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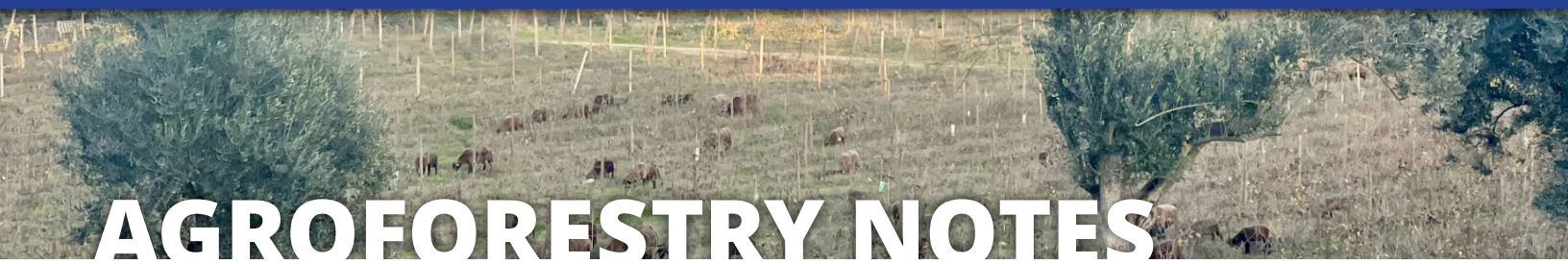

AGROFORESTRY NOTES

Silvopasture in Vineyards

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Introduction

Silvopasture is the practice of managing desired woody perennials, forages, and livestock on the same unit of land. Silvopasture systems can be applied in many settings, including vineyards. In vineyard silvopasture systems, vines are the perennial component and small livestock are grazed in the alleys between vine rows. While grapevines are not trees, they are woody perennials that provide some of the same functions as trees in silvopasture systems. Like trees, grapevines can be intentionally integrated with other components into a single system to generate benefits for both growers and for the environment.

In vineyard silvopasture systems, the pasture component can include cover crops, forage for livestock, or resident vegetation, including weeds. The forage component has several functions, such as feeding livestock, improving soil health, increasing soil water holding capacity, improving integrated pest management, and in many cases, enhancing grape quality. Small animals, such as sheep, certain breeds of pigs, and poultry, are considered the most appropriate livestock for use in vineyards because cattle are typically too large for the row spacing, goats have browsing habits that can damage grapes and vines, and most breeds of pigs can damage soil and vine roots by rooting. Livestock are typically grazed seasonally in vineyards so that they do not eat or damage developing shoots or ripening fruit.

In this silvopasture system in New Zealand, sheep are rotated through grapevines during the dormant season. Courtesy photo by Meredith Niles, University of Vermont.

If table grapes or raisins are being grown, as opposed to wine grapes, animals may also need to be excluded at certain times of the year to prevent contamination of ripening crops. While many vineyards are introducing groundcover, such as cover crops, without grazing, the introduction of livestock can aid with vegetation management and provide many other benefits.

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Banner Photo: Vineyard silvopasture in Alentejo, Portugal. USDA Forest Service photo by Katherine Favor.

Planning and Design Considerations

Vineyard Infrastructure: Integrating animals into a vineyard may require additional or modified infrastructure and resources. Animals need resources to keep them safe, healthy, and contained, such as electric fencing, watering stations, shelter structures, and livestock guardian animals. If grazing during winter dormancy, minimal infrastructural changes are required to protect grapevines from livestock, however, if grazing during the productive season, grapevines may need additional protective measures. For example, vineyards may benefit from bird netting, electric wire, or electric fencing to prevent animals from eating grapes, and trellis tubes to protect young vines. To prevent damage to irrigation lines, many growers install drip irrigation lines either at the surface of the ground, below-ground, or raised high off the ground, beyond where animals can reach.

Trellis systems can also be modified to accommodate livestock. If larger livestock such as sheep are being integrated, some growers have had success with installing higher trellis systems, typically from 35" to 60" high, depending on the breed of sheep, to prevent livestock from reaching clusters (Schoof et al. 2021, Schoenfeld 2022). Adding additional lateral wires that extend out horizontally on either side of the trellis may be added as well, to train vine shoots to extend up and out, instead of down where they can be reached by sheep. This allows shoots to grow above the height that sheep can reach, which promotes longer shoot length, to achieve a more optimal leaf area to fruit ratio, for higher fruit quality. Some growers have found success with horizontal vine training systems, in which trunks grow high and shoots grow on wires that extend horizontally across vineyard rows, providing shade to the forage and livestock below and keeping grapes far away from animals' reach.

