Green Status of Species: Supplementary information

Dimorphandra wilsonii

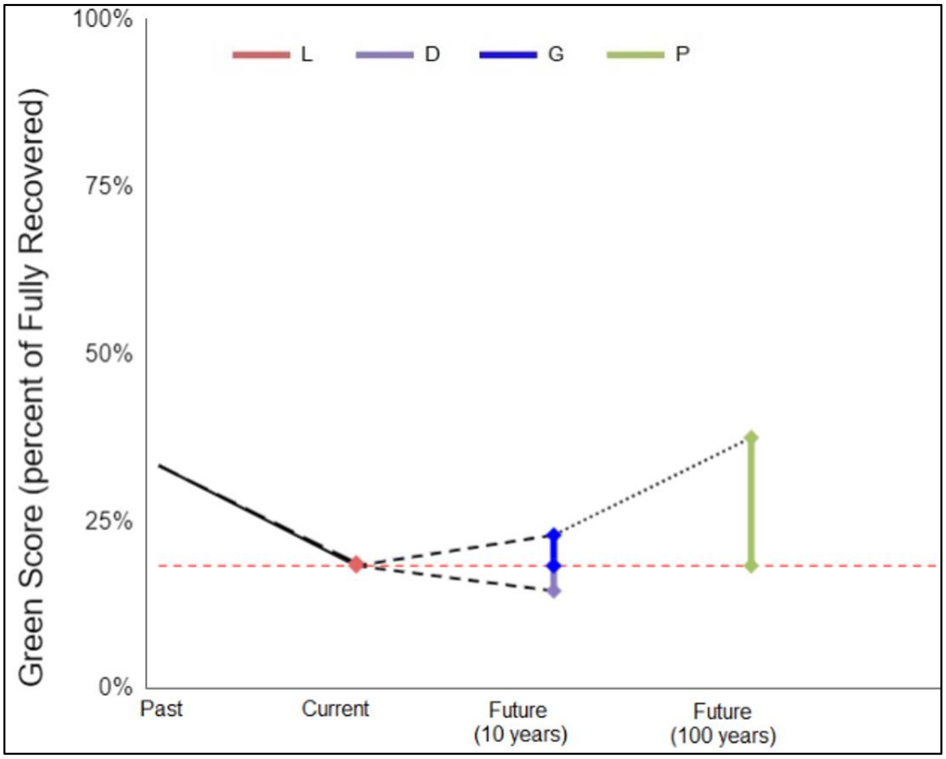

Figure S1. Graphical representation of the conservation metrics based on the Green Scores. Key: Vertical arrows represent the four conservation metrics: L – Conservation Legacy (may not appear if current and counterfactual states are the same); D – Conservation Dependence (may not appear if current and future-without-conservation states are the same); G – Conservation Gain (may not appear if current and future-with-conservation states are the same); P – Recovery Potential (may not appear if current and potential states are the same). The horizontal red dashed line represents the Current Green Score. Solid black line: observed change in the Green Score of the species (ignore it if "Former" state is not specified). Long-dashed black line: (counterfactual) past change expected in the absence of past conservation efforts. Dashed black lines: future scenarios of change expected with and without current and future conservation efforts. Dotted black line: long-term potential change expected with future conservation innovation and efforts.

