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Density and distribution mapping of invasive plant *Jatropha gossypiifolia* in priority savanna of Bama Resort, Baluran National Park, East Java, Indonesia

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Abstract. *Solfiyeni, Nurmalasari A. 2025. Density and distribution mapping of invasive plant* Jatropha gossypiifolia *in priority savanna of Bama Resort, Baluran National Park, East Java, Indonesia. Biodiversitas 26: 255-264. Jatropha gossypiifolia* (Bellyache bush) is one of the invasive alien plant species in the savanna of Baluran National Park, East Java, Indonesia. The invasiveness of *J. gossypiifolia* is the main focus of this study because this species has the potential to have a significant and far-reaching impact on the stability of the savanna ecosystem in Baluran National Park. This study aims to determine the density, distribution pattern, and distribution area of *J. gossypiifolia* and to analyze environmental factors that affect its presence in the savanna of Bama Resort, Baluran National Park. The survey method for distribution mapping and a single plot method to determine density and distribution pattern. Meanwhile, to analyze the relationship between environmental factors and plant density of *J. gossypiifolia*, Canonical Component Analysis (CCA) was used. The results showed that the density of *J. gossypiifolia* plants in the observation area of 400 m^2 was 1.94 individuals/m^2 or estimated in hectares around 19,400 individuals/ha and this plant was found growing in 15 sub-plots out of a total of 16 sub-plots observed in the field. The distribution pattern of *J. gossypiifolia* plants in the observation area is clustered with a Morisita Index value of 1.48. Furthermore, it is known that the distribution area of *J. gossypiifolia* plants in the priority savanna of Bama Resort is around 25 hectares of the total savanna area of Bama Resort of around 512 hectares. The existence of *J. gossypiifolia* plants is strongly influenced by the high and low light intensity. *Jatropha gossypiifolia* plants have spread quite widely in the priority savanna of Bama Resort, Baluran National Park. This plant is most commonly found growing in savannas close to the road, so it is necessary to routinely monitor each savanna as an effort to manage invasive alien plants in the savannas of Baluran National Park.

Keywords: Baluran, distribution, invasive, *Jatropha gossypiifolia*, savanna

INTRODUCTION

Indonesia is one of the world's richest regions in biodiversity, encompassing a wide variety of animals, plants, and microbes. Thanks to this wealth, Indonesia is recognized as a global mega biodiversity region. Unique examples of Indonesian flora include orchids (Metusala 2024), begonias (Saleh et al. 2023), gingers (Nurainas et al. 2024), soursop (Jirna et al. 2024), and bamboo (Ritonga et al. 2023a, b; et al. 2024a, b). One reason for the decline in unique plant species is the presence of invasive plants (Solfiyeni et al. 2023).

Invasive Alien Species (IAS) are the second most important global threat to global biodiversity after habitat degradation (Moshobane et al. 2022). Invasive Alien Species (IAS) are non-native species that can adapt, grow, and reproduce outside their natural habitat and are able to dominate their new habitat (Iqbal et al. 2020). The presence of IAS has become a major challenge for environmentalists because of its potentially serious impacts on food security, human health, economic development, and biodiversity (Convention on Biological Diversity 2016; Moshobane et al. 2019). Invasive alien plants canalter community structure, inhibit the growth of native species, and disrupt nutrient cycling, water balance, productivity, succession processes, and the integrity of biodiversity (Fabricante et al. 2021).

Jatropha gossypiifolia L. or bellyache bush, is native to tropical America in the central and southern regions of the Americas (Kumar and Singh 2012). *Jatropha gossypiifolia* is a perennial plant that is a small shrub or small tree with a height of about 2 m but in favorable areas can grow to exceed 4 m and grow sympodially. This plant has a thick, rather soft and hairy stem and when injured it will release watery sap. The leaves are purplish and sticky when young and glossy green when old. Each petiole and leaf margin is covered with sticky coarse hairs. The leaves are fingered with 3-5 lobes, about 16-19 cm long and 10-13 cm wide. Flowers are red with a yellow center, arranged in clusters at the end of the stem, and unisexual (Félix-Silva et al. 2014). The fruit is round or oval like a cherry and is separated into three lobes (mericarps) within which are three or four ovoid seeds. The root system is shallow and fleshy (Roberts and Florentine 2021).

Jatropha gossypiifolia was originally introduced to Australia in the late 1800's as an ornamental and medicinal plant. This plant has been widely used in traditional medicine such as in India to treat diarrhea and in Trinidad it is used to heal wounds and reduce pain, so it is widely introduced to various countries in the world (Wu et al.