Investing in infrastructure can be a steep upfront cost for many growers and should be planned for in advance. It is also important to remember that infrastructure and resources are just one factor to consider when planning a silvopasture vineyard. While infrastructure and resources are important considerations, there are other creative design and management strategies that growers can use to address risks and achieve goals, instead of making infrastructural changes.

Selecting Livestock: Different types and breeds of livestock can provide different kinds of benefits when rotationally grazed in vineyards. Sheep, for example, can help control weeds, graze cover crops to the proper height, prevent frost damage by keeping vegetation low, add fertility to the soil, and aid in the laborious tasks of suckering and leaf pulling. By controlling the grapevines' vegetative growth through suckering and leaf pulling, sheep can also help vineyards achieve an optimum leaf area to fruit ratio and modify the microclimate around clusters, which can result in improved wine quality. Certain breeds of pigs can also help manage vegetation and remove weeds. Poultry such as chickens, geese, ducks, and turkeys can benefit vineyards as well, by eating grape pests like snails and beetles, eating fallen or discarded grapes that may house pathogens, fertilizing the vineyard, and lightly tilling to prepare the ground for cover crop establishment. A successional rotation of sheep or pigs followed by poultry is possible if growers wish to satisfy multiple goals.

Different breeds of livestock can be selected, depending on the trellis height, row spacing, and forage quantity available. If the trellis height is lower, smaller breeds of sheep, such as Babydoll sheep, are recommended, to prevent damage to vines and grapes. Alternatively, sheep breeds that are not able to stand on two legs may be selected, such as the Danish Shropshire breed (Schoof et al. 2021).

Meat breeds of any type of livestock may be selected if generating a secondary income from meat is a goal. For example, several Vermont vineyards have found success grazing Ile De France sheep on resident vegetation, due to their meat suitability. Certain breeds of pigs can be integrated into vineyards as well, as long as they have shorter snouts so that they do not damage vine roots by rooting. Kunekune are a good breed for integration into vineyards because of their small size, shorter snout size, and aversion to rooting.

Livestock breed is an important consideration. At Shelburne Vineyard in Vermont, Dorset and Île-de-France crossbred ewes were selected due to their suitability for meat production and small size. Courtesy photo by University of Vermont.

Selecting Forage: Maintaining groundcover in vineyards, as opposed to leaving the soil bare, can provide many soil health benefits such as managing soil erosion, suppressing weeds, improving soil fertility, and more (Lazcano et al. 2020). When well-chosen groundcover is grazed by livestock, it can function as forage that not only benefits the soil, but that also benefits animals. The most successful vineyard silvopasture systems feature a mix of forage species that benefit both the soil and animals at the same time.

Livestock often have specific nutritional requirements and may not thrive on resident vegetation alone. For example, poultry may benefit from supplementation with grain, and sheep may benefit from grazing forages and cover crops in addition to resident vegetation, especially if they are breeding, lambing, or lactating. When integrating sheep into a vineyard, it is important to prioritize their nutritional needs by selecting forages that are high in both protein and carbohydrates. Sheep thrive on a diverse mix of grasses, forbs, and legumes, so for optimal animal health, select a variety of forage species. If the quality of the forage is inadequate to meet the nutritional requirements of the sheep, the producer may need to supplement the animals' diet through other means, which can be expensive. No matter what, it is always important to select varieties that will not promote excessive bloat and that are nontoxic for the livestock in the system.

Selecting forage varieties that will not interfere with grapevines in a negative way is also important. Certain forages may compete excessively with grapevines for resources such as water and nutrients and should be avoided. An example is Bermudagrass (Cynodon dactylon), which can form dense carpets of vegetation that are hard to eradicate. Some forages may also support grapevine pests or may be alternative hosts for certain grapevine viruses. For example, sharpshooters, which are common vectors for Pierce's disease, can be hosted by forages like Italian ryegrass (Lolium perenne L. ssp. multiflorum), perennial ryegrass (L. perenne L. ssp. perenne), and fescue (Festuca spp.) (University of California Agriculture and Natural Resources 2019). Avoiding forages such as these is an important integrated pest management consideration.

