

Synthesis of Observations to Date on Effects of Prairie Dogs on Vegetation of Boulder County Open Space: 2001 to 2011

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EXECUTIVE SUMMARY

Careful quantitative measures of vegetation in areas occupied by black-tailed prairie dogs (*Cynomys ludovicianus*) have been made on Boulder County Open Space at intervals of from 2 to 4 years from 2001 to 2011. Data from unoccupied sites have also been collected for comparison. Plague has caused the disappearance of prairie dogs from many of the monitoring sites during this period. Areas subject to prairie dog grazing tend to have one-half to three quarters the total live vegetation cover that unoccupied areas do. Some sites have little resistance to the close grazing of prairie dogs and are reduced to having only a few percent of the ground covered by live plants, mostly by annual weeds.

With a few exceptions, unoccupied sites possess far higher numbers of plant species per 100 m² than occupied sites. The exceptions occur almost entirely on occupied sites where plague has removed the prairie dogs and a host of annual/biennial plant species have successfully taken advantage of open ground.

The period since plague removed prairie dogs has been from four to six years on many sites. During this time, the degree to which processes of re-development of native grassland cover and species composition has been followed using the monitoring data. Some areas where the impacts of prairie dog grazing have been slower to manifest themselves are showing more rapid recovery. It can be said that it is evident from the data that the recovery process is related to many factors, most certainly one of the strongest is ample availability of moisture. Following the moist years of 2009 and 2010, recovery was accelerated.

Background

Black-tailed prairie dogs (*Cynomys ludovicianus*) are colonial ground squirrels (prairie dogs) that are endemic to the Great Plains of North America. In concert with virtually all the other plants and animals of the North American Grassland Biome, their numbers have been greatly reduced as a result of conversion of the bulk of these landscapes for agriculture and urban use. While conservation of *Cynomys ludovicianus* has been a concern, the conservation of native grassland as still exist under public protection, such as those within Boulder County Open Space, is also a concern. Toward the end of achieving a better understanding of the relationship of these ground squirrels to their plant community environments, repeated quantitative monitoring of plant abundance has been undertaken on areas with prairie dogs as well as adjacent unoccupied and ecologically similar areas. It is intended that these data allow detailed evaluation of the effects of the presence of these animals on plant communities and the response of plants. It is also intended that these data be useful in formulation of future management decisions that may need to be made to facilitate the long-term survival of biological elements of Open Space ecosystems.

The interaction of prairie dogs and native vegetation has been studied comparatively little. Much of the existing literature has to do with the interaction of other grazers and prairie dogs on native rangeland (see for example Miller et al. 2007, Fahnestock and Detling 2002). As pointed out by Whicker and Detling (1988), while the impact of domesticated grazing animals on native and

non-native vegetation has received considerable attention, similar attention to the impacts of native grazers, such as prairie dogs, has been rare.

Data on the temporal ecological dynamics of the vegetation of native grasslands, such as exist in Boulder County, with or without the presence of prairie dogs are almost non-existent. Although those grasslands have been described by many over the years, those works have been centered on qualitative description of grassland types and not detailed analysis of temporal dynamics based on repeated observation. The absence of such information is typical for grasslands in general, not just those of Boulder County. Without such an understanding in hand, assessing the impact of events such as prairie dog occupation is nearly impossible. Toward the end of beginning to accumulate at least some information addressing this void, both Boulder County Open Space and City of Boulder Open Space and Mountain Parks have initiated monitoring on the lands under their management. Some of the monitoring for both agencies has addressed areas occupied by prairie dogs. This report addresses only those data collected on Boulder County Open Space.

Quantitative monitoring of the vegetation in areas of Boulder County Open Space occupied by prairie dogs in comparison to nearby unoccupied and ecologically equivalent areas was begun in 2001 and has continued on an annual basis to the present. A document summarizing and synthesizing the results of the first three-years of monitoring from 2001 to 2004 was compiled in 2005 (Buckner 2005), and an update to that synthesis was compiled in 2008 for the monitoring years of 2005 through 2007 (Buckner and Vik 2008). The present document builds on those results, in consideration of an additional three years data collection (2008 through 2011) and continues the intention of the earlier document to provide the information in executive summary form.

Scope of the Monitoring Efforts

Given the paucity of careful and comparable time sequence observations on the nature of vegetation under the influence of prairie dog grazing anywhere, Boulder County Open Space in 2001 began a modest program to collect such data on their lands. The monitoring procedure was designed to produce data on plant species abundance and species richness. The methods used were intended to be subject to the minimum amount of inter-observer variability. Although each pair of monitoring transects was selected to include an occupied transect and an unoccupied (control) transect, the changeable extent of prairie dog colonization often saw the control site become occupied. It is important to emphasize that though the precision and repeatability of quantitative observations made were comparable and even higher than academic standards, the information collected was intended to answer practical questions about what was happening to vegetation in prairie dog colonies. It was not intended to constitute or even mimic large-scale academic endeavors. Hence, for example, the study sites were not fully instrumented to monitor such variables as atmospheric or soil climate, soil nutrients, or animal movements that might be included in large budget academic work.

General

Two previous syntheses of monitoring data from prairie dog occupied areas of Boulder County Open Space have been made since monitoring was initiated in 2001 (Buckner 2005, Buckner and Vik 2008). As of the most recent previous effort (2005 to 2007 data), areas in the northern County had been affected by plague while most in the south had not. As of this synthesis (2008 to 2011), most of those southern areas have also been affected by plague and most of the prairie dogs formerly present there are gone. This synthesis addresses patterns and rates of vegetational change that have become apparent following interruption of prairie dog occupation on the monitoring sites, emphasizing assessment of rates and patterns of recovery that are apparent at this time.

This report is written from the perspective of grassland conservation. The explicit value assumptions are:

- 1) Grasslands that are primarily native in nature (i.e. have not been converted to improved pasture) dominated by native perennial grasses (usually both cool and warm season) along with native perennial forbs constitute a desirable state;
- 2) Grassland conditions in which one or more of the latter lifeforms¹ are missing and in which introduced annual, biennial or perennial species are elevated in abundance represent an altered state.

If relieved of the outside stresses that caused the alteration, grassland plant communities altered so as to include expanded opportunities for invasive weed proliferation, tend to, at varying rates, change back to dominance by the perennial native grasses and forbs. During the initial stages of this process it is very common for the opportunistic plants (both native and non-native) that we label as weeds to take advantage of reduced perennial competition and proliferate. With some exceptions related to severe soil/substrate limitations, the "weed" stage is transitory, though it may be much longer than is tolerable to human managers / observers, eliciting the need for weed control. Reduction of weed abundance may or may not speed the recovery of perennial dominance depending on specific circumstances.

The process of re-attaining dominance by native perennial forbs and grasses is sometimes below referred to as recovery, because the process, absent further stress, moves in the direction of recovering a state apparently closer to the original, dominated by native perennial warm and cool season grasses and forbs. Sites in which soils have undergone severe alteration during the stress period are likely to require very long periods of time to recover to achieve the state described.

¹ Plant lifeforms are general categories of plants based on their anatomy and life cycle. General anatomical lifeforms that are referred to here are trees, shrubs, subshrubs (<10 cm height), grasses, and forbs. The latter roughly correspond to what are known as "wildflowers". Consideration of life cycle differences leads separation of annual and biennial forbs from perennial forbs. Annual plants die and begin from seed each year, biennials do so every other year, and perennials live for 3 or more years. In addition to these categorizations, it is useful to separately identify those that are native species from those that are non-native (introduced).

Summary of Vegetation Observations 2001 to 2011

Total Vegetation Cover

As regards the effects of prairie dog occupation on the total extent of live vegetation cover, the observed results are that compared to unoccupied sites, live cover is generally from $\frac{1}{2}$ to $\frac{3}{4}$ (often about $\frac{2}{3}$). If considering only sites such as Rock Creek where young soil with limited development exist, the prolonged occupation by prairie dogs leads to cover from 1 to 5 %, approximately $\frac{1}{6}$ that of unoccupied sites of ecological equivalence.

Species Diversity

Measures of the number of different plant species in a uniformly sized area (100 m²) produces a useful descriptor that may be referred to as “species density.” This measure is useful in assessing the effects of prairie dog occupation on species diversity of the affected plant communities. Based on the Boulder County Open Space data (and consistent with other data from the area), the general effect of the presence of prairie dogs is to reduce the number of species per 100 m². With a few exceptions, unoccupied sites possess far higher numbers of species per 100 m² than occupied sites. The exceptions occur almost entirely on occupied sites where plague has removed the prairie dogs and a host of annual/biennial plant species have attempted to take advantage of open ground.

The pattern of species diversity effects after an area of grassland has been colonized by prairie dogs can be summarized as follows:

- Cool season native grasses are apparently highly attractive to the prairie dog palate – they also have low enough resistance to defoliation that they are the earliest lifeform to disappear—usually within the first three to five years.
- Native perennial forbs are a highly variable category, but in general are vulnerable to being overgrazed and their numbers decline with length of prairie dog occupation.
- Warm season native grasses are somewhat more resistant to nearly complete defoliation than cool season grasses and apparently are at least somewhat least palatable. Nonetheless, after an extended period they are eliminated under continuous prairie dog grazing.
- Annual / biennial forbs have enhanced opportunities to occupy areas of extended prairie dog occupation. It is quite likely that they are an important food item for the animals when all palatable perennial growth has been eliminated. Upon the sudden disappearance of prairie dogs, as can happen with plague outbreaks, annual / biennial growth is typically immediately abundant.

Summary of Vegetational Change Following Plague-Induced Removal of Prairie Dogs

It has become apparent from the accumulated observations to date in Boulder County that recovery of native grasslands or any grasslands following the disappearance of prairie dogs is complex, but mostly slow and very slow with some exceptions. By use of the qualitative term “slow”, the author intends to convey a period from 5 to 15 years until species composition and abundance recover. For sites where longer than 15 years is likely needed, the descriptor “very slow” is applicable.

The complexities are driven by several factors:

- ***Degree of loss of the original vegetational components***. Prairie dog grazing is continuous during the growing season and live foliage is cropped very close to the ground surface. When plants are deprived of photosynthetic area (foliage), the flow of energy into the plant is severely restricted, and all parts of the plant are likely to be negatively affected. If the defoliation continues long enough, death of the plant ensues (see for example Sosebee 1977). Based on the Boulder County monitoring of areas newly occupied by prairie dogs, over the years it been clear that under such conditions native perennial cool season grasses disappear most rapidly. Most warm season grasses linger somewhat longer than cool season perennial grasses. Native forbs are able to remain under prairie dog occupation for highly variable periods with much variation between species. In the absence of prairie dogs, the recovery process seems to follow the reverse order of disappearance for at least the perennial grasses. For example, native cool season perennial grass disappears before and recovers more slowly than native warm season grasses. This may relate to native cool season grass having been largely or fully extirpated from the site and thus dependent on establishment from seed to return.
- ***Age of the original community***. Grasslands of Boulder County occur on a wide variety of geologic surfaces, some of which have been stable for hundreds of thousands of years, others of which are subject to ongoing erosional loss. Soils on the old stable sites are not only possessed of advanced profile development (as evidenced for example by well-developed subsurface clay or carbonate accumulations and deep weathering to very red color), but also give evidence by virtue of this advanced soil development of having supported vegetation development of correspondingly long periods. The Boulder County prairie dog monitoring data show a trend for plant communities of the older surface to show more resistance to change in the face of ongoing prairie dog herbivory. Upon plague outbreak, the older communities are more likely to have experienced less damage (in terms of full loss of perennial species) and be in better position for initiation of recovery (see point above). South-county sites (see Lindsay and Zaharias) document this well. Their recovery is facilitated by the tenacity of the native plants to resist extirpation under the near total defoliation that attends occupation by prairie dogs.
- ***Weather patterns***. Recovery is greatly aided by abundant moisture. Recovery in the north-County areas where plague struck first in the mid-2000s was limited by below average moisture until 2009 to 2011 when above-average moisture accompanied much accelerated re-establishment of native grasses and forbs lost during prairie dogs occupation.
- ***Weed Competition***. Sites that have little or no remnants of native perennial vegetation following prairie dog occupation can be so thoroughly overtaken by extensive weed development comprised of large and competitive species that even with favorable moisture, competition from weeds can retard recovery.

In consideration of Boulder County Open Space prairie dog monitoring data collected to date, an educated guess can be made as to how much time is needed to achieve re-establishment of grassland species composition and strength after prairie dog occupation ceases. It is projected

that following the disappearance of prairie dogs from Boulder County grassland sites, time to recovery of above-ground cover by native plants of the grassland communities to a composition approximating that which existed prior to the presence of prairie dogs may be 5 to 30 years, depending on the particular grassland community, its age / soil, and moisture conditions. However, the time to a full or nearly full recovery of ecological resistance and resilience is not known, but certainly it is longer than the time to recover above-ground species composition and abundance. The process and rate of recovery of resistance and resilience is very little understood. There is no evidence here or in the literature for how long the recovery of resistance to impact from heavy herbivory will take in Boulder County grasslands. Should climate change models predicting overall drier conditions be correct, recovery rates will definitely be slower because the Boulder County data do clearly show that dry conditions retard recovery and moist conditions accelerate recovery.

The quality of the plant community that gives it resistance and resilience in the face of stresses, such as those that accompany continual defoliation by prairie dogs, is likely related to and perhaps dependent on the strength of below-ground plant development. We do have recovery information from a site where previous cultivation had clearly removed the entire native plant community. At the City of Boulder Open Space and Mountain Parks Aweida II site, a restoration of prairie plants was undertaken on old wheat fields. The restoration begun in 1996 was proceeding well with well-developed cover by native warm and cool season perennial grasses. The site was colonized by prairie dogs, and by 1999, they had occupied over half the restoration area. Despite very strong development of the above-ground parts of the native species, the occupied portion of the restored grassland community collapsed to bare soil and bindweed within a single year after prairie dogs arrival (OSMP files, ESCO 2000, 2001, 2002, and 2003). Thus it is apparent that beyond the physical presence of vigorous native plant cover, there is something more that relates to the capacity of the native plants to sustain themselves under extremely heavy grazing pressure like that typically associated with prairie dogs.

For sites where plowing did not accomplish full destruction of native grassland, including most of the Boulder County Open Space monitoring sites, the carry-over of resistance after an episode of prairie dog occupation is unknown. It is likely that many prairie dog occupied sites where plague has removed them before complete eradication of native plants occurred will have retained some plant community resistance. Observations into the future may prove very instructive in evaluating the degree to which prairie dog occupation of varying length and in varying ecological sites can be maintained.

So far, it is clear from the monitoring data to date that the rate at which recovery occurs on grasslands stressed by temporary prairie dog occupation is dependent upon the degree to which the original array of native lifeforms and species survive as even small remnants. Sites such as Zaharias, where small remnants of native perennial cool season grasses (western wheatgrass and bottlebrush squirreltail), usually the first lifeform to be extirpated, survive after long prairie dog occupation and have the capacity to make rapid recovery. On sites where cool season native perennial grasses have been extirpated, such as Lindsay 1, the recovery of these grasses is very slow, likely because of the need to establish from seed rather than proliferating vegetatively. Sites where extirpation of native perennial components took place early in prairie dog occupation, such as Rock Creek Farm (young thin soils), are extremely slow to recover.

Site Details

In this section, specifics of the patterns of vegetation variation over the duration of monitoring are discussed for each of the monitoring sites. At each site, a pair of transects were originally established, an odd-numbered transect located in the prairie dog-occupied area was paired with an even-numbered transect in a nearby area not occupied. Pairs of such transects denoted by an odd number separated from an even number by a colon are referenced below, e.g. Lindsay 1:2. Given the colonizing nature of the prairie dogs, the unoccupied (even-numbered) sites sometimes became occupied, rendering the control function of data from those sites less clear. In many of these cases, data from other nearby monitoring sites that did remain unoccupied could be referenced. Supporting graphs and maps of prairie dog occupation of the monitoring sites are located at the end of this document.

In the discussion below, when mention is made of cover for a species or lifeform being “immeasurably small” it means that the plants in question were so sparse as to comprise less than 1% and usually much less than 1% cover, but were present within a 100 m² area surrounding the sample transect.

Lindsay

The Lindsay 1:2 site near the south edge of the County has been monitored in 2001, 2003, 2005 and 2008. It would appear that there has been diminishment but not cessation of prairie dog use on the occupied transect, perhaps related to plague, but also perhaps a change in foraging patterns. In any case, the occupied transect (Lindsay-1) entered the monitoring period in 2001 with 25% vegetation cover, about a third of which was native perennial cool season grass and half of which was native perennial warm season grass. As of 2008, total vegetation cover was 15%, of which none was perennial grass of any sort. The 2008 cover was virtually all snakeweed (*Gutierrezia sarothrae*), a subshrub, and bracted verbena (*Verbena bracteata*), an annual forb. The last time measurable cover by native perennial cool season grass was observed was 2003. The last measurable cover by native perennial warm season grass was seen in 2005. As of 2008, very small remnants of warm season grass remain but no presence of cool season perennial grass is observable at all.

The unoccupied transect at Lindsay (2) had come within the foraging range of *prairie dogs* by at least 2004. What had been grassland dominated by warm and cool season perennial native grasses in 2001, 2003 and 2005 possessed, as of 2008, half of the 2005 total vegetation cover had become largely dominated by Japanese brome (*Bromus japonicus*), an introduced annual grass similar to cheatgrass (*Bromus tectorum*). This clearly shows how quickly the abundance and competitive strength of the native grasses can be diminished by the foraging of prairie dogs.

Zaharias

Zaharias Transect 1 and 2 were monitored in 2002, 2004, 2005, 2008 and 2011. The Zaharias occupied site (Transect 1) had been continuously occupied since the beginning of monitoring in 2001 through the 2008 observations. Immediately after that however, plague removed the prairie dogs and thus the 2011 observations reflect three years of growth in the absence of prairie dogs. Transect 2 was unoccupied until 2004 and became unoccupied again after 2008. Both Transects 1 and 2 show recovery of warm season grass cover and the barest beginnings of recovery of cool season grass cover (note that cool season grass cover disappears first under prairie dogs grazing).

A pattern that has previously been discussed relative to the grasslands on the older soils, such as these grasslands of Verdos-age surfaces and soils (640,000 years old) is that they have seemed to be more resilient under the occupation by prairie dogs than other grasslands on younger sites (Buckner, manuscript in preparation). On the Zaharias 1 and 2 sites, the native grassland has been greatly altered during the tenure of prairie dogs on the site. As of 2002, the site had already been occupied for some time, and total vegetation cover was only 14%, but most of that was buffalograss and blue grama. By comparison, in 2002, an equivalent unoccupied site nearby (the Zaharias 2 transect) had 29% total cover including 22% cover by buffalograss. Native perennial warm and cool season grasses were reduced to 5% by 2008. During the prairie dog-free period of 2009 to 2011, additional native perennial forbs made themselves apparent on both Zaharias 1 and 2. These species even though they are often present in very small amounts are clearly available to restock the community if given the opportunity to sustain foliage sufficient to accomplish healthy growth.

Mayhoffer

Mayhoffer has, between prairie dog and grazing-monitoring, eight pairs of monitoring transects. Most (except Mayhoffer 7 and 8) are on very old soil (Vedros age, 640,000 years old). Mayhoffer 1 was occupied by prairie dogs from the original setup in 2001 through 2008. As of 2006, it had only 9% cover, most of which was fringed sage. By 2009 one year after prairie dogs departure and at the end of 4 to 5 years of dry conditions, cover was seven times greater and native perennial forbs (primarily western ragweed, *Ambrosia psilostachya*, and ironplant goldenweed, *Machaeranthera pinnatifida*) along with annual and biennial forbs (the introduced yellow sweetclover, *Melilotus officinalis* and Jim Hill mustard, *Sisymbrium altissimum*, with the native bracted verbena, *Verbena bracteata*) comprised the bulk. Mayhoffer 2, occupied from 2004 to 2008, showed a similar response as of 2009.

Mayhoffer 3 was occupied as of the beginning of monitoring (2001) from relocated prairie dogs and had prairie dogs disappear after 2007. By 2010, it had nearly 90% cover. Nearly half was cheatgrass, but there was 7% native cool season grass and 3% native perennial warm season grass. By 2011, total cover was at 56% and cheatgrass was only 6%. Native perennial cool season grass was 17% and native perennial warm season grass was 27%.

Mayhoffer 5 was temporarily occupied by prairie dogs for a short period of time in the summer of 2001 by relocated prairie dogs that were few in number and the translocated colony failed by the end of 2001. It has maintained fairly stable conditions over the years, with between 40 and 50% total cover, half to a little more comprised by native perennial warm season grass with the remainder divided between native perennial cool season grass, native perennial forbs and native subshrubs. It should be noted that although areas like Mayhoffer 5 have not experienced prairie dog occupation through the course of the monitoring, they are likely not perfect controls because foraging livestock almost inevitably are focused down to the few areas remaining that have useable forage. This is probably the reason that the warm season grass cover on Mayhoffer 5 includes a good bit of purple threeawn (*Aristida purpurea*), a species often indicative of excessively heavy grazing prior to its acquisition as Open Space.

Mayhoffer 7 was occupied from the 2001 initiation of monitoring until 2008. Prairie dogs were relocated to this site in 2001, and they expanded until plague eliminated the colony in 2008. As

of 2011, it was apparent that diffuse knapweed (*Acosta diffusa*) had established a strong hold on this site, and the recovery of native perennial species and lifeforms were very limited.

Carolyn Holmberg Preserve at Rock Creek Farm

The Rock Creek Farm site was monitored in 2001, 2003, 2006 and 2009. Prairie dogs were present at the occupied site (Rock Creek 1) almost continuously from 2001 onward. The “unoccupied” site (Rock Creek 2) was unoccupied only from 2001 to 2002.

The Rock Creek Farm sites are underlain by fine-textured shale-derived soils and as of 2001 were still representative of the grasslands of such soils with predominance of blue grama, buffalograss, and western wheatgrass. By 2003, although reduced, some of these grasses were still present. However, by 2006, all grasses had been eliminated. The vegetation on essentially the entire Rock Creek Farm parcel had converted to a community dominated by introduced annual plants, mostly common purslane (*Portulaca oleracea*) with smaller amounts of thymeleaf spurge (*Chamaesyce serpyllifolia*), and pickernelweed (*Picradeniopsis oppositifolia*). An unoccupied comparison has been unavailable as of 2006, so a reference transect east of U.S. 287 was established on Broomfield Open Space on similar soils. As of 2006, the total vegetation cover of the unoccupied reference site was 25% compared to 11 to 16% in the prairie dog occupied areas.

As of 2009, slightly less than 2/3 of the 27% total occupied cover was comprised of introduced annual and biennial forbs, including lambs quarters (*Chenopodium album*), Russian thistle (*Salsola australis*), and Jim Hill Mustard (*Sisymbrium altissimum*). The remainder of measurable cover was comprised of native annual and biennial forbs including fetid marigold (*Dyssodia papposa*), buffalobur (*Solanum rostratum*), and groundcherry (*Solanum triflorum*). No measurable presence of grasses was encountered although a trace of western wheatgrass was observed within the transect area, where none had been present in 2006.

In the Rock Creek “unoccupied” site, which has actually been occupied almost as long as the “occupied” site, no grasses survived by 2009. Although more than 8/10 of the 36% total vegetation cover was comprised of native and introduced annual and biennial forbs, almost 15% was of native perennial forbs (ironplant goldenweed, *Machaeranthera pinnatifida*, and scarlet globemallow, *Sphaeralcea coccinea*) surviving from the original native grassland. Thus the difference between eight years of occupation versus six years is that after only six, the barest presence of native perennial forbs continues to survive. All grasses, however, are gone.