2019). Several studies have also proven that this plant has potential as an antibiotic, antineoplastic, antimicrobial, anti-inflammatory, antioxidant, anticholinesterase, and antihypertensive. However, it has been considered invasive in 20 countries around the world because it has established dense monocultures that can reduce the presence of native plants in the invaded areas (Roberts and Florentine 2021). In addition, it has spread to 52 countries in Africa, Australia, and Asia. *Jatropha gossypiifolia* mostly grows in tropical and subtropical countries or known as pantropical plants (Wu et al. 2019).

The presence of *J. gossypiifolia* has raised ecosystem concerns in many regions. In northern Australia, the Northern Territory, and Queensland *J. gossypiifolia* has been categorized as a priority environmental weed, a weed that requires immediate control action and is one of 200 invasive plants with high toxicity. Whereas in South Africa *J. gossypiifolia* has not been included in the list of alien and invasive plants but has been categorized as a species under surveillance to facilitate eradication efforts. In addition, *J. gossypiifolia* is widely found and has a risk of invasion in the eastern and northern coastal areas of Indonesia such as in West Timor, Sumba, Sumbawa, Lombok and Sumbawa (Moshobane et al. 2022).

Jatropha gossypiifolia is known to be invasive due to its ability to grow in various habitat types, such as dry areas, savannas, and agricultural ecosystems, posing a threat to native biodiversity in many regions of the world (Roberts and Florentine 2021). As an invasive species, *J. gossypiifolia* has higher competitive properties, such as adaptability to a wide range of soil and climatic conditions and the ability to spread rapidly through seeds and vegetative shoots (Randall et al. 2009). This species can disrupt native vegetation community structure, reduce resource availability for native flora, and alter ecosystem dynamics through interactions with local pollinator fauna and herbivores. In addition, *J. gossypiifolia* also produces allelopathic chemical compounds that can inhibit the growth of native species, increasing its invasive potential in ecosystems (Heard et al. 2012).

Savanna is a term that refers to ecosystems in tropical and subtropical regions, characterized by the presence of large expanses of grassland that cover the ground evenly. Grass growth in savannas has different patterns according to the season, which is influenced by the availability of water. Meanwhile, woody plants are found to grow rarely and do not form a tight and closed canopy (Sutomo et al. 2016). Baluran National Park is one of the conservation areas in Indonesia that has the largest savanna vegetation on the island of Java, Indonesia so it is known as "Africa van Java". Savannas in Baluran National Park are inhabited by a variety of flora and fauna whose survival depends on the integrity of the savanna. However, the integrity of the savanna in Baluran National Park is beginning to be threatened by the presence of invasive alien plants that begin to interfere with the existence of native plants (Wahono et al. 2022).

Acacia nilotica (L.) Willd. ex Del., is an invasive plant that has a negative impact on the savanna in Baluran National Park because it forms a very dense growth pattern and forms a closed canopy (Wahono et al. 2022). Apart from that, *A. nilotica* can also be a threat to the savanna because its mature trees appear to be fire resistant and can form thorny bushes, causing several types of grass as the main component of the savanna to not survive. Apart from that, this could threaten the existence of large mammals in Baluran National Park due to reduced grass and land for activities (Sutomo et al. 2016). Therefore, in recent years Baluran National Park has focused on solving the problem of *A. nilotica* invasion, both by conducting various research and trying various management techniques (Wahono et al. 2022). However, this does not rule out the possibility of other potentially invasive foreign plants in Baluran National Park.

According to Wahono et al. (2022) there are 72 species of alien plants that have been identified until 2017 in Baluran National Park. The alien plants consist of 13 types of trees, 10 types of shrubs, 4 types of climber / creeper, 44 types of herbs and 1 type of grass. Of the various types of alien plants, one type that has been categorized as invasive besides *A. nilotica* in the savanna of Baluran National Park is *J. gossypiifolia*. In addition, based on the results of the risk analysis of alien plant species in the Baluran National Park area in 2017, it was found that *J. gossypiifolia* has the potential to pose a very high invasion risk and has been recommended to carry out management efforts by preventing the spread of alien plant species.

Based on the results of the risk analysis, data on the density, distribution pattern, and distribution mapping of *J. gossypiifolia* are needed as the first step to designing effective conservation and management strategies. Distribution pattern is one of the most important characteristics in community ecology. Information on the density and diversity of a plant species is not enough to provide a detailed picture of the state of the population of an area (Lonare et al. 2012). Analysis of the distribution pattern of a plant species can be done using the Morisita Index (Krebs 2014). In addition, the area of distribution of a plant species can be obtained by measuring the area of plant cover. This is based on the wider the spread of a species, the wider the cover (Zheng et al. 2015). The purpose of this study is to provide up-to-date information on the density and distribution pattern of *J. gossypiifolia* in a specific observation area, as well as the distribution area of *J. gossypiifolia in* the priority grassland of Bama Resort, Baluran National Park, East Java, Indonesia.

