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

**A REPORT TO THE**

## U.S. DEPARTMENT OF DEFENSE

## LEGACY RESOURCES MANAGEMENT PROGRAM

**documenting the findings of progress in investigating**

**ENHANCED SPECIES-LANDSCAPE MODELS OF AVIAN DEMOGRAPHICS**

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**and**

**THE INSTITUTE FOR BIRD POPULATIONS**

**prepared by**

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

## ENHANCED SPECIES-LANDSCAPE MODELS OF AVIAN DEMOGRAPHICS

### BACKGROUND

The Institute for Bird Populations, through its Monitoring Avian Productivity and Survivorship (MAPS) program (1994-2002), effectively monitored 34 landbird species on 13 U.S. Department of Defense installations (or groups of installations) across the eastern and central United States. 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*" (Rich et al. 2004). In 2006, the 1994-2005 bird banding data was used to track species of conservation concern on each installation and the local populations that had declined (i.e. species of management concern). By 2006 we had reorganized the network of monitoring stations by replacing eight stations on five of eight installations in 2003 (3), 2004 (3), and 2005 (2). The eight new stations were located to a) monitor the effects of land management intended to sustain military range activities (i.e., range sustainment), and b) better monitor birds of conservation concern on each of a subset of eight installations. Another station at Fort Knox will be moved at the beginning of the 2007 season to better monitor Blue-winged Warblers.

To provide management guidelines intended to maintain healthy populations or reverse local declines in Neotropical migratory birds and other landbirds, we constructed species-landscape models. To achieve this we explored the relationships between demographic parameters calculated from banding data and landscape metrics calculated from the National Land Cover Dataset (NLCD; 1992). These models were used to predict the effects of landscape change (i.e. management) on adults, trends in adults, numbers of young, and reproductive success.

For six species of conservation concern, we validated 10 models among eight stations located on six installations. Three of the models predicted adult numbers to within two individuals of the observed numbers. The other seven models underestimated the number of birds actually banded by as much as 40%. However, in three of the validations the observed numbers were an average of two years, and only a single year of data was available for the other three. Overall, however, the models were useful in predicting the numbers of individuals captured.

Here we report on the progress of model enhancements considering spatio-temporal environmental variation. The Legacy-funded MAPS dataset covers a large area of the United States and the different locations experience very different weather patterns during the breeding season. In addition, many species are migrants and a population from one location may experience very different winter conditions to those experienced by a population from another location that overwinters in a different portion of the winter range. Using 1994-2002 data we noticed that reproductive success was high towards the end of the period such that 24 of 34 species analyzed experienced overall increases in young and reproductive success between 1994 and 2002. Trends in numbers of young significantly increased for nine species including three species of conservation concern, Acadian Flycatcher, Prairie Warbler, and Painted Bunting. In all cases, the two most productive years of the whole period occurred in those last four years (1999-2002). Analysis of 1994-2005 data showed, for some species (e.g. Painted Bunting), further drastic increases in numbers of adults and young captured. Previous research (Nott 2002, Nott et al. 2002, Sillett et al. 2002) showed that high annual variation correlated with weather conditions on the both the breeding and overwintering grounds.

The Legacy-funded MAPS dataset is collected from a vast region including portions of Maryland, Virginia, North Carolina, Indiana, Kentucky, Kansas, Missouri, and Texas. We would therefore expect considerable spatial variation in weather conditions and climate across this region. Furthermore, populations of the same migratory species from different locations are likely to overwinter (and/or molt migrate) to different parts of the overwintering (and/or molt migration) range and experience different conditions. So, all other things being equal, a population in one part of the breeding range may exhibit a very different pattern of demographics to a population in another part of the breeding range. More importantly, the species- and population-specific influences of weather and climate need to be quantified in order to confidently assess the effects of land management.

## METHODS

We analyzed two publicly available global datasets quantifying precipitation and "greenness". Precipitation data were provided by the Global Precipitation Climatology Project (GPCP), which is maintained by the National Aeronautical and Space Agency and made available through the University of Washington's Joint Institute for the Study of the Atmosphere and Ocean (JISAO) as gridded monthly precipitation data in netCDF format (Huffman et al. 1997, Rew et al. 1993). We extracted seasonal datasets spanning 1981 to 2005 to reflect precipitation patterns a) during the North American monsoon (July-September) which may affect the quality of molt-migration habitat in northwest Mexico, b) prior to the breeding season (January to April) which may determine habitat conditions for returning migrants, and c) during the breeding season (May to August) which may affect invertebrate biomass.

**Table 1**. List of 13 Legacy-funded MAPS monitoring locations and associated DoD installations with location codes, states, and geographic coordinates to the nearest degree.

| Location | State | Military Installations | Lat | Long |
|---|---|---|---|---|
| BELV | VA | U.S. Army Fort Belvoir, U.S. Army Fort A.P. Hill, and Mason Neck National Wildlife Refuge | 38 | -77 |
| NAVY | MD | Patuxent River Naval Air Station, Dahlgren Naval Surface Warfare Center, and Indian Head Naval Weapons Support Center | 38 | -77 |
| TIDE | VA | Naval Amphibious Base Little Creek Annex Camp Pendleton, Naval Air Station Oceana, Naval Air Static Oceana Auxiliary Landing Field Fentress, and Naval Security Group Activity Northwest | 36 | -77 |
| BRAG | NC | U.S. Army Fort Bragg | 35 | -79 |
| JEFF | IN | U.S. Army Jefferson Proving Ground now operated by USFWS as Big Oaks NWR | 38 | -85 |
| KNOX | KY | U.S. Army Fort Knox | 37 | -86 |
| CRAN | IN | Crane Naval Surface Warfare Center | 38 | -86 |
| LEON | MO | U.S. Army Fort Leonard Wood | 37 | -92 |
| LEAV | KS | U.S. Army Fort Leavenworth and Sunflower Army Ammunition Plant | 39 | -94 |
| RILE | KS | U.S. Army Fort Riley | 39 | -96 |
| SWIF | TX | Texas National Guard Camp Swift | 30 | -97 |
| HOOD | TX | U.S. Army Fort Hood | 31 | -97 |
| BOWI | TX | Texas National Guard Camp Bowie | 31 | -98 |

These data were analyzed across an extent of North America, Mexico, and Central America (0-50ºN, 80-130ºW), and from individual 2.5 degree-resolution cells associated with DoD installations where Legacy-funded MAPS stations are operated (Table 1). For the period 1994-2005 we mapped temporal trends (1981-2005) in seasonal precipitation data (cm/month) to identify regions undergoing significant change.

