction among years, contrasting conditions and experimental plots ($G^2$ = 0.01, $P$> 0.91). However, height and coverage were significantly greater under the *B. conferta* canopy (($t$ = 3614, $P$ < 0.001 and $t$ = 2910, $P$ < 0.001, respectively) than without *B. conferta*, but not in terms of the stem base diameter ($t$ = 0.689, $P$ > 0.49). We concluded that *B. conferta* promotes the seedling growth of *A. religiosa*, reducing costs for commercial plantations or plantations aimed towards restoration.

**Keywords:** Mexico, nurse plant, plantation survival, seedling growth.

The knowledge of the natural processes involved in succession is fundamental to the success of species restoration and conservation programs, as well as for the maintenance of commercial forestry plantations [1-5]. Facilitation represents a successive process, where one species is capable of preparing the way for another species, and the latter can in turn prepare the way for the next one [6]. Specifically, the positive influence of an adult individual on a seedling is termed "nurse plant syndrome" and this effect is more common in environments where abiotic factors or herbivores may limit plant development [7, 8]. The role of the nurse plant is a well documented process found in different environments and among different plant types [9-13]. The nurse plant can play an important role in the restoration of damaged environments and the reintroduction of locally extinct or economically important species [1, 2, 4, 8].

In Mexico, there are eleven recognized species from the *Abies* species [14], which grow in mountainous and cold areas throughout the entire length and breadth of the country, at altitudes ranging between 2000 and 3500 m. *Abies* forests in Mexico occupy an area covering approximately 32000 ha [15]. In Veracruz State (Mexico) the *Abies religiosa* populations have declined dramatically due to uncontrolled forestry exploitation, habitat damage and land use change [16, 17]. In this region, the fir occupies the second largest surface area, consisting of 1528 ha and is second only to pasture. In order to mitigate the effect of deforestation, the solution has principally constituted the establishing of plantations, where the usual method is to fell and erase weeds and shrubs in order to clean the planting area (pers. obs.), without considering any potential nurse species which may be naturally present [8].

Natural regeneration of fir forests is significantly greater in clearings than under the canopy [18]. According to Gonzalez *et al*. (1991), *A. religiosa* also grows in open spaces. However, it has been observed that in these open areas regeneration is more successful under the canopy of the *Baccharis conferta* Kunth shrub. This suggests that *B. conferta* functions as a nurse plant which facilitates the regeneration of some species of the *Abies* genus [ 19]. The questions which we asked in this study were: Does *B. conferta* act as a nurse plant for *Abies religiosa*? and specifically, Is the growth and survival of *A. religiosa* seedlings under the canopy provided by individuals from *B. conferta* than in open areas?

This research was carried out in the Cofre de Perote National Park, Veracruz, Mexico (19° 31' 54.5" North and 97° 09' 14.8" West), at an approximate altitude of 3300 m. The climate is cool, temperate and sub-humid, with an

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annual mean temperature of 12° with a minimum of -5 °C and a maximum of 22 °C, with a summer rainy season and an average annual rainfall ranging between 1200 and 1500 mm. *Abies religiosa* is used for Christmas trees and mature trees provide wood for housing, furniture, construction, roofing, firewood and fencing.

The *A. religiosa* distribution is from Guatemala to Mexico, it is a lush tree in appearance, as some of their extensive branches grow only a short distance from the ground. They grow to a height of 35 to 40 m with trunk diameters normally exceeding 1.5 m. Twigs grow in a cross formation with alternate leaves which are linear and pointed, 20 mm long and bright green on top and dull on the underside and they have a sharp apex which is sometimes rounded. It is a monoecious plant. Age for reproduction ranges begin between 23 and 27 years. This species is considered to be shade tolerant, however it regenerates well in gaps between the canopy [18] *Baccharis conferta* Kunth (Asteraceae) is a shrub which grows to between 1 and 3 m high, with multiple stems, is endemic to Mexico and is known by the name of "quauhizquiztli" and is used to make rustic brooms (for street sweeping); it has spasmolytic and antibacteria properties as well as containing compounds such as flavonoids and triterpenes [20, 21]. *B. conferta* does not grow under the *A. religiosa* canopy but develops in open areas and is considered a pioneer species. Both *B. conferta* and *A. religiosa* share certain species of ectomycorrhizal fungi and it is thought that *B. conferta* serves as a backup source of ectomycorrhizal fungi for *A. religiosa* (Andrade - Torres *et al*. pers. com.).

