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# A Look at the Use of UAVs in Rangelands

UAVs, unmanned aerial vehicles, or drones as they are popularly called, are changing how society currently functions and how people go about life (Fellman). Ever since these drones started becoming more widely produced and distributed for civilian and commercial purposes, the uses and abilities have rapidly grown as well (Alkobi). Along with this rapid growth comes a change in our economy which influences how industries move forward (Weller). It's not only evident that production, commerce, and movement/transportation of people and goods are being influenced by these advancements (Weller) (Holley), but also industries like infrastructure and agriculture and the monitoring and inspecting necessary to ensure safety and reliability, and quality of production has already and continues to change (Weller). UAVs are now being used in precision agriculture to monitor crops, apply pesticides, and even disperse seeds (Fellman). Related to the field of agriculture is the management of natural resources, a field that UAV-use has also influenced. From wildlife surveys to assisting in reforestation efforts to monitoring and surveying an area for restoration efforts, the uses of UAVs continue to expand ("First-of-Their-Kind Drone") (Hodgson et al.) (Sankey et al.). A sub-field of natural resource management is also seeing a similar trend. Rangelands, "lands on which the indigenous vegetation is predominately grasses, grass-like plants, forbs, and possibly shrubs or dispersed trees," can support both livestock and wildlife and constitute about 30% of the land surface in the U.S. ("Rangelands"), and 70% of the land surface worldwide (Sankey et al.). It is no surprise then that these rangelands provide both opportunities for grazing livestock and large amounts of habitat for wildlife and should be managed with care (Thorne and Harper). They also provide numerous ecosystem services and goods, both tangible and non-tangible, which may include but are not limited to: habitat for endangered wildlife species, floodwater mitigation, carbon sequestration, recreational opportunities, an opportunity for renewable energy development, etc. (Breckenridge et al.). These rangelands are important and need protection, but as important as these rangelands are, the ways that they are managed are also important as management for these large areas can require large amounts of resources and time (Smith et al.). The use of UAVs for the care of these

rangelands is not only creating new ways of monitoring rangelands and making existing ways of managing rangelands more efficient, but existing ways of management are also becoming safer; this is evident in three separate categories: grazing operations, managing through application treatment, and surveying/monitoring.

Rangelands provide nutrition through vegetation which is important for grazing animals, both livestock and wildlife (Thorne and harper). As seasons progress, available grazing opportunities may change, calves are born, and livestock are rounded up and moved to different areas ("Horses and ATVs") ("Starting the Grazing"). Typically, this is done with either horses, ATVs, or a combination of the two ("Horses and ATVs"). Now, work is being done at Texas A&M University by Dr. David Walker using UAVs for checking on livestock and even moving them from one area to another (Byrns). In his experience, sheep respond positively to the drone and can be moved gently (Byrns). He also goes on to mention that RFID or radio frequency ID tags may be able to be used in the future with UAVs, equipped with the appropriate receiver technology, to monitor livestock and possibly find lost individual animals (Byrns). Right now, simple UAVs equipped with cameras can be used to check the condition of fences, the level of stock tanks or retention ponds, and do it with efficiency and ease (Byrns). In rural areas, poor road conditions can lead to long and slow drives for the rancher to check fences and water tanks; the use of a camera-equipped UAV is an excellent alternative in this situation. Walker goes on to mention that once a route has been flown to check fences, that route can be saved for future monitoring efforts (Byrns). Currently, UAVs do have some limitations such as the length of flight time on a single battery charge, which is roughly twenty-five minutes (Byrns), and also depending on the amount of tree cover, branches and limbs could inhibit where UAVs can fly (Byrns). Despite the limitations that it might have, UAVs can already be used and most likely will be increasingly used in the future with grazing operations as technology continues to improve.

