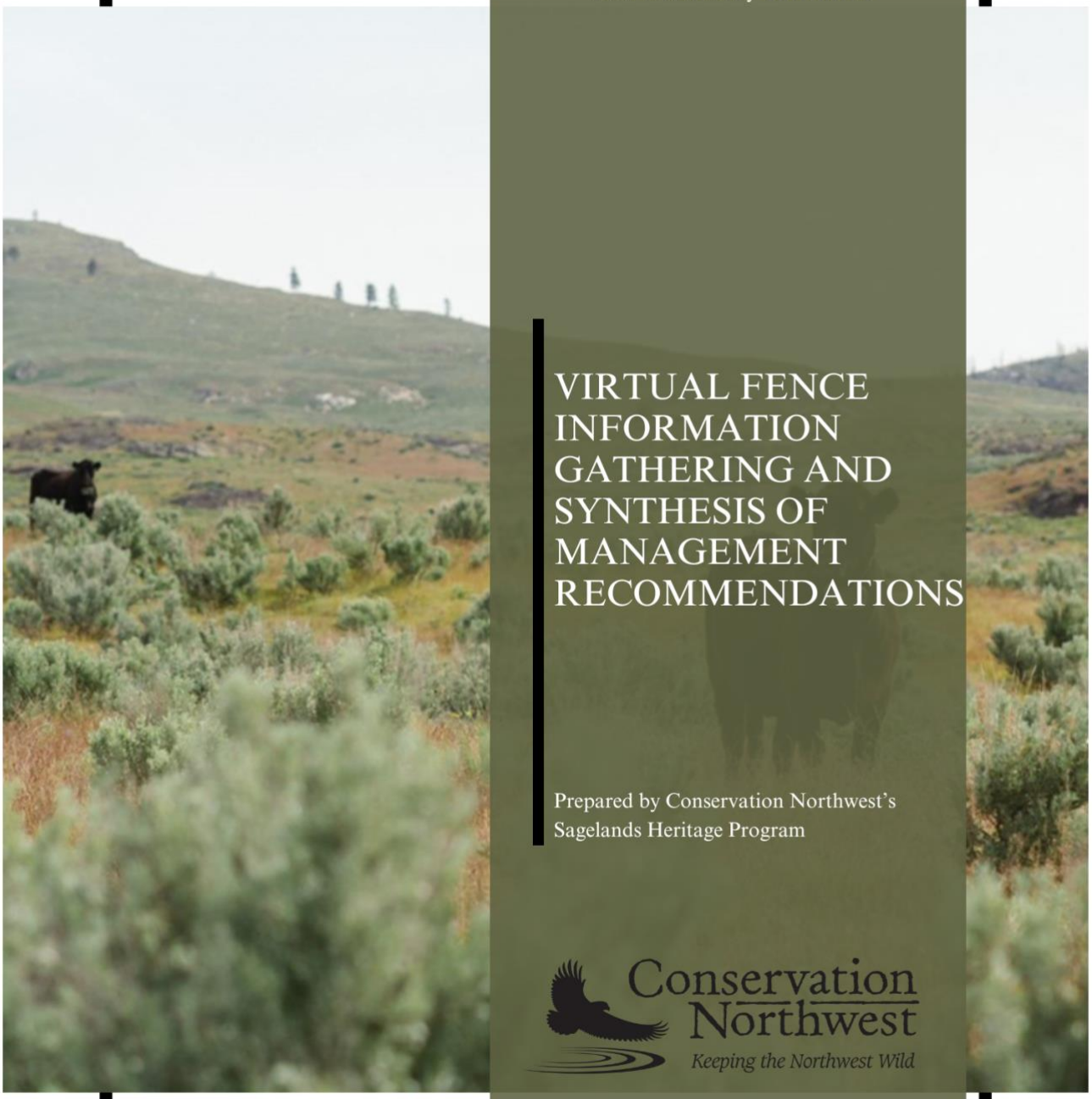
Washington Shrubsteppe Restoration and Resiliency Initiative



VIRTUAL FENCE INFORMATION GATHERING AND SYNTHESIS OF MANAGEMENT RECOMMENDATIONS

Prepared by Conservation Northwest's Sagelands Heritage Program

Conservation Northwest
Keeping the Northwest Wild

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Executive Summary

The Virtual Fence Information Gathering and Synthesis of Management Recommendations project ("Virtual Fence Report" or "Report"), facilitated by Conservation Northwest (CNW),[1] supports and informs the Washington Shrubsteppe Restoration and Resiliency Initiative's (WSRRI)[2] mission to explore ways virtual fencing technology can be used to support local working lands and producers[3] and to address the impacts and threats to Washington's native shrubsteppe ecosystems.

Following the 2020 wildfires that burned hundreds of acres in central Washington, the 2021 Washington State Legislature supported a proviso, the WSRRI, to fund restoration and resilience in our shrubsteppe habitats on both public and private lands. To support local working lands, WSRRI has facilitated the removal and replacement of burned fences with a wildlife-friendly alternative – virtual fences.

Virtual fencing is an innovative and wildlife-friendly fencing technology with a structural satellite tower or cellular connection that provides instructions to Global Positioning System (GPS) collars worn by livestock. The GPS collars influence livestock behavior to recognize stimuli (sound, pulse, and shock) as virtual fence boundaries. These virtual fence lines are managed by producers through computers and smartphone apps, allowing the boundaries to be remotely mapped and adjusted with individual preferences.

With continued advancements in a variety of technologies, services, and models, it is important for WSRRI to gather current information and community feedback. This informs the development of an action plan to support effective implementation of virtual fencing that maximizes benefits to Washington's resources, local working lands, and imperiled ecosystems.

This study is a two-phase project. Phase one includes gathering information and community feedback through interviews, surveys, and research, resulting in this Report on CNW's findings. From April-June 2025, CNW developed question templates for several identified audiences and conducted interviews to gather information and community feedback regarding virtual fencing. Phase two will be built on the findings of this Report. It will include meetings with public land managers[4] and the grazing community to develop a Recommendation Report. Throughout the project, CNW will actively collaborate with the WSRRI Steering Committee via virtual meetings, including an initial question template development session (May 1, 2025), a progress update (June 4, 2025), and a final presentation on findings (June 26, 2025).

Interviews with vendors – Vence, Gallagher, and Halter – assembled comparable information on virtual fencing technology, the diverse services offered, infrastructure and maintenance requirements, cost, and more. The technology does not interfere with local communication infrastructure and works across interstate and international borders. There is no potential for operability between vendors, as each company is focusing on ways to improve their current technologies and services. It is likely that base stations will continue to be required for some vendors

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[1] Conservation Northwest's mission is to protect, connect, and restore wildlands and wildlife. https://conservationnw.org/

[2] Washington Shrubsteppe Restoration and Resiliency Initiative, Washington Department of Fish and Wildlife, https://wdfw.wa.gov/species-habitats/habitat-recovery/shrubsteppe.

[3] "Producers" include livestock ranchers, farmers, agriculturalists, landowners, and ranch hands.

[4] "Public land managers" include local governments, Tribal communities, state agencies (Washington Department of Fish and Wildlife and Washington Department of Natural Resources), and federal agencies (United States Forest Service and United States Bureau of Land Management), and others.

and in remote locations (without cell coverage). Each vendor offers unique subscription or purchase models suitable for operations of different sizes. The costs of these services are comparable when considering the range of base stations, price of collars and batteries, functionality, and associated warranties. Producers will need to consider the options available and how they may fit into their specific operation needs. WSRRI can help facilitate this opportunity through public meetings, workshops, and by sharing educational materials with producers and land managers as planned in Phase 2.

Supplementary interviews with experts enhanced understanding of virtual fencing efficacy, benefits and challenges, examples of implementation at different stages, and how the technology may evolve. Researchers, practitioners, and others with knowledge of virtual fencing share the importance of setting up adequate coverage and the additional benefits of tailoring the technology to specific operations' needs. As technology matures, enhancements like improved battery life, better accuracy, or the ability to monitor livestock health and behavior is likely. Improved rotational grazing practices in grasslands have demonstrated an increase in carbon sequestration, which benefits the environment and may unlock additional funding sources.

CNW sought to engage with the Utilities and Transportation Commissioners (UTC) and division staff in discussions about existing infrastructure and regulations, managing multi-vendor networks for community benefit, and other collaboration potential related to virtual fencing. Despite various efforts, no response was received, so some regulatory perspectives and other insights may not be fully represented in this Report beyond what is able to be researched.

