8. COTTON

The habitat provided by fields planted to cotton (*Gossypium* spp.) has very little value to North American waterbirds. Cotton requires high temperatures to grow, and thus in North America, the crop is grown at southern latitudes that have at least a 180-day frost free growing season (Luttrell 1994, Acquaah 2005). In the U.S., the major cotton producing region spans across the southern states from California east to the Carolinas (Luttrell 1994; Figure 8-1). Although this region coincides with the wintering ranges, migratory pathways, and breeding grounds of many waterbirds, records of waterbird use of cotton resources are rare, and primarily involve generalist or opportunistic species such as geese, egrets, gulls, and blackbirds. In all cases in which use has been evaluated in comparison to the availability of cotton across the landscape, cotton fields appear to be avoided by birds. Although the energy value of cotton seed has not been evaluated, it is not consumed by waterbirds with sufficient frequency to warrant interest in its caloric content. The terrestrial invertebrates found in cotton fields are more likely to be of value to foraging waterbirds, but little is known about their typical abundance or consumption by birds. Effects of cotton production methods on waterbirds are mostly negative, or further detract from the quality of cotton habitat. The practices that most greatly diminish the value of cotton fields include conservation tillage and heavy pesticide use. The effects that these and other cotton production practices (i.e., heavy irrigation) have on waterbirds on a landscape scale are also of great conservation concern (see ALL CROP SUMMARY chapter). This chapter summarizes the state of current knowledge regarding the occurrence and abundance of waterbird species in cotton fields, potential cotton field resources of importance to waterbirds, how waterbirds use cotton fields, and the impacts of cotton production practices and landscape features on waterbirds.

USE BY WATERBIRDS

Records of waterbirds using cotton fields are scarce, and almost entirely from North America, even though cotton is also commonly grown in Russia, Asia (mostly China), India, parts of Africa, Brazil (Bottrell and Adkisson 1977), and elsewhere. Waterbird use of cotton fields in North America has been documented in two WWL focal BCRs (in bold throughout text) - **Shortgrass Prairie** (BCR 18), and **Mississippi Alluvial Valley** (BCR 26) - as well as in areas of the southeastern U.S. (BCR 25, BCR 27), the Gulf of Mexico Coast (BCR 37), California (BCR 32), and southwestern North America (New Mexico, BCR 35; Baja California, Mexico, BCR 33).

In North America, only nine WWL species have been observed in cotton fields, and all were using the land for foraging during fall migration, winter, or the breeding season. We did not find any accounts of waterbirds nesting in cotton fields. Of these nine species, three (Northern Pintail, American Woodcock, Sandhill Crane) are considered to be “Conservation Priority Species” by the National Audubon Society (i.e., they are listed under the U.S. Endangered Species Act, on the Audubon WatchList, as a USFWS Bird of Conservation Concern, and/or they exhibit significant population declines according to Christmas Bird Count or Breeding Bird Survey data). Species occurrences in cotton fields for all of North America and by focal BCR for the WWL project are summarized in Table 8-1. BCR regional species lists - species considered relatively abundant in each BCR (see Introduction) - are also shown.

© National Audubon Society, Inc. 2007

Waterfowl
Four waterfowl species have been observed in cotton fields in North America, all during fall migration or winter (Table 8-1). In southern Texas (BCR 37), Canada Geese, Snow Geese, and Greater White-fronted Geese visited disked cotton fields in abundances ranging from tens to hundreds of birds per field (Ballard 1993). Geese appeared to avoid cotton fields, however, as use was less than expected based on the availability of cotton across the landscape. In the Tulare Basin of California (BCR 32), Northern Pintail (a Conservation Priority Species) have been observed foraging in fallow or disked cotton fields that were flooded during fall and winter, but low use of fields indicated widespread avoidance of cotton compared to fallow or harvested fields of other crops such as wheat and barley (Fleskes et al. 2003).

Shorebirds
Only one shorebird species has been documented in cotton fields in North America (Table 8-1). In Louisiana (BCR 37), American Woodcock (a Conservation Priority Species) have been documented foraging in cotton fields during winter (Keppie and Whiting 1994).

Wading Birds
Cattle Egrets appear to be a common wading bird using cotton fields worldwide during the summer months. In the Nile Valley of Egypt, Cattle Egrets are commonly observed feeding on arthropods in cotton fields near nesting colonies (Mullié et al. 1992). In North America, from July through mid August, Cattle Egrets in Baja California, Mexico (BCR 33) have been observed flying from breeding colonies to newly irrigated cotton fields nearby, potentially in response to sudden increases in the densities of crickets, grasshoppers and spiders (Mora 1997).

Other Waterbirds
Two other species of waterbirds have been documented in cotton fields (Table 8-1). In northwestern Texas (**Shortgrass Prairie** region; BCR 18), Sandhill Cranes (a Conservation Priority Species) forage occasionally in cotton fields during the winter (Iverson et al. 1982, Iverson et al. 1985a, 1985b). Cranes have also been observed in cotton fields during winter in southwestern New Mexico (BCR 35) (Lewis 1977). Along the coast of Texas (BCR 37), Laughing Gulls were documented foraging during the breeding period (June) on invertebrates present in cotton fields (White et al. 1979).

Landbirds
Red-winged Blackbirds are the only WWL landbird species documented in cotton fields (Table 8-1). In western Tennessee (BCR 27), wintering Red-winged Blackbirds have been observed only occasionally in cotton fields, foraging instead primarily in corn, wheat and soybean fields in the area (Dolbeer et al. 1978). In Georgia, Red-winged Blackbirds forage in cotton fields during spring migration and summer, most commonly in fields managed with reduced-till or stripcover cropping methods (Cederbaum et al. 2004). In northern Louisiana (BCR 25 and BCR 26), Red-winged Blackbirds have been recorded foraging in cotton fields during fall migration (El Sayed et al. 1967).

RESOURCES
Overall, the foraging resources provided by cotton fields appear to be of limited value to most waterbirds during any time of year, and no species has been observed using cotton fields for

© National Audubon Society, Inc. 2007

nesting or brood-rearing (Table 8-2). Here we review what is known about the abundance and availability of cotton resources, and of their consumption and other use by waterbirds in North America.

Foraging Resources

Food resources available to waterbirds foraging in cotton fields include cotton seed and terrestrial invertebrates (Table 8-2). Some waterbirds may forage on weed seeds in cotton fields, but this has not been studied.

Cotton Seed

Cotton seed appears to be of minimal importance as a food resource (Table 8-2). Cotton seeds left in fields after harvest are normally attached to the cotton fibers, or 'lint,' that is lost at harvest (Bottrell and Adkisson 1977). Estimates of the amount of cotton seed normally left in fields after harvest do not appear to be available in the literature.