Rabbit Mountain: Brand Parcel

The Rabbit Mountain: Brand parcel was monitoring in 2001, 2003, 2008 and 2011. At the time of prairie dog disappearance in about 2003, the total vegetation cover in the occupied site was 17%, comprised nearly entirely of common bindweed (*Convolvulus arvensis*). Five years later as of 2008, woody plants and native perennial forbs each comprised about a third of total vegetation cover (still 17%), with common bindweed holding on to the remaining third. Warm and cool season perennial grasses, while completely absent in the sample in 2003, were present, though not measurably abundant, in 2008. Thus recovery at Brand has taken the form of woody plant and native perennial forb establishment with minimal native grasses back on the site, but no change in the low total vegetation cover has developed. Between 2008 and 2011, prairie dogs

returned to Transect 1. Bindweed and white prairie aster (*Aster (virgulus) falcatus*) comprised the bulk of vegetation cover as of 2011. Further recovery after the return of prairie dogs is not apparent.

Rabbit Mountain

Rabbit Mountain transects 1 and 2 had been sites of planting to Russian wildrye (*Psathyrostachys juncea*). These transects were sampled in 2001, 2003, 2008 and 2011. The last of the wildrye on the occupied transect had been reduced to below measurable cover on the occupied site by sometime shortly after 2003, and before the prairie dogs themselves disappeared in 2004-2005. As of 2008, the occupied site was almost completely dominated by snakeweed (*Gutierrezia sarothrae*). Occurrence of the native warm season grass purple threeawn and the non-native domesticated Russian wildrye was far below 1% cover. The originally unoccupied site (Transect 2) that had been briefly occupied before 2004-2005 as of 2008 had measurable Russian wildrye still present, while Transect 1 mentioned above did not. Recovery as of 2008 on the occupied site (Transect 1) after four to five years had thus amounted to a proliferation of snakeweed with a modest increase in total cover. The originally unoccupied then briefly (2 or 3 years) occupied Transect 2 reflecting that stress had shown an increase in snakeweed and recovery of native warm season and cool season grass. Russian wildrye had not been reduced to immeasurably small amounts as had occurred on Transect 1.

As of 2011, prairie dogs are still absent. Species diversity has gone up on the occupied site as introduced annual forbs invaded the site without being removed by *prairie dogs*. Monitoring data show that recovery on the occupied site (Transect 1) has moved from the heavy dominance of snakeweed to its extensive demise and replacement by cool season grasses including the originally planted non-native Russian wildrye as well as native perennial cool season grasses (bottlebrush squirreltail, *Elymus elymoides* and western wheatgrass, *Pascopyrum smithii*), and native warm season grass (mostly purple threeawn), and the appearance of nine new native perennial forbs (there had been only two in 2008) including western ragweed (*Ambrosia psilostachya*), prairie milkvetch (*Astragalus laxmannii*), shaggy dwarf morning glory (*Evolvulus nuttallianus*), scarlet gaura (*Gaura coccinea*), spotted gayfeather (*Liatris punctata*), puccoon (*Lithospermum multiflorum*), ironplant goldenweed (*Machaeranthera pinnatifida*), wild tarragon (*Oligosporus dracuncululus*), narrowflower scurfpea (*Psoralidium tenuiflorum*), and scarlet globemallow (*Sphaeralcea coccinea*).

Following the disappearance of prairie dogs at the Rabbit Mountain Site in approximately 2004, the next years (through 2008) were below average in precipitation, especially in regard to the metric of precipitation over the previous four and six months (Figure 1). During 2009 through 2011, on the other hand, moisture conditions were above average. The rather dramatic recovery of species and lifeforms since 2008 is likely strongly driven by much improved moisture availability.

Rabbit Mountain: Sherwood Parcel

The Sherwood site on Rabbit Mountain was monitored in 2001, 2004, 2007 and 2011. The occupied site (Rabbit Mountain 3 transect) was occupied from 1997 to 2004, then plague killed the prairie dogs on the occupied site, though prairie dogs were still living nearby. The occupied

site then became partially occupied from 2009 to 2011. The “unoccupied” site (Rabbit Mountain 4 transect) was unoccupied in 2001 and 2002, then occupied in 2003 and 2004, plagued out in 2005, reoccupied in 2006 and has remained so through 2011.

As of the first monitoring in 2001, the occupied site had already been so for 4 to 5 years at least and the vegetation was dominated by unpalatable fringed sage (*Artemisia frigida*) along with rubber rabbitbrush (*Chrysothamnus nauseosus*) along with cheatgrass (*Bromus (Anisantha) tectorum*). By 2004, it was even more thoroughly dominated by fringed sage and rubber rabbitbrush. By 2007 after three years without prairie dogs, fringed sage had declined substantially and introduced annual forbs, mostly filaree (*Erodium cicutarium*) and Jim Hill mustard (*Sisymbrium altissimum*), had become an extensive part of the cover. By 2011 with no or marginal prairie dog use since 2005, there was strong dominance by cheatgrass with the beginnings of a reappearance of western wheatgrass (*Pascopyrum smithii*) and purple threeawn (*Aristida purpurea*).

For the Rabbit Mountain 4 transect that began as an unoccupied site, the occupation of this site actually has been more continuous than Rabbit Mountain 3. Rabbit Mountain 4 probably experienced somekind of disturbance prior to 2001 as it was thoroughly dominated by cheatgrass at that time, although it was chosen as the unoccupied site in 2001. Since 2001, it had begun a recovery with appearance of native perennial cool season grass, but through the years with nearly continuous involvement of prairie dogs, it has come to approximate the long-term condition of Rabbit Mountain 3 with strong dominance by fringed sage and other subshrubs including snakeweed (*Gutierrezia sarothrae*) and wormwood (*Oligosporus dracunculus*).

Heil Valley Ranch 1:2

The Heil Valley Ranch Transect 1 and 2 were monitored in 2001, 2003, 2006, 2008 and 2011. The native vegetation cover at occupied Heil transect 1 was comprised primarily of cool season grass and grass-like plants, mostly Agassiz bluegrass (*Poa pratensis* ssp. *agassizensis*) and Canada bluegrass (*Poa compressa*). This assertion is based on the slope position and surrounding conditions. As of the beginning of monitoring at Heil 1 in 2001, all cool season grasses and grass-likes were gone. As of 2003, over 95% of the vegetation cover was common bindweed. With the disappearance of *prairie dogs* in 2006, the intervening two years saw a doubling of total cover, almost all of which was attributable to invasion of weeds which are opportunistic native and non-native plants that would have been systematically removed as they germinated in the presence of *prairie dogs*. Immeasurably small amounts of cool season grasses were also observed in 2008.

Thus in 2008, two years of recovery at Heil 1:2 had amounted primarily to a proliferation of weedy opportunists, some of which were County noxious weed targets. Thistles, common mullein, and diffuse knapweed were spot-sprayed by County staff in 2008. By 2011, with prairie dogs still absent, the vegetation of the formerly occupied transect was much the same as in 2008 except with the addition of over 50% ground cover by cheatgrass. The more favorable moisture conditions of 2008 to 2011 (and in particular late 2010 and early 2011) are likely to have facilitated the establishment of cheatgrass. Note that during these three moister years, unlike some other monitoring sites, no substantial progress toward re-establishment of native perennials

has occurred, even though the native species have had a continuous albeit very low abundance throughout the monitoring record.

Heil Valley Ranch 3:4

Heil Valley Ranch transects 3 and 4 were monitored in 2002, 2005, 2007 and 2010. Like Heil 1:2, the original native vegetation here was predominately Agassiz bluegrass and Canada bluegrass. And like Heil 1:2 at the start of monitoring, (2002 in this case), all cool season grasses (apparently *prairie dogs*' most preferred food lifeform) had completely disappeared. After the disappearance of *prairie dogs* in 2004, total cover began increasing as opportunistic plants thrived. By 2007, cover on the occupied Heil 3 area was up to 69% because of extremely vigorous growth by noxious weeds, including musk thistle and white horehound, as well as cheatgrass. By 2010, County Open Space efforts to control the noxious weeds had been effective. Unlike Heil 1:2, the extremely wet winter of 2009-2010 and the wet spring of 2010 successfully elicited a reappearance of cool season grasses in the previously occupied site including Agassiz bluegrass, Canada bluegrass, green needlegrass (*Nasella viridula*), as well as a small amount of sun sedge (*Carex pensylvanica* ssp. *heliophila*). This is a very positive step in recovery. The fact that it occurred six years after cessation of *prairie dog* occupation is probably important in combination with the effects of a very wet spring.

Hall Ranch

Hall Ranch transect 1 and 2 were monitored in 2001, 2003, 2007 and 2010. At this site, the plague die-off was incomplete, and the diminished presence of *prairie dogs* was only about three years. The only change during the period of *prairie dog* decrease was a slight increase in the abundance of annual weeds in 2007 as the previous *prairie dog* removal of weed seedlings was abated. By 2010, with full return of *prairie dog* numbers, the transition from a Russian wildrye planting, still evident at the initiation of monitoring in 2001, to a field of common bindweed was complete. No Russian wildrye was present at all in the sampling area as of 2010.

Here it can be reasonably said that about three years of diminished *prairie dogs* presence accompanied no significant recovery whatsoever.

The unoccupied Transect 2 has remained more or less stable through the monitoring period with strong cover by native species, but also having had consistent cover by cheatgrass also.

Colp

Colp 1 and 2 were monitored in 2002, 2005, 2008 and 2011 (no. 2 only). The Colp sites are present on Verdos-aged alluvium, and the original vegetation was a big bluestem grassland. As of the beginning of monitoring in 2002, the cool season grass component was already gone in the *prairie dog* occupied area (Transect 1). Subsequent to the disappearance of *prairie dogs* in 2006, the absence of continuous herbivory allowed a flush of annual weeds, primarily Jim Hill mustard (*Sisymbrium altissimum*), alyssum (*Alyssum parviflorum*), and cheatgrass to proliferate. The intervening two years of recovery prior to the 2008 observations saw no recovery of cool season graminoids. Recovery during the moist period 2009 to 2011 on Colp 1 and 2 is not known. However, sampling of the Grazing Monitoring Transects that are interspersed in this area and have experienced *prairie dog* occupation similar to Colp 1 and 2 shows that as of 2011, recovery

of native warm season grass, mostly big bluestem, has been strong. Introduced annual/biennial forbs, mostly alyssum and Jim Hill mustard are also still abundant.

Wolf Run

Wolf Run Transects 1 and 2 were monitored in 2001, 2003 and 2009. The Wolf Run-1 site offers what may be the only exception to the general observation that recovery after prairie dog occupation is slow to very slow. Transect 1 was occupied in 2001 and 2003. After 2004, plague removed the animals. As of 2005, Transect 1 was primarily covered by snakeweed and smooth brome. In 2009, approximately five years after *prairie dog* disappearance, recovery of a cool season grassland cover was very well along. This advanced recovery is likely related to two factors: 1) Loss of cool season grass cover was not nearly complete as of the appearance of plague and 2) this site is concave and the natural vegetation (western wheatgrass, *Pascopyrum smithii*) has strong potential to recover from underground stems (rhizomes). Such western wheatgrass sites have deeper soils and at least slightly enhanced moisture accumulation. From the underground stems, a western wheatgrass cover that is just diminished and not eliminated can restock its previous extent quickly.

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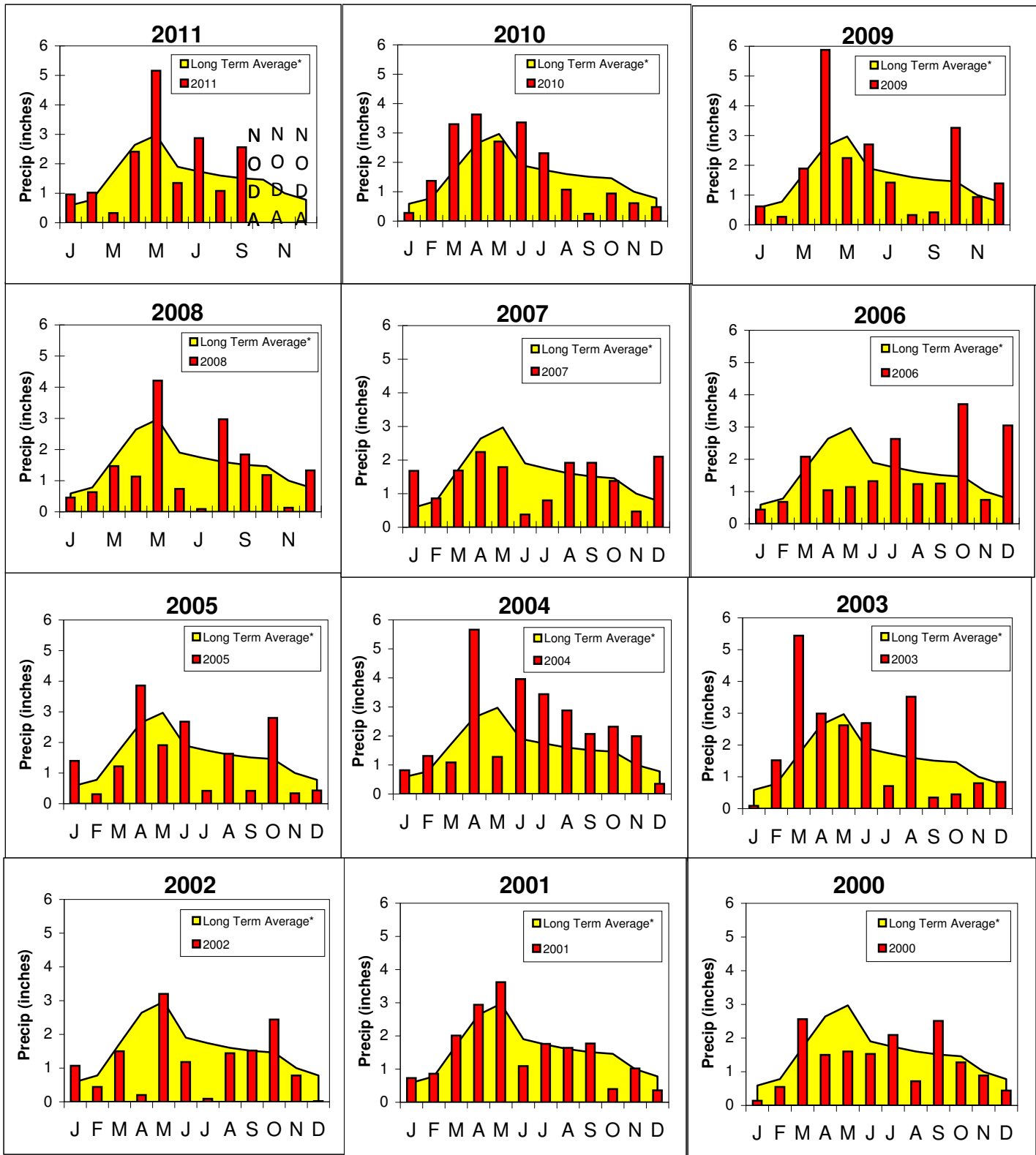
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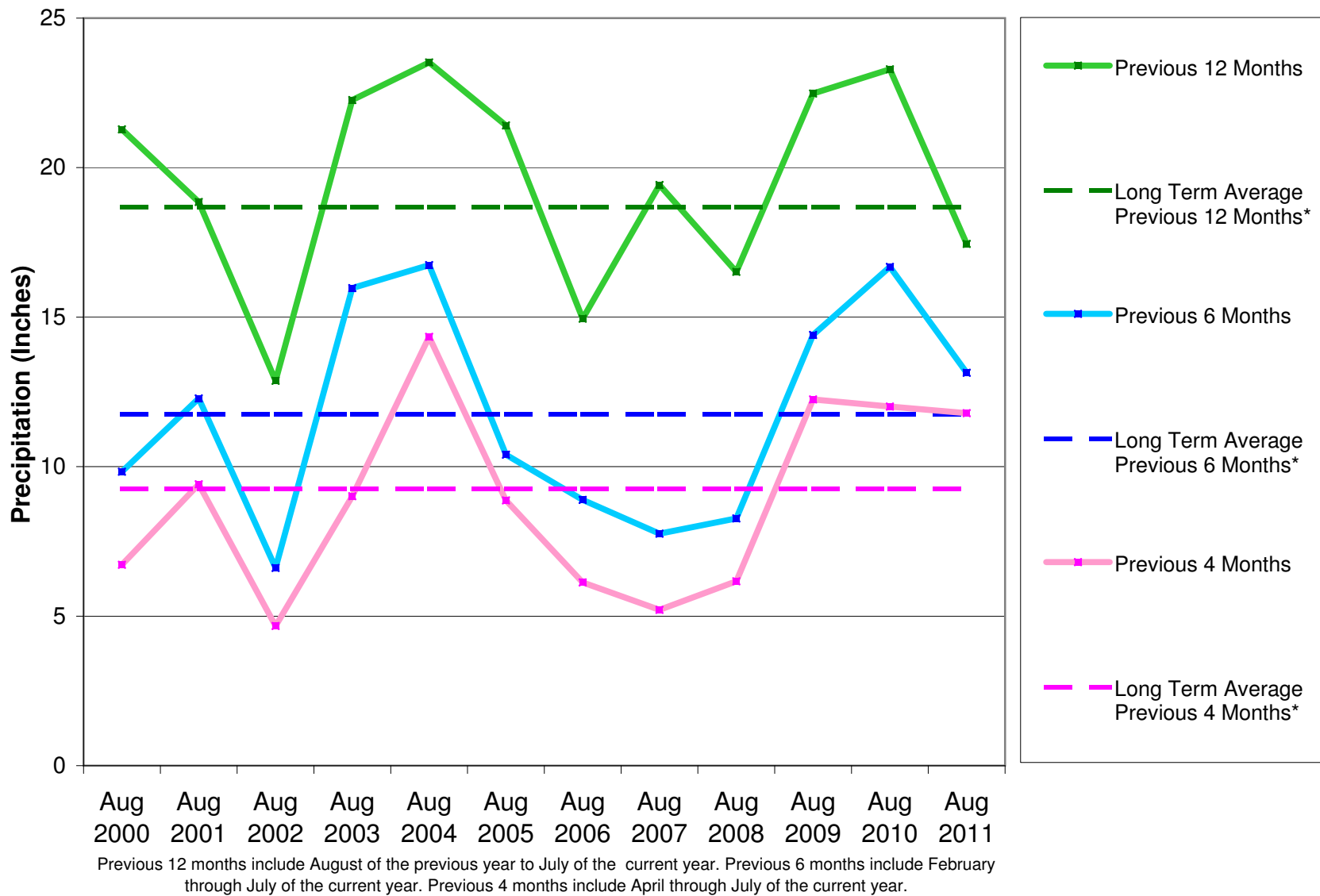
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Figure 4. Precipitation by Month and Year (2000-2011), Boulder NOAA Station Data, Grazing Monitoring
 Boulder County Open Space, CO - 2011

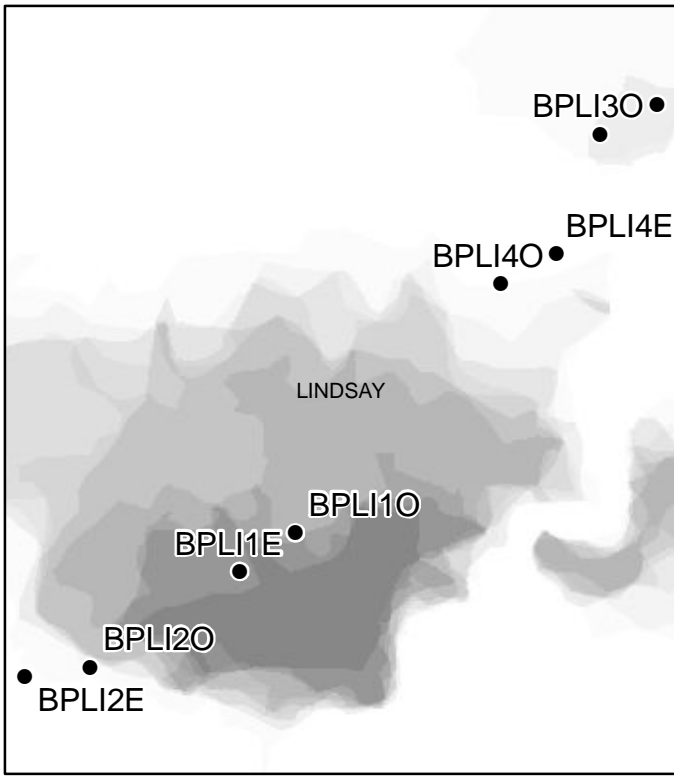


* Long term average for Boulder, Colorado NOAA Station (050848) 1893-2010

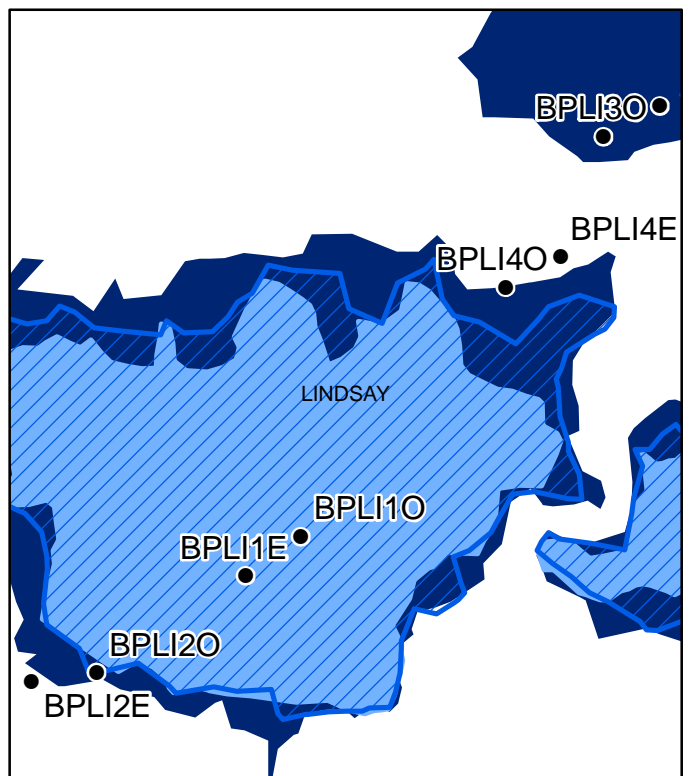
Figure 5. Total Precipitation for Previous 12, 6 and 4 Months as of August (2000-2011), Boulder NOAA Station Data, Grazing Monitoring, Boulder County Open Space, CO - 2011



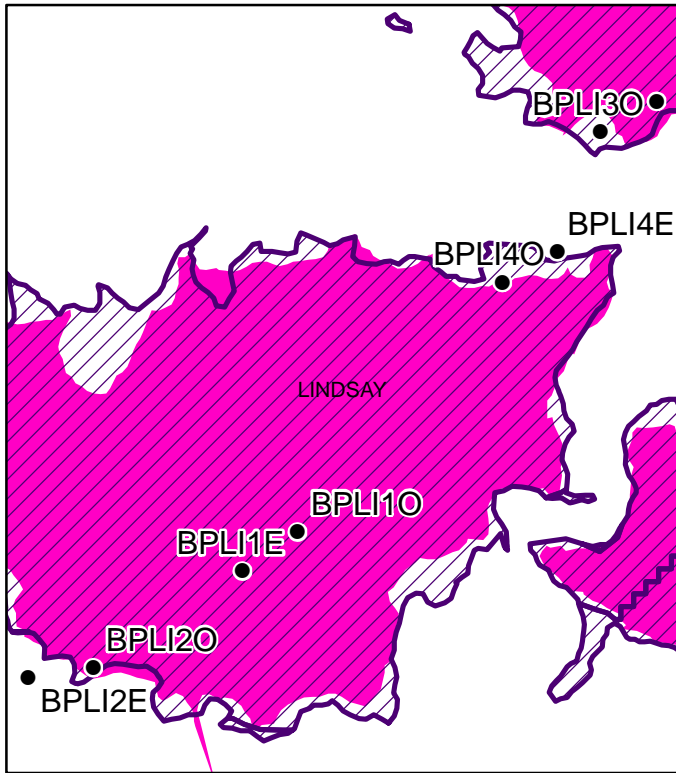
* Long term average for Boulder, Colorado NOAA Station (050848) 1893-2008



