MANAGEMENT STRATEGIES FOR REVERSING DECLINES IN LANDBIRDS OF CONSERVATION CONCERN ON MILITARY INSTALLATIONS:

A REPORT TO THE

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LEGACY RESOURCES MANAGEMENT PROGRAM

documenting the findings of a Technical Analysis

PERFORMANCE MEASURE ANALYSIS: EXAMPLES OF COMPARING AND CONTRASTING INSTALLATION-SPECIFIC DEMOGRAPHICS WITH REGIONAL DEMOGRAPHICS AND LANDSCAPE CHARACTERISTICS

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prepared by

M. PHILIP NOTT, PH.D., AND TERYK MORRIS

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS 27

LITERATURE CITED 28

BACKGROUND

The Department of Defense (DoD) is mandated to protect bird populations on its lands pursuant to a number of federal acts designed to conserve avian diversity in the United States: Alaska National Interest Lands Conservation Act of 1980 (16 USC 410hh-3233); Bald and Golden Eagle Protection Act of 1940 (16 U.S.C. 668-668d); Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.); Fish and Wildlife Act of 1956 (16 U.S.C. 742 et seq.); Fish and Wildlife Conservation Act of 1980 (16 U.S.C. 2901-2911); Fish and Wildlife Coordination Act (16 U.S.C. 661-667); Migratory Bird Conservation Act (16 U.S.C. 715-715d; 715e; 715f-715r); Migratory Bird Treaty Act (16 U.S.C. 703-711); National Environmental Policy Act of 1969 (42 U.S.C. 4321-4347); Sikes Act Improvement Act of 1997 (16 USC 670a-670o); and other Agreements to limit encroachments and other constraints on military training, testing, and operations (10 U.S.C. § 2684a).

Not surprisingly, because of this legislation, and the fact that large tracts of habitat have been left relatively undisturbed, many installations are regarded as important bird areas. Furthermore, some installations protect and maintain habitat for rare, endangered, and threatened species (e.g. Fort Bragg, NC; Jefferson Proving Ground, IN, and Fort Hood, TX). DoD installations also provide high quality habitat for other birds, including diverse communities of Neotropical migrants. In a survey-wide Breeding Bird Survey analysis spanning 1980-2005 (Sauer et al. 2005) 62% of the Neotropical migrants (total 37 species) that were surveyed declined and 40% significantly ($P<0.10$) declined; whereas only 19% of species significantly increased over that time period. This study will investigate the importance of DoD installations in providing large tracts of forested habitat where many Neotropical migrants breed (or otherwise utilize).

Performance measures

More recently, DoD and the U.S. Fish and Wildlife Service (FWS) entered into a memorandum of understanding (MOU) regarding incidental take of migratory birds on military installations. Thus, to assess any negative (or positive) impact of management relating to military activities, especially military Readiness and Range Sustainment (R&RS), upon bird populations, it is increasingly essential that conservation support tools are made available to natural resource managers of DoD installations. These tools will enable them to a) quantify the “background”

health of their bird populations relative to populations that breed on surrounding non-DoD lands, b) quantify the impact of proposed management on a suite of species, and c) implement management to maintain or improve the quality of breeding habitat for focal species of conservation concern.

Additionally, in 2004 the Defense Department has created a national Readiness and Environmental Protection Initiative (REPI) conservation buffer program which provides funding for the establishment of conservation easements around DoD installations. This not only provides more protected habitat but also reduces encroachment of DoD installations by development, which in addition to removing habitat might also introduce predators. Other conservation easement programs are already implemented including programs for endangered bird species at Fort Hood, TX and Fort Bragg, NC. It is therefore essential to quantify and map potential bird habitat surrounding each installation.

It is important to realize that management actions intended to benefit one or other species may have deleterious effects on populations of other species. By quantifying demographic performance measures and landscape patterns natural resource managers can identify a suite of focal species that are representative of the landbird community towards which conservation actions may be directed. By quantifying species' preferred habitat types/patterns within the boundaries of an installation (and hopefully other adjacent land) they can assess the extent of the preferred habitat and where management may be best directed. In this report we formulated examples of comparative measures termed "performance measures" that allow us to compare and contrast population demographics and landscape patterns and discuss them relative to a suite of focal species both within the boundaries of the installations and the surrounding landscapes.

Many DoD installations already monitor their bird populations, especially those installations that protect endangered, rare, and threatened species such as Red-cockaded Woodpecker (Fort Bragg, NC), Henslow's Sparrow (Jefferson Proving Ground, IN), Black-capped Vireo, and Golden-cheeked Warbler (Fort Hood, TX). The long-term study (1994-present) we report on here was conducted by the Institute for Bird Populations (IBP) through its Monitoring Avian Productivity and Survivorship (MAPS) program. IBP effectively monitored 34 landbird species, including

20 Neotropical migrants, on 13 U.S. Department of Defense installations (or groups of installations) across the eastern and central United States between 1994 and 2002, inclusive. Of these 34 species, ten are nationally or regionally listed (as of December, 2002) by the US Fish and Wildlife Service as "*Birds of Conservation Concern"* (BCC), and were the subject of several previous reports (e.g. Nott et al. 2003, Nott and Michel 2005). In the first report, the 1994-2002 data was used to identify focal species and construct species-landscape models that help us understand how land management impacts populations of species of concern, and allowed species-specific management recommendations to be made. Since 2004 IBP have reorganized the MAPS network to better monitor the suite of focal species in the context of managed land.

Earlier work in this project modeled demographic parameters as functions of landscape metrics derived from analyses of National Land Cover Dataset 1992. These models showed that that a) Acadian Flycatcher reproductive indices increased as a function of forest core area, b) reproductive indices for Wood Thrush, Worm-eating Warbler, Kentucky Warbler, Bewick's Wren, Prairie Warbler, and Field Sparrow increased as a function of forest area. In this report we used the 1994-2002 dataset from four large, mainly forested, installations to formulate demographic "performance measures" based on apparent survival rates (probability of an individual surviving from one year to the next) estimated from mark recapture data, and mean annual productivity indices based on the proportion of young in the catch. Furthermore, we focused on the extent and pattern of the forested habitats on these and other large installations.

We limited the geographic scope of the demographic analyses to 24 MAPS stations (Table 1) that operated between 1994 and 2002 on four US Department of Defense installations in Indiana (2), Kentucky (1), and Missouri (1). These 24 MAPS stations were pooled because they all lie within the North American Bird Conservation Initiative (NABCI) Bird Conservation Region #24 (Central Hardwoods) and provide the bulk of data for that region. We also included species other than those classified as BCC species if sufficient data were available to reliably estimate time-constant apparent survival rates and productivity indices. We did not include species with survival rate estimates if those estimates were associated with coefficients of variation above 30%.

Demographic Performance Measures

The values of survival and productivity parameters derived from demographic analyses of DoD MAPS data can be compared to regionally-derived estimates to provide demographic "performance measures", by which DoD land managers of each installation (or group of installations) may identify "healthy" populations (i.e. long-living and/or productive). In addition, managers may identify populations that are performing poorly relative to the surrounding region (i.e. low survival rate and/or low productivity), and implement land management strategies designed to increase the health of those populations, or maintain the quality of the habitat.

An additional performance analysis was conducted to exemplify comparing MAPS adult trends (1994-2002) with Breeding Bird Survey trends for appropriate regions over the same period. There are, however, potential problems comparing MAPS adult trend data with Breeding Bird Survey data. The most obvious difference is that MAPS catches birds in nets at fixed positions while BBS uses sight and sound survey techniques on standard routes. Most of the BBS routes follow county- or state-maintained roads which tend to attract commercial and residential development. On the contrary, MAPS stations associated with Department of Defense installations tend to be located in areas that are less likely to be developed because they are located in habitats that provide a buffer between military activities and surrounding private lands. We developed a bird community-based approach to compare the relative importance of forest and successional communities within each monitoring protocol, and also compared the BBS trends with MAPS adult trends for the same period (1994-2002).

Landscape Performance Measures

The MAPS protocol is intended to monitor landbirds in forested and successional habitats, rather than more open grassland habitats. Consequently, the placement of MAPS stations is not random among habitats within a military installation; in fact MAPS stations tend to be placed where birds will be regularly captured. Furthermore, any species-specific demographic performance measures resulting from MAPS data analysis might refer to the forested/successional habitat complex in which the MAPS stations were placed, and which may not be representative of habitats across the installation as a whole. So, although MAPS data may

suggest that individuals of local population are recurrent breeders, and very productive (hereto known as a high demographic performance) upon a particular installation, the species monitored may be representative of habitat that covers only a small percentage of the area of the installation. Other research has shown that MAPS stations probably monitor populations breeding within 2-5km of the station, as well as locally-resident individuals.

Alternatively, high demographic performance of a species may be associated with an extensive land cover type, thereby emphasizing the conservation value of that land as "source" habitat. Source habitat is essential to regional population dynamics because it supports a "source population" such that, overall, the population produces numbers of young birds (that survive to adulthood) that exceed the annual numbers of adult deaths. So, land managers also need to assess the extent and importance of habitat patches that support healthy bird populations, and how that habitat compares to similar habitat outside the installation boundary, hereto known as "landscape performance measures."

To formulate landscape performance measures we quantified the patterns of dominant habitat cover among the installations, especially forest cover, forest canopy cover, agriculture, and development. We also compared estimates of the area of forested, agricultural, and developed land that lies within a) the boundaries of 19 military installations, and b) a 20 kilometer buffer of the installation boundaries. These comparisons or landscape performance measures allowed us to assess the conservation value of the installations' habitat types with reference to the surrounding region. In this report we present and discuss landscape performance measures associated with 18 individual military land holdings upon which one or more MAPS stations operated between 1994 and 2002.

An examination of satellite imagery and derived products (i.e. NLCD2001 land cover and forest canopy cover layers), however, suggested that many of the 19 DoD military installations included in this study provide extensive refugia for landbird species associated with forest habitat. The larger installations appeared to support large tracts of forested land the size of which are not normally seen outside of USDA Forest Service or National Park land. However, land management practices on these military installations that are associated with range

sustainment and military readiness often maintain large tracts of grassland and successional habitat adjacent to forested areas. The development of ranges and the roads and tracks that are cut to access them tend to fragment large patches of contiguous forest.

Forest fragmentation is associated with decreased diversity (vanDorp and Opdam 1987), abundance, and productivity of many forest birds (Blake and Karr 1987, Whitcomb et al. 1981). Obligate interior species are maximally productive in the forest interior which we define here as as the area defined by forest that is at least 90m from the forest edge. Bender et al. (1998) showed that the declines in the population size of interior obligates resulting from habitat fragmentation were greater than greater than the declines predicted from pure habitat loss alone (Bender et al. 1998). For example, depending upon the shape and size of the patch, it is possible to remove a small area, for example 5% (i.e. bisecting a forest patch with a tank road), but cause the loss of >50% of the interior habitat.

We analyzed NLCD 2002 land cover and canopy cover datasets to quantify a suite of landscape performance measures relating to MAPS stations and to random points (and radii around those points) located within a) the boundaries of each installation, and b) 20 km buffer around each installation. More specifically we analyzed NLCD 2001 datasets to estimate:

- probabilities of encountering forested habitat, compared to
- probabilities of encountering high canopy cover (>=55%),
- mean percentages of forest cover within randomly placed 1 km radius areas,
- mean percentages of interior forest cover within randomly placed 1 km radius areas,
- percentages of agricultural land cover within randomly placed 1 km radius areas,

We also calculated the total percentage cover of land (including forest cover) cover classes within the installation boundaries and within the 20km buffers.

Finally, we mapped the core forested areas for each of the larger installations and discussed the resultant patterns in the context of management that could potentially increase the size of contiguous forested areas, or at least maintain the existing large patches, and hence the core area of forest that is so important to many species.

METHODS

The Institute for Bird Populations (IBP), through its Monitoring Avian Productivity and Survivorship (MAPS) program (DeSante et al. 2003), collected breeding season banding data from 24 monitoring stations (Table1, Figure 1) on four installations: U.S. Army Jefferson Proving Ground, IN (now operated by USFWS as Big Oaks NWR); U.S. Army Fort Knox, KY; U.S. Department of the Navy, Crane Naval Surface Warfare Center, IN, and U.S. Army Fort Leonard Wood, MO.

Demographic Performance Measures

To formulate examples of performance measures we estimated the annual numbers of captures of individuals, calculated the year to year change, and expressed the change as a percentage of the period mean (MAPS adult trend). We also estimated adult apparent survival rates as indicators of both survival and/or emigration, such that high values are indicative of long-lived individuals and high breeding site fidelity. Likewise, we calculated long-term indices of productivity from the ratio of young to adult captures. However, because the capture probabilities of young and adults vary across species, these indices can only be compared within-species such that the highest values may be indicative of productive source populations.

Comparing MAPS adult trends with BBS trends

MAPS adult trends were compared with BBS trends (Table 2) for set of focal species defined as those for which it is possible to derive reliable apparent survival rates from the MAPS data (Table 3). For each species trends in the annual numbers of adult individuals, and mean numbers of adults per station per year, captured at Indiana and Kentucky installations were extracted from the analyses completed in Nott and Michel 2005 (Appendix 2-13),

We then obtained BBS trend data for those same species and period (1994-2002) using BBS online analysis tools (estimating equations method) for two areas: BBS physiographic strata 14 and 15 (Ozark Plateaus and Ouachita, respectively); and the state of Indiana (Sauer et al. 2005). In both cases adult trends were expressed as the annual percentage change relative to the period mean (Adults/Station/Year and Number/Route/Year, respectively). We split the focal species into two groups representing forest and successional species and then averaged the trends.

MAPS abundances were expressed as the mean annual number of birds per station (corrected for missing effort) whereas BBS abundances were expressed as mean annual number of birds per BBS route. Clearly, direct comparisons between the numbers of adults captured by MAPS and the numbers of adults detected by BBS are not scientifically defensible. However, by examining the relative abundances of each species it is possible to make community comparisons. We calculated relative abundances for each species as the number of birds expressed as a proportion of all birds. For the forest and successional groups we totaled the abundances for each group and entered the totals into a 2x2 contingency table and tested the differences using Fisher Exact Test (two-tailed) and Chi-square Test (with Yates' correction).

Apparent survival rate estimation

We estimated annual adult apparent survival rates (phi), adult recapture probabilities (p), and the proportions of residents of birds seen once in year they were banded (tau), using modified Cormack-Jolly-Seber capture-recapture models. Specifically, we used the *ad hoc* Robust Design model described by Nott and DeSante (2002) and Hines et al. (2003). We estimated apparent survival rates from time-constant models for all 24 MAPS Stations across Indiana, Kentucky, and Missouri, and for 18 stations in Indiana and Kentucky. For these mark-recapture models, we only included data from stations that operated for at least four contiguous years during the study period.

All capture-recapture models were implemented using the computer program TMSURVIV (http://www.mbr-pwrc.usgs.gov/software.html). This program was designed and implemented by Phil Nott and David DeSante of IBP in collaboration with Jim Nichols and Jim Hines of Patuxent Wildlife Research Center, MD (Hines et al. 2003). The model is a modification of SURVIV (White 1983) and provides survival rate estimates based on both between-year and within-year information (*sensu* Pradel 1997, Nott and DeSante 2002). Such estimates are less biased by the numbers of transient adults captured each year; those individuals captured in only one year or, if captured more than once, all captures spanned a period less than seven days apart. Conversely, individuals marked as *a priori* residents were captured in more than one year or within a single year but seven or more days apart.

Apparent survival rates were estimated (or collated from other studies) for all four locations, the Indiana/Kentucky locations, Central Hardwoods Bird Conservation Region (BCR#24), and regional sets of MAPS data for the northeast, southeast, north-central, and south-central portions of the United States. We also recorded the conservation tier of each species from the Central Hardwoods Joint Venture (CHJV), who formed a partnership in 2000 with the primary purpose of elevating emphasis on all-bird conservation within BCR#24 (NABCI 2007).

Productivity indices

For each species and station we indexed productivity by counting the mean annual numbers of after-hatch-year (AHY) adult birds captured, and the mean annual number of hatch year (HY) individuals captured. The productivity index was expressed as the per station mean annual ratio of young individuals captured (HY/AHY).

Landscape layers

We extracted the layers (land cover type and forest canopy cover) from the 30-m resolution 2001 National Land Cover Dataset (NLCD 2001) for spatial analyses of a) forest canopy cover, b) land cover type, c) forested areas, and d) core area forest measured as the amount of forests within a 90m interior buffer of each forested patch.

The forest canopy cover dataset was a single layer raster image such in which pixel values represent the percentage of tree canopy cover within the 30 square meter area. Furthermore, we reclassified the NLCD 2001 land cover layer (http://www.mrlc.gov/mrlc2k_nlcd.asp) to approximate Level 1 classes but retained the three individual forest classes (Table X).

In order to analyze GIS layers within Department of Defense land boundaries, we extracted the boundaries of relevant military installations from the Indian & Federal Lands dataset from Mapcruzin.com (http://www.mapcruzin.com/geography_of_risk/fed_lands.htm). We mapped individual (or groups of) installations onto level I NLCD 2001 coverages to show the boundaries and 20km buffers around those boundaries (Figures 3 to 15)

Landscape Statistics

Landscape statistics were generated using FRAGSTATS v3.3 (McGarigal and Marks 1995; (http://www.umass.edu/landeco/research/fragstats/fragstats.html) and in house scripting in a variety of languages (Teryk Morris). We extracted the following parameters:

- Percentage of Landscape (PLAND) covered by each cover class.
- Percentage of Core Area (CPLAND) in the landscape defined as the total core area of a cover type expressed as a percentage of the total landscape area. In this case the core area of a patch was defined as the area of forest within the area bounded by a 90 meter internal buffer.
- Edge Density (ED) is a cover class-specific measure of the total length of all edge segments within the landscape expressed as a ratio of the area of the patches in meters per hectare.

Landscape Performance Measures

For constructing landscape performance measures we extended the scope of the study to include all DoD Legacy funded stations that operated up to and including 2002, the same set of stations included in Nott et al. (2003).. Using ArcView GIS (ESRI, Inc.) we superimposed the Legacy-supported MAPS stations upon a shapefile of the boundaries of military lands across the east, southeast, and south-central regions of the United States. This revealed 19 distinct installation boundaries within which one or more MAPS stations operated between 1994 and 2002. Each installation was given a one kilometer and 20 kilometer buffer around its boundary.

Within each 20km buffer we generated 666 random points using Hawth's Tools (http://www.spatialecology.com/htools/tooldesc.php) such that no two points were less than 100m distant from one another (this represents the typical size of a small landbird territory). Thus, a number of points fell "within" the installation boundary (plus 1 kilometer) and the rest fell "outside" but within the 20km buffer. We conducted three comparative analyses (comparing within to outside) using the boundaries, buffers, and the predefined set of random points:

1. Comparison of probabilities of encountering forested cells and mature forested cells (defined as >=55% canopy cover) using NLCD 2001 forest canopy cover dataset and random points.

2. Comparison of landscape statistics for one kilometer radius areas around each random point using the reclassified NLCD 2001 land cover dataset.
3. Comparison of landscape statistics for the entire installation area to those within a 20km buffer, using the reclassified NLCD 2001 land cover dataset.

Probability of encountering forested and mature forested cells

The points and installation boundary layers were superimposed upon the 30m resolution canopy cover percent layer from the National Land Cover Dataset 2001 (NLCD 2001, XXXX). For each installation and random point we recorded the percentage canopy cover that was associated with the underlying canopy cover cell. We calculated installation-specific values for the following parameters for those points within the boundary of a) the DoD installation (plus one kilometer), and b) a 20km buffer around the installation.

- Number of points analyzed
- $\mathbf{P_{(Forest)}}$ – the probability of a cell within the boundary being classified as forest ([No. of cells with canopy cover > 0] / Total No. of cells)
- $\mathbf{P_{(Mature)}}$ – the probability of a cell within the boundary being mature forest ([No. of cells with >=55% canopy cover] / [No. of forested cells])
- Percentage of mature forested cells within (100 x [$\mathbf{P_{(Mature)}}$ / $\mathbf{P_{(Forest)}}$]).

Landscape statistics for one-kilometer radius areas

To assess how landscape patterns surrounding MAPS stations compared to random locations we calculated FRAGSTATS landscape statistics from the NLCD 2001 dataset for one kilometer radii around each MAPS station and from 666 one-kilometer radii cookie-cuts made around each of the existing set of random points. We then compared the mean percentage (and coefficient of variation) of core forest area (90m internal buffer) of a) cookies associated with MAPS stations, b) cookies with center points that lay within the boundaries of the installation (+ 1 km), and cookies that lay outside (but within a 20 km buffer of) the installation boundary. We also compared percentages of agricultural cover for cookies within and outside the installation.

Installation- and 20km buffer-wide landscape analysis

We calculated FRAGSTATS landscape statistics for the land within each installation boundary and within the boundaries of 20 km buffers around each installation and compared a) total area, b) areas of deciduous, conifer and mixed forest, c) the total core forests area represented by the sum of all values in (b) as a percentage of total area, d) the area (sq. km.) of core forested area, and e) the difference between the expected % of core area forest (based on the area of the installation as a percentage of the total area), and the observed percentage calculated as the area of installation core forest expressed as a percentage of the total core forest within the 20km buffer.

RESULTS

Demographic Performance Measures

Comparing MAPS and BBS trends

Although comparisons between MAPS and BBS adult trends are difficult to interpret, the results presented in Table 2 revealed similarities and differences between the community patterns. Two clear patterns emerged from the MAPS adult trend data presented in Table 2. Trends for five of eight forest species were positive and three were negative, but none of the trends were statistically significant (i.e. all trends could be described as stable population trajectories). Kentucky warbler exhibited a nearly significant annual decline of 2%. However, Carolina Chickadee, Worm-eating Warbler, the four most highly ranked species by survival rate (i.e. survival rates lower than surrounding regions), were associated with positive trends. Overall, forest species increased by nearly 1% per year.

Successional species, however, showed significant ($P<0.05$) annual declines of between 5 and 11% for White-eyed Vireo, Gray Catbird, Blue-winged Warbler, Common Yellowthroat, Yellow-breasted Chat, and Field Sparrow. Prairie Warbler, Northern Cardinal and Indigo Bunting showed non-significant declines of below 5%. Carolina Wren was the only species to show a positive but non-significant trend. Overall, successional species declined by nearly 5% per year.

The analyses of BBS data for physiographic strata 14 & 15 showed a different pattern. Six of eight forest species increased; including four species that significantly ($P<0.05$) increased. Acadian Flycatcher, Carolina Chickadee, and Wood Thrush significantly increased by less than 5% annually, whereas Louisiana Waterthrush numbers increased by >11%. Worm-eating Warbler and Ovenbird declined non-significantly. Overall, the BBS population trends of forest species increased by 2% per year.

In contrast to MAPS results, successional species increased by 0.64% overall. Five species showed declines including Gray Catbird and Field Sparrow which significantly declined by <5%. Only two species, White-eyed Vireo and Carolina Wren, significantly increased.

However, the results for BBS routes in Indiana showed very similar results to the MAPS data whereby non-significant trends were detected for forest species, and negative trends were detected for eight of ten successional species, including significant($P<0.05$) declines for Common Yellowthroat and Field Sparrow, and an overall decline of 2.5 % per year.

Comparisons of the relative abundances of forest and successional species showed a highly significant difference between the community compositions. We compared total relative abundances for each group of species and found that the proportion of successional species was nearly 1.5 times higher in both BBS regions (0.84 and 0.84) than in the IN/KY MAPS data (0.58). Conversely, the proportional abundances of forest species in MAPS data (0.42) was over 2.5 times that in the BBS Strata 14 & 15 (0.16), or the Indiana BBS data (0.16).

Performance measures based on adult population trends, survival rates, and reproductive indices suggest that the populations of forest and successional species that breed on Jefferson Proving Ground, Fort Knox, NWSC Crane, and Fort Leonard Wood are healthier than those breeding within the surrounding regions.