Experimental Design. Two open areas with *Baccharis conferta* plants (70-80 % coverage) were random chosen. In each area a 16 X 48 m area was traced out. Each area was subdivided into eight plots measuring 10 X 8 m and four rectangles were randomly chosen where the *B. conferta* was left intact and four where *B. conferta* was absent; here the elimination of all *B. conferta* plants with a *machete* resulted in the plots being totally devoid of ground cover. In order to avoid a border effect, a meter wide perimeter was left along each side of the rectangle. In the first plot 114 *A. religiosa* were planted with a distribution of 14 seedlings per rectangle, 56 in the four rectangles where there was no *B. conferta* and 57 in the four rectangles where *B. conferta* was present. In the second plot 120 *A. religiosa* seedlings were planted, 60 seedlings in the four rectangles without any *B. conferta* and 60 in the four rectangles where *B. conferta* was present. Fifteen seedlings were planted in each rectangle. Planting of seedlings was equidistant (distance between plants was 2 m). *A. religiosa* seedlings used in this project were taken randomly selected areas from naturally regenerating forest, where they are very abundant. Seedlings were removed with the entire root ball, so as not to damage the root, with heights ranging between 20 and 35 cm and aged approximately two year (whorls in *Abies* are produced at the rate of one whorl per year -[22, 23]. After a month, dead seedlings were removed and replaced with living plants (obtaining100 % survival rate). Immediately after planting, the height, coverage and trunk base diameter of each seedling was recorded and these measurements were taken every year over a two year period. In order to measure the height and coverage we employed a flexible measuring tape and for the diameter, a metal outside caliper.

Methods of analysis. In order to compare survival (number of individuals at the end of the study) under the two contrasting conditions (nurse-no nurse), years (1 and 2), plots (1 and 2) (principal effects) and the interaction among contrasting conditions, year and plot, a log- linear models [24] were employed. The growth height, coverage and trunk base diameter were analyzed by applying the student's *t* test [24]. Growth rates were estimated by applying the following equation:

$$\Delta_C = \frac{\ln C_2 - \ln C_1}{t}$$

where $\Delta_C$ is the growth rate, ln is the natural logarithm, $C_2$ is the final height (coverage or trunk base diameter), $C_1$ is the initial height (coverage or trunk base diameter) and $t$ is time taken.

## RESULTS

The survival rate of *A. religiosa* seedlings under the canopy of *B. conferta* canopy was 65%, whereas the survival rate in the gaps was 55% (Fig. **1**). However, there were no significant differences between contrasting conditions, years, or plots ($G^2$ = 0.46, $df$ = 4, $P$ = 0.9775) or when their interactions are included ($G^2$ = 0.01, $df$ = 1, $P$ = 0.9124)..


**Fig. (1).** Number of live and dead seedlings of *Abies religiosa* after two years planted. Nurse *Baccharis conferta*.

Out of the three variables recorded (height, coverage and diameter at the base) we found that growth rates, in terms of height and cover were significantly greater for the seedlings of *A. religiosa* that grew under the cover of *B. conferta* than without cover (17.2±1.9 cm, 33472±764 cm$^2$ and 9.88±0.93 cm, 2234±152 cm$^2$, respectively) ($t$ = 3614, $P$ < 0.001 and $t$ = 2910, $P$ < 0.001, respectively). Whereas the expansion in trunk diameter manifested no significant differences in terms of the contrasting conditions (1.88±0.63 and 1.6±0.34 cm$^2$, respectively) ($t$ = 0.689, $P$ > 0.492) (Fig. **2**).

