Revista Árvore
ISSN: 0100-6762
r.arvore@ufv.br
Universidade Federal de Viçosa
Brasil

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Revista Árvore, vol. 37, núm. 6, noviembre-diciembre, 2013, pp. 1001-1010
Universidade Federal de Viçosa
Viçosa, Brasil

Available in: http://www.redalyc.org/articulo.oa?id=48829909002

REFORESTATION FEASIBILITY IN AREA FORMERLY USED FOR CATTLE RASING IN THE STATE OF RONDÔNIA, NORTHWEST BRAZILIAN AMAZON[1]

Michelliny de Matos Bentes Gama[2], Rodrigo Barros Rocha[2], Ana Karina Dias Salman[2], Ângelo Mansur Mendes[2] e Marivaldo Rodrigues Figueiró[2]

ABSTRACT – Little knowledge on initial behavior of native tree species in recovering landscapes in the Amazon is a current concern for expanding reforestation in the region. Thus, the aim of this study was to evaluate the establishment of native tree species that could be used for reforestation in area previously covered by a pasture of brachiaria grass (*Brachiaria brizantha*) destined for intensive cattle rasing in the State of Rondônia. For this, there were performed previous diagnostic of landscape changes and the election of tree species based on the ecological group information. Some of the critical macronutrients for plant growth were supplied in the holes to alleviate nutrient deficiencies. In addition, growth and survival parameters were taken to evaluate the initial behavior of species. Six native tree species planted with different combinations (10mx10m, 5mx5m and 3mx3m) had survival rate and growth (total height, girth stem and crown projection area) measured in different intervals: 6-month, 12-month and 24-month after planting. All the species presented survival rate over 90% at 24 months and comparable growth indices to other native species under similar situation and in the region. Overall, *Schizolobium amazonicum* (bandarra), the non-identified legume tree 1 (acácia grande) and *Colubrina glandulosa* (sóbrasil) averaged over 90% the highest girth stem growth all over the area. *S. amazonicum* and the non-identified legume tree 1 (acácia grande) presented the best results for height and canopy area growth parameters, respectively. The combination among native tree species from initial successional ecological groups and fertilizer was favorable to promote reforestation in the conditions of the study area in Rondônia.

Keywords: Legal Amazon; The Brazilan Forest Code; Environmental Adequacy.

VIABILIDADE DE REFLORESTAMENTO EM ÁREA ORIGINALMENTE UTILIZADA PARA CRIAÇÃO DE GADO NO ESTADO DE RONDÔNIA, NOROESTE DA AMAZÔNIA BRASILEIRA

RESUMO – O pouco conhecimento sobre o desempenho inicial de espécies nativas na recuperação de paisagens na Amazônia é uma limitação importante para a expansão do reflorestamento na região. Assim, o objetivo deste trabalho foi avaliar o estabelecimento de espécies arbóreas nativas no reflorestamento de área de pastagem anteriormente destinada à criação intensiva de gado no Estado de Rondônia. Para tanto, foi realizado um diagnóstico prévio das mudanças na paisagem do local e seleção de espécies com base na informação do grupo ecológico. Alguns dos macronutrientes críticos para o crescimento de plantas foram adicionados à cova para corrigir deficiências nutricionais. Adicionalmente, foram tomados os parâmetros de sobrevivência e crescimento para acompanhar o desempenho das espécies. Seis espécies nativas plantadas em diferentes arranjos (10 m x 10 m, 5 m x 5 m e 3 m x 3 m) tiveram taxa de sobrevivência e crescimento (altura total, diâmetro do coleto e área de projeção de copa) avaliados em intervalos distintos após o plantio das mudas: 6, 12 e 24 meses, respectivamente. Todas as espécies apresentaram taxa de sobrevivência acima de 90% aos 24 meses e índices comparáveis ao desempenho de espécies nativas em situação similar e na região. ***Schizolobium amazonicum*** *(bandarra), a leguminosa não identificada 1 (acácia grande), e* ***Colubrina glandulosa***

[1] Recebido em 25.10.2012 aceito para publicação em 06.11.2013.

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(sóbrasil) obtiveram o melhor desempenho em diâmetro de colo; ***S. amazonicum*** *e a leguminosa não identificada 1 (acácia grande) apresentaram os melhores resultados dos indicadores altura e projeção de copa, respectivamente. O uso de espécies nativas pertencentes a grupos ecológicos de sucessão inicial combinado com a fertilização foi favorável para promover reflorestamento nas condições da área de estudo em Rondônia.*

Palavras-chave: Amazônia Legal; Código Florestal Brasileiro; Adequação Ambiental.

1. INTRODUCTION

The expansion of areas for cattle raising together with slash-and-burn agriculture in the State of Rondonia has contributed to keep high deforestation rates since the strategy of regional occupation and development under colonization projects was initiated by the Brazilian government in the region (FEARNSIDE; GRAÇA, 2006; FEARNSIDE, 2007).