Survival rates of forest species

Table 3 shows the comparisons of survival rates estimated for MAPS stations pooled across a) all four installations in Indiana, Kentucky, and Missouri, and b) three installations in Indiana and Kentucky (Jefferson Proving Ground, Fort Knox and NWSC Crane) with regional estimates from BCR#24 (Central Hardwoods region) and regional sets of MAPS data for the northeast, southeast, north-central, and south-central portions of the United States. Comparisons with BCR#24 reflect the fact that the 24 stations located on military installations contribute a lot of data to the region. However, by including estimates from other MAPS regions to rank the species eight species ranked 1 or 2 (low survival rate compared to other regions), including four species that are also classified as high conservation priority Tier I species in the BCR#24 bird

conservation plan (NABCI 2007); Worm-eating Warbler, Louisiana Waterthrush, Kentucky Warbler, and Prairie Warbler. Four non-tier species were ranked as priority species (rank 1) based on survival rates; Carolina Chickadee, Ovenbird, Carolina Wren, and Gray Catbird. Other Tier I species, Acadian Flycatcher, White-eyed Vireo, Wood Thrush, Blue-winged Warbler, Yellow-breasted Chat, and Field Sparrow ranked 3 or above

Generally, survival rate estimates for forest species (Table 4) were higher than or comparable (i.e. at least 90% of) the BCR#24 estimates (19 of 23 estimates). Acadian Flycatcher estimates were obtained for all four locations and were higher than or comparable with estimates obtained for BCR#24, 27, and 28. For three locations, Red-eyed Vireo estimates were higher than or comparable with estimates obtained from all four BCRs, however, the estimate for Fort Leonard Wood was very low in comparison to all other estimates. Carolina Chickadee survival rate estimates were obtained for two locations and were comparable with the BCR#24 estimate, but higher than the estimates for BCR#22 and 28. Three Wood thrush estimates exceeded estimates for all four BCRs. Estimates for Worm-eating Warbler were obtained for NWSC Crane and Fort Leonard Wood which exceeded those obtained for three of the four BCRs, but were just under 90% of the value obtained for BCR#22. Similarly, survival rate estimates for Ovenbird at the same two locations exceeded the three BCR estimates; however, the estimate for Jefferson Proving Ground was very low in comparison. For Louisiana Waterthrush only one estimate was obtained (NWSC Crane) which was very low in comparison to those obtained for BCR#24, 22, and 28. Finally, three of the four Kentucky Warbler estimates were higher than or comparable with the four BCR estimates, but the estimate for Jefferson Proving Ground was lower. These results were summarized as scores ranging from 100 to -100 where positive values indicate a high overall performance in terms of survival rates. Fort Knox scored highest because all four survival estimates exceeded the regional estimate, followed by NWSC Crane (eight species, five exceeded the BCR#24 estimate) and Fort Leonard Wood (six species, four exceeded the BCR#24 estimate). Finally, of five estimates obtained for Jefferson Proving Ground only two exceeded the estimates for BCR#24.

Survival rates of successional species

In 22 of 31 cases, survival rate estimates for successional species were higher than (18), or comparable (4) to, the BCR#24 estimates. White-eyed Vireo estimates were obtained for all four locations; two were higher than the regional estimate, one was comparable, and the Fort Knox index was low. The single estimate obtained for Carolina Wren at Fort Knox exceeded estimates obtained for all four BCRs. The Gray Catbird estimate was high at Fort Jefferson but low at Crane. Three Blue-winged Warbler estimates were obtained which were higher than or comparable to the estimates obtained for BCR#24 and 28. The Prairie Warbler estimate from Fort Leonard Wood exceeded estimates for BCR#24 and 27, but the estimate for NWSC Crane was lower than both regional estimates. Three of the four Common Yellowthroat estimates were higher than or comparable to the four BCR estimates, but the estimate for Fort Knox was low in comparison to all estimates. With the exception of Fort Leonard Wood, for which a very high value was obtained, estimates for Yellow-breasted Chat were low in comparison to the three regional estimates. Field Sparrow estimates were obtained for three locations (excluding Fort Knox), two of which exceeded both regional estimates, however, the estimate for Jefferson Proving Ground was low in comparison to all estimates. Three of four Northern Cardinal estimates were very much higher than all four regional estimates; however, the Crane estimate was low in comparison to all estimates. Finally, three of four Indigo Bunting estimates exceeded the four regional estimates, but the estimate for Fort Jefferson was comparable to the estimate for BCR#24. Again the location-specific scores were all neutral (0) or positive (+) indicating that successional species performed well in terms of survival rates. Fort Leonard Wood scored highest (eight species, seven exceeded the regional estimate), followed by Jefferson Proving Ground (eight species, four exceeded the regional estimate), and Fort Knox (six species, three exceeded the regional estimate).

Reproductive indices for forest species

Table 5 showed that in 23 of 29 cases reproductive indices for forest species on military installations exceeded indices calculated for BCR#24 (20 cases) or were comparable (3 cases). Three of four Acadian Flycatcher indices exceeded, and the other was comparable, to the BCR#24 index which itself was low compared to indices for the other BCRs. Three of four Red-eyed Vireo indices exceeded the BCR#24 index but was low for Jefferson Proving Ground. No

index was calculated for Fort Knox but the other three indices far exceeded the regional index. Two of four Wood Thrush indices (Fort Jefferson and Crane) exceeded the regional indices, and although the Fort Leonard Wood index was close to 90% of the BCR#24 index it was comparable with or exceeded the other regional estimates. All four Worm-eating Warbler indices exceeded the regional index, and the estimate for Fort Knox exceeded the highest regional index for BCR#28. The productivity index for Ovenbird exceeded the regional index at NWSC Crane, was comparable at Fort Jefferson, but low for Fort Leonard Wood. NWSC Crane and Fort Knox showed very high indices for Louisiana Waterthrush and Kentucky Warbler, but low indices for Fort Leonard Wood. The Kentucky Warbler index at Jefferson was comparable to the regional index. Overall scores indicated that at NWSC Crane all eight forest species exhibited productivity levels higher than those of BCR#24 populations, followed by Fort Knox where indices for five of six species exceeded the regional index, and Fort Jefferson where six of seven species exceeded or were comparable to the regional indices. Fort Leonard Wood forest species scored negative with only three high and one comparable index among eight species.

Reproductive indices of successional species

In 24 of 36 cases (67%), productivity indices for successional species exceeded indices calculated for BCR#24 (19 cases) or were comparable (5 cases). All four White-eyed Vireo indices exceeded or were comparable to the regional estimate. Carolina Wren indices were 25-225% higher than the regional index and exceeded indices for the three BCRs, however, the Jefferson Proving Ground index was low. All four Blue-winged Warbler indices exceeded the regional index. Three of the four Prairie Warbler indices exceeded or were comparable with the regional index but the Fort Knox index was low, but all four Common Yellowthroat indices were lower than the regional index. Both Yellow-breasted Chat and Field Sparrow indices were higher than the regional index for Crane and Fort Leonard Wood but lower for Jefferson Proving Ground. Two of four Northern Cardinal indices were close to the regional estimate but the Crane and Fort Knox indices were lower. Similarly, three of the four Indigo Bunting indices were close to the regional index, but the Fort Knox index was low. Overall scores indicate poor reproductive performance (negative values) at Jefferson Proving Ground and Fort Knox, but good performance at Crane NWSC and Fort Leonard Wood.

Summary of Performance Measures

We consider the demo performance measures to be conservative because in each case the installation-specific data were part of the regional dataset. Had the datasets been separated, installation-specific values there would have been higher contrast when compared to values for the Central Hardwoods BCR (BCR#24). Poor performance in apparent survival rate is likely mostly due to high mortality during the non-breeding season or emigration, because breeding season (and non-breeding season mortality rates) are considered to be low (Sillett and Holmes 2002, Sillett et al. 2000). MAPS survival rate estimates and reproductive indices have been correlated with environmental conditions prior to spring migration of 13 Neotropical landbirds of the Pacific Northwest (Nott et al. 2000), Painted Bunting (Nott et al. 2005), and Wood Thrush (unpublished, in preparation). These results suggest that poor overwintering survival may be mostly due to high mortality during migration caused by poor body condition. Other factors that could lead to low survival rates include low fidelity to the breeding habitat such as that exhibited by eruptive species (e.g. Pine Siskin) that tend to occasionally pass through areas in large numbers, or sink populations in which the individuals are numerous, show low site fidelity, and are relatively unproductive.

Forest species

Overall, the summary table of performance measures (Table 6) strongly suggested that the populations of forest birds that breed on the four DoD installations were stable and healthy compared to the set of regional data, with only 18% of all performance measures (16 of 90) being negative, and 20% (6 of 30) of adult population trends. Overall, the highest population numbers are observed at NWSC Crane with a per species per station mean of (8.73) followed by Fort Jefferson (8.49), Fort Knox (6.09), and Fort Leonard Wood (5.81). Population declines (negative values of AHY_t) at Jefferson Proving Ground occurred in Worm-eating Warbler (but too few captures for reliable survival rate estimation) and Kentucky warbler, which exhibited a low survival rate.

At NWSC Crane no species suffered adult population declines and only Louisiana Waterthrush exhibited a low survival rate. At Fort Knox declining trends (<5% per year) were observed in Red-eyed Vireo and Worm-eating Warbler populations, and despite a stable population trend

(<5% change per year) the Wood Thrush reproductive index was below the regional index. Fort Leonard Wood exhibited the poorest performance measures for forest birds with population declines in Acadian Flycatcher and Carolina Chickadee, despite neutral or high values for survival rates and reproductive indices; low survival rate in Red-eyed Vireo. In comparison to regional indices we recorded low reproductive indices for Wood Thrush, Ovenbird, Louisiana Waterthrush, and Kentucky Warbler.

Successional species

For successional species 35% of all performance measures (38 of 108) were negative, including 42% (15 of 36) of adult population trends. Overall, the highest population numbers are observed at Fort Leonard Wood with a per species per station mean of (12.27) followed by Fort Jefferson (9.84), NWSC Crane (9.24), and Fort Knox (6.32).

Population declines (negative values of AHY_t) at Jefferson Proving Ground occurred in White-eyed Vireo ($P<0.05$) despite a high survival rate and good reproductive success. Prairie Warbler also declined (survival rate not calculated). The Common Yellowthroat population highly significantly declined ($P<0.01$) and exhibited poor reproductive success. Although Yellow-breasted Chat and Field Sparrow showed stable populations trends with relatively high abundances, the survival rate estimates and reproductive indices were all lower than the regional estimate. Northern Cardinal also showed a population decline but neither the survival rate nor reproductive index was considered low.

At NWSC Crane, four of 10 species showed population declines. The Gray Catbird population declined and also exhibited a low survival rate, whereas the Blue-winged Warbler population declined despite a high survival rate and high reproductive index. Field Sparrow populations declined and an average less than three adults are currently captured per year per station. Survival rate values were also low for Prairie Warbler, Yellow-breasted Chat, and Northern Cardinal, which also has a low reproductive index.

At Fort Knox five of eight successional species show declining trends (<5% per year) and three of those significantly ($P<0.05$) declined. Blue-winged Warbler significantly declined ($P<0.05$)

and capture rates were too low for reliable survival rate estimation. Common Yellowthroat showed a significant ($P<0.05$) population decline and low performance measures for survival rate and reproductive index. Two other species declined, Northern Cardinal and Indigo Bunting ($P<0.01$), and also showed low reproductive indices.

Fort Leonard Wood exhibited the best performance measures for successional species; only two of nine species showed population declines. Carolina Wren declined and numbers are too low for survival rate estimation, Common Yellowthroat declined and also showed a low reproductive index. White eyed Vireo, despite an increasing population size, exhibited both a low survival rate and reproductive index. Similarly, the Field Sparrow population was stable and exhibited both a low survival rate and reproductive index.

Species of Concern

We examined the MAPS survival rate ranks and summary demographic data for focal species of concern in the Central Hardwoods BCR. This revealed that Worm-eating Warbler, Louisiana Waterthrush, Kentucky Warbler, White-eyed Vireo, and Blue-winged Warbler were ranked 1 or 2 (low survival rates). The latter three species also showed significant (or near significant) declines in numbers of adults captured on one or more installations. Acadian Flycatcher is table across the four locations, but the survival rate estimate is higher Worm-eating Warblers performed poorly at Jefferson Proving Ground with a significant decline in adult numbers, an unreliable survival rate estimate, but a negative MAPS adult trend score was recorded for Fort Leonard Wood. Wood Thrush populations were stable except for low reproductive success recorded at Fort Know and Fort Leonard Wood. Kentucky Warbler declined at Fort Jefferson and had a low survival rate, but remained stable at every other location despite a low reproductive index at Fort Leonard Wood.

Of the five successional species of concern, White eyed Vireo, Prairie Warbler, Yellow-breasted Chat and Field Sparrow were associated with many negative demographic performance measures at three or four locations. Blue-winged Warbler populations were stable at Jefferson Proving Ground and Fort Leonard Wood but declined at Crane and Knox

Landscape performance measures

The results pertaining to landscape performance measures are shown in Tables 8-12.

Probabilities of encountering forest

Table 8 shows the results of investigating patterns of forest and canopy cover within (boundary plus external 1km buffer) and outside (between boundary plus one kilometer and boundary plus 20 km) installation boundaries.

Overall, the data show three patterns:

1. The probability of encountering a forest cell within the boundaries (average = 0.531) of an installation is very much higher than the probability of encountering a forested cell outside (0.452).
2. The probability of encountering a mature forest cell within the boundaries of an installation (0.452) is very much higher than the probability of encountering a mature forested cell outside (0.349).
3. The percentage of mature forest cells vary between installations but no significant difference was detected between cells within (78%) and outside (75%) the installations.

Five heavily forested installations that were associated with $P_{(Forest)}$ values greater than 0.75 included Fort A.P. Hill in Virginia (Figure 3), Fort Jefferson (Figure 8) and NWSC Crane in Indiana (Figure 9), Fort Knox in Kentucky (Figure 7), and Fort Leonard Wood in Missouri (Figure 10). The average value of $P_{(Forest)}$ was 0.84 compared to 0.57 for the corresponding "outside" values. The differences in percentages of mature forest within (mean 90%) and outside (mean 82%) the installations were nearly statistically significant (ANOVA, F=5.32, P=0.07).

Fort A.P. Hill covers more than 300 square kilometers in Caroline County close to the Rappahannock River. It is predominantly surrounded by wetlands, riparian corridors, and agricultural land. However, extensively developed land within the 20 kilometer buffer is associated with the cities of Fredericksburg to the northwest, and Bowling Green which is

adjacent to Fort Knox and to the south. Within the boundaries agricultural land covers ~8% of the land, but ~26% of the land within the 20km buffer.

Fort Jefferson (now managed as USFWS Big Oaks NWR) represents the largest contiguous block of forested habitat in southeastern Indiana, but is surrounded by farmland. Agricultural land covers 43.69% of the 20 km buffer, but less than 1% of the land within the installation boundary. However, the percentages associated with the 1 km radius cookie cuts were very close at 55.56% for outside and 51.28% for within (N=9). Because the installation is narrow in shape it is likely that radii with their centers within the boundaries (plus 1km outside) include land adjacent to the installation. This result suggests that a high percentage of agricultural land was adjacent to Jefferson Proving Ground.

NWSC Crane in Indiana covers 254 sq.km. (25,400 hectares) with a probability of ~0.88 of encountering forest cover (90% of which is mature) and less than 2% is agricultural land (Table 11). Outside the installation the probability of encountering forested land is less than 50% and only 80% of that is mature. Most of the forest outside of the installation lies to the north (privately owned) and south (Hoosier National Forest). Agriculture (overall 42.22% cover) predominated land cover to the west and east.

Fort Knox lies to the southwest of Louisville, KY which continues to grow through ribbon development whereby development radiates out from the city, following established road systems. The probability of encountering forest (Table 8) within the installation is over 80% (actual cover = 67.30%, Table 11), of which 86% was mature, but just less than 50% outside (actual cover = 48.31%, Table 12). Agriculture covers less than 6% within and over 35% outside.

Fort Leonard Wood is almost completely surrounded by Mark Twain National Forest showed the highest probability of encountering forest (0.91) of which 91% might be expected to be mature. Overall, 83% of the land within the installation boundary is forested, but 10% accounts for developed land. Because the majority of the land within the 20 km buffer comprised Mark Twain NF land nearly 75% was forested, 20% agriculture (2% within), and 5% developed.

Three installations were associated with $P_{(Forest)}$ values less than 0.75 but greater than 0.50; namely Fort Bragg (Figure 6) and the two Texas installations of Texas Reserve Army National Guard, Camp Swift (Figure 13) and Fort Hood (Figure 14). Fort Bragg data showed only a small difference in the probabilities of encountering forest (or mature forest) when comparing values either side of the installation boundary. The probability of encountering a forested cell was 0.65 of which 80% of points represented mature forest. A full extent analysis (Tables 11 and 12) revealed only ~54% forest cover within compared to ~35% outside. Grassland (~16%) and development (~13%) accounted for the majority of the remaining cover. Similar values were recorded within the 20km buffer but agricultural cover was over 18% compared to les than 1% within.

The probabilities of encountering forest on Camp Swift and Fort Hood, on the other hand, are over two and three times higher, respectively. While Camp Swift is predominantly surrounded by agricultural land, Fort Hood MAPS stations lie within a predominantly lacustrine habitat adjacent to Lake Belton, which is dominated by oak-juniper woodland. Outside of the installation developed land is close to Fort Hood's boundary, especially the towns of Killeen and Temple which lie within 20km. Otherwise, agricultural land and oak-juniper scrubland dominates the non-developed landscape.

Ten installations exhibited probabilities of encountering a forest cell that were below 0.5. Fort Belvoir (Figure 3) and NSWC Indian Head in Maryland (Figure 3), and NSWC Dahlgren in Virginia (Figure 3) exhibited $P_{(Forest)}$ values that were lower than the $P_{(Forest)}$ values for outside the installations. In addition $P_{(Mature)}$ values averaged 0.25 within the installations but 0.45 outside. NAS Patuxent River exhibited low $P_{(Forest)}$ and $P_{(Mature)}$ values but not very different from those values associated with outside the installation.

Although the South Carolina installations of NAVFEC, NAS Oceana, and NALF Fentress (Figure 5) exhibited $P_{(Forest)}$ values below 0.45 and $P_{(Mature)}$ values below 0.4 the values for outside the installations are very similar. NALF Fentress stations lie within mixed forest that adjoins a riparian corridor to the east. To the west and northwest the landscape is dominated by developed

lands including Portsmouth, Norfolk, and Chesapeake. NAS Oceana is predominantly a landing strip within a largely residential area.

Finally, the Kansas installations also showed low probabilities. Fort Riley MAPS stations (Figure 11) lie within the hardwood and grassland habitats surrounding the outlet to USACoE Milford Lake which drains into the Kansas River. The $P_{(Forest)}$ values (0.271) is considerably higher than the 0.168, probably because the vicinity of Fort Riley is heavily developed, agricultural land, or shrubland.

Fort Leavenworth (Figure 12) has the highest $P_{(Forest)}$ value among the Kansas locations (0.415) and 91% of cells were classified as mature. Outside the installation the landscape is dominated by development and flood plain habitat with $P_{(Forest)}$ value of 0.311 and only 71% mature.. Army Ammunition Plant Sunflower has the lowest $P_{(Forest)}$ value of all installations (0.106) which is only slightly less than that for outside (0.191).

A clear relationship existed between the size of the installation, measured by the number of points sampled, and the probability of encountering forest. The average $P_{(Forest)}$ value of 0.369 for the smaller installations ($N<=200$) was significantly smaller (ANOVA $F=16.6$, $P<0.001$) than the $P_{(Forest)}$ value of 0.692 for larger installations ($N>200$). All the installations that exhibited a $P_{(Forest)}$ value in excess of 0.5 were associated with over 200 sample points within the boundaries of the installation (i.e. associated with larger installations). We also conducted a matched paired t-test which revealed that the differences between the probabilities of encountering forest ($P_{(Forest)}$) within and outside installations are higher for larger installations ($F=19.6$, $P<0.001$). We conducted another matched pair t-test to compare the differences between within and outside percentages of mature forest ($P_{(Mature)}$), grouped by larger installations and smaller installations. The result was nearly significantly ($P=0.09$) and showed that larger installations had a higher percentage of mature cells than outside landscapes (mean difference of +8.11%) than smaller installations, which had less mature forest than outside (mean difference of -1.33%).

So, larger installations hold proportionately more forest than smaller installations and also a higher proportion of forest than do other lands within 20 kilometers of the installation

boundaries. Conversely, smaller installations tend to have an approximately equal or lower proportion of forest than the surrounding landscape, probably due to their role in providing military housing (e.g. Fort Leavenworth, KS), weapons storage (e.g. NSWC Indian Head, MD and AAP Sunflower, KS), and military airfield (e.g. NALF Fentress, SC and NAS Patuxent River, MD). Larger military installations tend to operate extensive military training areas and military ranges associated with larger areas of forest than exist in the surrounding landscapes, which tend to be privately owned by smaller landholders of residential or agricultural land. However, in some cases other federally managed lands are adjacent to military installations. NAS Crane in Indiana shares its eastern boundary with USFS Hoosier National Forest, Fort Leonard Wood shares ~90% of its boundaries with USFS Mark Twain National Forest which nearly encircles it.

Analyses of one-kilometer cookie-cuts

The analyses of one-kilometer cookie cuts (Table 9) showed high percentages of core forest cover associated with the larger installations. Not surprisingly, because some cookies included land adjacent (inside one-kilometer buffer) to the installations the percentages of agriculture were generally higher than the total percentage within the installations boundaries. Interestingly, the mean percentages of core forest within one-kilometer radii of the MAPS stations were very similar to the percentages of core forest associated with randomly placed one kilometer buffers. For larger installation, with respect to core forest area, the landscapes immediately surrounding MAPS stations are representative of the entire installation. .

Installation-wide and 20 km buffer land cover

A clear pattern emerged from analyses of the NLCD 2001 cover types within the boundaries of the 19 installations (Table 11); larger installations have higher percentages of forest cover and lower percentages of developed land. Seven installations, less than 20 square kilometers in forested area, contained over 20% cover of developed land (mean percentage of 38.57%), whereas the mean percentage of developed land in the 20 km buffers of these seven stations (Table 12) is only 16%. Nine of the remaining 12 locations, however, were over 20 square kilometers in forested area and contained developed land cover levels under 15%; (mean 7.00%) whereas a mean of 7.00% developed land was associated with the 20km buffers around these

installations. Forest cover levels of these installations were high, averaging ~65% total forest cover and accounting for over 2,000 square kilometers of forest cover. The forest cover percentage of the 20km buffers around each of these nine installations averaged only ~40% (Table 12). So, overall the mean percentage of forest cover on the nine installations, that also contained low percentages of developed land, was 1.5 times higher than the mean forest cover percentages associated with the surrounding landscapes. However, smaller installations tended to have low percentages of forested cover but high percentages of developed land exceeding those percentages associated with lands within the 20 km buffers. These results are supported by the data presented in Tables 9 and 10. Comparisons of the land cover associated with the mostly forested installations and surrounding landscapes suggest that, historically, outside of the installation the forested land that was previously converted to agricultural land is now becoming developed land for residential and commercial purposes.

Fort Bragg, Fort Knox, and Fort Hood each contained over 300 square kilometers of forested land, followed by Fort A.P. Hill, Fort Jefferson, NWSC Crane, and Fort Leonard Wood, which contained between 195 and 255 square kilometers. Fort Riley and Camp Swift contained the smallest areas of forest (mean <100 square kilometers), which also represented the lowest percentages of forest among the nine locations. Managed grasslands featured on installations with either (or both) large tracts of recreational grasslands associated with extensive residential, research, and storage development (e.g. Fort Leavenworth, Dahlgren Laboratories). Managed grasslands and agriculture were associated with military aircraft landing fields (e.g. NALF Fentress, NAS Oceana) because land within the installations was leased and farmed by local farmers. However, on average, the DoD installations contained only 13% agricultural cover whereas the 20km buffers thereof averaged ~28% agricultural land cover.

The high level of residential cover associated with AAP Sunflower (69.53%) was found to be misleading because aerial photographs of Sunflower revealed grids of ammunition bunkers within a managed grassland matrix. However, we discovered that NLCD 2001 classified this as either low or medium intensity developed land, which includes “areas with a mixture of constructed materials and vegetation.” Also, percentages of scrub/shrub, represented by NLCD 2001 (Level I) land cover class #5, ranged from zero to 5% for all the locations except the three

Texas locations; Fort Hood (17.57%); Camp Swift (13.11%); and especially Camp Bowie (62.51%), where you might expect scrub/shrub to be a significant and native component of the landscape.

In several cases there is potential for considering conservation easements across the installation boundaries onto private land. Furthermore, where installations are adjacent to other federal lands it would be possible to formulate bi-agency agreements with the goal of maintaining large patches of forested habitat. It is clear, however, that larger DoD installations have a responsibility to conserve large contiguous patches of forested habitat. Research conducted at Fort Hood (Noa et al. 2005) showed that smaller "island" shrubland habitats supported less productive populations with lower survival rates when compared with the larger contiguous patches.

Forest Core Area

The maps of core forest area for each installation (Figures x to x) show the patterns of fragmentation and allow the identification of a) forest patches that should be conserved because they are large and uniform in shape, and b) smaller adjacent patches of forest that could be easily joined to create a large patch and increase the percentage of interior forest.

Contiguous forest at Fort A. P. Hill, VA (Figure 16) occurs mainly within the northern half of the installation and covers ~84%. The southern portion features many buildings and "impervious surface" developments, such as airfield runways, some barren areas, and areas cleared for military training in the southeast corner. In the northeastern portion the size of contguous patches could be increased with abandonment of roads that bisect the forest patches.

The forests of Fort Bragg (Figure 17) are highly fragmented and only cover ~54% of the installation area. Fine grids of dirt roads have fragmented the forests of the western portion, and the center features barren land resulting from training activities and dropzones. The eastern portion is heavily developed by residential properties, equipment/vehicle storage and repair facilities, as well as production and engineering workshops. However, the percentage of core forest could be significantly increased with "gap filling" within a small north-pointing projection of land (approx. 30 sq. km. in area), which is currently fragmented by dirt roads.