Forage species may be chosen to meet the nutritional needs of livestock while also fulfilling other functions that enhance soil health and promote ecological resilience. For example:

- Many forage varieties can help suppress weeds in vineyards by creating a thick mulch layer. Examples in California include sheep fescue (Festuca ovina) and triticale (Triticosecale rimpaui C. Yen & J.L. Yang).
- Certain cover crops like cowpea (Vigna unguiculata), sunn hemp (Crotalaria juncea), and common oat (Avena sativa), among others, are nutritious for sheep and can simultaneously help reduce harmful nematode populations in the soil (Kruger et al. 2013, Wang et al. 2008).
- Legumes such as Egyptian clover (also known as berseem clover; Trifolium alexandrinum L.), bird's-foot trefoil (Lotus corniculatus), and subterranean clover (Trifolium subterraneum) fix nitrogen and add fertility to the soil while simultaneously providing food for sheep. However, some vineyards may choose not to seed legumes, as they can add too much nitrogen to the soil, which can be detrimental to grape quality.
- Flowering cover crops can attract beneficial insects that can help with pest control. For example, buckwheat (Fagopyrum esculentum) and alyssum (Lobularia maritima) attract the parasitic species Gonatocerus ashmeadi, which is used to control the glassy-winged sharpshooter (Homalodisca vitripennis), a grape disease vector (Irvin and Hoddle 2007).

Competition between grapevines and forage for belowground resources, like water and nutrients, is another key consideration. In vineyards, moderate water and nitrogen stress is often desirable to control excess vigor, which allows more sunlight to reach grape clusters, for improved quality. Moderate stress also triggers vines to allocate more resources, like sugar, to grape clusters instead of to shoots and leaves, which also improves wine quality. Controlled competition also helps maintain a small berry size, to increase the surface area of flavor-rich grape skins and to concentrate flavors. Because of this, many grape growers have noted positive benefits from controlled competition between forages and grapevines (Wheeler and Pickering 2003). See figure 1 for more details.

Sheep graze resident vegetation on a vineyard in New Zealand. Courtesy photo by Meredith Niles, University of Vermont.

And while forage does require water inputs, planting forage in vineyards can help improve water use efficiency overall by keeping the soil covered to reduce evaporation, reducing runoff, breaking up compaction for improved infiltration, and increasing soil organic matter for improved soil water holding capacity (Wang et al. 2021). Cover crop use in vineyards can also reduce excessive vine vigor and encourage vine roots to grow deeper, which can reduce the amount of irrigation water that vines use (Novara et al. 2021). Because of this, forage often has a minimal impact on soil water storage and overall water use in vineyards (Wang et al. 2021). See figure 1 for more details. In areas where water can be scarce, however, it is critical to select drought-tolerant forage varieties. Other key considerations when selecting forages include animal nutritional needs, soil health, annual rainfall, pest concerns, goals for grape quality, and equipment.