By the late 1970s, this portion of the Amazon comprised intensive land-use changes, mainly due to dynamic of human activities, that caused a hard replacement of its ample measures of natural forests (SHONE; CAVIGLIA-HARRIS, 2006), mainly with crop cultivation and pastures for livestock, especially dairy and beef cattle.

Forty years after the settlement, the causes of deforestation in this pioneer frontier are quite the same (ALMEIDA et al., 2006) and they are still reinforced by the expansion of new crop farming that may negatively affect the maintainence of of Legal Reserve (LR) and Permanent Protected (PP) areas in the majority of farms in the State of Rondônia.

The Amazon region accounts for nearly 80 million heads associated with a strong meat and milk industry (POCCARD-CHAPUIS et al., 2010). Regarding the Brazilian milk market, the State of Rondonia is the seventh largest producer and the largest one in the North Region – 706.6 million liters (IBGE, 2013), with around 90% of the production coming from small-scale/family-farm business, influencing 40% of the Gross Domestic Product - GDP (SANTANA, 2003). However, cattle production in the Amazon rainforest is strongly linked to few environmental benefits due to the modest productivity rates and doubtful sustainability.

One of the major challenges for sustainable livestock production in the Amazon region is to minimize the impact of deforestation accomplished with environmental regulations to keep forest standing. Moreover, reconciling production and environment under co-friendly production systems (POCCARD-CHAPUIS et al., 2010) may be considered a new dimension for cattle farming in the region.

The use of native species under mixed plantation systems in the tropical region is suitable for restoration, providing production, protection, besides biodiversity conservation (MONTAGNINI, 2001; BARBOSA et al., 2003; PIOTTO et al., 2004; MELOTTO et al., 2007, 2009; LIMA et al., 2009; GRIS et al., 2012).

As a result, over the last few years, initiatives in reforestation with native species in the Amazon rainforest, as a means of reducing negative environmental impact due to intensive production and towards the provision of environmental services, have increased (BARBOSA et al., 2003; ALMEIDA et al., 2006; ALVINO-RAYOL et al., 2011).

Methods for increasing the use of native species in reforestation in the Amazon rainforest have also been tested in recent years (TONINI; ARCO-VERDE, 2005; MELOTTO et al., 2007, 2009; LIMA et al, 2009; ALVINO-RAYOL, 2011). Despite the lack of an efficient spreading of technical information (propagation, establishment and tending) of suitable and promising native tree species for recovering and, or, revegetation is still a barrier for technicians and landowners to invest in reforestation practices.

Moreover, the use of native tree species is a recommendation to be followed according to the Brazilian Forestry Code, within forestation and or, reforestation activities in Legal Reserve and Permanent Protected areas of farms in the Brazilian Amazon (BRASIL, 2012).

Therefore, the objective of this study was to evaluate the feasibility of establishing six native tree species in area intensively used by cattle farms in the State of Rondônia, as an aid to reforestation initiatives under similar conditions.

2. MATERIAL AND METHODS

2.1 Study area

The study was carried out at the research station of Embrapa located in the municipality of Presidente Médici (Figure 1 - 11º17'S and 61º55'W and 390 m.a.s.l), Rondonia Sate, 400 km far from the capital. The climate is tropical with a dry season - A*w* (Köppen classification) with a rainfall ranging from 2.000 mm to 2.300 mm (TOWNSEND et al., 2003). Rainy season is from November to April, when 80.3% of total annual rainfall of the region has been recorded (SCERNE et al., 2000). Open Ombrophilous Forest is the dominant vegetation type, characterized by open canopy with emergent individuals and high frequency of palm trees (BRASIL , 1978; IBGE, 2012). The landscape presents smooth relief and has suffered alteration by cattle raising activity which is the main activity of land use in this region since the 1980's. Annual average temperature is 24.5°C with an average relative air humidity of 80% and Podzolic Red-Yellow as the predominant soil in the area (TOWSEND et al., 2000).

The research station of Embrapa has 95.63 ha (INCRA, 2008) and part of this area, as most native forest cover in the municipality, is highly fragmented and restricted to small-medium isolated spots of natural vegetation. The Embratel stream belongs to the hydrographic basin of Machado River and plays an important role as the main water source inside the research station. Deforestation surrounding the property is the main cause of the negative effects in the stream flow, which has been intensified with the presence of the dairy cattle, since the 1980s (PEREIRA; TAVARES, 2000). In the last five years, it has been observed that the Embratel stream flow presents high variation in volume of water, reaching critical levels mainly from May to October, which is the dry period in the region.

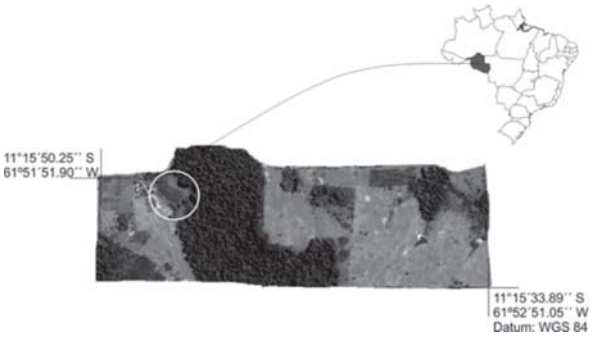

Figure 1 – Localization of the study area at the research station of Embrapa in the Municipality of Presidente Médici, State of Rondônia.