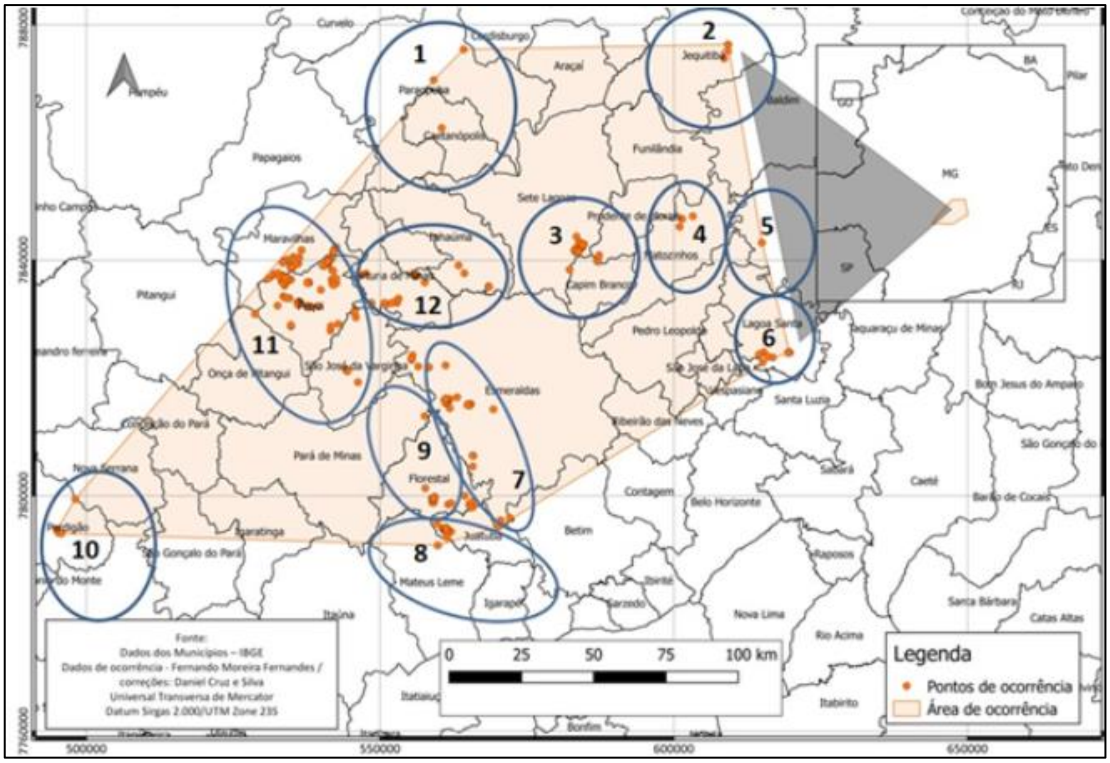

Figure S2. Recent occurrence records of *D. wilsonii*, with a minimum convex polygon showing the extent of occurrence (EOO). Municipalities were clustered into spatial units (roughly circled) based on connectivity, genetic structure, and threats. Eight additional spatial units covering the presumed former range were delineated: four within the EOO and four outside the EOO (see Figure S3).

