Australian Guayule Industry Strategic RD&E Plan (2022–2027)

by Michael Clarke
December 2021
Guayule (*Parthenium argentatum*) is a woody, perennial, rubber-producing shrub. It is an alternate natural rubber to the tropical rubber tree (*Hevea brasiliensis*), which is the only current commercial source.

The supply of natural Hevea rubber is under pressure, with production hampered by a drop in the availability of south-east Asian labour, an increase in competition for resources from palm oil industries, and endemic diseases. However, the demand for natural rubber is rapidly growing from China and India. Globally, it is estimated that a further 4.3 million to 8.5 million hectares of new Hevea plantation will be required to meet anticipated demand for natural rubber. The increased demand for natural rubber provides the Australian guayule industry with a great opportunity to grow and take a larger share of the market.

This Australian Guayule Industry Strategic Research, Development and Extension (RD&E) Plan is a crucial first step in the growth of this emerging industry. The Plan clearly outlines opportunities and barriers to industry growth and resulting RD&E priorities for the industry. Strategic RD&E Plans for emerging industries are resources that can be used by industry to help drive investment and growth within the industry.

The Plan is the result of extensive desktop research and stakeholder consultation across the Australian guayule industry and pulls together specific recommendations for future investment to support the long-term growth and competitive advantage of the industry.

This Strategic RD&E Plan has been produced as part of AgriFutures Australia’s Emerging Industries Program, which focuses on new industries with high growth potential. Emerging animal and plant industries play an important part in the Australian agricultural landscape. They contribute to the national economy and are key to meeting changing global food and fibre demands.

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Michael Beer
General Manager, Business Development
AgriFutures Australia

“...This Australian Guayule Industry Strategic Research, Development and Extension (RD&E) Plan is a crucial first step in the growth of this emerging industry...”
Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ARS</td>
<td>Agricultural Research Service of the USDA</td>
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<tr>
<td>C&amp;EN</td>
<td>Chemical and Engineering News</td>
</tr>
<tr>
<td>DPI</td>
<td>Department of Primary Industries and Regional Development (WA)</td>
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<td>DPI</td>
<td>NSW Department of Primary Industries</td>
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<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>GFC</td>
<td>Global Financial Crisis 2008</td>
</tr>
<tr>
<td>GVP</td>
<td>Gross value of production</td>
</tr>
<tr>
<td>Inc.</td>
<td>Incorporated</td>
</tr>
<tr>
<td>IP</td>
<td>Intellectual property</td>
</tr>
<tr>
<td>LLS</td>
<td>Limited Liability Company</td>
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<tr>
<td>MER</td>
<td>Monitoring, evaluation and reporting</td>
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<tr>
<td>MIS</td>
<td>Managed investment scheme</td>
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<tr>
<td>NDA</td>
<td>Non-disclosure agreement</td>
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<tr>
<td>NSW</td>
<td>New South Wales</td>
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<td>PIRSA</td>
<td>Primary Industries and Regions South Australia</td>
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<tr>
<td>PPE</td>
<td>Personal protective equipment</td>
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<tr>
<td>R&amp;D</td>
<td>Research and development</td>
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<td>RD&amp;E</td>
<td>Research, development and extension</td>
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<tr>
<td>RIRDC</td>
<td>Rural Industries Research and Development Corporation (now AgriFutures)</td>
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<td>SARDI</td>
<td>South Australian R&amp;D Institute</td>
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<tr>
<td>SA</td>
<td>South Australia</td>
</tr>
<tr>
<td>SWOT</td>
<td>Strengths, weaknesses, opportunities and threats (analysis)</td>
</tr>
<tr>
<td>UQ</td>
<td>University of Queensland</td>
</tr>
<tr>
<td>US</td>
<td>United States (of America)</td>
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<tr>
<td>USDA</td>
<td>United States Department of Agriculture</td>
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<tr>
<td>WA</td>
<td>Western Australia</td>
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<tr>
<td>WW2</td>
<td>World War 2</td>
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Executive summary

Guayule was first successfully trialled in Australia by the forerunner of the CSIRO in 1932 and again in 1942 when supplies of natural Hevea rubber from Malaysia became unattainable. Natural rubber is an essential industrial raw material and demand for this commodity is forecast to grow throughout the 21st century.

In the past, guayule has failed to establish in Australia due to ample low-cost supplies of Hevea rubber from South East Asia, a stop/start approach to research, and a lack of access to appropriate processing technology.

Success may be possible in the 2020s, with growing demand for and finite production of Hevea rubber, the recognition of guayule’s hypoallergenic qualities (latex production) and (tyre) industry interest in diversified, environmentally friendly supply chains. While commercial processing technology has also now been developed, success is likely to depend on processor ability to market a range of guayule co-products such as very high-energy biofuel.

The goal of this Strategic RD&E Plan is to guide investment in targeted research, development and extension activities that support an industry that aims to grow and process 5,000 ha of irrigated guayule for a range of profitable uses by 2027. The industry will be developed by processors, research scientists and Australian guayule growers.

The Strategic RD&E Plan is structured through research themes, strategies, activities and priorities. The body of the plan includes relevant KPIs. A summary of the plan is provided in the ‘Plan on a page’.
### Table 1: Australian Guayule Industry Strategic RD&E Plan themes, strategies, activities and priorities

<table>
<thead>
<tr>
<th>Theme</th>
<th>Strategies</th>
<th>Activities</th>
<th>Priority</th>
<th>Year</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Genetic improvement and seed supply</strong></td>
<td>Secure a commercial seed supply to facilitate Australian guayule production</td>
<td>Guayule Australia to work with SARDI Loxton to develop a SARDI-led seed production/extension facility project.</td>
<td>Very high</td>
<td>(year 1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>products</td>
<td>Guayule Australia to pursue commercial seed bulk-up opportunities with farmers within the greater Loxton area.</td>
<td>High</td>
<td></td>
<td>Test new guayule cultivars to improve crop performance</td>
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<tr>
<td></td>
<td></td>
<td>Source seed and funding for Australian trials from local and United States sources (potentially including the USDA).</td>
<td>High</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Support a targeted breeding program to maximise long-term grower returns</td>
<td>Medium</td>
<td></td>
<td>Expanding the industry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work with the University of Adelaide, Waite Research Institute or similar to design a guayule breeding program that facilitates crop establishment, uniform ripening, improved rubber yield and quality.</td>
<td></td>
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<tr>
<td><strong>Growing and harvesting guayule</strong></td>
<td>Invest in agronomic research to improve the economics of growing guayule</td>
<td>Research direct seeding, irrigation and dryland production techniques to ensure the crop is profitable when grown in large areas of marginal Australian cropping country.</td>
<td>Very high</td>
<td>(year 4)</td>
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<tr>
<td></td>
<td></td>
<td>Investigate guayule cultivation systems</td>
<td>Medium</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Research stand establishment, harvesting year and method i.e., is it better to harvest several times or remove whole crop after 2-5 years?</td>
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<tr>
<td><strong>Processing and co-product research</strong></td>
<td>Address the high cost of transporting guayule biomass prior to processing</td>
<td>Research the feasibility of mobile processing/pre-processing, especially given dispersed growing locations and the high cost associated with transporting bulky guayule biomass.</td>
<td>Low</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Develop systems to objectively measure guayule quality to ensure fair payment for growers</td>
<td>Low</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Research and recommend systems to cost effectively and objectively measure the quality of Australian grown guayule – latex yield, biomass produced, metabolites, provenance, etc.</td>
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</tr>
<tr>
<td><strong>Expanding the industry</strong></td>
<td>Raise the profile of guayule to maximise community, government and grower interest and support for the crop</td>
<td>Guayule Australia to articulate and communicate a clear vision for the Australian guayule industry to provide growers with confidence and community support for an environmentally friendly, climate change-proof industry.</td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Building industry capacity</strong></td>
<td>Develop an Australian guayule industry network</td>
<td>Assemble a database of stakeholders from development of this Strategic RD&amp;E Plan and the symposium, and use the database as a channel for communicating industry developments.</td>
<td>High</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Encourage processors to provide capability statements – stating interest in Australian grown guayule, the nature of the opportunity for growers and the indicative markets targeted for their products.</td>
<td>High</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Deliver extension messages to potential guayule growers</td>
<td>Medium</td>
<td>(year 3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deliver extension messages through the SARDI-led seed production/extension facility project at Loxton.</td>
<td>Very high</td>
<td>(year 3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Package and communicate agronomic information on growing guayule in Australia.</td>
<td>High</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Complete and communicate detailed analyses of the economics of growing and processing guayule in Australia.</td>
<td>Medium</td>
<td></td>
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</tbody>
</table>
Crop description