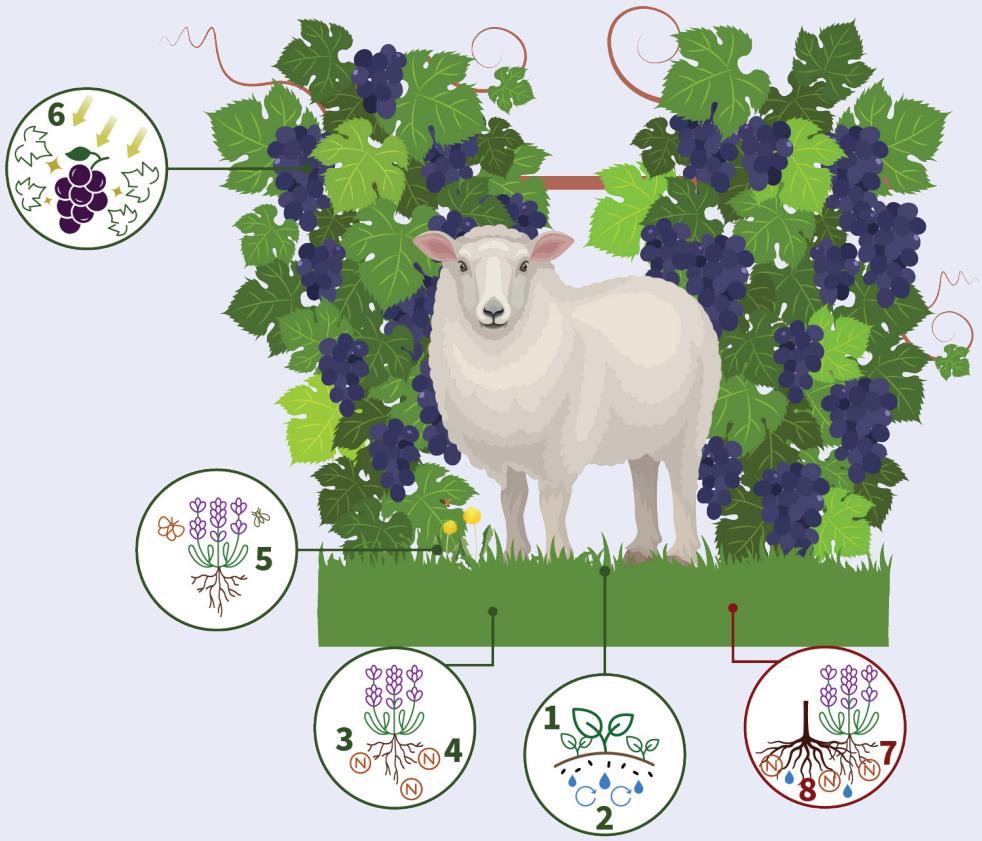

Figure 1—Positive and negative interactions in vineyard silvopasture systems.

Positive interactions

1. Forage covers the soil, creates a mulch layer, and keeps moisture in the ground. Hoe faction and trampling increase residue incorporation.
2. Forage roots can break up compacted soil and reduce runoff to improve water infiltration. Grazing triggers root growth, enhancing potential benefits to soil health if grazing appropriately.
3. Certain species of forages can fix nitrogen (N) and add fertility to the soil. Grazing animals enhance N cycling, adding N in the form of manure and urine and increasing microbial activity.
4. Forages can promote a healthy soil microbiome to cycle nutrients and maintain soil fertility. Microbial activity and diversity is often enhanced in grazed systems.
5. Certain species of flowering forages can attract beneficial insects and promote integrated pest management.
6. Slight competition for water and nutrients can reduce vegetative growth, which helps keep a balanced canopy to allow more sunlight to reach grape clusters. Grazing can help control this balance by limiting forage growth.

Negative interactions

7. If forage is left unmanaged, it can compete with grapevines for nutrients, which can reduce grape quality and production.
8. If forage is left unmanaged, it can compete with grapevines for water, which can reduce grape quality and production.
9. Improper grazing can cause soil compaction, which can harm vine roots and soil health.
10. Improper grazing can increase soil N levels, which can lead to leaching and/or cause excess vigor in vines.

Figure by Janine Siatkowski, USDA Forest Service, National Agroforestry Center.

Establishment

Vineyard silvopasture systems are commonly established by adding livestock, and often forage, to existing vineyards. In some cases, vineyard alleys already have resident vegetation established that is suitable for grazing, so establishing additional forage may not be necessary. However, in cases where resident vegetation is sparse or not nutritionally beneficial for livestock, desirable forage may need to be established. Forage is typically established either through drilling, broadcasting, or broadcasting with mechanical incorporation. Different forage varieties require different seeding methods, so it is important to select forage varieties based on what seeding equipment is available. Seeding rates will vary, so seed suppliers should be consulted to determine the recommended seeding rate for a selected variety and location. If a site is dominated by high concentrations of weeds, it may be advisable to focus on eliminating the seedbank for several seasons before sowing desired forages and cover crops.

Forages require water for establishment. If rainfall is not abundant, additional irrigation infrastructure, such as mobile microsprinklers, may be needed to establish forage. In some cases, forage may need to be irrigated for the duration of its life cycle.

If a new vineyard is being established, growers may wish to plan ahead to protect future grapes from livestock by installing a high trellis system. Depending on the size of livestock that are being integrated, trellis systems may be anywhere from 35 to 60 inches high to prevent livestock from reaching clusters (Schoenfeld 2022, Schoof et al. 2021). Once vines are planted, it may be prudent to wait several years before integrating cover crops and livestock to allow vines to develop strong root systems without competition or compaction.

In this vineyard silvopasture system in Vermont, grapes are grown on high trellises so that sheep have a more difficult time reaching grapes. Courtesy photo by University of Vermont.

