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Biological Invasion Pueraria Montana Var Lobata has Negative Impact Towards Water, Agricultural Land Use for Substance Farming and Sustainable Development

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Abstract

Invasive alien species (IAS) are species introduced into places outside their natural range that have negative impacts on native biodiversity. The study aims to document the identified sites and monitor eradication progress of all cleared sites in Mpumalanga and observe and record the number of missed plants and investigate the cause and best possible method to eradicate them in future. Alien invasive plants fuels climate change ,water shortage and health and environmental risk therefore there is a need to tackle them Monitoring and evaluation of biological invasion cleared sites is a crucial issue in South Africa thefore the study aims to close the gap. The applied study applied qualitative methodology. *Pueraria montana var lobata* has invaded at least four Provinces in South Africa, and within the four provinces ,there are contracting teams appointed to manage the populations. Mpumalanga Province has eleven known populations, KwaZulu Natal Province has five populations, Gauteng Province has one population and Limpopo has also one population. The total known population in South Africa are estimated to eighteen sites. The research will increase the knowledge in monitoring and evaluation.

Keywords: invasion, eradication, monitor, evaluation, species

Introduction and Background of study

Invasive alien species (IAS) are species introduced into places outside their natural range that have negative impacts on native biodiversity.IAS have major impacts on human health, livelihoods, land ,and food security, and undermine progress towards achieving many of the Sustainable Development Goals .Recently South African had harshly hit by floods in Provinces like KwaZulu Natal ,Mpumalanga ,Eastern Cape and one of the major impact is alien invasive plants *Pueraria montana var lobata* commonly known as Kudzu vine has been in South Africa for couple of decades before action was taken to attempt to control and contain further spread .*Pueraria montana var lobata* is regarded as one of the toughest or aggressive species in United State of America (CABI ,2023, Shurtleff,,1995,Forseth & Innis,2004 ,Kato-Noguchi,2023, Zhou et al,.2021, 30,Profetto et al., 2021).Pueraria montana is listed as category 1a according to the NEMBA regulations, this means the species it is a mandatory to eradication the species.

The vines of *Pueraria montana var lobata* can grow 10 to 30 m high (Miller, J-H. 1986. & Mitich, 2000 ,Ino et al., 1973, Kato-Noguchi,2023 ,Bautista et al.,2010).Through observation *Pueraria montana var lobata* seems to be not active in winter seasons it cannot stand for frost like other invasive species. (Gigon et al., ,2014Mitich, 2000, Tsugawa, 1986 ,Kato-Noguchi,2023) . *Pueraria montana var lobata* grow well during raining or summer season .(January -March) in South Africa .However in other countries some studies mention that *Pueraria montana var lobata* can survive in a 5-degree Celsius cool (Bautista,et al .,2010,Holm,1989, Shurtleff,1995, Zhou et al,.2021). *Pueraria montana var lobata* (Kudzu vine) prefer to grow well in winter and humid summer season (Lindgren et al. 2013, Kato-Noguchi,2013).

Pueraria montana var lobata (Kudzu vine) is a climber, energetic, leguminous plant from the Fabaceae family. Kudzu vine is native to eastern Asia China, Japan, and Korea, (Carter & Teramura,2016, Bentley ,2016,Tsugawa et al ,1997, Tsugawa, et al.,1986, Kato-Noguchi ,2023, Zhou et al,.2021). *Pueraria montana var lobata* was spotted in South Africa ,central and South America .(EPPO, 2007, Follak,

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2011, Zhou et al,.2021).In the United States, it spread from New York in the north, south to Florida, and west to Texas and Oklahoma (Forseth and Innis, 2004). Recently, it was also found in Canada, Switzerland, and Italy (EPPO, 2007, Follak, 2011, Bautista,et al.,2010, Hinman, 2011, Zhou et al,.2021).*Pueraria montana var lobata* grow well in many different soil types like loamy soil, clay soil, and sandy soils (CABI,2023,Mitich, 2000 & Lindgren et al.,2013 Kato-Noguchi, 2023 ,Profetto et al,.2021).

