Herpetological Conservation and Biology 16(2):295–302.
Submitted: 28 May 2020; Accepted: 21 May 2021; Published: 31 August 2021.

Local Extinction of *Tropidurus catalanensis* Caused by Plantation Forestry in the Pampas of Brazil

Alexis Grote Kellermann[1,3], *Mariana Scalon-Luchese*[1], *Renata Cardoso Vieira*[1], *Ismael Verrastro Brack*[2], and *Laura Verrastro*[1]

[1]*Universidade Federal do Rio Grande do Sul, Departamento de Zoologia, Laboratório de Herpetologia, Avenida Bento Gonçalves, 9500, prédio 43435, Agronomia, 91501-970, Porto Alegre, Rio Grande do Sul, Brazil*
[2]*Programa de Pós-Graduação em Ecologia, Universidade Federal do Rio Grande do Sul, Instituto de Biociências, Departamento de Ecologia, Avenida Bento Gonçalves, 9500, prédio 43422, Agronomia, 91501-970, Porto Alegre, Rio Grande do Sul, Brazil*
[3]*Corresponding author, e-mail: alexis.qix@hotmail.com*

Abstract.—**We evaluated the impact of a eucalyptus plantation on a population of Western Collared Spiny Lizard (*Tropidurus catalanensis*), a saxicolous lizard of the Pampas biome in Brazil. We monitored the population for 7 y, since before the trees were planted until the trees completely shaded the rocky outcrops occupied by the species. We captured and marked 286 lizards and recaptured 95 individuals throughout the study period. We observed a gradual decrease in the number of monthly captures of adult lizards and a trend of decreasing body mass, body condition, and survival probability. We also found differences on the daily and seasonal activity of *T. catalanensis*. Conversion of native grasslands into tree plantations can result in simplified and homogeneous habitats that exclude most species that depend on native open field environments. These changes affect the fauna, flora, and the physical and ecological processes of a site and our results show that such alterations intensify the threats to *T. catalanensis*.**

Key Words.—body condition; conservation; ecology; eucalyptus; forestry; saxicolous lizard; shading; survival

Introduction

Habitat loss and fragmentation are among the main threats to global biodiversity (Wilson et al. 2016). The conversion of natural landscapes into agricultural fields and tree plantations is one of the main causes of changes in landscape use (Foley et al. 2005). For instance, between 2000 and 2010, there was an increase of five million hectares of cropland annually around the world (Food and Agriculture Organization of the United Nations 2010). In Brazil, up to 2010, eucalyptus (*Eucalyptus* spp.) forests occupied 4,754,334 ha, whereas by 2015, this number had increased to 7,465,000 ha (Instituto Brasileiro de Geografia e Estatística 2015).

The Pampas biome is restricted to the great steppes of southern South America and occupies the southernmost region of Brazil covering 176,000 km^2 in the country (Picolli and Schnadelbach 2007). This biome encompasses great extensions of open formations, where grass species predominate (Overbeck et al. 2007; Suertegaray and Silva 2009). There are also patches of arboreal vegetation such as gallery and hillside forests (Suertegaray and Silva 2009). With the loss of approximately 50% of its natural coverage by 2009 (Instituto Brasileiro do Meio Ambiente 2011), the Pampas is the second most altered Brazilian biome, which makes the expansion of monoculture of woody species even more concerning. Despite this, only 0.36% of the biome is included in the Brazilian National System of Conservation Units (Sistema Nacional de Unidades de Conservação; Schwanzs 2010).

Changes in soil quality such as erosion, salinization, and acidification are among the impacts that the monoculture of exotic plant species can cause to the environment (Cannell 1999; Jobbágy and Jackson 2003; Jackson et al. 2005). The interference of water cycles, either by the reduction of water flow into rivers, drying of lentic water bodies, or by other mechanisms (Farley et al. 2005; Jackson et al. 2005) also affects biodiversity. These changes influence the richness, abundance, composition, and structure of the fauna and flora of ecosystems (Silva 2002; Kanowsky et al. 2005; Zahn et al. 2009; Schwanzs 2010).

Reptiles are considered a good model for analyzing the effects of environmental perturbations and habitat loss due to their ectothermy and low vagility (Vitt and Caldwell 2014; Saccol et al. 2017). The impact of exotic tree species to reptiles has been studied at a variety of sites (Valentine 2006; Mott et al. 2010; Martin and Murray 2011; Stellatelli et al. 2013; Saccol et al. 2017). Despite the abundant literature concerning the influence of exotic tree monoculture systems on reptile species, most of these studies demonstrate such effects by comparing sites with and without exotic trees, usually evaluating their effect on local communities or assemblages. The saxicolous Western Collared

Spiny Lizard (*Tropidurus catalanensis*) inhabits rocky outcrops in the Pampas and could be impacted by tree monocultures. This lizard is distributed in northwestern Uruguay, northeastern Argentina, southern Paraguay, and southern Brazil (Rodrigues 1987; Kunz and Borges-Martins 2013).