Management

Rotational Grazing: Rotating animals regularly and maintaining the proper stocking density is critical to silvopasture management. In vineyard silvopasture systems, rotational grazing is also essential for ensuring the safety and health of the livestock, supporting forage health and survival, avoiding soil compaction, and avoiding crop contamination.

Rotating animals requires careful planning and management. When kept in one area for an extended period of time, livestock can compact soil, overgraze vegetation, eat grapes, damage vines, and damage vineyard infrastructure like trellises, drip irrigation, and wires. Additionally, because livestock manure and urine are high in salts and leachable nitrogen, soil and ecosystem health can be compromised if animals are kept in one place for too long. Rotating animals is also important to prevent parasites and other diseases.

Determining the correct stocking density is also important. High-density, short-duration grazing can help achieve uniform grazing and keep animals focused on eating, which can prevent damage to grapevines. The right stocking density can also ensure that animals have enough food to meet their nutritional requirements while not overgrazing cover crops. Knowing how much forage the selected livestock will consume is a good way to estimate stocking density ahead of time. Mature sheep typically consume 3.7 percent of their body weight in forage per day, which translates to 4.8 to 7.4 pounds of forage required per day (Bauman 2021). Most mature poultry, on the other hand, consume far less—just 0.13 to 0.48 pounds of forage per day (SAREP 2020).

Growers have reported success with rotating their animals in vineyards every 2–3 days, but to determine the precise rotation schedule and stocking density that is right for a given property, developing a grazing plan is essential (Ryschawy et al. 2021). By comparing forage availability with livestock forage consumption rates, the producer can estimate stocking density and grazing durations. The "animal unit system" is a useful tool that can help with this process (Most and Yates 2022). U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) grazing specialists and local Extension agents may also be able to craft grazing plans and provide technical assistance about best practices for rotational grazing.

In this vineyard silvopasture system in New Zealand, sheep are carefully monitored so that forage is not overgrazed. Courtesy photo by Meredith Niles, University of Vermont.

Seasonal Grazing and Exclusion: In vineyards, livestock are often grazed seasonally and are excluded from the vineyard at certain times of the year. Sheep will eat and damage buds, young shoots, and ripe grapes, so many growers opt to graze animals only during the grapevines' dormant season, from right after harvest to just before budbreak (approximately 6 months). Once shoots get bigger in early summer, some growers allow sheep back in the vineyard to thin leaves and sucker shoots until just before veraison, when grapes begin to ripen. Alternatively, grapevines may be grown on high trellises so that sheep can't reach shoots or fruit (Schoenfeld 2022, Schoof et al. 2021). Some growers have also seen success with using muzzles for sheep that allow them to graze forage without allowing them to damage grapes, and other growers have successfully utilized bird netting to protect grapes from sheep. Poultry are less likely to damage grapes and may be grazed more freely at other times of the year.

If the vineyard is producing grapes for consumption and not for wine production, animals may need to be excluded from vineyards during certain times of the year to follow food safety guidelines, as animal manure and urine may pose a food safety concern. If the vineyard is certified organic, USDA's National Organic Program standards require that animals be excluded from grape-producing vineyards 90 days before harvest to avoid contamination. If the vineyard is not certified organic, there is no specific period of time that animals must be excluded from the vineyard, but the U.S. Food and Drug Administration does recognize the National Organic Program's standards as a prudent way to prevent contamination (U.S. Department of Health and Human Services; U.S. Food and Drug Administration; U.S. Center for Food Safety and Applied Nutrition 2018). Animals should also be excluded from the vineyard during wet periods when the soil is saturated to prevent soil compaction.

Because livestock are commonly excluded from vineyards at certain times of the year, it is important to plan for an alternative, non-vineyard holding place for them to graze during those times.

Working in Partnership: Many growers choose to partner with contract graziers to bring livestock to their vineyards at certain times of the year, rather than managing livestock themselves. Working with contract graziers can alleviate the need to purchase livestock infrastructure, learn new skills, and assume responsibility for animal livelihood and reproduction during times of the year when sheep are excluded from the vineyard. Most contract graziers offer their services for a fee, but some offer their services without charge, in exchange for healthy forage for their animals.

If growers wish to manage livestock themselves, they will need to plan for where livestock will be located and how they will be fed during the off-season when they are not grazing in the vineyard. Additionally, growers may need to invest in management infrastructure such as electric fencing, bird netting, watering stations, and a shelter for animals during cold and wet weather. If predators are an issue, livestock will also require some sort of protection from predators at night, such as livestock guardian dogs, llamas, or donkeys. Because of the challenges associated with caring for livestock during the off-season, the costs associated with livestock infrastructure, and the additional labor required to rotate animals, some vineyard managers opt to contract graze instead of managing livestock themselves.