Wintering Sandhill Cranes (a Conservation Priority Species) are the only waterbird species to have been documented consuming cotton seeds (Iverson et al. 1982), but only minimally as the proportion of the diet comprising seed was extremely low (1.2% frequency of occurrence; trace amounts by volume).

Energy Value of Cotton Seed. We did not find any information pertaining to the caloric value of cotton seed, likely because it is so seldom consumed by birds.

New Shoots and Seeds of Weed Species

The new shoots and seeds of weedy species growing in cotton fields may be a potential resource for waterbirds, particularly in organically managed fields, but their abundance and consumption by waterbirds has not been evaluated (Table 8-2). Fleskes et al. (2003) suggest that the avoidance and low use of cotton fields by nonbreeding Northern Pintail (a Conservation Priority Species) in California may be explained by the low abundance of important weed seeds in such fields. Weed seeds were common in the diets of wintering Red-winged Blackbirds that had foraged in agricultural fields in Tennessee, but because only 2% of observed birds had foraged in cotton vs. other crops, it is likely that ingested seeds came from fields containing other crops (Dolbeer et al. 1978).

Terrestrial Invertebrates

Terrestrial invertebrates such as orthopteran insects (grasshoppers, crickets), arachnids (spiders), lepidopteran larva, and other insect pests may be the most important potential food resources for waterbirds foraging in cotton fields (Table 8-2). In the absence of pesticides (see also **Pesticide Use, Organic Farming, and Stripcover Cropping** below), cotton fields can attract a diverse and abundant arthropod community, including as many as 300 non-pest species (Bottrell and Adkisson 1977, Sundaramurthy and Gahukar 1998). Little information exists regarding the consumption of these invertebrates by waterbirds, likely because a heavy reliance on pesticides by the cotton industry in recent decades (Luttrell 1994) has left most fields devoid of invertebrate foods to attract birds. We found only two references to waterbirds potentially foraging on invertebrates in cotton fields. During the breeding season, while feeding chicks, Cattle Egrets in Baja California, Mexico have been observed flying from colonies towards nearby cotton fields

© National Audubon Society, Inc. 2007

presumably to forage on crickets, grasshoppers and spiders that were attracted to irrigated fields (Mora 1997). Likewise, Laughing Gulls have been recorded foraging on various insects in cotton fields in Texas, some of which they likely fed to their chicks (White et al. 1979). Fleskes et al. (2003) suggested that Northern Pintail present in flooded cotton fields in winter may have been foraging on invertebrates, but that their low use of cotton fields suggested low invertebrate abundance in fields. To the best of our knowledge, there has been no evaluation of the abundance, availability, or importance of earthworms, a common prey item for shorebirds foraging in many environments (Skagen and Oman 1996), in cotton fields.

Breeding Resources

Although some waterbird species breed at southern latitudes where cotton is grown, we found no documented cases of waterbirds either nesting or rearing broods in cotton fields. This suggests either that research is lacking during the breeding season, or, more likely, that the breeding resources provided by cotton fields are of extremely low value to waterbirds. As the cotton growing season coincides with the nesting period for waterbirds, it could be that nest substrates within cotton fields are not suitable for waterbirds. Of those species most likely to nest in fields planted to cotton, the cover provided by plants would be too great for a species such as Killdeer, and not enough and of inappropriate vertical structure for nesting waterfowl. Moreover, with farm machinery operations associated with planting and pesticide applications coincident with nest initiation, any birds contemplating breeding in cotton would likely be deterred, and any existing nests probably destroyed. Alternative farming practices such as stripcover cropping (see **Pesticide Use, Organic Farming, and Stripcover Cropping** below) in tandem with conservation tillage (see S**oil and Residue Management in Preparation for Planting** below) may offer the only hope for providing valuable nesting cover for waterbird species inclined to nest in cotton fields (see Cedarbaum et al. 2004). If these practices were to be developed to increase the conservation value of these fields, one would also need to ensure that other aspects of crop production (e.g., pesticide use) do not counteract the effort and cause the crop to act as sink habitat that is harmful to waterbird populations.

Nesting Habitat

We found no documented cases of waterbirds nesting in cotton fields.

Brood-rearing/Post-fledging Habitat

We found no documented cases of waterbirds using cotton fields during the brood-rearing and post-fledging periods.

Resting Habitat

In Texas, wintering Sandhill Cranes (a Conservation Priority Species) have been known to rest in cotton stubble fields on occasion during the early morning hours (Iverson et al. 1985a, 1985b).

EFFECTS OF COTTON PRODUCTION METHODS

Documentation of the impacts of cotton farming methods on waterbirds is extremely limited, most definitely because so few waterbirds use cotton fields. The following is a summary of the known impacts, following the chronology of cotton production from soil and residue management in preparation for planting to cotton harvest. We additionally review any information pertaining to the influences of other aspects of cotton farming such as field size,

© National Audubon Society, Inc. 2007

hunting activity, and landscape context. Table 8-3 provides a synopsis of the current state of knowledge on these topics.

Soil and Residue Management in Preparation for Planting

Cotton fields are tilled following both conventional (residues only rarely reduced by plowing or burning in fall since cotton is a perennial plant; soil smoothed by disking and harrowing in spring; use of rotary hoe to dislodge germinating weeds) and conservation or reduced/no-till methods (no, or reduced, plowing or disking; slot planting seeds into previous crop residue; use of herbicides to control weeds). Conventional methods are certainly most common (Cederbaum et al. 2004). Although the effect of plowing on the abundance of cotton seed left in fields has not been assessed, cotton seed does not appear to be a food resource of much importance to waterbirds. Of greater concern is the effect that conventional tillage methods have on the terrestrial invertebrate food resources of potential value to those waterbirds that may forage in cotton fields. As conventional methods involve the removal or turning under of residual vegetation that typically provides valuable habitat for surface arthropods or soil invertebrates such as earthworms, long-term abundances of these invertebrates in tilled fields are likely lower than in fields where crop residues are not removed or manipulated. Indeed, Cederbaum et al. (2004) found that arthropod abundances in May were substantially higher on reduced-till cotton fields than on conventionally tilled fields, and the associated abundances of foraging Red-winged Blackbirds (and other songbirds not on the WWL list) in cotton fields were also higher during spring and summer. Farm machinery operations for tillage occurring during spring have the potential to affect birds nesting in cotton, but this threat is fairly insignificant given the low incidence and probability of cotton nesting by waterbirds.