In our study, we monitored a population of *T. catalanensis* that inhabited rocky outcrops since before eucalyptus trees were planted until when they had completely shaded the area. We evaluated the impact of the introduction of a eucalyptus plantation on the body condition and survival of this lizard population. We hypothesized that, with the increase of the shading imposed by the eucalyptus over the outcrops, habitat conditions for the species would be altered. We predicted that the body condition and the survival of these lizards would be significantly worse after trees matured than when the area was treeless.

Materials and Methods

Study site.—The study site consisted of a 1.9 ha rocky outcrop located at 29°58'42''S, 55°24'59''W (108 m elevation), in the municipality of Alegrete, Rio Grande do Sul State, southern Brazil (Fig. 1). The study area was located in the Pampas biome, and the climate is humid sub temperate with well-defined seasons, with well-distributed rainfall throughout the year. The mean precipitation of the area is 1,574 mm and the mean annual temperature is 18.6° C, varying from a monthly average of 12.7° C in the coldest month (June) to 42.8° C in the hottest (January; Maluf 2000). Originally, the outcrops were surrounded by two main habitats: grassy-woody Steppe (native grasslands) and alluvial Deciduous Seasonal Forest (Boldrini 1997). In August 2008, though, a private company planted eucalyptus seedlings in a linear arrangement around the outcrops about 5 m from its margins.

Figure 1. Location of the study area in the municipality of Alegrete (29°58'42''S and 55°24'59''W), State of Rio Grande do Sul, Brazil.

Data collection.—We conducted lizard capture-recapture surveys monthly from May 2008 to December 2011. We did not visit the area in 2012, resuming the monthly fieldwork to verify the presence of lizards from August 2013 to October 2014. In this last period, we also searched for lizards on outcrops nearby the study area, which are inhabited by other populations of the same species, to check for emigration to adjacent areas. To find the lizards, we randomly explored the area by looking at outcrops from above from a distance and then up close, inspected cracks between rocks and loose rocks. We always started searches at 0800 and ended at 1800. In all monthly visits, we standardized the sampling effort (54 person-hours) to avoid bias of different search effort.

When sighted, we captured lizards by hand. We recorded the snout-vent length (SVL) of each lizard with a caliper of 0.02 mm precision, and the body mass (BM) with a 30 or 600 g capacity hand scale with 0.2 and 0.5 g precision, respectively. According to the minimum reproductive size of the species (males: SVL > 81.6 mm, females: SVL > 74.8 mm; Arruda 2009), we classified them as juveniles or adults, and we determined the sex of adult individuals. According to Pinto et al. (2005), males have wider heads and thinner bodies than females of the same size and have colored ventral scales (yellow and black), while females have uniform colored ventral scales.

We marked and identified all lizards by assigning a number to each toe and amputating the last phalanx in a unique combination for each individual (Verrastro 1991). To avoid unnecessary disturbance, we noted naturally occurring markings to identify individuals when possible, such as blotches, colored scales, and scars. After capturing and marking, we released lizards in the same locations of capture.

Data analysis.—Data were both normally distributed ($P = 0.402$) and homoscedastic ($P = 0.105$). We used Analysis of Variance (Zar 1999) to compare the capture ratio of adults across different years, using the Holm-Sidak method for comparisons between years. We used Linear Regression to evaluate sexual dimorphism by comparing the SVL (mm) and the BM (g) of female and male adults, as well as the variation of body condition (quotient between BM and SVL) for each sex in relation to the years. We tested if the body condition varied through the years, between sexes, and the interaction between year and sex. Data met parametric assumptions for Linear Regression (following Zuur et al. 2009). We applied Tukey's Contrast Tests for pairwise comparison of body condition between years. We used Likelihood Ratio Tests to test the significance of the variables in the linear models, starting with the general model (with interaction term) and dropping variables sequentially. Linear models and Likelihood Ratio tests were fit on the R platform (R Development Core Team 2019). For all these tests, we considered $\alpha = 0.05$ for significance.

From the captures of individuals in each visit, we built individual capture histories and applied a Cormack-Joly-Seber (CJS) mark-recapture model for open populations (Cormack 1964; Jolly 1965; Seber 1965), following the procedures of Lebreton et al (1992). This model estimates the apparent survival probability (Φ, probability of an individual surviving and staying in the study area) between sampling occasions, and the capture probability (p) on the sampling occasions. We included the effect of the sampling year (correspondent to the growing stage of the trees) or/and the age class of the individual (i.e., juvenile or adult) on the apparent survival probability, and the effect of the age class of the individual and/or air temperature (linear and quadratic effects) on the capture probability.

We fitted the mark-recapture models under a maximum likelihood approach using MARK (Cooch and White 2016). We corrected irregular time intervals between occasions to obtain the apparent survival probability by month. We tested the model adjustment (goodness of fit) by calculating the median c-hat for the most parameterized model. Then, we incorporated the c-hat value to correct the estimates and to compute the Quasi-Likelihood Information Criteria of second order (QAICc), which was used to rank the models (i.e., the best ranked model is the one with the lowest QAICc value). We tested the effects of age and year in apparent survival contrasting different model hypotheses using AIC criteria. Similarly, we tested the effects of age and temperature (including a quadratic effect, i.e., inverted U shape relationship).