Although analyses of Fort Jefferson (Figure 18) suggest large areas of forest (covering ~91%), closer inspection of aerial photographs show dirt roads fragmenting the forest. Presumably these were not wide enough to be recognized in the NCLD 2001 classification as dominating the area of 30m resolution cells that the roads crossed. It is, however, possible that such narrow roads still delineate forest patches and reduce the percentage of forest interior. Much of the land in the southern portion is developed and planted forests cover much of the center of the installation. Forest patches of the northern portion could be joined to create large patches of interior forest.

Fort Knox (Figure 19) holds four or five large contiguous patches of forest that account for most of the 72% forested area. The forests of the eastern portion are adjacent to the densely developed city of Fort Knox and are crossed by many small roads and trails. The northern and western

forested portions are less fragmented by roads and trails and should be maintained as large contiguous patches. The forested patch in the southern portion of the installation is heavily fragmented by roads and trails associated with military training. Unfortunately, MAPS stations at Fort Knox are located in highly fragmented areas or on the edge of large forest patches.

NWSC Crane (Figure 20) appears as almost a single patch of forest that covers ~91% of the total area and features many small forest gaps caused by a complex dendritic network of narrow roads and weapons bunkers and. This network is particularly dense in the northwestern portion. The least fragmented forest occurs within one kilometer either side of the installation boundary. Efforts should be made to maintain the high percentage of interior forest cover associated with the eastern boundary, especially where the top half abuts USDA Forest Service land. The lower half of the eastern boundary and the entire southern boundary both have high percentage covers of interior forest crossing into private lands.

Fort Leonard Wood, MO (Figure 21) is fragmented by wide roads (20-30m) that divide the forest into many large, fairly uniformly-shaped patches, of which 20 appear to be between 2 and 4 sq. km. in area that fill ~83% of the total area. These larger patches should be conserved. The northern-central portion of the installation is heavily developed with residential areas, administrative buildings, vehicle and equipment storage and repair areas, and other buildings.

Camp Swift, TX (Figure 22) featured 27% forest cover restricted to the south and northern portions (where MAPS stations are located) of the installation. The northern most tip and central portions are mainly developed. Contiguous patches in the southeast corner should be preserved.

Fort Hood, TX (Figure 23) only had 22% forest cover which was mostly restricted to larger patches in the north, however, patches of forest also occur in the southwestern corner. Other areas of the installation are heavily developed (Coperas Cove and Killeen) or highly fragmented by tank ranges.

CONCLUSIONS

Managers of natural resources on DoD installations are required to implement management actions with the goal of balancing the conservation of natural resources, such as the bird populations discussed here, with the military mission, especially military Readiness and Range Sustainment. To achieve this goal it is necessary to both monitor and model the populations of birds that breed within the installations' various habitat types, and subsequently formulate essential support tools that enable natural resource managers of DoD installations to a) quantify the "background" health of their bird populations relative to populations on surrounding non-DoD lands, and b) be able to quantify the impact of current and proposed land management plans, and c) implement management to maintain or improve the quality of breeding habitat for a suite of focal species.

Accordingly, since 1994, the Institute for Bird Populations has collaborated with natural resource managers of up to 78 DoD installations to i) collect demographic data using the MAPS protocol from DoD installations and compare those data with data from other sets of MAPS data in the surrounding region, ii) construct species-landscape models that predict population performance given the landscape structure and pattern, iii) used the species-landscape models to formulate land management recommendations intended to increase the health of populations, or maintain long-living, highly productive populations.

Here we addressed the first requirement of the support tools by analyzing the 1994-2003 MAPS dataset and formulating and quantifying a suite of metrics, termed "performance measures", that allow managers to compare the demographic performance of landbird populations that breed on their installations with the demographic performance of populations in the surrounding region. These performance measures (and the landscape-based performance measures discussed below) can empower managers to decide which species and habitats should be the focus of active conservation. We exemplify this approach by this mapping forested habitat, and the interior "core" forested habitat that is so important to a suite of Neotropical migrants, and some resident and short distance migrants. These maps show where geographically on the installation it would be best to direct conservation efforts intended to maximize forest cover and increase the percentage of interior forest. For instance, it is possible to use forest maps to identify adjacent patches that are separated by a tank trail or other dirt road typical of larger military training

installations. In some cases a small area of reforestation between patches may result in the restoration of many hectares of interior forest.

The military installations studied in this report varied in size from approximately 9 sq. km. to 940 sq. km. In formulating avian demographic performance measures we restricted our analyses to four large installations in the Bird Conservation Region (BCR#24) typical of Central Hardwood forested communities. Compared to regional measures the demographic performance measures, populations of birds that breed in the forests of these four installations performed extremely well. However, Fort Leonard Wood in Missouri, showed the poorest performance measures for forest species but the highest performance measures for successional species. Among forest birds, the majority of MAPS adult trends were stable or positive, and values of both the apparent survival rates and productivity indices were higher than the regional values. We conclude that these populations performed better than their counterparts throughout the surrounding region and probably represent source populations, the offspring of which disperse throughout the surrounding landscape. Confirmation of this conclusion could be achieved with careful nest studies to estimate the nest success and probability of fledglings surviving to the next breeding season. Adherence to a standard nest study protocol (e.g. the BBird protocol from the University of Montana) would allow comparison to estimates from other regions for which the BBird database contains relevant data.

In formulating landscape performance measures we included another five large installations. All nine installations covered over 200 sq. km. and each featured a disproportionate percentage of total forest cover (mean 63% cover) compared to forest cover in the surrounding 20 km buffer landscape (mean 41% cover). Agriculture within the 20km radius accounted for an average ~25% cover which exceeded the mean 22% difference in forest cover. Differences in the percentages of developed land averaged around 0%. The simplest explanation of the differences is that the lands surrounding installations have experienced a loss of forest to agriculture. We conclude that many of the DoD installations included in this study act as regional refugia for large patches of contiguous forest, and that those patches should become the focus of conservation efforts for species that prefer interior forest. Specifically, natural resource managers should a) avoid management that will fragment existing large forest patches, b)

examine forest maps to identify opportunities for gap closure which will significantly increase the amount of core forest, and c) identify landowners whose lands could be included in a conservation area.

Currently, the Department of Defense is developing a program called the Recovery Credit System (RCS) pays private landowners to protect critical habitat and the endangered bird species that breed there, while allowing military activities to influence, and perhaps deteriorate, the quality of critical habitat within the boundaries of the installation. The RCS program is being implemented at Fort Hood for the federally-endangered Black-capped Vireo (BCVI) and Golden-cheeked Warbler (GCWA). The results presented here for Fort Hood suggest that a) outside of the installation, within a 20km buffer of the Fort Hood boundary (5,227 sq. km.), only 45 sq. km of core forest (mainly mixed) existed, whereas a greater area of nearly 50 sq. km. core forest habitat existed within the boundaries of the installation (940 sq. km.). Similarly, for shrub-scrub habitat Fort Hood holds 17.57% (165 sq. km.) compared to 5.75% within the 20 km. buffer (300 sq. km.), and only small areas of core shrub-scrub habitat existed on Fort Hood (2.25 sq. km.) and in the surrounding 20 km. (18 sq. km.). Considering these species' habitat preferences (Grzybowski 1995, Ladd, C., and L. Gass. 1999) the RCS program is designed to provide protected "source" habitat outside of the installation's boundary, and provide corridors between. Because of other species dependency upon large forest patches and the lack of such patches in the surrounding landscape we support the conservation of larger patches of forest on Fort Hood (and the other installations) as long as the existing large patches are not further fragmented by increasing military training activities or development.

These analyses showed that a) populations performed well on DoD installations, b) many installations held a higher forest (and core) cover percentage than was found within a 20 km buffer of the installation, and c) adjoining lands have forested cover that is continuous with forested cover within the installations boundary. Because forested habitat, especially large patches, is a diminishing natural resource it is also imperative to preserve larger patches near DoD installations, which is the goal of DoD's conservation easement program, REPI. We

recommend extending support for conservation easements from state, county, and private landowners in the vicinity of DoD installations.

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Table 1. Locations, station abbreviations, station numbers, names, geographic coordinates, elevation, primary habitat type, and years operated for 24 Monitoring Avian Productivity and Survivorship (MAPS) bird-banding stations located on four US Department of Defense installations; U.S. Army Jefferson Proving Ground (JEFF*) now operated by USFWS as Big Oaks NWR; Crane Naval Surface Warfare Center (CRAN); U.S. Army Fort Knox (KNOX), KY; and U.S. Army Fort Leonard Wood (LEON), MO.

Location	Station Abbr.	Station Name	Station Number	State	Lat	Long	Elev (m)	Primary habitat type	Years Operated
JEFF	AR54	Area 54	16620	IN	38.897	-85.375	268	successional upland forest	1994 - 2002
JEFF	AR27	Area 27	16621	IN	38.997	-85.375	277	riparian/upland deciduous/oldfield	1994 - 2002
JEFF	AR16	Area 16	16623	IN	39.014	-85.394	274	upland deciduous forest	1994 - 2002
JEFF	AR31	Area 31	16624	IN	38.967	-85.456	259	mature upland deciduous/oldfield	1994 - 2002
JEFF	AR07	Area 07	16625	IN	39.036	-85.436	259	mature/successional upland deciduous	1994 - 2002
JEFF	AR64	Area 64	16669	IN	38.933	-85.378	270	Successional upland forest, oldfield	1996 - 2002
CRAN	FIRS	First Creek	16626	IN	38.872	-86.903	162	mature deciduous bottomland forest	1994 - 2002
CRAN	WICE	Williams Cemetery	16627	IN	38.808	-86.883	219	deciduous upland forest	1994 - 2002
CRAN	SEED	Seedtick Creek	16628	IN	38.758	-86.886	149	mature deciduous bottomland forest	1994 - 2002
CRAN	SULP	Sulphur Creek	16629	IN	38.886	-86.736	177	upland deciduous/oldfield/riparian	1994 - 2002
CRAN	EABO	East Boggs	16630	IN	38.794	-86.836	152	upland deciduous/riparian/grassy	1994 - 2002
CRAN	AR14	Area 14	16631	IN	38.839	-86.794	198	upland deciduous/riparian/oldfield	1994 - 2002
KNOX	OHRI	Ohio River	16632	KY	37.975	-86.031	131	bottomland riparian forest	1994 - 2002
KNOX	MCSP	McCracken Springs	16633	KY	37.892	-86.031	171	deciduous floodplain/oldfield	1994 - 2002
KNOX	CEDA	Cedar Creek	16634	KY	37.811	-85.828	151	pond basin/oldfield/deciduous	1994 - 2002
KNOX	SARI	Salt River	16635	KY	37.942	-85.769	140	oldfield/cedar breaks/deciduous forest	1994 - 2002
KNOX	DULA	Duck Lake	16636	KY	37.967	-85.781	131	upland deciduous forest	1994 - 2002
KNOX	LDLA	Lower Douglas Lake	16637	KY	37.825	-85.878	221	upland deciduous forest	1994 - 2002
LEON	BIPI	Big Piney	14422	MO	37.739	-92.044	235	mature deciduous bottomland forest	1993 - 2002
LEON	LABO	Laughlin Bottoms	14423	MO	37.778	-92.178	300	deciduous upland forest	1993 - 2002
LEON	MIPO	Miller Pond	14424	MO	37.694	-92.111	326	mature deciduous bottomland forest	1993 - 2002
LEON	MACE	Macedonia	14425	MO	37.611	-92.236	360	upland deciduous/oldfield/riparian	1993 - 2002
LEON	SMRI	Smith Ridge	14426	MO	37.739	-92.197	320	upland deciduous/riparian/grassy	1993 - 2002
LEON	MIRI	Miller Ridge	14427	MO	37.717	-92.058	270	upland deciduous/riparian/oldfield	1993 - 2002

Table 2. Community comparison of analyses of Monitoring Avian Productivity and Survivorship data from 18 stations in Indiana Kentucky with analyses of Breeding Bird Survey data from physiographic strata 14 and 15 combined (Highland Rim and Lexington Plain, respectively), and Indiana. Species are shown in taxonomic order within two habitat associations; forest and successional species. Species names in bold denote Tier 1 Priority Species of the Central Hardwoods BCR as defined in the PIF Bird Conservation Plan. Each species is also ranked (bold ranks are priority species with rank of 1 or 2 for IN/KY/MO) according to performance measures relating to survival rates derived from MAPS capture-recapture data (from Table 2). MAPS adult trends and BBS trends for the period 1994-2002 (94-02) are expressed as annual percentage change relative to the period mean (Adults/Station/Year and Number/Route/Year, respectively). Trends are shown in bold when the P-value (P) of the regression is less than 0.05. MAPS and BBS period means are expressed as relative abundance (RA) and averaged for each group. The trends are also averaged by group.

	Indiana/Kentucky MAPS Analyses					BBS Analyses Strata 14 & 15				BBS Analyses – Indiana			
Common Name	Rank	MAPS Adult Trend	P	Adults/ Station/ Year	RA	BBS Trend 94-02	P	Number/ Route/ Year	RA	BBS Trend 94-02	P	Number/ Route/ Year	RA
Forest Species													
Acadian Flycatcher	3	-0.15	0.93	7.61	0.068	**3.16**	**0.03**	**2.82**	0.018	-0.77	0.68	2.25	0.017
Red-eyed Vireo	5	-1.83	0.40	6.69	0.060	1.27	0.11	7.01	0.044	-0.80	0.56	5.37	0.042
Carolina Chickadee	**1**	4.49	0.45	2.09	0.019	**3.35**	**0.00**	**6.43**	0.040	1.41	0.52	4.32	0.034
Wood Thrush	5	1.54	0.62	8.81	0.079	**2.46**	**0.03**	**5.37**	0.034	-1.58	0.29	4.54	0.035
Worm-eating Warbler	1	0.70	0.82	3.52	0.032	-2.57	0.47	0.3	0.002	-5.41	0.61	0.34	0.003
Ovenbird	1	3.54	0.20	5.30	0.048	-3.39	0.20	0.66	0.004	2.62	0.28	0.74	0.006
Louisiana Waterthrush	1	1.57	0.69	3.30	0.030	**11.39**	**0.01**	**0.42**	0.003	14.38	0.12	0.74	0.006
Kentucky Warbler	2	-2.00	0.06	9.57	0.086	1.03	0.60	2.05	0.013	-4.21	0.09	1.83	0.014
Average		**0.98**		**46.89**	**0.422**	**2.09**		**25.06**	**0.157**	**0.71**			**0.157**
Successional species													
White-eyed Vireo	3	**-8.10**	**0.01**	**7.11**	0.064	**4.55**	**0.01**	**4.43**	0.028	-3.23	0.26	1.58	0.012
Carolina Wren	1	5.67	0.30	2.54	0.023	**5.55**	**0.00**	**12.02**	0.075	-1.62	0.35	3.69	0.029
Gray Catbird	1	**-8.61**	**0.04**	**11.09**	0.100	**-3.43**	**0.03**	**2.68**	0.017	0.69	0.67	7.31	0.057
Blue-winged Warbler	4	**-6.54**	**0.00**	**5.47**	0.049	3.21	0.61	0.32	0.002	-9.77	0.20	0.21	0.002
Prairie Warbler	2	-4.46	0.40	4.30	0.039	-0.94	0.58	2.07	0.013	-1.53	0.74	1.07	0.008
Common Yellowthroat	4	**-5.57**	**0.04**	**8.90**	0.080	-0.76	0.32	13.42	0.084	**-2.12**	**0.04**	**14.36**	0.111
Yellow-breasted Chat	3	**-5.21**	**0.02**	**6.61**	0.059	-0.60	0.30	8.54	0.053	-2.19	0.35	3.54	0.027
Field Sparrow	3	**-10.88**	**0.00**	**5.43**	0.049	**-1.12**	**0.05**	**14.43**	0.090	**-4.40**	**0.00**	**10.54**	0.082
Northern Cardinal	4	-1.98	0.53	4.54	0.041	0.00	1.00	33.71	0.211	0.70	0.30	30.41	0.236
Indigo Bunting	5	-2.96	0.27	8.29	0.075	-0.06	0.88	43.08	0.270	-1.50	0.09	35.97	0.279
Average		**-4.86**		**64.28**	**0.579**	**0.64**		**134.70**	**0.843**	**-2.50**			**0.843**

Table 3. Regional comparisons of survival rates for 18 species using MAPS capture-recapture data from 24 stations on four military installations (6 stations on each) in Indiana (Jefferson Proving Ground and NAS Crane), Kentucky (Fort Knox), and Missouri (Fort Leonard Wood). Species are shown in taxonomic order within two habitat associations; forest and successional species. Species names in bold denote Tier 1 Priority Species of the Central Hardwoods BCR as defined in the PIF Bird Conservation Plan. Each species is also ranked according to performance measures relating to survival rates derived from MAPS capture-recapture data for five regional analyses; Bird Conservation Region #24 (BCR24; Central Hardwoods) and five MAPS regions representing the northeast, southeast, north-central, and south central United States. Time-constant annual survival rates (Φ) were estimated using a modified Cormack-Jolly-Seber mark-recapture model and expressed with their coefficients of variation (CV) expressed as a percentage of the survival rate estimate. Regional survival estimates are shown in italics if they lower than estimates for the Indian/Kentucky stations.

			Indiana/Kentucky/ Missouri			Indiana/Kentucky			BCR24		MAPS Region Northeast		MAPS Region Southeast		MAPS Region North-central		MAPS Region South-Central	
Common Name	**Scientific Name**	**BCR Tier**	**Rank**	**Φ**	**CV**	**Rank**	**Φ**	**CV**	**Φ**	**CV**	**Φ**	**CV**	**Φ**	**CV**	**Φ**	**CV**	**Φ**	**CV**
Forest Species																		
Acadian Flycatcher	*Empidonax virescens*	**I**	3	0.551	5.8	3	0.512	7.3	*0.517*	5.5	0.592	19.0	*0.483*	4.3			*0.502*	6.1
Red-eyed Vireo	*Vireo olivaceus*		5	0.587	6.7	6	0.612	7.3	*0.560*	*6.4*	*0.555*	*4.8*	*0.599*	*3.3*	*0.542*	*7.5*	*0.554*	*10.1*
Carolina Chickadee	*Poecile carolinensis*		1	0.417	17.3				0.455	15.3	0.517	19.3	0.499	10.3			0.489	12.9
Wood Thrush	*Hylocichla mustelina*	**I**	5	0.479	6.6	5	0.491	6.6	*0.449*	*5.9*	*0.426*	*5.3*	*0.449*	*3.5*	*0.417*	*12.5*	*0.325*	*27.3*
Worm-eating Warbler	*Helmitheros vermivorum*	**I**	1	0.453	16.8				*0.450*	14.8	0.501	10.2	0.594	8.3			0.535	24.8
Ovenbird	*Seiurus aurocapilla*		1	0.496	9.5	1	0.471	17.3	0.472	9.4	0.570	3.5	0.525	4.2	0.577	9.2	0.593	15.8
Louisiana Waterthrush	*Seiurus motacilla*	**I**	1	0.384	21.8				0.483	11.4	0.468	13.0	0.531	8.5			0.456	23.8
Kentucky Warbler	*Oporornis formosus*	**I**	2	0.545	3.9	2	0.516	4.5	0.521	3.7	0.558	20.4	*0.503*	*4.0*	0.604	10.3	0.596	5.1
Successional Species																		
White-eyed Vireo	*Vireo griseus*	**I**	3	0.504	6.4	3	0.475	7.7	0.490	6.0	*0.457*	10.7	*0.461*	5.2	0.509	20.4	0.539	3.5
Carolina Wren	*Thryothorus ludovicianus*		1	0.312	19.5				0.365	13.7	0.365	16.6	0.358	6.1	0.339	26.5	0.407	5.3
Gray Catbird	*Dumetella carolinensis*		1	0.398	9.4	2	0.399	9.4	*0.391*	*9.5*	0.516	2.2	0.421	7.3	0.503	3.4	0.559	5.5
Blue-winged Warbler	*Vermivora pinus*	**I**	4	0.552	7.3	5	0.588	9.3	*0.540*	*6.9*	*0.403*	*15.4*	*0.540*	*9.9*	0.620	12.0	*0.549*	*9.6*
Prairie Warbler	*Dendroica discolor*	**I**	2	0.436	17.4				0.500	12.3			*0.421*	13.1			0.550	17.6
Common Yellowthroat	*Geothlypis trichas*		4	0.463	6.3	5	0.457	7.3	*0.445*	6.1	0.493	3.6	*0.420*	5.5	*0.451*	5.0	*0.453*	9.0
Yellow-breasted Chat	*Icteria virens*	**I**	3	0.531	6.9				*0.507*	6.2	*0.462*	13.7	*0.335*	11.5			*0.510*	5.3
Field Sparrow	*Spizella pusilla*	**I**	3	0.422	11.6				0.456	9.4			*0.351*	17.3	0.430	8.8	0.484	5.6
Northern Cardinal	*Cardinalis cardinalis*		4	0.585	6.5	5	0.575	7.2	*0.551*	*5.2*	0.610	4.7	*0.532*	*3.2*	*0.499*	*7.6*	*0.547*	*2.8*
Indigo Bunting	*Passerina cyanea*		5	0.536	5.1	5	0.542	6.5	*0.501*	4.7	*0.427*	10.2	*0.501*	5.3	*0.481*	7.5	*0.464*	5.0

Table 4. Comparisons of apparent survival rates for 18 species using MAPS data from 24 stations on four military installations (6 stations on each) in Indiana (Jefferson Proving Ground and NWSC Crane), Kentucky (Fort Knox), and Missouri (Fort Leonard Wood). Species are shown in taxonomic order within two habitat associations; forest and successional species. Bird Conservation Regions BCR#22 (Eastern Tallgrass Prairie), BCR#24 (Central Hardwoods), BCR#27 (Southeastern Coastal Plain), and BCR#28 (Appalachian Mountains). Survival rate estimates are shown in bold if they are equal to or greater than the the BCR#24 estimate, and shown in italics if the estimate is less than 90%of the BCR#24 estimate. Scores range from -100 (poor) to +100 (high). Species names in bold denote Tier 1 Priority Species of the Central Hardwoods BCR as defined in the PIF Bird Conservation Plan.

Common Name	JEFF	CRAN	KNOX	LEON	BCR 24	BCR 22	BCR 27	BCR 28
Forest Species								
Acadian Flycatcher	0.466	**0.519**	**0.576**	**0.640**	*0.517*		*0.457*	*0.479*
Red-eyed Vireo	**0.653**	0.545	**0.619**	*0.488*	*0.560*	*0.590*	*0.604*	*0.538*
Carolina Chickadee		0.413		0.413	*0.455*	*0.385*		*0.362*
Wood Thrush	**0.491**	**0.471**	**0.517**		*0.449*	*0.457*	*0.385*	*0.381*
Worm-eating Warbler		**0.482**		**0.484**	*0.450*	*0.543*	*0.414*	*0.455*
Ovenbird	*0.380*	**0.585**		**0.596**	*0.472*		*0.519*	*0.576*
Louisiana Waterthrush		*0.316*			*0.483*	*0.586*		*0.698*
Kentucky Warbler	*0.465*	**0.535**	**0.526**	**0.654**	*0.521*	*0.596*	*0.519*	*0.549*
Score	0	50	100	50				
Successional Species								
White-eyed Vireo	**0.500**	0.482	*0.421*	**0.598**	*0.490*	*0.543*	*0.414*	*0.455*
Carolina Wren			**0.461**		*0.365*	*0.401*	*0.324*	*0.431*
Gray Catbird	**0.468**	*0.346*			*0.391*	*0.482*	*0.521*	*0.499*
Blue-winged Warbler	0.496	**0.679**		0.505	*0.540*			*0.453*
Prairie Warbler		*0.441*		**0.548**	*0.500*		*0.448*	
Common Yellowthroat	**0.468**	**0.485**	*0.381*	**0.489**	*0.445*	*0.489*	*0.363*	*0.465*
Yellow-breasted Chat	*0.333*	*0.413*	*0.347*	**0.628**	*0.507*	*0.423*		*0.437*
Field Sparrow	*0.374*	**0.459**		**0.459**	*0.456*	*0.438*		
Northern Cardinal	**0.620**	*0.459*	**0.590**	**0.639**	*0.551*	*0.517*	*0.536*	*0.536*
Indigo Bunting	0.491	**0.602**	**0.521**	**0.528**	*0.501*	*0.432*	*0.500*	*0.409*
Score	25	0	0	88				

Table 5. Comparisons of productivity indices (ratio of young to adults) for 18 species using MAPS data from 24 stations on four military installations (6 stations on each) in Indiana (Jefferson Proving Ground and NWSC Crane), Kentucky (Fort Knox), and Missouri (Fort Leonard Wood). Species are shown in taxonomic order within two habitat associations; forest and successional species. Species names in bold denote Tier 1 Priority Species of the Central Hardwoods BCR as defined in the PIF Bird Conservation Plan. Bird Conservation Regions BCR#22 (Eastern Tallgrass Prairie), BCR#24 (Central Hardwoods), BCR#27 (Southeastern Coastal Plain), and BCR#28 (Appalachian Mountains).