Winter Flooding

In California, agricultural land is often intentionally flooded during the winter to enhance habitat for nonbreeding waterfowl. Although this management approach is most common in ricefields (Elphick and Oring 1998, Elphick and Oring 2003), other crops such as safflower, barley-wheat, alfalfa, and cotton are also intentionally flooded (Fleskes et al. 2003). This uncommon feature of cotton fields in California is probably the only reason why Fleskes et al. (2003) recorded wintering Northern Pintails (a Conservation Priority Species) foraging in such fields. Pintail use of flooded cotton fields, however, was lower than all other types of flooded fields in the Tulare Basin, suggesting that, despite the winter flooding, food resources were very low (Fleskes et al. 2003).

Sowing Methods

In North America, cotton is planted during the spring months of March – May (Acquaah 2005). Although sowing coincides with the initiation of waterbird nesting, the potential risk of farm machinery passes impacting nests in cotton is insignificant given the low incidence and probability of waterbirds nesting in cotton.

Surface Irrigation

Cotton is perhaps the most water-consumptive crop in the world (Acquaah 2005). In all North American cotton growing regions, except for the southeastern U.S., irrigation is essential (Lutrell 1994). Moreover, because cotton is grown in arid regions, irrigation efficiency is typically lower than 40% (60% is lost to evaporation, seepage and poor water management) (WWF 2007).

© National Audubon Society, Inc. 2007

While the extensive use of water for cotton production is likely to have grave impacts on waterbirds at the landscape scale (see ALL CROP SUMMARY chapter), on a within-field scale, surface irrigation of cotton may enhance the abundance and availability of terrestrial invertebrates for some waterbirds. Mora (1997) observed regular and frequent foraging flights by breeding Cattle Egrets to nearby cotton fields, and he presumed that these were in response to an increase in the availability of arthropod prey from summer irrigation.

Pesticide Use, Organic Farming, and Stripcover Cropping

Cotton farming has a long history of intensive chemical use to control insect pests and weeds responsible for loss to cotton yields and revenue. In terms of the weight of pesticide applied, cotton ranks fourth (only grapes, tomatoes, and almonds have greater application) among crops in North America (EXTOXNET 2007). Conventional cotton typically receives 8-10 insecticide applications per year (F. Koppatschek, ABG, Inc., pers. comm.). Insecticides that have been used to combat cotton defoliators such as the Boll Weevil (*Anthonomous grandis grandis*), Cotton Bollworm (*Helicoverpa armigera*), Native Budworm (*Helicoverpa punctigera*), Cabbage Looper (*Trichoplusia ni*), Army Worms (*Spodoptera* spp.), and various spider mites (*Tetranychus* spp.) include pyrethroids (F. Koppatschek, ABG, Inc., pers. comm.), chlorinated hydrocarbons (e.g., endosulfan), carbamates (e.g., carbofuran), organophosphates (e.g., parathion), and organochlorines (e.g., dicofol) (El Sayed et al. 1967, White et al. 1979, Luttrell 1994, Clark et al. 1995). Herbicides (primarily glyphosates as GM cotton is prevalent) are also used extensively in cotton fields to control weeds on both conventional and reduced/no-till fields. While the insecticides used in cotton fields are classified as moderately to highly toxic to birds, the herbicides are only slight to moderately toxic (EXTOXNET 2007). Although most insecticides used are “restricted-use” pesticides, they may still pose a current threat as they may be purchased and administered on fields by certified growers (EXTOXNET 2007).

There are few accounts of direct mortality of waterbirds caused by insecticide use in cotton fields, although this result is almost certainly attributed to the low waterbird use of cotton, and perhaps also because pesticide-incurred mortalities have not been studied in detail. Because pesticides are applied to cotton fields during the summer months, the WWL species most at risk are the few species that forage in or near cotton fields during the breeding season (Table 8-1). Insecticides still available for controlling cotton pests have been responsible for waterbird mortality in the past. In Texas (BCR 37), White et al. (1979) documented lethal poisonings of 116 chicks and several adult Laughing Gulls that had consumed various insects from cotton fields that had been recently treated with the organophosphate pesticide parathion. In Louisiana, insecticide residues were found in dead Red-winged Blackbirds associated with cotton fields during fall (El Sayed et al. 1967).

The indirect effects of pesticide use in cotton fields are also detrimental, as they are responsible for obliterating any terrestrial invertebrate food resources or weed species of value to foraging waterbirds. As the carbamates and other insecticides that target crop pests are broad-spectrum chemicals that will also kill non-target invertebrates (EXTOXNET 2007), it is likely that terrestrial invertebrate food resources are diminished substantially in cotton fields in which insecticides are applied. Effects of herbicide use include reducing the new shoots and seeds of weed species, and depleting the arthropod communities that depend on weed habitats (Altieri

© National Audubon Society, Inc. 2007

1987, 1992, Freemark and Boutin 1995, Beecher 1998, Gibbons et al. 2006), both of which could be important foods for waterbirds foraging in cotton.

Due to the many negative impacts of cotton pesticide use on the environment, organic farming and integrated pest management (IPM) are gaining increased attention as alternatives for the sustainable production of cotton (WWF 2007). In general, organic farming and IPM practices include altering the timing of sowing and harvest to minimize exposure to pests, weed/insect pest monitoring and application of pesticides based on economic thresholds, manually removing weeds (cultivating with a rotary hoe), use of pheromones to trap pests, and using crop rotation and intercropping (including stripcover cropping) to help keep pest populations at bay. The effects of most of these methods on bird use of cotton fields have not been studied.

Stripcover cropping is one of the most promising alternatives to the use of chemicals for controlling insect pests in cotton agroecosystems, and it appears to be the only IPM method for which impacts on birds have been evaluated (see Cederbaum et al. 2004). A type of intercropping, stripcover cropping involves planting a nitrogen-fixing winter cover crop such as clover (*Trifolium* spp.) in alternating rows with a cash crop such as cotton. As the growing season progresses, the cover crop dies back naturally or is suppressed with herbicides. The cover crop provides habitat for predatory and parasitic arthropods well before the cotton crop is planted, and thus stripcover cropping may not only boost the productivity of terrestrial invertebrate prey for birds, but also provide effective biological control of cotton pests without the use of insecticides (Bugg et al. 1990, Bugg et al. 1991). In order to allow the growth and benefits of the cover crop, stripcover cropping is practiced in tandem with conservation tillage. In Georgia (BCR 27), Cederbaum et al. (2004) isolated the additional benefits (to those from conservation tillage) of stripcover cropping by documenting higher abundances of non-pest arthropods and associated numbers of various songbirds (including Red-winged Blackbirds, a WWL species) in reduced-tilled cotton fields with clover stripcover cropping than in fields that were either reduced-tilled or conventionally tilled with no stripcover management.