Producers provided feedback on virtual fencing through phone interviews and surveys, sharing insights on their current knowledge, interests, needs, or recent experiences. Interest in virtual fencing is growing, and producers are eager to learn about alternative solutions for improved grazing management. Increased costs of traditional fencing, wildfires destroying infrastructure, and advancements in technology are enticing producers to consider adopting virtual fencing. Producers are sharing information about the benefits and challenges of this new tool.

Gaining access to more land and being able to utilize it more effectively is an advantage of virtual fencing for producers, who also like the security of remotely checking livestock locations. Virtual fences allow producers to move livestock into cover crops or stubble, benefiting the agricultural system and allowing the rest and recovery of native habitat. Challenges to virtual fence adoption and retention include starting costs, the worry that it cannot work in varied topography, and the considerable learning curve required to successfully implement virtual fencing. Producers who use virtual fencing have been largely satisfied with the transition, even after acknowledging the difficulties of using new technology. Informational materials and opportunities for workshops, presentations, and one-on-one conversations between producers were of interest to the community.

Based on this information, CNW has developed recommendations to continue WSRRI's support of virtual fencing implementation while making judicious use of public funds.

- Continue engagement with the UTC or Federal Communication Commission (FCC) to gain a better understanding of current regulations and infrastructure, effective multi-vendor networks, and investigate collaborative opportunities.
- Support the development of informational materials and other resources detailing vendor services, costs, training, and technical support to help producers understand the technology and options.

- Organize workshops or other public meetings to allow vendors to demonstrate their technology and services and answer questions, foster discussions among producers, and involve land managers or potential funders to inspire cooperation.
- Invest in the cellular-only virtual fencing system where feasible would decrease infrastructure costs, and leveraging existing base station coverage to strategically fill gaps could improve current systems and increase access for more producers.
- As cost is a barrier to the implementation and continued use of virtual fencing, CNW recommends alternative funding sources to WSRRI be compiled and provided to producers during public meetings for further investigation.

Introduction

The Virtual Fence Report highlights WSRRI's adoption of virtual fencing technology as a significant innovation that will require informed decisions and community feedback to further support and progress. Virtual fencing offers a multitude of benefits for human communities and for wildlife. The working lands of Eastern Washington are largely centered around agriculture and livestock production, which necessitates the use of fences for land protection and management. This advanced technology increases the capability and profitability of producers by providing a more flexible and adaptable tool for livestock management while simultaneously reducing physical barriers for wildlife and facilitating the rest and recovery of native habitats.

Barbed wire and electrical fences are used as barriers for agriculture and livestock production. However, the construction and maintenance of these physical fences requires significant time and financial investment. For example, extreme weather impacts, like high winds and wildfires, can obliterate this infrastructure, leading to extensive costs and logistical challenges for impacted producers. Wildfires play a natural role in maintaining the health of shrubsteppe habitats; they clear fire hazard vegetation and promote new growth. Unfortunately, the frequency and intensity of wildfires in this region have increased resulting in a heightened risk of destructive disasters. Recent wildfires not only devastate vast tracts of imperiled shrubsteppe habitat but also impact rural communities by destroying homes and other structures, grazing lands, equipment, and livestock fences.

Shrubsteppe habitats are crucial to the ecological and economic landscape of Eastern Washington. This arid ecosystem is intermixed with agricultural lands that provide necessary resources for a wide range of native and migratory species. Species – including greater sage-grouse, Columbia Basin pygmy rabbits, mule deer, elk, pronghorn and many others – rely on the unique mixture of native grasses, shrubs, forbs, and delectable crops. These habitats are also integral for local rural communities, as they have supported and influenced this landscape for generations.

In 2020, devastating wildfires swept across Eastern Washington and served as a catalyst for a momentous move by the Washington State Legislature to direct the Washington Department of Fish and Wildlife, Washington Department of Natural Resources, and the Washington State Conservation Commission to spearhead the WSRRI. This initiative focuses on restoring and conserving shrubsteppe ecosystems while supporting the livelihoods of local communities who depend on these working lands. The Washington State Legislature specifically allocated an additional $1.5 million to replace burned fences with wildlife-friendly alternatives, with continued investments in the next biennium to plan for.

Producers in Eastern Washington started implementing virtual fencing in 2021, and its use has spread with the help and support of local producers, organizations, state and federal agencies, conservation districts, and Tribes. Technological advances in virtual fencing, along with the entry of new vendors, have expanded options and considerations for operations. The required informed decisions and facilitation of strategic implementation will open opportunities for producers while promoting wildlife conservation and the resilience of local communities reliant on these lands.

Virtual fencing is based on global positioning system (GPS)-enabled collars that communicate and guide livestock to recognize invisible boundaries set by producers while also tracking individual livestock or herd movements. This system trains livestock using predictable auditory and shock cues. Ultimately, this method reduces the need for traditional barbed wire or electrical fences and eliminates the need for construction or upkeep of miles of boundaries. For producers, virtual fencing facilitates more frequent and flexible rotational grazing, supports the recovery of native vegetation, and provides tremendous data to inform future management plans and decisions. For wildlife, it reduces barriers and obstacles within their shared habitat.

During initial investments in virtual fencing technology, only one service was available in the United States (U.S.). Today, many more services are being introduced to the region. Multiple companies have entered this competitive market and developed virtual fencing collars and transmitters (base stations) suitable for varying operations. With very limited potential for inoperability amongst vendors, CNW acknowledges that it is critical for strategic actions and investments to be informed by gathering information and community feedback for consideration by WSRRI, producers, land managers, and agencies. This Report will be an informative resource to help tailor decisions for specific circumstances and facilitate wildlife-friendly working lands throughout Washington.

Virtual Fence Report Methods

From April 2025 to June 2025, CNW collaborated with WSRRI to gather and synthesize critical information on virtual fencing technologies. This is phase one of the Virtual Fence Report, which consists of three primary tasks: developing interview question templates, conducting interviews, and summarizing findings and recommendations.

Indigenous peoples have inhabited the shrubsteppe since time immemorial, maintaining deep connections to the land. Each Tribe in the region maintains distinct lifestyles and cultural practices that are intricately tied to their relationship with the land, and all are vital to the effort to conserve and restore native ecosystems.[5] The interviews and this accompanying Virtual Fence Report do not represent important Tribal perspectives. Intentional engagement with Local Tribes will be essential to inform future action plans.

Task 1: Interview Question Templates

The standardized interview question templates were created in an effort to facilitate comparable and synthesizable feedback from different groups. Templates were tailored for each identified audience, including vendors, experts, the Utilities and Transportation Commission, and the Producer Community. CNW collaborated with the WSRRI Steering Committee to craft draft questions templates, met to solicit feedback, revised templates, and then consulted with the WSRRI Steering Committee before advancing to the next task.

[5] WSRRI Long-term Strategy, https://wdfw.wa.gov/publications/02489.

A. Vendors – Appendix A-1

The vendor question template focuses on gathering insights on the services offered, technology and cost, livestock behavior, and installation, maintenance, or management of varying systems.

B. Experts – Appendix A-2

This question template for Experts (researchers, practitioners, and others with knowledge of virtual fencing) was created to deepen the understanding of virtual fencing technology and its application. These questions focused on virtual fencing efficacy, benefits, challenges, use cases, and how technology might evolve.

C. Utilities and Transportation Commission (UTC) – Appendix A-3

The UTC question template was created to gain a better understanding of State regulations, infrastructure, and multi-vendor networks overseen by the UTC that may be relevant to virtual fencing.

D. Producer Community – Appendix A-4 and Virtual Fence Users – Appendix A-5

To gather insights from the producer community, CNW crafted question templates tailored for both users of virtual fencing and other local producers. CNW sought feedback on current experiences with virtual fencing, understanding of knowledge gaps or questions, and assessing interest levels and needs.

Task 2: Interviews and Surveys

A. Vendors and Experts

CNW conducted two interview sessions with virtual fence vendors Vence, Gallagher, and Halter. CNW held initial meetings with vendors to establish a relationship connection, introduce the project, provide the question template, and begin interviews. A second session followed with clarified questions, continued interviews, and finalized responses.

CNW contacted over 20 individuals and conducted 6 interviews with Experts. *(*An additional interview is scheduled for June 30, 2025.)

