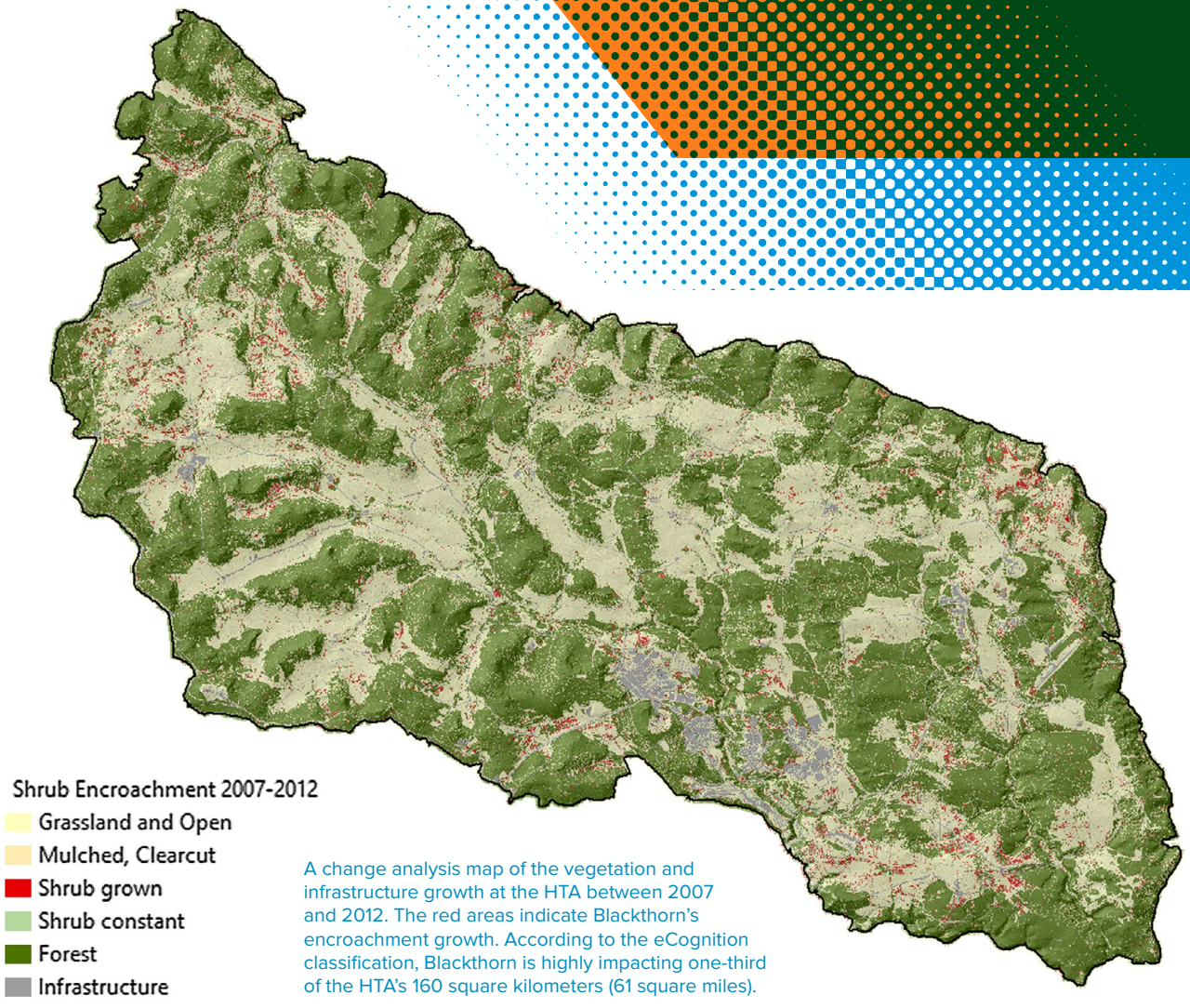

A change analysis map of the vegetation and infrastructure growth at the HTA between 2007 and 2012. The red areas indicate Blackthorn's encroachment growth. According to the eCognition classification, Blackthorn is highly impacting one-third of the HTA's 160 square kilometers (61 square miles).

Operation Eradication

How Advanced Geospatial Technology Helps Root Out Wily Vegetation

Prunus Spinosa, otherwise known as Blackthorn, is an invasive, hearty bush with gnarly branches and sharp thorns. Native to the United Kingdom and Northern Europe, Blackthorn typically forms natural hedgerows and blooms white flowers and bluish-black berries in late winter.

As it is rather adept at growing into a dense, spiny thicket, anyone tasked with managing or removing Blackthorn does so with extreme caution—its thorns can easily pierce the skin and leave nasty infections. The trick, the experienced say, is to maintain Blackthorn in its early growth phase, when it is less than 30 centimeters (12 inches) high. Miss it and you'll likely have a thorny issue on your hands.