Common Name	JEFF	CRAN	KNOX	LEON	BCR 24	BCR 22	BCR 27	BCR 28
Forest Species								
Acadian Flycatcher	**0.108**	**0.119**	**0.080**	0.070	*0.073*	*0.188*	*0.121*	*0.097*
Red-eyed Vireo	*0.064*	**0.101**	**0.107**	**0.187**	*0.072*	*0.035*	*0.042*	*0.137*
Carolina Chickadee	**1.212**	**0.877**		**0.927**	*0.770*	*1.186*	*0.904*	*0.654*
Wood Thrush	**0.314**	**0.378**	*0.179*	*0.221*	*0.250*	*0.222*	*0.175*	*0.216*
Worm-eating Warbler	**0.360**	**0.434**	**0.874**	**0.391**	*0.337*	*0.056*	*0.424*	*0.776*
Ovenbird	0.370	**0.665**		*0.257*	*0.388*	*0.188*	*0.898*	*0.521*
Louisiana Waterthrush		**0.836**	**1.269**	*0.415*	*0.672*	*0.64*	*0.819*	*1.175*
Kentucky Warbler	0.338	**0.560**	**0.407**	*0.312*	*0.362*	*0.236*	*0.239*	*0.635*
Score	43	100	57	-13				
Successional Species								
White-eyed Vireo	0.223	**0.299**	0.220	**0.357**	*0.241*	*0.210*	*0.443*	*0.217*
Carolina Wren	*0.680*	**1.821**	**1.099**	**1.117**	*0.861*	*1.064*	*0.657*	*0.548*
Gray Catbird	*0.117*	**0.428**			*0.228*	*0.470*	*0.329*	*0.470*
Blue-winged Warbler	**0.468**	**0.367**	**0.415**	**0.472**	*0.286*	*0.048*		*0.468*
Prairie Warbler	**0.879**	**0.350**	*0.117*	0.261	*0.294*		*0.442*	*0.358*
Common Yellowthroat	*0.282*	*0.261*	*0.194*	*0.202*	*0.325*	*0.271*	*1.015*	*0.355*
Yellow-breasted Chat	*0.038*	**0.172**		**0.203**	*0.123*	*0.146*	*0.085*	*0.151*
Field Sparrow	*0.149*	**0.512**		**0.423**	*0.262*	*0.368*		*0.394*
Northern Cardinal	0.269	*0.206*	*0.164*	**0.285**	*0.272*	*0.327*	*0.327*	*0.347*
Indigo Bunting	**0.101**	0.092	*0.064*	**0.093**	*0.093*	*0.064*	*0.14*	*0.223*
Score	-20	50	*-29*	67				

Table 6. Summary chart of performance measures for 18 species using MAPS data pooled from 6 stations on each of four military installations () in Indiana (Jefferson Proving Ground and NWSC Crane), Kentucky (Fort Knox), and Missouri (Fort Leonard Wood). Species are shown in taxonomic order within two habitat associations; forest and successional species. For each species and location an indication of the MAPS adult trend (AHY_t) is given; within +/-5% per year adult population change (0); greater than 5% annual increase (+); less than 5% annual decline (-). Statistically significant trends are denoted by multiple signs (e.g. – P<0.05, --- P<0.01). Apparent survival rates (Phi) and reproductive indices (RI) are given as (+) if the value is greater than or equal to that for BCR#24 (Central Hardwoods), (-) if it is less than 90% of the BCR#24 value, and (0) if it is between 90% and 100% of the BCR#24 value. Missing values given by (?)

	Jefferson Proving Ground				**NWSC Crane**				**Fort Knox**				**Fort Leonard Wood**			
	AHY	**AHY_t**	**Phi**	**RI**	**AHY**	**AHY_t**	**Phi**	**RI**	**AHY**	**AHY_t**	**Phi**	**RI**	**AHY**	**AHY_t**	**Phi**	**RI**
Forest Species																
Acadian Flycatcher	11.43	0	0	+	12.41	0	+	+	7.21	0	+	+	9.27	-	+	0
Red-eyed Vireo	10.01	0	+	-	11.97	0	0	+	8.37	-	+	+	5.19	+	-	+
Carolina Chickadee	3.30	+	?	+	2.76	+	?	+	1.84	+	?	?	2.63	-	0	+
Wood Thrush	10.97	0	+	+	12.37	0	+	+	9.86	0	+	-	3.79	+	?	-
Worm-eating Warbler	7.54	--	?	+	3.87	+	+	+	1.94	-	?	+	5.45	0	+	+
Ovenbird	7.67	0	-	0	7.01	++	+	+					4.43	0	+	-
Louisiana Waterthrush					4.04	+	-	+	7.29	0	?	+	6.80	0	?	-
Kentucky Warbler	10.46	-	-	0	15.44	0	+	+	11.72	0	+	+	8.88	0	+	-
Successional Species																
White-eyed Vireo	12.74	--	+	0	14.61	0	0	+	3.95	-	-	0	8.46	+	-	-
Carolina Wren	3.23	+	?	-	2.58	0	?	+	4.66	+	?	+	3.00	-	?	+
Gray Catbird	10.79	0	+	-	21.00	-	-	+								
Blue-winged Warbler	8.61	0	0	+	8.72	-	+	+	3.68	--	?	+	14.47	0	0	+
Prairie Warbler	5.21	-	?	+	6.91	0	-	+	3.04	+	?	-	10.57	+	+	0
Common Yellowthroat	15.99	---	+	-	12.22	0	+	-	7.64	--	-	-	9.36	-	+	-
Yellow-breasted Chat	11.34	0	-	-	7.51	-	-	+		?	-	?	24.41	0	+	+
Field Sparrow	9.69	0	-	-	2.59	--	?	+					15.36	0	-	-
Northern Cardinal	5.02	-	+	0	5.14	+	-	-	7.35	-	?	-	4.86	+	+	+
Indigo Bunting	15.74	0	0	+	11.08	0	+	0	13.89	---	+	-	19.91	0	+	+

Table 7: Reclassification scheme of the NLCD 2001 land cover dataset to create a Level I classification with separate forest cover classes.

Level 1 Class	Level 2 Class	Description
1	11	Open Water
1	12	Perennial Ice/Snow
2	21	Developed Open Space
2	22	Developed Low Intensity
2	23	Developed Medium Intensity
2	24	Developed High Intensity
3	31	Barren Land (Rock/Sand/Clay)
3	32	Unconsolidated Shore*
41	41	Deciduous Forest
42	42	Evergreen Forest
43	43	Mixed Forest
5	51	Dwarf Scrub
5	52	Shrub/Scrub
7	71	Grassland/Herbaceous
7	72	Sedge/Herbaceous
7	73	Lichens
7	74	Moss
8	81	Pasture/Hay
8	82	Cultivated Crops
9	90	Woody Wetlands
9	91	Palustrine Forested Wetland
9	92	Palustrine Scrub/Shrub Wetland
9	93	Estuarine Forested Wetland*
9	94	Estuarine Scrub/Shrub Wetland
9	95	Emergent Herbaceous Wetlands
9	96	Palustrine Emergent Wetland (Persistent)
9	97	Estuarine Emergent Wetland
9	98	Palustrine Aquatic Bed
9	99	Estuarine Aquatic Bed

Table 8. Analyses of the values of randomly selected cells from the NLCD2001 canopy cover dataset for 18 DoD installations where MAPS stations are operated. Each installation is assigned a location code (e.g. BELV) which corresponds to the analytical groupings of stations used in this report and previous reports (Nott et al. 2003, 2005). The number of random cells (>=100m apart) are given with the probability of encountering a forested cell ($P_{(Forest)}$), the probability of encountering a mature forested cell ($P_{(Mature)}$; defined as >55% canopy cover), and the percentage (%)of forested cells that are mature. These analyses were conducted for a) land within a one kilometer external buffer around the boundaries of each installation (Within Boundary), and b) land outside the one kilometer buffer but within a 20 km buffer (Outside Boundary).

Military Installation	Location Code	Area (km^2)	Within Boundary (+ 1km)				Outside Boundary(<1km)			
			N	$P_{(Forest)}$	$P_{(Mature)}$	%	N	$P_{(Forest)}$	$P_{(Mature)}$	%
Fort Belvoir, MD	BELV	35.7	136	0.456	0.287	63	1864	0.611	0.396	**65**
Fort A.P.Hill, VA	BELV	303.4	241	**0.821**	**0.763**	**93**	1759	0.648	0.581	90
NAS Patuxent R., MD	NAVY	31.6	73	**0.342**	**0.287**	84	1927	0.268	0.229	**85**
NSWC Indian Head, MD	NAVY	9.2	162	0.478	0.315	66	1838	0.623	0.500	**80**
NSWC Dahlgren, VA	NAVY	9.8	45	0.244	0.155	64	1955	0.500	0.456	**91**
Fort Bragg, NC	BRAG	572.9	347	**0.651**	**0.518**	**80**	1653	0.602	0.473	79
NAVFEC, NC	TIDE	17.0	83	0.434	0.373	86	1917	0.533	0.481	**90**
NAS Oceana, NC	TIDE	22.9	107	**0.439**	0.299	68	1893	0.406	0.305	**75**
NALF Fentress, NC	TIDE	13.8	136	**0.404**	**0.324**	**80**	1864	0.324	0.247	76
Jefferson Proving Gnd., IN	JEFF	215.2	203	**0.768**	**0.714**	**93**	1797	0.478	0.386	81
Fort Knox, KY	KNOX	444.1	336	**0.821**	**0.708**	**86**	1664	0.499	0.370	74
NAS Crane, IN	CRAN	254.0	254	**0.878**	**0.744**	**85**	1746	0.451	0.357	79
Fort Leonard Wood, MO	LEON	257.8	233	**0.906**	**0.828**	**91**	1767	0.758	0.671	89
Fort Riley, KS	RILE	420.8	314	**0.271**	**0.162**	**60**	1686	0.168	0.072	43
AAP Sunflower, KS	RILE	35.5	75	0.106	0.093	**88**	1925	0.191	0.131	69
Fort Leavenworth, KS	LEAV	21.4	53	**0.415**	**0.377**	**91**	1947	0.311	0.222	71
Camp Swift, TX	SWIF	211.1	221	**0.584**	**0.439**	**75**	1179	0.380	0.245	64
Fort Hood, TX	HOOD	940.4	450	**0.531**	**0.262**	**49**	1550	0.387	0.154	40
AVERAGE				**0.531**	**0.425**	78		0.452	0.349	75

Table 9. Results of FRAGSTATS analyses of one kilometer radius cookies around a) groups of six stations (“ denotes membership of first named group) 666 randomly stratified (>=100m apart) points associated with each of 18 DoD Installations. Randomly chosen points were located on land a) within a one kilometer external buffer around the boundaries of each installation (Within), and b) outside the external one kilometer buffer but within a 20 km buffer (Outside). For each set of stations, the Forest Core Area (90m internal buffer), and Agriculture cover classes, the mean percentage cover and standard error are given for each installation. Bold type denotes significantly (P<0.05) higher values when comparing the means of within and outside data (t-test).

Military Installation	Mean of MAPS stations	Forest Core Area				Agriculture			
		Outside		Within		Outside		Within	
		Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Fort Belvoir, MD	13.43	15.48	0.68	10.47	3.50	20.27	1.21	13.22	5.08
Fort A.P.Hill, VA	“	13.79	0.85	**23.09**	2.40	**35.98**	1.55	21.44	4.87
NAS Patuxent River, MD	5.56	10.24	0.88	1.91	5.22	21.90	1.78	3.89	16.35
NSWC Indian Head, MD	“	**19.79**	0.59	7.28	2.82	**20.98**	0.86	11.70	5.14
NSWC Dahlgren, VA	“	46.00	0.85	0.62	9.62	30.32	1.29	13.91	14.88
Fort Bragg, NC	0.00	31.11	1.66	**53.64**	2.18	27.13	1.37	13.78	7.13
NAVFEC, NC	0.48					59.98	1.44	57.29	5.87
NAS Oceana, NC	“					49.80	3.50	70.37	11.36
NALF Fentress, NC	“	3.27	0.59	0.94	2.03	54.51	1.81	54.06	7.16
Jefferson Proving Gnd., IN	59.66	16.89	0.85	**50.96**	2.21	55.56	1.26	51.28	6.61
Fort Knox, KY	26.67	24.69	1.46	**36.36**	2.84	**53.75**	1.61	15.98	8.55
NAS Crane, IN	65.31	27.82	1.22	**57.00**	2.24	**68.12**	1.54	20.67	14.45
Fort Leonard Wood, MO	42.43	31.67	0.90	**41.33**	2.31	**30.05**	1.45	17.73	7.72
Fort Riley, KS	1.41	0.55	0.31	**4.18**	0.77	**45.00**	1.73	29.95	6.52
AAP Sunflower, KS	“	43.56	0.61	4.05	3.10	**65.89**	1.06	50.67	7.04
Fort Leavenworth, KS	8.76	5.53	0.48	**14.48**	0.77	**65.13**	0.83	39.79	11.48
TXRNG Camp Swift, TX	n/a	31.63	3.42	**40.75**	6.29	**50.12**	1.36	30.74	5.19
Fort Hood, TX	n/a	21.83	2.40	**42.06**	2.80	**40.35**	3.50	0.00	0.00

Table 10. Comparison of the core (90m interior buffer) areas of three NLCD 2001 classifications of forest associated with a) a 20km buffer surrounding each of 19 DoD installations (Outside Installation), and b) within the boundaries of each installation (Within Installation). In each case the area of the installation is shown with the percentages of each forest type (which are summed to provide the total percentage of core area), and the core area expressed in square kilometers. The difference between the percentage of core forest outside the installation and that within the installation is also shown. The expected percentage is the area of the installation expressed as a percentage of the installation land plus the area of the 20km buffer. The observed percentage is the core area of forest within the boundaries of the installation expressed as a percentage of all forest core area within the 20km buffer.

	Outside Installation						Within Installation						Difference	
		Core Forest Type (%)						Core Forest Type (%)						
Military Installation	Area (sq.km.)	Deciduous	Conifer	Mixed	Total Core Forest (%)	Core Area (sq.km.)	Area (sq.km.)	Deciduous	Conifer	Mixed	Total Core Forest (%)	Core Area (sq.km.)	Observed %.	Expected %.
Fort Belvoir, MD	1789	11.45	0.07	0.00	11.52	206.06	36	8.86	0.02	0.00	8.87	3.17	1.51	1.96
Fort A.P.Hill, VA	3001	12.71	1.76	0.00	14.47	434.34	303	19.39	1.66	0.00	21.05	63.85	**12.82**	9.18
NAS Patuxent River, MD	1779	3.56	0.22	0.00	3.78	67.17	32	0.62	0.01	0.00	0.63	0.20	0.29	1.75
NSWC Indian Head, MD	1520	15.40	0.24	0.00	15.64	237.68	9	9.52	0.00	0.00	9.52	0.88	0.37	0.60
NSWC Dahlgren, VA	1506	12.06	0.53	0.00	12.59	189.61	10	0.58	0.00	0.00	0.58	0.06	0.03	0.65
Fort Bragg, NC	4114	0.05	2.94	0.00	2.99	122.87	573	0.01	10.44	0.00	10.45	59.84	**32.75**	12.22
NAVFEC, NC	1578	2.41	0.77	0.00	3.18	50.20	17	0.44	1.26	0.00	1.70	0.29	0.57	1.07
NAS Oceana, NC	1658	0.71	0.06	0.00	0.77	12.79	23	0.56	0.00	0.00	0.56	0.13	1.00	1.36
NALF Fentress, NC	1657	1.44	0.39	0.00	1.83	30.36	14	0.22	0.62	0.00	0.84	0.12	0.38	0.83
Jefferson Proving Gnd., IN	2863	15.73	0.02	0.00	15.75	450.93	215	72.57	0.02	0.00	72.59	156.21	**25.73**	6.99
Fort Knox, KY	3441	18.54	0.02	0.00	18.56	638.74	444	39.77	0.17	0.00	39.94	177.35	**21.73**	11.43
NAS Crane, IN	2922	21.59	0.00	0.00	21.59	630.99	254	66.53	0.04	0.00	66.57	169.09	**21.13**	8.00
Fort Leonard Wood, MO	2912	34.07	0.30	0.00	34.37	1000.93	258	47.92	0.22	0.00	48.14	124.10	**11.03**	8.13
Fort Riley, KS	3562	0.28	0.01	0.00	0.30	10.55	421	1.84	0.00	0.03	1.87	7.88	**42.73**	10.57
AAP Sunflower, KS	1780	2.22	0.00	0.00	2.22	39.51	36	2.10		0.00	2.10	0.75	1.85	1.96
Fort Leavenworth, KS	1680	3.45	0.00	0.00	3.45	57.88	21	3.36		0.00	3.36	0.72	1.23	1.26
TXRNG Camp Swift, TX	2837	0.20	1.29	0.19	1.67	47.50	211	0.37	6.33	0.47	7.17	15.14	**24.17**	6.93
Fort Hood, TX	5227	0.04	0.82	0.00	0.86	44.81	940	0.11	5.17	0.00	5.28	49.63	**52.55**	15.25
Camp Bowie		0.00	0.06	0.00	0.06	0.00	37	0.00	0.39	0.00	0.39	0.14		100

Table 11. Percentages of NCLD 2001 cover classes within the boundaries of each of 19 DoD installations. Focal cover classes are shown in bold; developed land (2), shrub (5), deciduous forest (41), evergreen forest (42), and mixed forest (43). The three forest cover classes were summed to give the total forest cover percentage and converted to give the forest area in square kilometers. Twelve locations are shaded to denote <15% developed land cover.

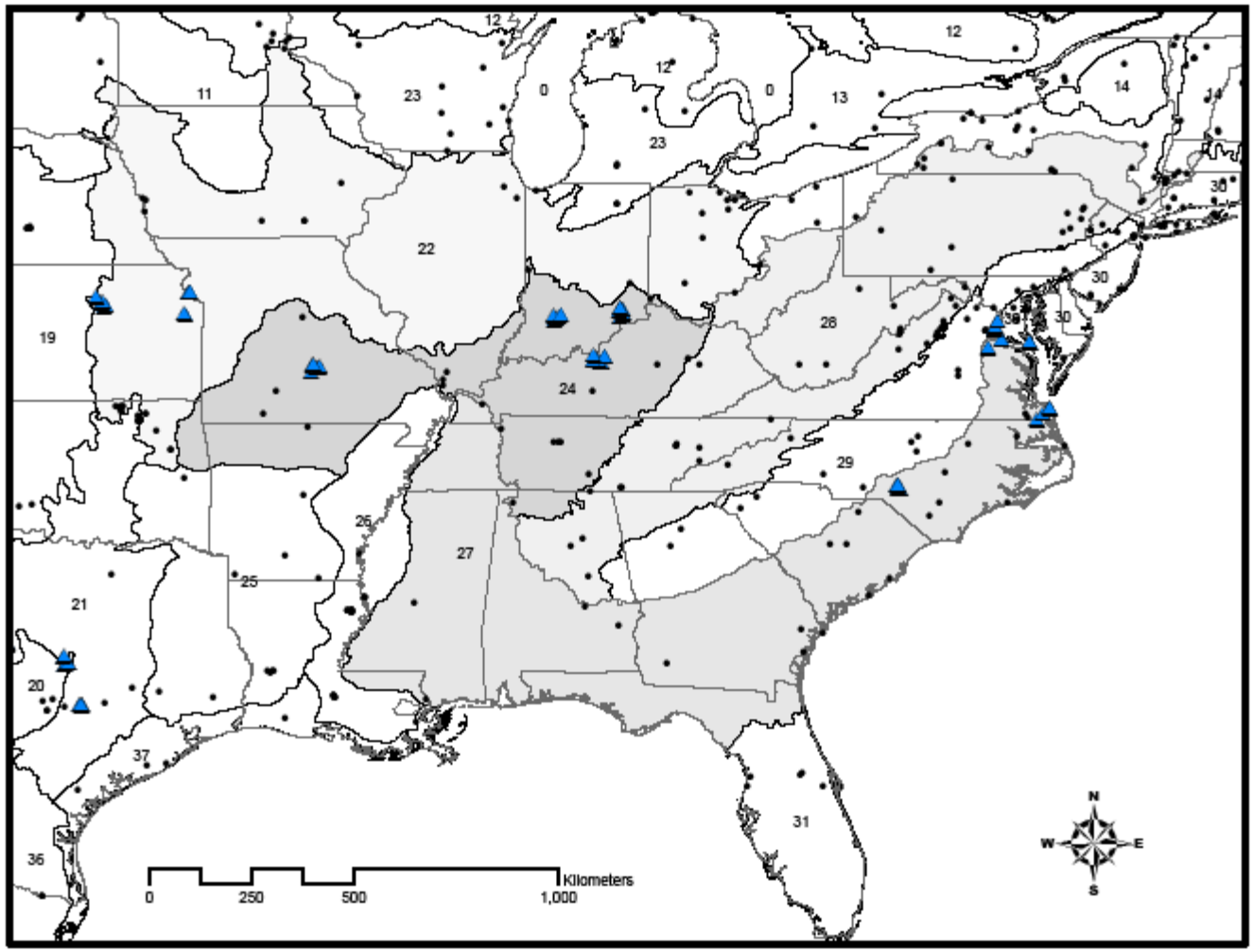
Military Installation	1	2	3	5	7	8	9	41	42	43	Total Forest%	Forest Area (sq.km)
Fort Belvoir, MD	3.79	**30.53**	2.24			10.16	2.70	**44.37**	**6.04**	**0.17**	**50.58**	18.06
Fort A.P.Hill, VA	0.09	**1.02**	4.34			7.80	2.90	**58.39**	**23.61**	**1.86**	**83.86**	254.09
NAS Patuxent River, MD	14.70	**37.00**	2.85			17.75	4.02	**13.64**	**8.06**	**1.97**	**23.67**	7.48
NSWC Indian Head, MD	22.21	**24.61**	2.67			9.31	3.30	**36.29**	**1.53**	**0.08**	**37.90**	3.49
NSWC Dahlgren, VA	3.81	**31.56**	7.00			17.83	8.24	**16.23**	**11.43**	**3.91**	**31.56**	3.09
Fort Bragg, NC	0.51	**13.32**	7.16	**0.87**	16.33	0.79	7.11	**4.26**	**48.67**	**0.98**	**53.91**	308.91
NAVFEC, NC		**1.35**	0.31			34.53	36.24	**15.60**	**10.79**	**1.19**	**27.57**	4.69
NAS Oceana, NC	0.15	**37.23**	0.97			40.06	1.87	**12.29**	**7.31**	**0.11**	**19.71**	4.51
NALF Fentress, NC		**2.95**	0.45			61.38	13.76	**10.50**	**10.90**	**0.07**	**21.47**	2.96
Jefferson Proving Gnd., IN	0.30	**2.32**	0.00	**4.78**	0.51	0.88	0.02	**90.62**	**0.52**	**0.05**	**91.18**	196.05
Fort Knox, KY	0.59	**5.85**	1.20	**0.10**	1.19	5.67	13.49	**67.30**	**4.15**	**0.46**	**71.91**	319.27
NWSC Crane, IN	1.38	**4.45**	0.29	**0.03**	1.16	1.92	0.06	**88.96**	**1.74**	**0.02**	**90.72**	230.42
Fort Leonard Wood, MO	0.28	**10.17**	1.30	**0.64**	1.43	2.05	0.64	**79.97**	**3.21**	**0.31**	**83.48**	215.39
Fort Riley, KS	0.54	**10.14**	0.03	**0.02**	66.89	2.83	1.90	**17.05**	**0.13**	**0.48**	**17.65**	74.33
AAP Sunflower, KS	0.19	**69.53**		**0.15**	0.58	15.06	0.13	**14.02**	**0.00**	**0.36**	**14.37**	5.10
Fort Leavenworth, KS	8.18	**39.55**		**0.49**	1.32	5.37	28.68	**16.28**	**0.00**	**0.13**	**16.41**	3.51
TXRNG Camp Swift, TX	1.84	**7.02**	0.03	**13.11**	1.48	15.04	5.62	**12.82**	**27.02**	**16.02**	**55.86**	117.86
Fort Hood, TX	1.30	**9.05**	0.65	**17.57**	33.41	0.29	1.47	**12.36**	**23.89**	**0.01**	**36.26**	340.83
Camp Bowie	0.30	**0.75**	0.03	**62.51**	12.30	0.03	0.05	**8.14**	**15.82**	**0.05**	**24.01**	8.79

Table 12. Percentages of NCLD 2001 cover classes within 20 kilometer boundaries of each of 19 DoD installations. Focal cover classes are shown in bold; developed land (2), shrub (5), deciduous forest (41), evergreen forest (42), and mixed forest (43). The three forest cover classes were summed to give the total forest cover percentage. Nine locations are shaded to denote those stations with <15% developed cover within installation and >70% forest cover (see Table 11).