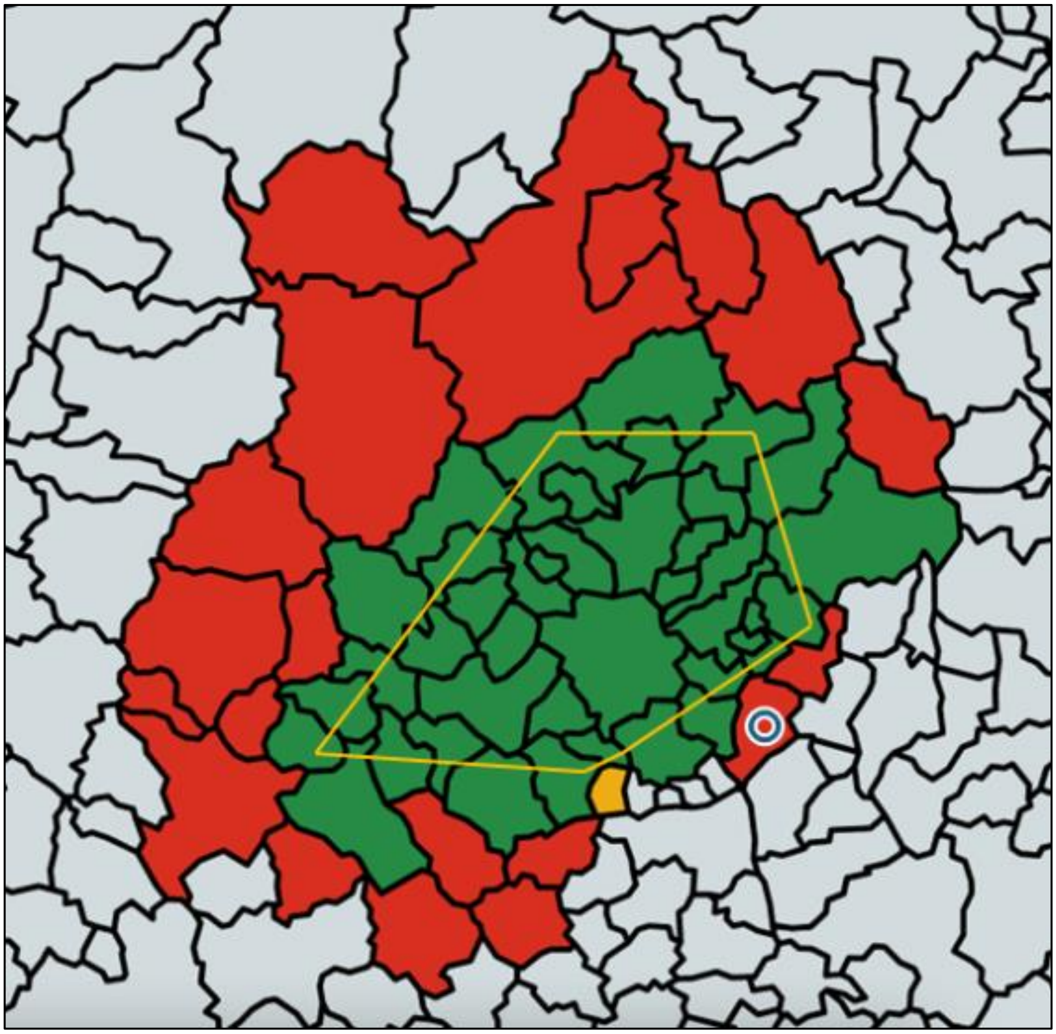

Figure S3. Indigenous municipalities of *D. wilsonii*, with a polygon showing the species' known extent of occurrence (EOO). Municipalities shaded green are within the known EOO; municipalities shaded red are outside the known EOO but estimated to have been formerly suitable based on climate models (Siqueira *et al*., unpub. data.) and expert knowledge of habitat requirements such as relief and soil type. The municipality of Igarapé is shown in orange as it contains reintroduced individuals that have not yet reached maturity. All municipalities are within the state of Minas Gerais (see Figure S2). The marker shows the capital of Minas Gerais, Belo Horizonte.