B. Utilities and Transportation Commission (UTC)

CNW tried to initiate shared discussions with the UTC Commissioners and division staff (of telecommunication, energy, and transportation), all who have knowledge of existing infrastructure and regulations, operating multi-vendor networks, and additional strategies to manage large networks to benefit local communities. However, despite attempting multiple methods of outreach – including contacting possible connections, phone calls and messages, and numerous emails – these attempts were unsuccessful. Without response from UTC representatives, some regulatory perspectives on virtual fencing may not be fully represented in this report. CNW was able to speak with Virtual Fence Vendors about the Federal Communication Commission (FCC) License requirements as well as the Industrial, Scientific, and Medical (ISM) Band radio frequencies used and have spent time meant for interviews investigating answers to the questions posed.

C. Producer Community

CNW contacted more than 30 producers using a combination of emails, phone calls, a virtual survey form, emails to Conservation Districts, flyers and draft messages to producers, and a Facebook social media ad. CNW conducted 12 interviews with producers who have already implemented virtual fencing and 14 others who have just heard of the technology. Eight of these interviews were captured in the survey form. This outreach gathered firsthand accounts of the practical challenges, benefits,

interests, and questions surrounding virtual fencing. It also unveiled helpful information on the application of these technologies and their impact on livestock management and habitat conservation.

CNW's Facebook social media post reached out to 11,052 subscribers and, as of June 23, 2025, has 412 post engagements, 359 link clicks, 41 post reactions, 5 likes, 4 comments, and 3 saves.

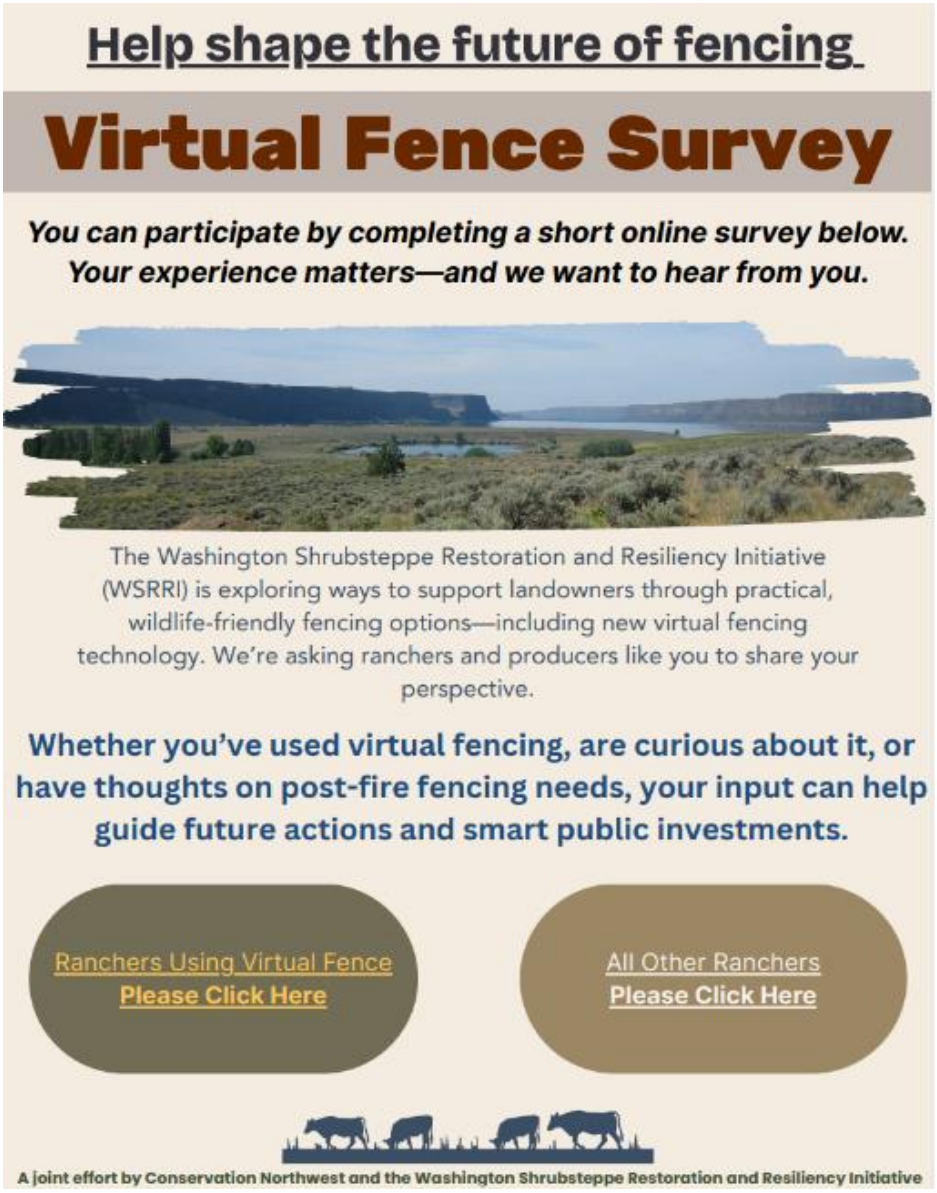

Figure 1: Flyer shared with Conservation Districts and producers over email and on Facebook.

Task 3: Findings and Recommendations

CNW compiled the Interviews and Survey responses and summarized insights to explore in the Report (discussed in Summary of Findings). CNW synthesized findings from the Interviews and Surveys, offering recommendations for ongoing investments in virtual fencing to support working lands, producers, wildlife habitat and connectivity.

Summary of Findings

A. Understanding Virtual Fencing

Unlike traditional physical barriers (e.g. barbed wire and electric fences) used exclusively for containment, virtual fencing is an innovative solution that uses a combination of technology, inherent livestock behavior, and stimuli to improve rotational grazing and seasonal movement. Virtual fencing is a valuable tool to monitor, manage, improve, and influence livestock behavior, stockmanship, habitat rest and recovery, rotational grazing plans, habitat conditions, as well as many other uses.

Virtual fence vendors offer different models and services; their individual services have their own benefits and drawbacks for varied operations (depending on location, terrain, size of herd, acres grazed, etc.).

	Vence	Gallagher	Halter
Most Suitable for (with exceptions)	Larger cow/calf Operations of 100 or more and on over 1,000 contiguous acres.	Operations of 4 or more cows.	Operations of 50 or more cows.
Infrastructure Required	Collar, Base Station, Computer, Cell Service	Collar, Base Stations (if limited cell service), Computer, Cell Service	Collar, Base Stations, Mobile Phone, Cell Service
Training	Each producer is assigned a Rancher Success Specialist who guides producers through onboarding, tutorials for the Herd Manager Software, helps explain realistic expectations and answers questions remotely.	The Costumer Success Team (located in Kansas City) schedules an Onboarding Call and is available for calls or assistance remotely.	Halter has a dedicated onboarding team, regional staff, and a 24/7 Customer Support Team to help with training.
Training Resources/Materials	Written manuals and videos for collaring, base station assembly, and deployment. There are tutorials and tips embedded in the web app.	Videos and resources are provided during onboarding, and there is a Help Center in the web app.	Guides and resources are provided, and there is a 24/7 Customer Support Team.

B. Virtual Fence Technology

Vendors' technologies have very little interference or interaction with existing infrastructure (communications or other radio frequencies) in the U.S. or surrounding countries. Operating using these networks and frequencies often requires a FCC license to broadcast over standard cellular networks. Virtual fencing technology relies heavily on cellular and Long Range (LoRa) networks for seamless operation and communication. Discussions with vendors highlight that this technology adheres to FCC licensing requirements, which are crucial for maintaining compliance and avoiding interference with other communication systems. Some vendors describe the unlicensed use of ISM Bands as reserved for international scientific or medical research and other industrial purposes.

These bands operate at frequencies that are separated from regular radio or other broadcasting and are designated for use by vendors. Notably, there are no reported issues with broadcasting virtual fence coverage across borders, including interstate and international boundaries (like those between the U.S. and Canada).

Central to the virtual fencing system are GPS-enabled collars worn by livestock. Vendors are piloting virtual fence collars on bison, goats/sheep, and/or yearlings. Calves are not collared. The collars have communication features built into them to influence livestock to recognize predictable and avoidable stimuli as a barrier. The collars store instructions set by the producers which influence livestock behavior by emitting auditory sound, pulse, and shock stimuli to direct livestock to move or steer away from the virtual fence boundaries.

Producers use a computer and/or mobile application to view current livestock locations, track movement and behavior, assign virtual fencing boundaries and exclusion areas, among other features. Once instructions are created by the producer, the update is sent through the cellular network and/or provided by the base stations to the collar. Base stations operate as a gateway device that transmits over Cellular and LoRa Networks. The collars take 10-30 minutes to check in or receive the producer's instructions and updates to the virtual fence boundaries. This could be delayed if livestock are outside of both cellular and base station coverage. In this case, the collar still operates autonomously with programmed (planned) fence instructions, but the collar will need to return to the coverage area to send updated locations and receive new instructions.