The Normalized Difference Vegetation Index (NDVI) provides a rough measure of photosynthetic activity (or "greenness") which has been shown to be correlated with green leaf biomass and green leaf area index (Cihlar et al. 1991). Although NDVI provides a good measure of green canopy cover it is not a good indicator of physiological activity (Stylinski 2000). This 1-degree resolution gridded dataset covers the period 1980-1999 and was analyzed to provide maps of trends in greenness.

We developed a suite of programs in the MatLab programming environment (Mathworks Inc.) to a) extract, analyze, and visualize annual patterns of seasonal precipitation (GPCP) and greenness (NDVI), and b) investigate temporal correlations with pre-analyzed demographic data from groups of MAPS stations for which seasonal precipitation data were analyzed from appropriate 2.5 degree resolution GPCP cells. Appendices to this document show histograms of monthly means or annual variation in seasonal precipitation.

## RESULTS

At the resolution of 2.5 degrees (approximately 275km), spatial patterns of precipitation show a high degree of spatial auto-correlation such that neighboring DoD installations exhibit similar patterns. Thus, we report (Appendix 1) on the following clusters of locations for the period 1981-2005:

Cluster I - The NAVY and BELV locations of coastal Virginia and Maryland lie at a latitude of ~37°N (12 stations in two neighboring cells). Monthly precipitation (mean

9.39cm/mo) varied little (9-11cm/mo) throughout the year, but peaked in the months March, May, and July.

Cluster II - The BRAG and TIDE locations of inland and coastal Carolinas lie around the latitudes of ~35-36°N (12 stations in two neighboring cells). Monthly precipitation (mean 10.75cm/mo) varied more (6-15cm/mo) than it did further North throughout the year but, typically for the southeastern region of the United States, peaked in the months July and August.

Cluster III - The JEFF, CRAN and KNOX locations of southern Indiana and northern Kentucky lie around the latitudes of ~37-38°N (18 stations in three neighboring cells) and inland by 700 miles. Monthly precipitation (mean 9.60cm/mo) varied between 7 and 15cm/mo throughout the year, and peaked in the months April through July, and later in November and December.

Cluster IV - The LEON, RILE, and LEAV locations in Missouri and Kansas lie at between the latitudes of ~37-39°N (18 stations in three non-adjacent cells), but are separated by four latitudinal degrees. Consequently, although the monthly mean patterns are similar, the more southerly LEON exhibits a pattern more similar to the Indiana and Kentucky locations with peaks in April through July and again in November and December. The monthly precipitation varied between 6 and 12cm/mo throughout the year (mean 9.57cm/mo). At RILE and LEAV, however, mean monthly rainfall was lower (8.01 and 9.38cm/mo, respectively) and more variable, peaking in the summer months at ~15cm/mo but below 5cm/mo in January. There is no second peak in November and December. Considering these results, LEON should perhaps be grouped with the Indiana and Kentucky stations.

Cluster V - The SWIF, BOWI, and HOOD locations of central Texas lie at a latitude of ~30-31°N (18 stations in three neighboring cells). Monthly precipitation at SWIF and HOOD (mean 9.15cm/mo) varied between 5 and 14 cm/mo throughout the year and peaked in the months May and June. A second peak occurred between September and

November. The pattern was very similar at BOWI but generally drier such that monthly precipitation (mean 6.44cm/mo) varied between 4 and 10cm/mo throughout the year.

**Patterns of seasonal rainfall (1981-2005)**

The October to March period represents the period of least precipitation in most of the southeastern and central southern states (Appendix 2). In Texas, January and February are normally the driest months but precede the return of Neotropical migrants in the Spring. Long-term patterns in October to March precipitation (1981-2005) show common maxima in 1983, 1984, 1987, 1993, 1994, 1998, and 2003 for east coast locations (NAVY, BELV, BRAG, and TIDE). Patterns for the inland cluster of locations (JEFF, KNOX, CRAN, and LEON) differ, with common maxima in 1984, 1985, 1989, 1991, 1994, 1997, 2002 and 2005. Patterns for the more westerly inland locations (LEAV and RILE) are similar with common maxima in 1984, 1985, 1993, 1998, 1999, 2001, 2003, 2004, and 2005. The wetter Texas locations (SWIF and HOOD) showed common maxima in 1983, 1985, 1987, 1992, 1993, 1995, 1998, 1999, 2001, 2003 and 2005. Most of these wettest years coincide with EL-Nino events that occurred in the winters of 1983-84, 1987-88, 1991-92, 1992-93, 1994-95, 1997-98, and 2002-03. The driest years common to most locations were 1981, 1984, 1988, 1996, 1999 and 2000 which coincided with La Nina conditions in 1988-89, 1998-99, and 2000-01.

The long term trends for east coast and inland locations are mostly slightly negative but not statistically significant, with the exception of LEAV which is getting drier by 0.04cm/mo for the winter months ($P<0.05$). All three Texas locations have increased non-significantly. In the shorter-term of Legacy-funded MAPS station operation (1994-2005), no significant trends were detected, but east coast locations declined and all other locations increased.