Results

We captured and marked 286 lizards (55 males, 69 females, 162 juveniles) and recaptured 95 individuals (39 males, 27 females, 29 juveniles). Of these 286 individuals, 49 were captured in 2008 (34 adults), 84 in 2009 (32 adults), 78 in 2010 (38 adults) and 75 in 2011 (20 adults). The mean SVL of 93 males was 108.89 ± 11.71 (standard deviation) mm (range, 85.86–130.5 mm) and BM was 55.47 ± 18.02 g (range, 18.50–90.00 g). For 96 females, mean SVL was 88.05 ± 7.17 mm (range, 74.90–107.4 mm) and BM was 25.98 ± 8.55 g (range, 13.75–50.00 g). The SVL and BM of males were significantly greater than those of females (SVL: $F_{1,185} = 9{,}753$, $P < 0.001$; BM: $F_{1,179} = 1{,}433$, $P < 0.001$).

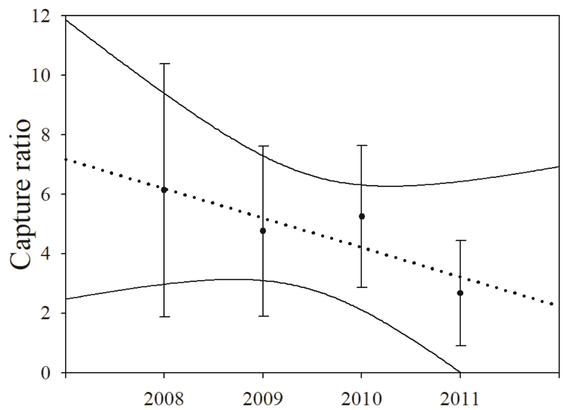

Figure 2. Monthly capture ratio of adult individuals of the Western Collared Spiny Lizard (*Tropidurus catalanensis*) from 2008 to 2011 in the study area in Alegrete, Rio Grande do Sul, Brazil. Dotted line indicates the linear tendency through the years.

Throughout the study period, there was a gradual decrease in the number of monthly captures of adults ($F_{3,40} = 2.92$, $P = 0.046$; Fig. 2), with significant differences between 2008 and 2011 (Holm-Sidak, $P = 0.010$). In 2013 and 2014, we concluded that the population was locally extinct because we conducted six surveys using the same methods as before and we found no individuals. In fact, in 2011 eucalyptus had already grown tall enough to shade a great portion of the study area, and the rocky outcrops received direct sunlight only for about 1 h during the solar zenith (Fig. 3). We did not find any marked lizards in 2013 and 2014 in surrounding rock outcrops.

We found an effect of sex ($F_{1,202} = 93.08$, $P < 0.010$) and year ($F_{3,203} = 42.82$, $P < 0.010$) on body condition (Fig. 4), but not a sex-year interaction ($F_{3,199} = 1.14$, $P = 0.330$). There were no significant differences of body condition between 2008 and 2009 (Tukey HSD; $P = 0.085$), or between 2010 and 2011 (Tukey HSD; $P = 0.996$). Body condition of lizards for all other combinations of years (2008 and 2010, 2008 and 2011, 2009 and 2010, 2009 and 2011) were significantly different (all Tukey HSD; $P < 0.001$). In comparison with individuals captured in 2008, the body condition of males and females was reduced 25.44% and 36.27%, respectively.

According to the top ranked model (Table 1), the average apparent monthly survival probability (Φ) was lower along the sampling years (β2008 = 2.58 ± 0.97 [standard deviation]; β2009 = 1.49 ± 0.27; β2010 = 1.26 ± 0.28; β2011 = 0.89 ± 0.31); while the capture probability (p) was affected by the temperature (quadratic effect) and the age class ($\alpha Int = -4.94 \pm 1.34$; $\alpha age = 0.72 \pm 0.30$; $\alpha temp = 0.38 \pm 0.18$; $\alpha temp^2 = -0.01 \pm 0.01$). The monthly survival probability decreased gradually over the four initial years of the