Guayule (Parthenium argentatum A. Gray, pronounced why DOD lee) is a woody, perennial, rubber-producing shrub and a member of the daisy family. Under cultivation, guayule grows to about 1.3 m in height and 1.4 m in width, and requires two years to mature. Guayule is a native of the north-central Mexican desert (Chihuahua region) and south-west Texas. Guayule is suitable for cultivation in semi-arid areas, including marginal cropping country that may be impacted by climate change (Tideman, 1982).

The tropical rubber tree (Hevea brasiliensis) is the only current source of commercial, natural rubber. The rubber dandelion (Taraxacum kokssaghyz) and the more commercially advanced guayule offer potential additional sources of natural rubber.

Growing and harvesting guayule

Guayule requires well-drained soils with medium to fine textured subsoils, preferably neutral to alkaline. The crop may be grown under either dryland conditions, especially when dry rubber production is targeted, or irrigation when higher-value latex is required. Australia has a large area of land with soils and environmental conditions suitable for guayule. An area extending from New South Wales (NSW) to Charters Towers in Queensland within the 500-700 mm rainfall belt offers favourable conditions for guayule cropping (George et al., 2005). Large areas in South Australia (SA), from Mildura in Victoria to Wagga Wagga in NSW, and in Western Australia (WA) have also been identified as suitable for guayule (Tideman, 1982).1,2

The crop has been grown on an experimental basis in the US via seedling transplants and more recently through cost-effective direct seeding (Allhands, undated).3 Guayule suffers few pests and diseases3 and a preliminary agronomy package for SA has been prepared. The crop requires careful and intensive management during establishment but after three months requires little maintenance. Guayule does not spread as a weed (George et al., 2005). The plant is harvested 5 cm above the ground and regrows, or dies, in its entirety. The biomass can be compacted for transport using cotton module makers or conventional hay balers. Guayule stands reach maximum productivity at seven years, after which yield rapidly declines (Dr Henry Brockman, Senior Development Officer New Crops, DPIRD, WA, pers. comm., June 2021). Rubber yield from the guayule plant is relatively modest at between 0.6 and 1.0 t/ha/year1 and this impacts the crop’s cost-effectiveness against tropical Hevea rubber (Heng and Joo, 2017).

In 2021, guayule is a mostly domesticated crop. The guayule genome has been sequenced by NRGene in partnership with the US Bridgestone tyre company (Rekhiv 2021). Processes for breaking seed dormancy are proven, and mechanisation techniques have been developed for growing, harvesting and baling guayule through the adaptation of conventional farming equipment. Many of the building blocks needed for a commercial industry have been put in place (Rousset et al., 2021).

1 It is absolutely imperative that guayule is grown on very well-drained soils. It will not tolerate waterlogged soils even for a few days. On alluvial soil at University of Queensland (UQ) Gatton, a crop succumbed to root rot (Rhizoctonia solani) after waterlogging following a period of heavy rain lasting three days. Preliminary pot trials in a glasshouse established that plants die after only one day of waterlogging. This work was not published but does warrant further investigation. Guayule could have a place in dryland areas on sandy loam soils with limited rainfall. Rubber yields would be low, but harvest could be delayed. The drought resistance of the crop is outstanding (Dr Doug George, guayule researcher, Crop Consult, pers. comm., July 2021). A large area extending from Wagga Wagga NSW through to the SA border is suitable for guayule. A trial site planted last century near Hay NSW by NSW Department of Primary Industries (DPI) researcher Peter Mithen is still evident 20 years after plant establishment (Premawansa Dissanayake, agronomist, pers. comm., June 2021). Direct seeding is more cost-effective but requires special conditions because of the small seed size (1,000 seeds/gram) of guayule. Thus, the soil needs to be of fine tilth, the seed placed at no more than 10 mm depth and irrigation supplied for several weeks until seedlings are established. High soil temperatures need to be avoided because of the risk of seedling desiccation. Additionally, seedling growth is slow, so weeds need to be controlled to reduce competition (Dr Henry Brockman, Senior Development Officer New Crops, DPIRD, WA, pers. comm., June 2021). Red-legged earth mites have been problematic in a poorly established experimental stand in WA (Dr Henry Brockman, Senior Development Officer New Crops, DPIRD, WA, pers. comm., July 2021). Red-legged earth mites have been problematic in a poorly established experimental stand in WA (Dr Henry Brockman, Senior Development Officer New Crops, DPIRD, WA, pers. comm., July 2021).

2 Trial work completed by UQ Gatton would suggest yields are lower than this, around 0.3 to 0.4 t/ha/year (Dr Doug George, guayule researcher, Crop Consult, pers. comm., July 2021).

3 Direct seeding is more cost effective but requires special conditions because of the small seed size (1,000 seeds/gram) of guayule. Thus, the soil needs to be of fine tilth, the seed placed at no more than 10 mm depth and irrigation supplied for several weeks until seedlings are established. High soil temperatures need to be avoided because of the risk of seedling desiccation. Additionally, seedling growth is slow, so weeds need to be controlled to reduce competition (Dr Henry Brockman, Senior Development Officer New Crops, DPIRD, WA, pers. comm., June 2021). Direct seeding, a single uniform seed set and rubber yield improvements is possible that following agronomic research in the 1990s and 2000s, Australia has the world’s most productive guayule cultivars. Australian cultivars produce larger seeds, 800 seeds per gram (US is 1,200 per gram) and achieve 60% germination. Despite this ‘head start’, Australia would benefit from a targeted cultivar breeding program (Michael Verwey, Guayule Australia, pers. comm., June 2021).

4 Now trading as AgriFutures Australia. AgriFutures Australia, formerly known as the Rural Industries Research and Development Corporation (RIRDC) and US corporation Yulex completed successful trials in Queensland (Chinchilla, Gatton, Dalby) in partnership with cotton growers and in WA and NSW with grain growers exploring opportunities for complementary crops (George et al., 2005).

In Australia, more work is required to achieve cost-effective direct seeding, a single uniform seed set and rubber yield improvements. It is possible that following agronomic research in the 1990s and 2000s, Australia has the world’s most productive guayule cultivars. Australian cultivars produce larger seeds, 800 seeds per gram (US is 1,200 per gram) and achieve 60% germination. Despite this ‘head start’, Australia would benefit from a targeted cultivar breeding program (Michael Verwey, Guayule Australia, pers. comm., June 2021).

Global rubber market share, by application, 2019

Guayule would be a useful alternative or complementary crop for farmers currently growing cotton (Wageningen University and Research, undated). The Rural Industries Research and Development Corporation (RIRDC) and US corporation Yulex completed successful trials in Queensland (Chinchilla, Gatton, Dalby) in partnership with cotton growers and in WA and NSW with grain growers exploring opportunities for complementary crops (George et al., 2005).