In the early 1900s farmers in the USA used *Pueraria montana var lobata* various socio-economic benefits (ornamental & fodder). *Pueraria montana var lobata* serve as fodder for sheep, Cattle and chickens (Lindgren et al.,2013 & Hinman, 2011, Shurtleff,1995`).The study aims to document the identified sites and monitor eradication progress of all cleared sites in Mpumalanga and observe and record the number of missed plants and investigate the cause and best possible method to eradicate them in future. Monitoring and evaluation are the key components of project management ;therefore, it is important to evaluate the project before closing out the project .

Monitoring and evaluation are used to measure the project progress and is essential for problem identification .Currently there is no system in plan to monitor or evaluate the cleared project in Mpumalanga Province. Mpumalanga region is pilot project used to eradication progress of identified populations of Pueraria montana var lobata and the province used as lesson learn to other Provinces. Currently there is no literature for monitoring and evaluation of clearing Kudzu vine in South Africa that can serve as a guidance for this climber .

In South Africa in the nine(9) provinces *Pueraria montana var lobata* has invaded at least four (4) Provinces, and within the four provinces ,there are contracting teams appointed to manage the populations. Mpumalanga Province has eleven (11) known populations), KwaZulu Natal Province has five (5) populations, Gauteng Province has one (1) population and Limpopo has also one (1) population. The total known population in South Africa are estimated to eighteen (18) sites.

Pueraria montana var lobata can misbehave towards the environment, ecology as well as the economics of the country and has negative impact towards the biodiversity (Forseth,2004, Gigon et al,.2014, Miller, 1986) . *Pueraria montana var lobata* is also a threat to the agricultural land ,railways line ,building telephone poles and other infrastructures if they are not urgently attended to. (Zhou et al,.2021,McClain et al,2006 11,Frankel1 et al.,1989,). The tourism industries are also affected by the alarming rate of *Pueraria montana var lobata* invasion as it affects the quality of the Private land ,National Parks and Game Reserves .In order to preserve the fauna and flora it is empirical to monitor the threats to diversity like eradicating the alien invasive plants and preventing the spread (Kovach-Hammons et at.,2023 ,Miller, 1986, Zhou et al,.2021, Frankelet al,.1989).Once it is introduced it is difficult to control especially in dense areas

The economic cost of *Pueraria montana var lobata* clearing yearly is estimated to R300 ,0000 whereas USAN total cost spent on *Pueraria montana var lobata* clearing amount to $100 million yearly (Lindgren et al,.2013, Pimentel,2011& Michael & Miller, 1986.).Our natural forest systems also play a crucial role towards Conservation however with alarming rate of alien invasive plants companies are paying approximately R500 per hectare per year for from one year - five years to control *Pueraria montana var lobata* infestation (Pimentel,2011, Miller, 1986), while power companies are paying 1.5 ZAR a year to manage *Pueraria montana var lobata* and make up for power loss in developing countries (Miller,1986. & Pimentel,2011, Zhou et al,.2021).The biological invasive cost may increase as more localities are identified and when the populations are not controlled .This may lead to species to be out of hand and become widespread .Ecosystems also suffer and lead to water shortage if alien invasive plants are not controlled.

To ensure the preservation of native fauna and flora, it is imperative to proactively monitor and manage the diversity-threatening factors, including the eradication of alien invasive plants and the prevention of their propagation (Britton et al.,2002,Kovach-Hammons et al., 2023; Miller,1986, Zhou et al,.2021). Once introduced, this species becomes particularly challenging to control, especially within densely infested areas.

At Bushbuckridge and Mbombela, there are rural communities in which people drink un-purified and polluted water from the canal, sharing water with animals in the process. Such people do not appreciate the value and importance of groundwater in their communities. There are people who need to travel more than five kilometres to fetch water for cooking and this might be because of the dispersal of the alien invasive that consume water and outcompete for space . Some members of the community travel long distances for washing clothes in the river because they have no access to tap water in their yard or household. Although water shortage is experienced by people living in all areas under Bushbuckridge and Mbombela local municipalities, the shortage of water is relatively more severe at Bushbuckridge Municipality (Muller, 2018 Britton et al.,2002). Water

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pollution threatens SDG 14 (Life Below Water) by damaging aquatic ecosystems, leading to the loss of biodiversity. Additionally, it can disrupt livelihoods dependent on these ecosystems, affecting SDG 1 (No Poverty) and SDG 8 (Decent Work and Economic Growth)