Long –term patterns in breeding season precipitation (May to August) also showed coincidence to El Niňo events with maxima in 1984, 1992, 1998, and 2003 (Appendix 3). Although this was true for east coast and inland locations, the more westerly locations (LEAV, RILE and Texas locations).showed the opposite pattern. For those locations most El Niňo events coincided with the lowest summer precipitation levels in 1984, 1988, 1998, and 2003. For most locations, record summer precipitation levels for the 25-year period were recorded in either 2003 or 2004, Wet summers were also widespread over the periods 1981-1983 and 1989-1992,

Over the shorter period of Legacy-funded MAPS station operation (1994-2005) summer precipitation increased at all locations except LEON because high levels were recorded after 1999. On the east coast high precipitation was recorded in 2000, 2003, and 2004. JEFF, KNOX, CRAN and LEON showed common maxima in 2003 and 2004. For LEAV and RILE high levels were recorded in 1995, 2001, 2004, and 2005. The Texas locations peaked in 2001, 2002, and 2004.

**Large-scale patterns**

Stressors on migratory North American landbirds may operate throughout the life cycle such that their ability to survive and produce offspring may depend upon conditions that they experience on the breeding grounds, the wintering grounds, and during migration. Another group of species have evolved as molt-migrants (e.g. Painted Bunting in Texas), which typically leave the breeding grounds as early as July to fly to habitats of northwest Mexico where they stop for several weeks to replace their flight feathers before continuing to their wintering grounds further south. Although 15 species are typically recognized as molt migrants there may be as many as 30 that follow this evolutionary strategy.

The annual North American monsoon region is typically described as the region which receives more than 50% of its annual rainfall in the months July through September. Appendix 4.1 depicts maps of statistics associated with July to September precipitation. The monsoon region covers southeast Arizona, southwest New Mexico, south to the Sierra Madre Occidental in the Mexican states of Sinaloa, Durango, Sonora and Chihuahua. This region includes the critical habitats in which molt migrant species replace their flight feathers. A cell-by-cell analysis of GPCP data for the annual Nort American monsoon precipitation (July-September) revealed highly variable seasonal means along the west coastal region of North America from 20°N to 40°N (Appendix 4.1b), especially in the monsoon region where a maximum CV of 1.2 was detected around Baja and Sonora. High variability also extends from the coastal states across Idaho, Nevada, Utah, California, Arizona and New Mexico.

A cell by cell regression map (Appendix 4.1c) shows that since 1981 precipitation has declined significantly ($P<0.05$) across the region of high variability detailed above. Further south, however, below the Tropic of Cancer (23°N) trends are mainly positive, especially in the Mexican state of Oaxaca and in Guatemala ($P<0.05$). In contrast, mean monthly precipitation has significantly ($P<0.05$) decreased across Honduras and Nicaragua by up to 5cm per decade. Panama and the northwest tip of Venezuela, at the southern tip of the Painted Bunting wintering range, experienced annual increases in monsoon season precipitation of up to 5cm per decade ($P<0.05$). The precipitation trend map for the monsoon months of July and September (Appendix 4.1c) showed increasing precipitation across a huge swath of North America from Maine, southwest along the Atlantic coast, around the Gulf of Mexico (including the Caribbean islands), and across to southwest Mexico.

One might expect that across this vast region, increases in seasonal precipitation during the growing season would cause variation in leafy biomass. Apart from annual variation, long-term changes in leafy biomass result from land-use change or succession to mature forest. Across much of the eastern, southeastern, and south-central states vast hardwood forests were logged by the 1930's. Since then regeneration has occurred and portions of the original forested areas are now reaching maturity.

A map of Normalized Difference Vegetation Index (NDVI) trends (1981-1999) revealed spatially extensive patterns of increasing greenness. Indeed, maps of mean monthly NDVI trends for the North American monsoon months, July to September, (Appendix 4.2) revealed significantly ($P<0.05$) increasing trends throughout a wide swathe from

Maine across to Ohio and Pennsylvania and then southwest across the central southern states into Texas, southeast of the Edwards Plateau, to the Rio Grande. The strongest increasing trends occurred in the region of the Dakotas and Montana. These patterns persisted for analyses of NDVI during the months April to June when the Painted Buntings in this study normally breed. Inspection of annual values from a subset of selected cells across the breeding and wintering ranges typically revealed high NDVI values in 1983, 1992, and 1998, corresponding to breeding seasons that followed El Niňo events. Precipitation was also high in those years.

It is difficult to assess the proximate reason for the recent widespread increases in NDVI. Although these long-term increases may be due to forest succession and canopy maturation, annual variation in precipitation will limit the greening potential. We would expect more leafy biomass in years of higher growing-season precipitation , such as occurred in the several particularly “green” years that coincided with El Nino activity. Reynolds (1997) also reported that in Texas, precipitation fluctuates as a function of El Nino Southern Oscillation (ENSO) activity whereby springtime precipitation is likely lower than average following La Nina events. It is likely that greener years support higher invertebrate biomass too, leading to increased avian productivity.

In a separate account we established relationships between annual Painted Bunting demographics from the three Texas locations and molt-migration conditions (July-September) in northern Mexico. Following is the abstract of that study extracted from manuscript (Nott et al., Painted Bunting demographics in Texas: survival, reproduction, and migration connectivity) intended for submission to a peer-reviewed journal.

“In 2002, the United States Fish and Wildlife Service (FWS) listed the Painted Bunting (*Passerina ciris*) as a “Bird of Conservation Concern”, and in 2005 recommended it as a focal species of the FWS Migratory Bird Program. Here, we focus on the western race (*ssp. Pallidior*), which according to the North American Breeding Bird Survey (BBS) declined by nearly 2% annually between 1966 and 2005. This decline is generally attributed to loss of breeding habitat, molt-migration habitat in southeastern Arizona and northwestern Mexico, and overwintering habitat in Mexico and Central America. Here we present an analysis of 12 years (1994-2005) of Monitoring Avian Productivity and Survivorship (MAPS) banding data collected at 49 stations throughout Texas and Oklahoma, and two years of data from 14 MoSI (Monitoreo de Sobrevivencia Invernal) stations in Mexico and central America. Both MAPS and BBS data show that a reversal of the long-term population declines has occurred since 2000. MAPS detected drastic increases in the numbers of both adults (40% increase) and young (95% increase). A survival rate analysis revealed that annual survival rates have been high since 2000.