The management software that is provided to users is map-based, allowing producer managers to view livestock locations, mark important structures or water sources, draw exclusion areas, and manage fences or movements. Fences can be assigned to individuals or herds. The management applications (Herd Manager, eShepherd, or Halter) also offer producers the ability to view insights on livestock movement or behavior over time. You can track individual livestock or full herds to see interactions with the fences, stimulus received, infer lameness or stress events, grazing intensity, and much more. Halter collars are equipped with health monitoring capabilities, like reproductive status. This information is stored securely using servers or in the Cloud and is displayed in the management software for access solely by producers.

Vendors highlight the importance of gathering timely feedback and implementing updates/changes when needed in order to promote the evolution of technology. Base stations are likely to be required for the foreseeable future, especially in many areas around central Washington where there is varying terrain and limited cell service. Vendors mentioned that direct communication with satellites is not currently feasible or affordable.

The learning curve for a technology like this can be large, often taking the first year for producers to fully understand and correctly utilize the technology to its intended ability. To maximize the use of virtual fencing, active engagement and monitoring are essential. This technology is not meant to be a "set it and forget it" solution. Rather, it requires ongoing involvement to ensure the system is functioning as needed. Producers will need to regularly adjust and manage virtual boundaries to align with grazing plans and anticipated livestock behavior. This is made possible through active data collection and visualization techniques made possible through management applications offered by vendors.

The future of virtual fencing is poised for significant advancements and possibilities. Improvements such as better batteries, updated training materials and protocols, integrated livestock health and behavior monitoring tools, and increased mobile app functionality are all on the horizon. Advances

in technology and Artificial Intelligence (AI) will further improve grazing management insights and practices. Information gathered from vendors is subject to change. Please visit each vendor's website for more information and contact them about these products.

Base Station			
	Vence	**Gallagher**	**Halter**
Cost (as of June 2025)	$10,000 each self-installed; $12,500 each Vence-assisted installed.	$6,000 for the first Base Station + $5,000 for each additional Base Station. The Costumer also provides the 12V Battery.	$4,500 each.
Own or Lease	Purchaser owns the tower	Purchaser owns the tower	Purchaser owns the tower
Required?	Yes	Not in areas with good cell coverage	Yes
Lifespan	at least 10 years	7 years	6 years
Warranty	90-day	3-year	Lifetime Warranty under Subscription Service
Power Source	Solar panel and four 12 V Batteries	Solar Panel and one 12V Battery	Solar Panel and two 12V Batteries
Mobile	Yes, however, the trailer and mounting equipment are not included (and it voids the warranty).	Yes, however, the trailer and mounting equipment are not included (and it voids the warranty). This is not recommended.	No
Installation Time	It typically takes 2-3 people 4-5 hours to assemble and install a base station.	It typically takes one person about 2 hours to assemble and install a base station.	It typically takes one person about 30 minutes to assemble and install a base station
Maintenance	It is recommended that users clean off solar panels and tighten guy wires when needed or at least once a year. 12V batteries may require maintenance or replacement every 4-6 years.	12V batteries may require maintenance or replacement every 2-3 years.	No maintenance required.

Collars			
	Vence	**Gallagher**	**Halter**
Cost (as of June 2025)	$40 per collar each year + $10 per single-use battery.	Purchase Tiered Costs: 4-19 collars = $350 each 20-59 collars = $300 each 60+ collars = $250 each + Data Charge for Cellular: $2.00/Neckband/Month + Data Charge for Base Stations: $1.50/Neckband/Month	$72/collar each year
Own or Lease	Lease	Own	Own
Lifespan	3+ years	7 years	6 years
Warranty	Vence will replace dysfunctional or broken collars.	3-year	Lifetime Warranty under Subscription Service
Training	4-day Training Protocol	5-7 Day Training Protocol	7-10 Day Custom Training Plan
Power Source	Lithium Primary Battery (D cell)	Solar panel and large internal battery.	2 Small solar panels.
Maintenance	The life of the battery depends on the frequency of interactions with virtual fences. Some batteries may need to be replaced occasionally.	Collars can be left on and adjusted for the life of the collar (7 years).	Collars adjusted for fit, if needed.
Future Upgrades	Extend battery life, reduce wires for easier battery replacement. Researching future integration across MERCK Animal Health services (such as heat detection, SenseHub, and EID).	Researching future integration of Animal Health Monitoring tools and a Panic Mode.	Ongoing improvements based on customer feedback.

Management Software App			
	Herd Manager	**EShepherd**	**Halter**
Capabilities	Gives users the means to track livestock using GPS; group collars into herds; access maps to design virtual boundaries; assign fences to individuals or herds; manage a calendar that allows users to schedule fences in advance and see previous changes; etc.	Gives users the ability to track livestock using GPS; monitor livestock and herds; view behavioral traits; use maps to create virtual fences or exclusion areas; assign fences to livestock or herds; schedule movements; etc.	Allows users to monitor a livestock's location, reproduction status, and behavioral data, an schedule shifts.
Notifications	Prompts users to check on livestock that have not moved in 24 hours; sends notifications on collar battery status; reports if livestock escapes a boundary, or enters an exclusion zone, or is out of coverage, etc.	Sends notifications to phones or computers when livestock has moved very little or not at all or leaves the virtual fence boundary. There are additional alerts on battery charge, solar panel health, and significant events.	The app sends important notifications to your phone.
Mobile App (users can access apps from phones in the field if there is cell coverage)	Users can access data without making changes in phone browsers. (An app is being created, but it is not currently available.)	The app has limited ability. Users can view livestock locations and turn fences on or off, but it recommends that fences be drawn on computers.	The app allows for changes from the field.
Post-Grazing Season Data	The Grazing Screen displays grazing locations, when livestock receive stimulus, and it allows users to visualize or replay grazing patterns through heat maps, point maps, and individual livestock tracking over time. The calendar tracks fence history, changes, updates, and other significant events.	It displays grazing locations, when livestock interact with virtual fences, and allows users to visualize or replay grazing patterns through detailed heat maps. Infer livestock behavior and future rotational grazing plans.	It displays and provides data on where and how long livestock grazed.
Tech Support	The Rancher Success Team is available during normal business hours (Monday-Friday, 8am-5pm), or for scheduled sessions when needed. It has tutorials and tips embedded.	The Costumer Success Team and Sales Representatives can assist and there is a Help Center in the Web App.	There are regional staff and a 24/7 Customer Support Team to assist when needed.
Future Upgrades	Developing a mobile app requested by users.	Updating the mobile app to draw fences from the field.	Increased functionality based on direct feedback from producers.

C. Investment Costs of Virtual Fencing

Virtual fencing vendors provide a diverse range of models and services, each tailored to meet the unique needs of individual producer operations at varied investment costs. This is reflected in flexible purchase and leasing models, allowing producers to choose a service that best fits their budget and operational scale. Not all vendors require base stations to operate, which can save money on infrastructure and maintenance. Additionally, the base stations differ, with some covering extensive ranges (within 10 line-of-sight miles), making them suitable for large properties and operations. While others have shorter (within 2-4 line-of-sight miles) ranges with higher accuracy that are designed for more confined areas or strict landscape priorities. The collars themselves have very different designs, power sources, and functions. Collars are either purchased and require an additional data charge, leased and require battery purchase and replacement, or owned through annual subscription. Each offers warranties or services that provide different levels of assurance and support. For example, Vence offers a staff-assisted installation service for an added fee, providing hands-on support during set-up. Whereas Gallagher includes a small monthly data charge per owned collar and Halter's subscription model provides a lifetime warranty on all components. Unfortunately, there is no possibility for operability amongst vendors, which will require producers to implement systems that align with their individual goals or constraints. Neighboring operations work collaboratively and more efficiently to utilize shared virtual fence coverage, while still maintaining independent and secure access to their own data. This cooperation could be fostered through regional public presentations and discussions that introduce the different vendors' costs and services, while aligning potential cost-share opportunities and landscape priorities. Vence has 31 producers and Gallagher has 6 producers using virtual fences in Washington.

Cost is one of the major barriers to virtual fence implementation identified by vendors, experts, and producers. But as more infrastructure (base stations) and funding opportunities become available, the accessibility of virtual fencing will increase for local producers.