Military Installation	1	2	3	5	7	8	9	41	42	43	Total Forest%
Fort Belvoir, MD	10.06	**34.67**	0.82			11.51	1.59	**37.46**	**3.74**	**0.15**	**41.35**
Fort A.P.Hill, VA	4.37	**3.96**	2.12			25.95	3.78	**44.49**	**14.15**	**1.18**	**59.82**
NAS Patuxent River, MD	55.33	**3.82**	1.44			11.60	5.47	**16.16**	**5.18**	**0.99**	**22.34**
NSWC Indian Head, MD	17.19	**15.21**	1.26			13.01	2.28	**44.75**	**5.99**	**0.31**	**51.05**
NSWC Dahlgren, VA	25.36	**2.65**	1.19			21.95	3.40	**37.66**	**6.74**	**1.04**	**45.45**
Fort Bragg, NC	0.93	**14.12**	0.09	**2.62**	15.58	18.48	12.84	**8.52**	**24.24**	**2.58**	**35.34**
NAVFEC, NC	2.26	**3.50**	1.85			39.40	28.68	**16.87**	**7.30**	**0.13**	**24.30**
NAS Oceana, NC	37.86	**25.34**	1.50			16.89	8.44	**5.44**	**4.42**	**0.10**	**9.96**
NALF Fentress, NC	13.55	**21.07**	1.28			32.03	15.12	**10.38**	**6.44**	**0.13**	**16.95**
Jefferson Proving Gnd., IN	1.21	**5.30**	0.05	**0.05**	1.91	43.69	0.09	**45.42**	**2.15**	**0.14**	**47.70**
Fort Knox, KY	1.37	**11.72**	0.15	**0.03**	1.96	35.03	1.44	**45.62**	**2.47**	**0.23**	**48.31**
NAS Crane, IN	0.96	**5.37**	0.05	**0.54**	3.53	42.22	0.10	**46.71**	**0.50**	**0.02**	**47.22**
Fort Leonard Wood, MO	0.35	**4.78**	0.10	**0.14**	1.45	19.34	0.40	**67.95**	**4.35**	**1.13**	**73.44**
Fort Riley, KS	4.95	**6.55**	0.03	**0.01**	49.96	26.61	1.51	**9.90**	**0.39**	**0.10**	**10.39**
AAP Sunflower, KS	1.69	**20.20**	0.32	**0.21**	4.74	57.05	0.88	**14.52**	**0.04**	**0.35**	**14.91**
Fort Leavenworth, KS	1.65	**10.41**	0.08	**0.43**	3.66	59.54	2.34	**21.59**	**0.01**	**0.29**	**21.89**
TXRNG Camp Swift, TX	0.56	**5.89**	0.06	**18.95**	4.02	37.79	5.82	**11.40**	**8.25**	**7.25**	**26.90**
Fort Hood, TX	1.82	**5.33**	0.10	**15.75**	43.87	8.98	1.89	**10.24**	**12.01**	**0.01**	**22.26**
Camp Bowie	0.85	**4.05**	0.01	**51.29**	25.59	5.56	0.12	**3.89**	**8.61**	**0.03**	**12.53**

Figure 1

Map of the MAPS avian monitoring network (black dots) featuring 78 MAPS stations (blue triangles) arranged in clusters of six stations on 13 DoD installations (or groups of nearby installations and other federal land). A total of 19 DoD installations were included in a spatial analysis of surrounding landscapes. The focus of a demographic performance analysis included estimates from four installations (24 MAPS stations) in the Central Hardwoods Bird Conservation Region (BCR) and groups of stations located in Bird Conservation Regions BCR#22 (Eastern Tallgrass Prairie), BCR#27 (Southeastern Coastal Plain), and BCR#28 (Appalachian Mountains).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12
12
11
23
0
0
13
14
14
23
36
22
30
30
19
28
24
29
26
27
25
21
20
37
31
36
0
250
500
1,000
Kilometers
N
W
E
S

Figure 2.

Map depicting MAPS stations associated with four installations (24 MAPS stations) in the and 17 other MAPS stations Central Hardwoods Bird Conservation Region (BCR), from which regional demographics were calculated. The four locations were in Indiana (Jefferson Proving Ground and NWSC Crane), Kentucky (Fort Knox), and Missouri (Fort Leonard Wood). The outer line surrounding each location represents a 20 km buffer around the installation boundary (inner line).

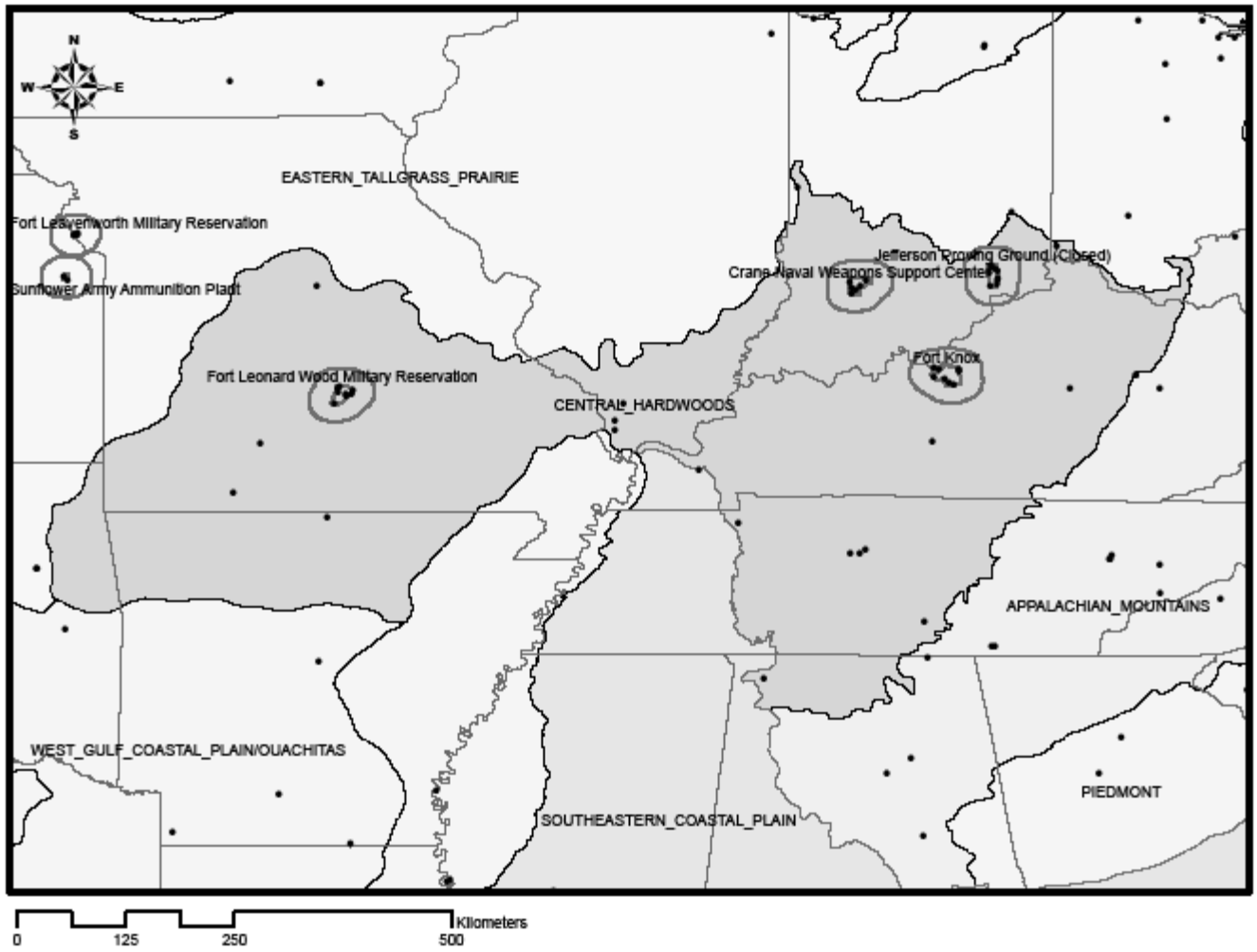

N
W
E
S
EASTERN_TALLGRASS_PRAIRIE
Fort Leavenworth Military Reservation
Sunflower Army Ammunition Plant
Fort Leonard Wood Military Reservation
CENTRAL_HARDWOODS
Crane Naval Weapons Support Center
Jefferson Proving Ground (Closed)
Fort Knox
APPALACHIAN_MOUNTAINS
WEST_GULF_COASTAL_PLAIN/OUACHITAS
SOUTHEASTERN_COASTAL_PLAIN
PIEDMONT
0
125
250
500
Kilometers

Figure 3.

Map of nine MAPS stations (yellow dotted triangles) associated with four DoD installations in Maryland and Virginia; Fort Belvoir, MD (2 stations); NWSC Indian Head, MD (2 stations); NWSC Dahlgren, VA (1 station); and Fort A.P. Hill, VA (2 stations). Two other stations were associated with Stump Neck NWR, MD. The stations, installation boundaries (inner lines), and 20 km buffers (outer lines) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

Fort Belvior, MD NSWC Indian Head, MD, NSWC Dahlgren, VA Fort A.P. Hill, VA

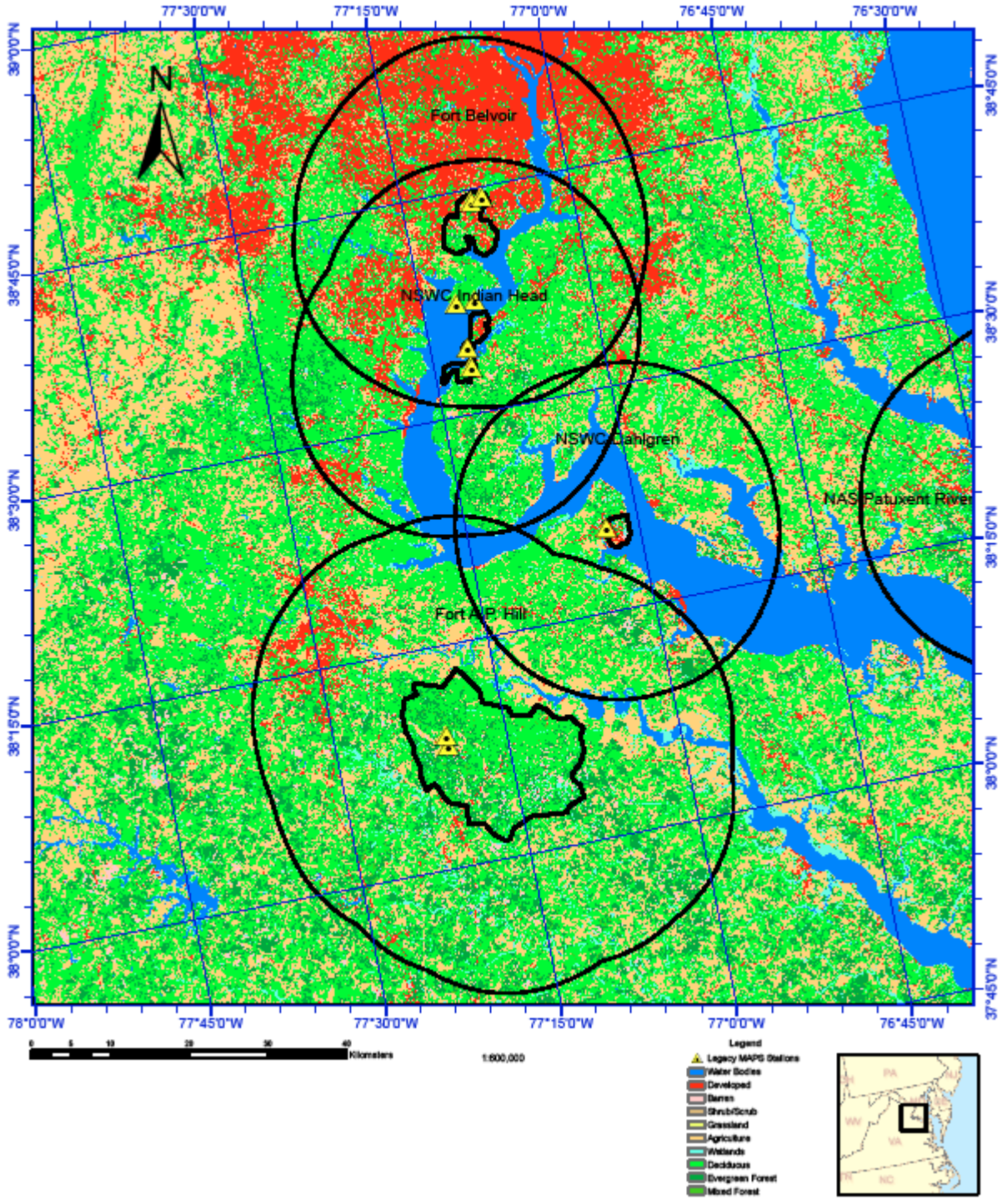


Figure 4

Map of two MAPS stations (yellow dotted triangles) associated with Naval Air Station Patuxent, MD. The stations, installation boundary (inner line), and 20 km buffer (outer line) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

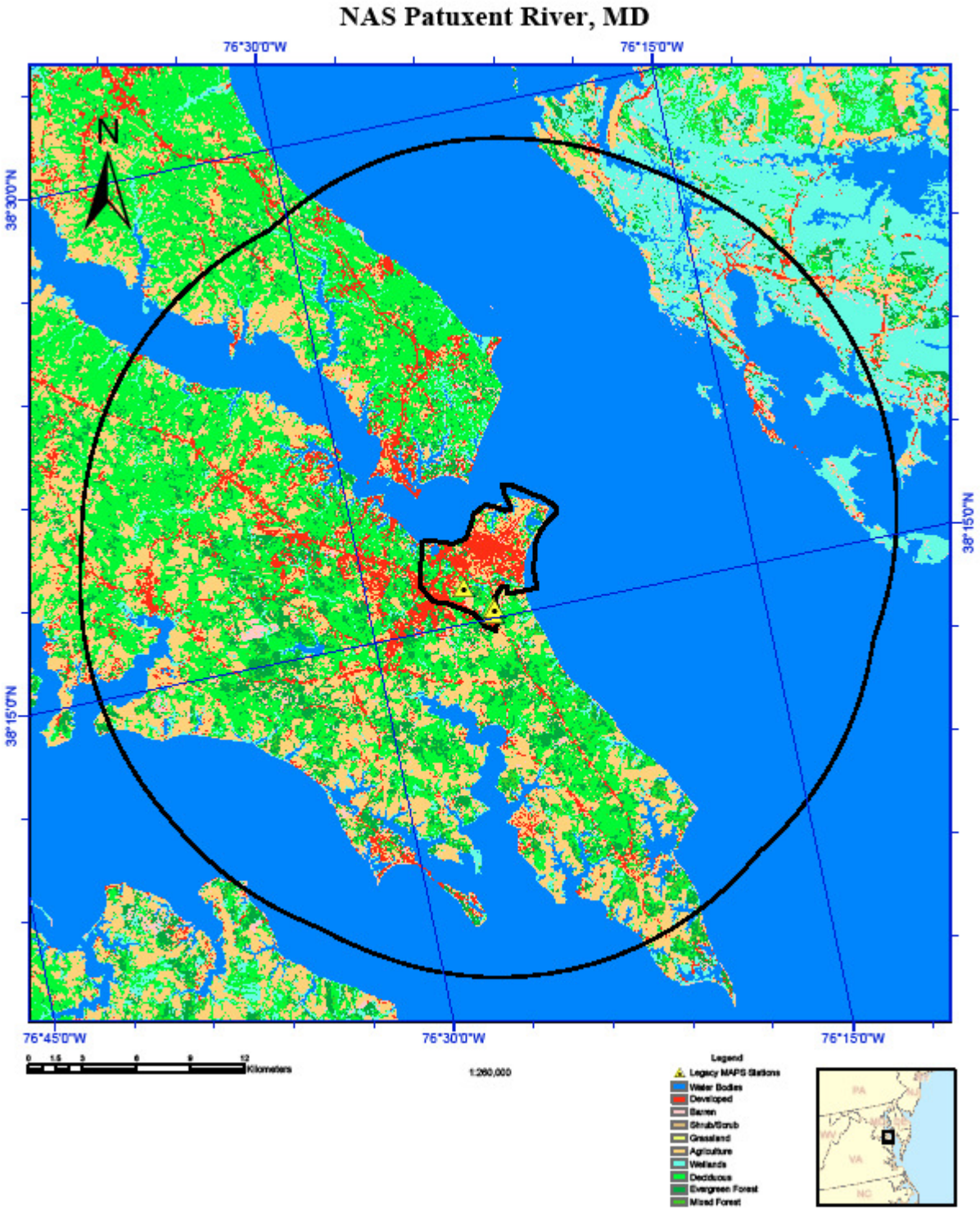

NAS Patuxent River, MD
76°30'0"W
76°15'0"W
38°30'0"N
38°15'0"N
N
76°45'0"W
76°30'0"W
76°15'0"W
Kilometers
1:260,000
Legend
Legacy MAPS Stations
Water Bodies
Developed
Barren
Shrub/Scrub
Grassland
Agriculture
Wetlands
Deciduous
Evergreen Forest
Mixed Forest

Figure 5

Map of six MAPS stations (yellow dotted triangles) associated with three DoD installations in North Carolina; NAVFEC (1 station); Naval Air Station Ocena (3 stations); Naval Air Landing Field Fentress (2 stations). The stations, installation boundaries (inner lines), and 20 km buffers (outer lines) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

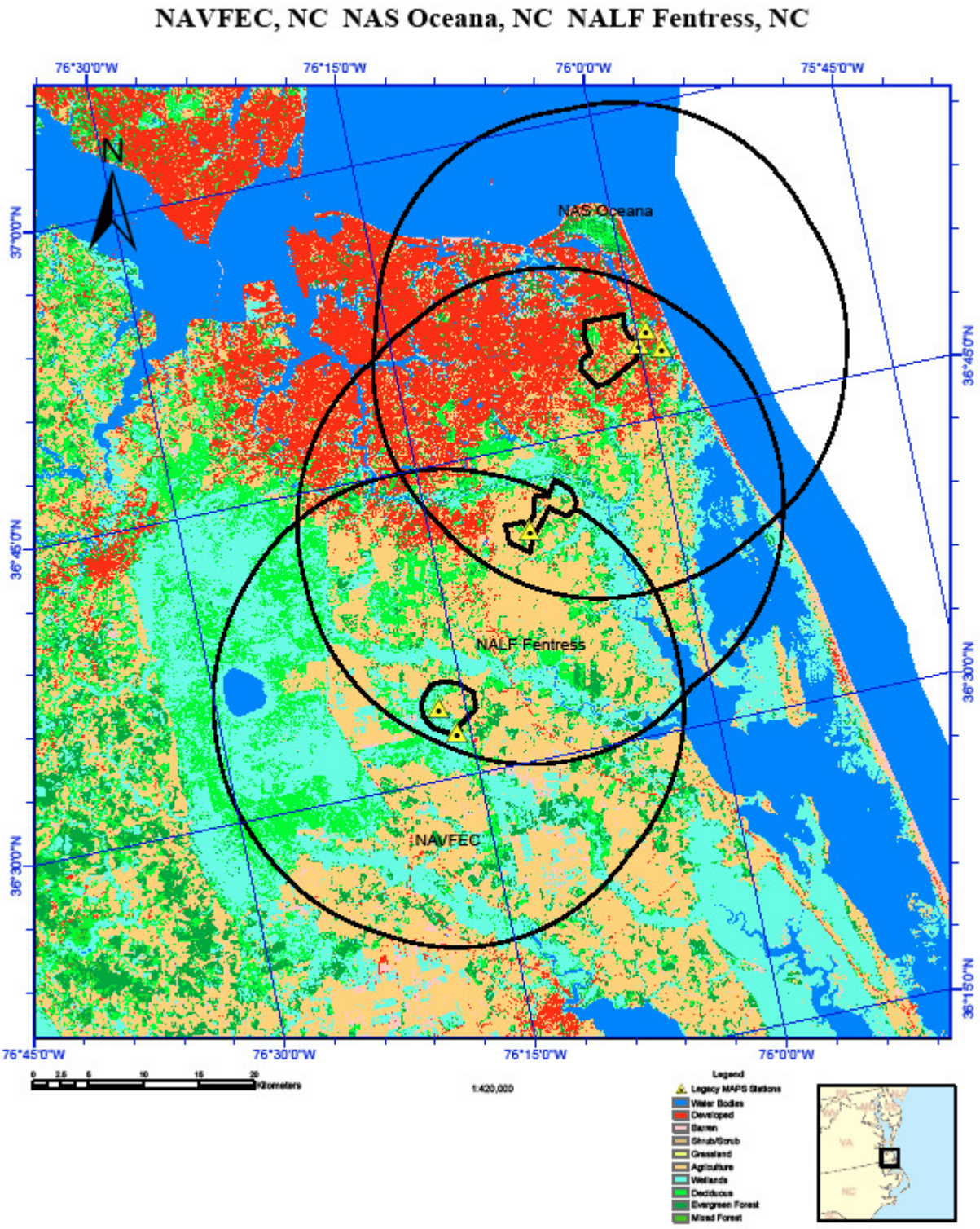

NAVFEC, NC NAS Oceana, NC NALF Fentress, NC
76°30'0"W
76°15'0"W
76°0'0"W
75°45'0"W
37°0'0"N
36°45'0"N
36°30'0"N
36°15'0"N
N
NAS Oceana
NALF Fentress
NAVFEC
Kilometers
1:420,000
Legend
Legacy MAPS Stations
Water Bodies
Developed
Barren
Shrub/Scrub
Grassland
Agriculture
Wetlands
Deciduous
Evergreen Forest
Mixed Forest

Figure 6

Map of seven (six active) MAPS stations (yellow dotted triangles) associated with Fort Bragg, NC. The stations, installation boundary (inner line), and 20 km buffer (outer line) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

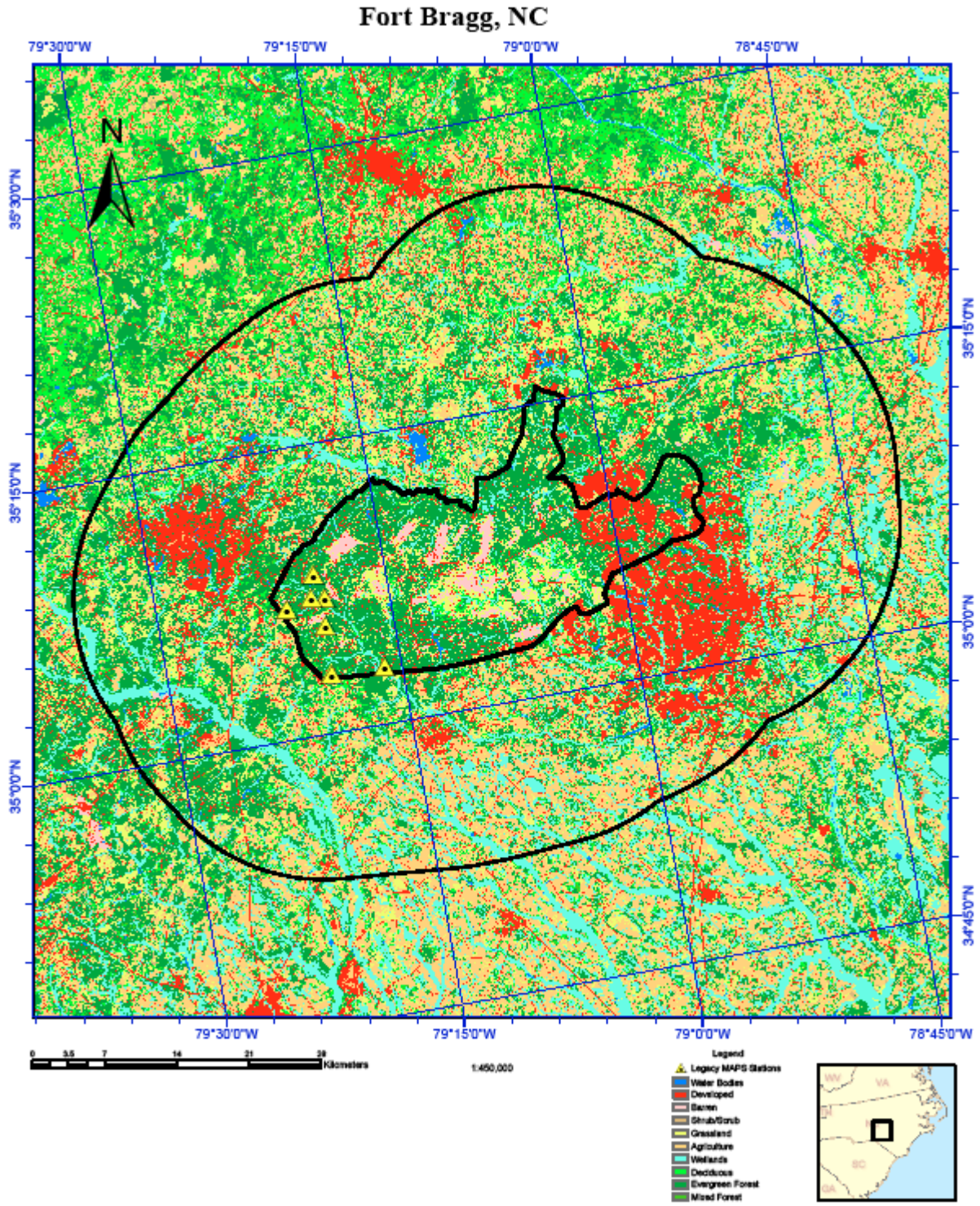

Fort Bragg, NC
79°30'0"W
79°15'0"W
79°0'0"W
78°45'0"W
35°30'0"N
35°15'0"N
35°0'0"N
34°45'0"N
N
0 3.5 7 14 21 28
Kilometers
1:450,000
Legend
Legacy MAPS Stations
Water Bodies
Developed
Barren
Shrub/Scrub
Grassland
Agriculture
Wetlands
Deciduous
Evergreen Forest
Mixed Forest