In Australia, more work is required to achieve cost-effective direct seeding, a single uniform seed set and rubber yield improvements. It is possible that following agronomic research in the 1990s and 2000s, Australia has the world’s most productive guayule cultivars. Australian cultivars produce larger seeds, 800 seeds per gram (US is 1,200 per gram) and achieve 60% germination. Despite this ‘head start’, Australia would benefit from a targeted cultivar breeding program (Michael Verwey, Guayule Australia, pers. comm., June 2021).

Figure 1: Worldwide consumption of rubber, 2019. Source: Fortune Business Insights, 2020

Rubber (cis -1,4-polyisoprene) is an essential industrial raw material. Worldwide, rubber is used in the manufacture of 40,000 products, including 400 medical devices (George et al., 2005). Most rubber is used in the production of tyres for vehicles (Figure 1).
Industry profile

Rubber for the production of manufactured goods is available in two forms, natural and synthetic. Synthetic rubber derived from petroleum accounts for about 55% of the total rubber market. The balance is a natural product from plants (George et al., 2005).

Natural rubber possesses high performance properties that cannot be achieved by synthetic forms. These properties include resilience, elasticity, abrasion resistance, efficient heat distribution, impact resistance and malleability at cold temperatures. Due to its superior quality, natural rubber is an essential raw material for many products. While some rubber products are blends of natural and synthetic rubber, 100% natural rubber is required for a range of products, including medical equipment (e.g., gloves, catheters, feeding nipples and condoms) (George et al., 2005). Demand for natural rubber is expected to increase from 14 million tonnes in 2019 to 15.3 million tonnes by 2030 (Table 2). The value of all raw rubber is forecast to increase from US$40.77 billion in 2019 to US$81.21 billion in 2027, driven mainly by automotive uses along with growth in the consumer goods, equipment (e.g., gloves, catheters, feeding nipples and condoms) (George et al., 2005). Demand for natural rubber is expected to increase from 14 million tonnes in 2019 to 15.3 million tonnes by 2030 (Table 2). The value of all raw rubber is forecast to increase from US$40.77 billion in 2019 to US$81.21 billion in 2027, driven mainly by automotive uses along with growth in the consumer goods, equipment (e.g., gloves, catheters, feeding nipples and condoms) (George et al., 2005).

Table 2

<table>
<thead>
<tr>
<th>Year</th>
<th>Natural rubber</th>
<th>Synthetic rubber</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>6.0</td>
<td>9.0</td>
<td>15.0</td>
</tr>
<tr>
<td>2018</td>
<td>13.7</td>
<td>18.9</td>
<td>32.6</td>
</tr>
<tr>
<td>2019</td>
<td>14.0</td>
<td>15.0</td>
<td>29.0</td>
</tr>
<tr>
<td>2020*</td>
<td>9.3</td>
<td>10.5</td>
<td>19.8</td>
</tr>
<tr>
<td>2025f</td>
<td>14.0</td>
<td>19.0</td>
<td>33.0</td>
</tr>
<tr>
<td>2030f</td>
<td>15.3</td>
<td>22.0</td>
<td>37.3</td>
</tr>
</tbody>
</table>

Source: Various including Diasanayake et al., 2004; Jana et al., 2019; and the Malaysian Rubber Board, 2021. # market impacted by COVID-19, f = forecast. NB: The table does not consider changing consumer demands for environmentally sustainable replacements for petroleum-based synthetic rubber.

History of guayule production

There is a long history of guayule development in the US without the establishment of a permanent and profitable industry. In 1910, guayule was the source of 50% of the rubber consumed in the US, an estimated 10,000 tonnes (10% of the world’s rubber supply). US inventor Thomas Edison provided technical advice to the industry. Guayule rubber was produced from wild-harvested plants and processed at 20 mills in the US and Mexico. The industry collapsed during disruption caused by the Mexican Revolution and depletion of the wild guayule supply (Reikhaev 2021).

In 1902, the Intercontinental Rubber Company, owned by US industrialist John D. Rockefeller and based in San Diego, investigated guayule genetic selection as part of the US Government’s Emergency Rubber Project. Major US Government investment in the cultivation of guayule followed during World War 2 (WW2). Guayule research resources were marshalled during WW2 when supplies of tropical Hevea rubber from South East Asia were disrupted by Japanese occupation. Following WW2, the cultivated guayule industry failed due to resumption in the supply of low-cost Hevea rubber from Malaysia and the development of synthetic rubbers (Tideman, 1982).

In the 1950s, CSIRO in Australia achieved trial guayule yields of 1.2 t/ha/year of rubber, with seed sourced from the US. SA trials were completed in 1942 when supplies of natural rubber from Malaysia were unavailable. The WA Government considered support for a large-scale guayule development in 1959 with the Pacific Rubber Company. However, WA trials sites failed, possibly due to high soil salinity (Tideman, 1982).

In 1979 and again in 1982, oil price shocks dramatically increased the cost of synthetic rubber and interest was rekindled in guayule production. In 1979, the SA Branch of the Australian Institute of Agricultural Science investigated new guayule cultivars from the US, the potential for resin as a guayule co-product, and the use of selective herbicides in guayule production (Tideman, PBRSA 1982).

In 1981, Tideman, working for the SA Government, visited the US to understand recent guayule developments, including outputs from breeding programs at the University of California Davis. The Los Angeles Arboretum provided Tideman with germplasm and seed of prospective varieties suitable for SA. Promising agronomic developments were subsequently terminated in the absence of processing and marketing commitments by the rubber industry. Bridgestone Australia was interested in guayule rubber but was overruled by its parent company (Tideman, 1982).

The late 1980s saw an increase in the use of disposable medical/personal hygiene items and the emergence of a Hevea-based latex allergy. Guayule was tested and found to be hypoallergenic (i.e., does not cause allergic reactions). One in 10 people are estimated to be allergic to residual proteins in Hevea products, such as rubber catheters, gloves, feeding nipples and condoms. Once again, guayule found new supporters.

In 1993, Pacific Dunlop Australia (tyres, Ansell gloves, Dunlop sporting goods) and Australasian Rubber Manufacturers worked with the Australian Government Department of Regional Development to import and test USDA guayule varieties. Pacific Dunlop was interested in securing its own domestic source of raw rubber (Michael Vinvey, Guayule Australia, pers. comm., June 2021).

In 2000, RIRDC (now AgriFutures Australia) funded guayule production trials in Queensland (Chinchilla, Gatton, and Dalby) under contract with the Outback Regional Development Organisation Inc which had secured guayule seed from the USDA under a material transfer agreement (George et al., 2005). RIRDC also supported guayule processing research (Gupta et al., 2015). Post 2000, companies have become interested in demonstrating their sustainability credentials and switching from fossil fuel-sourced raw materials such as synthetic rubber to plant-based alternatives. Companies are also interested in risk spreading and having an alternative, possibly domestic, source of natural rubber. Post 2015, the US and European Union (EU) governments have provided funding to industry to develop guayule rubber (Reikhaev 2021).

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Dr Katrina Cornish provided advice that the 2030 forecast appears too low (Dr Katrina Cornish, EnergyEne Inc., pers. comm., July 2021). 

Post 2015, the US and European Union (EU) governments have provided funding to industry to develop guayule rubber (Reikhaev 2021).

*Dr Katrina Cornish provided advice that the 2030 forecast appears too low (Dr Katrina Cornish, EnergyEne Inc., pers. comm., July 2021).

**Guayule production in saline areas can be managed by using a mounded seed bed and flushing with fresh water (Dr Henry Brockman, Development Officer New Crops, DPIRD, WA, pers. comm., June 2021).
Potential guayule products

Guayule has been used commercially in Patagonia brand wetsuits but was substituted with low-allergen Hevea rubber when a shortage of guayule emerged (Figure 2). Guayule has been suggested for high-quality motor vehicle, truck, agricultural and aircraft tyres. Guayule offers the durability and elasticity needed for high-pressure tyres.