Figura 1 – *Localização da área de estudo na estação experimental da Embrapa no município de Presidente Médici, Estado de Rondônia.*

2.2 Site selection and preparation for planting

A preliminary survey along the Embratel stream was carried out in December, 2007 to evaluate the main effects of the current cattle farming management system. By then, the reforestation of the surrounding area of the riparian forest was taken as an urgent task to attend the environmental law requirements for Legal Reserve and Permanent Protected areas. At that time, around 3.86 ha of Marandu grass (*Brachiaria brizantha*) was the main vegetation surrounding the edge of Embratel stream.

The species were classified into successional groups according to Carvalho (2003, 2006) and Rede (2004). Thus, six target species - canopy and understory trees - frequent and adapted to the edafoclimatic conditions of Northwest Brazilian Amazon were chosen (Table 1). The plant strategy of species followed the characteristics of each successional group, and it is described according to Gris et al. (2012) as follows: i) pioneer: light demanding species during most of their lifetime, with very fast initial growth and short lifetime (from four to 30 years); important in the formation of seed banks; ii) secondary species: shade tolerant species in the beginning of their lifetime, with a moderate to rapid initial growth and a lifetime from 25 to 100 years; iii) climactic: strong shading tolerant species, may remain in the understory during their entire lifetime, slow groth, and a moderate to very long lifetime, forming plantlet banks. The elected species are also commonly used in reforestation campaigns under the Rehabilitation Land Program held by the Environmental Policy Quarters of Candeias do Jamari, settled 20 km far from the capital, Porto Velho.

According to procedures of Embrapa (CLAESSEN, 1997), soil samples from 0-20, 20-40 and 40-60 cm layers were taken using a hand Auger for soil pH (H_2O), organic matter (MOS), phosphorus (P), and exchangeable cation K^+ and Ca^{2+}+Mg^{2+} analyses , all measured at the Soil Laboratory of the Federal University of Rondônia - UNIR (Table 2).

Table 1 – Tree species and spacing in the reforestation trial in the Municipality of Presidente Médici, State of Rondonia. Each group represents a different tree planting strategy.

Tabela 1 *– Espécies arbóreas e densidades do reflorestamento no município de Presidente Médici, Estado de Rondônia. Cada grupo de espécies representa uma estratégia diferente de plantio.*

Scientific name,Botanical family, Successional group	Common name,Spacing	Number of plants
Colubrina glandulosa Perkins, Rhamnaceae, Secondary	Sóbrasil, 10m x 10m	32
Hymenaea courbaril var. *stilbocarpa* Leguminosae, Climax	Jatobá, 10m x 10m	5
*Tabebuia serratifolia*Bignoniaceae, Secondary	Ipê amarelo, 5m x 5m	15
Colubrina glandulosa Perkins, Rhamnaceae, Secondary	Sóbrasil, 5m x 5m	59
Hymenaea courbaril var. *stilbocarpa* Leguminosae, Climax	Jatobá, 5m x 5m	18
Tabebuia serratifolia, Bignoniaceae, Secondary	Ipê amarelo, 5m x 5m	15
Non-identified 1, Leguminosae, Secondary	Acácia pequena, 3m x 3m	15
Non-identified 2, Leguminosae, Secondary	Acácia grande, 3m x 3m	20
Schizolobium parahyba var. *amazonicum* (Vell), Leguminosae, Pioneer	Bandarra, 3m x 3m	45
	Total	224

Table 2 – Soil chemical characteristics at different depths in the reforestation trial at Embrapa's research station, Presidente Médici, State of Rondonia.

Tabela 2 – *Características químicas do solo a diferentes profundidades no reflorestamento piloto na estação experimental da Embrapa, Presidente Médici, estado de Rondônia.*

Depth m	Clay g kg-1	MOS g kg-1	pH H_2O 1:1	$P_{Mehlich^{-1}}$ mg kg^{-1}	$K_{Mehlich^{-1}}$ $cmolckg^{-1}$	Ca+Mg $cmolckg^{-1}$	Al $cmolckg^{-1}$	H+Al $cmolckg^{-1}$	CTC $molckg^{-1}$	V %	m %
Area with Poaceae cover											
0-20	256	10.89	5.23	1.02	0.09	1.82	0.44	2.69	4.58	36.78	20.33
20-40	194	5.56	5.35	0.69	0.21	1.71	0.13	2.47	4.36	41.44	6.11
40-60	226	3.78	5.33	1.07	0.17	1.21	0.43	2.40	3.74	35.56	14.00
Forest fragment											
0-20	223	13.67	4.27	2.50	0.17	1.40	0.17	2.80	4.37	35.67	9.67
20-40	247	8.67	4.37	2.63	0.50	1.17	0.23	2.77	4.10	32.33	15.33
40-60	253	7.00	4.47	3.97	0.49	1.43	0.23	2.77	4.33	36.00	13.33