	Vence	Gallagher	Halter
Year 1	1 base station, 100 collars and 150 batteries: **$18,000**	2 base stations, 100 collars, monthly data charge, and two 12V batteries: $**38,000** Cellular: 100 collars and monthly data charge: $**27,400**	2 base stations and subscription for 100 collars: **$16,200**
Year 2	Collar lease and batteries: **$5,500**	Data charge with base stations: **$1,800** Cellular: **$2,400**	Subscription: **$7,200**

These calculations are estimates for first and second-year costs based on information gathered in June 2025.

D. Virtual Fence Installation and Maintenance

The installation process typically involves assembling and deploying base stations, which are critical for most services and in areas with limited cellular coverage. Maintenance is minimal, requiring producers to ensure that efficient coverage is set up before training, collars are fitted and functioning properly, power sources for base stations and/or collars are charging or replaced when needed, and virtual boundaries are regularly monitored and adjusted to achieve improved grazing management.

If producers or land managers choose the flexibility of a mobile base station, it is important that trailers and mounting equipment are not included and that it voids the warranties offered by vendors. Halter's base stations cannot be mobile. This is because the batteries, connections, and technology are sensitive to vibrations that could damage the base stations. If done carefully, many have utilized mobile base stations to travel between training and grazing locations, expanding year-round use of virtual fences for operations with separate seasonal allotments, and reducing upfront infrastructure costs. Function and cost must be contemplated when setting up virtual fence systems, as vendors stress the importance of adequate coverage for successful operations.

With landowner permission, base stations can be strategically located on and broadcast coverage over public and/or private lands. Operations and coverage are unhindered across borders, including interstate borders and the transboundary border between the U.S. and Canada. Virtual fence companies already work with state and federal landowners and managers to implement virtual fencing throughout the U.S., for multiple producers with permits or leases across large landscapes. Many research institutions have partnered with virtual fence companies and producers to study virtual fence impacts on livestock, habitat health, invasive weeds, graze fire breaks, and other innovative use-cases.

E. Livestock Behavior Training

Virtual fencing technology influences livestock behavior by leveraging predictable and avoidable stimuli. It often takes 4-7 days to train livestock to recognize auditory, pulse, and shock stimulus as barriers and achieve over 90% containment. The virtual fencing technology system uses auditory signals that serve as a preliminary warning, followed by a mild pulse or shock if livestock continue to approach the virtual boundary. This method encourages livestock to alter their path and avoid crossing over virtual fences, allowing producers to manage and plan improved grazing patterns.

For each vendor, the initial training involves setting up a virtual fence aligned with a physical fence so that the livestock can both visualize and connect the stimulus with a tangible boundary. The training area is often reduced to test and observe how cattle interact and respond with the virtual fence before releasing cows into larger pastures and rotating full herds through the landscape. This training helps mitigate the need for cross fences or increased labor.

The ongoing system of engagement promotes successful interactions between livestock and their environment and improves livestock welfare and grazing efficiency. Producers are encouraged to avoid the predictable conflicts by thinking like livestock; to read the topography and consider the livestock's appetite, water sources for hydration, and other environmental factors when planning movements and expecting containment.

Although vendors and researchers agree that nearly all livestock learn to respond to virtual fences, virtual fence technology is also designed with cautionary practices. The electrical stimulus is less strong than contact with an electric fence, and after training, many livestock never actually reach or receive the electrical stimulus. Virtual fences act as a one-way gate, allowing livestock to return back to the boundary without being deterred by further stimulus. Virtual fencing data allows the producers and the vendors' Specialist Teams to view and assess livestock behavior, including lameness, calving, increased stress or disturbance, interactions with predators, etc. The collars are equipped with breakaway points at 700-750 pounds of pressure to avoid the livestock from getting caught on trees, fence lines, or each other. Gallagher and Halter collars will recognize if livestock are running and shut off the stimulus to protect the livestock in the case of an emergency. All vendors have acknowledged the need for a button that allows producers to shut-off all fences in the case of an

emergency. Researchers are working to create models that analyze and predict all these events by using virtual fencing tracking data. This could be improved with integrated health monitoring technologies that vendors already have or are planning to implement in the future.

F. Experts Feedback

Virtual fencing represents a cutting-edge approach to livestock management. The strategies to successful virtual fence implementation are grounded in practical, community-driven insights. CNW spoke with a diverse group of researchers and local organizations with expertise in this field, who actively collaborate with local producers, land managers, and vendors to gain insights into the practical applications, benefits, and challenges associated with virtual fencing. Many successfully receive funding to explore this virtual fence technology further, often working directly alongside producers who gain the ability to implement and improve rotational grazing management. By connecting with the research community and national, local or regional organizations with knowledge of virtual fencing, we gained additional informative feedback about the technology and community interests.

Producers, researchers, and other professionals recognize the potential to transform traditional grazing practices by providing flexible, invisible boundaries that can be easily adjusted to meet the needs of producers and the landscape. Although no tool will be 100% effective all the time, the efficacy of virtual fencing is reported to be generally high.

G. Maintenance Flexibility

Primary benefits of virtual fencing management include enhanced flexibility, less need for physical fence construction or maintenance, and improved access and land use. The ability to quickly create and adjust boundaries makes it easier to manage and inform rotational grazing plans and protect sensitive areas. However, some challenges remain, such as the initial cost of technology serving as its own barrier for producers or collaboratives, the need for strategic planning in areas with variable or rough topography, and the need to monitor or replace batteries in collars and base stations. Key performance indicators identified by experts included the percentage of time that livestock remain in designated areas, how they interact with virtual fences, overall health of the livestock (such as collar fit, learning and stress), and savings in cost and time.

H. Sustainable Practices

Virtual fencing shows promise for promoting improved, sustainable grazing practices that benefit the landscape. Researchers across the U.S. have studied the use of virtual fencing to graze fuel breaks, protect riparian areas, and aid in the rest and recovery of disturbed habitats. The use of virtual fences can enable more precise control over grazing areas resulting in preventing overgrazing, supporting native plant growth, and strategically targeting invasive weed species. This is particularly important in central Washington where wildfires and widespread cheat grass degrade sensitive natural landscapes. Local practitioners who were in different stages of implementation were excited about this potential but acknowledged that it would take time to witness the impacts of improved grazing management with virtual fencing. Virtual fencing opens opportunities to remove and replace degraded or unnecessary fences with a virtual alternative, reducing barriers for wildlife and increasing habitat connectivity. This all aligns with the guiding principles and actions supported by WSRRI.

I. Utilities and Transportation Commission

The UTC[6] ensures that investor-owned utilities (energy, telecommunications, water, etc.) and transportation services are accessible, safe, and affordable. The Telecommunications Division manages hundreds of companies[7] and vendors as part of this expansive network. They operate successful multi-vendor networks to ensure equitable, affordable options for communities. The entry of new vendors into this competitive market results in the need to develop a strategic virtual fence network for local communities and learn from experts like the UTC. We are unaware of regulations administered by the UTC that apply to the use of virtual fencing in Washington, as the FCC manages licensed use of cellular networks. Collaborations with UTC would leverage existing infrastructure to support the expanded implementation of virtual fencing or determine necessary regulations that impact the growth of virtual fencing. CNW continues to establish contact with the UTC to learn more about these large networks, including the regulations and collaboration, to support the extension of virtual fencing for the benefit of communities, habitats, and wildlife.

J. The Producer Community

Most producers contacted for this Report manage livestock operations in Washington State, one resides in Colorado, and a couple others are located in British Columbia. Those producers consist of virtual fence users, individuals interested in adopting the technology, and those who were just informed of it.

Producers use a variety of methods to manage livestock movement, including trucks and All-Terrain Vehicles, horses or dogs, and barbed wire and electric fencing. Some manage and move temporary fencing while others rely on traditional, physical fencing and the landscape. Additional technologies employed by producers include cellular game cameras, Field Net[8] or Field Smart,[9] StockSmart,[10] Electronic Identification EID Ear Tags, GPS equipment for farming, and some have now introduced technology to their operation by implementing virtual fencing.

i. Benefits, Challenges, and Questions

Producers' excitement stems from the technology's potential to reduce labor, increase profit, and the utilization of more land. An overwhelming number of producers thought virtual fencing would compare well in function and cost to traditional fencing methods, but a few wondered if it would work for their specific operations. These operations varied in size and concerns were shared about limited cell service, varied topography, small herd sizes, and cost being potential barriers to virtual fence adoption.