The Bridgestone tyre company is currently interested in guayule for risk mitigation purposes and to reduce the company’s reliance on natural rubber sourced from a single region, i.e., South East Asia. The Bridgestone website explains that a single source of natural rubber is “bad business” and leaves the company’s supply chains vulnerable to interruption from tropical Hevea blight, infestation, bad weather, political instability and even war.

In 2015, the Bridgestone Group produced the first tire made from guayule-derived natural rubber. This was an impressive step toward “expansion and diversification of renewable resources.”

Figure 2: Patagonia’s Yulex, ‘BioRubber’ wetsuit. Source: Patagonia website, June 2021

Synthetic rubber is not that suitable for tyres requiring high loading, and natural rubber is preferred. In 2015, Bridgestone produced its first non-commercial guayule tyre with the aim of “expansion and diversification of renewable resources” (Figure 3).

The Cooper Tire & Rubber company of Arizona, in partnership with guayule cultivar and harvester developer PanAridus LLC, Clemson University and Cornell University, developed a prototype car tyre, the CS4, made entirely of guayule rubber. The partnership received US Government funding to further develop the tyre (Autologue 2015). European and Asian tyre companies are also investigating guayule rubber (Michael Vervey, Guayule Australia, pers. comm., June 2021).

Only 6% of the guayule plant’s biomass is extracted for latex or rubber, 10% is resin and the balance is bagasse. A range of co-products are possible from the resin and bagasse, and these products may end up being more valuable than the rubber (George et al., 2006).

Table 3
Potential guayule products. Source: Adapted from Rousset et al., 2021

<table>
<thead>
<tr>
<th>Rubber products</th>
<th>Co-products</th>
</tr>
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<tbody>
<tr>
<td>Catheters (latex)</td>
<td>Wood preservative (resin)</td>
</tr>
<tr>
<td>Medical gloves (latex)</td>
<td>Adhesives (resin)</td>
</tr>
<tr>
<td>Feeding nipples (latex)</td>
<td>Wax (resin)</td>
</tr>
<tr>
<td>Angioplasty balloons (latex)</td>
<td>Tackifier for tyres (resin)</td>
</tr>
<tr>
<td>Condoms (latex)</td>
<td>Natural insecticides (resin)</td>
</tr>
<tr>
<td>Party balloons (latex)</td>
<td>Bioenergy, aviation fuel (bagasse)</td>
</tr>
<tr>
<td>Wetsuits (latex)</td>
<td>Composite board, cardboard (bagasse)</td>
</tr>
<tr>
<td>Tyres (dry rubber)</td>
<td>Briquettes for use in cooking fires (bagasse)</td>
</tr>
<tr>
<td>Powder coatings (dry rubber)</td>
<td>Activated carbon (bagasse)</td>
</tr>
<tr>
<td>Lineman gloves (dry rubber)</td>
<td>Soil amendment (bagasse)</td>
</tr>
<tr>
<td>Pharmaceuticals (guayulins)</td>
<td>Cosmetics and perfume (monoterpenes)</td>
</tr>
</tbody>
</table>

11This is not a no-allergen product – just lower in protein like doubled centrifuged HNRL or Vytex. The US Food and Drug Administration will not allow HNRL to be labelled non-allergenic (Dr Katrina Cornish, EnergyEne Inc., pers. comm., July 2021). 12 PanAridus is no longer in production. The only new funding on a large scale is the US$15 million SBAR grant from USDA to the University of Arizona and Bridgestone Americas (Dr Katrina Cornish, EnergyEne Inc., pers. comm., July 2021). 13 This number is from publicly released guayule lines, EnergyEne Inc. and Dr Katrina Cornish expect Bridgestone Americas has more productive lines (Dr Katrina Cornish, EnergyEne Inc., pers. comm., July 2021).
Guayule produces a potentially valuable resin for use in the chemical industry. Guayule resin can be used as a wood preservative, adhesive, wax and as a feedstock for specialty chemicals (coatings and rubber additives) (George et al., 2005). Extracts from guayule resin may also be suitable for fungicides, miticides and insecticides (Jara et al., 2019). Guayule resins have particular promise for use as a tackifier for tyres (Rubber & Plastic News, 2019). Unfortunately, some of the literature reports that the composition of guayule resin varies with cultivar, cultivation site, harvest date and processing history. Natural variation makes use of guayule resin challenging for processors and more research is required (Ray, 1991).

Guayule bagasse is available for beneficial use after the resin has been extracted. Guayule bagasse is particularly prospective for use as a high-quality cellulosic biofuel and French firm Guayule SAS is interested in its potential as an aviation fuel (Michael Verwey, Guayule Australia, pers. comm., June 2021). EnergyEne Inc. and its partner Piedmont Bioproducts have pyrolytically produced a heavy bio-oil with an energy content of 50,000 J/g from the bagasse left after latex extraction (Dr Katrina Cornish, EnergyEne Inc., pers. comm., July 2021). Guayule bagasse is attractive as it is easier to refine than other biofuel feedstocks and its production is not at the cost of food production. Other potential guayule co-products include composite board, cardboard, cooking fire briquettes, activated carbon, soil amendment and even pharmaceutical, cosmetic, and perfume products (Rousset et al., 2021).

Guayule processing

Unlike tropical Hevea, rubber in the guayule plant does not flow freely in channels. Natural rubber in guayule is suspended in the parenchyma cells, mainly in the bark of the plant, and must be released during processing. Harvested and baled guayule is delivered to the mill and processed in one of two ways depending on the purpose for which the rubber will be used. The first method uses solvents to extract hard, dry rubber suitable for tyres from dried shrub. This method has been used successfully on an experimental scale by Texas A&M, and at Bridgestone in Arizona (George et al., 2005). Solvent-based extraction has now been further refined by Bridgestone to produce a near-commercial product. Production of a commercial guayule tyre is limited by a suitable, large-scale supply of guayule rubber.

The second milling method uses an aqueous process that was developed and patented by the USDA Agricultural Research Service (ARS). Under the second process, the plant matter is run through a centrifuge in an alkali solution and the rubber particles rise to the top. The product is a latex emulsion, used for ‘dipped’ products such as gloves and balloons.

The guayule processing technique developed by the ARS was licensed to Yulex Corporation, which has produced prototype hypoallergenic medical gloves. However, the patents for this process have expired (Dr Katrina Cornish, EnergyEne Inc., pers. comm., July 2021). Dr Katrina Cornish developed new IP around guayule latex extraction, and this issued patent is exclusively licensed to her startup company, EnergyEne Inc. The company has received USDA funding to develop guayule radiation attenuation medical gloves. Other potential manufacturers include Guayule SAS in France, which produces hypoallergenic latex using a different, patented, water-based extraction technique (Michael Verwey, Guayule Australia, pers. comm., June 2021; Dr Katrina Cornish, EnergyEne Inc., pers. comm., July 2021).

Yulex Corporation/EnergyEne Inc. have worked on the assumption that 8,000 ha of irrigated guayule crop is required to support localised processing. Guayule SAS reported 5,000 ha of irrigated guayule is required for a sustainable extraction plant (Michel Dorget, President, Guayule SAS, pers. comm., June 2021). Allhands (undated) suggested 40,000 ha of irrigated guayule crop is required to feed a commercial-scale processing plant. Different crop areas may be required for differently focused processing operations. For example, a processing plant producing for the hypoallergenic latex market may be smaller than the plant required for commercial tyre production.

World and Australian guayule production

World guayule production is analysed and reported in four “blocks” – the US, the EU, rest of the world, and Australia.