Planning Pesticide Interactions: Pesticide use is another consideration when integrating livestock into a vineyard. Agrochemicals can be harmful to livestock, so it is important to exclude animals from the vineyard during and after pesticide applications. Even some organic pesticides like copper—a commonly applied organic fungicide for grapes—can induce chronic copper toxicosis in sheep and should be avoided (Trouillard et al. 2021). Coordinating livestock grazing with pesticide applications and fruit ripening will minimize the risk of chemical exposure and ensure compliance with food safety standards.

Adapting to and Mitigating Climate Change

When grapevines, forage, and livestock are intentionally integrated into a single system, several climate change mitigation benefits may occur. Long-term grazing combined with cover crops has been shown to increase soil microbial communities and soil organic carbon storage in vineyards, compared to alleys with bare soil (Brewer et al. 2023).

Silvopasture in vineyards can also reduce emissions associated with certain inputs. For example:

Livestock can help with vineyard floor management by terminating cover crops and grazing weeds. This can reduce reliance on energy-intensive herbicides and tractor passes, which can help reduce carbon dioxide (CO_2) emissions (Niles et al. 2018). Vineyards that graze sheep have on average 2.2 fewer tractor passes per year and 1.3 fewer herbicide applications (Niles et al. 2018).

Livestock can cycle nutrients in the system by consuming plants and turning them into manure and urine, making nutrients more available to grapevines and reducing reliance on energy-intensive chemical fertilizers (Niles et al. 2018).

Poultry can control certain grape pests, helping reduce reliance on energy-intensive chemical pesticides (Wilson and Daane 2017). Growers have observed success managing snails, beetles, fruit flies, and other pests by rotating poultry through vineyards (SAREP 2020).

Silvopasture can help vineyards adapt to climate change as well. In some areas, climate change is projected to cause vines to break bud earlier, often before the last frost, which can result in frost damage. Grazing vineyards immediately before bud break, using silvopasture, can help reduce the risk of frost damage by lowering cover crop or weed height. Grazing can also help reduce fuel loads in and around vineyards, which may be beneficial for wildfire prevention and mitigation.

A vineyard silvopasture system in Alentejo, Portugal. USDA Forest Service photo by Katherine Favor.

Silvopasture can also help vineyards adapt to climate change by diversifying income streams. Livestock can provide an additional source of income to the farm, such as meat, wool, dairy products, or eggs. Additional sources of income can help vineyards stay afloat in the event that grapes experience yield losses or reductions in quality due to climatic events.

Benefits and Challenges

Integrating livestock into vineyards can be a complex process that requires intentional planning and intensive management, but many growers consider the benefits to outweigh the challenges. The following benefits and challenges must be carefully weighed by each individual grower.

BENEFITS	CHALLENGES
• Reduced soil erosion • Increased soil carbon • Improved soil microbiome • Reduced weed pressure • Improved pest control for certain pests • Reduced frost risk • Lower fuel use • Lower herbicide use • Lower fertilizer use • Potential for multiple income sources • Potential for enhanced grape quality • Potential to enhance marketability of products • Enjoyment from interaction with animals	• More complex management in partnership • More complex pesticide application • A more diverse skillset required • Potential upfront infrastructure costs • Competition between vines and forages for water and nutrients if not managed correctly • Potential for increased soil salinity if not managed correctly • Potential for increased soil compaction if not managed correctly • Potential need for additional space for animals during the non-grazing season • Potential need for additional feed for animals when not grazing in the vineyard

Conclusion

Silvopasture in vineyards can be a useful approach to enhancing vineyard management. When integrated intentionally into a single system, grapevines, forages, and animals can interact in favorable ways. Growers can achieve several key benefits, including weed control, pest control, improved soil health and fertility, erosion prevention, and reduced dependence on inputs. These benefits can often lead to grower savings, new income sources, and improved grape quality, while simultaneously reducing emissions and contributing to climate change mitigation.

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CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Contact: USDA Forest Service National Agroforestry Center, 402–437–5178 ext. 4011, 1945 N. 38th St., Lincoln, NE 68583-0822. https://www.fs.usda.gov/nac/

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