There are several different ways that UAVs are starting to be used in applying treatment to rangeland systems. Rangelands, though, are typically managed with a minimal amount of input (Bidwell and Woods). It's also important to know that these rangelands have historically evolved to accommodate a level of disturbance from fire or grazing (Fuhlendorf and Engle). Because of this, these latter two are both used as management tools to increase biodiversity in

rangeland systems (Fuhlendorf and Engle). As previously stated, UAVs are already able to be used in grazing operations. Now, they are starting to be used and developed for and used in applying prescribed fire (Brocious). The University of Nebraska – Lincoln has developed a UAV that is now able to deliver a combustible payload, spheres that ignite on the ground after being deployed from an airborne UAV (Brocious). This technology is still being improved but has already been used and tested in the field to start high-intensity fires (Brocious); these high-intensity fires are needed to help control invasive woody plant species, like the Eastern Red Cedar, *Juniperus virginiana* (Brocious) (McDonald). Another purpose of these fires is also to help germinate seeds and reduce dead plant material (Brocious). The common way of prescribed burning, using drip torches around the periphery, can now be aided by autonomous aviation igniting interior areas from above (Brocious). This not only creates better efficiency, but also a safer method as previously stated. Firefighters would often have to walk or ride (on ATVs) in rugged and rough terrain, "often in cedar-filled canyon country" (Brocious); these safety hazards can be mitigated through the use of UAVs. Unmanned aerial vehicles equipped with a camera in a prescribed fire also offers another method of safety through aerial monitoring of the fire's progress. During prescribed fire operations, there are often many hands involved, and keeping track of everyone may sometimes be difficult despite already having radio communication; having another "pair of eyes" above, then, can offer another level of safety (Brocious). The use of drones for fire ignition and aerial monitoring during prescribed fire operations is not yet wide-spread but may likely play a major part in this type of management on rangelands in the future.

Rangelands typically are not managed with any pesticide or fertilizer treatment (Bidwell and Woods), but there are times that these lands get so overburdened by invasive plant species due to mismanagement that some level of intervention is necessary (Bidwell and Woods). Pesticide application is often used on 'woody' plant species that have taken over an area due to overgrazing and fire suppression (Bidwell and Woods). Similarly, fertilizer application on rangelands is not common (Bidwell and Woods). When used, it is in a fashion that attempts to positively alter the chemistry in the soil and add any lacking nutrients for the benefit of improved forage production (Bidwell and Woods); this applying of fertilizer is typically done more in introduced pastures (Bidwell and Woods). As with the application of prescribed fire, UAVs can be useful in the application of pesticide and fertilizer (Giles and Billing) (Kim et al.) ("First-of-Their-Kind Drone"). Unmanned aerial systems have been and are still being developed for

precision agriculture and smart farming, and have been developed and used worldwide for rice farming, grape vineyards, and other crops (Giles and Billing). Further, these UAVs can now be used to recognize weeds, assess fertility, map agricultural lands, and forecast crops (Kim et al.). As shown, precision agriculture is making large strides with the increasing efficiency and continued development of UAVs. It would be no large step then for these UAV applications and abilities to be used on rangeland systems, especially in the right setting and where the need exists.

Related to the land treatment choices of prescribed burning and pesticide/fertilizer is the restoration application of broadcasting seed. On rangelands, applying seed is used in many different situations: when native plants are trying to be re-established after a fire or other major disturbance, increasing potential forage for grazing, or establishing ground cover to aid in preventing soil erosion and mitigating water runoff (Rector). In the western rangelands of the U.S., shrublands, specifically, sagebrush systems, are some of the most imperiled systems in the U.S. (Finch et al.). This has led to conservation concern for the Greater Sage Grouse, a sagebrush-obligate species (Finch et al.). Work has already been done to try to restore some of these important sagebrush systems with conventional methods such as a tractor and seed drill (Finch et al.). This is a complex issue and an ongoing one that continues to need research done to fill in gaps of knowledge that are missing (e.g., the effectiveness of these initial restorations, whether a drill or broadcast system would be more effective in seed germination and vegetation establishment, etc.) (Finch et al.). Nevertheless, time is of the essence as only 50% of sagebrush systems remain today, and this remainder is at risk of disappearing in the next 50 years ("First-of-Their-Kind Drone"). As with the treatments of prescribed fire and pesticide/herbicide, UAVs can be used to assist in seed dispersal ("First-of-Their-Kind Drone"). One company in Washington State, DroneSeed, has partnered with the Nature Conservancy to use drone swarm technology in deploying ‘vessels’ of native seed in areas that need to be restored ("First-of-Their-Kind Drone"). This is the first time that the FAA has approved a company operating a swarm of five UAVs that weighs more than 55 pounds; each of these aerial vehicles is also able to carry 57 pounds of seed vessels ("First-of-Their-Kind Drone"). Compared with the other types of treatment applications, the use of UAVs in re-vegetating areas may prove to be unmatched in their utility due to their increased efficiency and not being hindered by terrain or topography (“First-of-Their-Kind Drone”). Regardless of how this technology progresses, it’s safe to say that