Figure 7

Map of nine (six active) MAPS stations (yellow dotted triangles) associated with Jefferson Proving Ground, IN. The stations, installation boundary (inner line), and 20 km buffer (outer line) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

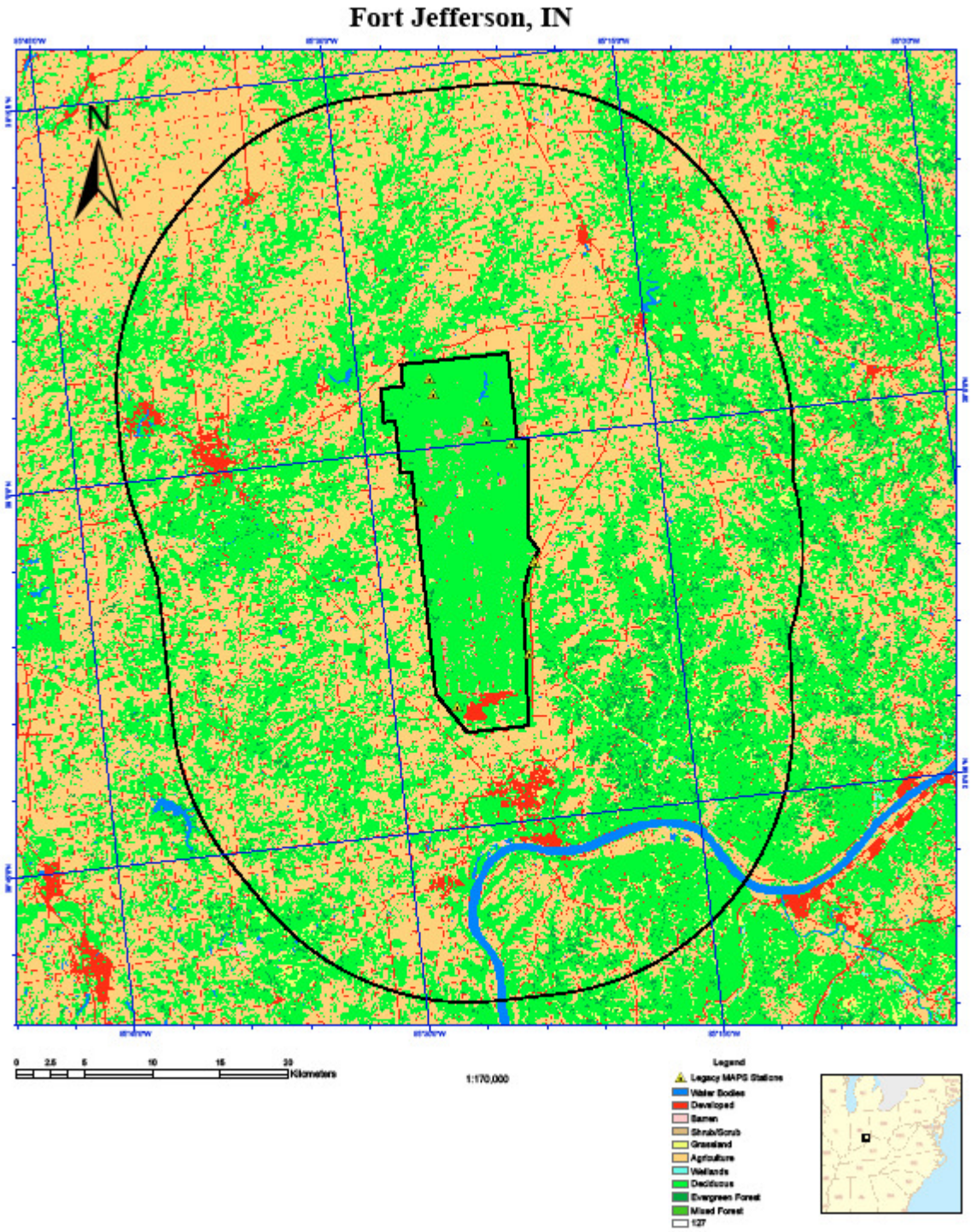

Fort Jefferson, IN
N
0 2.5 5 10 15 20
Kilometers
1:170,000
Legend
Legacy MAPS Stations
Water Bodies
Developed
Barren
Shrub/Scrub
Grassland
Agriculture
Wetlands
Deciduous
Evergreen Forest
Mixed Forest
127

Figure 8

Map of eight (six active) MAPS stations (yellow dotted triangles) associated with Fort Knox, KY. The stations, installation boundary (inner line), and 20 km buffer (outer line) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

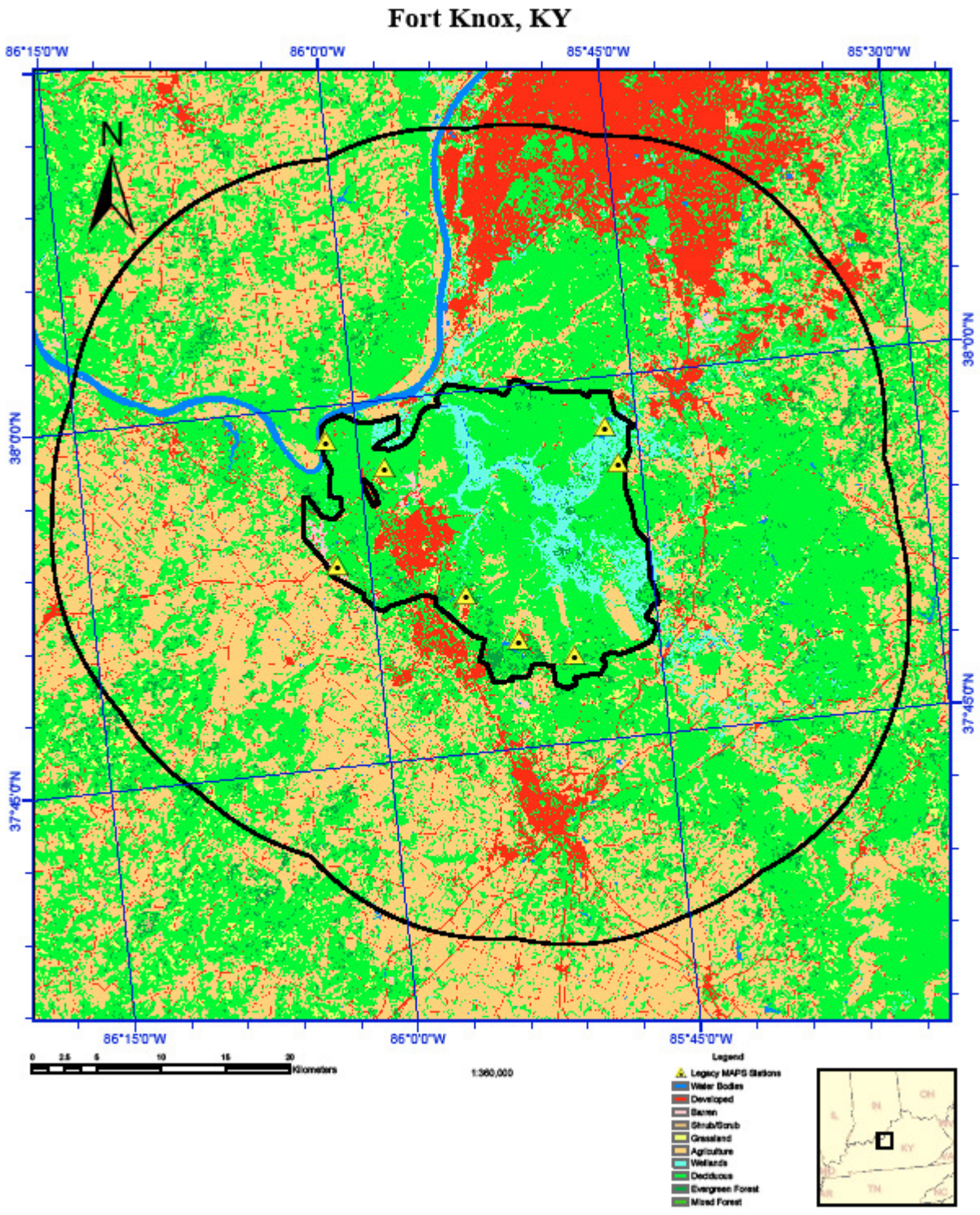

Fort Knox, KY
86°15'0"W
86°0'0"W
85°45'0"W
85°30'0"W
38°0'0"N
37°45'0"N
N
0 2.5 5 10 15 20
Kilometers
1:360,000
Legend
Legacy MAPS Stations
Water Bodies
Developed
Barren
Shrub/Scrub
Grassland
Agriculture
Wetlands
Deciduous
Evergreen Forest
Mixed Forest

Figure 9

Map of six active MAPS stations (yellow dotted triangles) associated with NWSC Crane, IN. The stations, installation boundary (inner line), and 20 km buffer (outer line) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

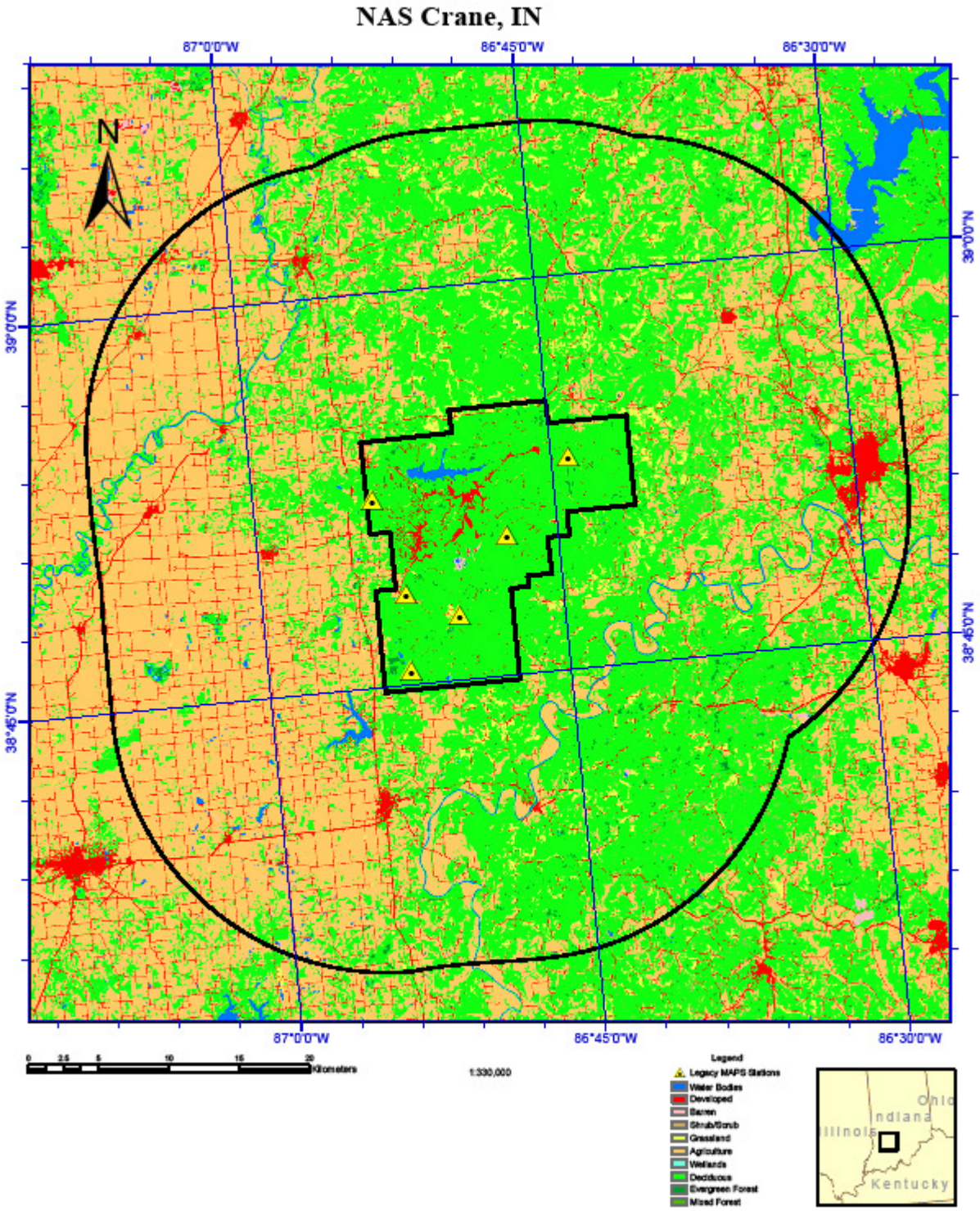

NAS Crane, IN
87°0'0"W
86°45'0"W
86°30'0"W
39°0'0"N
38°45'0"N
N
0 2.5 5 10 15 20
Kilometers
1:330,000
Legend
Legacy MAPS Stations
Water Bodies
Developed
Barren
Shrub/Scrub
Grassland
Agriculture
Wetlands
Deciduous
Evergreen Forest
Mixed Forest
Ohio
Indiana
Illinois
Kentucky

Figure 10

Map of eight (six active) MAPS stations (yellow dotted triangles) associated with Fort Leonard Wood, MO. The stations, installation boundary (inner line), and 20 km buffer (outer line) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

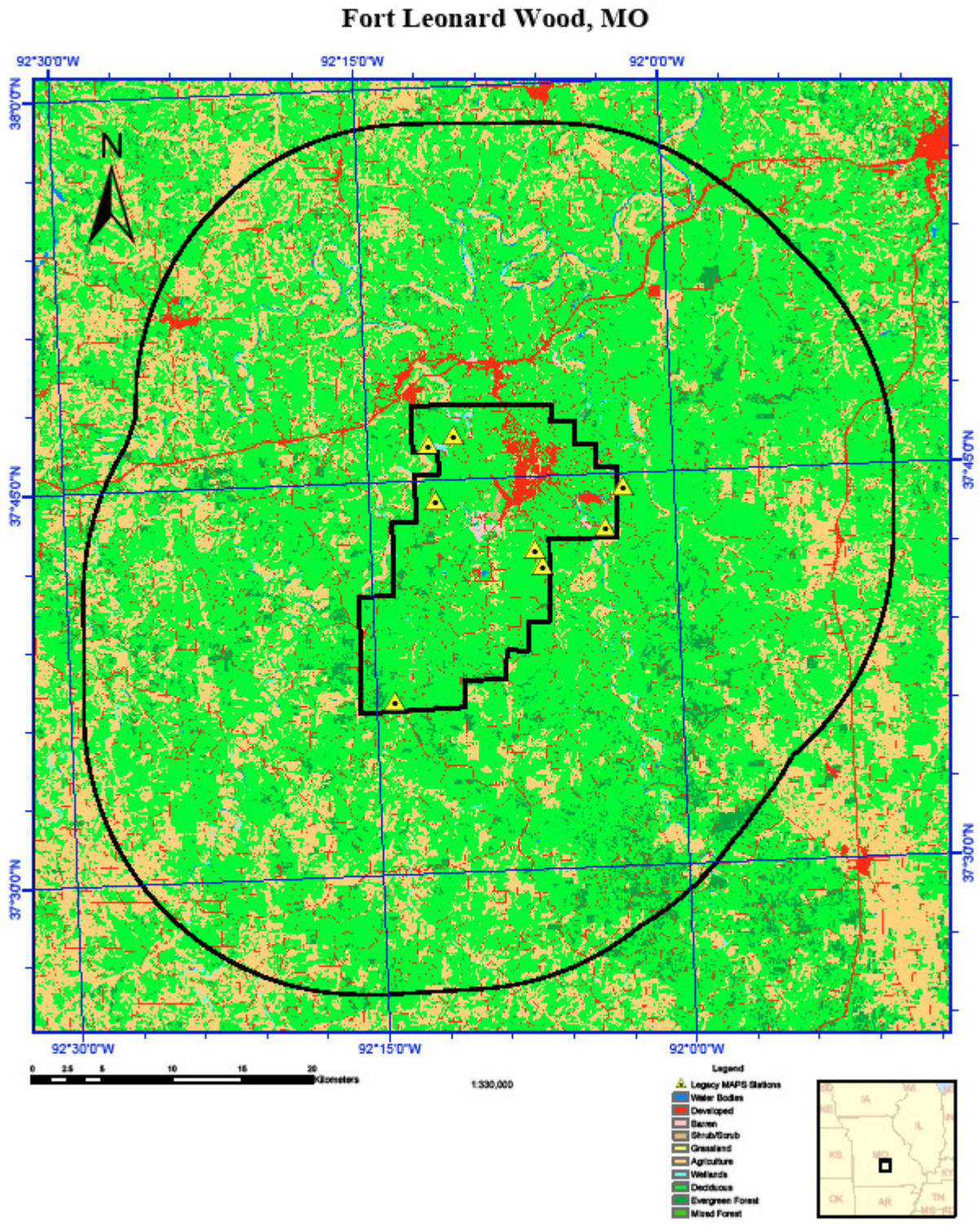

Fort Leonard Wood, MO
92°30'0"W
92°15'0"W
92°0'0"W
38°0'0"N
37°45'0"N
37°30'0"N
N
0 2.5 5 10 15 20
Kilometers
1:330,000
Legend
Legacy MAPS Stations
Water Bodies
Developed
Barren
Shrub/Scrub
Grassland
Agriculture
Wetlands
Deciduous
Evergreen Forest
Mixed Forest

Figure 11

Map of six MAPS stations (yellow dotted triangles) associated with Fort Riley and AAP Sunflower, KS. The stations, installation boundary (inner line), and 20 km buffer (outer line) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

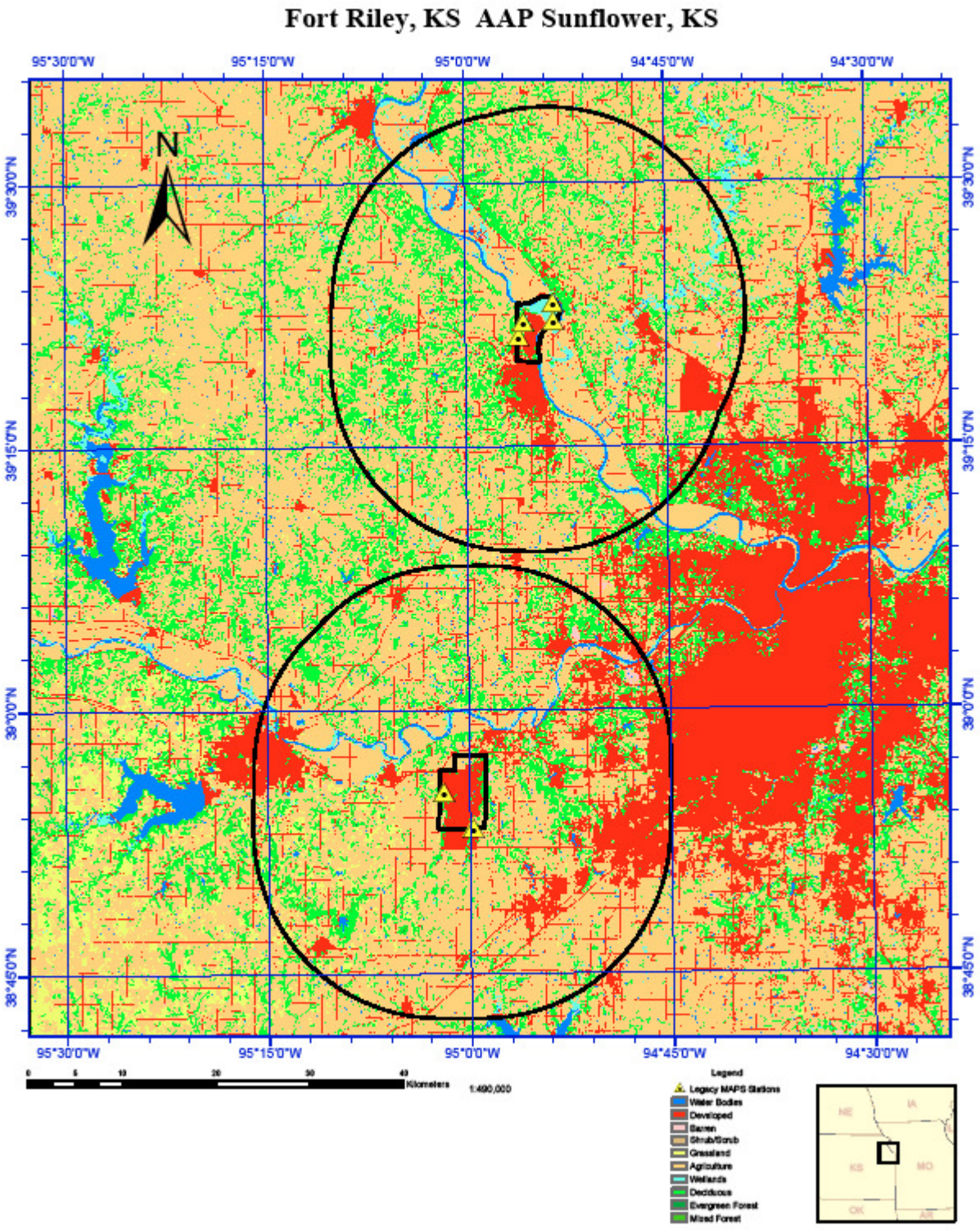

Fort Riley, KS AAP Sunflower, KS
95°30'0"W
95°15'0"W
95°0'0"W
94°45'0"W
94°30'0"W
39°30'0"N
39°15'0"N
39°0'0"N
38°45'0"N
N
Kilometers
1:490,000
Legend
Legacy MAPS Stations
Water Bodies
Developed
Barren
Shrub/Scrub
Grassland
Agriculture
Wetlands
Deciduous
Evergreen Forest
Mixed Forest

Figure 12

Map of four MAPS stations (yellow dotted triangles) associated with Fort Leavenworth, KS. The stations, installation boundary (inner line), and 20 km buffer (outer line) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