We also analyzed Global Precipitation Climatology Project (GPCP) gridded precipitation data and gridded "greenness" data provided by the Normalized Difference Vegetation Index (NDVI). Despite a 20 year drying trend throughout the molt migration habitats, July-September precipitation, representing the North American monsoon, has been extremely high since 2000. Also, winter (November to February) precipitation has increased across a huge swathe of the United States, from Texas to Maine. Consequently, the winter NDVI levels have increased suggesting the region has become warmer and greener.

An analysis of wing chord lengths from breeding and wintering sites revealed fine-scale geographic variation on the breeding grounds and suggested strong winter site fidelity. Consequently, strong positive correlations emerged between spatially-explicit precipitation data and the Painted Bunting annual survival data throughout the molt-migration region and northern portions of the wintering range. Also, our results suggest that higher winter rainfall on the breeding grounds determine subsequent reproductive success."

These findings underline the need for international cooperation and coordination of extensive year-round demographic monitoring and protection of Neotropical migrants, especially with regard to critical habitats such as molt-migration habitat. In future studies, we intend to explore spatio-temporal relationships between environmental conditions and location-specific demographics for each of the 10 species of management concern, 9 of which are short-distance or Neotropical migrants that are the focus of this agreement. Furthermore, we will attempt to formulate species-landscape models using groupings of stations that experience similar weather patterns (e.g. Indiana and Kentucky locations).

## ACKNOWLEDGEMENTS

We would like to thank the Legacy Resources Management Office for providing the funding to conduct this research. In addition, we would like to thank all previous MAPS biologists and interns who collected these data, and staff of the DoD installations who facilitated access to monitoring sites. Our thanks also extend to Todd Mitchell of the Joint Institute for the Study of the Atmosphere and Ocean (JISAO) at the University of Washington for his advice and help.

**This is Contribution Number 293 of The Institute for Bird Populations**

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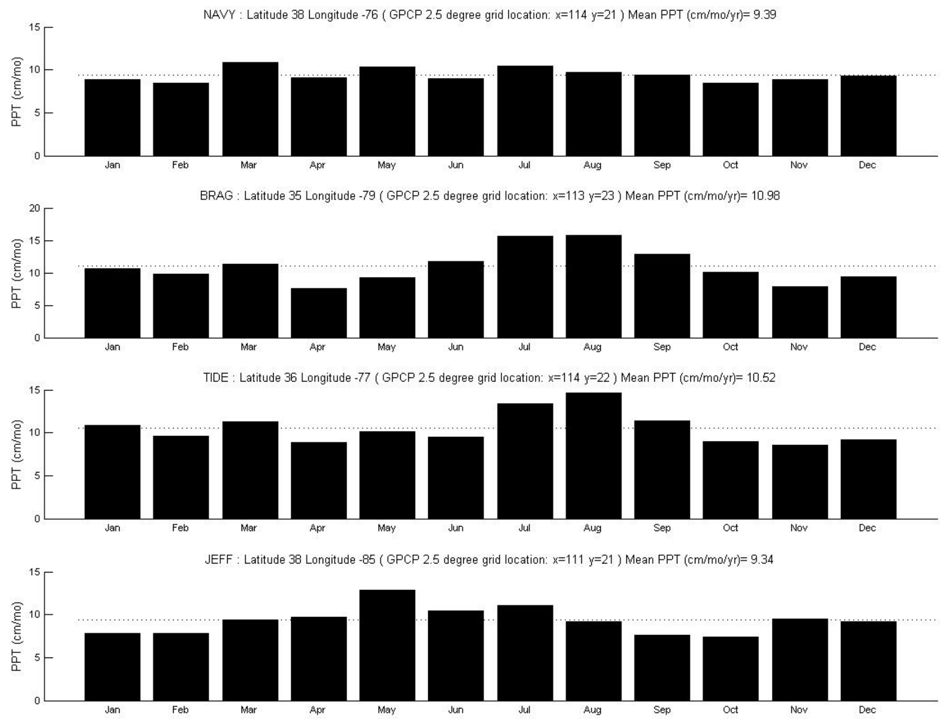
# APPENDIX 1

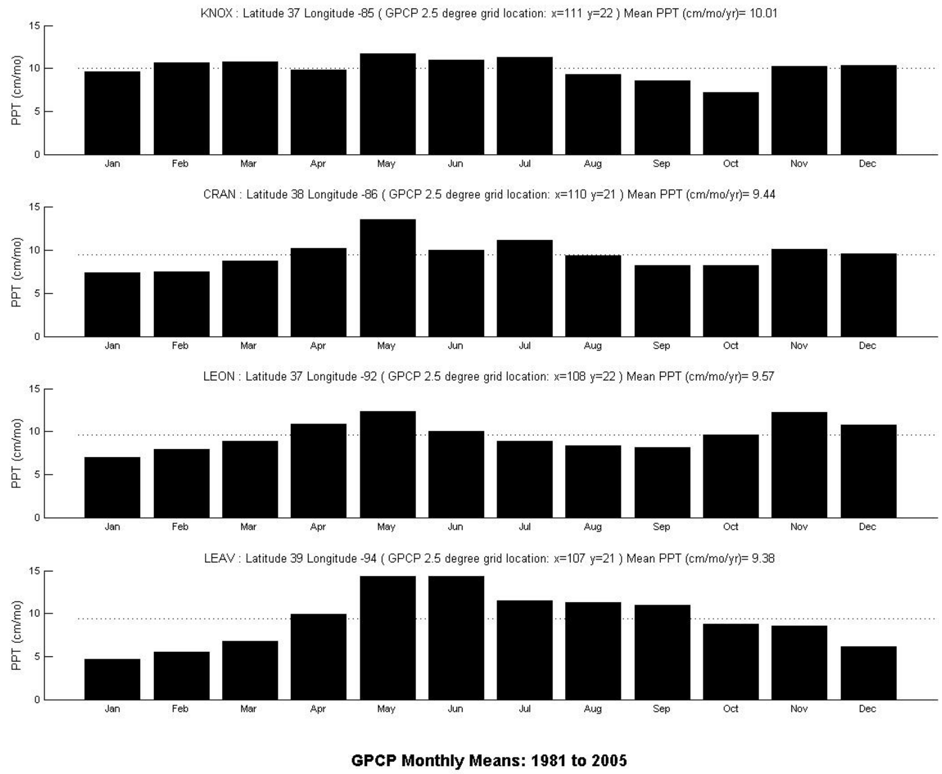
Histograms of monthly mean precipitation calculated from the global 2.5 degree resolution GPCP dataset over the period 1981-2005 at 12 locations where Legacy-funded MAPS stations are operated. NAVY and BELV locations are considered in the same 2.5 degree cell.