Because of the relief conditions on the farm, the reforestation trial was settled in 0.65 ha in the beginning of the rainy season in January,2008. Different plant densities (10mx10m, 5mx5m and 3mx3m) formed 31 rows, set according to the number of plants and its ecological group (GRIS et al., 2012; LIMA et al., 2009; RODRIGUES and GANDOLFI, 1996). Seedlings with 0.30 m of average height were planted in holes of 50 cm depth x 50 cm diameter. Mineral fertilization with some of the critical macronutrients for plant growth were supplied in the holes only to soothe nutrient deficiencies, as follows: 100g.kg^{-1} dolomite calcarium (70% PRNT) + 1 liter of dry bovine manure + 10g.kg^{-1} simple superphosphate (sps) + 5g.kg^{-1} potassium chloride + 4g.kg^{-1} FTE (micronutrients).

All holes were set 30m away from the edge of the stream to avoid contamination by the fertilizers. Electric isolation protected the perimeter of the planted area. Weeding and plants coronation were made as cultural tracts twice a year. Survival (%) and growth rates (total height in m, and girth in cm), with adaptions from Melotto et al. (2009), of a sample of 224 measurable seedlings were taken in three different intervals, 6, 12 and 24 months, after planting. In addition, all seedlings had crown projection area (m^2) assessed at the ages of 12 and 24 months, following Hemery et al. (2005). Plants were recorded as dead when the stem was dry and had no leaves.

2.3 Statistical analysis

Aiming to quantify the effects and iteration, the species growth parameters at the three plant densities were considered according to:

$$Y_{ij} = \mu + A_i = E_j + AE_{ij} + ei_{jk},$$

where:

Y_{ij} = ith specie within jth plant density,

U = general mean of the experiment,

A_i = ith plant density,

$E_{j:}$ jth species,

AE = iteraction between the ith plant density and the jth species, and

ei_{jk} = experimental error.

The PROC GLM procedure of SAS PROC GLM Statistical Analysis System (SAS, 1990) was used to adjust unbalanced experiments. Turkey's t test was conducted on significant variables by ANOVA to test differences among the means (CALLEGARI-JACQUES, 2003).

3. RESULTS

More than 90% of all seedlings survived even 24 months after planting in Presidente Médici, which is consistent with other studies on initial behavior of native tree species in recovering degraded lands from agriculture and cattle raising in Brazilian rainforests (BARBOSA ET AL., 2003; MELOTTO ET AL., 2009; GRIS ET AL., 2012). The non-identified legume tree species 1 and 2 (*Acácia grande* and *acácia pequena*) and *S. amazonicum* (bandarra) showed the highest survival rate. The highest seedlings loss (15%) was presented by *C. glandulosa* (sóbrasil) followed by *T. serratifolia* (ipê amarelo) (11%) and *H. courbaril* (7%). Considering only the leguminous tree species, *S. amazonicum* (bandarra) presented the lowest mortality rate (5%).

Regarding seedling height growth, no density effects in the age of evaluation were found. *S. amazonicum* (bandarra) and the non-identified 1 species (acácia grande), pioneer species, sustained growth over the subsequent 2 years and exhibited the highest values when compared to the other species in the area (Figure 2). Much of height growth was observed at the end of the 24th-month, with more than 60% of species reaching over 3.10 m, including *C. glandulosa* and the non-identified 2 species (acácia pequena), secondary species whereas *H. courbaril*, with expressive survival rate, did not present sufficiently good growth among the tested species.

The highest values for girth stem were observed for the non-identified 1 species (acácia grande) and *S. amazonicum* (bandarra), respectively (Figure 3). The light demanding species *T. serratifolia* (ipê amarelo) did not present a superior performance.

Estimates of stand density had no effects on the growth behavior of the evaluated species. Considering the crown projection as a landscape recovery indicator, results showed that more than 50% of the species were able to promote important protective functions in the area (Figure 3) in the 24-month period, as weed suppression by shadowing the soil, mainly represented by the non-identified 1 legume tree (acácia grande) and *S. amazonicum* (bandarra).

In this context and even with lower values, results found observed for *H. courbaril* can be considered satisfactory when compared to Tonini and Arco-Verde (2005), who observed 60.8 m^2 of crown projection area for this species at the age of seven years in the State of Roraima, under 2.5m x 2.0m spacing.

4. DISCUSSION

Environmental adaptative capacity is one of the main factors for species survival in forestation and reforestation programs. The establishment of the native tree species in this trial tended to favorable results, due to the plasticity of the species (ALVINO-RAYOL et al., 2011), and although growth behavior should be monitored over time (WISHNIE et al., 2007), the highest mortality rates for all species were mostly found only after the critical establishing phase for tropical seedlings, and in the beginning of the third year of the trial.

The low mortality rate for some species, as for example the pioneer leguminous tree species *S. amazonicum* - bandarra (5%), also found in Alvino-Rayol et al. (2011) in pure stands with the species, also contributes to corroborate this species as a good source of environmental services on farms, even under modified natural forest cover conditions and deficient water availability during the dry season in the region.