United States

• Arizona is the centre of US guayule production in the semi-arid Southwest.
• The USDA ARS had a 240 ha research plantation in Maricopa, Arizona. Cooper Tire & Rubber had access to guayule rubber grown by the USDA ARS. Dr Katrina Cornish reported that this production area no longer exists (pers. comm., July 2021).
• Bridgestone has a separate 110 ha research station at Eloy, Arizona, some of which was planted to guayule in 2013 (Rubber & Plastic News, 2019).
• Yulex LLC (Successor to Yulex Corporation since 2015) has an unstaed area of guayule crop and processing facilities in Arizona.
• EnergyEne Inc. has partnered with Texas Tech University and is planting advanced lines of guayule in West Texas (Dr Katrina Cornish, EnergyEne Inc., pers. comm., July 2021).

European Union

• The European Union (EU) proposed a policy aimed at supporting the development of a guayule industry. The policy proposed the planting of 2,000 ha of guayule for seed production in Greece, Spain, Italy and Morocco. It also proposed plant extraction pilots, an economic feasibility study and training for extension staff (EU, 2015).

• The policy proposed genomics research targeting rubber yields of more than 1 t/ha/year and the development of agronomic systems, including planting, irrigation, harvest and quality/yield control guides (EU, 2015).

• Under the policy, a 5 t/day plant capable of producing both dry rubber and latex was intended. The policy is targeting 25,000 ha of commercial production to deliver 2-3% of the EU’s natural rubber needs by 2022 (EU, 2015).

• If successful, the policy would target tyre production and facilitate the relocation of the natural latex glove industry from Asia to the EU, with resultant employment in France, Germany, Italy and Spain (EU, 2015).

• In 2009, Yulex Corporation entered a non-exclusive technology transfer agreement with the Italian chemical producer ENI Versalis, which was scaling up guayule production in southern Italy. ENI is a major Italian multinational oil and gas company and Versalis is ENI’s chemical, plastics, rubber and renewable resources company (Rubber & Plastic News, 2019). Subsequently, it is noted that the Yulex Corporation-ENI Versalis partnership did not bear fruit (Dr Katrina Cornish, EnergyEne Inc., pers. comm., July 2021).

• In 2021, it is understood that 5,000 ha of guayule was planted in Sicily and that the Pirelli tyre company is a partner with Versalis on the project (Michael Verwey, Guayule Australia, pers. comm., June 2021).

• Guayule SAS France, in association with agricultural research and cooperation organisation CIHAD, also has large-scale guayule plantings used for experimental purposes (Michael Verwey, Guayule Australia, pers. comm., June 2021).

• Spain has a guayule project funded by Nokian Tire in collaboration with Universidad de Castilla-La Mancha and is building a pilot plant modelled on the latest Cornish process (Dr Katrina Cornish, EnergyEne Inc., pers. comm., July 2021).

Rest of the world

• Guayule has been proposed as both a new industry and a poverty alleviation opportunity for Eastern Cape, South Africa. Under the proposal, guayule bagasse would be processed into briquettes for use in cooking fires (Cornish, 2021).
• Guayule is currently being explored in West Africa as an alternative to cotton by the Wageningen University.
• Guayule has been grown experimentally in Argentina with a view to establishing a domestic rubber industry (Chemical & Engineering News, 2019).
• Yulex has licensed its growing and processing technologies to Israel, which is interested in developing a guayule industry (Ilene Copley, Yulex LLC representative in Australia, pers. comm., June 2021).
• Guayule is under consideration in India by Indian multinational tyre company Apollo Tyres Limited.

### Australia

• From 2000 to 2008, Queensland cotton and WA and NSW grain growers worked with Yulex Corporation to trial guayule as a crop. Once difficulties associated with locating a nursery of sufficient size to grow seedlings and the high cost of transporting seedlings to trial sites was addressed, the trial was a success. Unfortunately, the Global Financial Crisis (GFC) in 2008 prevented further commercialisation of the crop.
• In 2021, Guayule Australia has the only trial site in the country, at Normville SA. Occasionally, Guayule Australia will receive a request from researchers to access trial seed. To date this has not resulted in additional guayule field trials (Michael Verwey, Guayule Australia, pers. comm., June 2021).
• Commercial interest in sourcing Australian grown guayule is currently being expressed by US, French, Indonesian, Indian, Pakistani and domestic firms for both ‘dipped’ latex products and tyre production. Potential growers, processors and investors are advised to contact Guayule Australia.

**Guayule as a commercial proposition**

Low annual rubber yields (0.6 to 0.9 t/ha/year) and high crop establishment costs (approximately $1,800/ha)16 have kept guayule commercialisation in Australia.17 Even when tapped by hand in South East Asia, natural Hevea rubber is a low-cost commodity at approximately US$1.10/1, high volume demand, and high proﬁtability. The guayule rubber has been estimated at US$2.70/1, with a yield of 1.4 t/ha/year and the utilisation of co-products. Further research is required to deliver the crude rubber yield modelled in this feasibility study. Co-product value was extracted from the use of bagasse to power the milling of the guayule plant (Jara et al., 2019).

Guayule is most likely to achieve commercial success in two market segments. The first segment will be for guayule grown under contract to end users targeting high-end latex products where premium prices can be obtained. Buyers in this segment may be willing to pay more than commodity prices for crude rubber. Products targeted might be hypoallergenic gloves, catheters and condoms. Companies in this category include EnergyEne Inc of the US, GuaTecs SAS of France, and Yulex LLC of the US (Michael Verwey, Guayule Australia, pers. comm., June 2021).

Guayule Australia has reported that dryland guayule production is potentially proﬁtable at the current time for Australian farmers (Michael Verwey, Guayule Australia, pers. comm., June 2021).

**Why has the industry failed to establish in the past? Why might it establish now?**

The guayule industry has failed to establish in Australia in the past due to ample, low-cost supplies of Hevea rubber from Malaysia, a stop-start approach to R&D, and a lack of attention to processing technology.18 Success may be possible in the 2020s amid growing demand for and finite production of Hevea rubber, the recognition of guayule’s hypoallergenic qualities (latex production) and (tyre) industry interest in diversified, environmentally friendly supply chains. While commercial processing technology is also now in place, success will depend on processor ability to market a range of guayule co-products.

**A cautious and credible industry is now required**

The Australian guayule industry experienced a setback in the early 2000s when trials on Queensland cotton properties undertaken as a partnership between PIRDC and commercial party Yulex were terminated prior to commercialisation due to the GFC.19 Subsequently, some Australian growers are understood to view guayule as a high risk and similar to tax-driven and unsuccessful managed investment schemes promoted in the 1990s.

What is now required is a cautious and credible approach that can demonstrate a pathway to industry establishment. Guayule Australia has indicated that this would be best achieved with a partnership that included an SA Government-supported seed production/extension facility located at the Loxton Research Centre and a sustained commitment from one or more international commercial partners. The Loxton Research Centre would need access to a guayule harvester and seed cleaning equipment to provide guayule seed for commercial plantings.20

In 2021, the status of the Australian guayule industry is:

- No known grower interest in cropping guayule.
- Consequently, communication with farmers and providing information about the industry is a key priority contained in this Strategic RD&E Plan.
- Guayule Australia and its potential commercial partners believe that with an appropriate approach, there would be interest from farmers in growing guayule, including in the greater Loxton area.
- PIRSA-SARDI interest in seed production/extension facility – interest was tested with SARDI, which indicated in-principle support for irrigated guayule production to ‘bulk up’ seed supply and demonstrate the crop to interested potential growers.
- International entities are interested in securing a supply of guayule biomass with preliminary processing in Australia (e.g., GuaTecs SAS, EnergyEne Inc, Yulex LLC, etc.).