Increasing costs associated with traditional fencing construction and maintenance have motivated some to explore alternative options. Additionally, much of central Washington has been impacted greatly by wildfires, destroying infrastructure and forcing producers to consider alternatives. Producers hope that implementing virtual fencing will save them time and money, make it easier to monitor livestock, gain security by checking on livestock from home or in the field, and improve grazing efficiency and land access. Producers saw virtual fencing as a valuable tool to allow

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[6] The Utilities and Transportation Commission, https://www.utc.wa.gov/about-us/about-commission.
[7] The Utilities and Transportation Commission Telecommunication Companies, https://www.utc.wa.gov/companies?&exposed_select_industry=566
[8] Field Net, https://nextgen.myfieldnet.com/organization/9e081485-b3dd-4337-830b-a309b21f5421/equipment/equipment.
[9] Field Smart, https://fieldsmart.ca/.
[10] Stock Smart, https://www.stock-smart.com/.

aftermath grazing in croplands and to utilize areas where traditional fencing is not feasible. The large learning curve for virtual fencing was acknowledged, but producers know that it takes time and are willing to try it out, or let third parties, like relatives or vendor support staff, help with the technology.

Producers do worry about the higher initial costs of adopting virtual fencing, and few are aware of potential funding sources or cost-share programs, like NRCS and WSRRI. Many were very interested in learning more about these or other opportunities. Producers shared interest in cooperative systems or networks that make virtual fencing more accessible and affordable. Those who are located in areas with good cell coverage were excited to hear about a full cellular system that does not require base stations (Gallagher).

Producers prefer public meetings, workshops, and conferences allowing one-on-one conversations amongst producers. Resources like videos, one-pagers, and other informational materials are best presented at local NRCS or Conservation District Offices, or with local Cattlemen's Associations.

ii. Producers Using Virtual Fence ("Users")

Virtual fencing provides advanced solutions for traditional management challenges. The adoption of virtual fencing has grown since 2021 in Washington State. Many producers are pleased with their investments and are most excited about the ability to track and check on herds virtually. This was worth the cost and changes required to implement virtual fencing for many users.

Additional benefits of virtual fencing experienced by users include improved grazing management and capability, travel and labor savings, and improved forage or habitat. Users shared enthusiasm about being able to place livestock on cover crops, stubble fields, steeper hills, and other areas that are harder to reach and manage livestock movement. This places less strain on rangelands, facilitates habitat restoration, allows livestock access to nutritious forage, and can benefit lessee/landowner relationships.

Washington producers often move livestock to seasonal grazing areas and must travel great distances to check on or manage livestock. Having the ability to monitor livestock locations and activity from home, or in the field remotely, significantly decreases the time and cost of travel or labor for many producers.

Producers report seeing notable improvements in the habitat, such as increased grass cover and less overgrazing, as virtual fencing allows land to rest and recover after fires. The technology can serve as a habitat restoration tool and assist with protecting riparian or other sensitive areas, quickly move livestock through landscapes to promote growth and biodiversity or use livestock to target graze fuel breaks and invasive weeds. Physical fences are often left during brief trial periods, but many producers look forward to removing these fences while almost eliminating the need for traditional fence construction or maintenance. Once removed, there will be increased benefits for producers and wildlife who can move unhindered across the landscape. This technology and the associated learning curve are not suitable for all operations. Some producers were accepting the software and vendor support during set-up and training, while others relied on family members to help. A couple producers claimed to be overwhelmed and reactively limited their engagement to only using the technology at a simple level that includes seeing where livestock are located.

Perimeter fencing is often still required, especially in areas where livestock can get access to roads or neighboring herds, but virtual fencing allows for more flexible use without the need for physical infrastructure changes. Adequate coverage provided by cellular networks or base stations is critical for effective operations, increasing the accuracy of locations and frequency of check-ins to provide

real-time information. If gaps in coverage are present or too few base stations are deployed, it can have an impact on the user experience and ability to make timely updates or access precise data. This has occurred in situations where the high costs of base stations limit producers from achieving adequate coverage, prompting producers to shift grazing priorities to work with the tools and coverage they have available. Collars out of range still work autonomously, enforcing pre-programmed fences and movements until returning to service to transmit locations and receive updated instructions.

Base stations and collars require maintenance by producers. Collar retention was mentioned as an issue for first year users, but many get more comfortable and familiar with collaring livestock. Dropped or dysfunctional collars are replaced by the vendor. The one-time use batteries in Vence collars are a drawback for some as it requires extra time gathering and handling livestock. The solar-powered collars provided by Gallagher and Halter do not require battery replacement and, therefore, require less handling. Some base stations require the occasional cleaning of solar panels, replacement of batteries, or tightening of guywires. Producers who use mobile base stations appreciate the flexibility (and affordability) of being able to establish coverage in priority areas for grazing management. Mobile base stations are required to be set in specific, agreed-upon locations. Keeping these mobile base station locations consistent helps provide repeatable and more efficient coverage for operations. Gallagher operates without base stations in areas with adequate cellular coverage, eliminating maintenance needs and reducing infrastructure costs.

To be successful, users urge those considering virtual fencing to embrace learning opportunities, consider needs and conditions, and actively learn, engage, and adjust with the technology. Learning opportunities include speaking with neighbors or other producers, attending workshops or presentations, and speaking with vendors. Producers contemplating virtual fencing will need to consider the current conditions and needs of their operations, livestock, and the landscape and whether it would be compatible with virtual fencing. Lastly, producers have a more positive experience when they actively engage with technology, work with vendor support staff, and adapt management strategies based on learnings.

K. Recommendations and Best Management Practices

Gathering information and community feedback, insights on what technology is currently available and how it might evolve, needs of the producer community, and current virtual fence adoption and implementation were discussed in this report. Drawing from this information, CNW has developed six key recommendations:

i. Further engage with the Utilities and Transportation Commission or the Federal Communications Commission.

Continuing collaborative efforts with the UTC or FCC will address unresolved questions (Appendix B) that could not be addressed in this report. Ongoing engagement will guarantee a thorough understanding of existing regulations and infrastructures, gather insights into successful multi-vendor networks, and further inform strategies to support virtual fence implementation.

ii. Develop educational and outreach materials for producers.

Utilizing the information gathered in this report, the WSRRI steering committee could support the creation of effective educational and outreach materials for producers, to share at public meetings, in Conservation District and NRCS offices, at Cattlemen's Association meetings, workshops, or conferences. One comprehensive resource could explore the services that each vendor offers,

including anticipated costs, set-up and training requirements, technical capabilities and support – all in a menu-style chart. Supplementary one-pagers, videos, and other simple outreach materials could help show producers what is available so that they can consider what would be most suitable for their own operations while encouraging producers to attend public meetings or discussions. This approach aligns with the feedback received on what producers want to know about virtual fencing and uses the methods of communication producers prefer (Appendix C).

iii. Host public meetings to discuss virtual fencing services.

Producers are very interested in attending public meetings to discuss virtual fencing. A statewide webinar, workshop, or conference (similar to the one hosted in Wenatchee by CNW in 2024, "Washington Virtual Fence Conference") will be a great platform for vendors to demo their services, present helpful information, and answer questions from producers. Vendors express interest in participating in events or meetings similar to this with an opportunity to reach many participants and inspire producers to attend future regional follow-up meetings.

Effective one-on-one conversations with other producers, agencies, and vendors are of most importance to the community and would be further facilitated through regional meetings throughout the state. These meetings will unite producers, land managers, and funders to review and discuss which technology would be most appropriate for individual operations. Or, more importantly, facilitate cooperative dialogue among neighboring operations, who could work together to strategically locate base stations (if necessary) to reduce costs and infrastructure needs. With funding and technical support from WSRRI and other partners (state and local agencies, Tribes, NRCS, conservation districts, etc.), regional cooperative networks could effectively cover a wide range of public and private lands, providing accessible coverage for many producers.

iv. Invest in the cellular-only option, where feasible.

For some vendors, base stations are required to operate their virtual fence system. However, there is a full cellular option currently offered by Gallagher that has increased the ability to operate virtual fences without needing to purchase base stations. The elimination of base stations reduces initial setup costs and maintenance needs for producers, land managers, or other partners supporting virtual fence adoption, but does come with a more expensive collar purchase and data charge. This will be particularly beneficial for smaller operations but may not apply to more remote regions outside of cell coverage.[11] Base stations will still be required in many remote regions in eastern Washington (or if producers choose to utilize Vence or Halter systems). Ultimately, more options are available that could be intentionally considered by WSRRI (and producers) to create a versatile and cost-effective solution that supports working lands while promoting habitat and wildlife conservation.

v. Leverage current virtual fence operations and coverage.