Studies have reported the accelerating growth rates of native species over the time in the Amazon region (SAMPAIO ET AL., 1989; NEPSTAD ET AL., 1991; BARBOSA ET AL., 2003; TONINI; ARCO-VERDE, 2005; ALMEIDA ET AL., 2006; MELOTTO ET AL., 2009).

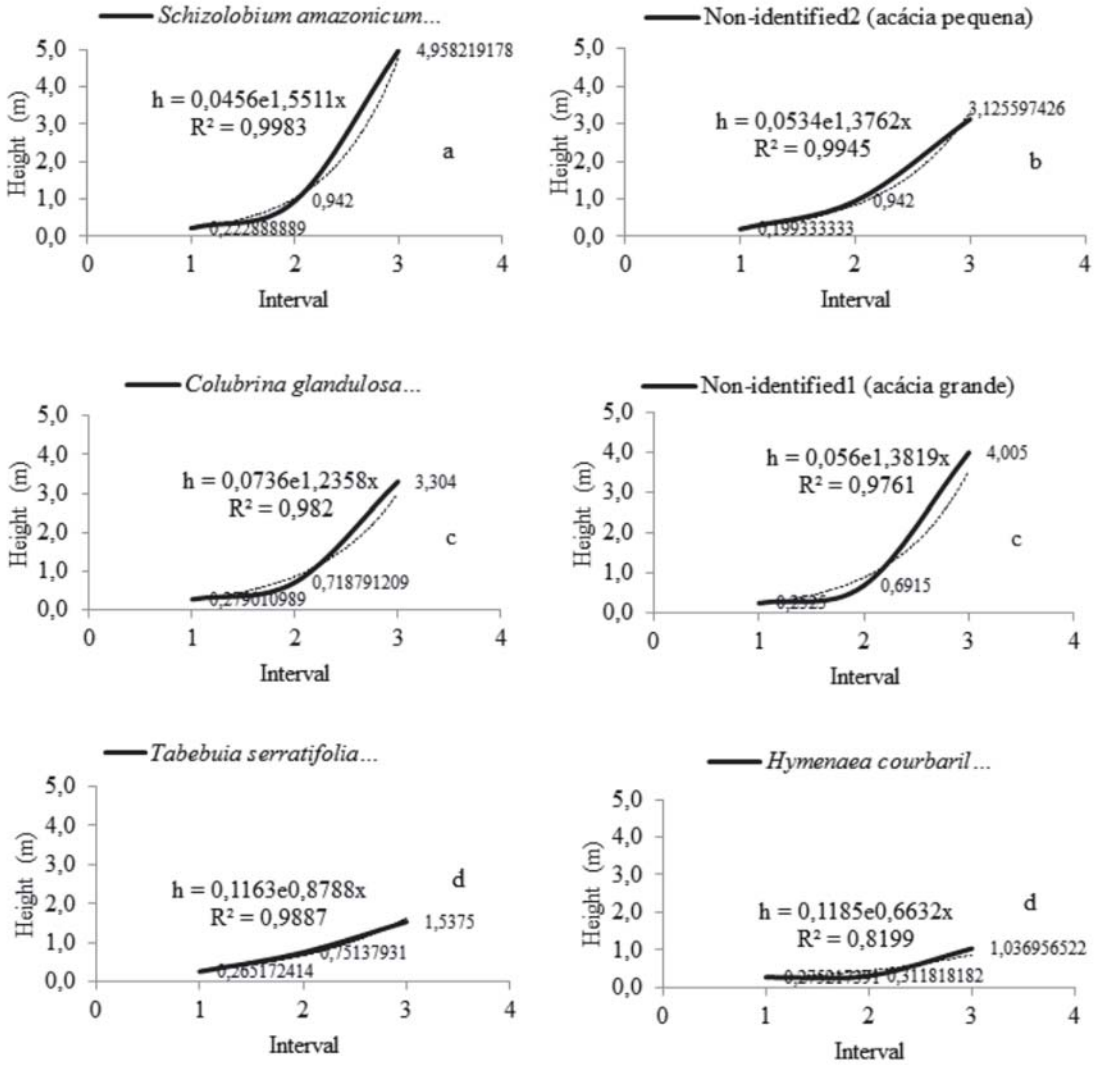

Figure 2 – Height (m) of six native tree species established in the Municipality of Presidente Médici, State of Rondônia. Where: Interval 1 = 6-month, Interval 2 = 12-month and Interval 3 = 24-month. Common letters indicate means that are not significantly different from one another at 5% significance level.

Figura 2 – *Altura (m) de mudas de seis espécies arbóreas nativas plantadas no município de Presidente Médici, Estado de Rondônia. Onde: Intervalo 1 = 6 meses, Intervalo 2 = 12 meses e Intervalo 3 = 24 meses. Médias seguidas de mesma letra não diferem significativamente ao nível de 5% de probabilidade.*

The height growth for most species followed a trend found in other areas in the Amazon region, such as *C. glandulosa*, the non-identified 2 species (acácia pequena), both secondary species. *S. amazonicum* presented expressive growth in height, which reached over 3.10 m in the late evaluation of this study at the age of 24 months in Presidente Médici. Such results represent 30% of the height found by Rossi et al. (2003) in the Central Amazon for the species under 3m x 2m spacing and 48 months of age. According to Vieira et al. (1998), wide initial densities might avoid the effects of mutual competition among species.