Another potentially promising alternative to the use of broad-spectrum insecticides is the adoption of "*Bt* cotton", whereby the crop is genetically engineered to produce insecticidal proteins from *Bacillus thuringiensis* (*Bt*) which confers a built-in resistance to lepidopteran and coleopteran insect pests (Naranjo et al. 2005a, Romeis et al. 2006). Although a major environmental concern with *Bt* crops is their potential impact on beneficial non-target invertebrates, including those used in biological control (Romeis et al. 2006), available evidence suggests that densities of various terrestrial non-target arthropods and other insects are not affected by the insecticidal properties of *Bt* cotton (Head et al. 2005, Torres and Ruberson 2005, Whitehouse et al. 2005, Naranjo 2005b, 2005c). Consequently, researchers have proposed that the planting of *Bt* cotton provides a number of environmental and economic advantages by significantly reducing the need for conventional, broad-spectrum insecticides (typically 2-3 applications/year; F. Koppatschek, ABG, Inc., pers. comm.), and by increasing opportunities for biological control (Naranjo et al. 2005a, Romeis et al. 2006). Depending on the extent to which terrestrial invertebrates in cotton fields can be an important food resource for the few waterbirds using fields (a significant knowledge gap, see **Summary and Synthesis – Knowledge Gaps and Research Needs** below), the adoption of *Bt* cotton could be beneficial to waterbirds, and certainly to birds as a whole. In 2004, 46% of field cotton in the U.S. was planted to GM

© National Audubon Society, Inc. 2007

cultivars producing *Bt* toxins (Naranjo et al. 2005a), and there is an increasing yearly trend in the area allocated to *Bt* crops worldwide (Romeis et al. 2006b).

Management of Pest Bird Species

Although there are accounts of cotton farmers in Texas filing complaints regarding cotton depredation by Sandhill Cranes, Iverson et al. (1982) dismissed this threat as minimal given the extremely low frequency of occurrence (1%) of cotton in the diet of cranes.

Harvest Methods

In North America, cotton harvest occurs during late summer and early fall (Acquaah 2005). We found no specific references to the effects of harvest methods on waterbird use of cotton fields.

Crop Rotation, Fallow Land

In North America, cotton is often grown in rotation with soybeans and sorghum (Ballard 1993, Flickinger and Pendleton 1994, Acquaah 2005). Thus, waterbirds are likely to benefit greatly from the periodic planting of fields back to these more beneficial crops, particularly sorghum (see SORGHUM, SOYBEAN chapters).

EFFECTS OF OTHER MANAGEMENT ACTIVITIES

Hunting Activity

To the best of our knowledge, recreational hunting of waterbirds does not occur in cotton fields in North America.

EFFECTS OF LANDSCAPE FEATURES

Field Size

We did not find any literature pertaining to the importance or effect of field size on waterbird use of cotton fields.

Landscape Context

Studies in wetland landscape ecology (Naugle et al. 1999, Riffell et al. 2003, Taft and Haig 2006) suggest that waterbird use of agricultural fields could be affected by habitat features of the surrounding landscape, or by the “landscape context” of fields. The coverage, placement and connectivity of various features in the surrounding landscape may be important, including that of other suitable habitat, natural wetlands, hunting refuges, roost sites, and roads and other sources of disturbance. We did not find any studies that explicitly examined the potential influence of landscape context on waterbird use of cotton fields. However, food resources and bird use are likely greater in traditional (no stripcover cropping) cotton fields that are adjacent to fields managed with stripcover cropping than in those fields that are either isolated or in a uniform landscape of traditionally managed cotton (see above). Understanding the effect of landscape context on the resources and bird use within cotton fields could affect management decisions for cotton growing regions. Given the low use of cotton fields by waterbirds, however, the most likely landscape effects will involve the impact of cotton farming on the use of fields planted to other crops that are more valuable to waterbirds.

© National Audubon Society, Inc. 2007

SUMMARY AND SYNTHESIS

The following is a review of the major themes relating to the use of cotton fields by waterbirds, resources available to waterbirds in cotton fields, positive and negative effects of cotton production practices on waterbirds, and gaps in knowledge of these issues. In summarizing these topics, we also highlight current avian conservation challenges and future research needs presented by cotton agriculture.

Waterbird Use

Available information strongly suggests that the habitat and resources provide by North American cotton fields are of little value to waterbirds (Tables 1, 2). Few waterbird species have been documented in cotton fields at any time of year, and assessments of use relative to availability indicate an active avoidance of cotton fields by most species (e.g., Dolbeer et al. 1978, Iverson et al. 1985a, b, Iverson et al. 1992, Ballard 1993). The few accounts of high use of cotton fields by waterbirds appear to be cases of intense, but sporadic, use by opportunistic species such as Cattle Egrets and Laughing Gulls in association with brief periods of insect outbreaks during the growing season (e.g., White et al. 1979, Mora 1997). Taking into account the risks of pesticide exposure during such events, cotton fields have the potential to act as population sinks if such brief but intense use is the norm under which cotton fields are typically visited by waterbirds. All accounts of waterbird use have involved birds foraging in cotton fields; no waterbird species has been documented nesting in cotton.

WWL Species and Bird Conservation Regions

Of the 216 species identified for the Waterbirds on Working Lands project, only nine have been observed in cotton fields in North America, of which three are Conservation Priority Species (Table 8-1). Of these nine species, seven use cotton fields during winter, four during spring and/or fall migration, and three during the breeding season. Use of cotton fields has been documented for less than 1% of those species considered to be relatively abundant (i.e., the focal species on BCR regional lists) within each of the focal BCRs (**Shortgrass Prairie**, BCR 18; **Mississippi Alluvial Valley**, BCR 26). Although there might be occasional use of cotton fields by additional species, these low numbers undoubtedly represent a true low use of cotton fields in these regions.