An emerging Australian guayule industry now needs leadership, critical mass, commercial support and targeted government support. Guayule Australia has set a goal of growing 5,000 ha of guayule under irrigation in Australia by 2027.
An Australian guayule industry SWOT analysis is documented below. The SWOT has been completed for the whole industry and includes non-RD&E issues.

**Strengths**

**Genetic improvement**
- Locally available cultivars have been selected for Australian conditions.
- Guayule is suitable for genetic modification as it is not a food crop.

**Growing and harvesting**
- The agronomy of growing guayule in Australia is known.
- Australia has large-scale production and mechanised farms – guayule prerequisites.
- Existing cropping equipment can be modified to grow and harvest guayule.
- Guayule is complementary to cotton – similar growing system but requires less water.
- Cereal-growing regions have been successfully used for dryland trials.
- Guayule is a suitable crop for a drying environment.
- There is a large area of suitable land in Australia.
- Stands are harvestable after two years. This compares well with Hevea, which takes seven years.
- Guayule has low input/low environmental impact compared with Hevea and sequesters CO2.

**Processing and co-products**
- Guayule processing technology is well advanced.
- Original hypoallergenic latex processing technology is off patent but new improved process IP exists (licensed to EnergyEne Inc.).
- The Australian guayule industry may not need to support processing, international entities may build their own facilities.\(^\text{1}\)
- Co-product research is underway, with one firm researching guayule resins.
- Biofuel produced from guayule bagasse post latex extraction has very high energy value due to resin content, residual rubber and high lignin content, and may be suitable for aviation fuel.

**Markets and market outlook**
- The quality of natural guayule rubber is recognised as equivalent to that of Hevea and superior for some applications.
- Growth in demand for natural rubber is forecast, including for both hypoallergenic latex and sustainable dry (tyre) rubber.
- There may not be enough Hevea to meet forecast demand.
- Guayule is a flexible crop that can be directed to different needs as markets change e.g., from rubber to biofuel.

**Industry capacity**
- Experienced Australian researchers with an ongoing interest in the industry.
- PIRSA-SARDI may host seed production/extension facility at Loxton.

**Weaknesses**

**Genetic improvement**
- Seed production (bulk-up) is required before commercial cropping can commence.
- Crop establishment, uniform seed ripening and rubber yield require improvement.
- There have been difficulties with seed germination in WA.
- The Australian guayule industry would benefit from a targeted breeding program.

**Growing and harvesting**
- There is no commercial production of guayule in Australia and only limited production in other parts of the world.
- Transplants are currently required to establish the crop, and this is expensive.
- Guayule is low yielding (0.3 to 1.0 t/ha/year) when compared with even smallholder grown Hevea (1.2 t/ha/year).
- Growing guayule may not be profitable.
- Dryland production systems need to be developed.
- A large production area (5,000 ha) is required to support a single commercial processor.
- The Australian guayule industry would benefit from a commercial seed supply and demonstration/extension capacity.

**Processing and co-products**
- Some processors may be more interested in selling seed and technology than in establishing a profitable industry.
- Processing guayule is more complex than processing Hevea. Guayule requires whole plant grinding, solvents and removal of impurities. Hevea only requires coagulation and drying.

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1Dr Katrina Comish has indicated that this will probably not occur (Dr Katrina Comish, EnergyEne Inc., pers. comm., July 2021).
Strengths, weaknesses, opportunities, threats

Opportunities

• Potential processors are interested in securing supply of Australian guayule (major opportunity).
• Australia is well located in relation to expanding industrial markets in Asia (medium opportunity).
• Improvements in the allergenic qualities of Hevea rubber (e.g., ‘Yulex Pure’) may see guayule repositioned as a source of resin or aviation biofuel rather than a natural rubber for the medical/personal hygiene market (minor opportunity).

Threats

• An alternative source of natural plant rubber (rubber dandelion; Taraxacum kok-saghyz supported by Continental Tires) outcompetes guayule (minor threat).
• R&D delivers ongoing improvement in the flexibility and anti-allergy qualities of cost-effective synthetic rubber (medium threat).
• Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization may require royalties to be paid to Mexico if guayule seeds were sourced from Mexico (medium threat).
• Growers may end up relying on a single buyer who will have price setting power and may exit the Australian industry if its commercial situation changes (major threat).

Industry stakeholder analysis

Organisations that are stakeholders in the guayule industry

The following organisations make up the historical, current and potential guayule supply chain.

Guayule Australia Pty Ltd (Australia)

• Michael Verwey, Director and company principal.
• 30 years’ experience with guayule, authority on the industry and its development.
• Company shareholders include agronomist Premawansa Dissanayake and researcher Dr Henry Brockman.
• Worked with Yulex Corporation on growing trials in Queensland, NSW and WA from 2005 to 2008.
• In 2021 has the only guayule trial in Australia and has a supply of guayule seed.
• Has a current Memorandum of Understanding with French firm GuaTecs SAS to support commercial cropping and processing of guayule in Australia.
• Has working relationships with potential guayule end users.

PIRSA-SARDI (Australia)

• Dr Peter Appleford, Executive Director, SARDI.
• The South Australia Growth Plan has set a target of annual 3% gross state product growth, which will require expansion of new industries in low-rainfall, marginal cropping and livestock areas across the state. Support for guayule, a crop suited to marginal, semi-arid growing areas, is consistent with the Growth Plan.
• In-principle, SARDI would be prepared to manage and contribute resources to a project focused on seed production and guayule extension hosted at its Loxton facility. The Loxton facility is currently supporting a similar project for AgriFutures Australia aimed at furthering the development of the Australian hemp industry.

EnergyEne Inc. (United States)

• Dr Katrina Cornish, Chief Executive Officer, 30 years’ guayule research experience.
• Dr Cornish also associated with USDA ARS guayule research, and Yulex Corporation.
• Holds patents for guayule hypoallergenic latex production and medical products.
• Dr Cornish formed the company with Tom Fontana (Ohio, US), Australian researcher Dr Henry Brockman and Michael Verwey. Dr Henry Brockman and Michael Verwey are now associated with Guayule Australia Pty Ltd. Guayule Australia Pty Ltd has no commercial link to EnergyEne Inc. (US) and has only Australian shareholders.
• EnergyEne Inc. (US) willing to discuss sublicensing IP to Guayule Australia Pty Ltd. The company “has processing capacity and discussions have been held to import the processing plant into Australia under a licence agreement” (Michael Verwey, Guayule Australia and Dr Katrina Cornish, EnergyEne Inc., pers. comm., June, and July 2021).

25Synthetics are petro-derived and not sustainable, so not a significant threat to alternative natural rubber markets (Dr Katrina Cornish, EnergyEne Inc., pers. comm., July 2021).
Industry stakeholder analysis

GuaTecs SAS (France)
• Michel Dorget, President.
• Has a working relationship with Ansell, which remains interested in guayule latex.
• Interested in sourcing guayule rubber from Australia. Understood that it is prepared to invest in processing facilities in this country if it can raise the required funds.
• Has an arrangement with Guayule Australia to “import processing plant into Australia and manufacture medical products here as much as possible”. This French company and Guayule Australia agree that “while high-price latex is the driver, there is a need to accommodate rubber for industry and transportation, biofuels and other co-products” (Michael Verwey, Guayule Australia, pers. comm., June 2021).

Yulex LLC (United States)
• Jeff Martin, Chief Executive Officer.
• Ilenna Copley is Yulex LLC’s representative in Australia.
• Dr Katrina Cornish was previously Vice President of R&D, Yulex Corporation.
• Yulex Corporation was part-owned by major rubber gloves manufacturer Ansell.
• Worked with Australian cotton growers in the early 2000s to establish guayule crops.
• Yulex Corporation restructured in 2015 to become Yulex LLC. Also supports the website “American BioRubber”, Yulex LLC works with both guayule and Hevea rubber.
• Provided funding for guayule growing trials in Australia in 2016.
• Has indicated that it would like to return to guayule growing in Australia.
• In 2021, Yulex LLC is seeking funding support for grower trials in Queensland.