MATERIALS AND METHODS

Study area

This research was conducted in the priority savanna area of Bama Resort, Baluran National Park, Banyuputih Sub-district, Situbondo District, East Java Province, Indonesia. The topography of this research location is flat, with altitudes ranging from 15 to 35 meters above sea level (masl). Priority savanna is a savanna that is prioritized in terms of restoring the savanna ecosystem from the threat of invasive plants such as *A. nilotica* and including *J. gossypiifolia* (Figure 2). These savannas are the center of

activity for most wildlife in Baluran National Park. Priority savannas are divided into 8 management areas, namely West Bekol, Bekol I, Bekol II, East Bekol, Central Bekol Tower, Derbus, Curah Udang, and Bama savannas (BTN Baluran 2020). Plotting for data collection on the number of individuals was carried out in one of the savannas selected by purposive sampling, namely in Bama savanna with coordinates 7º50'37.6" S and 114º27'27.6" E (Figure 1).

Data collection

There are two methods used in this research, namely a survey method with quadratic plots and a survey method without plots but a direct survey based on the distribution area of *J. gossypiifolia*. For the quadratic plot method, a plot measuring 20×20 m was created, which was divided into 16 sub-plots measuring 5×5 m (Figure 3) which were placed using purposive sampling on the Prioritas Bama Resort savanna. The vegetation in the study area is relatively uniform because it is dominated by the *J. gossypiifolia* species, so the number of 16 sub-plots is considered to represent vegetation conditions (Kent and Coker 1992). In each sub-plot, the number of *J. gossypiifolia* individuals found and abiotic factors such as air temperature, air humidity, and humidity are recorded. light intensity, soil pH and soil temperature. Apart from that, the height and water content of the ground were also measured. Quadratic plot data were used to analyze the density and distribution patterns of *J. gossypiifolia*.

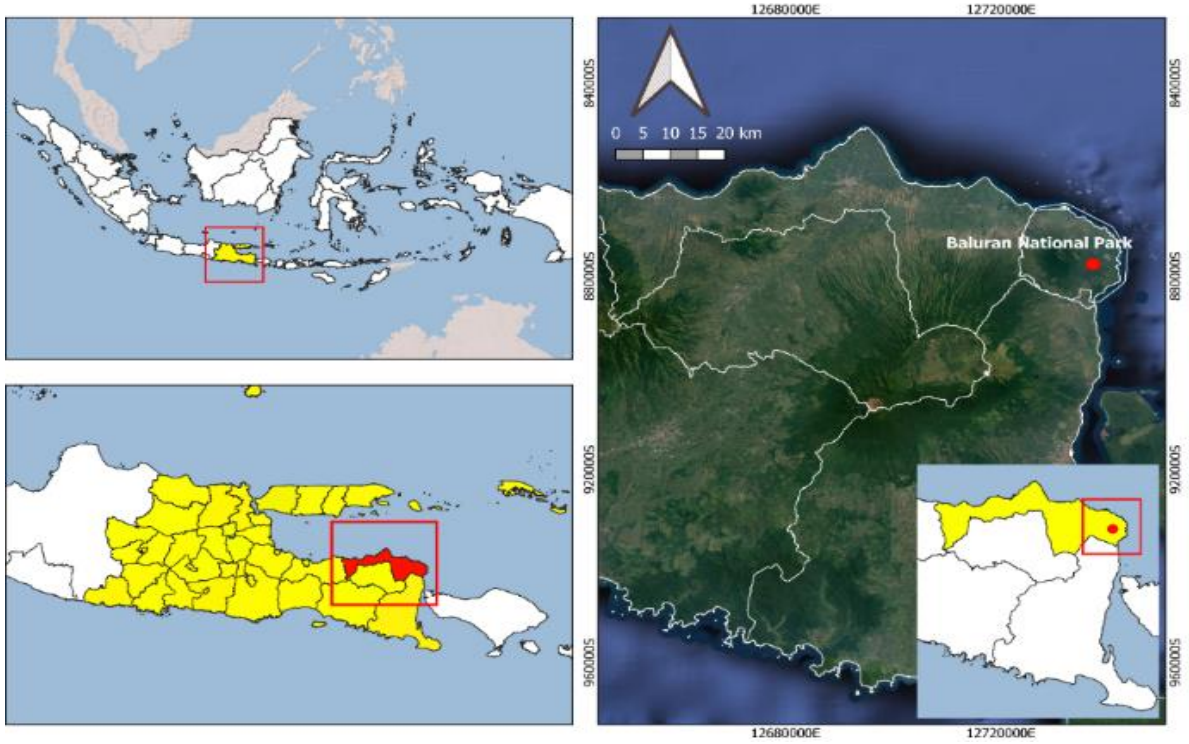

Figure 1. Location ofthe study area in Bama Resort, Baluran National Park, Situbondo, East Java, Indonesia