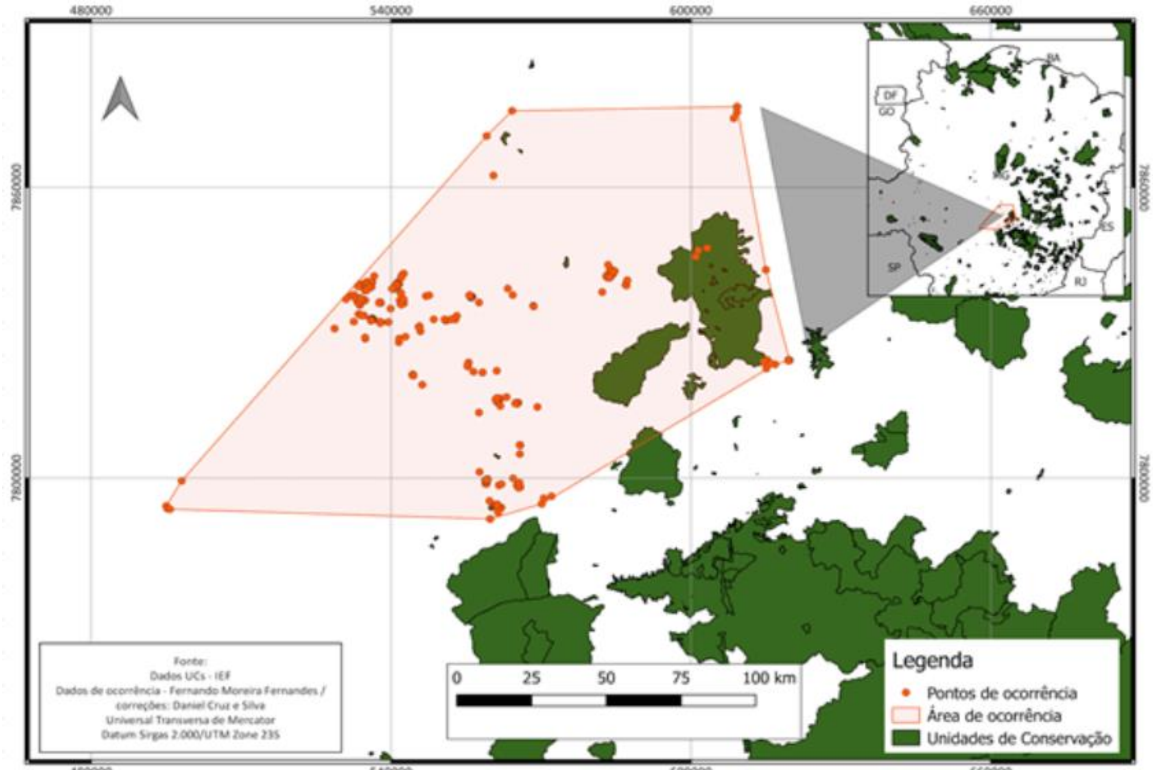

Figure S4. Known occurrence sites of *D. wilsonii* and the protected areas network within and surrounding its extent of occurrence.

Appendix 1. Information about *D. wilsonii*'s range

Dimorphandra is a genus most commonly found in Amazonia (Silva 1986). Five species occur in southeast Brazil, most of them rare, but one – *D. mollis* - is widespread in Cerrado and present in *D. wilsonii*'s EOO. During a 2005 field trip researching *D.wilsonii*, the team of Programa de Conservação do Faveiro-de-Wilson (hereinafter the PCFW) found the first records of *D. exaltata* for this region (Fernandes and Rego 2014), another rare species. In the central region of Minas Gerais these three species' ranges overlap (Fernandes and Rego 2014), so it is possible that *D. wilsonii* is evolutionarily derived from *D. mollis* and *D. exalta,* which have larger ranges and less specific habitat requirements (F. Fernandes pers. comm.).

Between 2004 and 2014, the PCFW team visited 74 municipalities to look for the species in the field, established 180 observation points and interviewed ~900 local residents to obtain information on *D. wilsonii*'s past and current whereabouts. Their efforts revealed that the species, recorded at only two municipalities at the time of its description (Rizzini 1969), was present in 18 municipalities in central Minas Gerais (Fernandes and Rego 2014). After this, researchers undertook more targeted searches in old and new localities, leading to many additional occurrence records, including in five new municipalities (one of these being outside, but close to, the previously recorded EOO; F. Fernandes pers. comm.).

The species is now known to occur in 23 municipalities of Minas Gerais state, with a population size of 441 mature individuals (F. Fernandes pers. comm.). The currently known population is composed of 12 subpopulations, unevenly distributed across the defined Spatial Units. The largest geographically-defined subpopulation comprises 198 individuals, while the smallest hosts two mature plants. Based on the IUCN Red List's definition of area of occupancy (AOO), which uses a resolution of 4 km², the species' AOO is 104 km². However, *D. wilsonii* subpopulations are highly scattered and isolated, and measuring occupancy at a higher resolution (10 ha) indicates that the area covered by the species is ~9 km² (Fernandes and Rego 2014). The extent of occurrence (EOO) of *D. wilsonii* is very large compared to its AOO and population size, so it is likely that the species was once much more abundant with connected subpopulations. *Dimorphandra wilsonii* was already scarce in Paraopeba and Caetanópolis in the 1960s, as pastures were steadily spreading across the landscape (Fernandes and Rego 2014). The widespread presence of the introduced species *Urochloa eminii* (=*Urochola decumbens*) in the area affects the nutrition of *D. wilsonii*, inhibiting *Bradyrhizobium* nitrogen fixation and limiting the development of the juvenile plants (Fonseca *et al*. 2013).

According to maps by the Brazilian Institute of Geography and Statistics (IBGE 2012), 20 of *D. wilsonii*'s range municipalities are within the mesoregion of the greater metropolitan area of Belo Horizonte (in the microregions of Belo Horizonte, Pará de Minas, and Sete Lagoas municipalities), and three are within the western mesoregion of the state (in the microregion of Divinópolis). All 23 municipalities are embedded in watersheds, either in the Paraopeba River, the Pará River, or the Rio das Velhas River, all of which are tributaries of the São Francisco River and most of which are located within the São Francisco-Velhas ecoregion (sensu Arruda *et al.* 2008). The Espinhaço Mountain Range, which is among the most ancient geographic features in eastern Brazil, seems to be a natural barrier for *D. wilsonii* and defines its easternmost distribution limit: the species has never been recorded at any site on Espinhaço's easternmost slopes.