Individually consulted during Strategic RD&E Plan preparation

Table 4 is a guayule industry stakeholder map. It identifies all known participants within the industry, their relevance to the industry and the method by which they were consulted during preparation of this Strategic RD&E Plan.

Table 4
Guayule industry stakeholder map

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Relevance to the Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Peter Appleford</td>
<td>Executive Director, SARDI. In-principle, SARDI is supportive of guayule seed production and extension at Loxton, SA.</td>
</tr>
<tr>
<td>Dr Henry Brockman</td>
<td>Completed guayule salinity tolerance research with DPIRD in Katanning, WA. Partner in Guayule Australia Pty Ltd.</td>
</tr>
<tr>
<td>Dr Tony A. Catfalt</td>
<td>Research Geneticist, USDA ARS, Phoenix, Arizona. Provided advice on Australian trials in the early 2000s.</td>
</tr>
<tr>
<td>Ilenna Copley</td>
<td>Yulex LLC representative in Australia.</td>
</tr>
<tr>
<td>Dr Katrina Cornish</td>
<td>Prominent in the international literature. Was at USDA ARS. Has her own guayule development company (EnergyEne Inc). Also assisted with establishment of the French and Spanish guayule industries.</td>
</tr>
<tr>
<td>Premawansa Dissanayake</td>
<td>Principal Research Agronomist at UQ Gatton, employed by Yulax Corporation from 2006-08 to set up Queensland trials. Shareholder in Guayule Australia Pty Ltd.</td>
</tr>
<tr>
<td>Michel Dorget</td>
<td>President, GuaTecs SAS. French guayule processor, interested in investing in an Australian guayule processing plant.</td>
</tr>
<tr>
<td>Dr Doug (DL) George</td>
<td>Crop Consult Pty Ltd. Lead author in 2005 RIRDC-UQ Gatton study on evaluating new guayule varieties.</td>
</tr>
<tr>
<td>Dr Madan (ML) Gupta</td>
<td>Senior Lecturer in Agricultural Engineering. Lead author in 2015 RIRDC study on de-barking guayule to improve processing efficiency.</td>
</tr>
<tr>
<td>Jeff Martin</td>
<td>Yulex LLC Chief Executive Officer.</td>
</tr>
<tr>
<td>Vicki Mavrakic</td>
<td>Trade &amp; Investment South Australia. Investigated market demand for guayule.</td>
</tr>
<tr>
<td>Dr Dennis T. Ray</td>
<td>University of Arizona. Guayule authority and distinguished researcher.</td>
</tr>
<tr>
<td>Michael Verwey</td>
<td>Guayule Australia Pty Ltd, Normanton, SA.</td>
</tr>
</tbody>
</table>

A copy of the draft Strategic RD&E Plan was circulated to these stakeholders prior to Plan submission to AgriFutures Australia. Post Plan finalisation, it is anticipated that Guayule Australia Pty Ltd will be the central conduit through which industry information flows.
Australian Guayule Industry Strategic RD&E Plan (2022-2027)
Plan scope
This Strategic RD&E Plan was prepared to describe the Australian guayule industry’s current situation, attract industry participants, and enable targeted investment. Investment will need to be sourced from a variety of investors, including government and the private sector.

Research themes investigated
The following research themes were investigated and provide a justification for proposed investment.

Genetic improvement and seed supply
No further essential research is required prior to the commencement of commercial guayule cropping. However, seed production (bulk-up) is required before commercial cropping can commence. This might be achieved with 1 ha of irrigated guayule at SARDI Loxton and 0.5 ha under dryland on a local farmer’s property, and provision for a seed harvester and use of seed cleaning operations. The approximate cost for this project might be $250,000 over two years.

A breeding program costing $3m over five years may bolster the industry in the medium term. The breeding program would target new cultivars with easy crop establishment (direct sowing), uniform seed ripening and additional rubber yield.

Growing and harvesting guayule
Preliminary guayule growing and harvesting practice has been established for Queensland, NSW, SA and WA. While further research would be advantageous, enough agronomy is known at the current time to grow a commercial guayule crop in Australia. Extension funds are required to package and communicate agronomic information.

Harvesting can be achieved by adapting conventional farming equipment, e.g., cotton module builders. Consequently, harvesting is a low priority for Australian research.

Processing and co-product research
A small, agriculturally focused public research program will have difficulty funding research into industrial processes, including co-product research. Consequently, it may be appropriate to assume that if the guayule industry is to advance in Australia, processing technology will be provided (and owned and operated) by committed overseas entities. A financial (or in-principle) commitment from an overseas guayule processor should be in place before growers commit to this crop.

Expanding the guayule industry
Guayule is an emerging industry with a low profile in Australia. Those who are familiar with the crop may have had an unfavourable experience as a result of participation in Queensland cotton grower trials in the early 2000s. The time is now right to raise awareness and communicate the investment opportunity. Consequently, it is proposed that Australia’s first Guayule Symposium be convened. Invites would include international rubber processors and researchers, potential farmers (e.g., cotton and grain growers), and farmers’ advisors. The Guayule Symposium would be used to articulate a clear development trajectory for the industry, e.g., seed bulk up by 2024, processing plant site selection commenced by 2026, growers contracted to supply 5,000 ha by 2027.

A database of growers should be aggregated from those contacted as part of the development of this Plan, growers who participated in the Queensland cotton trials in 2005-06, and the Guayule Symposium. The database should be used as a channel for ongoing communication with industry and potentially to form an industry association.

Capacity building and extension
The merits of appointing an industry development officer (IDO) to provide the industry with forward momentum was canvassed. Consensus was that if the industry value chain is established, an IDO isn’t required.

Effective extension materials, including agronomic information, are required. Most information already exists and simply requires packaging. Extension materials could be distributed at the proposed Guayule Symposium. While the production and distribution of guayule processor capability statements was canvassed, stakeholders believed that this was a role for processors rather than an organisation such as AgriFutures Australia.

Industry stakeholders saw merit in establishing an industry reference board (IRD) to lead the growth and development of the industry and the implementation of this Strategic RD&E Plan. Ideally, the IRD would be made up of interested processors, researchers, leaders and growers potentially interested in the opportunity. Guayule Australia Pty Ltd would be able to deliver this function as part of an externally funded production/extension project.

The development of a seed production/extension facility at Loxton in partnership with SARDI is a high priority for guayule in Australia. SA Government participation is required to improve credibility and, potentially, increase the scale of the investment.

Program goal
The goal of this Strategic RD&E Plan is to guide investment in targeted research, development and extension activities that support an industry that aims to grow and process 5,000 ha of irrigated guayule for a range of profitable uses by 2027. The industry will be developed by processors, research scientists and Australian guayule growers. A guayule industry of this size will have a GVP of approximately $17.8 million (gross income of $3,560/ha planted).

Priorities, strategies, and activities
Ranking priorities is helpful for an investor to identify where investment would be best spent. Priorities were ranked “very high,” “high,” “medium” and “low.” A realistic program of $400,000 over five years will provide an investor with confidence that progress can be made and that there is not an insurmountable list of needs associated with the development of this industry.

The Strategic RD&E Plan structured through research themes, strategies, activities and priorities is shown in Table 5.

Table 5.