Figure 2. Morphology of *Jatropha gossypiifolia*

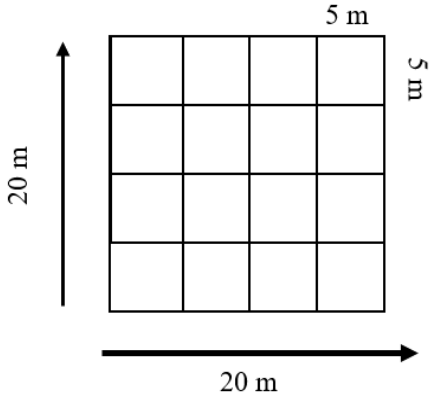

Figure 3. Density observation plot and distribution pattern

The second method is the survey method, this method is used to obtain data on the distribution of *J. gossypiifolia* in the priority savanna of Bama Resort. Distribution data collection was carried out directly to the field by recording the presence point of *J. gossypiifolia* plants in the priority savanna of Bama Resort using the Avenza Maps application that has been installed on a smartphone (Greenleaf et al. 2023), this activity was guided directly by Baluran National Park staff. The growth of *J. gossypiifolia* in the field forms dense and extensive groups, making it impossible to record coordinates of each individual. Therefore, distribution data was collected by surrounding the plant group or forming polygons according to the outermost point of *J. gossypiifolia* growth with the Avenza Maps application.

The avenza maps application in this study is used as a substitute for GPS to obtain coordinate point data or distribution polygons which will later be processed in the QGIS application. There are 38 polygons marked as distribution groups of *J. gossypiifolia*. Avenza Maps is an application that can be used for mapping areas, photographing conditions in the field, determining coordinate points, measuring distance and area, providing descriptions of findings, and importing and exporting placemarks (Merry and Bettinger 2019). The advantages of this application are (i) high accuracy for mapping; (ii) can be used for mapping at the desired point only; (iii) can be used when there is no signal (offline mode) (Turohmahohmah et al. 2021).

Before data collection in the field, a map of the observation location in the form of a PDF file was uploaded to the Avenza Maps application. The map is the base layer for the mapping process and serves to determine the boundaries of the mapping unit. When *J. gossypiifolia* plants were found in the field, the first step was to adjust the current position on the base map in Avenza Maps. Then, path recording or the formation of distribution polygons in the application was carried out by activating the "GPS path recording" feature in the application while walking around the outermost point of *J. gossypiifolia* growth. After the first and last recording starting points meet, a polygon can be formed. The same thing was done until the entire distribution of *J. gossypiifolia* plants in the Bama Resort priority savanna was recorded. In Avenza Maps, coordinate point data and distribution polygons recorded in the field will be directly added on top of the observation location map as a second layer. In addition, the area of *J. gossypiifolia* distribution polygons can be directly read on Avenza Maps in units of square meters or hectares. Furthermore, the data from Avenza Maps is exported as a shapefile so that it can be processed in the QGIS application.

Data analysis

Density

The density of a species is the number of individuals of a species per unit area. According to Kusmana et al. (2022), the density of a species can be calculated by the following formula:

$$\text{Density (D)} = \frac{\text{Total number of individuals}}{\text{Sample plot size}}$$

Frequency

The frequency of a species is the intensity with which a species is found in an observation plot. According to Kusmana et al. (2022) the frequency of the presence of a species can be calculated by the following formula:

$$\text{Frequency (F)} = \frac{\sum \text{Subplots found a species}}{\sum \text{all sample subplots}}$$

Distribution pattern

Analysis of the distribution pattern of *J. gossypiifolia* plants can be calculated using the Morisita Index (Krebs 2014). The following equation can determine the Morisita Index (Id) value:

$$Id = n\left(\frac{(\sum x^2 - \sum x)}{(\sum x)^2 - \sum x)}\right)$$

Where,

Id : Morisita scatter index

n : Number of observation plots

Σx^2 : The square of the number of individuals found in each plot ($x_1^2+x_2^2+ \ldots$)

Σx : Total number of individuals found in each plot ($x_{1+}x_{2+} \ldots\ldots\ldots$)

The results of the Morisita spread index (Id) analysis can be defined as follows: Id=1: the distribution pattern is random; Id>1: the distribution pattern is clustered; Id<1: the distribution pattern is uniform.

Distribution mapping

Polygon area data of *J. gossypiifolia* plant populations obtained in the avenza maps application, then exported and inputted in the QGIS application (Version 3.36.2). In the QGIS application, the polygons of each *J. gossypiifolia* plant population will be displayed on the Rupa Bumi Indonesia base map equipped with several additional information features. After that, the area of each polygon is summed up to determine the total area of *J. gossypiifolia* distribution in the Bama Resort priority savanna. The final result is a map of *J. gossypiifolia* plant distribution in the priority savanna area of Bama Resort, Baluran National Park.