Alien invasive plants increase evaporation rates and reduce stream flow and dilution capacity. The biomass inputs of alien invasive plants, especially nitrogen fixers such as Acacia spp., alter nutrient cycles and can elevate nutrient concentrations in groundwater (Forseth,2004) .The financial implications of managing *Pueraria montana var lobata* are substantial, with annual clearing costs estimated at R300,000, and a staggering $100 million expended by USAN (Lindgren et al., 2013; Pimentel, 2011; Michael & Miller, 1986). The impact on natural forest systems, integral to conservation efforts, is substantial. Companies are dedicating around R500 per hectare annually over one to five years to combat *Pueraria montana var lobata* infestations, while power companies are allocating R1.5 million per year to mitigate both the presence of the species and the resultant power loss in developing nations (Miller, J-H., 1986; Pimentel, 2011).

As further areas of infection are found and populations are allowed to grow unchecked, the biological and economical costs of invasive species may increase. This process can result in an unchecked spread of the species, threatening nearby ecosystems and possibly exacerbating the water crisis if the growth of foreign invasive plants is not successfully stopped. About 20.7% of households in South Africa work in agriculture, and 65% of those households rely on subsistence farming to cover their food needs. Both figures have probably gone up because of the coronavirus pandemic's effects on the economy and South Africa's rising jobless rate.

In South Africa, most subsistence farmers are from rural areas, where subsistence farming is a more important means of enhancing one's standard of living than it is in metropolitan areas. By guaranteeing food security, subsistence farming is a livelihood approach that has the power to end hunger and poverty. Nonetheless, these communities' subsistence farmers confront a variety of difficulties, such as: The effects of climate change, low educational attainment, ignorance of cutting-edge techniques to boost sustainability and productivity, A lack of skilled labour to maintain the continuation of subsistence farming and the use of marginal land that makes it difficult to access market activities

In the early 1900s farmers in the USA used *Pueraria montana var lobata* various socio-economic benefits (ornamental & fodder).Kudzu vine serve as fodder for sheep, Cattle and chickens (Lindgren et al.,2013 & Hinman, 2011, Corley et al,2023 7,Corley et al.1997,).The aims to monitor and evaluate all cleared sites in Mpumalanga and count the number of missed nodes and investigate the cause best possible method to eradicate them in future. Monitoring and evaluation are the key components of project management ;therefore, it is important to evaluate the project before closing out the project .Monitoring and evaluation is used to measure the project progress and is essential for problem identification .Currently there is no system in plan to monitor or evaluate the cleared project in Mpumalanga. Mpumalanga region is pilot project used to check if monitoring tools used are effective to make sure project produce successful results after implementation and to give recommendation for best possible solution going forward .Currently there is no literature for monitoring and evaluation of clearing Kudzu vine in South Africa that can serve as a guidance species specific.

Climate change and availability of natural resources

Climate change affects all of us. Acting on it is fundamental for a thriving, resilient state (DWS, 2018). Extreme weather events can disrupt natural resource management by damaging ecosystems both on land and water. Changes in weather patterns also shift suitable habitat for many species. These conditions lead to new challenges for land managers and can lead to disputes about land tenure and water management systems. It is therefore important that biological invasion be managed to reduce the spread and increase water flow and land for agricultural practice, and this will reduce the challenge of poverty, food security ,climate change and water shortage. It is estimated that a growing number of people in South African cities and towns will be exposed to the devastating impacts of weather-induced natural hazards such as flooding, heatwaves, droughts, coastal flooding, wildfires, and storms. (Le Roux, van Niekerk, Arnold, Pieterse, Ludick, Forsyth, Le Maitre, Lotter, du Plessis, & Mans, 2019

A wide variety of flora and wildlife can be found in Zimbabwe's diversified habitats and vegetative ecosystems, which are classified by ecoregions within a subtropical climate. Native biodiversity has been impacted by invasive alien species (IAS) in practically every kind of ecosystem in the nation. They are one of the main causes of the loss of biodiversity and hence a threat to human well-being as well as the integrity and function of ecosystems. Additionally, because IAS have an adverse effect on human health, forestry, fisheries, agriculture, and wild biodiversity all of which are frequently the main sources of income for people living in underdeveloped nations they also worsen poverty and pose a danger to sustainable development. The introduction of agricultural insect pests, which has led to