Locations 1-4

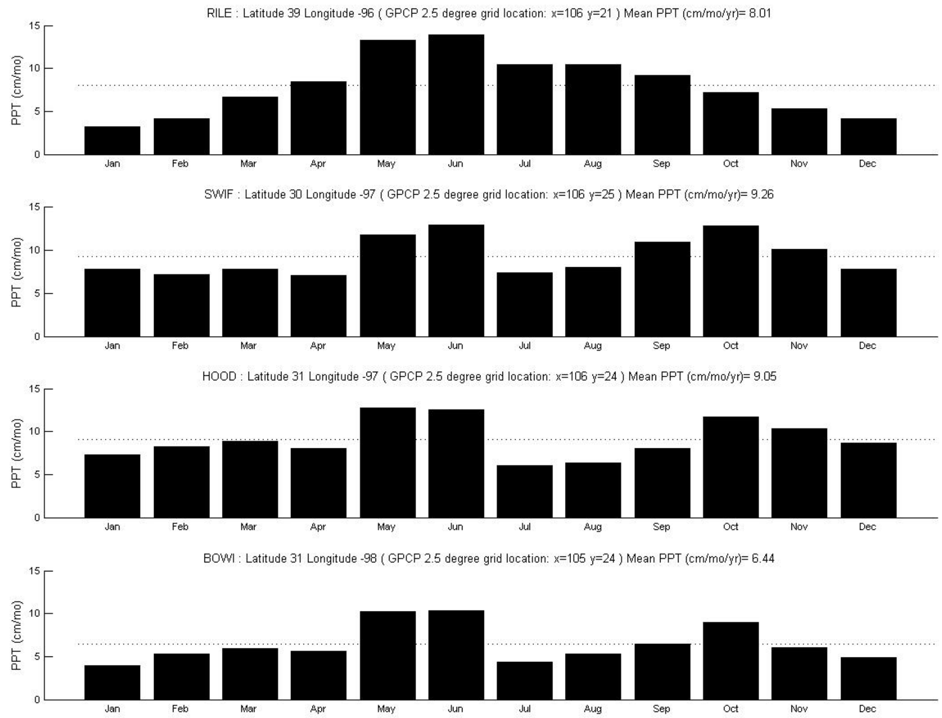



**GPCP Monthly Means: 1981 to 2005**

Locations 5-8



Locations 9-12

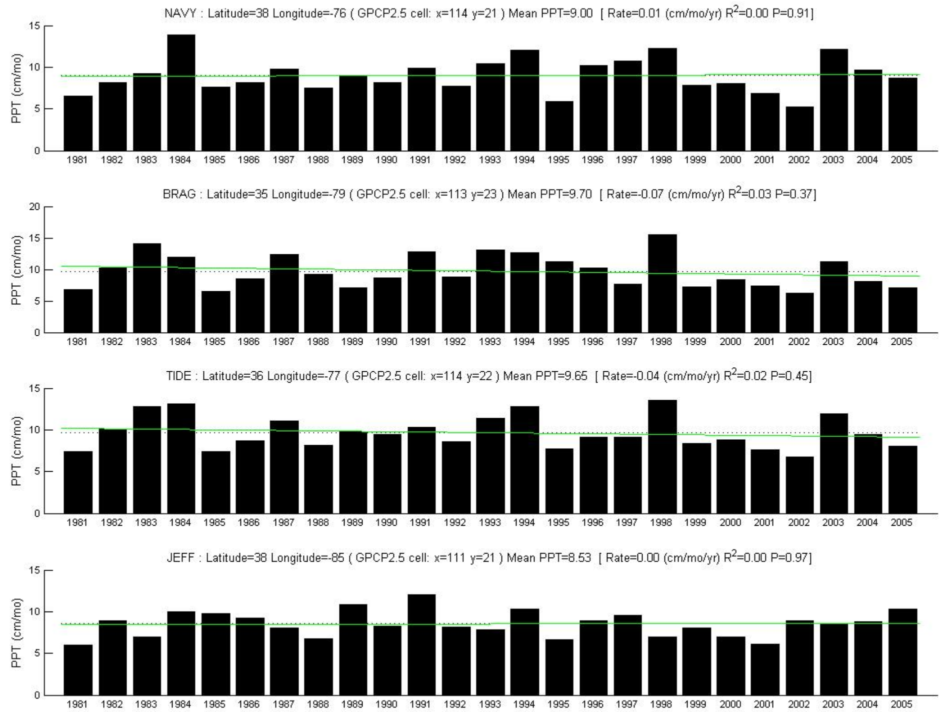



**GPCP Monthly Means: 1981 to 2005**

# APPENDIX 2

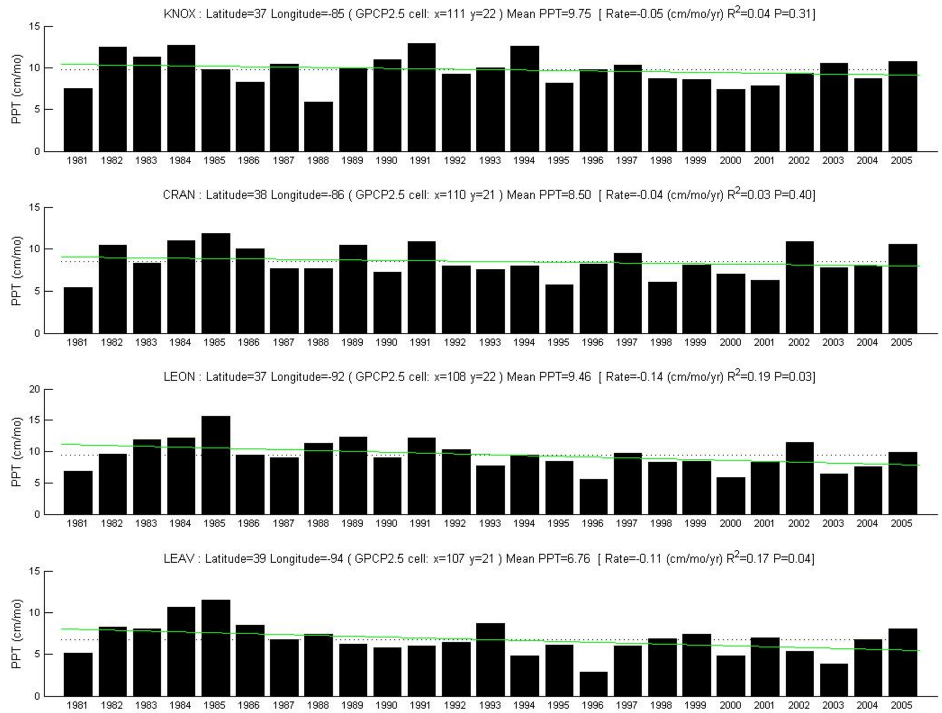
Histograms of seasonal (October to March) mean precipitation calculated from the global 2.5 degree resolution GPCP dataset over the period 1981-2005 at 12 locations where Legacy-funded MAPS stations are operated.