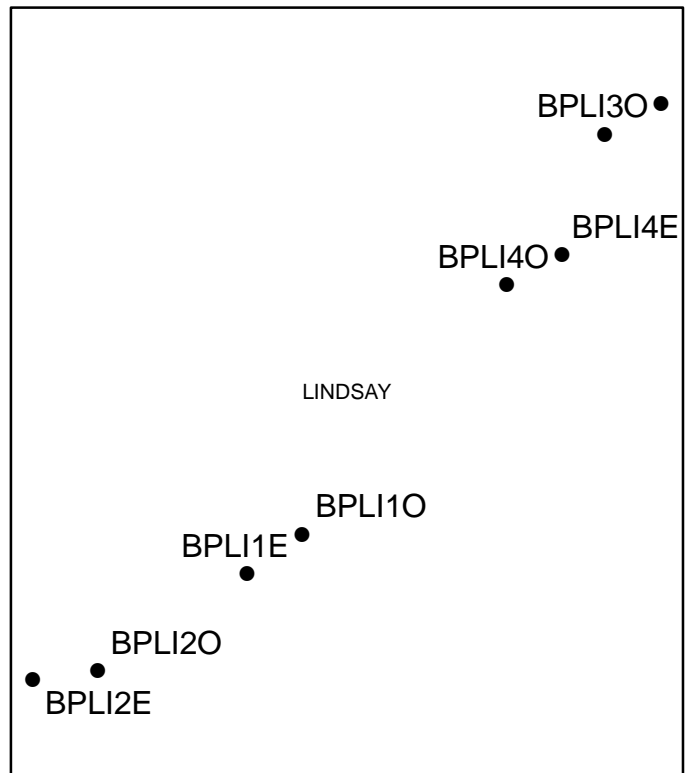
1997-2006



2004-2006



2007-2009



2010-2011

Map 1. Boulder County - Prairie Dog Colony Mapping - LINDSAY PARCEL

~1997 darkest gray >> 2006 lightest gray

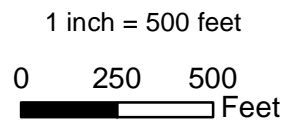
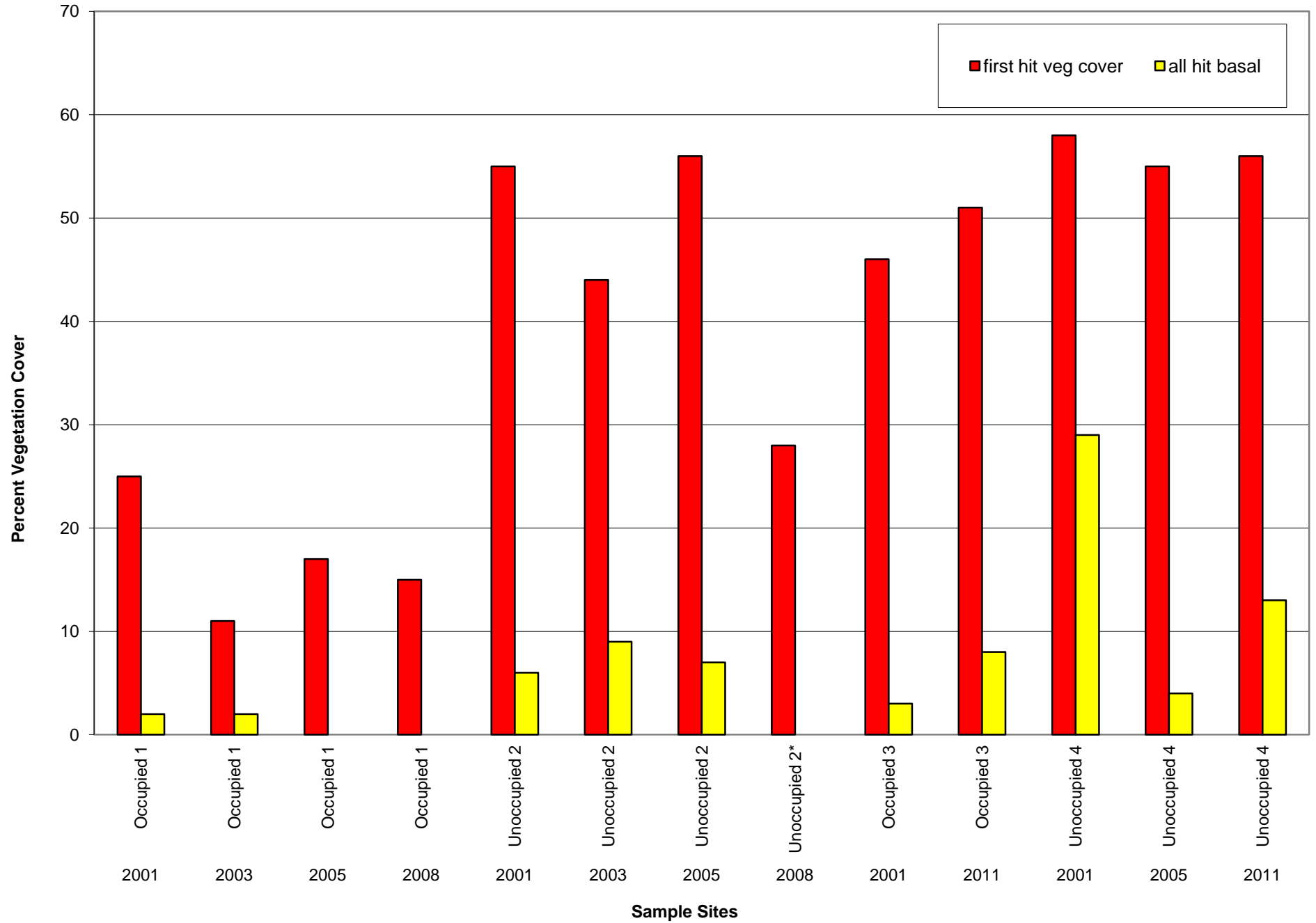
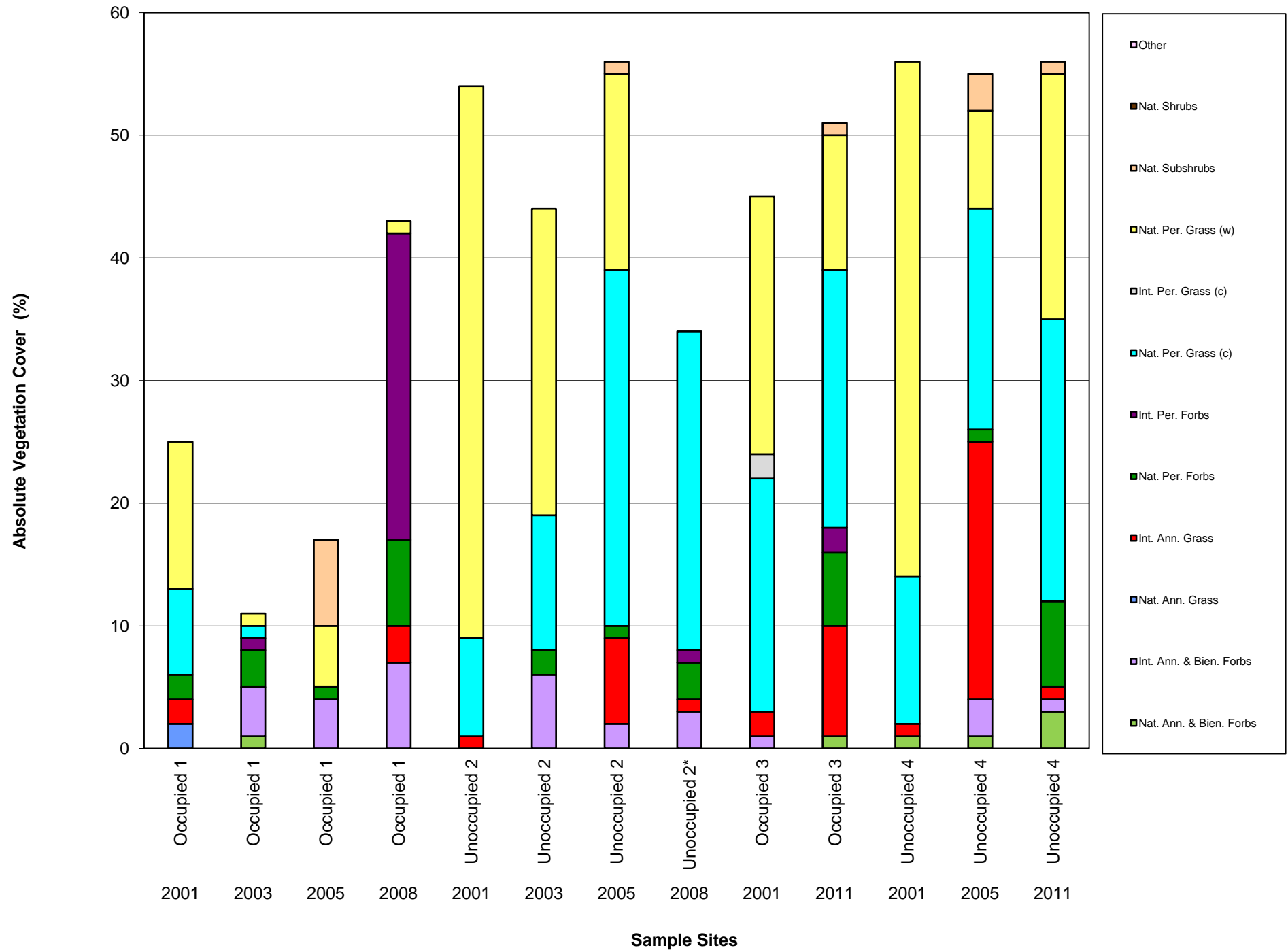


Figure 1a. Total Vegetation Cover - Lindsay Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2005 and 2011



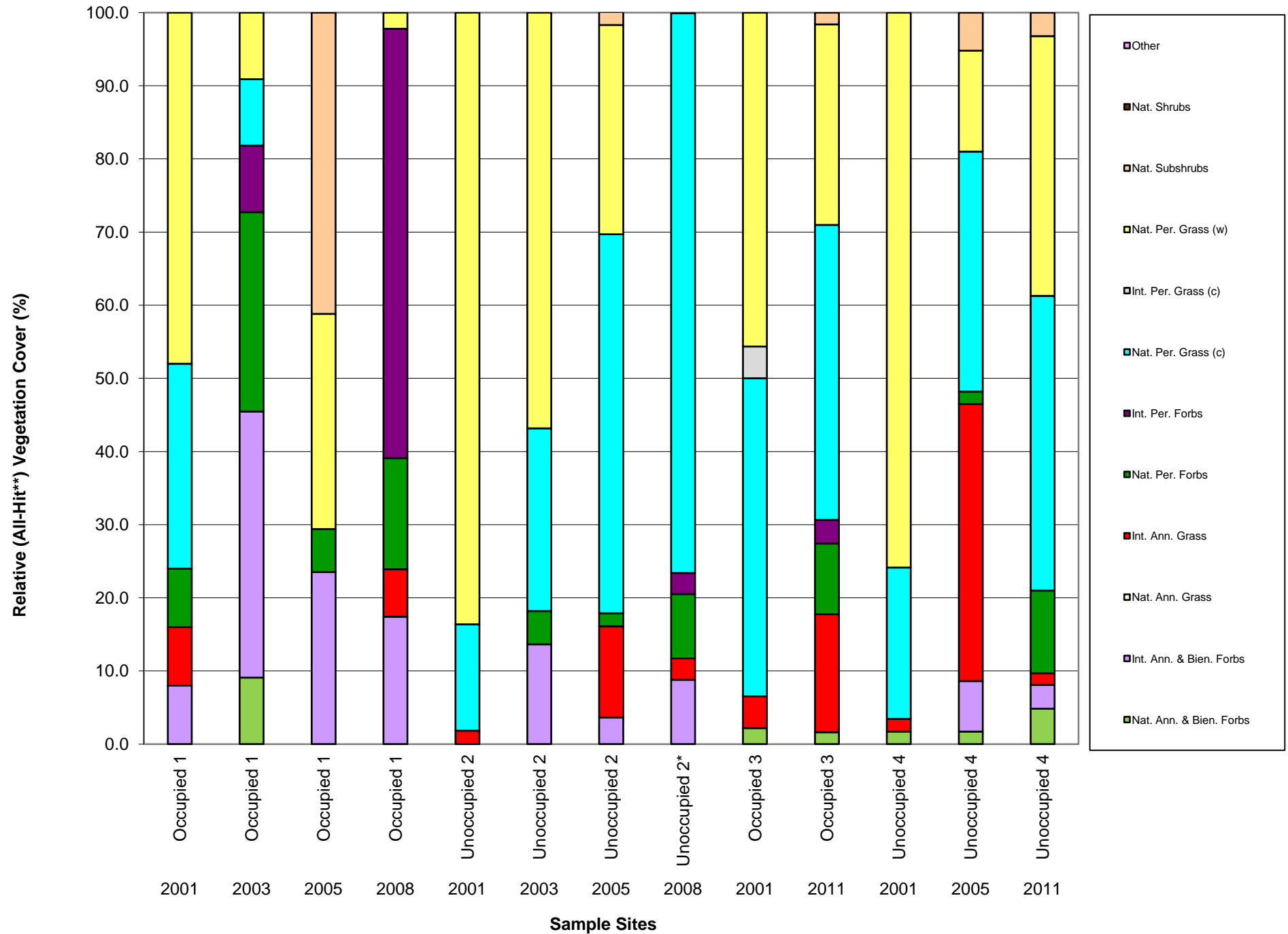
* Occupied as of 2008

Figure 1b. Absolute Vegetation Cover by Lifeform - Lindsay Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2005 and 2011



* Occupied as of 2008

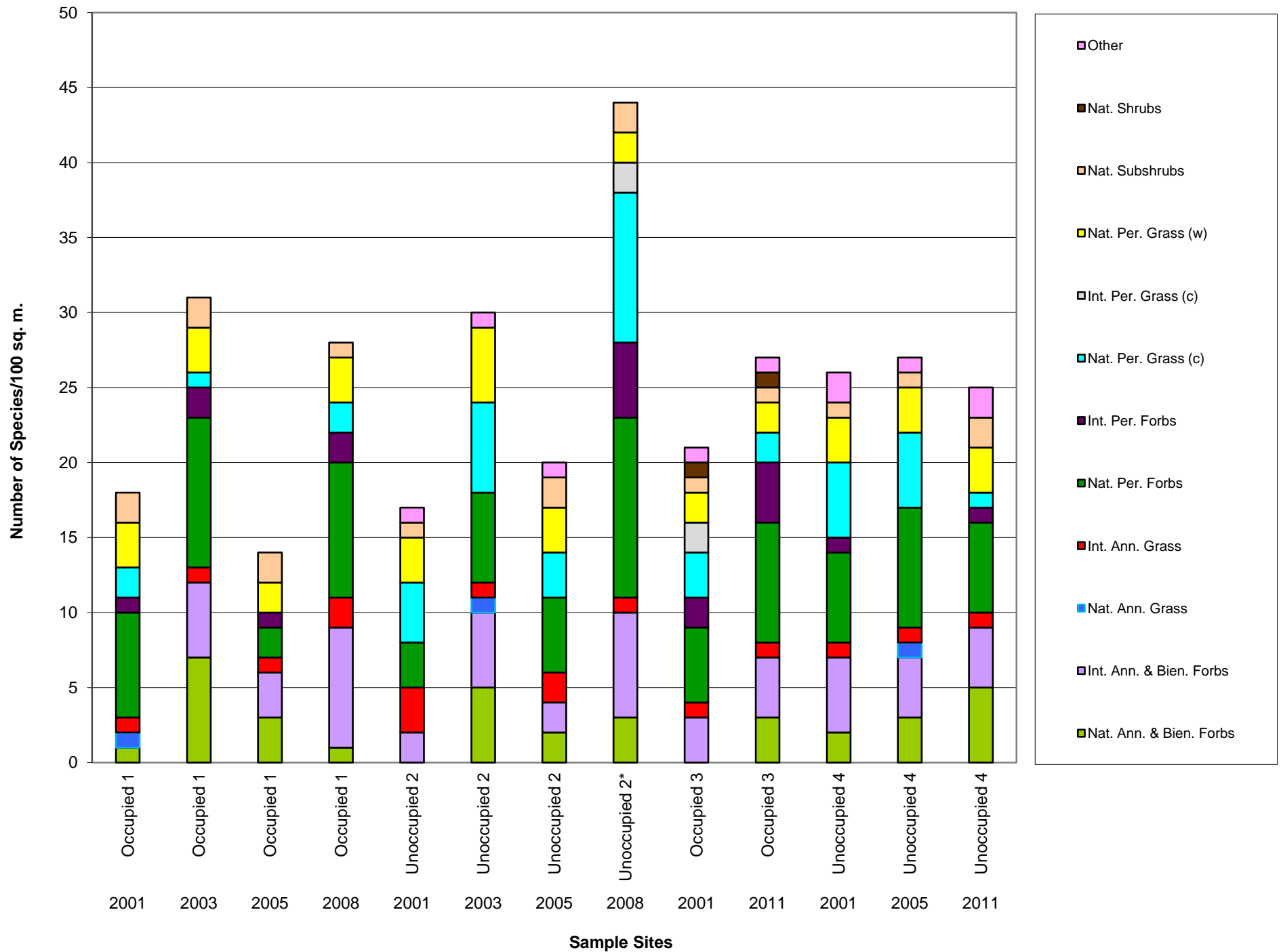
Figure 2. Relative Vegetation Cover by Lifeform - Lindsay Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2005 and 2011



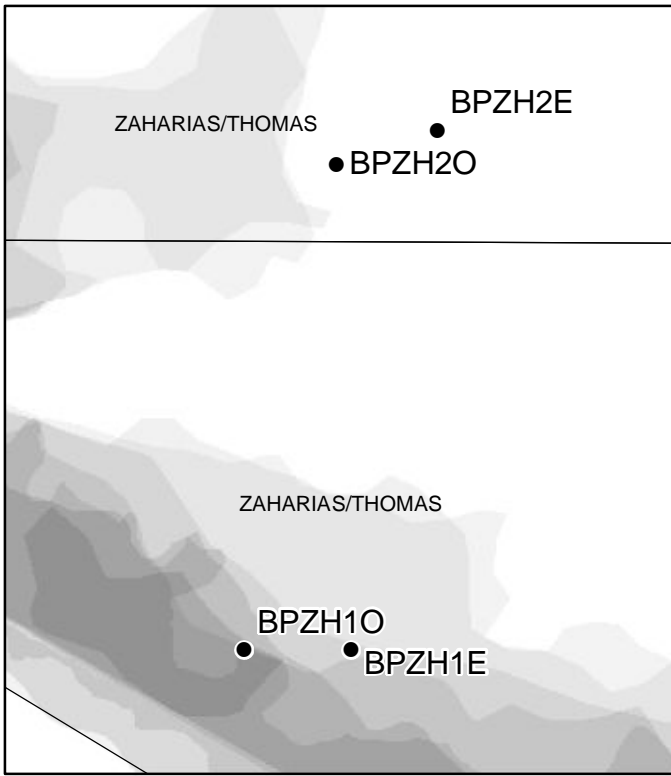
* Occupied as of 2008

**All Hit data include 1st and 2nd hits-1st hit is top layer of veg. canopy, below 1st hit may exist other interceptions = 2nd hits.