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lower yields in important staple crops like grains, is the largest threat to agriculture biodiversity (Mujaju et al.2021 Edwards ,1981,)

The importance of biodiversity and ecosystems for water security

Effective management of the landscape within the Strategic Framework for Water Reform (DWS, 2018) requires the availability of water to maintain terrestrial, riparian, wetlands and stygian ecosystems that require groundwater. The variety of genes, populations, species, communities, ecosystems, and ecological processes that make up life on Earth – underpins ecosystem services, sustains humanity, is foundational to the resilience of life on Earth, and is integral to the fabric of all the world 's cultures. Biodiversity provides a variety of ecosystem services that humankind relies on, including provisioning (e.g. food, freshwater, wood and fiber, and fuel); regulating (e.g. of climate, flood, diseases); cultural (e.g. aesthetic, spiritual, educational, and recreational), and supporting (e.g. nutrient cycling, soil formation, and primary production (Mafuwane,2020 These ecosystem services contribute to human wellbeing, including our security, health, social relations, and freedom of choice and action, yet they are fragile and being diminished across the globe. We are at risk of losing much of biodiversity and the benefits it provides humanity. As humankind's footprint has swelled, unsustainable use of land, ocean, and freshwater resources, has produced extraordinary global changes, from increased habitat loss, invasive species, to anthropogenic pollution and climate change.(Mafuwane ,2020).

Material and Methods

Study sites

This study area is in ,Mbombela Mpumalanga South Africa .Survey was conducted at eleven (11) sites across the Mpumalanga province, namely :Kaapsehoop ,Twycross, SAPPI, Gladdespruit ,Likweti road ,Queensriver ,Twycross ,Schagen stream, muddy house and Kaapsehoop2 & Kaapsehoop 3 Mahiyane RDP houses. Monitoring was conducted between April and May ,July 2023 (Table 1).

Material

The survey was conducted on foot. Coordinates were recorded using a hand-held global positioning system receiver (Garmin Oregon 750). Pen and notebook were used to record the species spotted. Photographs were taken using Canon Camera. While taking pictures in each species we were taking a full Picture of plant, leaves, flowers, seeds as well as picture of overview for the area surveyed

Site Name	Species Name	GPS coordinate	Area Size	No of initial Ha cleared	No of treatment /follow up	Vegetation Type
Schagen Muddy House	*Pueraria montana var. lobata*	25 22'6.74"S 30 41'5.32"E	2.63	1	7	Afromontane grassland
Schagen Sappi Plantations 005	*Pueraria montana var. lobata*	25 19'56.31"S 30 44'41.30"E	19.73	1	7	Afromontane grassland
Schagen Stream 007	*Pueraria montana var. lobata*	25 20'23.61"S 30 43'31.99"E	4.39	1	7	Afromontane grassland
Schagen Farm 006	*Pueraria montana var. lobata*	25 20'45.48"S 30 44'3.80"E	108.46	1	7	Afromontane grassland
Gladdespruit Nelspruit 004	*Pueraria montana var. lobata*	25 27'45.53"S 30 56'50.21"E	11.4	1	5	Afromontane grassland

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Pine Valley Plantation 008	*Pueraria montana var. lobata*	25 20'45.20"S 30 42'33.18"E	0.95	1	7	Afromontane grassland
Likweti road 1	*Pueraria montana var. lobata*	25 21'26.16"S 31 3'10.79"E	0.45	1	3	Afromontane grassland
Likweti road 2	*Pueraria montana var. lobata*	25 22'28.36"S 31 3'36.35"E	17.56	1	3	Afromontane grassland
Kaapsehoop Stream 002	*Pueraria montana var. lobata*	25 39'53.83"S 30 54'45.92"E	85.51	1	7	Afromontane grassland
Kaapsehoop Farm 003	*Pueraria montana var. lobata*	25 38'35.53"S 30 54'48.45"E	38.10	1	5	Afromontane grassland
Kaapsehoop 001	*Pueraria montana var. lobata*	25 39'20.72"S 30 55'34.39"E	1.11	1	7	Afromontane grassland

How often was the population counted

Populations were measured based on the density estimation using the following scale :Rare (0-0,9) ,occasional (1.00-4.5) ,very (5.00) scattered ,scattered (6.00-25.00),medium (26.00-50 .00),Dense (51-75), and closed (75-100). Muddy house (Site 1) Number of missed nodes counted or found inside the polygon amount to One hundred and two (102) nodes. There were fifty-five (55) new growth coming out and others Ninety (92) matured ones that were missed during clearing this might be because team was rushing to finish work and community protest the contractor .The means that the class for the density estimation for site 1 was it ranging between 6-25 % (scattered).Population was counted three times during monitoring and evaluation

The population was completely cleared no plant or nodes were observed during the monitoring .