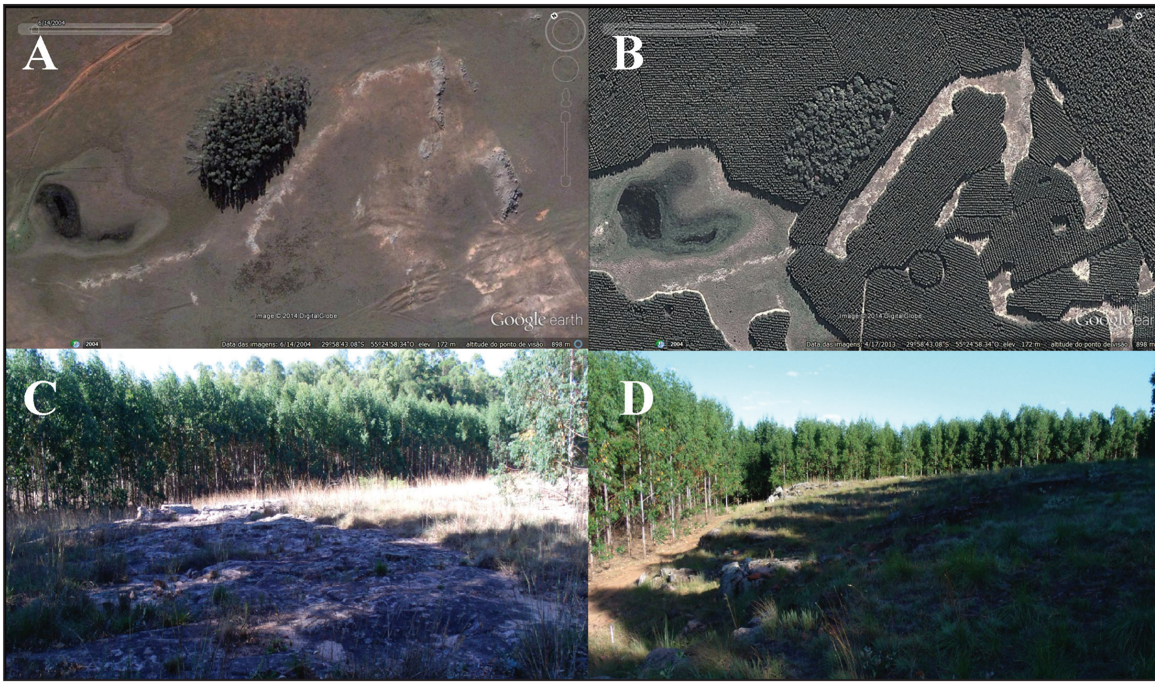

Figure 3. Satellite images (A in 2004; B in 2013) and photographs (C and D: from 2013) of the rocky outcrops at the study area in Alegrete, Rio Grande do Sul, Brazil. In A and B, the patch of trees in the center were older eucalyptus (*Eucalyptus* sp.), not planted for commercial purposes. In satellite image B and the photographs, outcrops are fully surrounded and shaded by eucalyptus trees. (A and B, Google Earth; C and D photographed by Alexis Grote Kellermann).

study, averaging 93% (95% Confidence Interval [CI] = 67–99%) in 2008 and 71% (95% CI = 57–82%) in 2011 (Fig. 5). The mean recapture probability of adults was higher than younger individuals, and this probability was higher at intermediate temperatures. Recapture probabilities ranged from 4% (95% CI = 1–10%) for juveniles and 8% (95% CI = 3–18%) for adults at a daily mean temperature of 6° C, with a peak of 8% (95% CI = 5–14%) and 16% (95% CI = 10–24%) for juveniles and adults, respectively, at 14° C, to 1% (95% CI = 1–4%) and 3% (95% CI = 1–7%) at 25° C.

Table 1. Cormack-Jolly-Seber model selection results for the apparent survival and detection probability of the Western Collared Spiny Lizard (*Tropidurus catalanensis*) from 2008 to 2011 in Alegrete, Rio Grande do Sul, Brazil. Models were ranked by Quasi-Likelihood Information Criteria of second order (QAICc) adjusted for c-hat (c-hat = 1.24). Acronyms are **Δ**QAICc = difference between the QAICc of the model with the lowest QAICc and the following models, wQAICc = QAICc weights (QAICcwt; from 0 to 1), and n Pars = number of parameters of the model. Only the first five models are listed.

Model	QAICc	ΔQAICc	wQAICc	n Pars
Φ(year) *p*(age + temp²)	591.05	0.0	0.355	8
Φ(.) *p*(age + temp²)	592.98	1.93	0.135	5
Φ(year + age) *p*(age + temp²)	593.04	1.99	0.131	9
Φ(year + age) *p*(temp²)	593.68	2.63	0.095	8
Φ(age) *p*(age + temp²)	594.01	2.96	0.080	6

Discussion

We found that after the growth of the eucalyptus plantations in our study area, the population of *T. catalanensis* suffered a decline in numbers, body condition, and survival probability, culminating in the total absence of *T. catalanensis*. To verify a possible migration of the individuals, in the following years we investigated outcrops nearby, where other populations of the species live without the presence of eucalyptus. We did not find any lizards from the study population (i.e., marked specimens), which may indicate that they could not establish themselves in the adjacent outcrops.