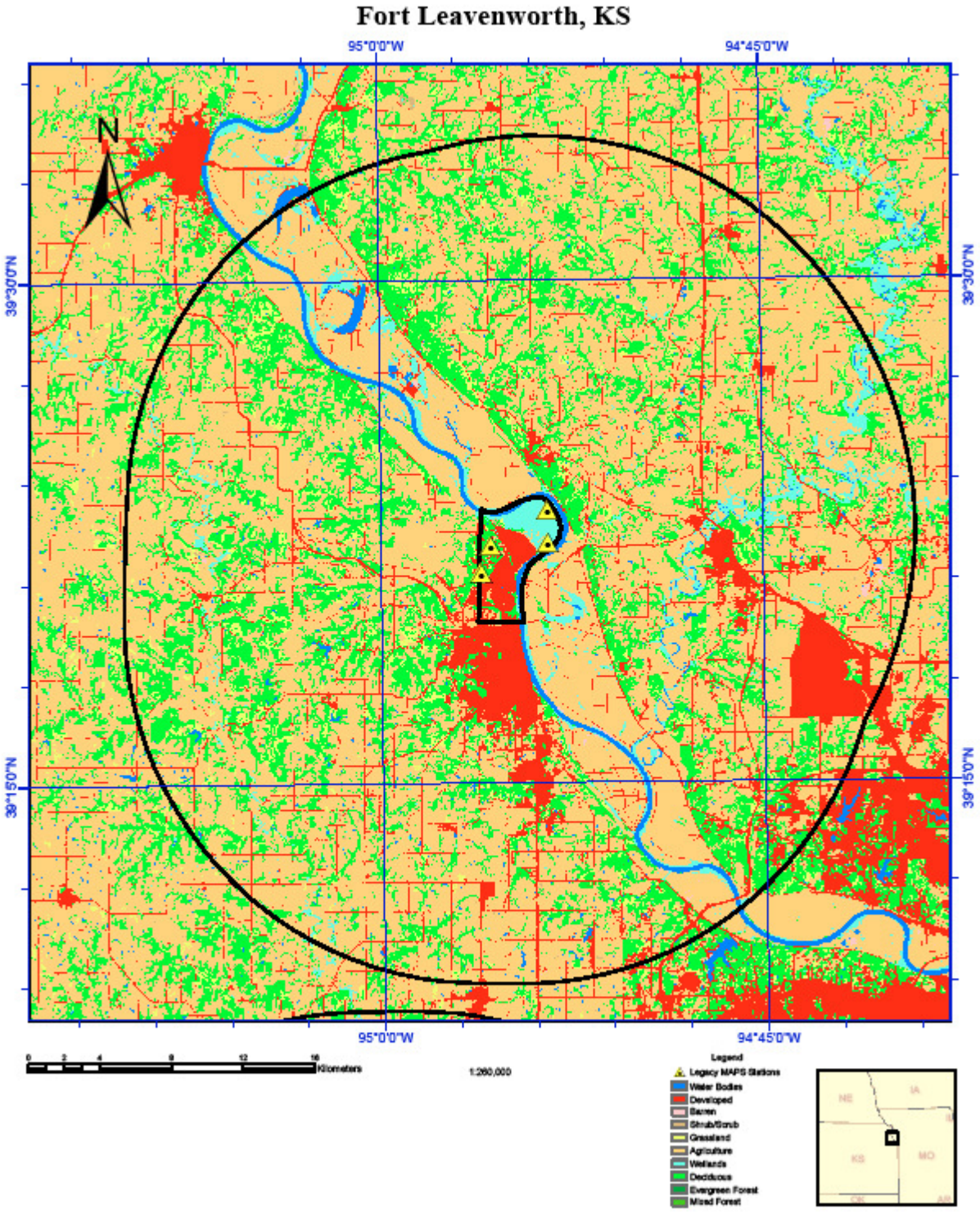

Fort Leavenworth, KS
95°0'0"W
94°45'0"W
39°30'0"N
39°15'0"N
N
0 2 4 8 12 16
Kilometers
1:260,000
Legend
Legacy MAPS Stations
Water Bodies
Developed
Barren
Shrub/Scrub
Grassland
Agriculture
Wetlands
Deciduous
Evergreen Forest
Mixed Forest
NE
IA
KS
MO

Figure 13

Map of seven (six active) MAPS stations (yellow dotted triangles) associated with Texas Army Reserve National Guard Camp Swift, TX. The stations, installation boundary (inner line), and 20 km buffer (outer line) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

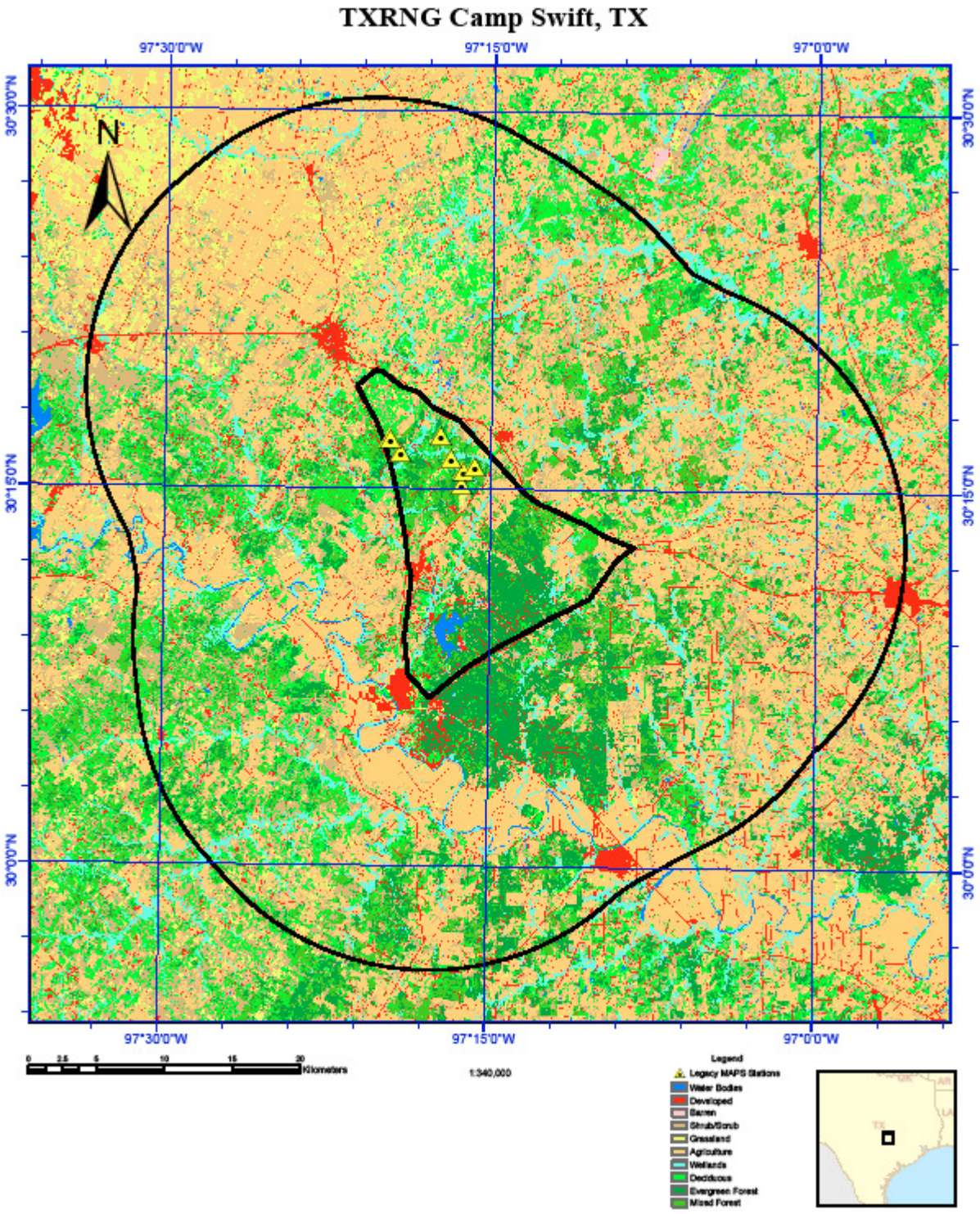

TXRNG Camp Swift, TX
97°30'0"W
97°15'0"W
97°0'0"W
30°30'0"N
30°15'0"N
30°0'0"N
N
0 2.5 5 10 15 20
Kilometers
1:340,000
Legend
Legacy MAPS Stations
Water Bodies
Developed
Barren
Shrub/Scrub
Grassland
Agriculture
Wetlands
Deciduous
Evergreen Forest
Mixed Forest

Figure 14

Map of seven (six active) MAPS stations (yellow dotted triangles) associated with Fort Hood, TX. The stations, installation boundary (inner line), and 20 km buffer (outer line) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

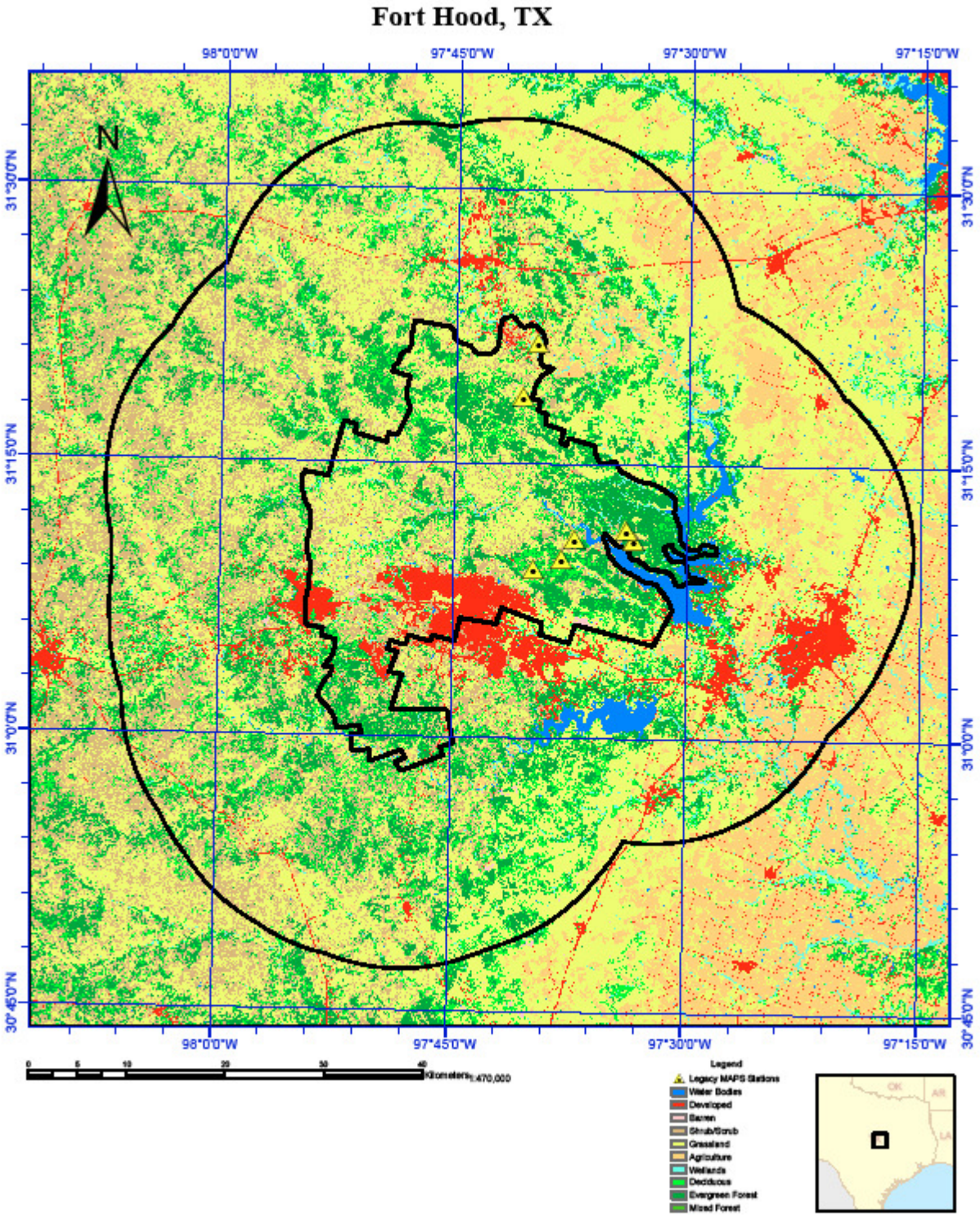

Fort Hood, TX
98°0'0"W
97°45'0"W
97°30'0"W
97°15'0"W
31°30'0"N
31°15'0"N
31°0'0"N
30°45'0"N
N
Legend
Legacy MAPS Stations
Water Bodies
Developed
Barren
Shrub/Scrub
Grassland
Agriculture
Wetlands
Deciduous
Evergreen Forest
Mixed Forest

Figure 15

Map of seven (six active) MAPS stations (yellow dotted triangles) associated with Texas Army Reserve National Guard Camp Bowie, TX. The stations, installation boundary (inner line), and 20 km buffer (outer line) are superimposed upon a modified Level I classification of the 2001 National Land Cover Dataset (NLCD 2001).

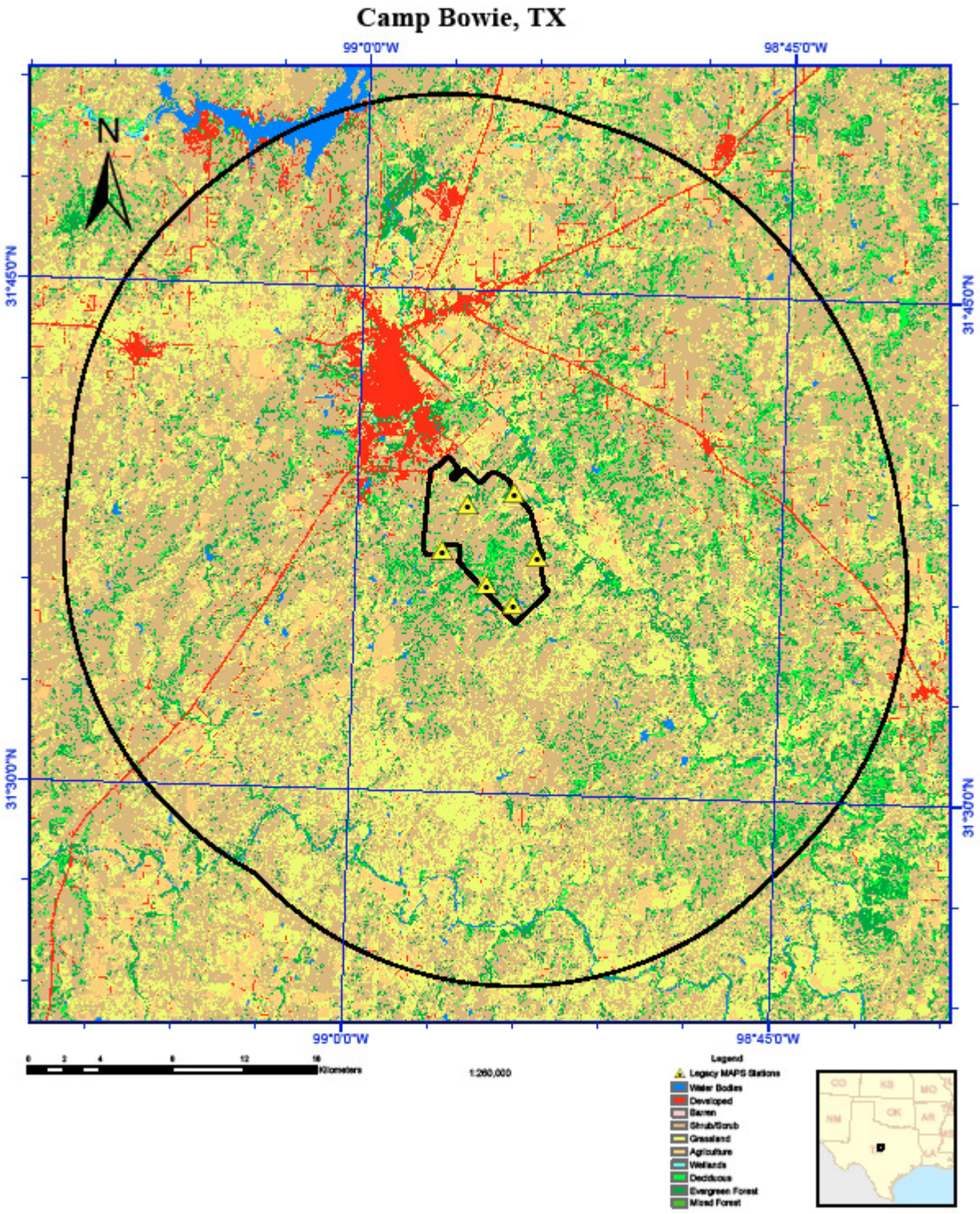

Camp Bowie, TX
99°0'0"W
98°45'0"W
31°45'0"N
31°30'0"N
N
Kilometers
1:260,000
Legend
Legacy MAPS Stations
Water Bodies
Developed
Barren
Shrub/Scrub
Grassland
Agriculture
Wetlands
Deciduous
Evergreen Forest
Mixed Forest

Figure 16

Map of forest cover within the boundaries (plus 1km) of Fort A. P. Hill, VA. White space denotes land cover other than forest. Forest patches are shown as green outlines and yellow patches whereby the green outline represents a 90m wide interior buffer and the yellow area is defined as forest core area (i.e. at least 90m from forest edge).

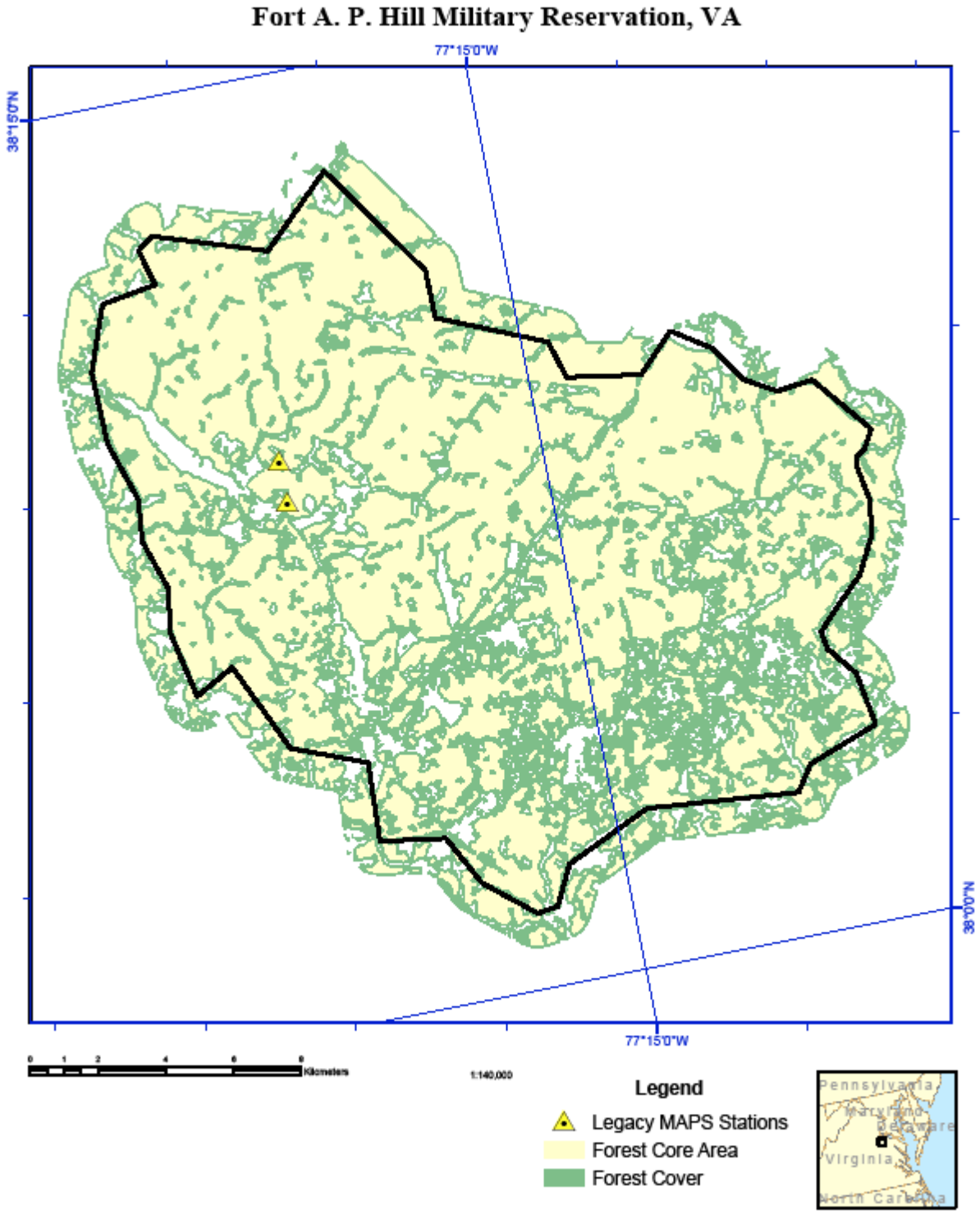

Fort A. P. Hill Military Reservation, VA
77°15'0"W
38°15'0"N
38°0'0"N
77°15'0"W
0 1 2 4 6 8
Kilometers
1:140,000
Legend
Legacy MAPS Stations
Forest Core Area
Forest Cover
Pennsylvania
Maryland
Delaware
Virginia
North Carolina

Figure 17

Map of forest cover within the boundaries (plus 1km) of Fort Bragg, NC. White space denotes land cover other than forest. Forest patches are shown as green outlines and yellow patches whereby the green outline represents a 90m wide interior buffer and the yellow area is defined as forest core area (i.e. at least 90m from forest edge).

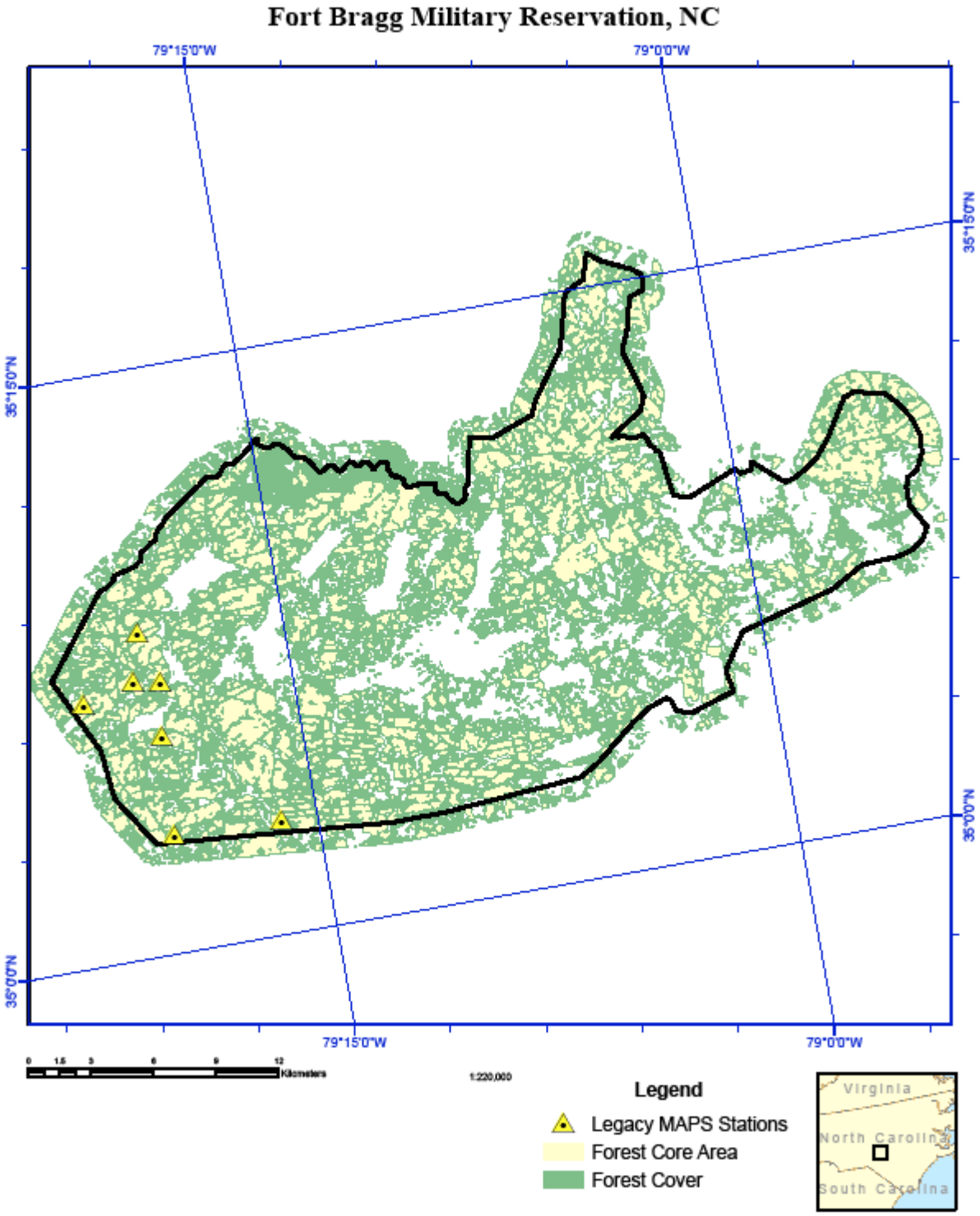

Fort Bragg Military Reservation, NC
79°15'0"W
79°0'0"W
35°15'0"N
35°0'0"N
0 1.5 3 6 9 12
Kilometers
1:220,000
Legend
Legacy MAPS Stations
Forest Core Area
Forest Cover
Virginia
North Carolina
South Carolina

Figure 18

Map of forest cover within the boundaries (plus 1km) of Jefferson Proving Ground, IN. White space denotes land cover other than forest. Forest patches are shown as green outlines and yellow patches whereby the green outline represents a 90m wide interior buffer and the yellow area is defined as forest core area (i.e. at least 90m from forest edge).