## DISCUSSION

Some research has indicated that the regeneration of *A. religiosa* thrives under the closed canopy [15, 17, 25], whereas Lara- Gonzalez *et al*. (2009) demonstrated that regeneration of *A. religiosa* is significantly higher in canopy gaps than it is under the canopy. However, in open areas it has been suggested that regeneration of *A. religiosa* occurs in association with *B. conferta* [19]. Our results to some extent support this hypothesis, because the survival of seedlings of *A. religiosa* was not significantly different when individuals were growing under *B. conferta*, compared to those in open

spaces. However, it was observed that the height and seedling coverage of *A. religiosa* increased significantly when they grew below the canopy provided by *B. conferta* individuals, when compared to open areas. On other Mexican forest *B. vacciniodes*, a species which is functionally similar to *B. conferta* acts as a nurse species to *Quercus* spp. and *Pinus* spp. in the highlands of Chiapas in Mexico [26]. In the case of other species found in temperate forests (e.g. *Quercus rugosa*, *Q. castanea*, *Magnolia dealbata*, *M. iltisiana*) it has been shown that the survival of their seedlings is significantly greater under a nurse species than in open areas [4, 27-30]. This seems to indicate that both in temperate zones, as well as in many types of ecosystems [8], nurse plants are more common than previously thought.

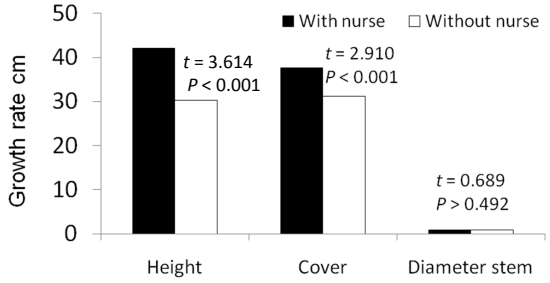


**Fig. (2).** Annual growth rate by height, coverage and trunk diameter of *Abies religiosa* seedlings after two year planted (plot average). Nurse *Baccharis conferta*.

Nurse plants include shrubs, broad-leaved trees, pines, grasses and agaves, among others. Shrubs have proved to be the most successful type of nurse plants [29]. The role of the nurse may be to provide shade during the summer dry season which reduces the stress on seedlings caused by drought [33]. Most pioneer species such as *B. conferta* are important as they are able to act as facilitators; offering protection from weeds, wind action, frost and generally against sudden temperature changes [32]. Pines for example promote the survival and growth of many broad leaf species [5, 36]. We know that without the presence of these nurse plants, very high seedling mortality can occur [4, 34, 35].

If certain species of shrubs act as nurse plants, then this process can be used to aid in restoration and rehabilitation projects for these ecosystems, protecting seedlings from drought, trampling by ungulates and impact from abrupt changes in climate [8, 31, 36-38]. A reduction in vegetation cover also reduces the soil's ability to retain water and increases evaporation rate [39], facilitating the invasion of annual species with lower water requirements [40] and accelerating the decline of native annual species, associated with trees and shrubs.

Also *Abies* is a genus which reproduces with relative ease in natural forests, even though it tends to register low percentages of viability and a high number of empty seeds [41]. Likewise, *A. religiosa* is a species which grows extremely slowly when in the nursery [42]. Thus, the extraction of seedlings from natural forests with high densities of regeneration may offer an option for procuring seedlings for the restoration of degraded areas. Alternatively, in other reforestation programs in Mexico, it is common practice to clear the area to be reforested, or in other words to cut down shrubs and perennial and annual grasses (pers. obs.). This practice incurs costs and in the case of species which require a certain amount of shade in order to become established and grow vigorously, this eliminates the possibility of maintaining a favorable environment, where the plantation can be more successful. This is the case of plantations of *A. religiosa*; a species with a certain capacity for shade tolerance, and thus we recommend that reforestation programs of this kind should not eliminate *B. conferta* ground cover, at least during the first two years subsequent to planting.

In short, we can conclude that in the case of *A. religiosa* plantations, it is not necessary to remove the *B. conferta* shrubs, as neither the establishment, nor the survival of *A. religiosa* seedlings depends on the presence or absence of this shrub. On the other hand, both the height and coverage of *A. religiosa* seedlings was greater under the *B. conferta* canopy, which can also provide protection against cattle should they escape from grazing areas.

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