During the Pre and post monitoring we did not notice any sign of regrowth or nodes or miss plants left out .Estimated area size was 1 Ha, and the density coverage was ranging between (0-5%) two (2) miss plant spotted and no nodes

Control Mechanism

For this study we have looked at the two-method used namely Foliar application and cut and spray (Chemical method).Foliar application method were applied to the leaves to supress the biomass while cut and spray was mainly used to target the rhizomes. Small or seedling plants we have applied the uprooting methods. *Pueraria montana var lobata* has a registered herbicide Triclopyr 480 g/l Garlon 480 EC .For foliar application which was applied at the rate of 500 mλ (0,5 % mixture) in 100 Litres of water and 20ml of wetter and Dye.

This rate is applied for actively growing plants ensuring a thorough wetting. Limited re-growth may occur requiring a follow-up treatment. South African pesticide companies is regulated under Fertilizers ,Farm Feeds ,Seeds and Remedies Act of 1947. All pesticide registration and product labelling happen under the FFFAR Act. . Where multiple stumps are present, all cut surfaces must be treated. In all cases, apply until the point of run-off. In the event of some regrowth and depending on the species, a follow-up spray as a coppice application with either Garlon 480 EC (Reg. No. L4916 Act No. 36 of 1947) or Plenum 160 ME.

When was the control conducted.

- Continuous clearing of *Pueraria montana var lobata* started back in 2013 to date and the last follow up treatment was in 2023 March .
- 2013 Management trials and eradication plan developed and implemented.
- 2014 all populations around Sudwala were treated as follow up.
- 2019/20 New locality spotted at Gladdespruit as follow up work and Likweti as initial work In Mpumalanga Province

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- 2015 -Two 2 population spotted at RDP houses at Kaapsehoop, and initial clearing started in 2016
- Portion of Muddy House farm currently on substance farming was treated
- New population Identified to be verified this 2022/23 clearing season at Kaapsehoop Donga
- 2021/22 -MP teams continue to do work on known populations. One new locality was identified at Kaapsehoop RDP Houses closer to the road.

Control costs

Species	Year	Budget	No of Jobs created
Pueraria montana var lobata	2012/13	*R 772 644.15*	*36*
Pueraria montana var lobata	2013/14	*R 553 777.45*	24
Pueraria montana var lobata	2014/15	*R412 465.76*	24
Pueraria montana var lobata	2015/16	*R328 772.15*	12
Pueraria montana var lobata	2016/17	*R245 031.85*	12
Pueraria montana var lobata	2017/18	*R102 554.85*	12
Pueraria montana var lobata	2018/19	*R103554.00*	12
Pueraria montana var lobata	2019/20	*R195 837.44*	12
Pueraria montana var lobata	2020/21	*R222 031.50,*	12
Pueraria montana var lobata	2021/22	*R228 954.31*	24
Pueraria montana var lobata	2022/23	*R208855.86*	24

Herbicides cost

Each financial herbicide request was submitted based to on the needs of the projects and data collected using the task verification tool .The herbicide registered for treating Pueraria montana var lobata was Plenum 160 ME and Garlon 480EC.The estimated cost for a 5Liters– Garlon EC used for Cut-Stump killer (NUVOGON) ranges from R1,660.00 .Since 2013 the Mpumalanga region has spent +_ R19 920.00 for herbicide procurement

Personnel cost:

Since 2013 -2023 conduct the field survey monitoring the clearing of Pueraria montana var lobata and the budget below shows how budget as used Mpumalanga regional for staff to do the field work. Formular for calculation is as follows :

Three (3) x personnel x income x days

3x 24 days x 1500.00

=R108 000.00

How were Monitoring and evaluation done.