Relationship between environmental factors and density

Measurement data on environmental factors were collected in each observation sub-plot and analyzed using CCA (Canonical Correspondence Analysis) using the Past program version 4.03.exe. This analysis is to determine what environmental factors can affect the presence of *J. gossypiifolia* plants in the priority savanna of Bama Resort.

RESULTS AND DISCUSSION

The density of *Jatropha gossypiifolia* plant

Based on Table 1, there were 776 individuals of *J. gossypiifolia* found in the observation area measuring 20×20 m with a total area of 400 m^2. From these results, the density value of *J. gossypiifolia* is 1.94 individuals/m^2. If converted into units of hectares, it can be estimated that the density of *J. gossypiifolia* plants in one hectare of land in Bama Resort is 19,400 individuals/ha. The number of *J. gossypiifolia* plants obtained varied in each observation sub-plot, the highest number was found in sub-plot 13, namely 127 individuals, and was not found in sub-plot 3, namely 0 individuals (Table 1). In sub-plot 13, *J. gossypiifolia* was found the most because the sub-plot conditions were more open without being covered by tree canopy (Figure 4.A) compared to other sub-plots, so that the incoming light intensity was high at 48.22% (Table 1). In sub-plot 3, no *J. gossypiifolia* plants were found, because the sub-plot is in a place that is shaded by the tree canopy that grows around the observation sub-plot (Figure 4.B), causing the incoming light intensity to be low, which is 26.85% (Table 1). To determine the minimum sampling area plot size, a species area curve is created. Based on this curve, the size of the sampling area created is considered representative because the curve has begun to flatten and the increase in the number of *J. gossypiifolia* individuals is not significant as in Figure 4.

The number of *J. gossypiifolia* plants is more open than shaded locations. This is because this plant needs sunlight to support its germination process and is not tolerant of shade (Roberts and Florentine 2021). This statement is also supported by Xu et al. (2011), who states that one of the environmental factors that most affect the presence of plants in a location is the intensity of sunlight and shade. This is also reinforced by the opinion of Solfiyeni et al. (2022a), who states that invasive plants can grow well in open locations with high sunlight and are supported by other environmental factors, such as certain temperatures and humidity.

Furthermore, based on Table 1, it can be seen that *J. gossypiifolia* plants can be found in 15 sub-plots out of a total of 16 observation sub-plots (Figure 5). Based on the number of sub-plots found *J. gossypiifolia*, the frequency value of the presence of *J. gossypiifolia* can be obtained is 0.94. This shows that the distribution of *J. gossypiifolia* in the 400 m^2 observation area is almost evenly distributed.

Table 1. Number of *Jatropha gossypiifolia* plants and relative light intensity in each observation sub-plot

Observation sub-plot	Number of individuals	Relative light intensity (%)
1	8	34.05
2	15	35.12
3	0	26.85
4	26	38.37
5	54	37.41
6	33	35.97
7	28	38.05
8	39	39.91
9	44	37.22
10	48	38.24
11	46	38.03
12	90	43.28
13	127	48.22
14	105	47.58
15	79	41.30
16	34	35.11
Total	**774**	

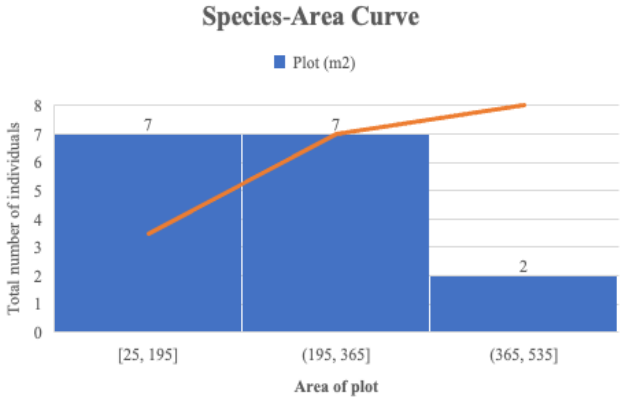

Figure 4. The species area curve

Figure 5. Observation sub-plot condition. A. Open and B. Sheltered

However, this result only applies to the observation area and cannot describe the presence of *J. gossypiifolia* as a whole in the savanna of Bama Resort. According to Dillis et al. (2017), there are three important parameters that can describe the size of a population occupying space in a forest structure, one of which is density. This can be seen from the number of individuals found at the observation location, namely the more the number of individuals found, the higher the density and frequency values and vice versa.