Locations 1-4



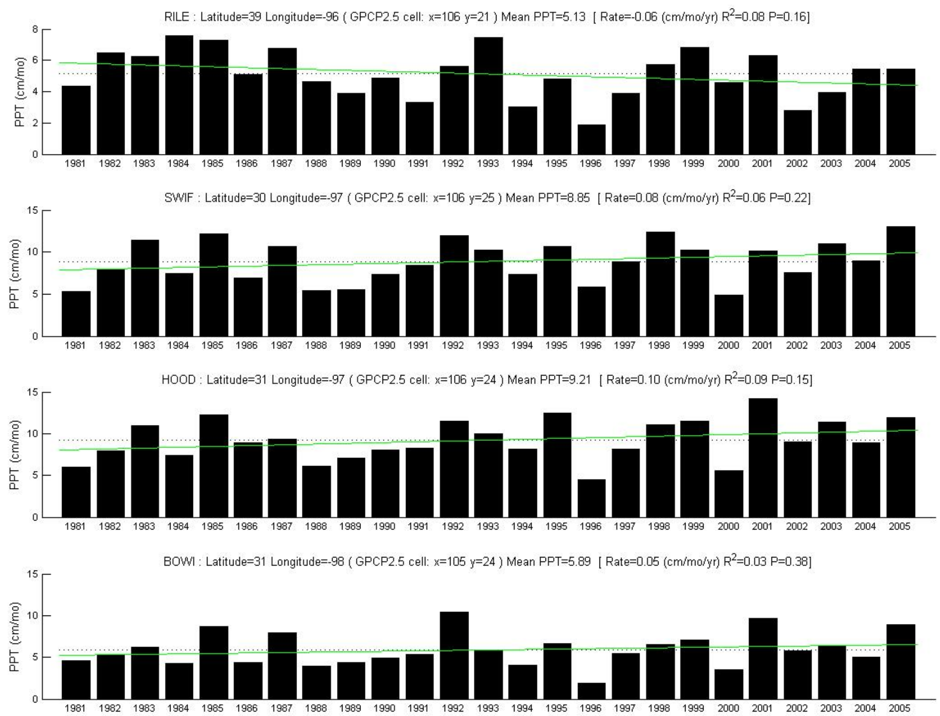

**GPCP monthly means for Oct to Mar (0 year lag)**

Locations 5-8




**GPCP monthly means for Oct to Mar (0 year lag)**

Locations 9-12

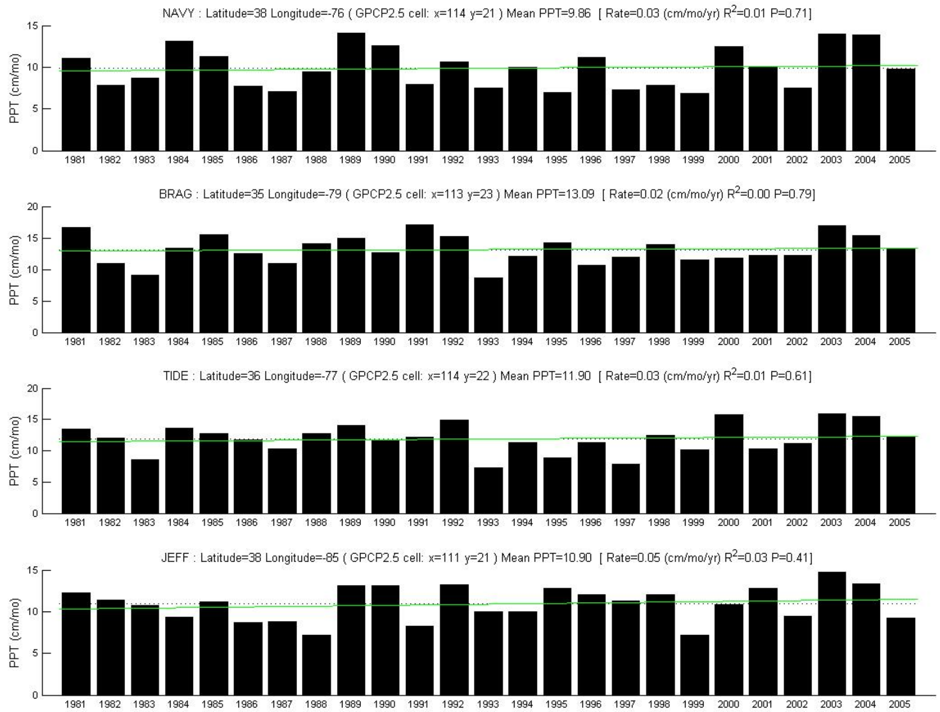



**GPCP monthly means for Oct to Mar (0 year lag)**

# APPENDIX 3

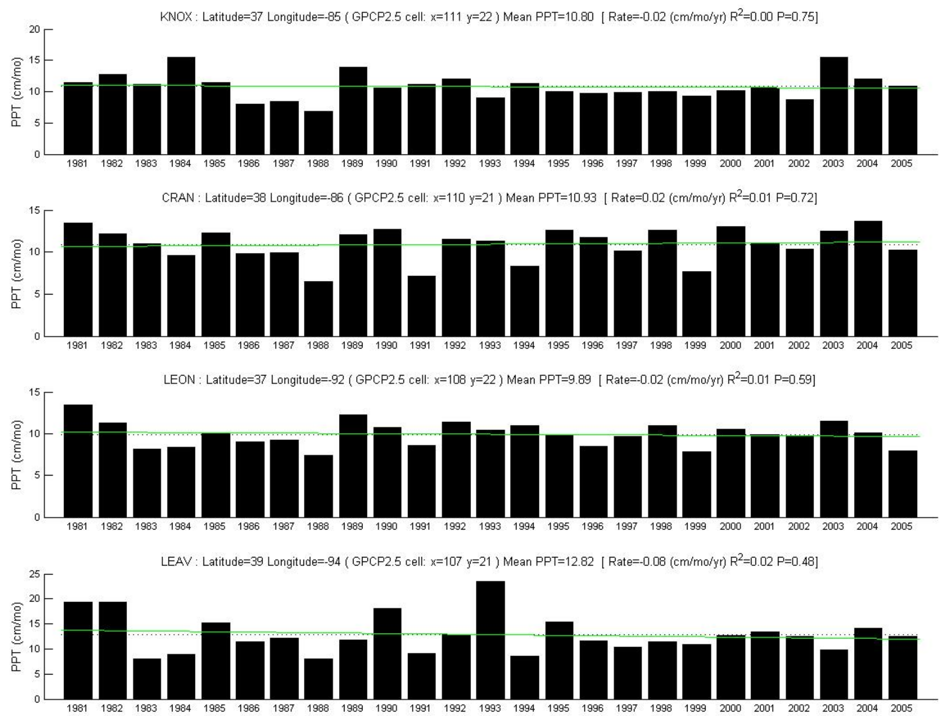
Histograms of seasonal (October to March) mean precipitation calculated from the global 2.5 degree resolution GPCP dataset over the period 1981-2005 at 12 locations where Legacy-funded MAPS stations are operated.