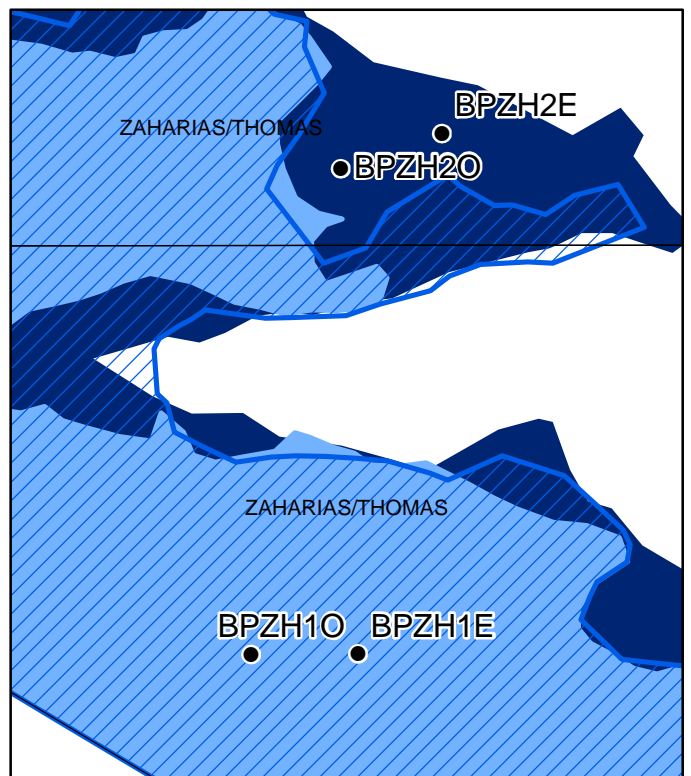
Figure 3. Species Density by Lifeform - Lindsay Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2005 and 2011



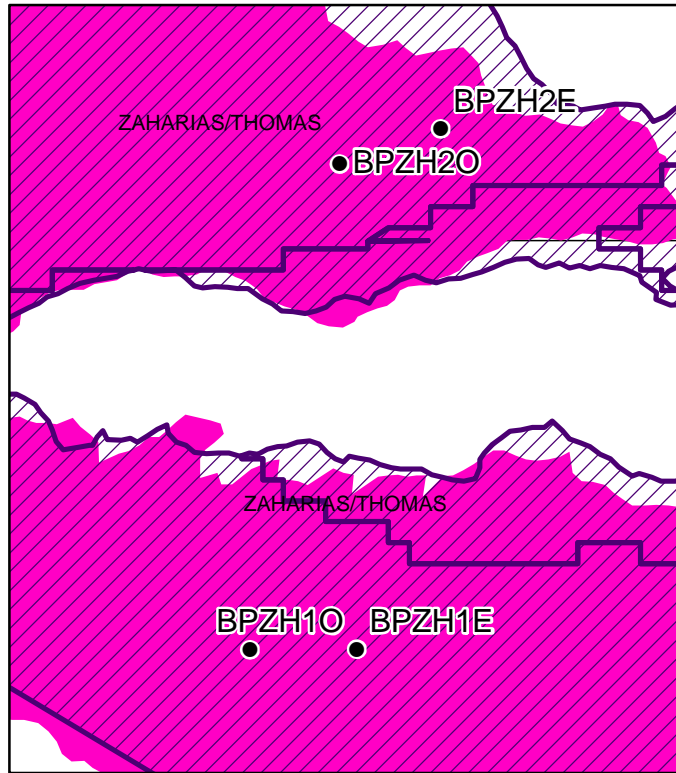
* Occupied as of 2008



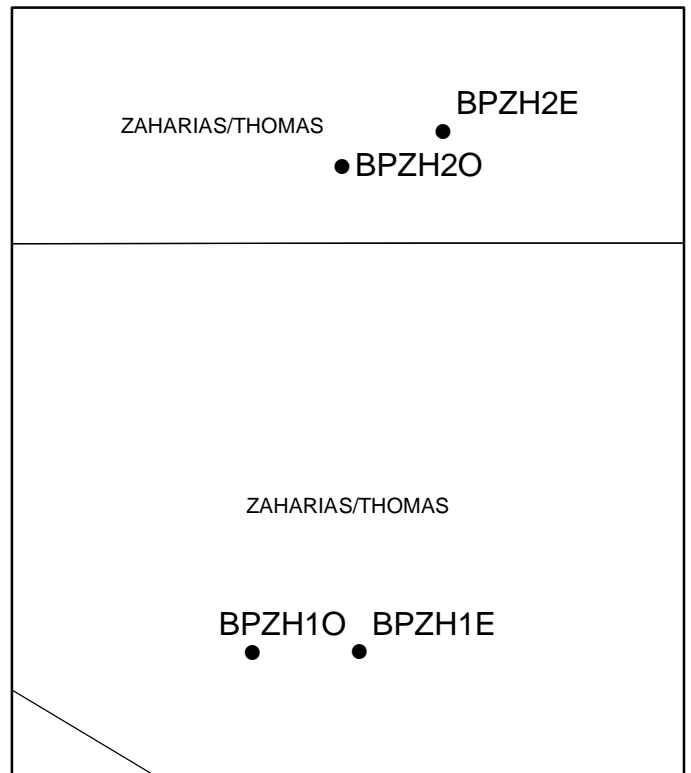
1997-2003



2004-2006



2007-2009



2010-2011

Map 1. Boulder County - Prairie Dog Colony Mapping - ZAHARIAS PARCEL

~1997 darkest gray >> 2003 lightest gray

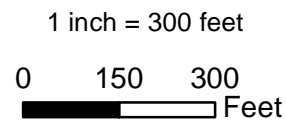
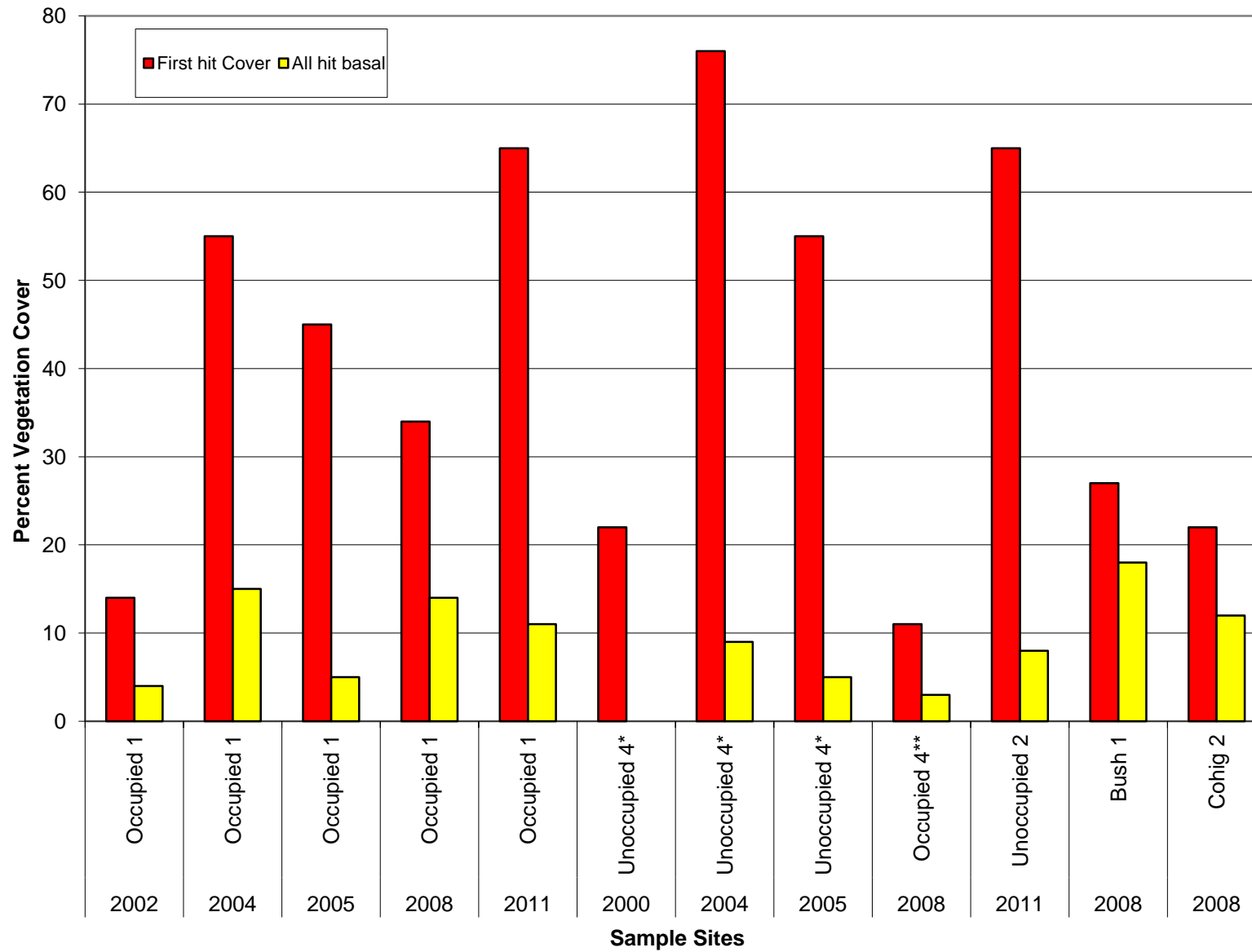


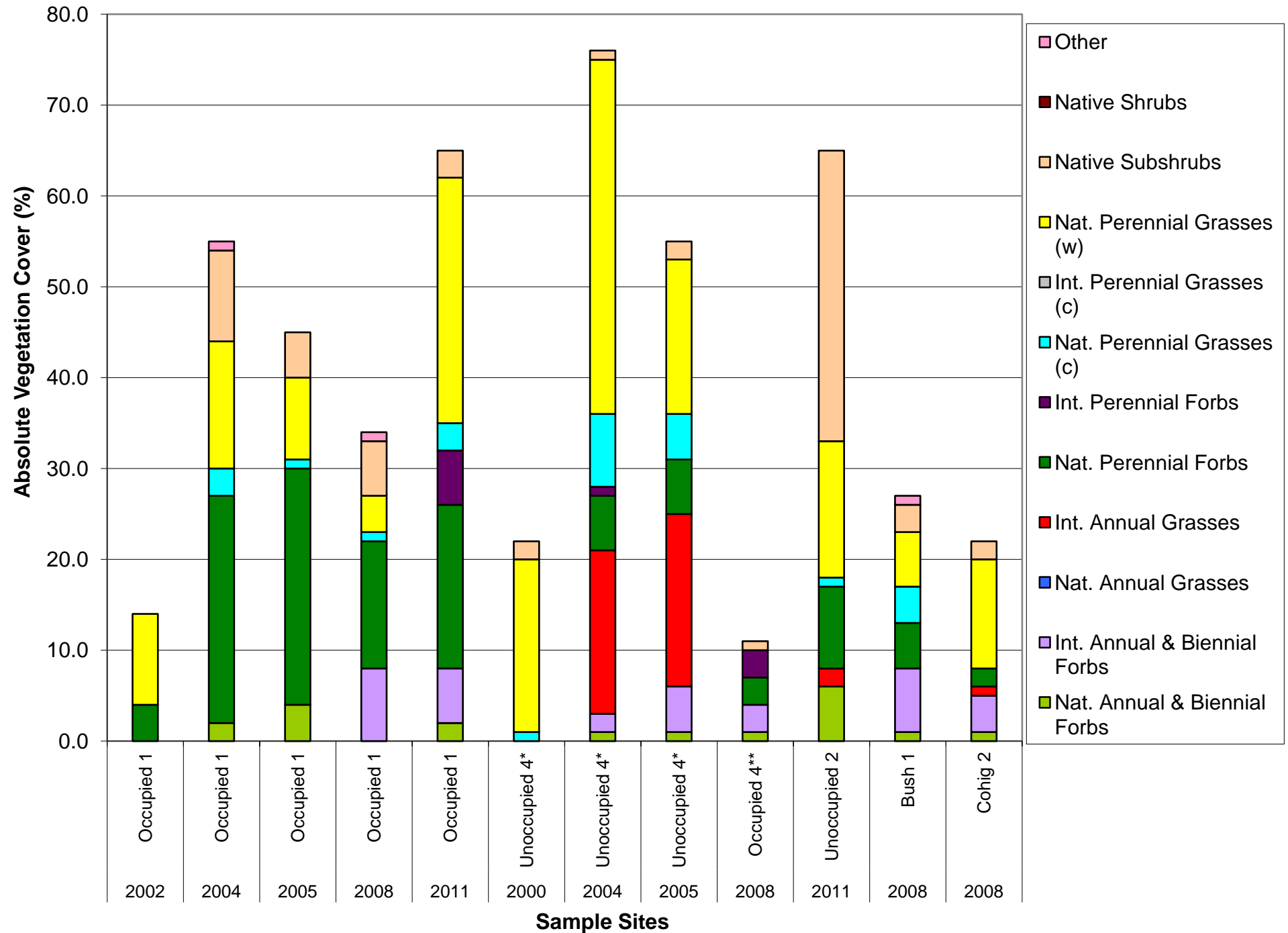
Figure 1a. Total Vegetation Cover - Zaharias Parcel, Prairie Dog Study, Boulder County Open Space, CO - 2000/2002, 2004, 2005, 2008 and 2011



* Zaharias 4 Boulder County Grazing used as control for Zaharias Prairie Dog 1.

** Zaharias 4 became occupied sometime between 2005 and 2008.

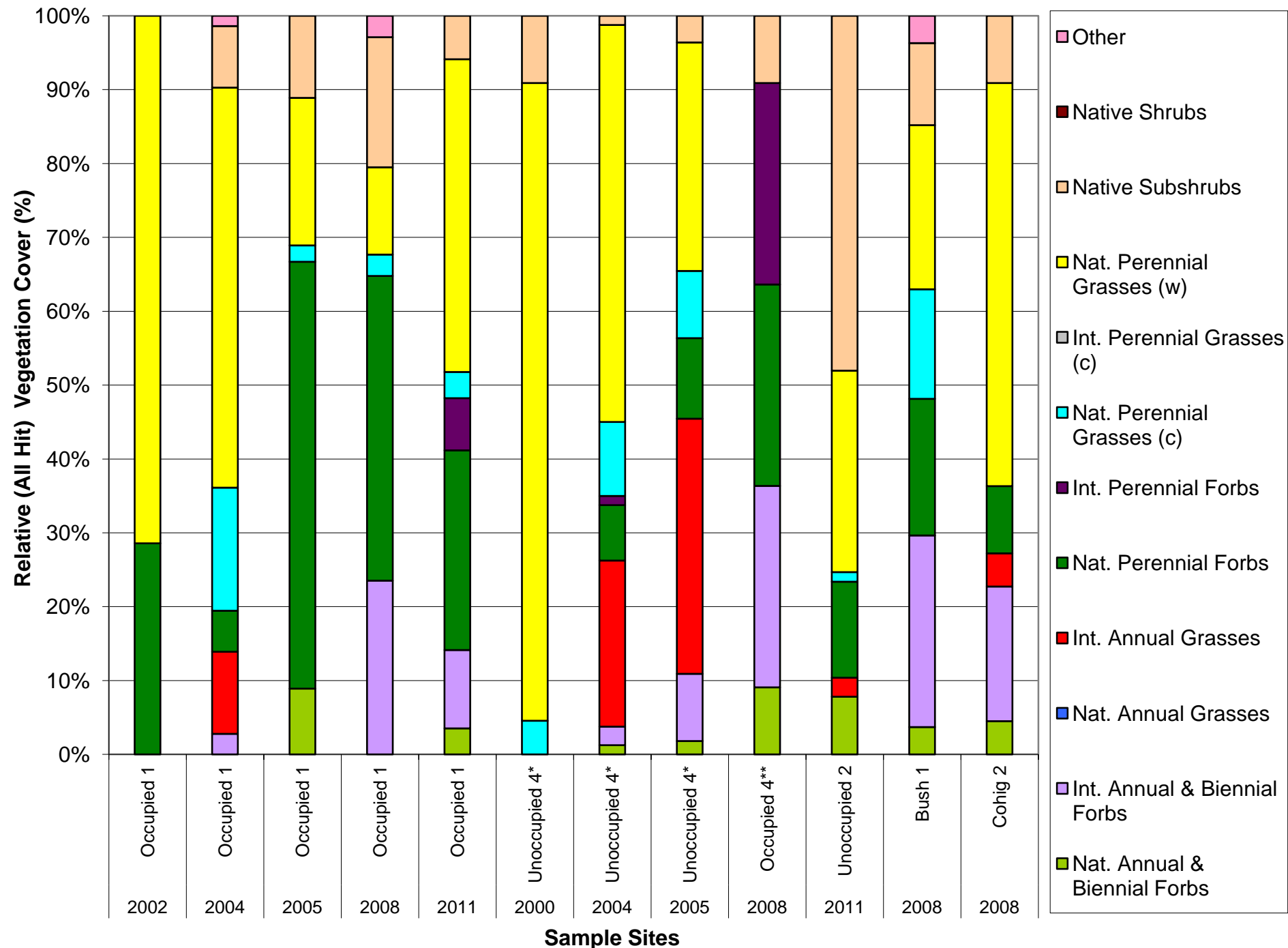
Figure 1b. Absolute Cover by Lifeform - Zaharias Parcel, Prairie Dog Study, Boulder County Open Space, CO - 2000/2002, 2004, 2005, 2008 and 2011



* Zaharias 4 Boulder County Grazing used as control for Zaharias Prairie Dog 1.

** Zaharias 4 became occupied sometime between 2005 and 2008.

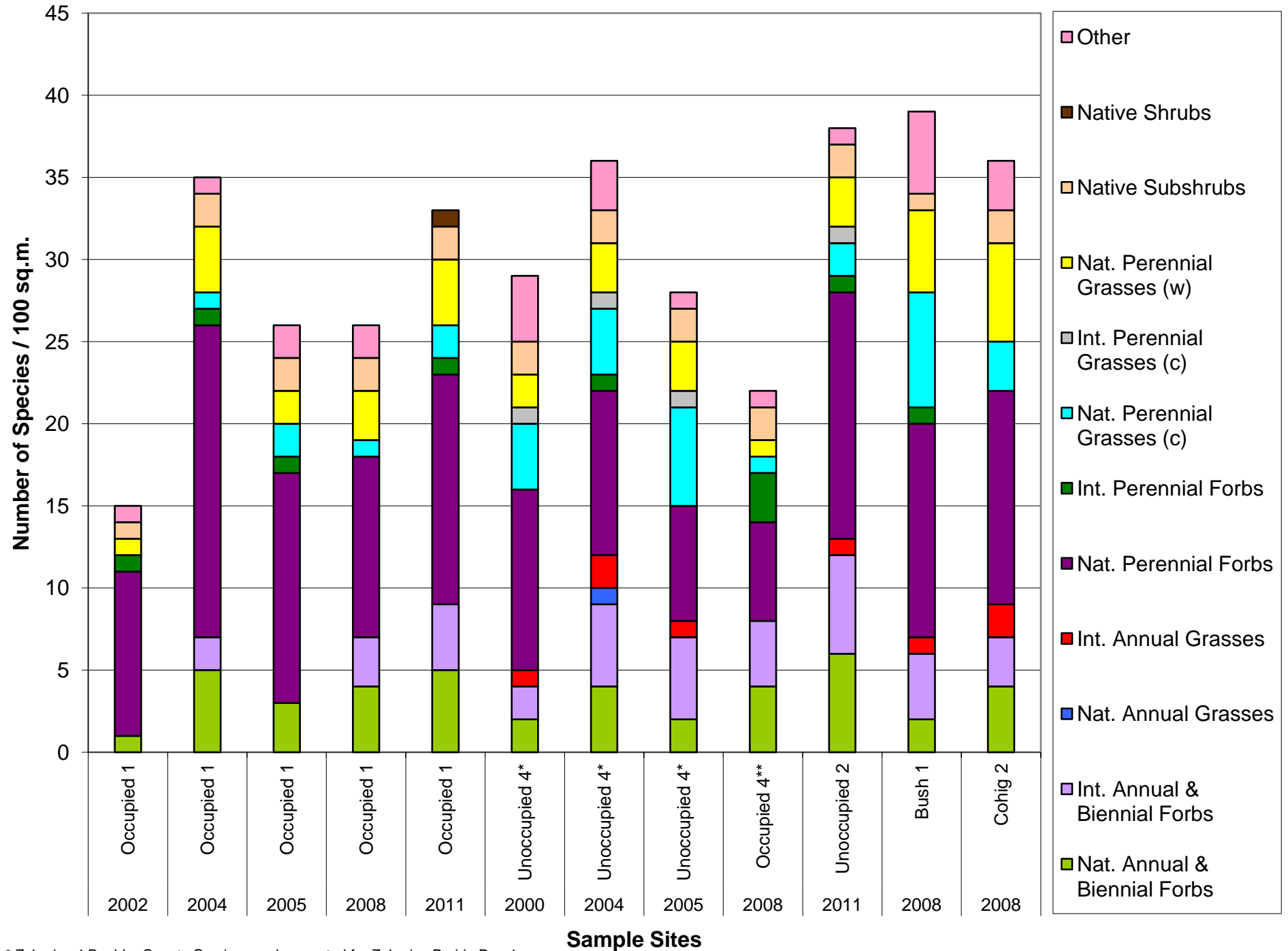
Figure 2. Relative Cover by Lifeform - Zaharias Parcel, Prairie Dog Study, Boulder County Open Space, CO - 2000/2002, 2004, 2005, 2008 and 2011



* Zaharias 4 Boulder County Grazing used as control for Zaharias Prairie Dog 1.

** Zaharias 4 became occupied sometime between 2005 and 2008.

Figure 3. Species Density by Lifeform - Zaharias Parcel, Prairie Dog Study, Boulder County Open Space, CO - 2000/2002, 2004, 2005, 2008 and 2011

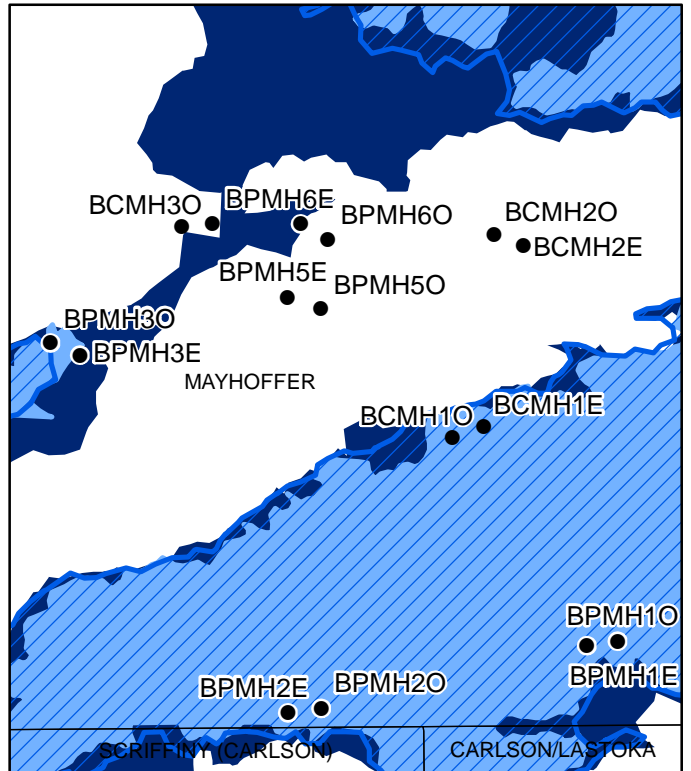


* Zaharias 4 Boulder County Grazing used as control for Zaharias Prairie Dog 1.

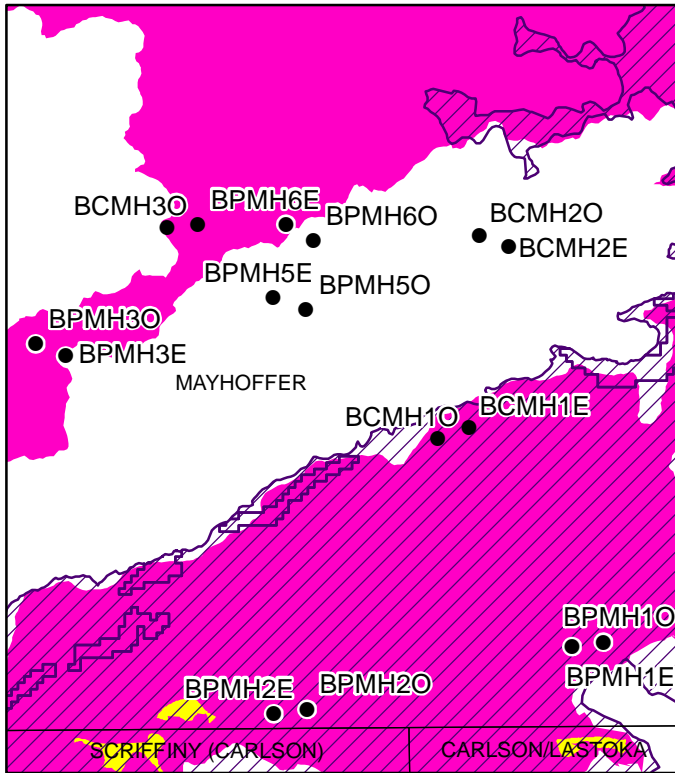
** Zaharias 4 became occupied sometime between 2005 and 2008.