Distribution pattern of *Jatropha gossypiifolia* plants

Based on calculations using the Morisita index formula, the results show that the distribution pattern of *J. gossypiifolia* plants in the observation plot is clustered. Morisita index value obtained is 1.48 with the value of Id>1, which is based on the provisions in the Morisita index; if the value of Id>1, then the distribution pattern of a species is clustered. According to Ahmed et al. (2020), clustered distribution patterns are the most common distribution patterns found in the distribution of a species in nature. They arerarely found in random or uniform distribution patterns. According to Solfiyeni et al. (2022b), this distribution pattern can provide an overview of the horizontal distribution of invasive alien plant species populations in nature.

The clustering pattern of *J. gossypiifolia* distribution indicates that the environmental conditions in the observation area are heterogeneous. This is in accordance with the opinion of Adhya et al. (2024) which states that *J. gossypiifolia* populations tend to grow and gather in environmental conditions that suit their needs (Adhya et al. 2024). According to Hartini et al. (2021), non-uniform environmental conditions indicate that the resources available at that location are limited. This leads to competition between individuals from different or the same population in obtaining nutrients, space, and light at a location. It is the interaction between biotic and abiotic components such as this that.

Clustered distribution is caused by heterogeneous environmental conditions and is influenced by the group's behavior and the plant's reproductive ability (Sidabukke et al. 2021). According to Randall et al. (2009), *J. gossypiifolia* plants have high reproductive capabilities because they can reproduce vegetatively and generatively. In addition, it is also supported by spreading, which naturally, the fruit can explode (explosive) to release the seeds so that they will be scattered around the mother plant. This is supported by the statement of Abolmaali et al. (2018) that plants that reproduce by seeds usually have a clustered distribution pattern; Idris and Hariri (2024) state that this is due to the tendency of the fruit/seed to fall near the parent.

The relatively fast life cycle of *J. gossypiifolia* and its high seed production ability also support the formation of new population groups in an area within a short period. According to Randall et al. (2009) this plant can produce about 50 pods per month, where each pod contains 3-4 seeds in it. Mature *J. gossypiifolia* plants are capable of producing around 2,000-12,000 seeds per year, with the flowering period of this plant taking place quickly, which is around 53 days after germination, followed by the next seed production on day 80. However, this varies depending on the climatic conditions in a particular location.

The physical condition of the environment is also a very important factor in determining the distribution pattern of a plant species (Hartini et al. 2021). This is because plants will make morphological and physiological adaptations to survive in certain environmental conditions (Abolmaali et al. 2018). Based on environmental parameters measured in the field, it shows that environmental conditions that suit the needs of *J. gossypiifolia* plants (Table 2)

Based on Table 2, the average air temperature for *J. gossypiifolia* growth in the observation area is 30ºC with 60% air humidity and 38% relative light intensity. According to Solfiyeni et al. (2024a, b). The high temperature can be influenced by the sparse tree cover in the study site so that the light intensity reaching the forest floor becomes higher and the air humidity becomes low. In addition, according to Moshobane et al. (2022), the suitable temperature for *J. gossypiifolia* ranges between 10°C and 30°C. Furthermore, soil pH 7.3, soil temperature 36°C, and soil moisture content 24.07% were obtained, these results indicate that *J. gossypiifolia* plants can grow in dry soil conditions.

According to Rengifo et al. (2002), *J. gossypiifolia* plants can adapt well to environmental conditions such as savannas by proportionally reducing the thickness and area of their leaves. These plants can also close stomata to reduce water evaporation during the photosynthesis process. According to Randall et al. (2009), most *J. gossypiifolia* plants can also shed their leaves during extreme drought, leaving only a few small leaves at the end of the stem (Figure 6).

***Jatropha gossypiifolia* plant distribution**

The total area of *J. gossypiifolia* plant distribution obtained from the measurement of the polygon area formed from the growth of *J. gossypiifolia* clustered in each priority savanna in Bama Resort is 25 ha with the percentage of distribution in the priority savanna of Bama Resort is 4.8% of the total priority savanna area (Table 3). Based on Table 3, it can be seen that the first largest distribution of *J. gossypiifolia* plants is in Bama savanna, which is 10 ha or about 20% of the total savanna area. Furthermore, the second largest distribution is in Bekol II savanna, which is 4 ha or about 30% of the total savanna area.

Visually, the distribution of *J. gossypiifolia* plants in the Bama Resort priority savanna can be seen in Figure 6. Based on Figure 6, it can be seen that the most extensive distribution of *J. gossypiifolia* is in the Bama savanna. On the map, the Bama savanna is indicated by a yellow area, while the distribution of *J. gossypiifolia* is denoted by a light green polygon. In particular, the map shows that this plant grows by forming extensive clusters in each of the priority savannas in Bama Resort. This important finding is in line with the statement of Wahono et al. (2022) who have observed similar clustered formations in the National Park, thus further supporting the results of this study that *J. gossypiifolia* plants are found growing scattered in certain

locations forming extensive clusters with homogeneous and dense cover and are generally found in open to moderate locations.