Lower capture rates have already been linked to eucalyptus plantations in the Cerrado (tropical savannah) biome of Brazil. The decrease of radiant energy and the habitat homogenization were the main causes of the reduction of the original fauna, presenting substantial loss in species richness, endemism, equitability and captures within the evaluated lizard communities (Gainsbury and Colli 2014). Similarly, smaller abundances of the sand lizard (*Liolaemus wiegmanni* complex) were associated with higher densities of Sydney Golden Wattle (*Acacia longifolia*) in their natural environments, related to a decrease in thermal quality of micro-habitats induced by the shading of the exotic trees (Stellatelli et al. 2013). Although we did not conduct experiments on thermoregulatory quality and efficiency, several studies demonstrated that eucalyptus introduction alters physical

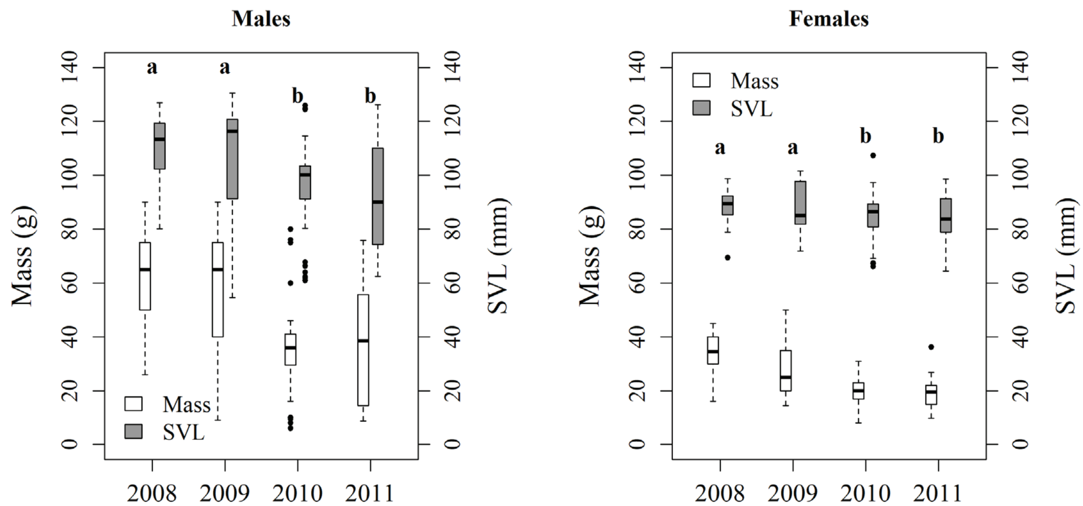

Figure 4. Variation in body mass (g) and snout-vent length (SVL; mm) from which the body condition was calculated of males and females of the Western Collared Spiny Lizard (*Tropidurus catalanensis*) from 2008 to 2011 in Alegrete, Rio Grande do Sul, Brazil. Equal letters indicate that there was no significant difference in body condition between those years.

factors such as wind, incidence of solar radiation, and environment temperature (e.g., Yirdaw and Luukkanen 2004; Lemenih et al. 2004; Kanowski et al. 2005; Hejda et al. 2009; Gainsbury and Colli 2014). Also, we observed that the outcrops shifted from a condition of total solar incidence (about 12 h/d, depending on the season) to just one hour on the zenith of the sun. Such reduction may have greatly influenced the gradual decrease in the number of lizards found in each sample because *T. catalanensis* is a heliophilous species highly influenced by environmental variables of open areas (Ribeiro et al. 2007; Vieira 2009).

Lower body condition of lizards has been reported as a consequence of forestation of non-native plants. In another study with the same population of *L. wiegmanni* (mentioned above), Stellatelli et al. (2015) observed that lizards in the forested environment were smaller and had a body condition 22% lower than those in natural environments. They attributed this to the reduction in thermoregulatory efficiency, leading to an impairment of cellular functions and/or ability to capture prey. The authors also reported that a 20% reduction in body mass is harmful to animals, given that heavier individuals usually have higher fat reserves or higher energy acquisition rates that increase survival probabilities under poor environmental conditions (Stellatelli et al. 2015). In our study, we found that the reduction of body condition of lizards was up to 25.4% (males) and 36.3% (females), indicating that lizards, regardless of size, were thinner in later years. Such reduction may represent an important factor in the 21% decline of the apparent survival probability (Φ) of the population because body condition reflects the previous food intake rate and the size of energy reserves in reptiles (Bonnett and Naulleau 1994; Forsman and Lindell 1996) and is associated with both direct and indirect costs and benefits that may influence survival (Civantos and Forsman 2000).

Considering this, we conclude that the large-scale silviculture of exotic woody monocultures represents a major threat to the saxicolous reptiles native to open grassland areas, such as the Pampas. Even though the rocky outcrops in our study area remained without planted eucalyptus, the deep shade resulting from the close distance of the trees to the outcrops caused the local extinction of the lizard population. Adequate conservation and management measures of forestry plantations should take into account the distance to rocky

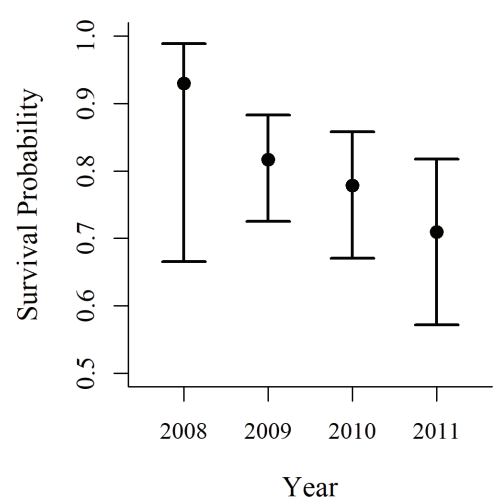

Figure 5. Mean survival probability (**Φ**) of the population of the Western Collared Spiny Lizard (*Tropidurus catalanensis*) studied from 2008 to 2011 in Alegrete, Rio Grande do Sul, Brazil, according to the top ranked model {**Φ**(year) *p*(age + temp²)}.

outcrops and the connectivity between rocky habitats to guarantee the viability of saxicolous species. Currently, only 50% of original grasslands remains in the Pampas (Cordeiro and Hasenack 2009), mainly due to the conversion into exotic pastures, intensive crops, and forests (Pillar et al. 2009). Despite this, only 453 km² (< 0.5%) of the biome is under legal protection (Overbeck et al. 2007).