“...the goal of this Strategic RD&E Plan is to guide investment in targeted research, development and extension activities that support an industry that aims to grow and process 5,000 ha of irrigated guayule for a range of profitable uses by 2027.”
### Table 5: Australian Guayule Industry Strategic RD&E Plan themes, strategies, activities and priorities

<table>
<thead>
<tr>
<th>Theme</th>
<th>Strategies</th>
<th>Activities</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Genetic improvement and seed supply</strong></td>
<td>Secure a commercial seed supply to facilitate Australian guayule production</td>
<td>Guayule Australia to work with SARDI Loxton to develop a SARDI-led seed production/extension facility project.</td>
<td>Very high (year 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Guayule Australia to pursue commercial seed bulk-up opportunities with farmers within the greater Loxton area.</td>
<td>High</td>
</tr>
<tr>
<td><strong>Growing and harvesting guayule</strong></td>
<td>Test new guayule cultivars to improve crop performance</td>
<td>Source seed and funding for Australian trials from local and United States sources (potentially including the USDA).</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Research direct seeding, irrigation and dryland production techniques to ensure the crop is profitable when grown in large areas of marginal Australian cropping country.</td>
<td>Very high (year 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Research stand establishment, harvesting year and method i.e., is it better to harvest several times or remove whole crop after 2-5 years?</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Processing and co-product research</strong></td>
<td>Address the high cost of transporting guayule biomass prior to processing</td>
<td>Research the feasibility of mobile processing/pre-processing, especially given dispersed growing locations and the high cost associated with transporting bulky guayule biomass.</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Research and recommend systems to cost effectively and objectively measure the quality of Australian grown guayule – latex yield, biomass produced, metabolites, provenance, etc.</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Develop systems to objectively measure guayule quality to ensure fair payment for growers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Theme: Expanding the industry

- **Strategies**: Raise the profile of guayule to maximise community, government and grower interest in and support for the crop.
- **Activities**: Guayule Australia to articulate and communicate a clear vision for the Australian guayule industry to provide growers with confidence and community support for an environmentally friendly, climate change-proof industry.
- **Priority**: High (year 1)

- **Activities**: Convene and publicise a Guayule Symposium at the Loxton Research Centre – attendees to include end product users, guayule processors, researchers, farmers and advisors.
- **Priority**: Very high (year 3)

#### Theme: Building industry capacity

- **Strategies**: Develop an Australian guayule industry network
- **Activities**: Assemble a database of stakeholders from development of this Strategic RD&E Plan and the symposium, and use the database as a channel for communicating industry developments.
- **Priority**: High

- **Activities**: Encourage processors to provide capability statements – stating interest in Australian grown guayule, the nature of the opportunity for growers and the indicative markets targeted for their products.
- **Priority**: High

- **Activities**: Deliver extension messages to potential guayule growers
- **Priority**: Very high (year 3)

- **Activities**: Deliver extension messages through the SARDI-led seed production/extension facility project at Loxton.
- **Priority**: High

- **Activities**: Package and communicate agronomic information on growing guayule in Australia.
- **Priority**: High

- **Activities**: Complete and communicate detailed analyses of the economics of growing and processing guayule in Australia.
- **Priority**: Medium
Communication and extension

A copy of the final Australian Guayule Industry Strategic RD&E Plan 2022-2027 published by AgriFutures Australia will be forwarded by Guayule Australia Pty Ltd to interested parties.

Guayule Australia will also provide routine reports on progress of the following activities, and communication and extension activities will follow their actioning.

- Establishment of the SARDI-led seed production/extension project at Loxton, SA (year 1 of the Plan).
- A Guayule Symposium at the Loxton Research Centre (year 3 of the Plan).
- Development and delivery of guayule extension messages (year 3 of the Plan).
- An agronomic research project to improve the economics of growing guayule (year 4 of the Plan).

All these activities are contingent on ongoing processor commitment to the purchase of Australian grown guayule.
Monitoring, evaluation and reporting

The monitoring, evaluation and reporting (MER) plan for RD&E investment is summarised in Table 6.

### Table 6
MER plan for investment to develop the Australian guayule industry

<table>
<thead>
<tr>
<th>Project</th>
<th>KPIs</th>
<th>Timing</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishment of the SARDI-led seed production/extension project at Loxton, SA</td>
<td>Guayule Australia has worked with SARDI to prepare a funding application that is acceptable to a funding body.</td>
<td>2022-23</td>
<td>Guayule Australia, SARDI</td>
</tr>
<tr>
<td>Mid-term review of the Australian Guayule Industry Strategic RD&amp;E Plan 2022-2027</td>
<td>A discussion within industry about the ongoing relevance of the Strategic RD&amp;E Plan has been held. Changes to the Plan have been made where these are required.</td>
<td>2024-25</td>
<td>Guayule Australia</td>
</tr>
<tr>
<td>Guayule Symposium</td>
<td>A Guayule Symposium has been held at the Loxton Research Centre, SA.</td>
<td>2024-25</td>
<td>Guayule Australia, SARDI</td>
</tr>
<tr>
<td>Guayule extension</td>
<td>Guayule extension messages have been developed and communicated to current and potential stakeholders.</td>
<td>2024-25</td>
<td>Guayule Australia, SARDI</td>
</tr>
<tr>
<td>Agronomic research</td>
<td>An agronomic research project to improve the economics of growing guayule has been prepared by a suitable researcher for funding consideration.</td>
<td>2025-26</td>
<td>Suitable researcher</td>
</tr>
<tr>
<td>Formal review of the Australian Guayule Industry Strategic RD&amp;E Plan 2022-2027</td>
<td>The Australian Guayule Industry Strategic RD&amp;E Plan has been reviewed.</td>
<td>2026-27</td>
<td></td>
</tr>
</tbody>
</table>

Plan implementation

### Investors

This Strategic RD&E Plan has been prepared to provide potential investors in the Australian guayule industry with a roadmap for investment and some indication of what is required to establish an industry in Australia. Investors might include government agencies, modern manufacturing investment funds, overseas-based processors and farmers looking for diversification options. It is anticipated that this group of stakeholders will be the major users/beneficiaries of the Plan.

### Risk management

Industry risks and risks associated with achieving Plan outcomes are addressed in Table 7.

### Table 7
Risk management

<table>
<thead>
<tr>
<th>Risk</th>
<th>Likelihood</th>
<th>Consequence</th>
<th>Mitigation measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retirement of key industry personnel</td>
<td>Medium</td>
<td>High</td>
<td>Develop guayule knowledge and expertise in the Loxton Research Centre, SA.</td>
</tr>
<tr>
<td>Guayule processor fails to commit to Australia</td>
<td>High</td>
<td>High</td>
<td>Reconsider ongoing investment in guayule RD&amp;E</td>
</tr>
<tr>
<td>No funding co-contribution to the proposed guayule seed production/extension facility is received</td>
<td>High</td>
<td>High</td>
<td>Guayule Australia to work closely with SARDI to ensure an appropriate proposal is prepared</td>
</tr>
<tr>
<td>Low awareness of the guayule industry by potential Australian growers</td>
<td>Medium</td>
<td>High</td>
<td>Deliver the extension and awareness-raising measures described in this Plan</td>
</tr>
</tbody>
</table>

Evaluation of the Strategic RD&E Plan

Two reviews of the plan are proposed. A mid-term review will be a simple exercise completed by Guayule Australia that reviews progress and the ongoing relevance of Plan KPIs. A more formal review of the plan should occur in 2026-27 and may include a benefit-cost analysis of funds invested. The results of the formal review may inform the next Strategic RD&E Plan.
Allhands, J. (undated). Farmers in Pinal County Arizona are facing water shortages. Shouldn’t they be growing less thirsty crops?


Stewart, G. A., ed. (1986). Guayule in Australia: Potential Production of Natural Rubber from Guayule (Parthenium argentatum) in Australia. CSIRO, Canberra, Australia