The US Army Europe (USAREUR) learned this lesson the hard way. For the past five years, the leadership at its Joint Multinational Readiness

BY MARY JO WAGNER

The beginnings of a problem. Small-growth Blackthorn bushes dot the HTA landscape.

Center's (JMRC) Hohenfels Training Area (HTA) in Germany has been trying to effectively manage the advancement of Blackthorn across its training facility. And it has been one of their toughest challenges.

"The early growth stage of Blackthorn is rather slow, but left unchecked, it can reach a height of four meters (13 feet)," says Dr. Albert Boehm, the Directorate of Public Works, in the Environmental Branch of USAG Bavaria-Hohenfels. "It becomes incredibly dense and, with its extensive root systems, it can cover large areas really quickly. Its thickness and sharp thorns make it impenetrable, which reduces the available training areas and greatly affects the soldiers' ability to move around safely."

Compounding the encroachment issue is the fact that approximately 92 percent of the 160-square-kilometer (61-square-miles) training area has been designated a flora-fauna and bird habitat protection area under the European Union's directive known as Natura 2000 FFH. And that has produced an operational and environmental conundrum for USAREUR—how to balance the military's training needs with an elevated responsibility to protect threatened species and habitats.

In response, the JMRC launched a first-of-its-kind project to bring the Blackthorn under control, while staying true to the protected nature of the site. Using a combination of high-resolution 3D Light Detection and Ranging (LiDAR) data, satellite and aerial imagery and advanced land-classification technology, the JMRC was able to not only identify and map the Blackthorn's movements, it also gathered the needed intelligence to develop strategies to proactively manage the Blackthorn.

A thorny issue

Located in Hohenfels, in the southeast of Germany, the HTA is a 40,000-acre swath of hills, forest and rocky outcrops that has served as fertile grounds for military exercises since 1938. For the past five years, more than 60,000 soldiers (US and allied) have deployed to HTA every year to train.

As it has remained disconnected from pressures of development and public use for decades, the area has been prized for both its military role and its environmental value—Germany's federal forest agency, the Bundesforstbetrieb, counts 1,000 red-listed, or threatened species, in Hohenfels alone.

With the at-times intense training use of the area, the military has implemented various management programs to protect the landscape and its rare biotopes. However, 2001 was a defining year, both militarily and environmentally. After September 11, the number of troops training at HTA dropped dramatically because they were deployed for battle, creating a significant downturn in high-impact training. That downturn coincided with a European Union-sponsored comprehensive environmental survey that identified the area as an "ecological gem," prompting the Natura 2000 designation and elevating the need to effectively preserve the protected habitats.

Blackthorn can grow into a sizeable problem, costing up to $1 million US per square kilometer to remove it.

Elke Kraetzschmar measures the height of a Blackthorn bush as part of their ground verification tests. There was not a single mismatch between what eCognition classified as Blackthorn and what was on the ground.

With fewer and smaller rotations, the training area became the perfect breeding ground for vegetation growth, particularly Blackthorn, which grows long, spreading roots that send up shoots, which quickly become healthy, hearty trees, and a sizeable problem for the military both physically and financially.

"Blackthorn is less than 40 centimeters high for the first five years," says Boehm. "But then its height and its density mushrooms and the amount of physical and financial effort to remove it quadruples. Depending on its size, it could cost $400,000 US and $1 million US per square kilometer to remove it."

By 2010, the Blackthorn's encroachment on the HTA's open space was so significant, USAREUR had to activate a plan to resolve the problem. To do that successfully, it had to understand the bush—where it had taken root, its growth pattern and its extent. Since the expanse of the HTA and its several protected-status zones made it unfeasible to physically walk the ground to acquire that inventory, the Center's leadership needed a more viable method to size up the Blackthorn.

The HTA's hills, forest and rocky outcrops have served as fertile grounds for military exercises since 1938. Since 2010, more than 60,000 soldiers (US and allied) have deployed to HTA every year to train.

Having used LiDAR data for land-management applications previously, USAREUR tasked IABG, a geospatial technology company based in Ottobrunn, Germany, in 2012 to acquire an updated LiDAR dataset of the HTA. But unlike in the past, the LiDAR data would not be limited to a digital terrain and surface model (DTM/DSM), rather IABG would pair it with other datasets

A subsection of the eCognition classification. IABG integrated LiDAR-derived DEMs, optical satellite imagery, aerial photos and other data into eCognition to distinguish Blackthorn from other vegetative types.

and use Trimble's eCognition® image analysis technology to directly identify Blackthorn and map its encroachment patterns and extent –– a promising, yet untested approach for such a sizeable, heterogenous landscape.

"Although we knew the classification capabilities of eCognition, and we knew the LiDAR data would give us the key vegetation height detail, we had never before compared and classified LiDAR data over such a large area," says Elke Kraetzschmar, a remote sensing and image analysis specialist with IABG. "And we needed to map the extent of the Blackthorn's growth over time using imagery with different resolutions and accuracies. It was a bit of a risk, but it resulted in a great reward."