The only protected areas hosting *D. wilsonii* are three Environmental Protection Areas (APAs), a type of Conservation Unit (CU) permitting sustainable use. APAs have little political relevance and low enforcement. The three APAs in which the species occurs are very disturbed and suffer acutely from human activities. In the municipality of Matozinhos, inside the APA Carts Lagoa Santa (established to protect karst relief), there are three specimens of *D. wilsonii* in pasture inside a farm (F. Fernandes pers. comm.) and no more than this.

Discussions with elderly locals indicate that *D. wilsonii* has not been exploited for specific purposes, although its wood, together with that of other local species, was used in the making of charcoal (Fernandes and Rego 2014). In the 1940s and 1950s, there was extensive deforestation in Paraopeba and Caetanópolis, with the wood used in charcoal production for metallurgy (a major industry in the region) and as firewood for industrial boilers (Fernandes and Rego 2014). Curiously, in the same year *D. wilsonii* was discovered (1968), a large fabric factory was built in Caetanópolis (Prefeitura de Paraopeba, 2018). In the 1980s, only 18 registered *D. wilsonii* trees remained in these two municipalities, and these were saved from felling by the botanists Carlos Rizzini and Ezechias Heringer, who informed the farmers of the rarity of the species and the need to protect it (Fernandes and Rego 2014).

In the present day, the absence of dispersers may help to explain the limited distribution of the species. In 2005, Bizerril *et al*. (2005) showed that Lowland Tapirs (*Tapirus terrestris*) are dispersers of *D. wilsonii* congener *D. mollis*. Given that the fruits of these congeners are very similar in shape, size, and smell, and the fact that tapirs are known to be an important disperser of many plant species, it is likely that tapirs were once dispersers of *D. wilsonii* too. Today, however, tapirs are near-extinct in *D. wilsonii*'s range (Fernandes and Rego 2014). While other native mammals could act as dispersers of *D. wilsonii*, the tree's range is so disturbed and fragmented by human activities that cattle may now be its main disperser. Cattle are abundant throughout *D.wilsonii*'s range and eagerly consume ripe *Dimorphandra* fruits. Seeds of *D. wilsonii* have been found intact or germinating in cattle feces (F. Fernandes pers. comm.), and *D. wilsonii* recruits are occasionally spotted in *Urochloa* pastures (F. Fernandes pers. comm.). Nonetheless, cattle pastures and their management remain one of the most prominent threats to the species.

Modelling present-day occurrences:

The occurrence database of *D. wilsonii* used in the present work was provided by Fernandes (personal database) and amounted to 417 occurrence records, not necessarily attributed to a herbarium voucher. In order to reduce sampling bias Siqueira *et al*. (unpub. data) subsample species' records in modelR package removing duplicates and select one record per pixels of 1 km (Sánchez-Tápia *et al.* 2017). We used bioclimatic variables (Hijmans *et al.* 2005) from WorldClim (http://worldclim.org), with a 30 arc-second spatial resolution (1 km). We selected six variables that showed relatively low correlation among each other (Pearson' $r < 0.8$): 1) mean diurnal range, 2) maximum temperature of warmest month, 3) minimum temperature of coldest month, 4) precipitation of wettest month, 5) precipitation of driest month and 6) precipitation of warmest quarter. Present projections was performed based on variables from version 1 (1960–1990) and future projections variables based on three General Circulations Models: 1) HaGEM2-ES (Hadley Global Environment Model Earth System, Collins *et al*. 2011), 2) MIROC 5 (Model for Interdisciplinary Research for Climate, Nozawa *et al*. 2007), 3) Max Planck Institute Earth System Model, (MPI-ESM-LR, Blok and Mauritsen 2013), also we test two representative concentration pathways for future GCMs (RCP 4.5 and 8.5). These GCMs present good predictions for climate conditions in South America mainly MIROC5 and HaGEM2-ES that was used to create ETA model regional for South America (Koutroulis *et al.* 2016, Chou *et al.* 2017, Barros and Doyle 2018).