Locations 1-4



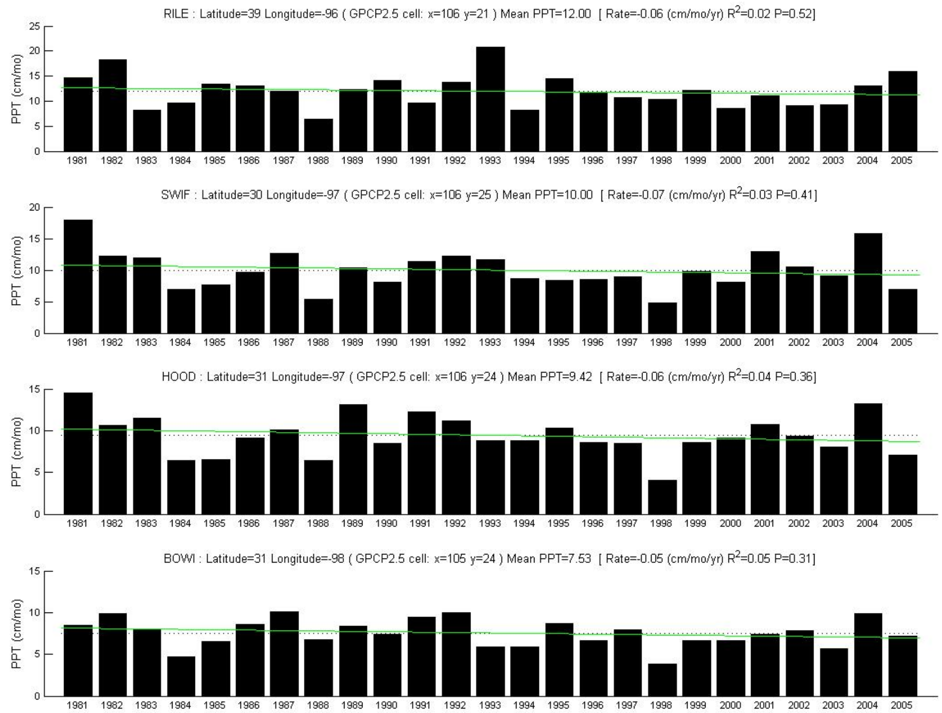

**GPCP monthly means for May to Aug (0 year lag)**

Locations 5-8




**GPCP monthly means for May to Aug (0 year lag)**

Locations 9-12



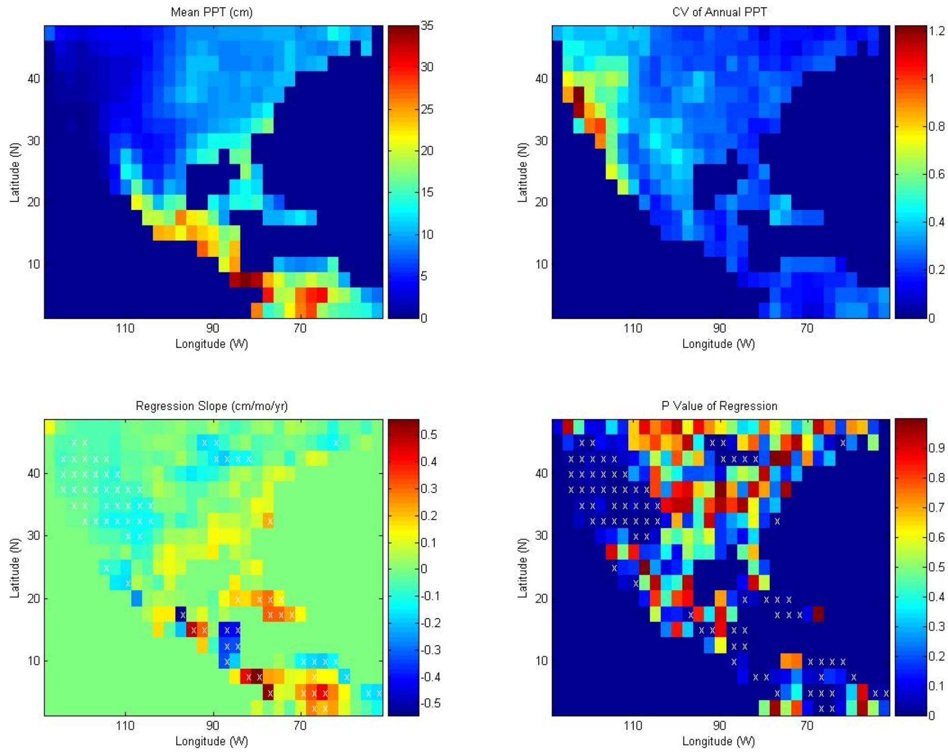

**GPCP monthly means for May to Aug (0 year lag)**

# APPENDIX 4

1) Maps of monsoon season (July to September) precipitation statistics calculated from the global 2.5 degree resolution GPCP dataset over the period 1981-2005 showing, from left to right, a) mean precipitation (cm/mo), b) coefficient of variation in mean precipitation, c) trend (regression slope) in seasonal precipitation "x" denotes a significant ($P<0.05$) slope, and d) associated P-values of the trend map.