Based on the distribution map of *J. gossypiifolia* plants in priority savannas in Bama Resort, it can be seen that *J. gossypiifolia* is most commonly found in savanna areas around the road. This is due to the savanna area around the road which tends to have open vegetation, and human activities around the road. This condition causes the savanna area to always be exposed to sunlight so that it becomes a habitat that is highly favored by *J. gossypiifolia* plants. In addition, human activities around the area can also support the dispersal activities of *J. gossypiifolia* plants. This is in accordance with the statement of Bebawi et al. (2007) that *J. gossypiifolia* plants prefer to grow on open land with natural vegetation that has been damaged or disturbed by animals or by human activities such as road construction.

In addition, the presence of *J. gossypiifolia* in the priority savanna of Bama Resort is also supported by the topography and altitude of the location. Based on field measurements, the altitude of the savanna in Bama Resort ranges from 15-35 meters above sea level. This shows that *J. gossypiifolia* plants prefer to grow in locations that are lowlands. According to Sidabukke et al (2021), the presence of a plant species is also influenced by variations in location altitude above sea level. This is reinforced by the statement of Roberts and Florentine (2021), which states that *J. gossypiifolia* plants are more commonly found growing at low altitudes, namely 0-60 masl.

The wide distribution of *J. gossypiifolia* plants is inseparable from the role of seed dispersal agents in helping spread the seeds of these plants. The process of seed dispersal of a plant species can be assisted by wind (anemocory), water (hydrocory), animals (zookory), and the plant itself (autocory). The fruit of the *J. gossypiifolia* plant can float in water so that it can flow with rainwater to lower places. In addition, *J. gossypiifolia* seeds contain elaiosomes (small parts attached to the seed and containing a lot of fat and other dead cells) and are rich in carbohydrates, lipids, and proteins that can attract animals to eat them such as ants (Hartini et al. 2021). The seeds can also be dispersed through the feces of mammals and birds that eat the seeds (Idris and Hariri 2024). *Jatropha gossypiifolia* plants can also spread through the release of seeds (ballistochory) from fruit capsules that can launch seeds as far as 13 m from the parent plant Roberts and Florentine (2021).

Table 2. Environmental parameters at the observation site

Environmental parameters	Average value measurement results
Air Temperature	30°C
Air Humidity	60 %
Soil pH	7.3
Soil Temperature	36°C
Moisture content of Soil	24.07 %
Relative Light Intensity (RLI)	38 %

Table 3. The extent of *Jatropha gossypiifolia*plant distribution in priority savanna

Savanna name	Savanna area (ha)	Distribution area of (ha)	Percentage distribution (%)
Bekol I	112.13	1.70	1.30
Bekol II	13.43	4	30
West Bekol	33.90	1	3
East Bekol	64.43	3	4.70
Bekol Middle Tower	17.50	1.50	7.40
Derbus	101	1	1
Curah Udang	120	2.80	2.30
Bama	50	10	20
Total	512.48	25	4.8

Figure 6. A. Morphology of *Jatropha gossypiifolia* in the dry season (Bebawi 2022); B. Morphology of *J. gossypiifolia* in the rainy season