Cotton Resources

The potential foraging resources available to waterbirds in cotton fields include cotton seed (Iverson et al. 1982), new shoots and seeds of weed plants (Fleskes et al. 2003), and terrestrial invertebrates (e.g., Bottrell and Adkisson 1977, Mora 1997, Sundaramurthy and Gahukar 1998, Fleskes et al. 2003, Cederbaum et al. 2004). The energy content of cotton seed has not been evaluated, but the cotton seed available in fields after harvest appears to be consumed by waterbirds only rarely. It is unknown whether weed plants are an important resource for waterbirds, especially in organically farmed cotton fields where their potential value is greatest. Terrestrial invertebrates are likely the most valuable food resource to be found in cotton fields, especially if managed using conservation tillage, stripcover cropping, or organic farming practices (e.g., Mora 1997, Cederbaum et al. 2004). Cotton fields do not typically provide nesting habitat for waterbirds, but the use of clover stripcover cropping may offer hope for providing suitable nesting cover for some species (Cedarbaum et al. 2004). The value of cotton fields for resting birds is relatively unknown.

© National Audubon Society, Inc. 2007

Practices Benefiting Waterbirds

It is unlikely that many cotton production practices directly benefit waterbirds (Table 8-3). Those practices that contribute anything to the value of cotton fields include conservation tillage, surface irrigation (although probably only on a short-term, within-field scale; see ALL CROP SUMMARY chapter), stripcover cropping, and *Bt* cotton. Conservation tillage on cotton fields, namely the practice of leaving crop residues in fields after harvest, has been shown to increase the production of terrestrial invertebrate foods of potential value to waterbirds, including non-pest arthropods useful in the biological control of crop pests (Cederbaum et al. 2004). Surface irrigation may act to attract terrestrial invertebrates temporarily (e.g., Mora 1997) and concentrate potentially valuable food resources for waterbirds. Finally, as they promote the production of terrestrial invertebrates and reduce the need for pesticides (Bugg et al. 1990, Bugg et al. 1991), stripcover cropping and *Bt* crops are cotton production methods with the most potential to increase the value of cotton to wildlife (Cederbaum et al. 2004, Naranjo et al. 2005a, Romeis et al. 2005), including waterbirds.

Practices Negatively Affecting Waterbirds

Although cotton fields are of low intrinsic value to waterbirds, a number of crop production practices act to degrade their worth even further. Heavy pesticide use (Luttrell 1994) and conventional methods of tillage on cotton fields significantly discourage the presence of any terrestrial invertebrates of potential importance as a food source for birds (e.g., Sundaramurthy and Gahukar 1998, Cederbaum et al. 2004). Moreover, herbicides further preclude the presence of weedy plants that provide habitat for arthropods and whose seeds could be an important food resource for waterbirds (e.g., Freemark and Boutin 1995, Gibbons et al. 2006). Given the heavy reliance on pesticides in cotton agroecosystems, insecticide use is likely to cause mortalities both within fields and in the surrounding landscape. Cotton fields themselves pose a significant risk of mortality to any bird species that use them during the spring and summer months when most chemicals are applied (e.g., El Sayed et al. 1967, White et al. 1979). The risks of waterbird exposure to any toxic chemicals applied to cotton fields may also extend well beyond field boundaries as most insecticides used within fields infiltrate via runoff and soil erosion into neighboring habitats, particularly rivers and wetlands (see ALL CROP SUMMARY chapter). At a larger spatial scale, the high water use of cotton farming perhaps has the greatest negative impact on waterbirds. The development of less water-consumptive ways to grow cotton could, therefore, provide important conservation benefits.

Knowledge Gaps and Research Needs

Knowledge of cotton field use by waterbirds, resources found in cotton fields, and the effects of cotton production practices on waterbirds are fairly adequate, simply because cotton fields receive so little use by waterbirds. There are a few areas of research, however, that could further strengthen our ability to improve cotton habitat for waterbirds and other wildlife species.

Waterbird Use

It is likely that the small number of studies that have documented waterbirds in cotton fields, both within focal BCRs and in other regions, accurately reflects the limited value of this habitat. Minimal use by only a few species appears to be a consistent pattern across all locales in which cotton is grown (Table 8-1). Most observations of bird use are from research conducted outside

© National Audubon Society, Inc. 2007

the focal BCRs (e.g., the southeastern U.S., the Gulf of Mexico coast, California, and southwestern North America), and few observations come from focal BCRs **Shortgrass Prairie** (BCR 18) and **Mississippi Alluvial Valley** (BCR 26). Given the extremely low value of this crop to waterbirds, however, we do not believe that the lack of observations in each focal BCR represents a major gap in knowledge of the use of this crop.

Resources
While it is clear that both pest and non-pest arthropods can be abundant in cotton fields, the extent to which these potential prey are typically consumed, or are of importance to the few waterbird species observed in cotton fields, has not been studied. Further work in this area would help to assess whether the value of cotton fields could be enhanced via the management of terrestrial invertebrates, how waterbird use may interact with methods of biological control, and whether the adoption of *Bt* cotton would benefit waterbirds. Knowledge of the extent to which the new shoots and seeds of weed species are an important resource for waterbirds in cotton fields would also be helpful.

Effects of Crop Production Methods, Other Management Activities, and Landscape Features
Few crop production practices warrant further research as to how they affect waterbirds. In terms of working towards enhancing the low value of cotton for all wildlife, however, research goals of highest priority should be to quantify further how tillage methods impact terrestrial invertebrate food resources (including soil fauna such as earthworms) and associated waterbird use, and to evaluate further the efficacy and wildlife value of the various organic farming and integrated pest management options such as adopting cotton cultivars that are resistant to pests (e.g., *Bt* cotton), altering the timing of sowing and harvest to minimize exposure to pests, manually removing weeds (cultivating with rotary hoe), use of pheromones to trap pests, and crop rotation and stripcover cropping. Focusing on these questions should help alleviate some of the many negative impacts of cotton agriculture on wildlife. Additionally, research to evaluate the negative impacts on natural wetland systems of high water consumption by cotton, and to develop production practices that reduce water consumption, would be extremely valuable.

Important broader research issues of concern regarding cotton production include documenting the impact on waterbirds of land conversion from other crops (especially rice) to cotton, as well as the negative effects of high water use in cotton agroecosystems on nearby natural habitats such as wetlands (also see ALL CROP SUMMARY for further discussion of these).

References

Acquaah, G. 2005. Principles of Crop Production: Theory, Techniques, and Technology. Pearson Education, Upper Saddle River, New Jersey.

Altieri, M. A. 1987. Agroecology: the scientific basis of alternative agriculture. Westview Press, Boulder, Colorado.

Altieri, M. A. 1992. Agroecological foundations in alternative agriculture in California. Agriculture, Ecosystems & Environment **39**:23-53.

Ballard, B. M. 1993. Sorghum management for waterfowl wintering in southern Texas. M.S. thesis. Texas A&I University, Kingsville.

© National Audubon Society, Inc. 2007

Beecher, N. B. 1998. Birds and agroecological relationships in organic and nonorganic farmland. M.S. thesis. University of Nebraska, Lincoln, Nebraska.