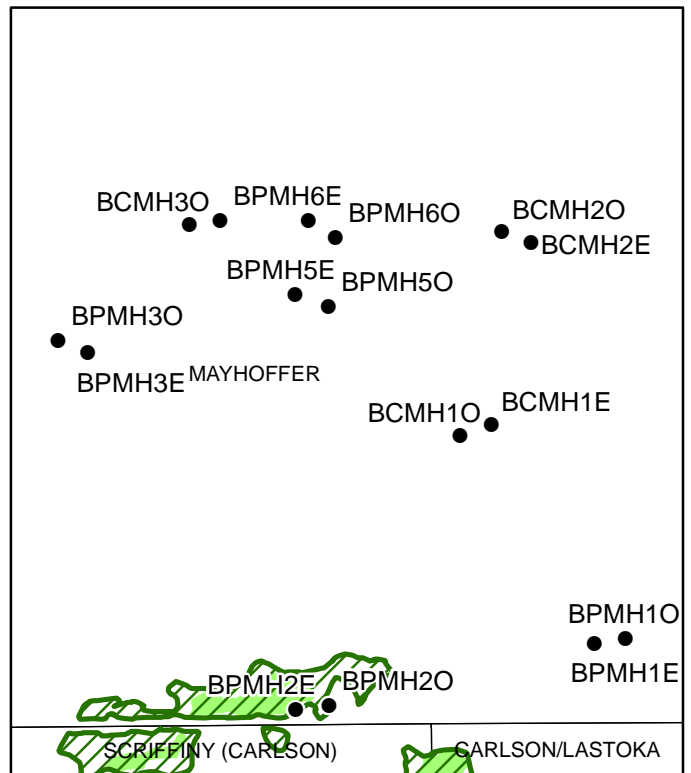
1997-2006



2004-2006



2007-2009



2010-2011

Map 1. Boulder County - Prairie Dog Colony Mapping - MAYHOFFER PARCEL

~1997 darkest gray >> 2006 lightest gray

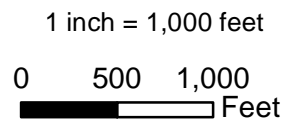
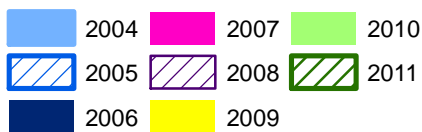
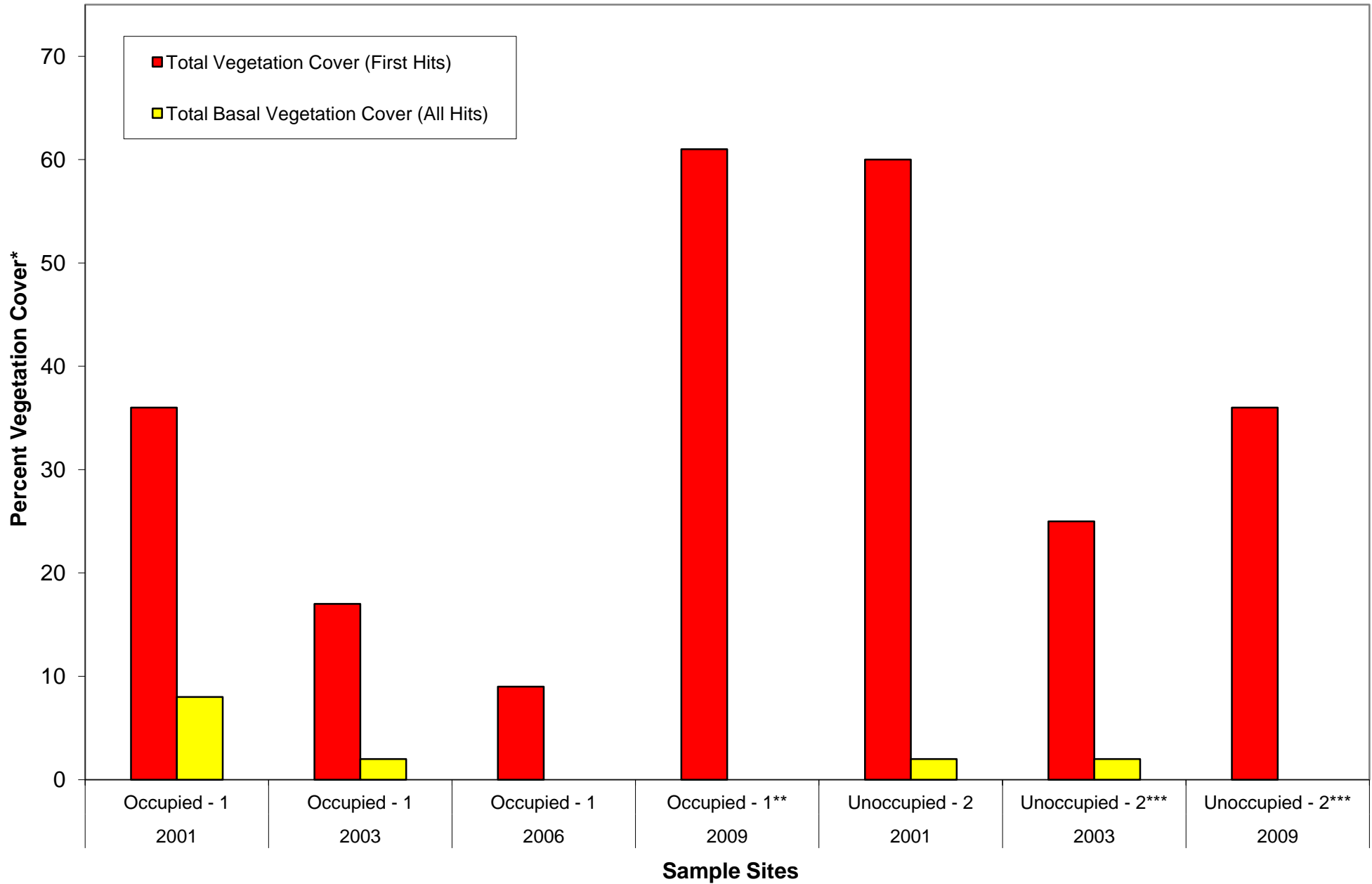


Figure 1a. Total Vegetation Cover - Mayhoffer Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006 and 2009



*Data was not recorded from Mayhoffer 2 in 2006 due to occupation

**Mayhoffer 1 (Occupied) now Dead

***Mayhoffer 2 (Unoccupied) was occupied in 2003 after sampling but is now Dead

Figure 1b. Absolute Vegetation Cover by Lifeform - Mayhoffer Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006 and 2009

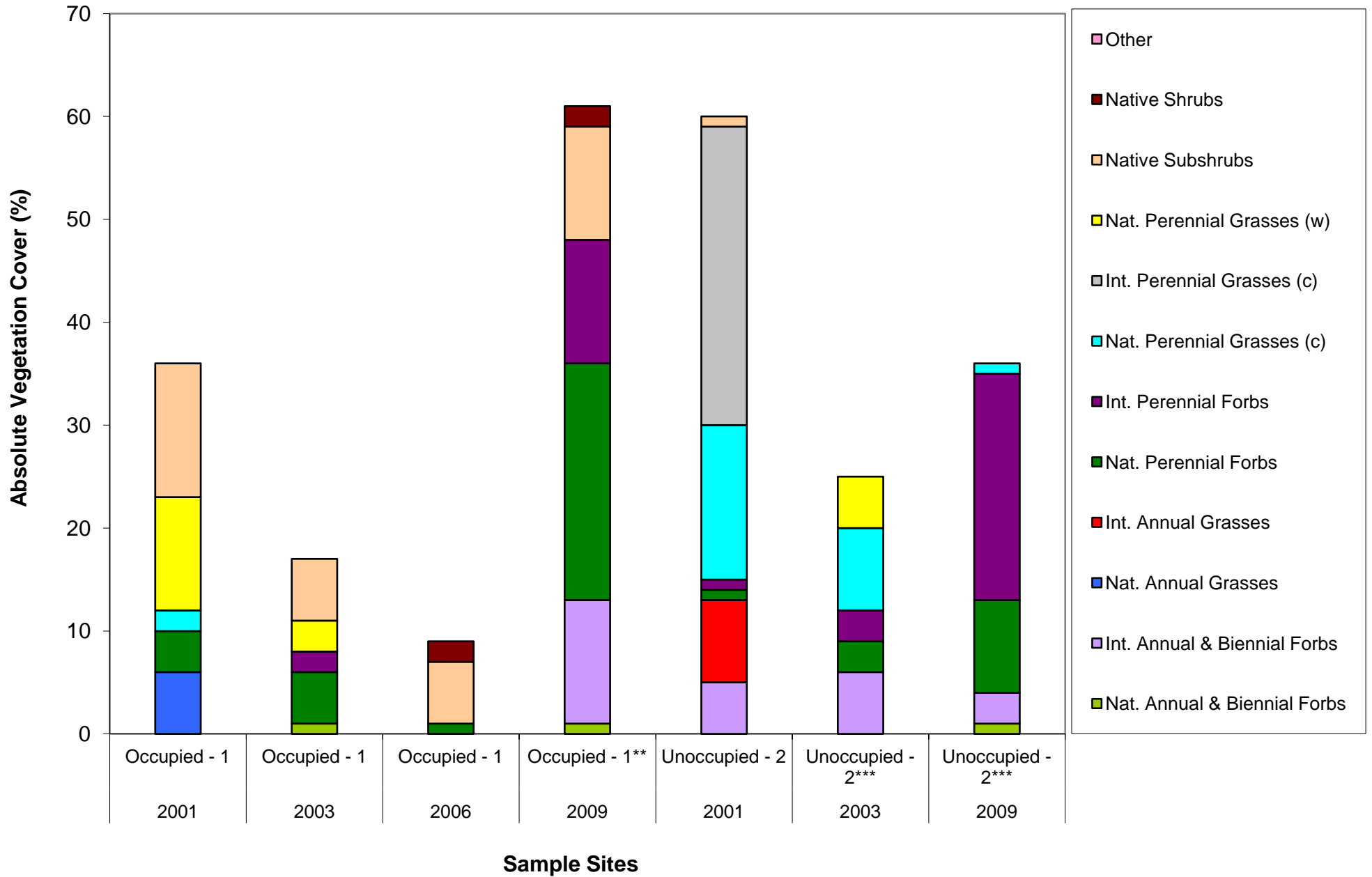
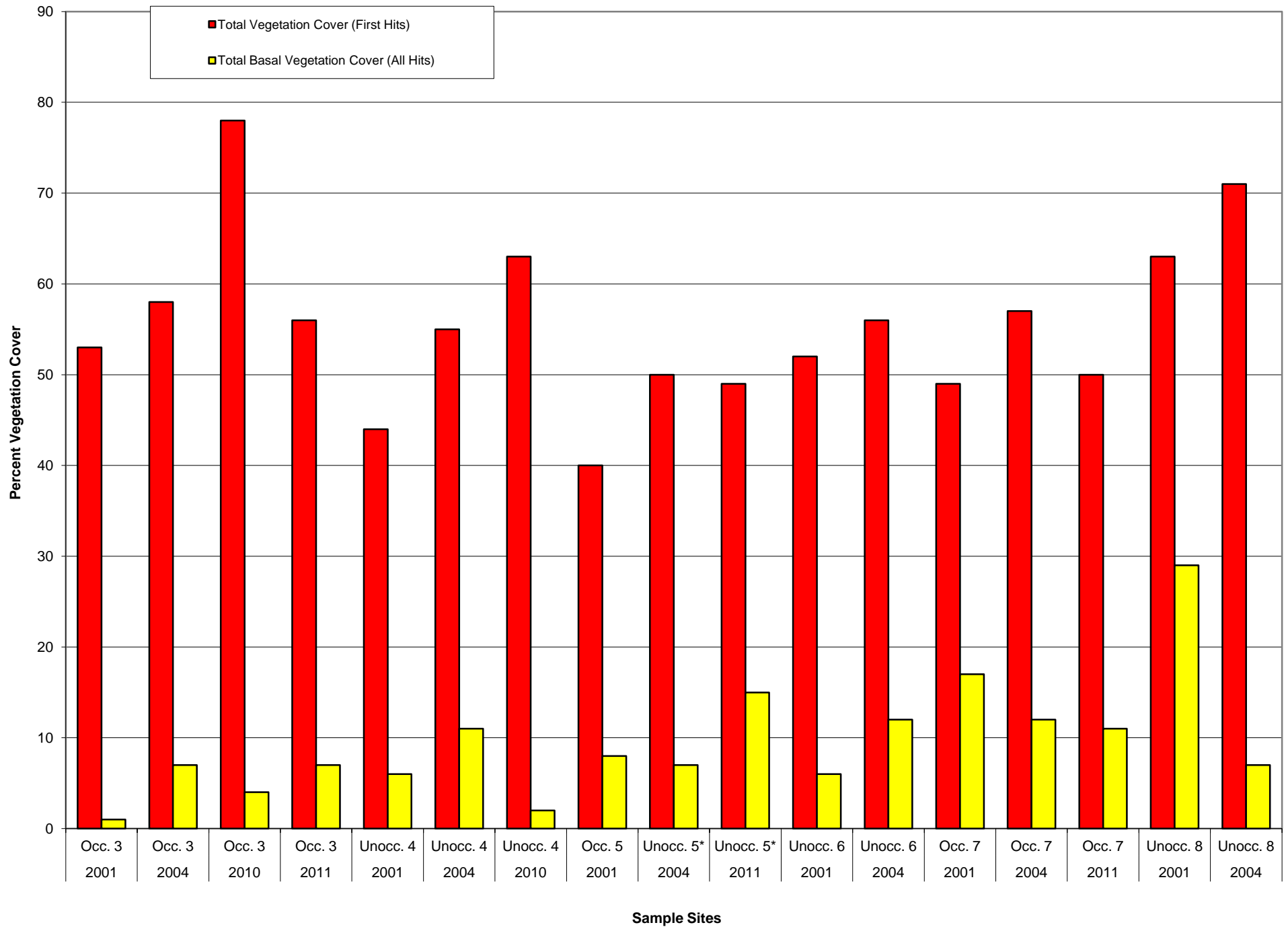
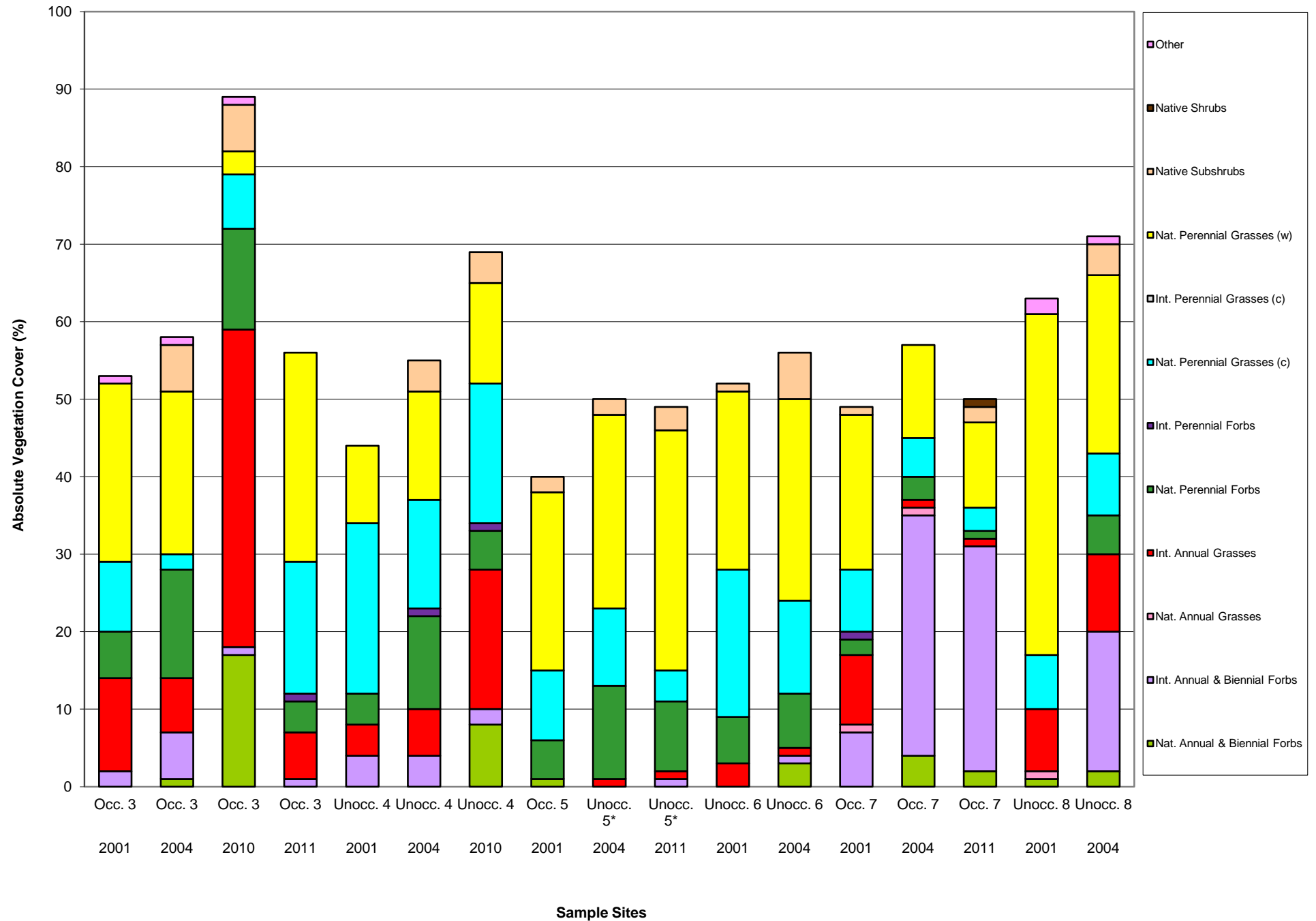


Figure 1a. Total Vegetation Cover - Mayhoffer Parcel, Prairie Dog Study, Boulder County Open Space, CO - 2001, 2004, 2010 and 2011



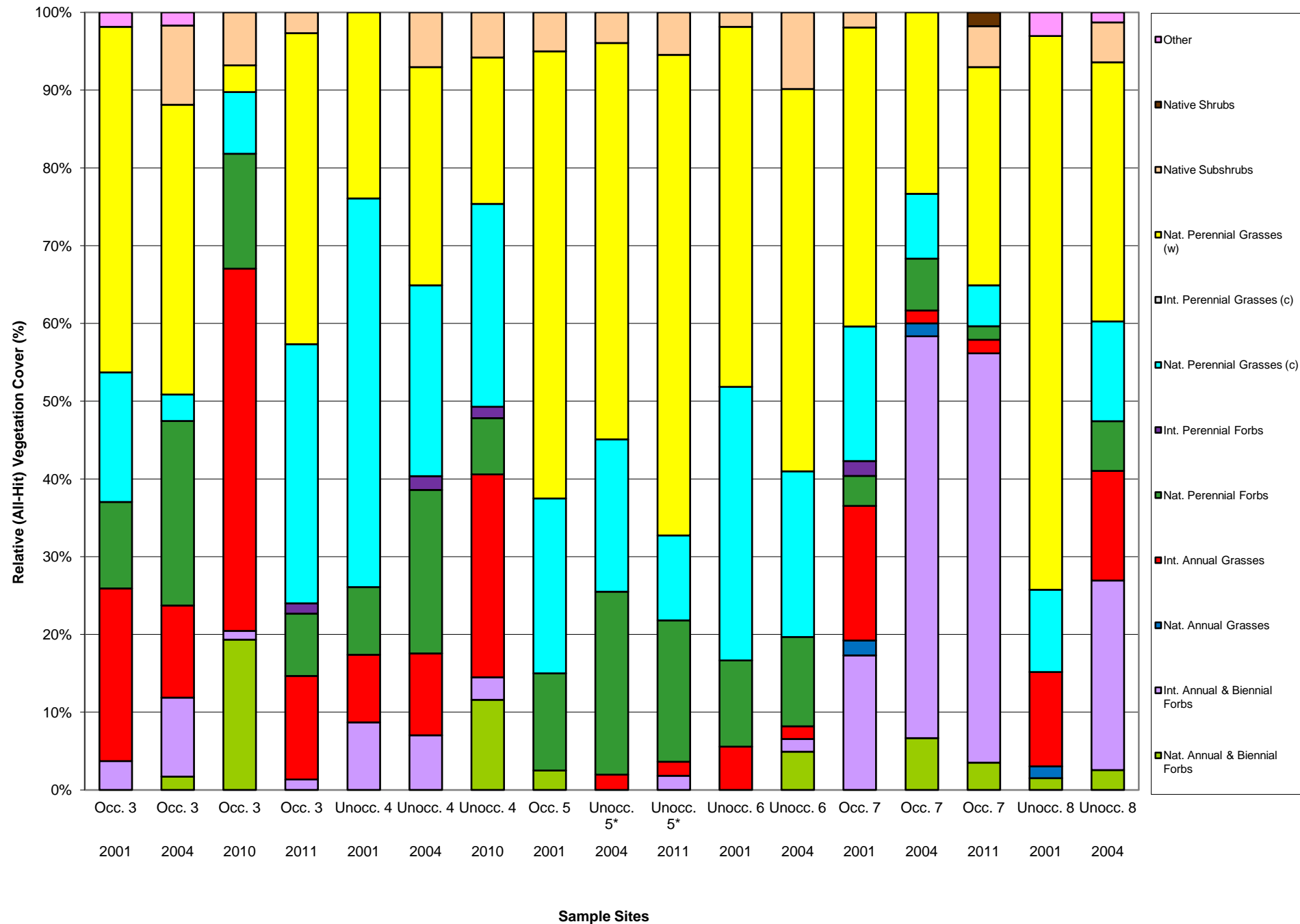
*Previously occupied sample 5 was unoccupied in 2004

Figure 1b. Absolute Cover by Lifeform - Mayhoffer Parcel, Prairie Dog Study, Boulder County Open Space, CO - 2001, 2004, 2010 and 2011



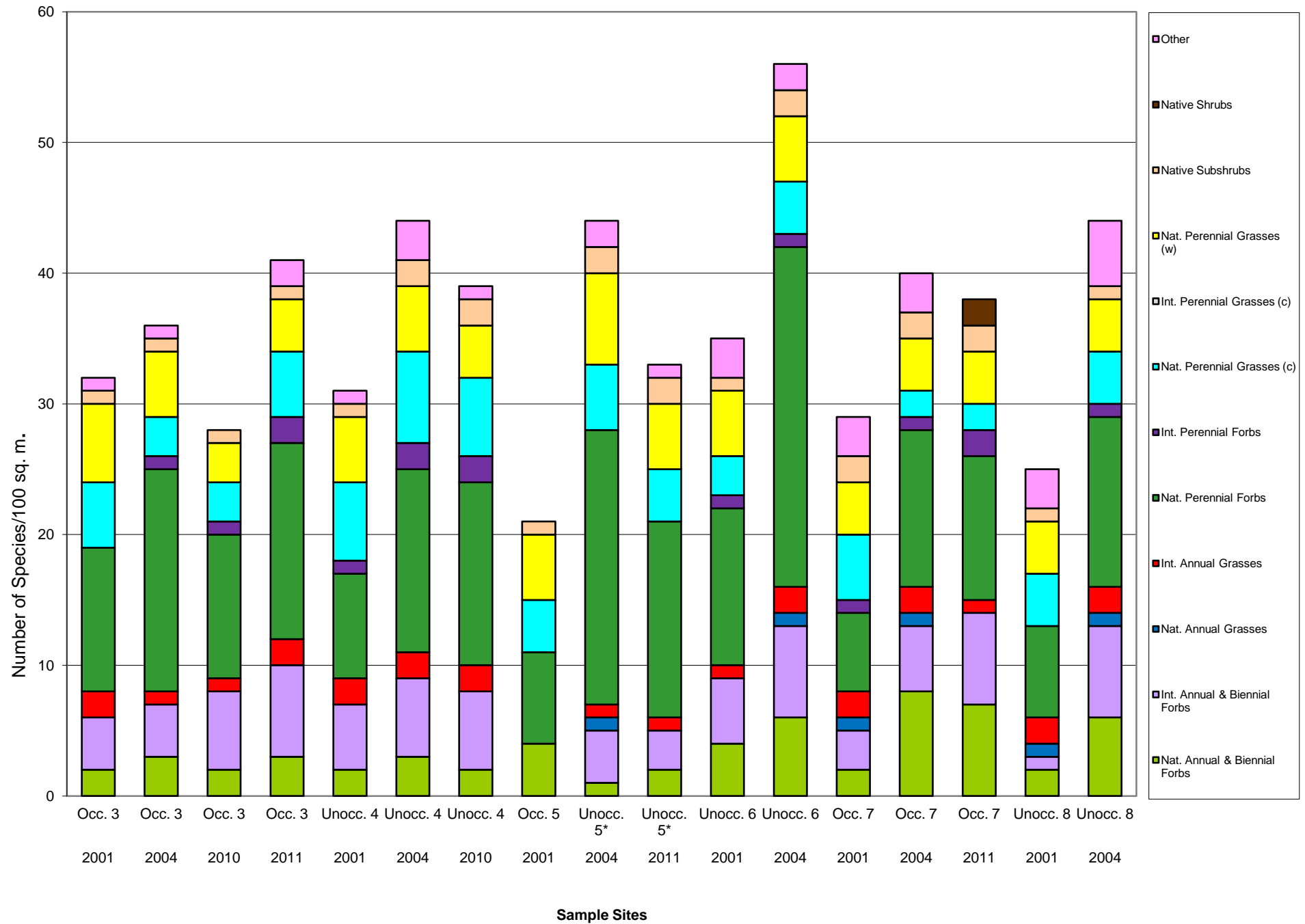
*Previously occupied sample 5 was unoccupied in 2004