Few species as for example *H. courbaril* did not present sufficiently good growth among the tested

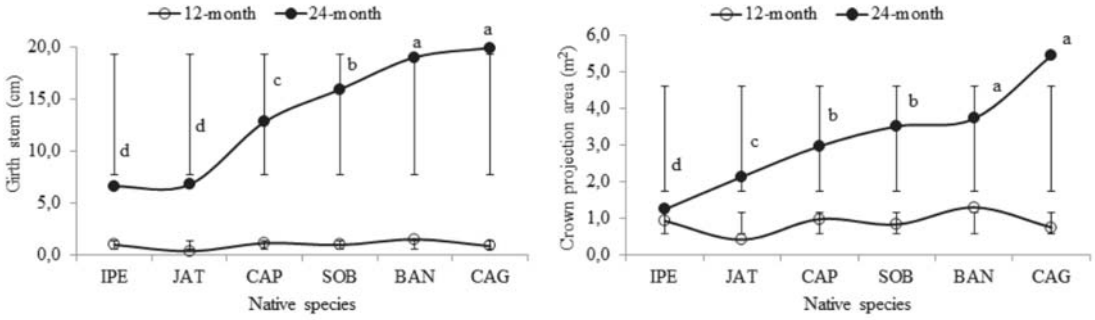

Figure 3 – Girth stem (cm) and crown projection area (m^2) of native tree species established in the Municipality of Presidente Médici, State of Rondônia. Where: IPE - *Tabebuia serratifolia*, JAT – *Hymenaea courbaril* (jatobá), CAP – non-identified 2 (acácia pequena), SOB – *Colubrina glandulosa* (sóbrasil), BAN – *Schizolobium amazonicum* (bandarra), and CAG - non-identified 1 (acácia grande). Common letters indicate means that are not significantly different from one another at 5% significance level.

Figura 3 *– Diâmetro de colo (cm) e projeção de copa (m^2) de espécies arbóreas nativas plantadas no município de Presidente Médici, Estado de Rondônia. Where: IPE -* ***Tabebuia serratifolia****, JAT –* ***Hymenaea courbaril*** *(jatobá), CAP – non-identified 2 (acácia pequena), SOB –* ***Colubrina glandulosa*** *(sóbrasil), BAN –* ***Schizolobium amazonicum*** *(bandarra), e CAG - non-identified 1 (acácia grande). Médias seguidas de mesma letra não diferem significativamente ao nível de 5% de probabilidade.*

species, partially due to its ecological characteristics, suggesting that it may be suitable for reforestation under the same site conditions, however. These findings were similar in Lima et al. (2010), who observed plants of *H. courbaril* with average height of 41.67 cm at 4 months of age in the Municipality of Ji-Paraná, 90 km away from Presidente Médici.

The light demanding species *T. serratifolia* did not present higher superior performance as expected. A similar behavior for this genera was found in Melotto et al. (2007), who observed low values of girth stem for *Tabebuia* sp. in a mixed plantation with *Brachiaria brizantha* under the age of 12 months.

Crown projection can be used as another important parameter to follow species behavior in reforestation initiaves (TONINI; ARCO-VERDE, 2005), mainly in this region in the Amazon forest, where understanding ecological and functional characteristics of target native tree species (MELLOTO et al., 2009) are of major need for promoting reforestation for structural and functional diversity in areas where cattle farming needs to fit to environmental requirements.

5. CONCLUSION

The low mortality and initial growth characteristics (plant height, girth stem, crown diameter) of native tree species from initial successional ecological groups adapted to Amazon soil and climate conditions, with the supplying of critical macronutrients by artificial fertilization tends to favor the recovery in areas previously used for cattle farming as their values continually increased as plant age increased. Despite the intrinsic ecological and functional characteristics of each native tree species used in the experiment, the pioneer *Schizolobium amazonicum* and the secondary *Colubrina granulosa* aachieved the highest growth values in all growing seasons.

6. ACKNOWELDGEMENTS

The authors thank Neilton Santos Pereira, Giovana Fiorella Zamora López and Poliana Heloisa da Silva Capelasso for their important contributions in the different stages of this initiave sponsored by Embrapa, and coordinated by its Animal Production Scientific Core in Rondônia.

7. REFERENCES

ALMEIDA, E.; SABOGAL, C.; BRIENZA JÚNIOR, S. **Recuperação de áreas alteradas na Amazônia: experiências locais, lições aprendidas e implicações para políticas públicas**. Indonésia: CIFOR, 2006. 202p.

ALVINO-RAYOL, F. O.; ROSA, L. S.; RAYOL, B. P. Efeito do espaçamento e do uso de leguminosas de cobertura no manejo de plantas invasoras em reflorestamento de *Schizolobium amazonicum* HUBER EX. DUCKE (PARICÁ). **Revista Árvore**, v.35, n.3, p.391-399, 2011.