Rooting out Blackthorn

Kraetzschmar and her colleague Sylvia Guenther, a remote sensing and image analysis specialist, were given a 1-m-resolution LiDAR-derived DEM from 2007 and the .5-m-resolution LiDAR-derived DEM from the 2012 flight. They also acquired 8-band, 1-m-resolution optical imagery from the Worldview-2 satellite, existing aerial photos, and ancillary datasets including an infrastructure layer—all of which were integrated into the eCognition object-based image analysis (OBIA) software to build a customized rule set, the if-then processing tree that the software will follow to determine specific vegetative types.

To bring the training site's 160 sq km down to manageable size and to verify the validity of the classification approach, the team chose four, 2 x 2-sq-km (0.8 x 0.8-sq-mi) test sites.

After pre-processing and validating the quality of the raster data, Kraetzschmar and Guenther used Esri's ArcGIS to calculate a Normalized Vegetation Index and texture layers to separate vegetation from non-vegetation areas—detail that would be integrated into the classification process.

And then they began writing rules to instruct the software to distinguish Blackthorn from other vegetative types based on its height, spectral qualities and textural features—a process similar to how the human brain distinguishes specific objects.

"The power of OBIA technology is that it automatically combines both the traditional image-processing method of matching a pixel's spectral properties with its typical land class, but it also considers an object's environmental surroundings," says Guenther. "Analyzing the contextual detail of an object provides more accurate classifications. It is also the only tool we know of that can sufficiently handle the complexities of comparing and classifying LiDAR imagery with different resolutions."

In two months the IABG team had developed a classification rule set to distinguish four class types: forest, medium-high Blackthorn shrub, low Blackthorn shrub and open grassland. Although the rule set took months to build, it only took the software 15 hours to run the workflow and produce land use maps for 2007 and 2012 and a derived land use change map to indicate the bush's growth in each test site between those two years.

They then brought the preliminary results to the JMRC to validate the data on the ground and to show the leadership how the data could be used for building vegetation-management strategies. For the field verification, they chose 40 different Blackthorn bushes in each site and measured them using a yardstick, comparing their real-world height and shape with their classified counterpart on the map. And there was not a single mismatch between what eCognition classified as Blackthorn (including its varying heights) and what was on the

ground. It was an unexpected result that "surprised everyone," says Boehm.

"From the outset we knew the biggest challenge for us would be to derive a classification scheme to replicate the growth of Blackthorn in reality," he says. "This is a big area with difficult terrain issues like tank ruts, which can make classifications vulnerable to errors, so we weren't sure how accurately the software would be able to mirror the growth on the ground. We were overwhelmed with how good the results were."

Based on the quality of the test sites classifications, Kraetzschmar and Guenther then extended the classification methodology across the 160-sq-km site.

In September 2013, IABG delivered the classification results to the Center's leadership, which showed, in part, that Blackthorn was highly impacting one-third, or about 50 sq km (19 sq mi), of the training area.

"With the number of challenges we had, particularly with the diverse source data and different resolutions, we were quite surprised with the high accuracy of the classification over the entire area," adds Kraetzschmar. "Now the military not only has a detailed comparison of Blackthorn between 2007 and 2012, they have a completely new, informative tool that can help them develop cost-effective Blackthorn reduction strategies."

Managing Blackthorn

Indeed, by having an accurate inventory and map of the Blackthorn's growth stages and extent, JMRC environmental and training planners can better create cost-effective and efficient removal and control strategies.

When Blackthorn is less than 30 cm high, the JMRC~~~ can use a herd of nearly 10,000 sheep to help manage its growth.

Traditionally, the military has controlled the invasive Blackthorn species with a mix of high-impact training exercises to impede the bush's growth, spot burning, mowing and a herd of nearly 10,000 sheep, who feed on the early Blackthorn growth. That method has cost about $30,000 US per sq km. From there, the costs and management efforts rise as quickly as the Blackthorn grows.

Using the classification maps, the Center's leadership have begun developing smart eradication plans. They have identified a number of target areas throughout the training area and based on a number of parameters such as accessibility, degree of overgrowth and costs, they have identified the best cost-effective and efficient methods to either remove the Blackthorn or greatly reduce it.

To date, approximately 200 hectares of Blackthorn have been treated. And because the classification datasets give them a clear indication of the Blackthorn's extent and current heights, the military has the ability to accurately forecast the bush's growth pattern for the next five years and develop sufficient control measures to properly manage its spread.

"We estimate that it will take at least five years to bring two-thirds of the 50 square kilometers back to manageable levels," says Boehm. "And because of the data, we've been able to create cost estimates for achieving that goal. It's a far more proactive approach and unlike in the past, we can now manage Blackthorn, rather than let it manage us."

Mary Jo Wagner is a Vancouver-based freelance writer with over 20 years experience in covering the geospatial technology.