Figure 2. Relative Cover (All-Hit) by Lifeform - Mayhoffer Parcel, Prairie Dog Study, Boulder County Open Space, CO - 2001, 2004, 2010 and 2011



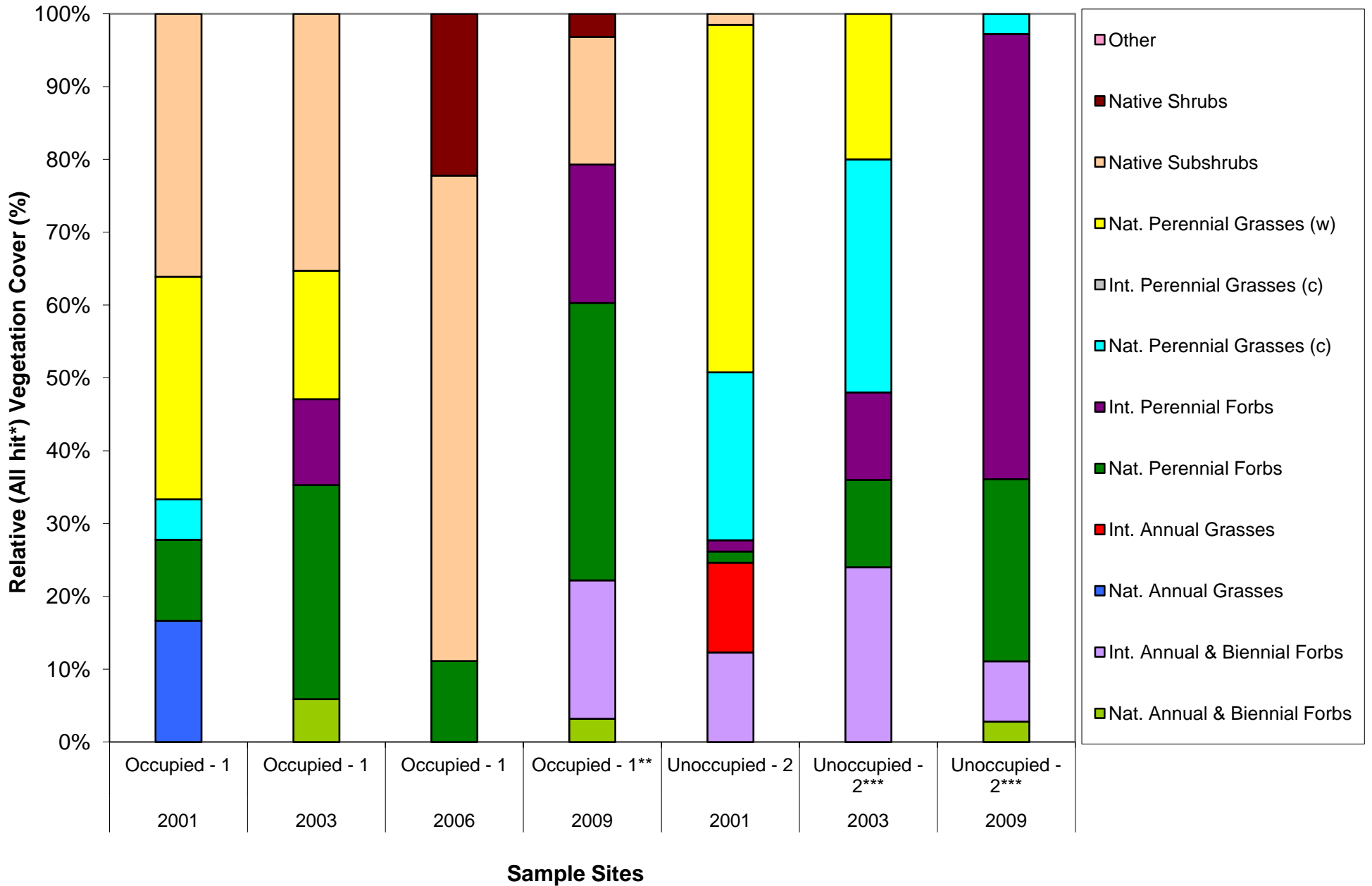
*Previously occupied sample 5 was unoccupied in 2004

Figure 3. Species Density by Lifeform - Mayhoffer Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2004, 2010 and 2011



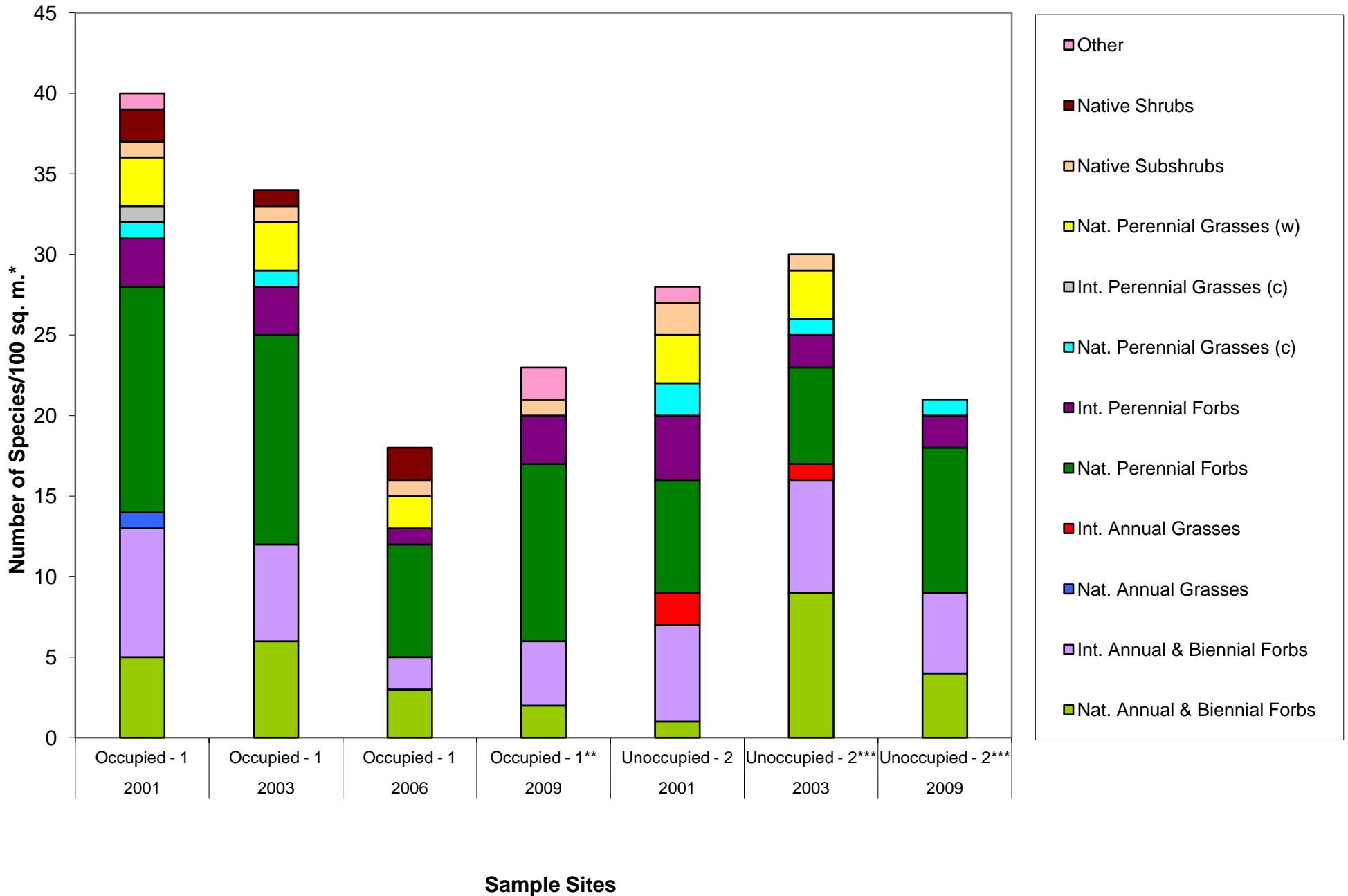
*Previously occupied sample 5 was unoccupied in 2004

Figure 2. Relative Vegetation Cover by Lifeform - Mayhoffer Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006 and 2009



*All Hit data include both 1st and 2nd hits-a 1st hit is the top-most layer of the vegetation canopy, below a 1st hit interception may exist other interceptions-referred to as 2nd hits.

Figure 3. Species Density by Lifeform - Mayhoffer Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006 and 2009

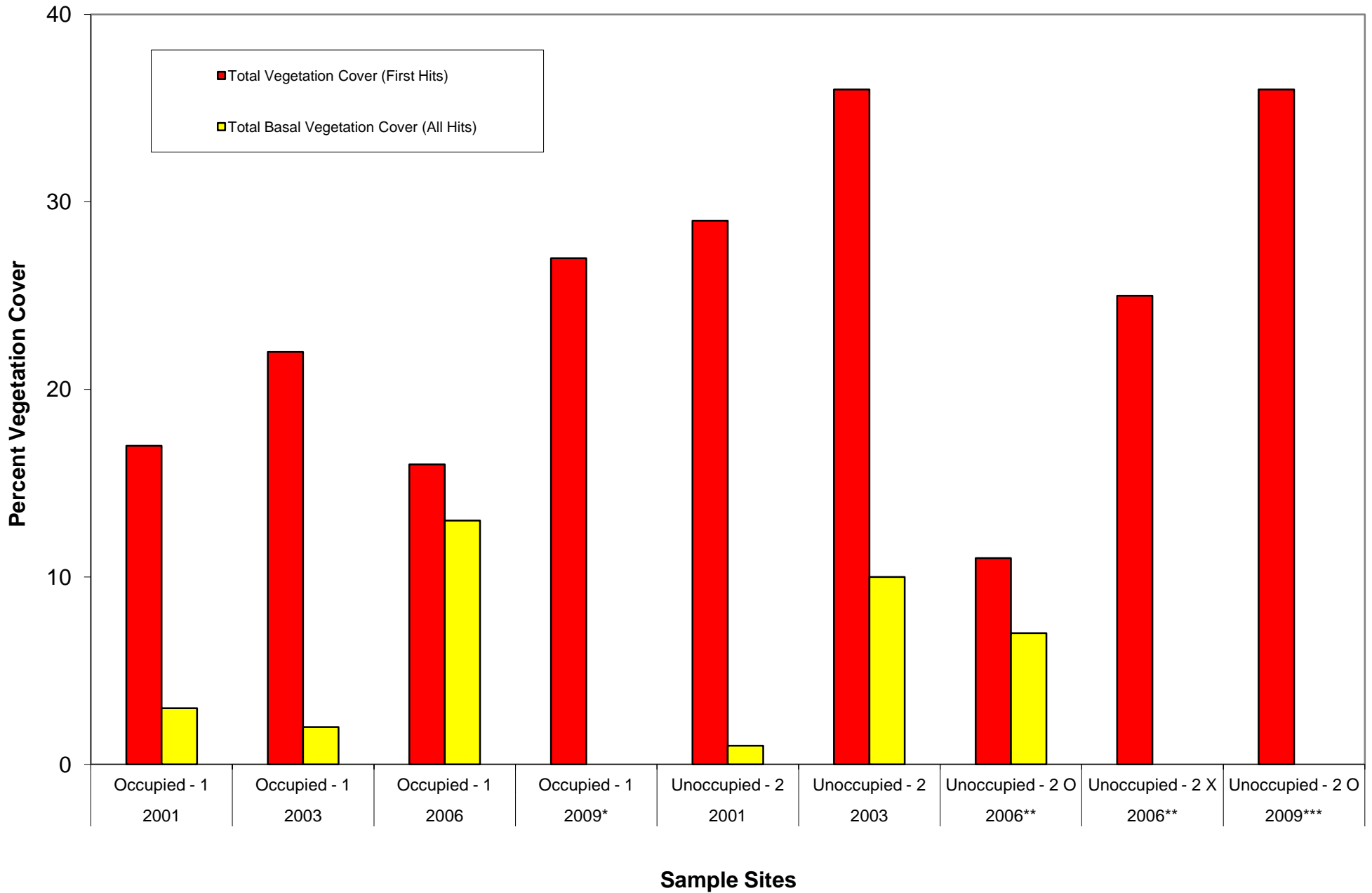


*Data was not recorded from Mayhoffer Transect # 2 in 2006

**Mayhoffer 1 (Occupied) now Dead

***Mayhoffer 2 (Unoccupied) was occupied in 2003 after sampling but is now Dead

Figure 1a. Total Vegetation Cover - Rock Creek Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006 and 2009

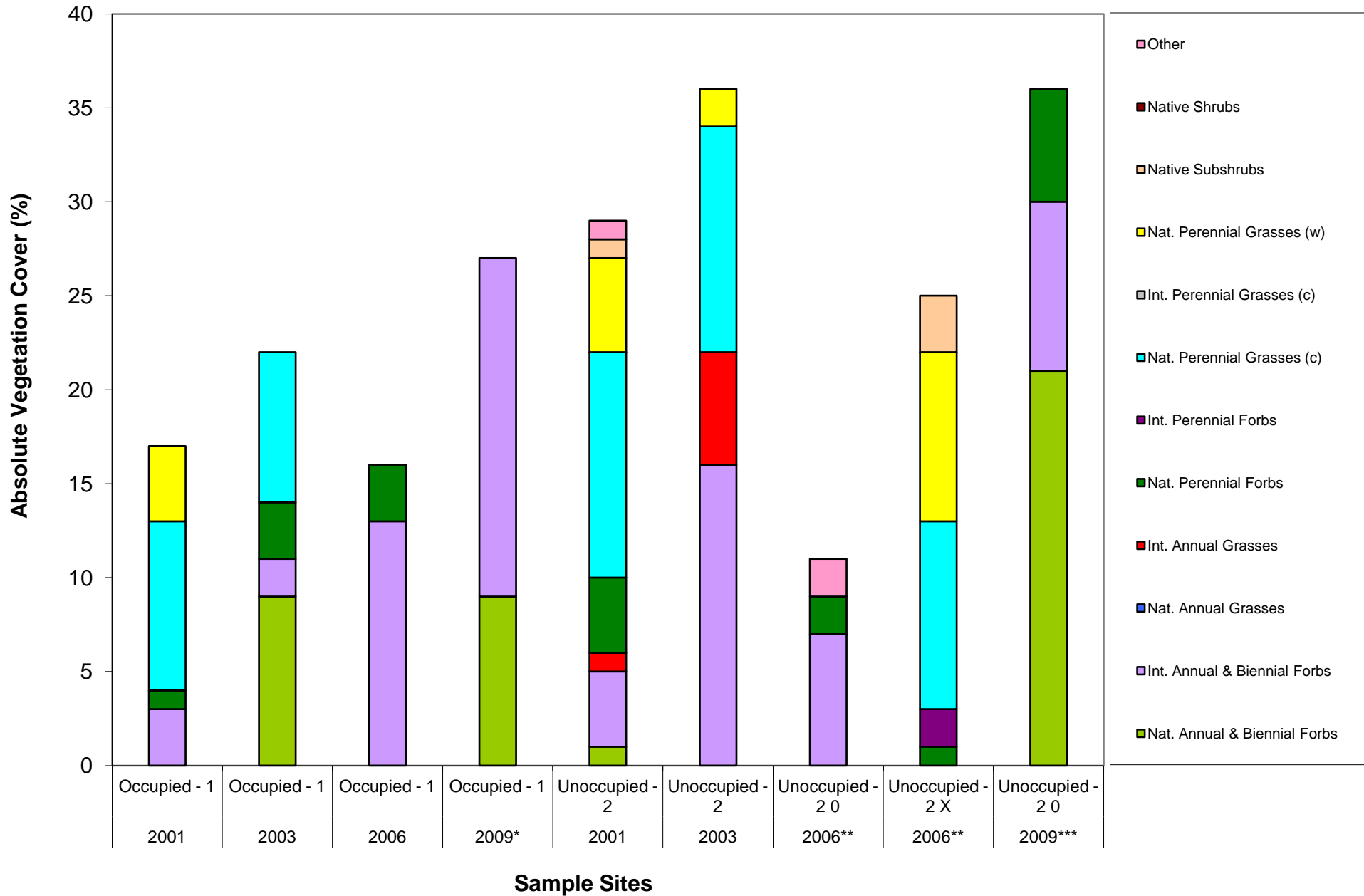


*Rock Creek 1 is unoccupied as of 2009.

**Rock Creek was occupied as of 2006. Unoccupied replacement sample for Rock Creek 2 O was sample 2 X.

***Rock Creek 2 O is unoccupied as of 2009.

Figure 1b. Absolute Vegetation Cover by Lifeform - Rock Creek Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006 and 2009

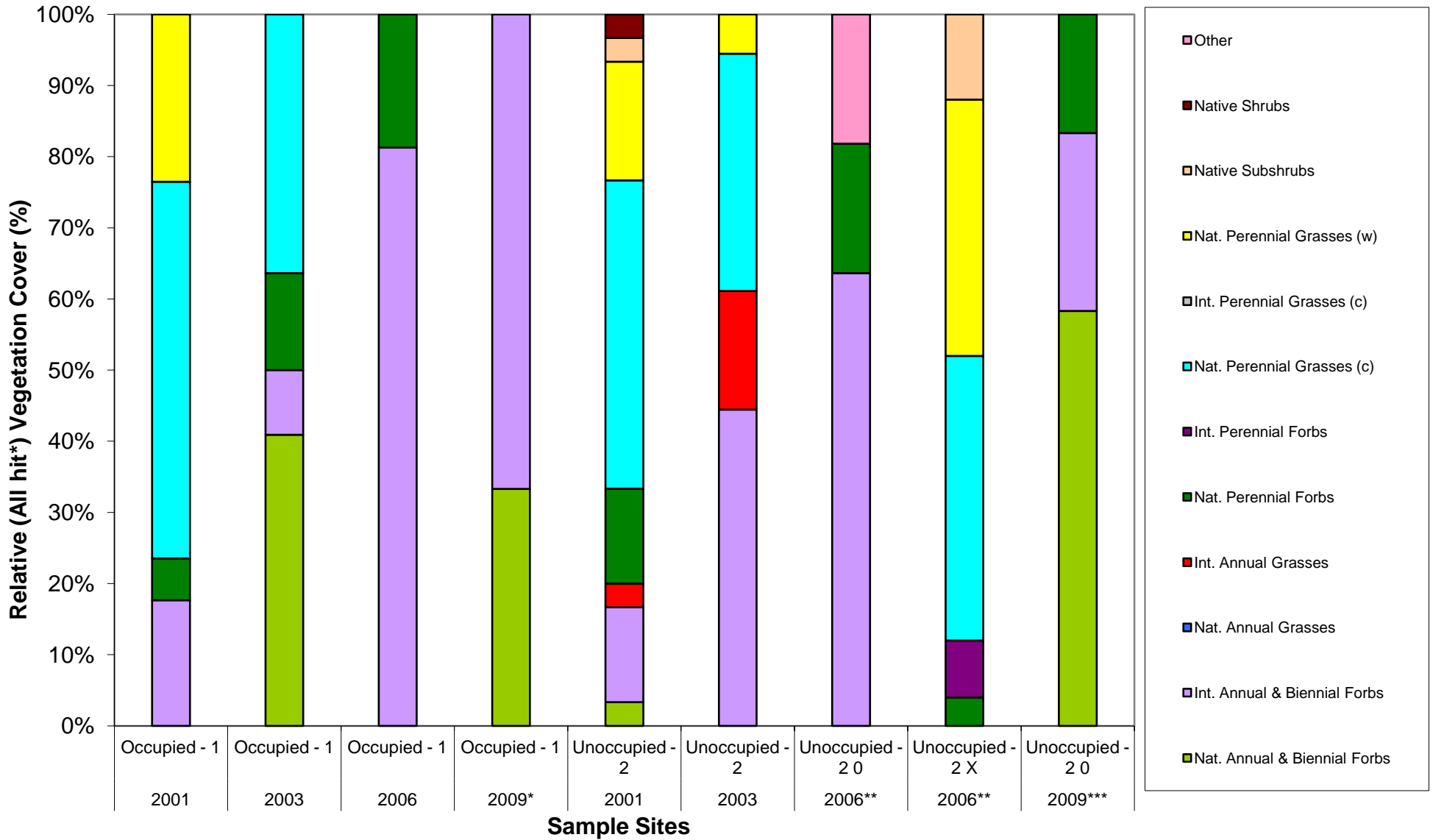


*Rock Creek 1 is unoccupied as of 2009.

**Rock Creek was occupied as of 2006. Unoccupied replacement sample for Rock Creek 2 O was sample 2 X.

***Rock Creek 2 O is unoccupied as of 2009.

Figure 2. Relative Vegetation Cover by Lifeform - Rock Creek Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006 and 2009



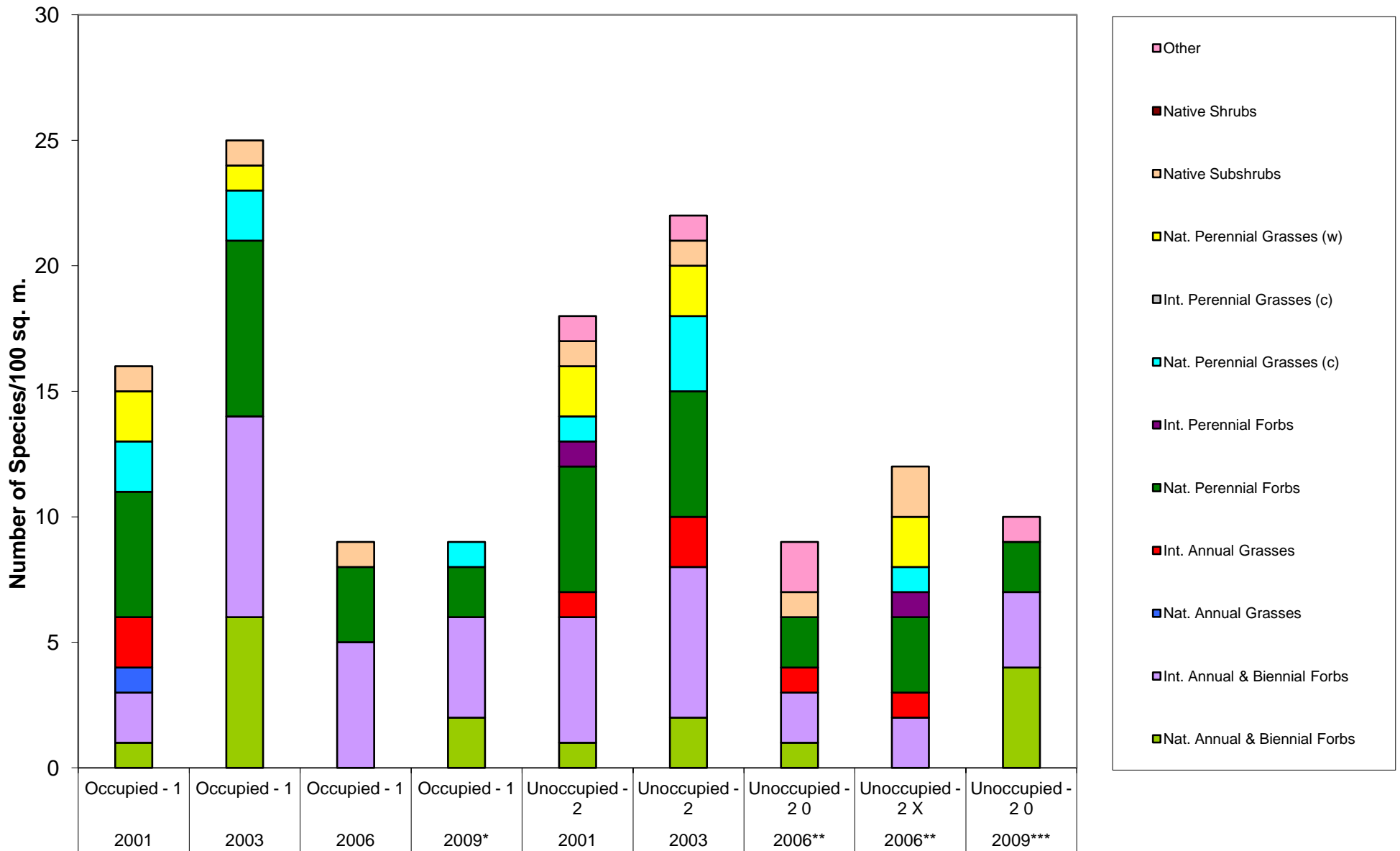
*All Hit data include both 1st and 2nd hits - a 1st hit is the top-most layer of the vegetation canopy, below a 1st hit interception may exist other interceptions - referred to as 2nd hits.