We were walking around the sites taking the GPS tracks and taking pictures. Checking if the plants are dead and if there are no miss plants and to check if indeed only targeted species are applied with herbicide without any harm of indigenous plants .For each site the monitoring will only be done for an hour especially where the area was easily accessible**.**

How often was monitoring conducted

Since 2013 -2023 the project did Pre-Evaluation and post from January -March in all clearing work done in the Mpumalanga region. Data was collected and stored in the Mpumalanga Region.Anothercycle of monitoring was conducted a month before the clearing starts ,during clearing and after clearing was completed**.**

Site 1 -Sudwala

The study area was conducted at Mankele (Muddy House) farm where we calculated by 5000x 5000 square =1Hectare and we do the tracks of miss nodes within the farm .The following materials were used using GPS ,Notebook,pen,Tape measure. In site 1 we have observed that *Pueraria montana var lobata* grow well in loam soil. The soil at Muddy house look futile because the community members practice substance farming and nearby the are we observe mines which has minerals to increase the soil fertility .Muddy house is an area with high rain fall due to the plantation and the escarpment .It was easy to count the nodes of *Pueraria montana var lobata* because the area was burned .Number of missed nodes counted or found inside the polygon amount to One hundred and two (102) nodes. There were fifty five (55) new growth coming out and others Ninety (92) matured ones that were missed during clearing this might be because team was rushing to finish work and community protest against the contractor .Clearing was done from 01 March 2023 to 31 March 2023 .February was a rainy season and

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clearing couldn't take place and has increase the density of *Pueraria montana var lobata* from where it was .The method for treatment *Pueraria montana var lobata* of was Foliar application and cut stump where they were targeting the nodes of *Pueraria montana var lobata*. Garlon Max 270 was used as registered herbicide for *Pueraria montana var lobata* at the rate of 3% to 10litres of water with 30 ml of dye and wetter. The biomass was dense .It took the team three days to clear the site at the team of 24 people .The strategy use was free styling they were opening two to three meters far apart starting from up and going down wards .Community stop the clearing and team in rush to finish .

Site 2-Twycross

Pueraria montana var lobata was invading the powerline and contracting team using Knapsack with Herbicide. There were no nodes spotted during monitoring and evaluation .The *Pueraria montana var lobata* was completely dead. *Pueraria montana var lobata* was also at matured stage .The area was monitoring was done around 15-17 May 2023 after clearing has been completed in March .The density coverage for *Pueraria montana var lobata* before clearing was 80% coverage .The method for treatment was Foliar application and cut stump where they were targeting the nodes of *Pueraria montana var lobata*. Garlon Max 270 was used as registered herbicide for *Pueraria montana var lobata* at the rate of 3% to 10litre of water with 30 ml of dye and wetter. It took them 3 hours to treat the site as it was a small population .

Site -Schagen Stream

In study area 3 there was more complicated the team could not cross to the other site because there was no bridge the area was flooded with water in February. During the Pre and post monitoring we did not notice any sign of regrowth or nodes or miss plants left out .Estimated area size was 1 Ha, and the density coverage was ranging between (0-5%) two (2) miss plant spotted and no nodes

Site 4 -SAPPI

SAPPI was very critical site to clear .88 nodes of regrowth were counted during monitoring .Team was sent back to do follow work three times. Treatments were replicated 3 times in a completely randomized design. Plots were 45 ft wide and about 200 ft long, extending from a ridge to the lower slope of a kudzu patch in west central SAPPI plantation. The SAPPI soils were a loam. *Pueraria montana var lobata* had been growing on this land more than 10 years. Experiment of finding best possible methods was conducted in 2015 at SAPPI site

Site 5-SAPPI Plantation

Sappi Plantation is second biggest site in Sudwala with at 90 % density. It took the team 4 days to treat the site application was made in March 2023 , after 4 days inch rain, which was followed in 2 days by a period of frequent rains. The month of March in Mpumalanga is known to be rainy month and its difficult time to treat to treat *Pueraria montana var lobata* if rainfall is to too much. When it's raining, they cannot apply herbicide, and this affect the effective treatment. Experiments were conducted to determine the best control method. Plots were randomly selected, and different treatments methods were applied. The efficiency of the control method used was assessed 2 weeks after the control operations by recording the number of missed plants, number of regrowth and number of dead plants. Herbicides used were Plenum 160 ME (by Dow Agrosciences) and manual treatment, complete removal of plant structure by digging.