Finally, degradation and habitat loss are the major extinction threat to animal species (Fontana et al. 2003), and specifically herpetofauna, along with the introduction of exotic species (Gibbons et al. 2000; Rodrigues 2005). Substitution of the natural open landscapes by forests of exotic species dramatically reduces floral diversity and alters irreversibly the fauna composition (Santos 2006). Therefore, to promote sustainable forest production, it is necessary to understand the impact of such activity on biodiversity, and this should be a research priority (Mortelliti et al. 2015) and a requirement for any enterprise that plan large-scale planting of exotic species.

Acknowledgments.—We are grateful to Instituto de Biociências da Universidade Federal do Rio Grande do Sul (IB/UFRGS) for transportation logistics, to Mr. Virgino for receiving us in his place, and to all fieldwork assistants. MSL thanks the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and the Universidade Federal do Rio Grande do Sul (UFRGS) for the scientific research scholarships granted. The research received authorization number 12611 from the National System of Biodiversity Information (SISBIO/ICMBio) and the procedures with the animals were approved by the Ethics Committee on the Use of Animals of Universidade Federal do Rio Grande do Sul (CEUA/UFRGS) under the project number 22981.

Literature Cited

Arruda, J.L.S. 2009. Ecologia de *Tropidurus torquatus* (Squamata: Tropiduridae) no Bioma Pampa, extremo sul do Brasil. MSc. Thesis, Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul, Brazil. 76 p.

Boldrini, I. 1997. Campos do Rio Grande do Sul: Caracterização fisionômica e problemática ocupacional. Boletim do Instituto de Biociências 56:1–39.

Bonnet X, and G. Naulleau. 1994. A body condition index (BCI) in snakes to study reproduction. Comptes Rendus de l'Académie des Sciences - Series III - Sciences, Vie 317:34–41.

Cannell, M.G.R. 1999. Environmental impacts of forest monocultures: water use, acidification, wildlife conservation and carbon storage. New Forests 17:239–262.

Civantos, E., and A. Forsman. 2000. Determinants of survival in juvenile *Psammodromus algirus* lizards. Oecologia 124:64–72.

Cooch, E.G., and G.C. White. 2016. Program MARK: A Gentle Introduction. 14th Edition. Colorado State University, Fort Collins, Colorado, USA.

Cormack, R.M. 1964. Estimates of survival from the sighting of marked animals. Biometrika 51:429–438.

Food and Agriculture Organization of the United Nations (FAO). 2010. Global Forest Resources Assessment 2010 - Main Report. FAO, Rome, Italy. 344 p.

Farley, K.A., E.G. Jobbágy, and R.B. Jackson. 2005. Effects of afforestation on water yield: a global synthesis with implications for policy. Global Change Biology 11:1565–1576.

Foley, J.A., R. Defries, G.P. Asner, C. Barford, G. Bonan, S.R. Carpenter, F.S. Chapin, M.T. Coe, G.C. Daily, H.K. Gibbs, et al. 2005. Global consequences of land use. Science 309:570–574.

Fontana, C., G.A. Bencke, and R.E. Reis. 2003. Livro Vermelho da Fauna Ameaçada do Rio Grande do Sul. Editora da Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil.

Forsman A., and L.E. Lindell. 1996. Resource dependent growth and body condition dynamics in juvenile snakes: an experiment. Oecologia 108:669–675.

Gainsbury, A.M., and G.R. Colli. 2014. Effects of abandoned *Eucalyptus* plantations on lizard communities in the Brazilian Cerrado. Biodiversity and Conservation 23:3155–3170.

Gibbons, J.W., D.E. Scott, T.J. Ryan, K. Buhmann, T.D. Tuberville, B.S. Metts, J.L. Greene, T. Mills, Y. Leiden, S. Poppy, and C.T. Winne. 2000. The Global Decline of Reptiles, Déjà Vu Amphibians. Bioscience 50:653–666.

Hejda, M., P. Pysek, and V. Jarosík. 2009. Impact of invasive plants on the species richness, diversity and composition of invaded communities. Journal of Ecology 97:393–403.

Instituto Brasileiro de Geografia e Estatística (IBGE). 2015. Produção da extração vegetal e da silvicultura. Produção da Extração Vegetal e da Silvicultura 30:1–48.

Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováveis (IBAMA). 2011. Monitoramento do desmatamento nos Biomas brasileiros por satélite: Relatório do Monitoramento do Bioma Pampa 2008–2009. IBAMA, Ministério do Meio Ambiente (MMA), Brasília, Distrito Federal, Brazil. 37 p.

Jackson R.B., E.G. Jobbágy, R. Avissar, S.B. Roy, D.J. Barrett, C.W. Cook, K.A. Farley, D.C. Le Maitre, B.A. Mccarl, and B.C. Murray. 2005. Trading water for carbon with biological carbon sequestration. Science 310:1944–1947.

Jobbágy, E.G., and R.B. Jackson. 2003. Patterns and mechanisms of soil acidification in the conversion of grasslands to forests. Biogeochemistry 64:205–229.

Jolly, G.M. 1965. Explicit estimates from capture-recapture data with both death and immigration-stochastic model. Biometrika 52:225–248.

Kanowski, J., C.P. Catterall, and G.W. Wardell-Johnson. 2005. Consequences of broadscale timber plantations for biodiversity in cleared rainforest landscapes of eastern Australia. Forest Ecology and Management 208:359–372.

Kunz, T.S., and M. Borges-Martins. 2013. A new microendemic species of *Tropidurus* (Squamata: Tropiduridae) from southern Brazil and revalidation of *Tropidurus catalanensis* Gudynas & Skuk, 1983. Zootaxa 3681:422–426.

Lebreton, J.D., K.P. Burnhan, J. Clobert, and D.R. Anderson. 1992. Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. Ecological Monographs 62:67–118.

Lemenih, M., T. Gidyelew, and D. Teketay. 2004. Effects of canopy cover and understory environment of tree plantations on richness, density and size of colonizing woody species in southern Ethiopia. Forest Ecology and Management 194:1–10.

Maluf, J.R.T. 2000. Nova classificação climática do estado do Rio Grande do Sul. Revista Brasileira de Agrometeorologia 8:141–150.

Martin, L.J., and B.R. Murray. 2011. A predictive framework and review of the ecological impacts of exotic plant invasions on reptiles and amphibians. Biological Reviews 86:407–419.

Mortelliti, A., D.R. Michael, and D.B. Lindenmayer. 2015. Contrasting effects of pine plantations on two skinks: results from a large scale 'natural experiment' in Australia. Animal Conservation 18:433–441.

Mott, B., R.A. Alford, and L. Schwarzkopf. 2010. Tropical reptiles in pine forests: assemblage responses to plantations and plantation management by burning. Forest Ecology and Management 259:916–925.

Overbeck, G.E., S.C. Müller, A. Fidelis, J. Pfadenhauer, V.D. Pillar, C.C. Blanco CC, I.I. Boldrini, R. Both, and E.D. Forneck. 2007. Brazil's neglected biome: the South Brazilian Campos. Perspectives in Plant Ecology, Evolution and Systematics 9:101–116.

Picolli, L.R., and C.V. Schnadelbach. 2007. O Pampa em Disputa: a biodiversidade ameaçada pela expansão das monoculturas de árvores. Amigos da Terra Brasil, Porto Alegre, Rio Grande do Sul, Brazil. 64 p.

Pillar, V.P., S.C. Muller, Z.M.S. Castilhos, and A.V. Jacques. 2009. Campos sulinos: conservação e uso sustentável da biodiversidade. Ministério do Meio Ambiente, Brasília, Brazil. 408 p.

Pinto, A.C.S., H.C. Wiederhecker, and G.R. Colli. 2005. Sexual dimorphism in the neotropical lizard, *Tropidurus torquatus* (Squamata, Tropiduridae). Amphibia-Reptilia 26:127–137.

R Development Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org.

Ribeiro, L.B., S.C. Gomides, A.O. Santos, and B.M. Sousa. 2007. Thermoregulatory behavior of the saxicolous lizard, *Tropidurus torquatus* (Squamata, Tropiduridae), in a rocky outcrop in Minas Gerais, Brazil. Herpetological Conservation and Biology 3:63–70.

Rodrigues, M.T. 1987. Sistemática, ecologia e zoogeografia dos *Tropidurus* do grupo torquatus ao Sul do Rio Amazonas (Sauridae: Iguanidae). Arquivos de Zoologia 31:105–230.

Rodrigues, M.T. 2005. Conservação dos répteis Brasileiros: os desafios de um país megadiverso. Megadiversidade 1:87–94.

Saccol, S.S.A., A.M.R. Bolzan, and T.G. Santos. 2017. In the shadow of trees: does *Eucalyptus* afforestation reduce herpetofaunal diversity in southern Brazil? South American Journal of Herpetology 12:42–56.

Santos, L. 2006. Monoculturas de árvores exóticas e conservação da diversidade da fauna no Rio Grande do Sul. Ph.D. Dissertation, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil. 54 p.

Schwanzs, A.K. 2010. Florestamento - desenraizamento: a transformação da paisagem nos Pampas e a identidade do gaúcho. M.Sc. Thesis, Universidade Estadual de Maringá, Maringá, Paraná, Brazil. 217 p.