*Rock Creek 1 is unoccupied as of 2009.

**Rock Creek was occupied as of 2006. Unoccupied replacement sample for Rock Creek 2 O was sample 2 X.

***Rock Creek 2 O is unoccupied as of 2009.

Figure 3. Species Density by Lifeform - Rock Creek Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006 and 2009

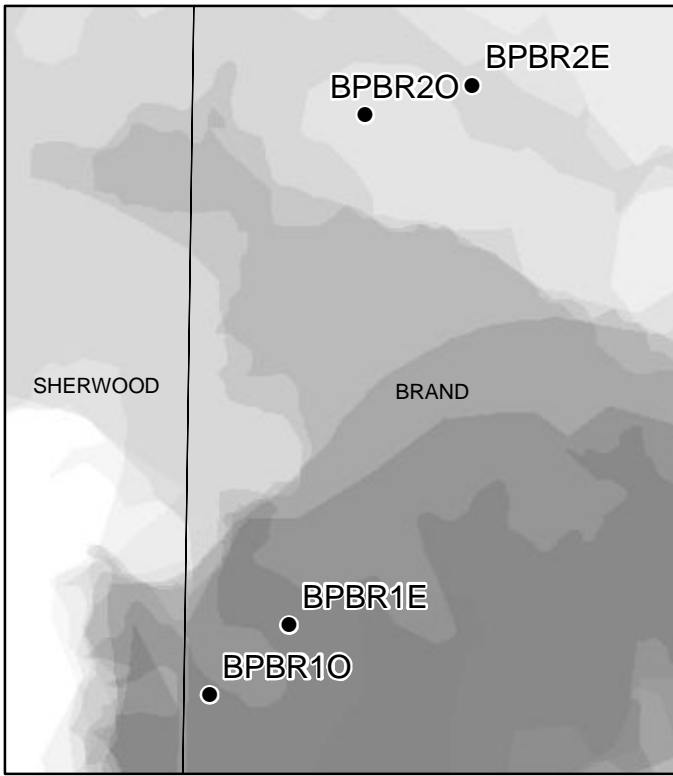


*Rock Creek 1 is unoccupied as of 2009.

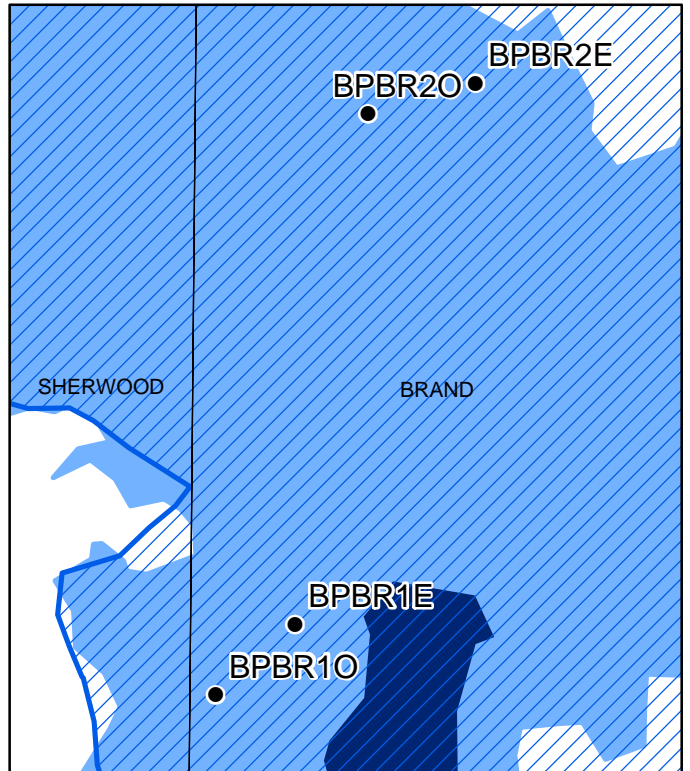
**Rock Creek was occupied as of 2006. Unoccupied replacement sample site Rock Creek 2 O was sample 2 X.

***Rock Creek 2 O is unoccupied as of 2009.

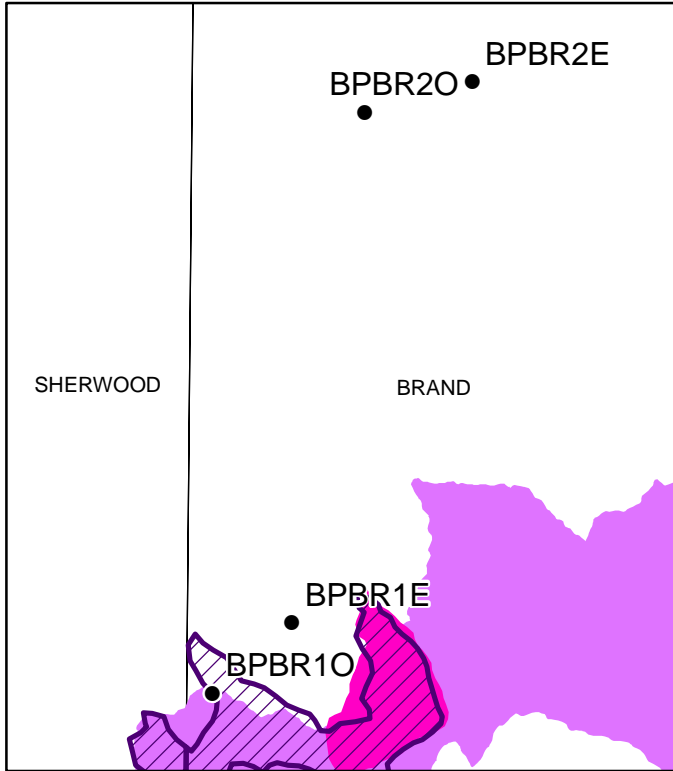
Sample Sites



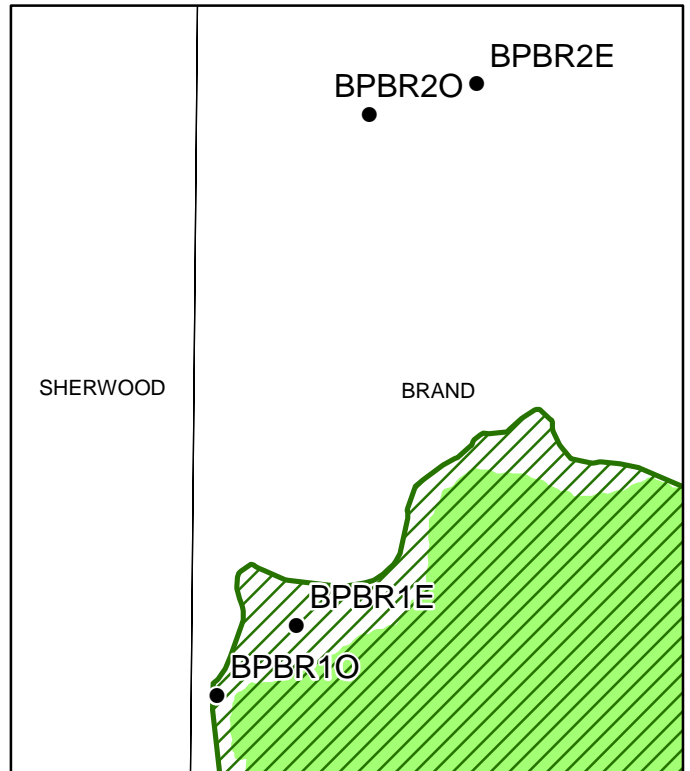
1997-2006



2004-2006



2007-2009



2010-2011

Map 1. Boulder County - Prairie Dog Colony Mapping - BRAND PARCEL

~1997 darkest gray >> 2006 lightest gray

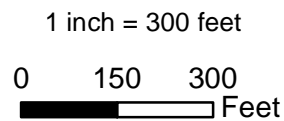
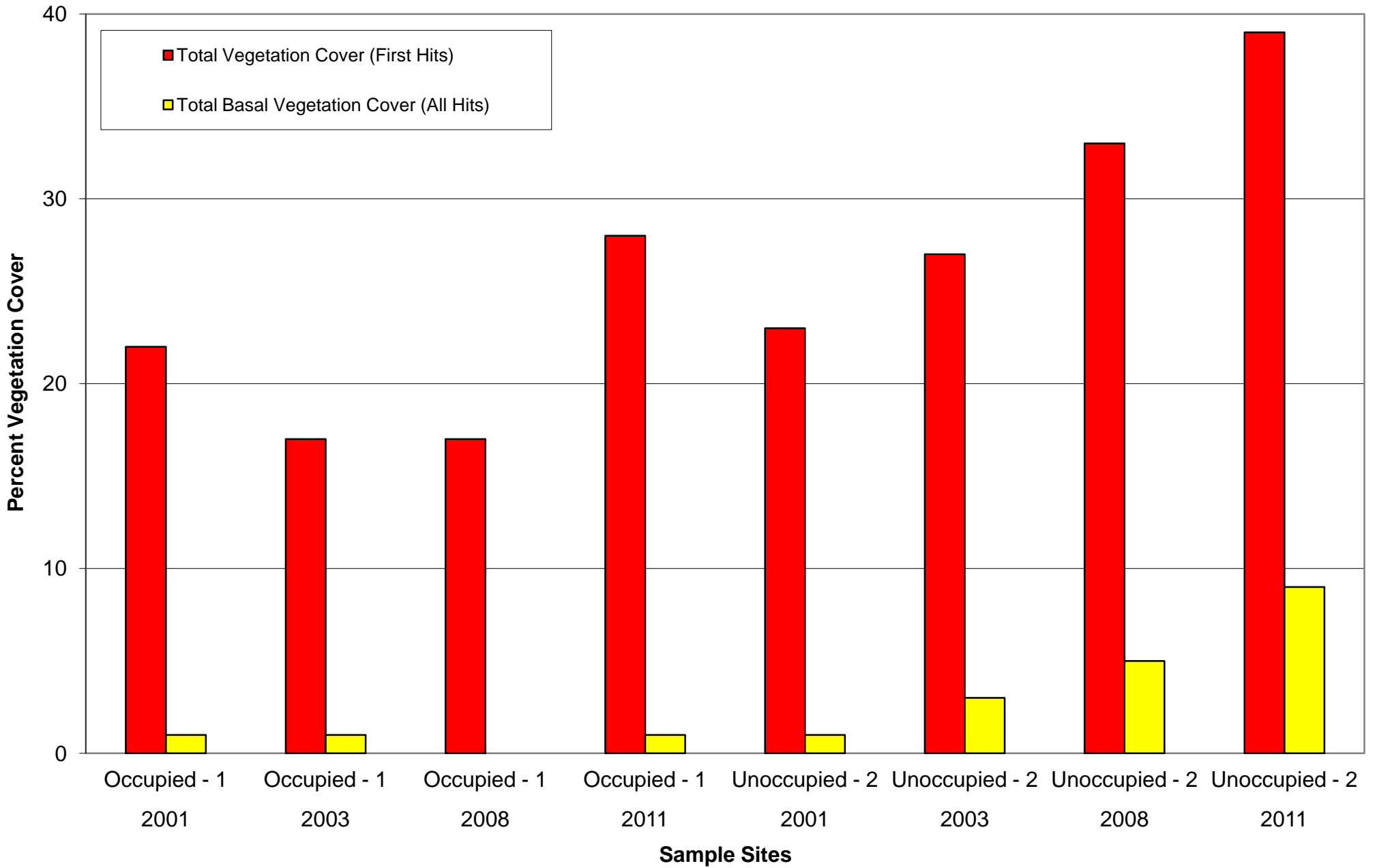
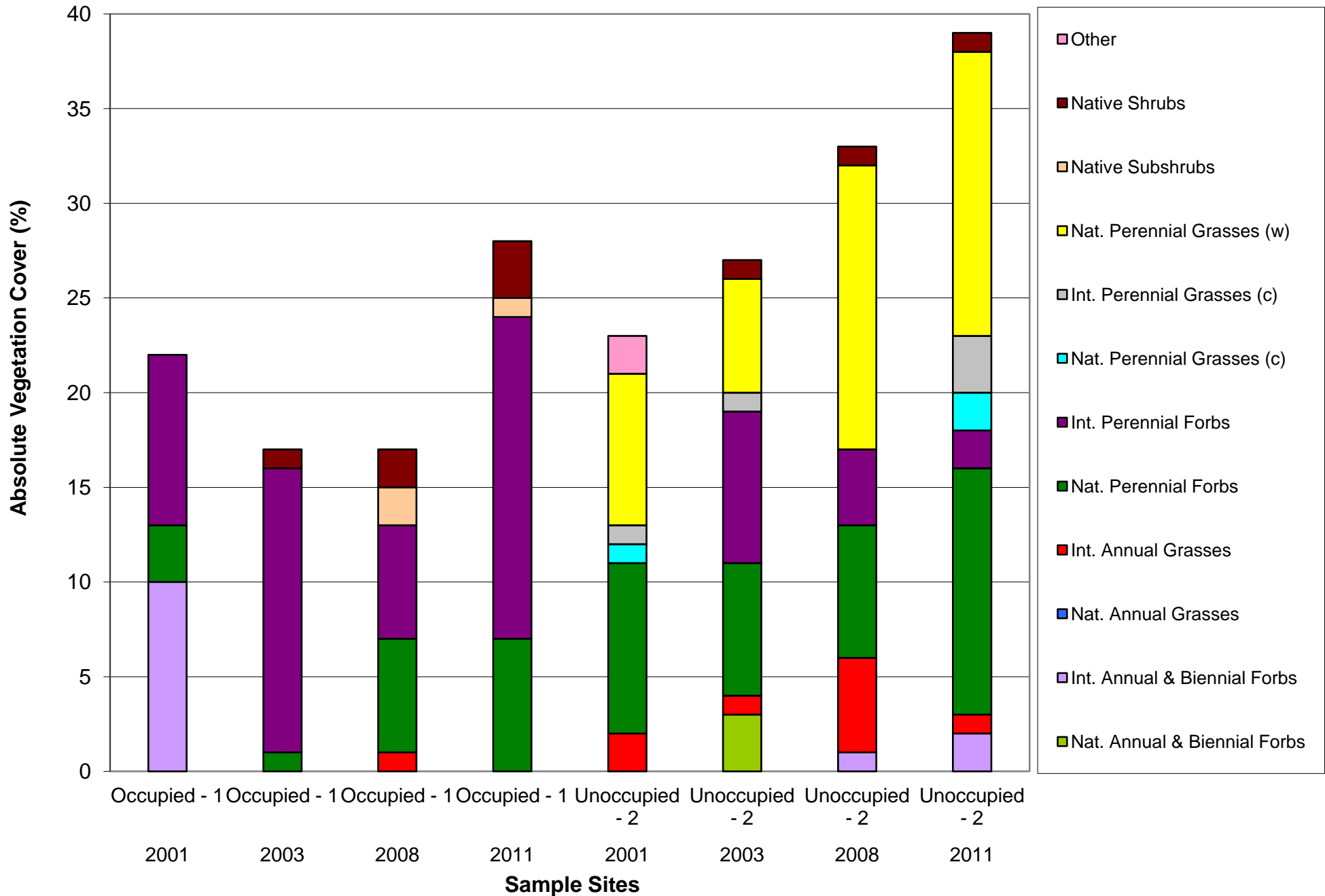


Figure 1a. Total Vegetation Cover - Brand Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2008 and 2011



*2003, previously unoccupied transect 2 was occupied by prairie dogs

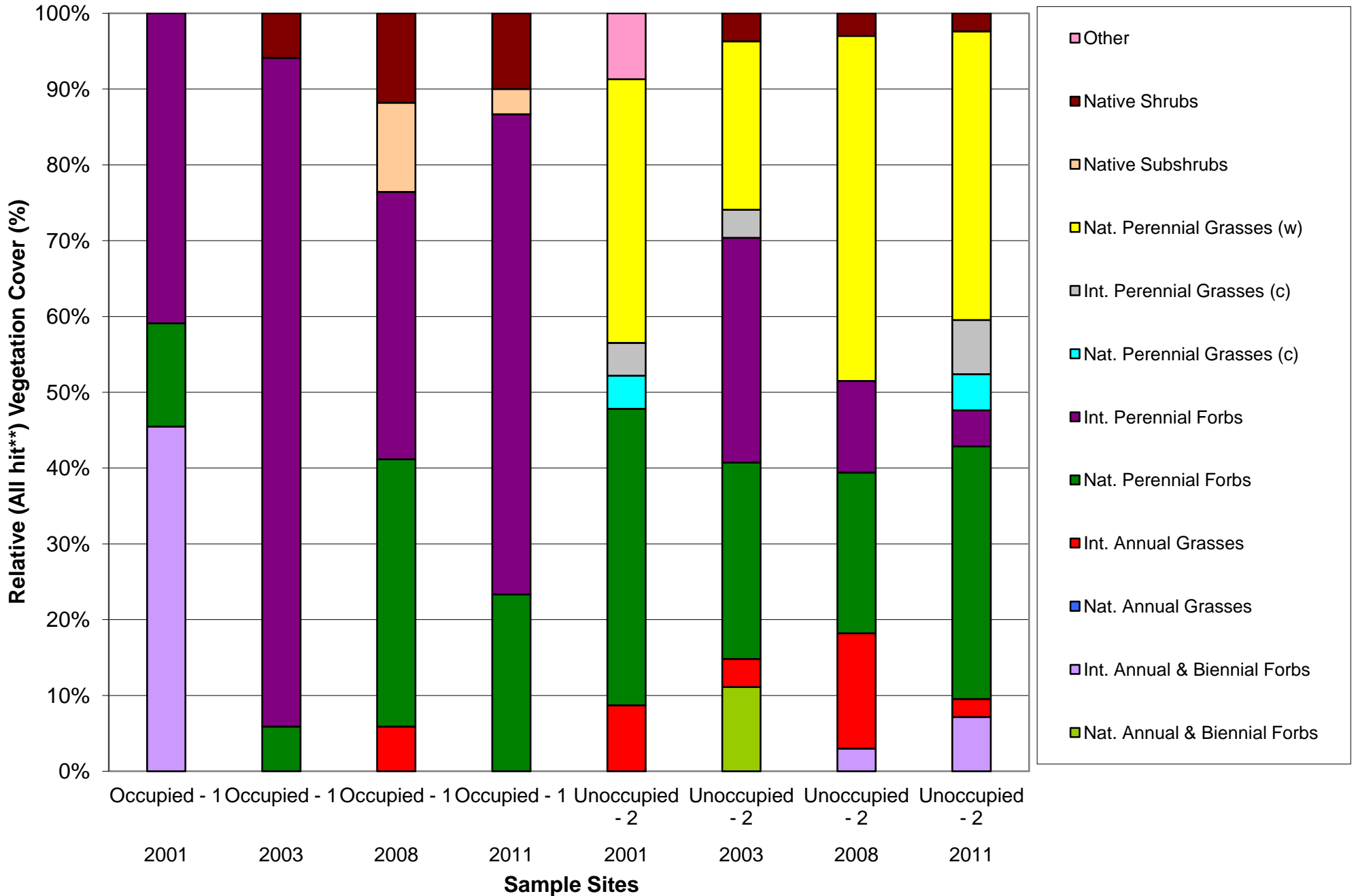
Figure 1b. Absolute Vegetation Cover by Lifeform - Brand Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2008 and 2011



*2003, previously unoccupied transect 2 was occupied

**All Hit data include both 1st and 2nd hits - a 1st hit is the top-most layer of the vegetation canopy, below a 1st hit interception may exist other interceptions - referred to as 2nd hits.