Site 6-Kaapsehoop stream

This is a longest stream with more infestation of *Pueraria montana var lobata* .Initial clearing was conducted in 2013 and currently the area is under maintenance phase (Follow up).During monitoring we have spotted and recorded seven (7) young plants and Six (6) regrowth

Site 7-Queens river

Both chemical and manual treatments methods were used to supress the spread of *Pueraria montana var lobata* population found in Queens River on Barberton Road. Initial and five follow up clearing was conducted in past decades. Floods affected the control especially to the population that was near to the river. During the monitoring we have notice 66 missed plants this might be due to the accessibility. The area requires manual clearing and digging of the rhizomes. We have also observed eight (8) re-sprouting or regrowth . Digging was the most labour-intensive method, whereas foliar spraying was the cost-effective method. In areas closer to water, digging was recommended

Site 8-Likweti

Monitoring was conducted in May and August 2023 to count the number of miss plants ,regrowth and nodes coming out after clearing .Both chemical and manual treatments methods were found to be effective. There was no re-sprouting or regrowth observed. Two methods were applied which is Digging and foliar application ,Digging was the most labour-intensive method, whereas foliar spraying was the cost-effective method. In areas closer to water, digging was recommended. One initial clearing and three follow up work

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has been conducted. *Pueraria montana var lobata* in Likweti formed a dense mat over the ground and next to the road and invading the forest and causing trees to collapse has been treated. During the monitoring only one small plant was recorded and there was no re-sprouting or regrowth observed. The soil type was loamy and fertile. We also observe a stream-like covered by tree's barks and leaves .

Site 9-Gladdespruit

Monitoring and evaluation was conducted at Gladdespruit in March and August 2023 with an aim to check the number of missed plants regrowth and nodes left unattended at this spruit .Initial work and three follow up work was done since 2018 after the locality was spotted .Teams used Digging and foliar application method .Foliar application was used to supress the biomass and digging was used to kill the rhizomes .Digging and cutting of the rhizomes was the most labour-intensive method and effective , whereas foliar spraying was the cost-effective method. In areas closer to water, digging was recommended to avoid herbicide spillage into water. During the monitoring in August 2023, we have only seen two (2) missed plants that was growing next to the rocks and covered with leaves and reeds. The missed plants were observed clearly because the area was burnt during the monitoring There was no re-sprouting or regrowth observed seen .

Site 10-Mahiyani

This population was spotted inside a donga and accessibility was difficult to use the digging method .Team was advised to use the follow application to suppress the leaves .Chemical method was used for 5 days and for three days teams did search for the nodes and rhizomes and only six of them was treated with herbicide and the herbicide treatments methods were found to be effective. There re-sprouting observed which require the digging, which is most labour-intensive method, due to the danger of the area high altitude team was requested to assist with the follow up clearing

Site 11- Schagen 1

Both chemical and manual treatments methods were found to be effective. There were no nodes observed. All plants spotted was cleared

Site 12-Schagen 2

Both chemical and manual treatments methods were found to be effective. There was no re-sprouting or regrowth observed. Digging was the most labour-intensive method, whereas foliar spraying was the cost-effective method. In areas closer to water, digging was recommended

RESULTS AND DISCUSSION

Mpumalanga Province has eleven (11) known populations), KwaZulu Natal Province has five (5) populations, Gauteng Province has one (1) population and Limpopo has also one (1) population. The total known population in South Africa are estimated to eighteen (18) sites. The infested area is estimated to 272 Hectares Findings indicated that *Pueraria montana var lobata* thrived in the Three land where residents practice substance farming KaMahiyani ,two sisters farm and Muddy House in Sudwala those area were densely distributed. Some population of *Pueraria montana var lobata* are at large stream that flows towards Two sisters ,Gladdespruit and Likweti stream . These findings indicate that *Pueraria montana var lobata* has big runners, that can be misidentified when growing with other species like *Thunbergia agatiflora.*

Pueraria montana var lobata (Kudzu vine) is a perennial vine with purple flower ,that can engulf powerline ,roads and buildings. The SANBI team estimated the percentage coverage of *Pueraria montana var lobata* in each population before clearing can commence to quantify the extend of density. The focus was to check the canopy cover and estimated the number of flower groups (inflorescences (if any) and pod groups in the population because of inaccessibility to some populations as it was difficult to count each plant. During the monitoring and evaluation, we have noted that *Pueraria montana var lobata* spreads through rhizomes and vines and this doesn't mean *Pueraria montana var lobata* does not spread through seeds. *Pueraria montana var lobata* has covered other well-established species and indigenous plants that were growing in the same space. During the monitoring we have noted that the soil type and climatic condition has impact towards the increase of *Pueraria montana var lobata* . This data helped in quantifying the extent or the decrease of the *Pueraria montana var lobata* populations.