Bottrell, D. G., and P. L. Adkisson. 1977. Cotton insect pest management. Annual Review of Entomology **22**:451-481.

Bugg, R. L., S. C. Phatak, and J. D. Dutcher. 1990. Insects associated with cool-season cover crops in southern Georgia: implications for pest-control in truck-farm and pecan agroecosystems. Biological Agriculture & Horticulture **7**:17-45.

Bugg, R. L., F. L. Wackers, K. E. Brunson, J. D. Dutcher, and S. C. Phatak. 1991. Cool-season cover crops relay intercropped with cantaloupe: influence on a generalist predator, *Geocoris-puntipes* (Hemiptera, Lygaeidae). Journal of Economic Entomology **84**:408-416.

Cederbaum, S. B., J. P. Carroll, and C. M. Cooper. 2004. Effects of alternative cotton agriculture on avian and arthropod populations. Conservation Biology **18**:1272-1282.

Clark, D. R., Jr., E. L. Flickinger, D. H. White, R. L. Hothem, and A. A. Beilsle. 1995. Dicofol and DDT residues in lizard carcasses and bird eggs from Texas, Florida and California. Bulletin of Environmental Contaminants and Toxicology **54**:817-824.

Dolbeer, R. A., P. P. Woronecki, A. R. J. Stickley, and S. B. White. 1978. Agricultural impact of a winter population of blackbirds and starlings. Wilson Bulletin **90**:31-44.

El Sayed, E. I., J. B. Graves, and F. L. Bonner. 1967. Chlorinated hydrocarbon insecticide residues in selected insects and birds found in association with cotton fields. Journal of Agriculture and Food Chemistry **15**:1014-1017.

Elphick, C. S., and L. W. Oring. 1998. Winter management of Californian rice fields for waterbirds. Journal of Applied Ecology **35**:95-108.

Elphick, C. S., and L. W. Oring. 2003. Conservation implications of flooding rice fields on winter waterbird communities. Agriculture, Ecosystems & Environment **94**:17-29.

EXTOXNET. 2007. The EXtension TOXicology NETwork. http://extoxnet.orst.edu/ghindex.html:(accessed 2 Jan 2007).

Fleskes, J. P., R. L. Jarvis, and D. S. Gilmer. 2003. Selection of flooded agricultural fields and other landscapes by female northern pintails wintering in Tulare Basin, California. Wildlife Society Bulletin **31**:793-803.

Flickinger, E. L., and G. W. Pendleton. 1994. Bird use of agricultural fields under reduced and conventional tillage in the Texas Panhandle. Wildlife Society Bulletin **22**:34-42.

Freemark, K. E., and C. Boutin. 1995. Impacts of agricultural herbicide use on terrestrial wildlife in temperate landscapes: a review with special reference to North America. Agriculture, Ecosystems & Environment **52**:67-91.

Gibbons, D. W., D. A. Bohan, P. Rothery, R. C. Stuart, A. J. Haughton, R. J. Scott, J. D. Wilson, J. N. Perry, S. J. Clark, R. J. G. Dawson, and L. G. Firbank. 2006. Weed seed resources for birds in fields with contrasting conventional and genetically modified herbicide-tolerant crops. Proceedings of the Royal Society B **273**:1921-1928.

Head, G., W. Moar, M. Eubanks, B. Freeman, J. Ruberson, A. Hagerty, and S. Turnipseed. 2005. A multiyear, large-scale comparison of arthropod populations on commercially managed *Bt* and non-*Bt* cotton fields. Environmental Entomology **34**:1257-1266.

Iverson, G. C., T. C. Tacha, and P. A. Vohs. 1982. Food contents of Sandhill Cranes during winter and spring. Pages 95-98 *in* Proceedings of the 1981 Crane Workshop. National Audubon Society, Tavernier, Florida.

© National Audubon Society, Inc. 2007

Iverson, G. C., P. A. Vohs, and T. C. Tacha. 1985a. Habitat use by Sandhill Cranes wintering in western Texas. Journal of Wildlife Management **49**:1074-1083.

Iverson, G. C., P. A. Vohs, and T. C. Tacha. 1985b. Distribution and abundance of sandhill cranes wintering in western Texas. Journal of Wildlife Management **49**:250-255.

Keppie, D. M., and R. M. Whiting, Jr. 1994. American Woodcock (*Scolopax minor*), No. 100. *in* A. Poole and F. Gill, editors. The Birds of North America. The Academy of Natural Sciences; The American Ornithologists' Union, Philadelphia, PA; Washington, D.C.

Lewis, J. C. 1977. Sandhill Crane. Pages 4-53 *in* G. C. Sanderson, editor. Management of migratory shore and upland game birds in North America. International Association of Fish Wildlife Agencies, Washington, D.C.

Luttrell, R. G. 1994. Cotton pest-management. 2. A U.S. perspective. Annual Review of Entomology **39**:527-542.

Mora, M. A. 1997. Feeding flights of cattle egrets nesting in an agricultural ecosystem. Southwest Naturalist **42**:52-58.

Mullié, W. C., A. Massi, S. Focardi, and A. Renzoni. 1992. Residue levels of organoclorines and mercury in Cattle Egret, *Bubulcus ibis*, eggs from the Faiyum Oasis, Egypt. Bulletin of Environmental Contaminants and Toxicology **48**:739-746.

Naranjo, S. E. 2005b. Long-term assessment of the effects of transgenic *Bt* cotton on the abundance of nontarget arthropod natural enemies. Environmental Entomology **34**:1193-1210.

Naranjo, S. E. 2005c. Long-term assessment of the effects of transgenic *Bt* cotton on the function of the natural enemy community. Environmental Entomology **34**:1211-1223.

Naranjo, S. E., G. Head, and G. P. Dively. 2005a. Field studies assessing arthropod nontarget effects in *Bt* transgenic crops: introduction. Environmental Entomology **34**:1178-1180.

Naugle, D. E., K. F. Higgins, S. M. Nusser, and W. C. Johnson. 1999. Scale-dependent habitat use in three species of prairie wetland birds. Landscape Ecology **14**:267-276.

Riffell, S. K., B. E. Keas, and T. M. Burton. 2003. Birds in North American Great Lakes coastal wet meadows: is landscape context important? Landscape Ecology **18**:95-111.

Romeis, J., M. Meissle, and F. Bigler. 2006. Transgenic crops expressing *Bacillus thuringiensis* toxins and biological control. Nature Biotechnology **24**:63-71.