Modelling future scenarios:

The three future climate models present different results according to different greenhouse gas emission scenarios. These scenarios are classified into Representative Concentration Pathways (RCP). This term was chosen to emphasize the primary purpose of providing space- and time-dependent projections of atmospheric concentrations of greenhouse gases. They do not only function as a specific concentration value, but rather the trajectory that is taken over time to achieve a given result (IPCC AR5 2014). In this study, we used two scenarios for the year 2050: RCP 4.5 and RCP 8.5. The RCP 4.5 scenario refers to an intermediate scenario of greenhouse gas emissions, where the radioactive force stabilises at 4.5W/m² just after the year 2100 (Stockholm Environment Institute 2017). The RCP 8.5 ("business-as-usual") scenario, in contrast to the scenario literature, depicts the worst-case scenario, which reflects high gas emission rates (Riahi *et al*. 2011). When comparing the RCP 8.5 scenario with the RCP 4.5 scenario, we see a slower rate of socioeconomic development, where there is a rapidly growing population with a high food demand, with a relatively slow pace of technological change (Riahi *et al*. 2011). After carrying out the projections, the MIROC5 circulation model was chosen to represent the future projected distribution of the species, as it was the model that presented the most consistent results with the current distribution of the species and because it is the climate model that presents the largest climate sensitivity when compared to other IPCC 5 models (Nozawa *et al.* 2007).

Ecological niche models analysis:

Ecological niche models were developed using the modelR package (Sánches-Tápia *et al.* 2017) in the software R (version 3.6, R Core Team. 2012). We used three modeling algorithms, which were complementary in terms of mathematical structure and input data requirements: an algorithm that used presence-only data (BIOCLIM and DOMAIN), a statistical algorithm that uses presence versus absence data (Random Forest), and a and machine learning algorithm that uses presence versus background data (MAXENT). We ran each algorithm five times, randomly selecting 80% of the occurrence records for model calibration and 20% for model testing. We evaluated the model's performance using True Skill Statistics ranging from -1 to 1 (Allouche *et al.* 2006), created using the maximum sensitivity plus specificity threshold value. This threshold method produces final models with higher performance measures and is not affected by the type of input data used, making it suitable for all the algorithms used (Liu *et al.* 2013). Algorithm models with TSS performance higher than 0.4 were lumped in a unique model by mean, resulting in a continuous model per algorithm representing climate suitability. One final consensus model was built by mean among algorithms. Finally, we applied a fixed threshold of 0.2 to calculate area suitability. This threshold was chosen following Varela *et al*. (2014), once our goal is identifying the suitable climatic areas rather than gradient.

Appendix 2. Assessor Self-Review

1. **Disclose any potential conflicts of interest, which could bias the assessment.**
   There is no conflict.

2. **Is there any discrepancy between this assessment and the Red List assessment for the species? If so, comment on the likely reason for this discrepancy.**
   No, except some new information.

3. **Review the impact that you assigned to the various threats and conservation actions. Would the trajectory of the species be very different if other choices were made? If so, review your justification for these choices. If appropriate, widen the bounds on tabs 4 and 5-8 (change the lower and upper plausible values) to reflect the uncertainty introduced by the possibility of these other choices. How, if at all, did this review question cause this assessment to change? If no changes were needed, please write "no changes".**
   No change.

Appendix 3. Reviewer Self-Review

1. **Disclose any potential conflicts of interest which could bias your review.**
   There is no conflict.

2. **After reviewing the assessment, and given any personal knowledge of the species and the region, can you think of any other factors which could affect species' status besides those listed by the assessor(s)?**
   No.

3. **Can you think of any other conservation actions which may have had an impact on species' status besides those listed by the assessor(s)?**
   No.

4. **Do you disagree with the assessor(s)' evaluation of the impact of any of the factors or conservation actions on the species? E.g., do you disagree with the evaluation of the extent (spatial or temporal) of the factor/action, or its magnitude (in the case of actions, effectiveness)?**
   No.

5. **Do you disagree with any of the probabilistic assertions made by the assessor(s) (i.e., do you disagree that on the balance of the evidence, a certain outcome would be observed)?**
   No.

6. **Do you feel that uncertainty in outcomes has been appropriately accounted for?**
   Yes.

7. **Do you have knowledge of any conflict of interest on the part of the assessor(s) that they did not document?**
   No.

8. **Do you have any concerns about the assessment process which was employed?**
   No.

9. **What is the effect (if any) of your answers to 1-8 on the final assessment made by the assessor(s)?**
   None.

10. **Do you recommend that the assessment be referred for further evaluation?**
    No.

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