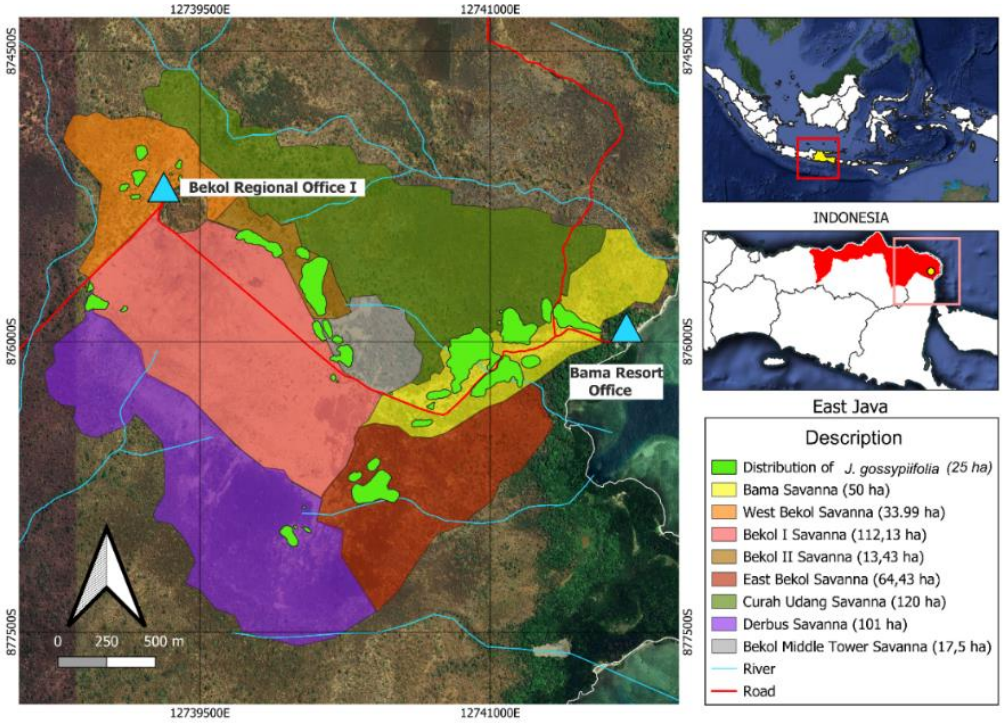

Figure 7. *Jatropha gossypiifolia* plant distribution in priority savanna

Jatropha gossypiifolia plant density relationship with environmental factors

Environmental conditions can significantly influence the density of a plant species in a given location. As shown in Figure 7, the graph presents the relationship between the density of *J. gossypiifolia* plants in each observation sub-plot and the abiotic environmental factors in the priority savanna of Bama Resort. The blue dots represent observation sub-plots, and the blue lines symbolize environmental variables, showing to interpretation of the data. As Gunawan et al. (2021) suggest, the closer the point is to the variable vector line, the stronger the influence of the variable on the observed object.

Environmental conditions can significantly affect the density of a plant species in a location. As shown in Figure 8, the graph presents the relationship between *J. gossypiifolia* plant density in each observation sub-plot and abiotic environmental factors obtained around the observation area. The blue dots represent the observation sub-plots, and the blue line represents the environmental variables, indicating the interpretation of the data. As stated by Gunawan et al. (2021), the closer the point is to the variable vector line, the stronger the influence of the variable on the observed object.

Based on the results of Canonical Correspondence Analysis, to analyze the relationship between environmental variables (temperature, air humidity, soil pH) and the distribution or density of the *J. gossypiifolia* species. In this picture, the density of *J. gossypiifolia* shows that the location of the species is related to environmental variables. This species has a positive relationship with air temperature, where in Figure 8 it can be seen that its position is close to the temperature vector. *Jatropha gossypiifolia* is more likely to be found in areas with high air temperature and is less related to air humidity. Soil pH has a greater influence on the distribution of other species that are not visible in this plot.

According to Zoratti et al. (2014) light is an environmental factor that plays an important role in supporting plant growth and development so that it can affect the abundance of a plant species. In Figure 8, it can also be seen that air humidity is negatively correlated with *J. gossypiifolia* plant density; namely, when the air humidity at the research site is high, the plant density is low. This result is in accordance with the statement of Roberts and Florentine (2021), which states that *J. gossypiifolia* plants really need full sunlight to support the germination process and are intolerant of shade.

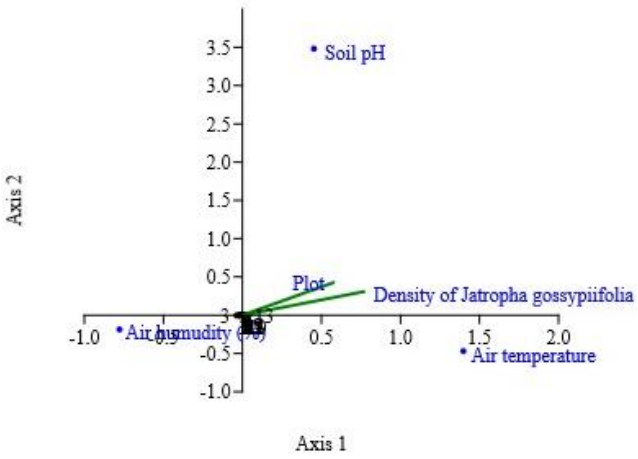

Figure 8. Canonical Correspondence Analysis **(**CCA**)** of *Jatropha gossypiifolia* plant density with abiotic environmental factors

This study concluded that the density of *J. gossypiifolia* plants in the observation area of 400 m^2 was 1.94 ind/m^2 or about 19,400 ind/ha. Furthermore, the presence of *J. gossypiifolia* plants is mostly found in the observation sub-plots, namely in 15 sub-plots out of a total of 16 observation sub-plots. There are several environmental factors that affect the density of *J. gossypiifolia* plants in the priority savanna of Bama Resort, namely light intensity, air temperature, and soil pH. The distribution pattern of *J. gossypiifolia* plants is clustered with a distribution area reaching 25 hectares of the entire priority savanna area in Bama Resort. The most extensive distribution of *J. gossypiifolia* is in Bama savanna, which is 10 hectares.

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