BARBOSA, A. P. et al. O crescimento de duas espécies florestais pioneiras, pau-de-balsa (*Ochroma lagopus* Sw.) e caroba (*Jacaranda copaia* D. Don), usadas para recuperação de áreas degradadas pela agricultura na Amazônia Central, Brasil. **Acta Amazonica**, v.33, n.3.p.466-482, 2003.

BRASIL. Ministério das Minas e Energia. Departamento Nacional de Produção Mineral. Projeto RADAM BRASIL. **Levantamento de Recursos Naturais, Região Folha sc. 20, Porto Velho**. Rio de Janeiro, v.16. 1978. 668p.

BRASIL. **Lei nº 12.651, de 25 de maio de 2012**. Dispõe sobre a proteção da vegetação nativa; altera as Leis nos 6.938, de 31 de agosto de 1981, 9.393, de 19 de dez. de 1996, e 11.428, de 22 de dezembro de 2006; revoga as Leis nos 4.771, de 15 de setembro de 1965, e 7.754, de 14 de abril de 1989, e a Medida Provisória no 2.166-67, de 24 de agosto de 2001; e dá outras providências. Disponível em: <http://www.planalto.gov.br/ccivil_03/_Ato2011-2014/2012/Lei/L12651.htm>. Acesso em: 09 jul. 2013.

CALLEGARI-JACQUES, M.S. **Bioestatística**: princípios e aplicações. Porto Alegre: Artmed, 2003. 255p.

CARVALHO, P. E. R. **Espécies arbóreas brasileiras**. Brasília, DF: Embrapa Informação Tecnológica; Colombo: Embrapa Florestas, 2003. v.1. 1039p. (Coleção Espécies Arbóreas Brasileiras).

CARVALHO, P. E. R. **Espécies arbóreas brasileiras**. Brasília, DF: Embrapa Informação Tecnológica; Colombo: Embrapa Florestas, 2006. v.2. 647p. (Coleção Espécies Arbóreas Brasileiras).

CLAESSEN, M. E. C. (Org.). **Manual de métodos de análise de solo**. 2.ed. Rio de Janeiro: EMBRAPA-CNPS, 1997. 212 p. (Documentos, 1).

FEARNSIDE, P.M. Brazil's Cuiabá-Santarém (BR-163) Highway: The environmental cost of paving a soybean corridor through the Amazon. **Environmental Management,** v.39, n.5, p.601-614, 2007.

FEARNSIDE, P.M.; GRAÇA, P. M. L. A. BR-319: Brazil's Manaus-Porto Velho highway and the potential impact of linking the arc of deforestation to Central Amazonia. **Environmental Management**, v.38, n.5, p.705-716, 2006.

GRIS, D.; TEMPONI, L. G.; MARCON, T. R. Native species indicated for degraded area recovery in Western Paraná, Brazil. **Revista Árvore**, v.365, n.1, p.113-125, 2012.

HEMERY, G. E.; SAVILL, P. S.; PRYOR, S. N. Applications of the crown diameter–stem diameter relationship for different species of broadleaved trees. **Forest Ecology and Management**, v.215, n.1-3, p.285-294, 2005.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA - IBGE. **Indicadores IBGE**. Rio de Janeiro: 2012. 70p. Disponível em: <http://www.ibge.gov.br/home/estatistica/indicadores/agropecuaria/producaoagropecuaria/abate-leite-couro-ovos_2012_publ_completa.pdf >. Acesso em: 01 de abr. 2013.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA - IBGE. **Manual técnico da vegetação brasileira:** sistema fitogeográfico, inventário das formações florestais e campestres, técnicas e manejo de coleções botânicas, procedimentos para mapeamentos. Rio de janeiro: IBGE- Diretoria de Geociências, 2012. 271p. (Manuais Técnicos de Geociências, 1).

INSTITUTO NACIONAL DE COLONIZAÇÃO E REFORMA AGRÁRIA – INCRA. **[Processo administrativo nº. 0248/91] 2008**. Consulta local, realizada por Neilton Santos Pereira na Unidade Avançada de Ji-Paraná – RO do INCRA em 2008.

AMPRECHT, H. **Silvicultura en los trópicos**. Göttingen: Instituto de Silvicultura de la Universidad de Göttingen, 1986. 335p.

LIMA, J. A.; SANTANA, D. G.; NAPPO, M. E. Comportamento inicial de espécies na revegetação da mata de galeria na Fazenda Mandaguari, em Indianópolis, MG. **Revista Árvore**, v.33, n. 4, p. 685-694, 2009.

LIMA, A. L. S.; ZANELLA, F.; CASTRO, L. D. M. Crescimento de *Hymenaea courbaril* L. var. *stilbocarpa* (Hayne) Lee et Lang. e *Enterolobium contortisiliquum* (Vell.) Morong (Leguminosae) sob diferentes níveis de Sombreamento. **Acta Amazonica**, v.40, n.1., p.43-48, 2010.