Virtual fencing projects and infrastructure have already been implemented across the state. By leveraging existing virtual fence coverage, WSRRI could strategically address coverage gaps, enhance existing operation, and support additional producers. This approach not only optimizes resources but also ensures that more producers benefit from increasing advancements and investment in virtual fencing. This may not be necessary in areas with good cell coverage, allowing focus on areas that are more remote, have complex topography or other unique considerations.

[11] Cellular Coverage in Washington, https://broadbandmap.fcc.gov/location-summary/mobile?version=dec2024&lon=-116.729429&lat=50.031054&addr_full=50.031054%2C+-116.729429&zoom=5.91&vlon=-120.471851&vlat=47.303357&env=0&tech=tech4g.

Collaborating with vendors is necessary to identify these gaps and gain the proper permissions from producers to share (and benefit from improved) coverage. CNW and Vence are working together to develop maps that identify coverage gaps in Washington, and this may be replicated with other vendors. This effort not only benefits individual producers but also contributes to the broader goal of improved, sustainable land management

vi. Collect and share additional funding opportunities beyond WSRRI.

Cost was identified as one of the largest barriers to virtual fence adoption. Many producers who currently use virtual fencing are concerned when funding support is no longer available. Those who are interested in technology, worry that large upfront costs would prevent them from being able to try the technology. Funding opportunities beyond WSRRI are available through NRCS[12] local conservation districts, carbon programs[13] or other grant opportunities. Providing a resource with alternative funding opportunities for producers to investigate will help support working lands and our communities. By researching and compiling other funding opportunities, WSRRI could have a significant impact far beyond the current funding available for wildlife-friendly fence replacement. These could be stored in Conservation district offices or presented during public meetings.

Conclusion and Next Steps

The Virtual Fence Report explores the potential of virtual fencing technology, supports Washington's local working lands and producers, and addresses impacts to native shrubsteppe habitat. Phase one, facilitated by CNW, aligns with the WSSRI mission to enhance ecological and economic resilience through innovative solutions and strategic use of public funds.

This effort was split into 3 tasks: Task 1) developed the Report's question templates; Task 2) conducted interviews with three virtual fence vendors, experts[14], and producers; and Task 3) compiled and summarize findings, culminating in a set of recommendations for virtual fencing implementation. Phase 2 will include public meetings with producers and land managers to gather further insights and inform the creation of a recommendation plan.

CNW extends our sincere gratitude to the vendors – Vence, Gallagher, and Halter – for sharing information on services offered, the technology, and expertise. We thank each expert who enriched our understanding of virtual fencing's efficacy, implementation, and future potential. A special thanks to the many producers who participated in interviews and surveys, providing valuable feedback and perspectives on virtual fencing adoption and challenges. Lastly, we are grateful to the Washington Shrubsteppe Restoration and Resiliency Initiative for the opportunity to contribute to this important project, supporting the sustainable management and conservation of Washington's shrubsteppe ecosystem.

[12] NRCS Factsheet on Virtual Fencing, https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.nrcs.usda.gov/sites/default/files/2024-11/NRCS_Virtual%2520Fence%2520Systems%2520for%2520Managing%2520Livestock_Factsheet_111224_0.pdf&ved=2ahUKEwi9pbX1gIuOAxX9LTQIHZ-yDxgQFnoECBcQAQ&usg=AOvVaw3gZPpaaEhUZRDDyji0jKTS

[13] Kateri Carbon, https://katericarbon.com/.

[14] One final interview with an expert is scheduled for June 30, 2025.

Appendix A: Interview Templates[15]

A-1: Questions for Vendors

CNW will provide these questions to vendors for written response and then follow up with virtual meetings to gather complete answers.

Technology

1. How would you describe the technology behind your virtual fencing system?
    a. How does your system manage livestock movement and grazing patterns?
    b. How does it change and monitor animal behavior?
2. What infrastructure is required to operate your system effectively (towers/base stations, mobile devices, cell service, etc.)
    a. What role does GPS technology play in your virtual fencing system?
    b. Can your system operate in areas with limited or no cellular coverage?
3. What type of power source does your system require, and how reliable is it (solar, batteries, or other)?
    a. Collars:
    b. Towers/Base Stations:
4. What is the lifespan of your system's components (collars, base stations/towers, etc.)? Are there any warranties or guarantees provided with your system?
5. How does your system integrate or interact with existing local infrastructure (communication towers and systems, radio frequencies, etc.)?
6. Can your tower/base station be mounted to a mobile station (trailer or other options)?
7. What is the ideal ranch size (herd head and acreage) for your system to work most effectively?
8. What capabilities does your management app give users? What data or analytics does your system provide to users?
    a. Does it send notifications to keep ranchers informed?
    b. Does your system include a mobile app that allows changes from the field?
    c. What type of post-grazing season data and support do you offer to assist ranchers with improvements in management practices for the next year?
9. How do you ensure the virtual fencing system is user-friendly for ranchers?
10. What kind of technical support does your company provide, and what are the response times?
11. How would neighboring operations interact in your systems?
12. How does your system ensure data security and privacy for users?
13. How often are system updates released, and how are they implemented?
14. What sets your virtual fencing technology apart from competitors in the market?

[15] Note: The term "rancher," "ranches," and "ranching" used in the Interview Templates incorporates the same meaning as the Virtual Fence Report term "producers," which broadly defines cattle ranchers, farmers, agriculturalists, landowners, and ranch hands.

Note: The terms "animal" and "cattle" used in the Interview Templates incorporates the same meaning as the Virtual Fence Report term "livestock."

15. Is there interoperability between your system and other virtual fence vendor systems? Does your virtual fence signal support the use of other vendor collars, or do your collars communicate with other virtual fence systems? Do you foresee improvements to interoperability coming?
16. Are there any additional features or upgrades planned for the future?
    a. Are towers/base stations always required? Will there be options or upgrades in the future that make towers/base stations unnecessary?
17. What are your company's long-term goals for virtual fencing technology?

Cost

1. What are the initial costs of implementing your system, and what annual costs are expected after year 1? (What are the initial costs and what costs will be recurring?)
    a. Tower/Base Station Cost:
    b. Collar (purchase or lease):
2. Are there annual subscription or maintenance fees associated with your service? What are those?
3. What does the rancher own vs. lease and what maintenance is required?
4. Do you offer any financing options, programs or payment plans for ranchers?
5. How does your system help reduce labor costs or workload for ranchers? How does your system enhance productivity and profitability for ranch operations?

Animal Behavior

1. What training is required for cattle to learn the system?
2. How does your system ensure the safety and well-being of livestock?
3. How does your system respond to emergency situations (predator interaction, wildfire, etc.)?
4. Does your system accommodate different livestock species?

Installation/Maintenance/Management

1. How long does the installation process typically take, and what does it entail? What is included during initial installation, and are there any additional costs?
2. Do you provide training for ranchers and staff on how to use the system effectively? What training resources or materials do you provide to new users?
    a. How does your system handle variable terrain or obstacles?
    b. How does your system handle harsh weather conditions?
    c. Are there any community or network opportunities for ranchers using your system?
3. What kind of customer feedback have you received, and how have you addressed it?
4. Has your system been implemented on public lands (DNR, BLM, USFWS, USFS, DFW, etc.)
5. Are there any partnerships between your virtual fencing company and research institutions? What research or resources have been developed to study and explain the benefits of your system?
6. Are there case studies or testimonials from ranchers in Washington State (or similar habitats?)

A-2: Questions for Experts *(researchers, practitioners, and others with knowledge of this technology)*

CNW will reach out to experts (via email and phone) to gather answers to these questions. A google form will be created if necessary.

1. How reliable is virtual fencing in comparison to traditional fencing methods?
2. What are the key performance indicators for evaluating virtual fencing systems?
3. What are the primary benefits of virtual fencing for ranch management?
4. What challenges do you foresee in integrating virtual fencing with existing ranch infrastructure?
5. How do you ensure the security and privacy of data collected through virtual fencing?
6. Can virtual fencing technology integrate with other smart agriculture technologies or practices?
7. How would you define and what are the benefits of regenerative grazing?
8. Could AI and machine learning impact the future of virtual fencing?
9. What feedback have you received from ranchers using virtual fencing technology?
10. Are there any environmental impacts or benefits associated with virtual fencing technology?
11. Can virtual fencing technology be used for wildlife conservation efforts?
12. Can virtual fencing be used to suppress invasive species and wildfire fuels?
13. What innovations are being explored as an alternative to fencing or to improve virtual fencing?
14. How might virtual fencing technology evolve over the next decade?