Skagen, S. K., and H. D. Oman. 1996. Dietary flexibility of shorebirds in the western hemisphere. Canadian Field-Naturalist **110**:419-444.

Sundaramurthy, V. T., and R. T. Gahukar. 1998. Integrated management of cotton insect pests in India. Outlook on Agriculture **27**:261-269.

Taft, O. W., and S. M. Haig. 2006. Importance of wetland landscape structure to shorebirds wintering in an agricultural valley. Landscape Ecology **21**:169-184.

Torres, J. B., and J. R. Ruberson. 2005. Canopy- and ground-dwelling predatory arthropods in commercial *Bt* and non-*Bt* cotton fields: patterns and mechanisms. Environmental Entomology **34**:1242-1256.

White, D. H., T. G. Lamont, K. A. King, C. A. Mitchell, and E. F. Hill. 1979. Parathion causes secondary poisoning in a laughing gull breeding colony. Bulletin of Environmental Contamination and Toxicology **23**:281-284.

Whitehouse, M. E. A., L. J. Wilson, and G. P. Fitt. 2005. A comparison of arthropod communities in transgenic *Bt* and conventional cotton in Australia. Environmental Entomology **34**:1224-1241.

© National Audubon Society, Inc. 2007

WWF. 2007. World Wildlife Fund: Agriculture and Environment - Cotton. http://www.panda.org/about_wwf/what_we_do/policy/agriculture_environment/commodities/cotton/environmental_impacts/water_use/index.cfm:(accessed 2 Jan 2007).

© National Audubon Society, Inc. 2007

Table 8-1. Waterbird species reported in cotton fields in North America and in focal BCRs during winter, migration, and breeding seasons. Use by landbirds presented only for species on the Waterbird on Working Lands (WWL) species list. Species on each BCR regional list are considered relatively abundant (compared to other focal BCRs) within the BCR. All documentation of species occurrence based on single-species studies. Under Migration, "S" refers to spring migration, and "F" refers to fall migration. Apparent absences may reflect incomplete information in the published literature for a given season or region.

			North America					**Shortgrass Prairie (BCR 18)** [a]			
GROUP Common name	On WWL Species List	Species of Conservation Priority	Winter	Migration	Breeding Foraging	Breeding Nesting	On BCR 18 Regional List	Winter	Migration	Breeding Foraging	Breeding Nesting
WATERFOWL											
Canada Goose	X		X	F			X				
Snow Goose	X		X	F			X				
Greater White-fronted Goose	X		X	F							
Northern Pintail	X	X	X				X				
SHOREBIRDS											
American Woodcock	X	X	X								
WADING BIRDS											
Cattle Egret	X				X		X				
OTHER WATERBIRDS											
Sandhill Crane	X	X	X				X	X			
Laughing Gull	X				X						
WWL LANDBIRDS											
Red-winged Blackbird	X		X	S/F	X		X				

© National Audubon Society, Inc. 2007

Table 8-1. Continued.

GROUP Common name	On WWL Species List	On BCR 26 Regional List	Mississippi Alluvial Valley (BCR 26) [b] Winter	Migration	Breeding Foraging	Breeding Nesting
WATERFOWL						
Canada Goose	X	X				
Snow Goose	X	X				
Greater White-fronted Goose	X	X				
Northern Pintail	X	X				
SHOREBIRDS						
American Woodcock	X	X				
WADING BIRDS						
Cattle Egret	X	X				
OTHER WATERBIRDS						
Sandhill Crane	X					
Laughing Gull	X	X				
WWL LANDBIRDS						
Red-winged Blackbird	X	X		F		

[a]No comprehensive multi-species surveys conducted in BCR.

© National Audubon Society, Inc. 2007

Table 8-2. Summary of cotton resources available to waterbirds during the different phases of cotton production in North America. Gray shaded boxes indicate not applicable, or resource not available during the time period.

RESOURCES	**SOWING** (Spring)	**IRRIGATION** (Summer)	**PRE-HARVEST** (Growing Crop, Summer)	**HARVEST** (Fall)	**POST-HARVEST** (Winter)	**FALLOW LAND**
FORAGING RESOURCES O Cotton Seed				seed left in stubble fields – cranes [1]	seed left in stubble fields – cranes [1]	
O Weed Species: new shoots and seeds					possibly pintail, blackbirds [2,3]	
O Terrestrial Invertebrates		egrets, gulls – forage on invertebrates attracted to irrigated fields [4,5]	egrets, gulls – forage on invertebrates in fields [4,5]	possibly pintail [2]	possibly pintail [2]	
BREEDING RESOURCES O Nesting Habitat	no documented nests in cotton	no documented nests in cotton	no documented nests in cotton			
O Brood-rearing/ Post-fledging Habitat						
RESTING					cranes [6,7]	

Sources:

1 Iverson, G. C., T. C. Tacha, and P. A. Vohs. 1982. Food contents of Sandhill Cranes during winter and spring. Pages 95-98 *in* Proceedings of the 1981 Crane Workshop. National Audubon Society, Tavernier, Florida.

2 Fleskes, J. P., R. L. Jarvis, and D. S. Gilmer. 2003. Selection of flooded agricultural fields and other landscapes by female northern pintails wintering in Tulare Basin, California. Wildlife Society Bulletin **31**:793-803.

3 Dolbeer, R. A., P. P. Woronecki, A. R. J. Stickley, and S. B. White. 1978. Agricultural impact of a winter population of blackbirds and starlings. Wilson Bulletin **90**:31-44.

4 Mora, M. A. 1997. Feeding flights of cattle egrets nesting in an agricultural ecosystem. Southwest Naturalist **42**:52-58.

5 White, D. H., T. G. Lamont, K. A. King, C. A. Mitchell, and E. F. Hill. 1979. Parathion causes secondary poisoning in a laughing gull breeding colony. Bulletin of Environmental Contamination and Toxicology **23**:281-284.

6 Iverson, G. C., P. A. Vohs, and T. C. Tacha. 1985a. Habitat use by Sandhill Cranes wintering in western Texas. Journal of Wildlife Management **49**:1074-1083.

7 Iverson, G. C., P. A. Vohs, and T. C. Tacha. 1985b. Distribution and abundance of sandhill cranes wintering in western Texas. Journal of Wildlife Management **49**:250-255.

© National Audubon Society, Inc. 2007

Table 8-3. Summary of documented impacts of cotton production methods and landscape features on waterbird groups using cotton fields in North America. Open boxes without text indicate potential data gaps or areas for further research.