Seber, G.A.F. 1965. A note on the multiple-recapture census. Biometrika 52:249–260.

Silva, C.R. 2002. Riqueza e diversidade de mamíferos não-voadores em um mosaico formado por plantios de *Eucalyptus saligna* e remanescentes de Floresta Atlântica no município de Pilar do Sul, SP. M.Sc. Thesis. Universidade de São Paulo, Piracicaba, São Paulo, Brazil. 95 p.

Stellatelli, O.A., L.E. Vega, C. Block, and F.B. Cruz. 2013. Effects of tree invasion on the habitat use of sand lizards. Herpetologica 69:455–465.

Stellatelli, O.A., L.E. Vega, C. Block, and F.B. Cruz. 2015. Responses of two sympatric sand lizards to exotic forestations in the coastal dunes of Argentina: some implications for conservation. Wildlife Research 41:480–489.

Suertegaray, D.M.A., and L.A.P. da Silva. 2009. Tchê Pampa: histórias da natureza gaúcha. Pp. 42–59 *In* Campos Sulinos: Conservação e Uso Sustentável da Biodiversidade. Pillar, V.P., S.C. Müller, Z.M.S. Castilhos, and A.V.A Jacques (Eds.). Ministério do Meio Ambiente, Brasília, Distrito Federal, Brazil.

Valentine, L.E. 2006. Habitat avoidance of an introduced weed by native lizards. Austral Ecology 31:732–735.

Verrastro L. 1991. Aspectos ecológicos e biológicos de uma população de *Liolaemus occipitallis* Boul. 1885, nas dunas costeiras da praia Jardim Atlântico, Tramandaí, RS (Reptilia-Iguanidae). M.Sc. Thesis, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil. 145 p.

Vieira, R.C. 2009. Ritmo de atividade e dinâmica populacional de *Tropidurus torquatus* (Wied, 1820) (Sauria, Tropiduridae) no Rio Grande do Sul, Brasil. M.Sc. Thesis, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil. 59 p.

Vitt, L.J, and J.P. Caldwell. 2014. Herpetology: An Introductory Biology of Amphibians and Reptiles. 4th Edition. Academic Press, Cambridge, Massachusetts, USA.

Wilson, M.C., X.Y. Chen, R.T. Corlett, R.K. Didham, P. Ding, R.D. Holt, M. Holyoak, G. Hu, A.C. Hughes, L. Jiang, et al. 2016. Habitat fragmentation and biodiversity conservation: key findings and future challenges. Landscape Ecology 31:219–227.

Yirdaw, E., and O. Luukkanen. 2004. Photosynthetically active radiation transmittance of forest plantation canopies in the Ethiopian Highlands. Forest Ecology and Management 188:17–24.

Zahn, A., A. Rainho, L. Rodrigues, and J.M. Palmeirim. 2009. Low macro-arthropod abundance in exotic *Eucalyptus* plantations in the Mediterranean. Applied Ecology and Environmental Research 7:297–301.

Zar, J.H. 1999. Biostatistical Analysis. Prentice Hall, Upper Saddle River, New Jersey, USA.

Zuur, A., E.N. Ieno, N. Walker, A.A. Saveliev, and G.M. Smith. 2009. Mixed Effects Models and Extensions in Ecology with R. Springer-Verlag, New York, New York, USA.

Alexis Grote Kellermann is a Biologist from the Federal University of Rio Grande do Sul, Brazil. He obtained his Master's degree in Zoology at the same university, analyzing the influence of exotic eucalyptus plantations on the quality of life of saxicolous lizards. (Photographed by Alexis G. Kellermann).

Mariana Scalon-Luchese holds a B.Sc. in Biology and a Master’s degree in Animal Biology from the Federal University of Rio Grande do Sul, Brazil. She has experience with herpetology, and her main focus of research is ecology and conservation of reptiles, especially crocodilians. Mariana is currently teaching Biology at the basic level. (Photographed by Martin Schossler).

Renata Cardoso Vieira is a Biologist with a Master's and Doctorate degrees in Animal Biology from the Federal University of Rio Grande do Sul, Brazil, with an emphasis on lizard ecology. Currently she works in forensic sciences. (Photographed by Renata C. Vieira).

Ismael V. Brack is a PhD. student in Ecology at the Federal University of Rio Grande do Sul, Brazil, and has an interest in modeling animal populations and in the development of methods to sampling wildlife. In his Ph.D. research, he has explored the use of drones and hierarchical models to study and monitor deer populations of South America. (Photographed by Douglas Oliveira Berto).

Laura Verrastro is Professor and Researcher at the Federal University of Rio Grande do Sul, Brazil, teaching at the undergraduate and postgraduate levels, and directing Master’s and Ph.D. students. Her research interest is in herpetology with emphasis on natural history, biology, and ecology, mainly of lizards. During 30 y, she has carried out several studies on topics such as diet, reproductive behavior, thermal ecology, phylogeography, and population dynamics of species of lizards threatened with extinction or restricted to biomes and ecosystems typical of southern Brazil. (Photographed by Gustavo Scaron).