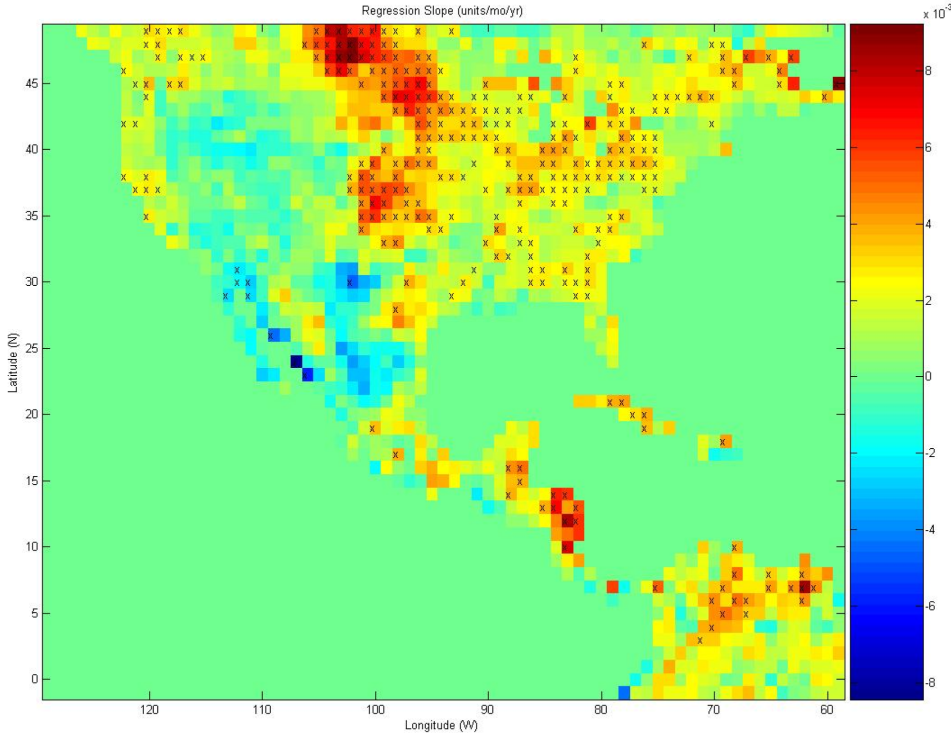
2) Trend (regression slope) map of monsoon season (July to September) NDVI values calculated from the global 1 degree resolution NDVI dataset over the period 1981-2005. Significant trends ($P<0.05$) are denoted by an 'x' in the cell. Steep positive slopes are colored red, and steep negative trends are colored blue.

# Appendix 4.1. Global Precipitation Climatology Project




**GPCP2.5 Precipitation Data Analysis: 1981 to 2005 for Jul-Sep (0 year lag)**

Appendix 4.2. Normalized Difference Vegetation Index Trend Map.




**NDVI 1 Degree Data Analysis: 1980 to 1999 for Jul-Sep (0 year lag)**