MELOTTO, A. M. et al. Sobrevivência e crescimento inicial em campo de espécies florestais nativas do Brasil Central indicadas para sistemas silvipastoris. **Revista Árvore**, v.33, n.3, p. 425-432, 2009.

MELOTTO, A. M. et al. Crescimento inicial de mudas de espécies florestais nativas do Brasil Central plantadas em pastagem de *Brachiaria brizantha* cv. Marandu. **Revista Brasileira de Biociências**, v.5, supl.1, p.288-290, 2007.

MONTAGNINI, F. Strategies for the recovery of degraded ecosystems: experiences from Latin America. **INCI,** v.26, n.10, p.498-503, 2001.

NEPSTAD, D. C.; UHL, C.; SERRAO, E. A. Recuperation of a degraded Amazonian landscape: forest recovery and agricultural restoration. **Ambio**, v.20, n.6. p.248-255, 1991.

ORONHA, N. C. et al. Recovery of degraded pasture in Rondônia: macronutrients and productivity of *Brachiaria brizantha*. **Revista Brasileira de Ciência do Solo**, v.34, n.5, p.1711-1720, 2010.

PEREIRA, R. G.; TAVARES, A. C. **Comportamento produtivo de búfalos para carne em Porto Velho-RO**. Rondônia: Embrapa-CPAF, 2000. 5p. (Circular Técnica, 183).

PROJETO RADAM-BRASIL. Folha sc. 20 Porto Velho. Rio de Janeiro: 1978. v.16. 668p. (Levantamento dos Recursos Naturais, 12).

PIOTTO, D. et al. Pure and mixed forest plantations with native species of the dry tropics of Costa Rica: a comparison of growth and productivity. **Forest Ecology and Management**, v.190, n.2-3, p.359-372, 2004.

POCCARD-CHAPUIS, R. et al. Cattle production in the Amazon Rainforest: reasons for the success, challenges for ecological intensification. **Advances in Animal Biosciences**, v.1, p.520-520, 2010.

REDE de sementes da amazônia. **Ipê amarelo – *Tabebuia serratifolia* (Vahl) Nichols.** 2004. Disponível em: <http://www.rsa.ufam.edu.br:8080/sementes/especies/pdf/doc5.pdf>. Acesso em: 18 de maio 2009.

RODRIGUES, R. R.; GANDOLFI, S. Recomposição de florestas nativas: princípios gerais e subsídios para uma definição metodológica. **Revista Brasileira de Horticultura Ornamental**, v.2, n.1, p.4-15, 1996.

ROSSI, L. M. B. et al. Potential forest species for plantations in Brazilian Amazonia. In: WORLD FORESTRY CONGRESS, 12., 2003. Quebéc. Disponível em: <http://www.fao.org/docrep/article/wfc/xii/0537-b1.htm>. Acesso em: 19 de dez. 2010.

SAMPAIO, P. T. B.; BARBOSA, A. P.; FERNANDES, N. P. Ensaio de espaçamento com caroba – *Jacaranda copaia* (AUBL.) D. Don. Bignoniaceae. **Acta Amazonica**, v.19, único, p.383-389, 1989.

SANTANA, A. C. Descrição e análise da cadeia produtiva do leite no Estado de Rondônia. **Movendo Idéias**, v.8, n.14, p.24-36, 2003.

SAS INSTITUTE INCORPORATED, SAS/STAT®. **User's guide**. Version 6. 4.ed. Cary: SAS Institute Incorporated, 1990. v.2. 846p.

SCERNE, R. M. C. et al. **Aspectos agroclimáticos do município de Ouro Preto D'Oeste - RO**: Atualização qüinqüenal. Belém: CEPLAC/SUPOR, 2000. 48p. (Boletim Técnico, 17).

SHONE, B. M.; CAVIGLIA-HARRIS, L. Quantifying and comparing the value of non-timber forest products in the Amazon. **Ecological Economics**, v.58, n.2, p.249-267, 2006.

TONINI, H.; ARCO-VERDE, M. F. Morfologia de copa para avaliar o espaço vital de quatro espécies nativas da Amazônia. **Pesquisa Agropecuária Brasileira**, v.40, n.7, p.633-638, 2005.

TOWNSEND, C. R. et al. **Condições térmicas ambientais sob diferentes sistemas silvipastoris em Presidente Médici – Rondônia**. Rondônia: EMBRAPA - CPAF, 2000. 4p. (Comunicado Técnico, 188).

TOWNSEND, C. R. et al. Condições térmicas ambientais sob diferentes sistemas silvipastoris na Amazônia Ocidental. **Pasturas Tropicales**, v.25, n.3, p.42-44, 2003.

VIEIRA, A. H.; LOCATELLI, M.; SOUZA, V. F. **Crescimento de castanha-do-Brasil em dois sistemas de cultivo.** Porto Velho: EMBRAPA – CPAF, 1998. 13p. (Boletim de Pesquisa, 22).

WISHNIE, M. H. et al. Initial performance and reforestation potential of 24 tropical tree species planted across a precipitation gradient in the Republic of Panama. **Forest Ecology and Management,** v.243, n.1, p.39-49, 2007.