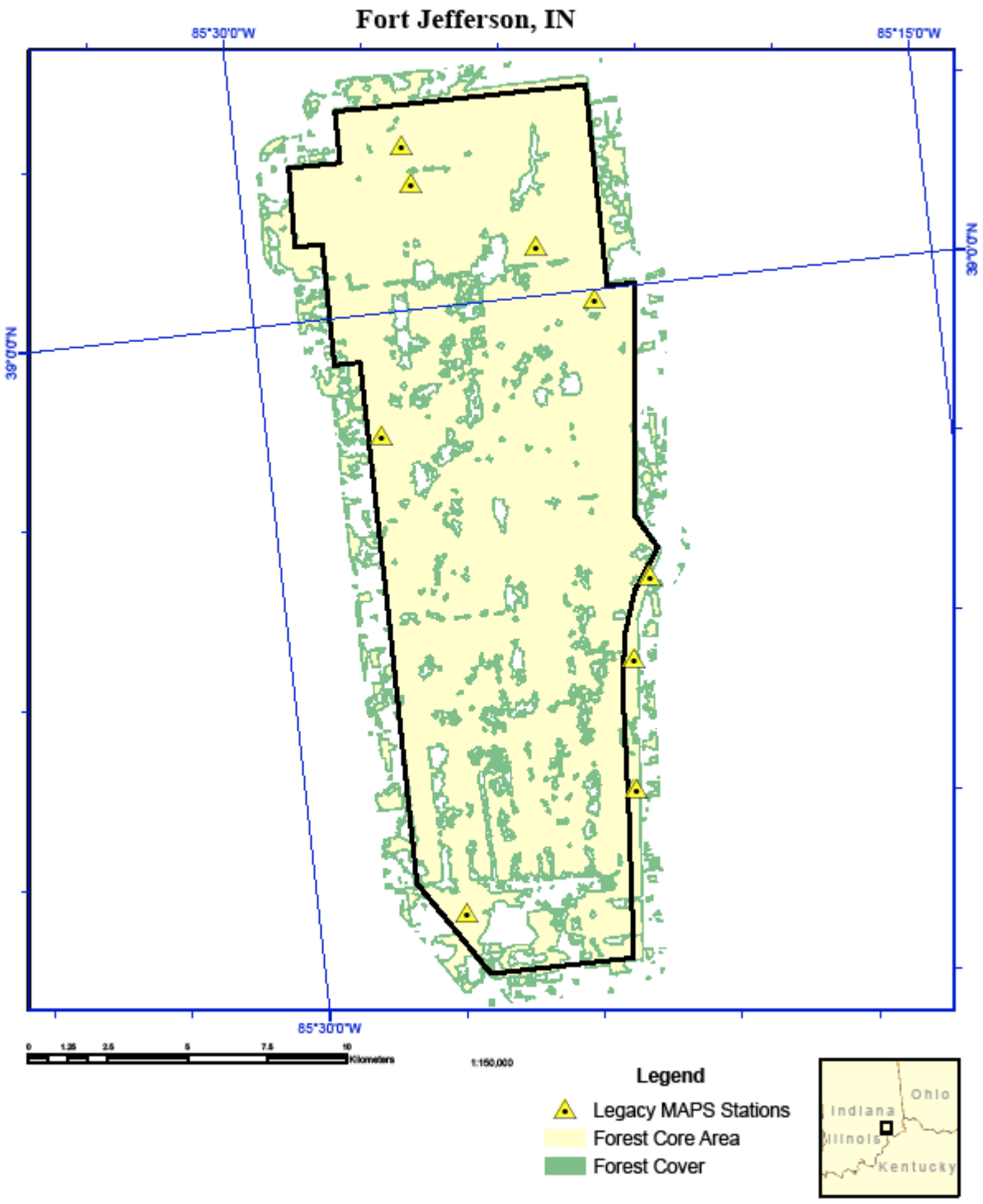

Fort Jefferson, IN
85°30'0"W
85°15'0"W
39°0'0"N
39°0'0"N
85°30'0"W
0 1.25 2.5 5 7.5 10
Kilometers
1:150,000
Legend
Legacy MAPS Stations
Forest Core Area
Forest Cover
Indiana
Ohio
Illinois
Kentucky

Figure 19

Map of forest cover within the boundaries (plus 1km) of Fort Knox, KY. White space denotes land cover other than forest. Forest patches are shown as green outlines and yellow patches whereby the green outline represents a 90m wide interior buffer and the yellow area is defined as forest core area (i.e. at least 90m from forest edge).

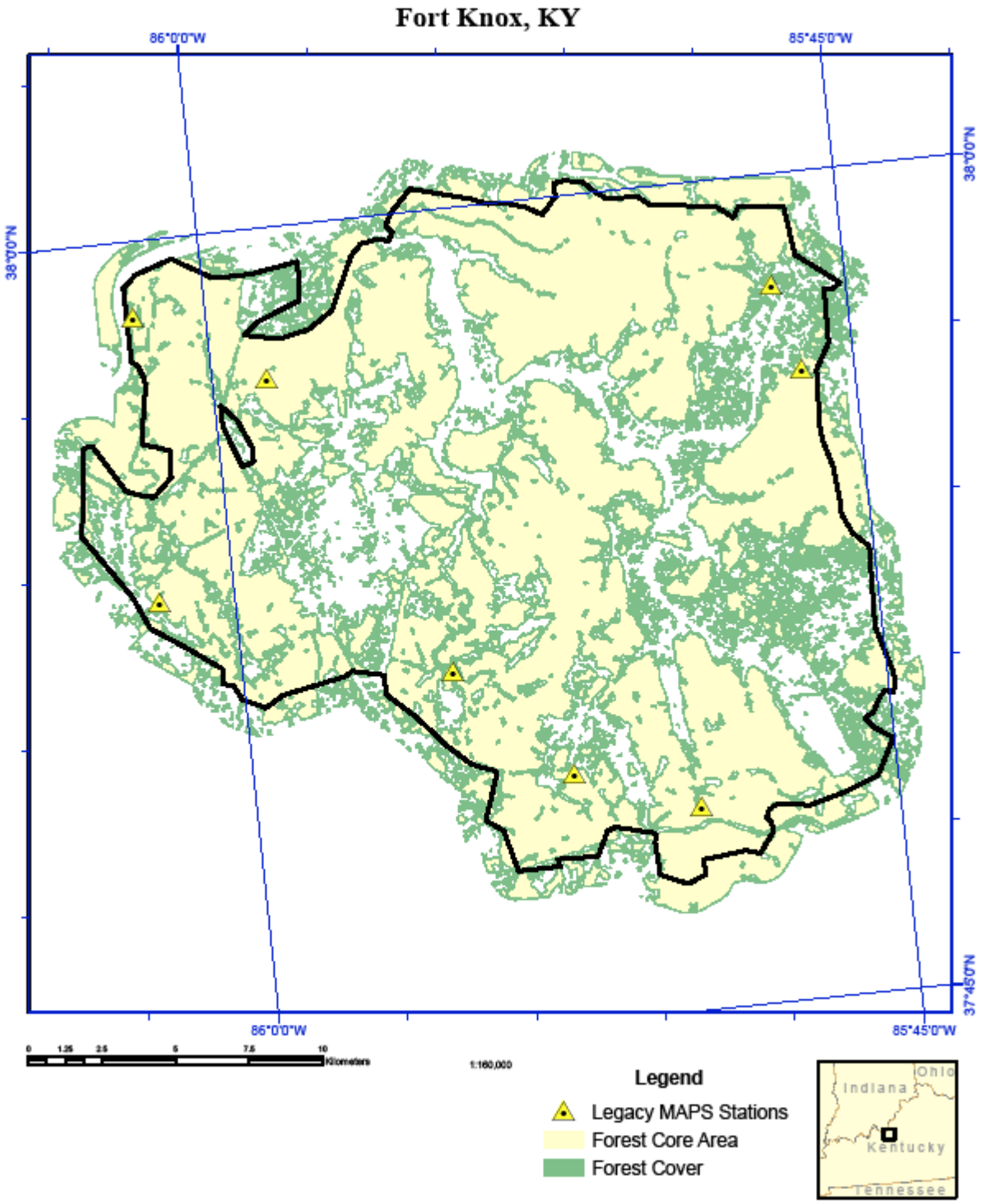

Fort Knox, KY
86°0'0"W
85°45'0"W
38°0'0"N
37°45'0"N
0 1.25 2.5 5 7.5 10
Kilometers
1:160,000
Legend
Legacy MAPS Stations
Forest Core Area
Forest Cover
Ohio
Indiana
Kentucky
Tennessee

Figure 20

Map of forest cover within the boundaries (plus 1km) of NWSC Crane, IN. White space denotes land cover other than forest. Forest patches are shown as green outlines and yellow patches whereby the green outline represents a 90m wide interior buffer and the yellow area is defined as forest core area (i.e. at least 90m from forest edge).

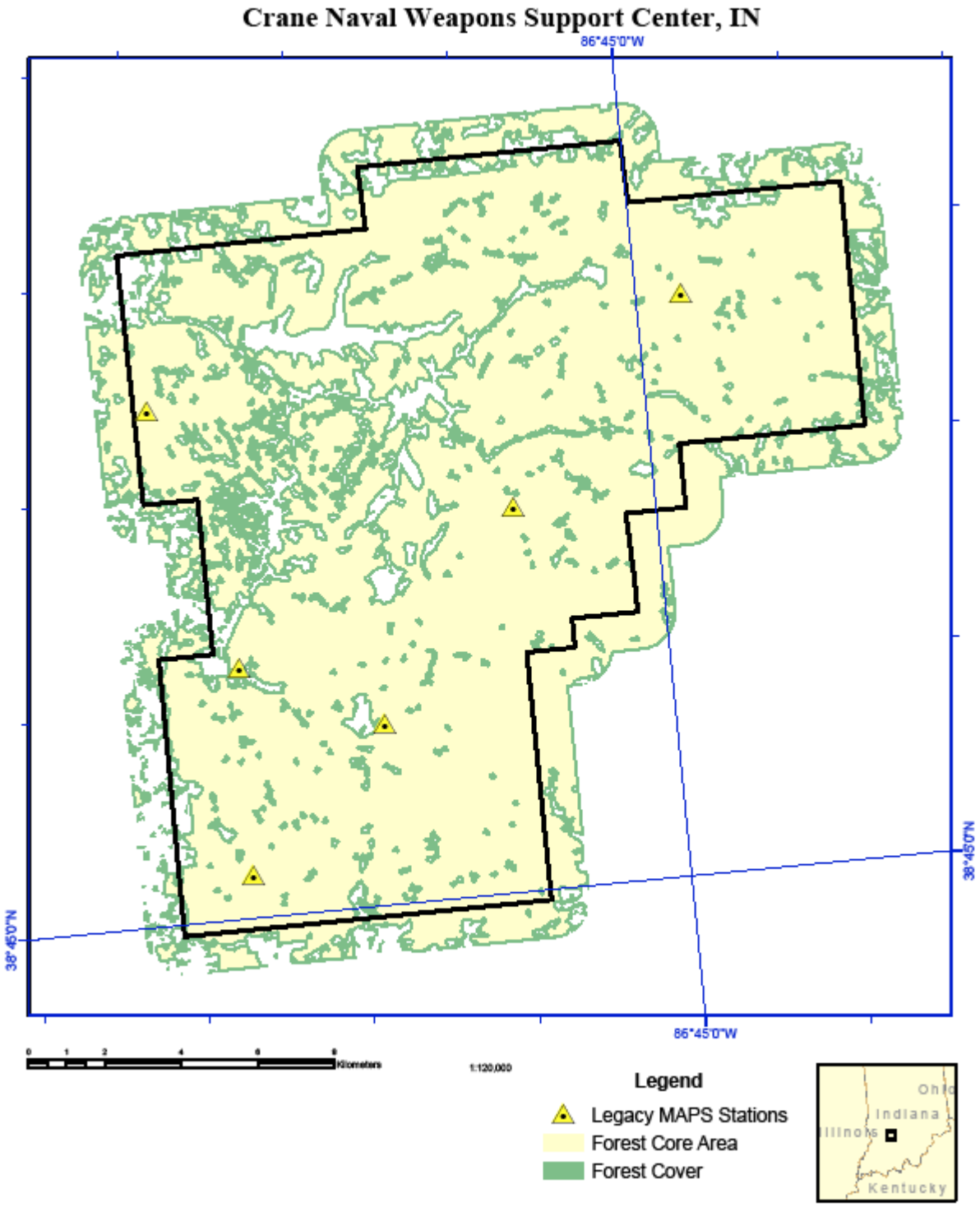

Crane Naval Weapons Support Center, IN
86°45'0"W
38°45'0"N
0 1 2 4 6 8
Kilometers
1:120,000
Legend
Legacy MAPS Stations
Forest Core Area
Forest Cover
Ohio
Indiana
Illinois
Kentucky

Figure 21

Map of forest cover within the boundaries (plus 1km) of Fort Leonard Wood, MO. White space denotes land cover other than forest. Forest patches are shown as green outlines and yellow patches whereby the green outline represents a 90m wide interior buffer and the yellow area is defined as forest core area (i.e. at least 90m from forest edge).

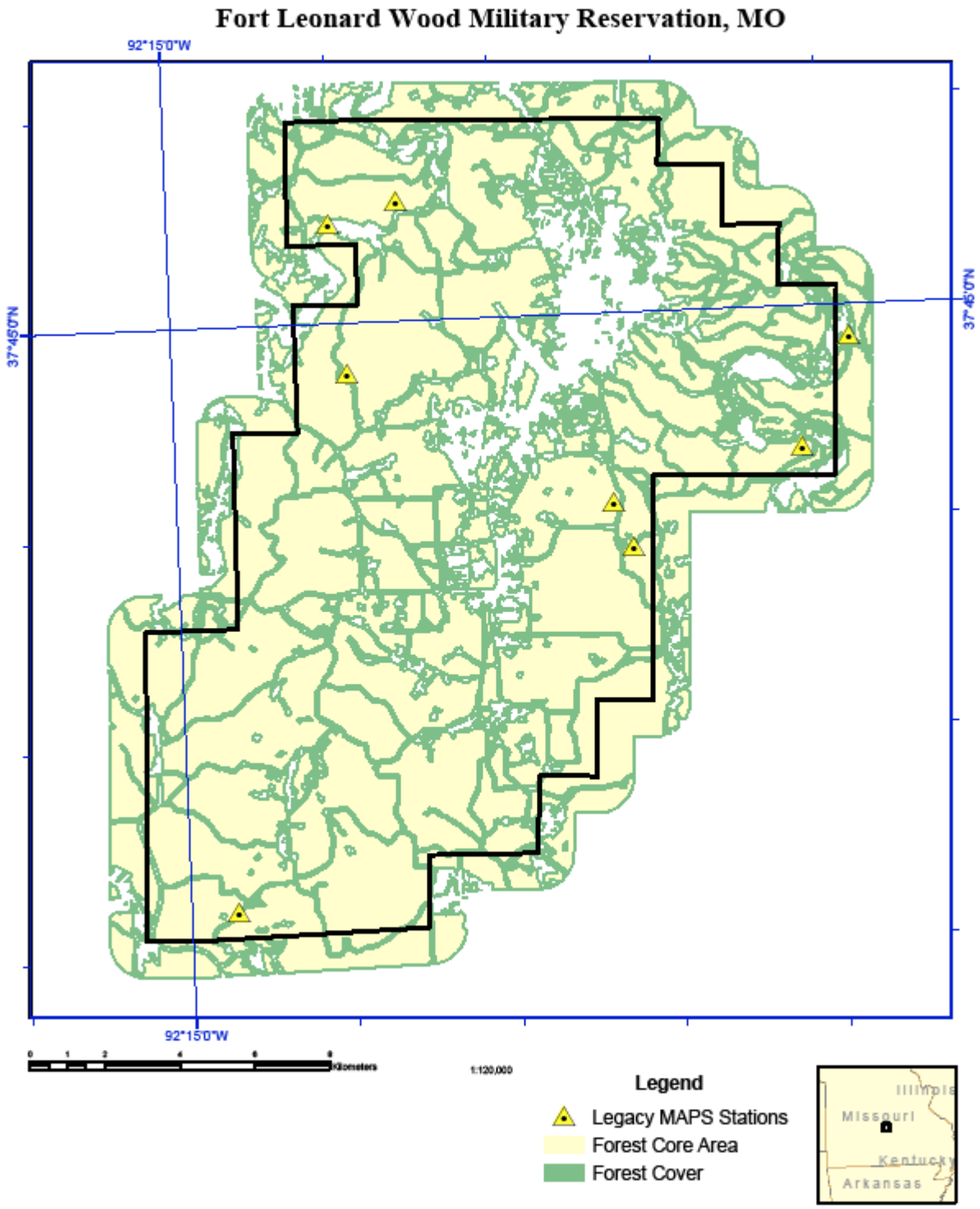

Fort Leonard Wood Military Reservation, MO
92°15'0"W
37°45'0"N
92°15'0"W
37°45'0"N
0 1 2 4 6 8
Kilometers
1:120,000
Legend
Legacy MAPS Stations
Forest Core Area
Forest Cover
Missouri
Arkansas

Figure 22

Map of forest cover within the boundaries (plus 1km) of Camp Swift, TX. White space denotes land cover other than forest. Forest patches are shown as green outlines and yellow patches whereby the green outline represents a 90m wide interior buffer and the yellow area is defined as forest core area (i.e. at least 90m from forest edge).

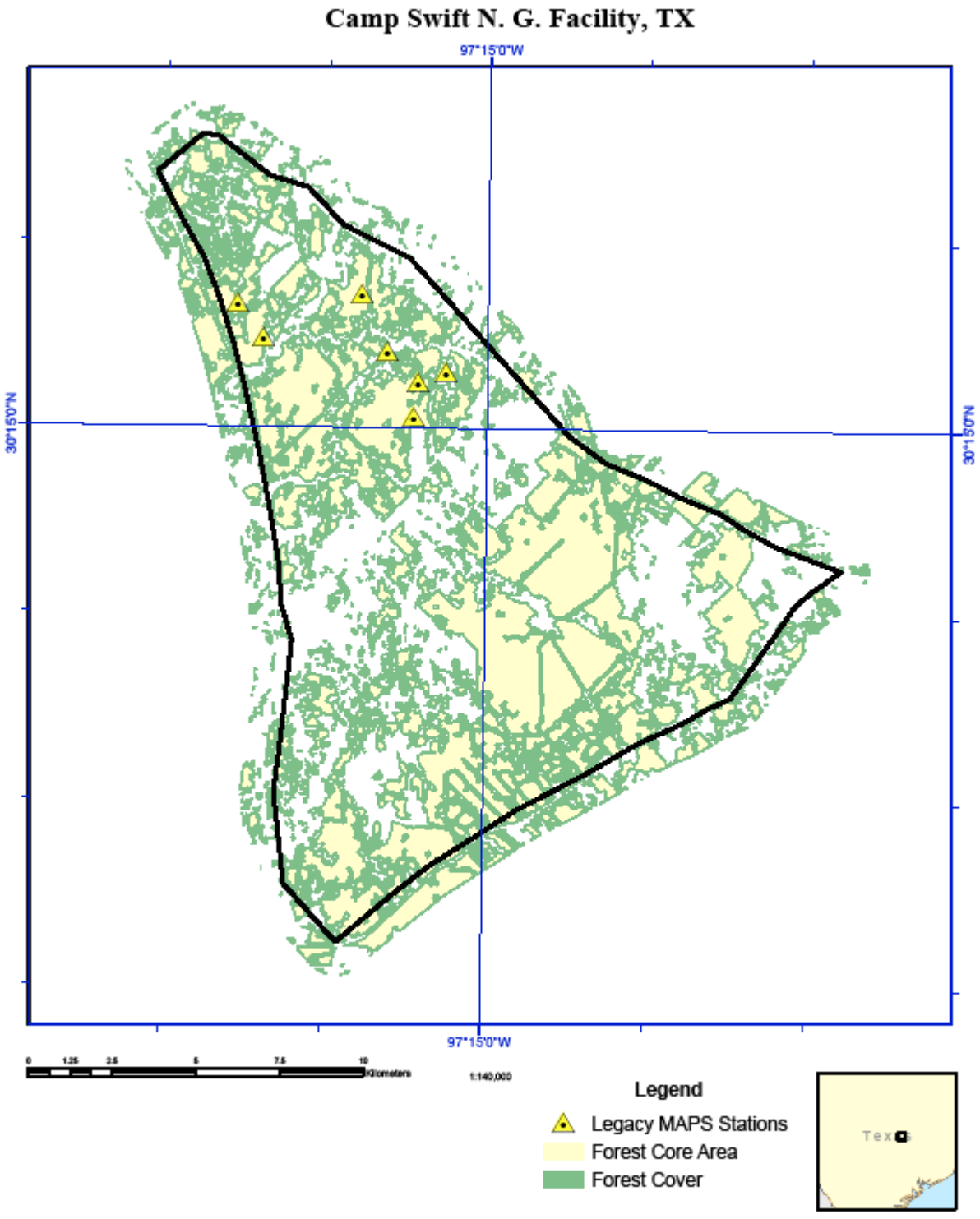
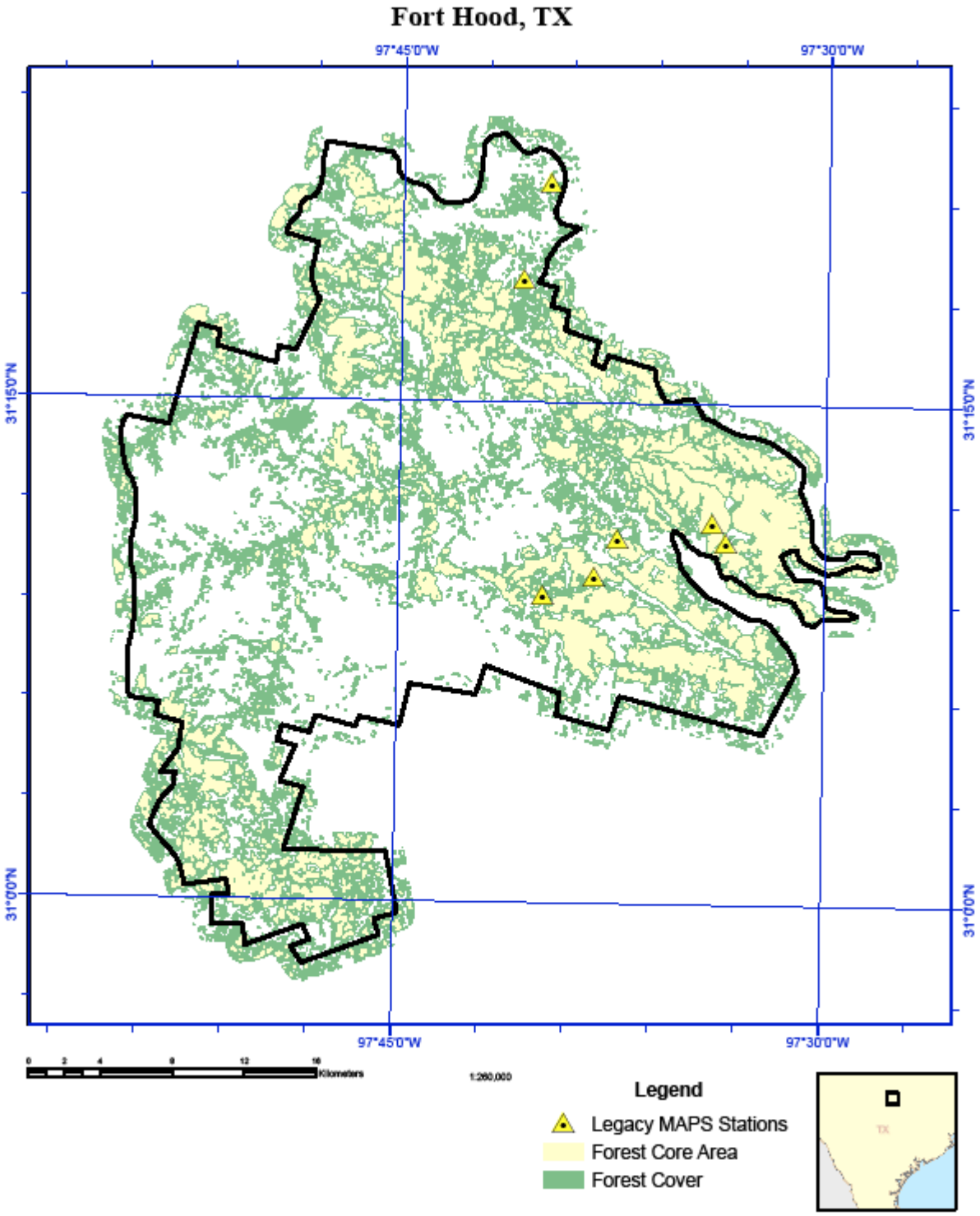

Camp Swift N. G. Facility, TX
97°15'0"W
30°15'0"N
97°15'0"W
30°15'0"N
0 1.25 2.5 5 7.5 10
Kilometers
1:140,000
Legend
Legacy MAPS Stations
Forest Core Area
Forest Cover
Tex

Figure 23

Map of forest cover within the boundaries (plus 1km) of Fort Hood, TX. White space denotes land cover other than forest. Forest patches are shown as green outlines and yellow patches whereby the green outline represents a 90m wide interior buffer and the yellow area is defined as forest core area (i.e. at least 90m from forest edge).


Fort Hood, TX
97°45'0"W
97°30'0"W
31°15'0"N
31°0'0"N
0 2 4 8 12 16
Kilometers
1:260,000
Legend
Legacy MAPS Stations
Forest Core Area
Forest Cover
TX