UAVs will play a major role in managing rangelands not only through aiding in prescribed fire applications but also through the application of pesticide and herbicide, as well as through restoration and revegetating of rangelands.

UAVs are now being used to monitor and survey vegetative characteristics on rangelands (Sankey et al.) (Hogan et al.). Traditionally, the monitoring of rangelands has been both time-consuming and expensive (Smith et al.) (Sankey et al.). Such tasks as soil mapping, fence mapping, taking note of vegetative characteristics, and mapping of other features were done regularly to provide basic range information (Smith et al.). These monitoring efforts have been important as they are typically used for planning and making decisions on land objectives and goals and how the land should be used to meet those objectives/goals (Smith et al.). Along with the expense and time consumption though, the issue of data collector subjectivity has been an issue (Sankey et al.). With long-term data sets, field measurements can be influenced by individual personnel, which may change once or more over a long period (Sankey et al.). The development of UAVs has offered a solution to these dilemmas. These UAVs can now be used for aerial imagery with cameras that are equipped with multispectral capabilities (Sankey et al.) that can pick up on differing light signatures reflected off plants. This may allow seeing the difference in vegetative heights, the difference in plant vigor, etc. (Sankey et al.) (Hogan et al.). Similarly, LIDAR (light detection and ranging) mapping uses laser pulses to model topography as well as structural shape and height, which may include vegetation (Hogan et al.). These capabilities have allowed the monitoring of rangelands on a landscape level and with great efficiency (Sankey et al.). Specifically, a handful of key ecological species can continue to be mapped and monitored year after year to give a good idea of the degree of spread of particular invasive species (Sankey et al.). Any more than roughly ten species of monitoring is not practical due to the current technological capabilities. Though, this would be the ideal method of monitoring invasive species such as pinyon pines and juniper species that are taking over rangelands in the western states (Sankey et al.). As technology continues, these multispectral capabilities could be used to determine forage species from non-forage and invasive plant species and determine forage height at different growing stages and predict forage production based on these growth changes (Hogan et al.). This information then can inform stocking rate decisions (Hogan et al.), as well as the effectiveness of other management decisions such as pesticide/herbicide application and prescribed fire (Sankey et al.). As shown, The uses of

multispectral sensors as well as regular aerial imagery can have many benefits in managing rangelands.

As technology improves, UAVs will increasingly continue to be used on rangelands throughout different aspects of range management including grazing operations, managing through application treatment, and surveying/monitoring. Rangelands are important not only because they provide grazing opportunities for livestock as well as habitat for wildlife species which may include endangered species (Breckenridge et al.). These rangelands also provide many more additional ecosystem services including clean water, carbon sequestration, floodwater mitigation, recreational opportunities, and many more (Breckenridge et al.). It is apparent that these rangelands are important and need to be protected and managed with stewardship in mind. As the use of UAVs continues to grow throughout different industries and influence the economy, the field of natural resource management, and specifically rangeland management, has seen this influence as well. As technology continues to progress and become more efficient, cost-effective, and easy to use, the use of UAVs will undoubtedly play a large part in the future management of these rangelands.

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