We have not noticed any leave grazed by herbivores in all populations ,this was done by checking the selected 15 leaves randomly from each population. We have only recorded the leaves eaten by insects randomly and 30 leaves were recorded in all population. We have also counted eight (8) pine trees that was covered by the climber *Pueraria montana var lobata.* We also noted any other important features such as locality like checking if the species is growing next to a river or not, in a plantation or not (Kaapsehoop stream and Schagen stream).We have check if rhizomes are easily breakable and we have noted that the rhizomes cannot be broken by hand without using slashers when they are not dry. During the

monitoring we have noted that team had done cut stump and apply the herbicide on the tuberous taproots .

Pueraria montana var lobata (Kudzu vine) rhizomes were cut and left on the ground as we were observing we have not seen *Pueraria montana var lobata (* Kudzu vine) that was cut growing again . Seeds pods from treated plants were also dry up there was no sign of fertility of the seeds as the sack shows to be dried and dead. Experiments were conducted in 2021 June 14 to determine the best control method. Plots were randomly selected, and different treatments methods were applied. The efficiency of the control method used was assessed 2 weeks after the control operations by recording the number of missed plants, number of regrowth and number of dead plants. Herbicides used were Plenum 160 ME (by Dow Agrosciences) and manual treatment, complete removal of plant structure by digging.

Both chemical and manual treatments methods were found to be effective. There was no re-sprouting or regrowth observed. Digging was the most labour-intensive method, whereas foliar spraying was the cost-effective method. In areas closer to water, digging was recommended.

During the monitoring we have found out that treatment for site 1,2,3,4,&6 was successful as compare to site 5,7,8,9&10.The successful treatment for site 1,2,3,4 was basically because of the consistent follow up clearing and targeting of the nodes and rhizomes than focusing on treating the leaves .Number of days allocated to control was ranging between 50 to 60 days which gives team ample time to do more follow up work before actual end date of the contract. Team was more productive and there were no days lost due to rain . Both chemical and manual treatments methods were found to be effective. There was no re-sprouting or regrowth observed. Digging was the most labour-intensive method, whereas foliar spraying was the cost-effective method. In areas closer to water, digging was recommended

Conclusion and Recommendation

Management ,Monitoring and evaluation are the key components to programme management and play important role in the success of project. The spread of biological invasion in farms and conservation land may be because of lack of awareness therefore it is important to increase awareness in our communities and farmers . It is therefore important to ensure that we protect the fauna and flora by eradicating or managing it before its widespread. The success of monitoring and evaluation provide insight into progress of effectiveness control .It is important to collect data and analyse the results ,create timeline for monitoring and evaluation .The is a need for framework for monitoring and evaluation of project implementation within biological invasion .Currently the is no system in place for monitoring and evaluation the projects before close out of projects .In order to measure the effectiveness of the project Standard operating procedure and Framework must be developed and followed. This will increase the chances of not losing follow up work .It is important to democratised data in order to improve productivity and save time There is need for effective monitoring elements which include to observe change within the project ,monitoring the intervention performance and monitoring the results .Monitoring help to identify potential problems before they become critical problem and adjust strategies accordingly .Monitoring is an important tool to assist weather project is on track or is achieving its aim. It is also recommended that chemical companies must ensure they do more trial of herbicide and innovative ways to eradicate *Pueraria montana var lobata* must be initiated and implemented. It is important to conduct continuous follow up to receive good results. If biological invasion is not well managed, they will impact the biodiversity and increase the negative impact they might have towards the biodiversity. It is recommended that skills for monitoring and evaluation be provided to Staff managing the biological invasion .

Conflict of Interest

There is no conflict of Interest

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