	SOIL AND RESIDUE MANAGEMENT Conventional Tillage vs. No-till	**SOWING**	**PESTICIDE USE, ORGANIC FARMING**	**HARVEST METHODS**	**FIELD SIZE**
ALL WATERBIRDS	terrestrial invertebrate abundance and diversity lower in conventional than reduced-tilled cotton fields [1]		documented mortalities of Laughing Gulls and Red-winged Blackbirds from insecticide use in cotton fields [2,3]; terrestrial invertebrate resources likely reduced by heavy use of insecticides, but not studied; seeds and new shoots of weed species probably reduced by herbicide use, but not studied; stripcover cropping a promising method for enhancing invertebrate food resources and biological control on cotton fields [1]		
Waterbird Species Richness					
Waterbird Abundances	greater abundance of Red-winged Blackbirds in reduced-tilled cotton fields [1]				
WATERFOWL			seeds and new shoots of weed species probably reduced by herbicide use, but not studied		
SHOREBIRDS			terrestrial invertebrate resources likely reduced by heavy use of insecticides, but not studied		
WADING BIRDS			terrestrial invertebrate resources likely reduced by heavy use of insecticides, but not studied		
OTHER WATERBIRDS			documented mortalities of Laughing Gulls from organophosphate use in cotton fields [2]; terrestrial invertebrate resources likely reduced by heavy use of insecticides, but not studied		

© National Audubon Society, Inc. 2007

Table 8-3. Continued.

	SOIL AND RESIDUE MANAGEMENT Conventional Tillage vs. No-till	**SOWING**	**PESTICIDE USE, ORGANIC FARMING**	**HARVEST METHODS**	**FIELD SIZE**
LANDBIRDS	greater abundance of Red-winged Blackbirds in reduced-tilled cotton fields [1]		documented mortalities of Red-winged Blackbirds from chlorinated hydrocarbon use in cotton fields [3]; terrestrial invertebrate resources likely reduced by heavy use of insecticides, but not studied; seeds and new shoots of weed species probably reduced by herbicide use, but not studied		

1 Cederbaum, S. B., J. P. Carroll, and C. M. Cooper. 2004. Effects of alternative cotton agriculture on avian and arthropod populations. Conservation Biology **18**:1272-1282.

2 White, D. H., T. G. Lamont, K. A. King, C. A. Mitchell, and E. F. Hill. 1979. Parathion causes secondary poisoning in a laughing gull breeding colony. Bulletin of Environmental Contamination and Toxicology **23**:281-284.

3 El Sayed, E. I., J. B. Graves, and F. L. Bonner. 1967. Chlorinated hydrocarbon insecticide residues in selected insects and birds found in association with cotton fields. Journal of Agriculture and Food Chemistry **15**:1014-1017.

© National Audubon Society, Inc. 2007

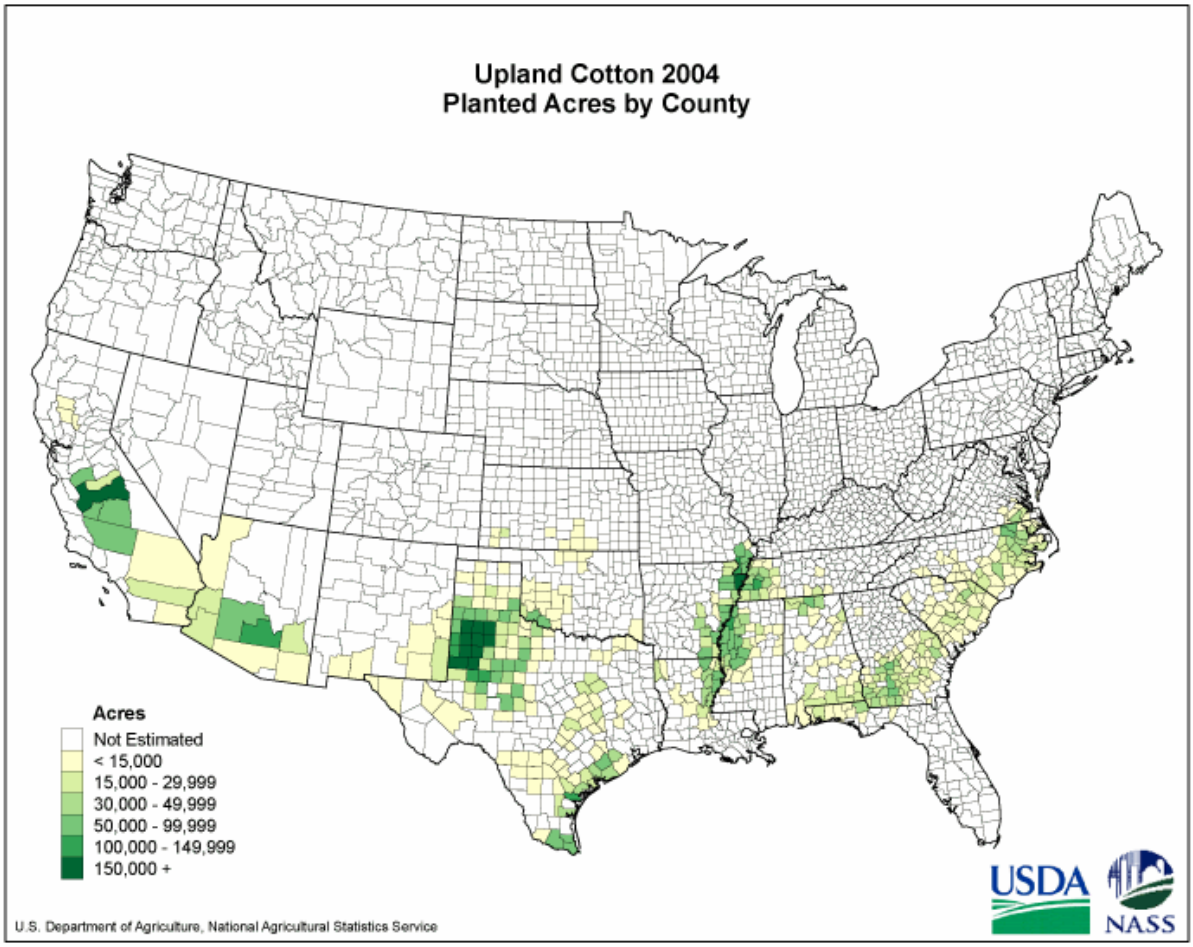

Figure 8-1. Map of the distribution of cotton planted in the United States during 2004, the most recent year for which data are available. From the United States Department of Agriculture National Agricultural Statistics Service (http://www.usda.gov/nass/aggraphs/cropmap.htm).

© National Audubon Society, Inc. 2007