A-3: Questions for Utilities and Transportation Commission

First, if possible, CNW will provide a presentation on virtual fencing before gathering answers to the following questions:

1. What current regulations administered by the UTC or FCC apply to the use of virtual fences in WA?
2. Are you aware of any cross-boundary regulatory issues that might apply to systems that cross state lines with Idaho or Oregon? What about cross-boundary issues with Canada?
3. What strategies do you use to manage and optimize network performance across different vendors?
4. Can you describe the infrastructure requirements necessary to support a multi-vendor network?
5. How do you handle troubleshooting, maintenance, and general operation in a multi-vendor environment?
6. What are the key challenges you face when operating a network with multiple vendors?
7. How do you ensure compatibility and seamless integration among different vendors' systems?
8. How do you ensure data security and privacy across various vendor platforms?
9. What are the potential benefits of partnering with other providers to utilize existing infrastructure?
10. What role does vendor collaboration play in successful network operations?
11. Can you share any case studies or examples of successful multi-vendor network operations?
12. The statewide telecommunication network is extensive, are there partnerships or lease options that allow companies to utilize this existing infrastructure to operate? What are those?
13. Can existing infrastructure be leveraged to support larger-scale virtual fencing implementation?
14. Is there potential for collaboration between virtual fencing companies and regulated industries (telecommunications, conservation and energy, or transportation)?
15. What regulatory actions are needed for this technology? Do you see a role for the UTC in regulating virtual fencing?

A-4: Questions for the Ranching Community

CNW will reach out to Ranchers (via phone) to gather answers to these questions and will also create a google form for Ranchers who would prefer providing feedback on their own time.

1. How do you manage livestock movement on your ranch?
    a. What role does technology currently play in your ranch management?
    b. What other technologies or new practices have you adopted on your ranch?
2. Are you currently using virtual fencing on your ranch? **NO**
3. Have you heard of virtual fencing, or have you talked to other ranchers about virtual fencing? What have you learned?
    a. Have you attended any workshops or talks on virtual fencing?
4. How do you think virtual fencing compares to traditional fencing methods?
5. Are you considering adopting virtual fencing for your ranch? Why or why not?
    a. How do you think virtual fencing could impact your day-to-day operations?
    b. Are there specific features/capabilities you would look for in a virtual fencing system?
6. What benefits would you expect if you were to implement virtual fencing?
7. What are your thoughts on the initial setup and the learning curve for virtual fencing? What kind of support or training would you want to confidently implement virtual fencing?
8. What do you know and think about the costs of virtual fencing?
    a. How would virtual fencing affect your labor needs on the ranch?
    b. How do you think virtual fencing could impact your ranch's profitability?
    c. Are you aware of any local, state, or federal funding/support for adopting virtual fencing?
9. How would you measure the success of virtual fencing on your ranch?
10. What questions do you have about the maintenance of virtual fencing systems?
11. What information do you feel is missing about virtual fencing? What are the most pressing questions you have about virtual fencing?
12. Would you be interested in participating in a virtual fence cooperative or similar system that is managed by an organization and open for users to pay a share to use? What are your thoughts on a network system that would only require producers to purchase collars without needing to maintain or purchase towers/base stations?
13. What is your preferred method for learning about new technologies like virtual fencing (public meetings, recordings/videos, one on one conversation, etc.)?

A-5: Questions for the Ranching Community (Virtual Fence User)

CNW will reach out to Ranchers (via phone) to gather answers to these questions and will also create a google form for Ranchers who would prefer providing feedback on their own time.

1. How do you manage livestock movement on your ranch?
    a. What role does technology currently play in your ranch management?
    b. What other technologies or new practices have you adopted on your ranch?
2. Are you currently using virtual fencing on your ranch? **YES**
3. How is virtual fencing working for you and your operation? How does virtual fencing fit into your overall ranch management strategy?
    a. How do you think virtual fencing compares to traditional fencing methods? How much do you use traditional fencing with the virtual system? And do you expect to reduce your use of traditional fencing over time?
    b. What benefits have you seen since implementing virtual fencing? What specific problems have you encountered while implementing virtual fencing?
4. What are your thoughts on the initial setup and the learning curve for virtual fencing? What kind of support or training would you want to keep confidently using virtual fencing?
5. How does virtual fencing impact your day-to-day operations?
6. Have you talked to other ranchers about virtual fencing? What have you learned?
    a. Have you attended any workshops or talks on virtual fencing?
    b. What advice would you give to someone else considering virtual fencing?
7. How do/would you measure the success of virtual fencing on your ranch?
8. What do you think about the costs of virtual fencing?
    a. How does virtual fencing affect labor needs on your ranch?
    b. Has virtual fencing impacted your ranch's profitability?
    c. Were you able to use, or are you aware of any local, state, or federal funding/ support for adopting virtual fencing?
9. Are there specific features you enjoy about the system you are using, or are there features/capabilities you wish it had? Do you have any requests or recommendations for improving the system?
10. What maintenance has been required to keep systems operational?
    a. Towers/Base Stations (Technology, solar panels, wires, door panels, etc.):
    b. Collars (fitting, battery replacement, etc.):
11. What do you wish you knew before implementing virtual fencing? Do you have any outstanding questions about virtual fencing?
12. Would you be interested in participating in a virtual fence cooperative or similar system that is managed by an organization and open for users to pay a share to use? What are your thoughts on a network system that would only require producers to purchase collars without needing to maintain or purchase towers/base stations?
13. What is your preferred method for learning about new technologies like virtual fencing (public meetings, recordings/videos, one on one conversation, etc.)?

Appendix B: Questions for Utilities and Transportation Commission[16]

1. What strategies do you use to manage and optimize network performance across different vendors?
2. Can you describe the infrastructure requirements necessary to support a multi-vendor network?
3. How do you handle troubleshooting, maintenance, and general operation in a multi-vendor environment?
4. What are the key challenges you face when operating a network with multiple vendors?
5. How do you ensure compatibility and seamless integration among different vendors' systems?
6. What are the potential benefits of partnering with other providers to utilize existing infrastructure?
7. Can you share any case studies or examples of successful multi-vendor network operations?
8. The statewide telecommunication network is extensive, are there partnerships or lease options that allow companies to utilize this existing infrastructure to operate? What are those?
9. Is there potential for collaboration between virtual fencing companies and regulated industries (telecommunications, conservation and energy, or transportation)?
10. What regulatory actions are needed for this technology? Do you see a role for the UTC in regulating virtual fencing?

[16] Despite attempting multiple methods of outreach – including contacting possible connections, phone calls and messages, and numerous emails – these attempts were unsuccessful. Without response from UTC representatives, some regulatory perspectives on virtual fencing may not be fully represented in this report.

Appendix C: Interview Compilation (separate document)

Appendix D: Supplementary Resources

Vence
Virtual Fencing for Livestock Management
Vence – Strickland Ranch (2 min.)
NextGen Fencing: The Future of Pasture Management (7 min.)

Gallagher
eShepherd Virtual Fencing
eShepherd Presentation US (20 min.)
eShepherd Success: Virtual fencing with Nick Jorgensen (5.5. min.)
eShepherd explained: How eShepherd virtual fence works (2 min.)

Halter
Virtual Fencing and Pasture Management
Halter's Guidance Cues and System Overview (3.5 min.)
Halter 101: Episode 1 – Installing Towers & Collaring Cows (15.5 min.)
Halter 101: Episode 2 –Training Cows on the Halter Collar (20 min.)

Conservation Northwest
Virtual Fencing
Virtual Fencing – The Next Evolution in Range Management (10 min.)

Beef Cattle Producer Perspectives on Virtual Fencing – Rangeland Ecology & Management: Dana Hoag, Anthony G. Vorster, Krista Ehlert, Paul Evangelista, Lily Edwards-Callaway, Daniel F. Mooney, Josh Virene, Beef Cattle Producer Perspectives on Virtual Fencing, Rangeland Ecology & Management, Volume 96, 2024, Pages 143-151, ISSN 1550-7424, https://doi.org/10.1016/j.rama.2024.06.004.

Virtual Fencing Effectively Excludes Cattle from Burned Sagebrush Steppe - Rangeland Ecology & Management: Chad S. Boyd, Rory O'Connor, Juliana Ranches, David W. Bohnert, Jon D. Bates, Dustin D. Johnson, Kirk W. Davies, Todd Parker, Kevin E. Doherty, Virtual Fencing Effectively Excludes Cattle from Burned Sagebrush Steppe, Rangeland Ecology & Management, Volume 81, 2022, Pages 55-62, ISSN 1550-7424, https://doi.org/10.1016/j.rama.2022.01.001.

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