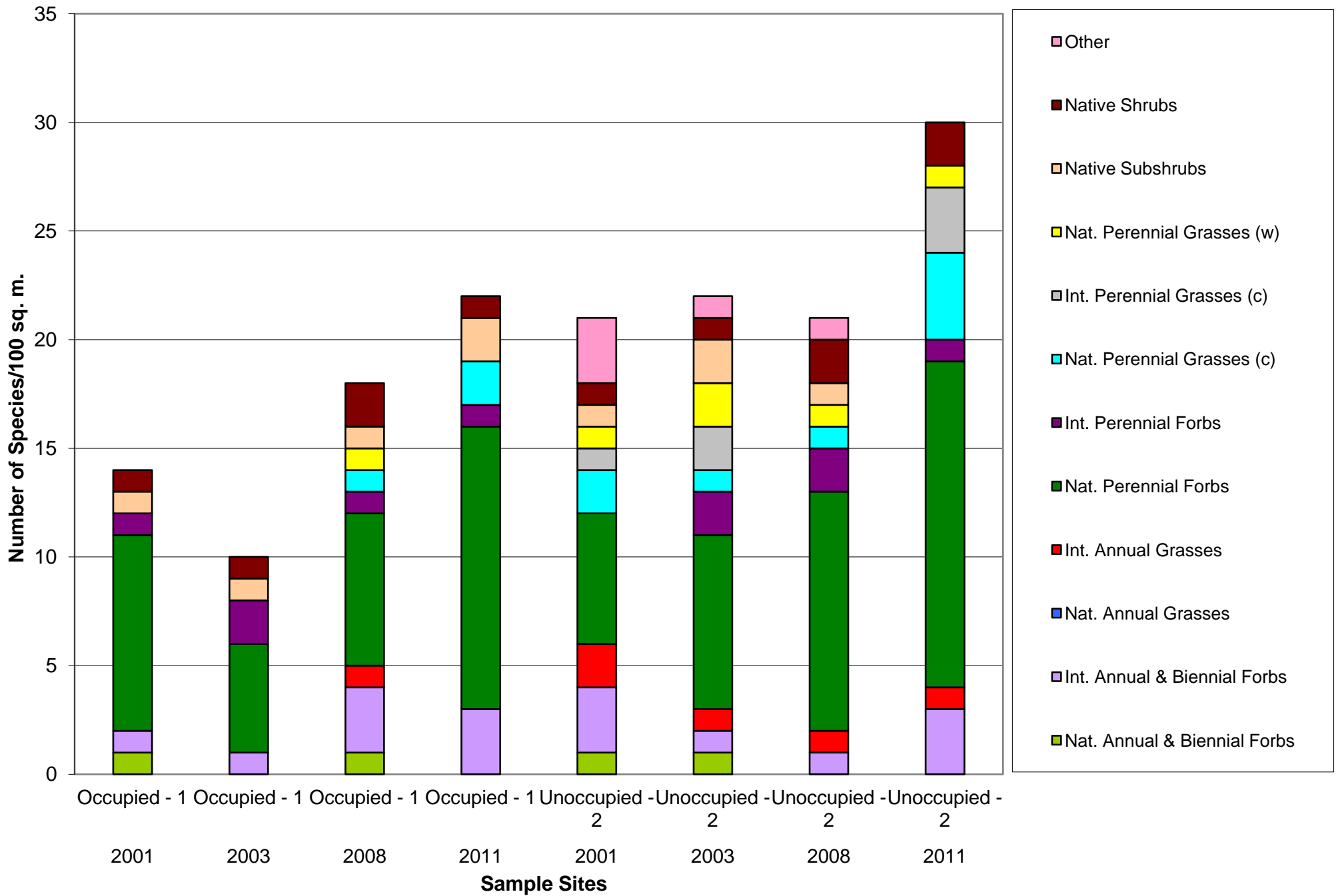
Figure 2. Relative Vegetation Cover by Lifeform - Brand Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2008 and 2011



*2003, previously unoccupied transect 2 was occupied

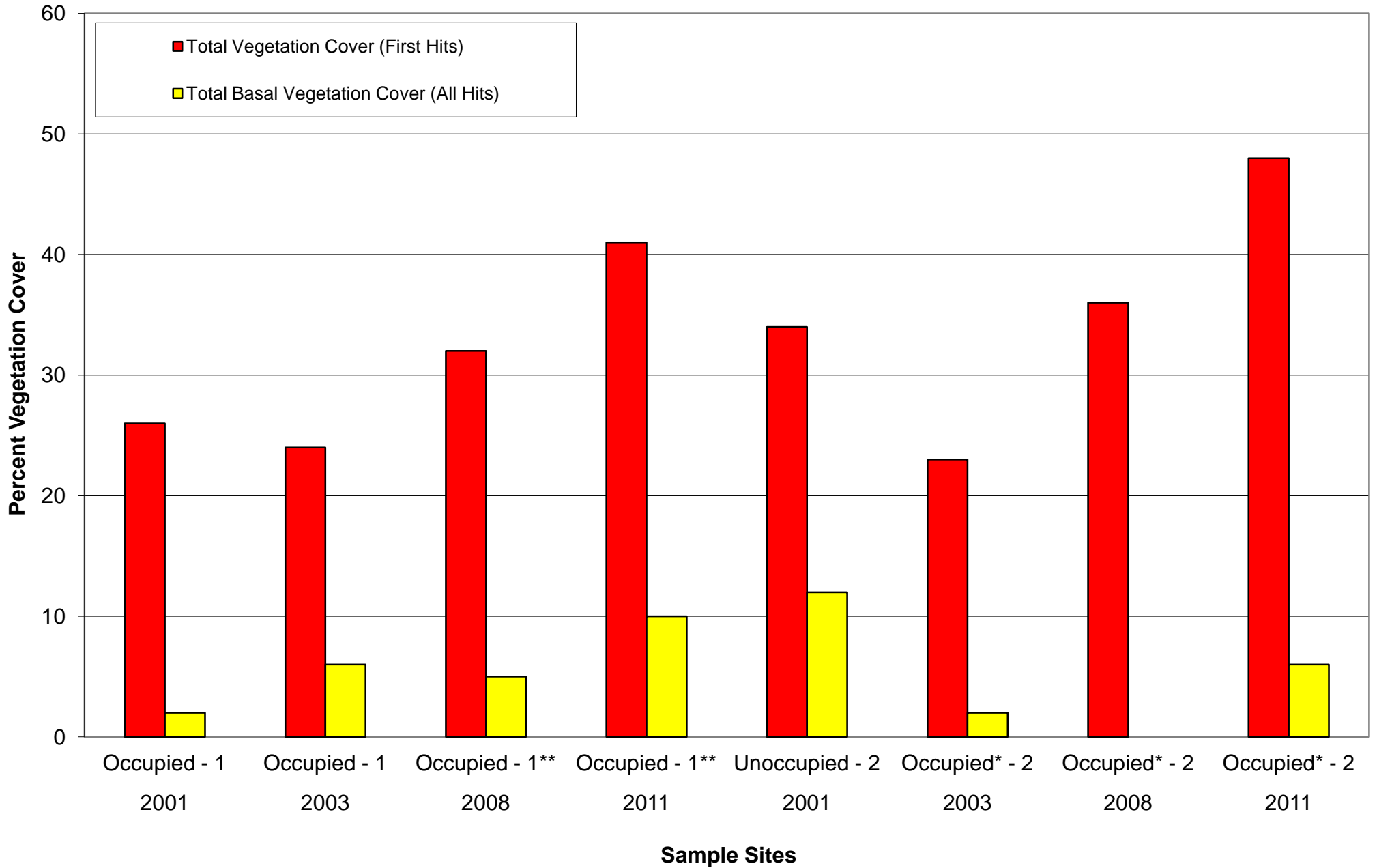
**All Hit data include both 1st and 2nd hits - a 1st hit is the top-most layer of the vegetation canopy, below a 1st hit interception may exist other interceptions - referred to as 2nd hits.

Figure 3. Species Density by Lifeform - Brand Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2008 and 2011



2003, Previously unoccupied transect 2 was occupied by prairie dogs

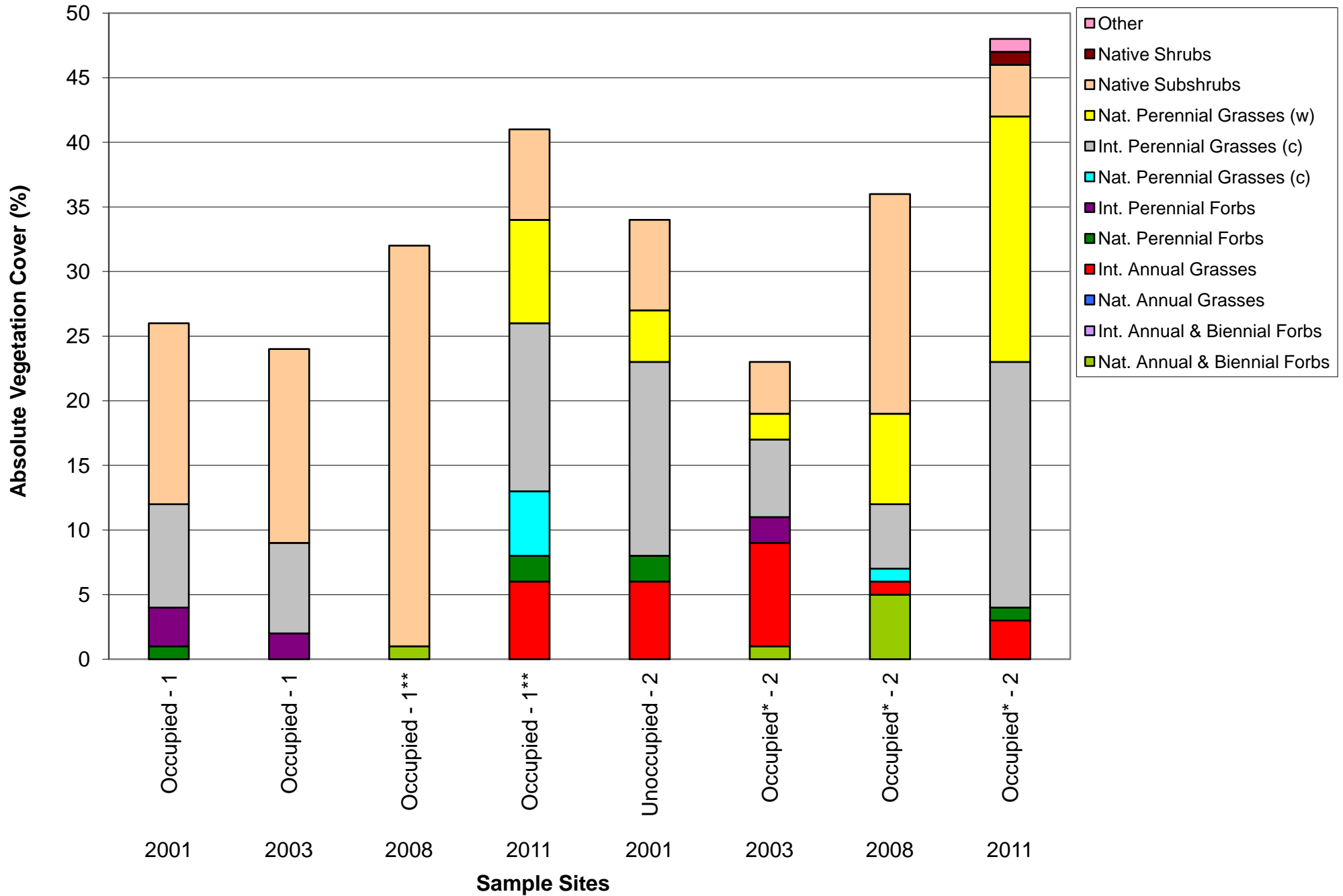
Figure 1a. Total Vegetation Cover - Rabbit Mountain Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2008 and 2011



*2003, previously unoccupied transect 2 was occupied by prairie dogs

*2008, prairie dogs at previously occupied transect 1 died from plague

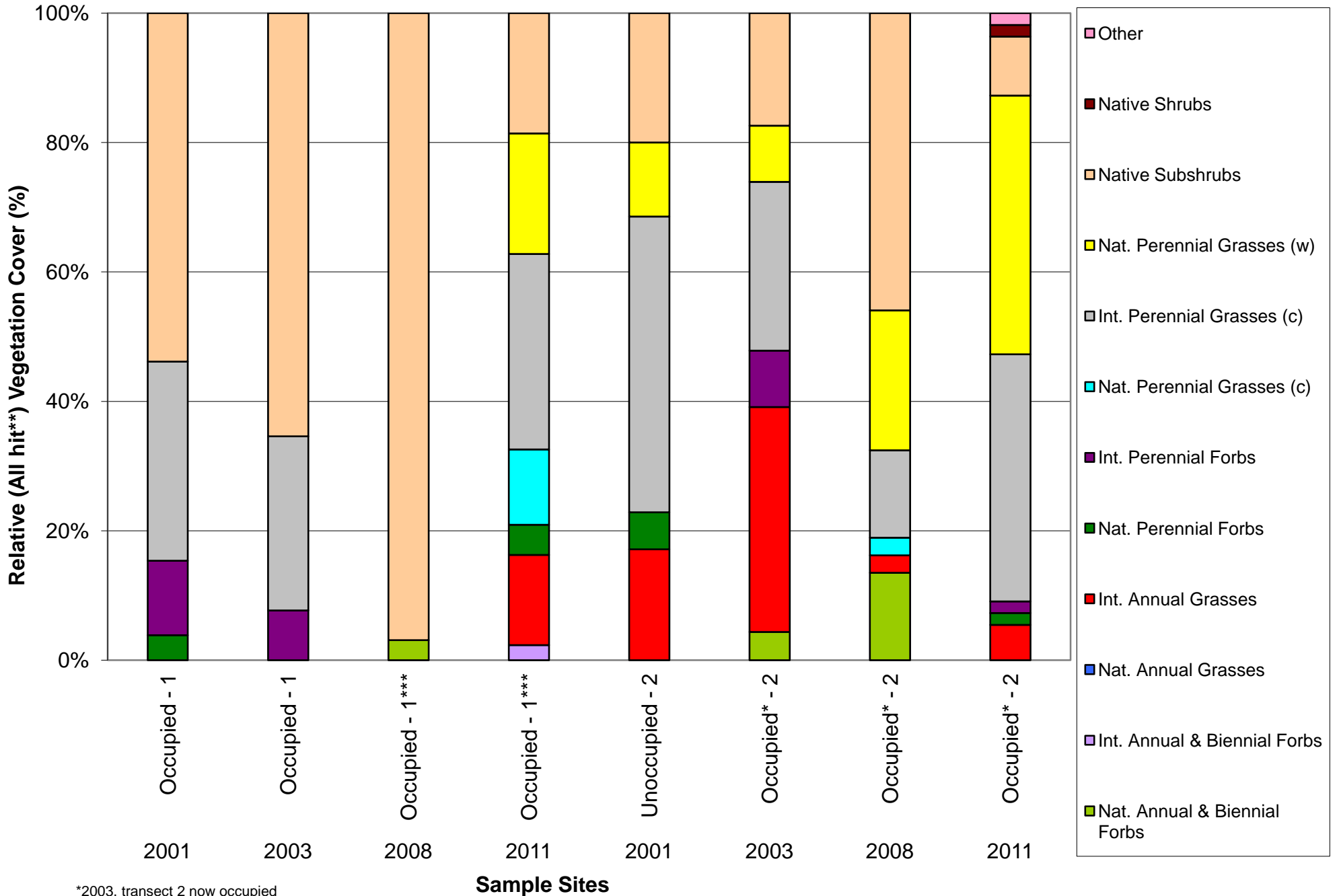
Figure 1b. Absolute Vegetation Cover by Lifeform - Rabbit Mountain Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2008 and 2011



*2003, transect 2 now occupied

**2008, prairie dogs at transect 1 died from plague

Figure 2. Relative Vegetation Cover by Lifeform - Rabbit Mountain Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2008 and 2011

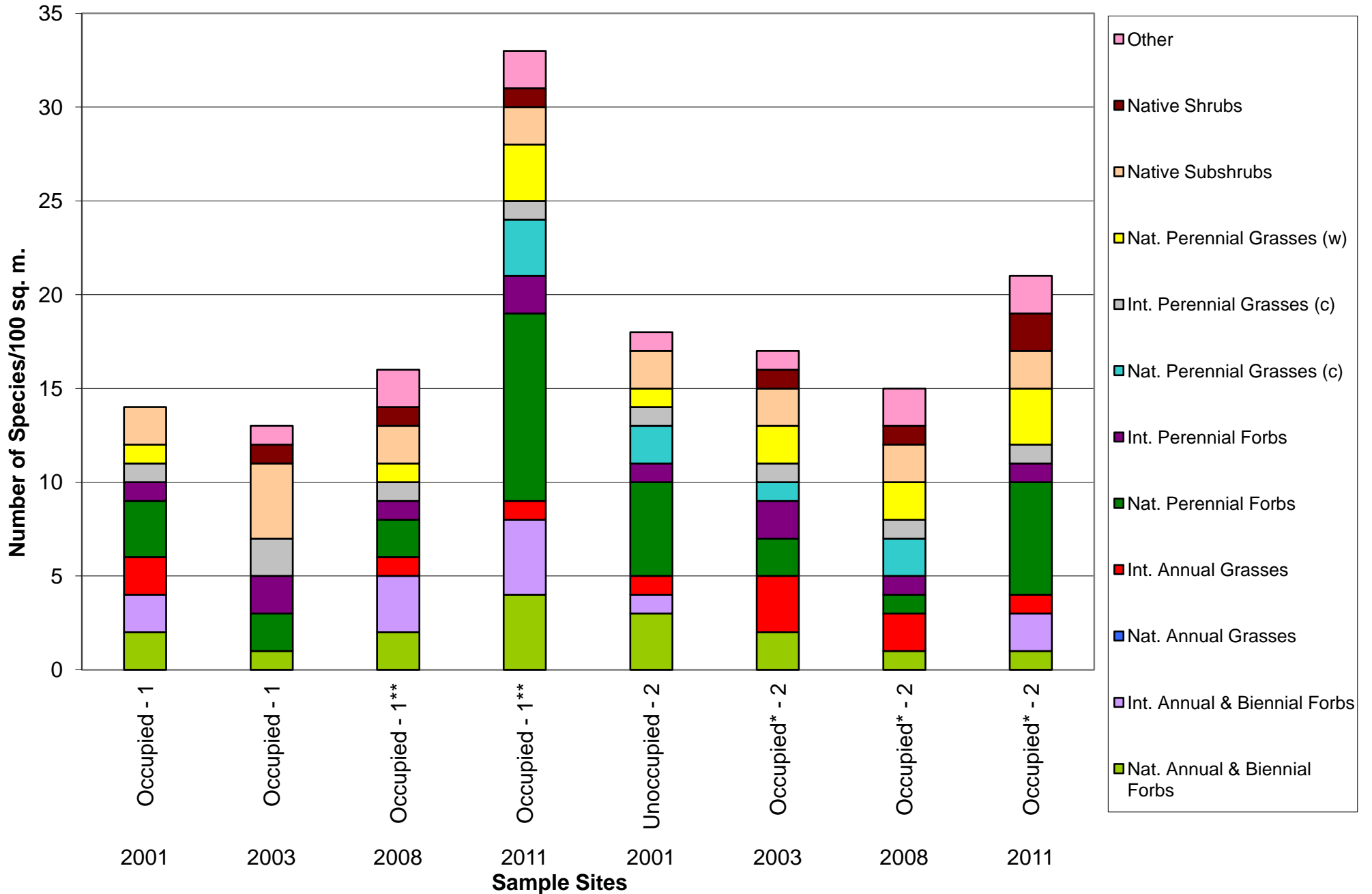


*2003, transect 2 now occupied

**All Hit data include 1st and 2nd hits-1st hit is top layer of veg. canopy, below 1st hit may exist other interceptions = 2nd hits.

***2008, prairie dogs at transect 1 died from plague

Figure 3. Species Density by Lifeform - Rabbit Mountain Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003 and 2008

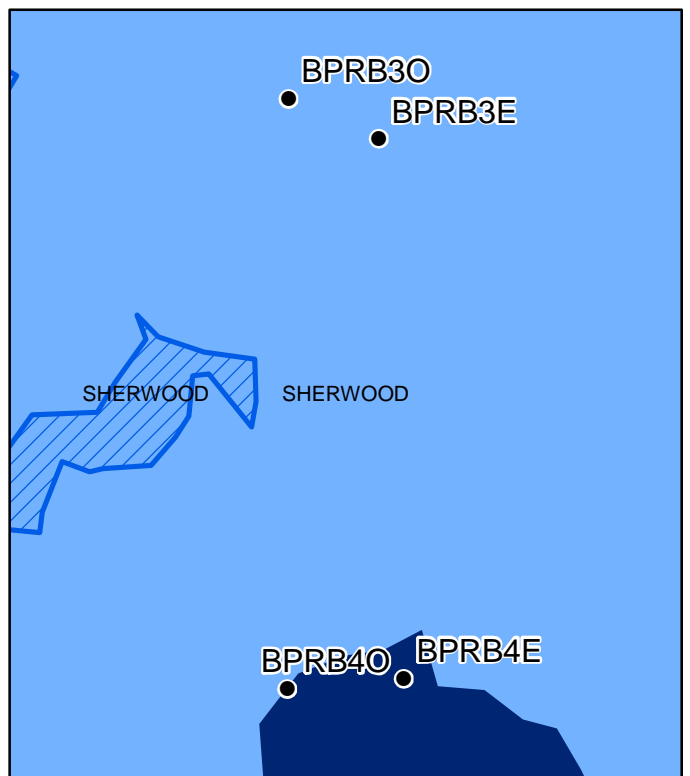


*2003, Previously unoccupied transect 2 was occupied by prairie dogs

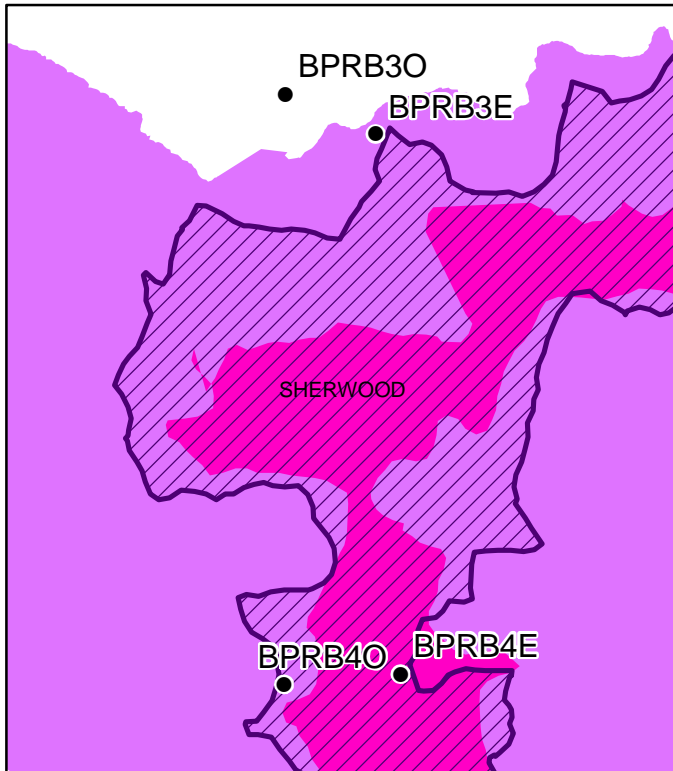
**2008, prairie dogs at transect 1 died from plague



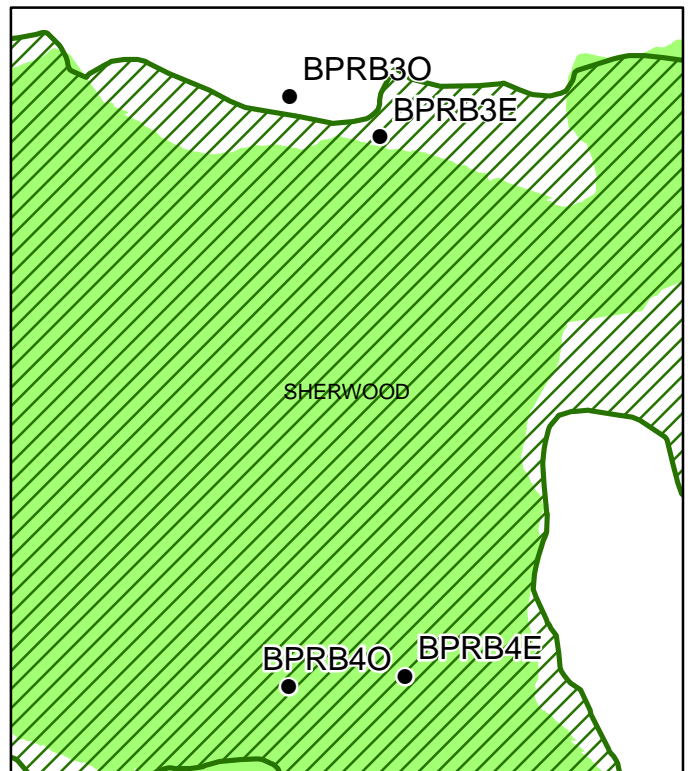
1997-2006



2004-2006



2007-2009



2010-2011

Map 1. Boulder County - Prairie Dog Colony Mapping - SHERWOOD PARCEL

~1997 darkest gray >> 2006 lightest gray

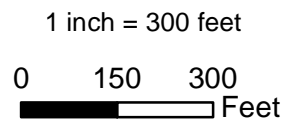


Figure 1a. Total Vegetation Cover - Sherwood Parcel, Prairie Dog Study, Boulder County Open Space, CO - 2001, 2004, 2007 and 2011

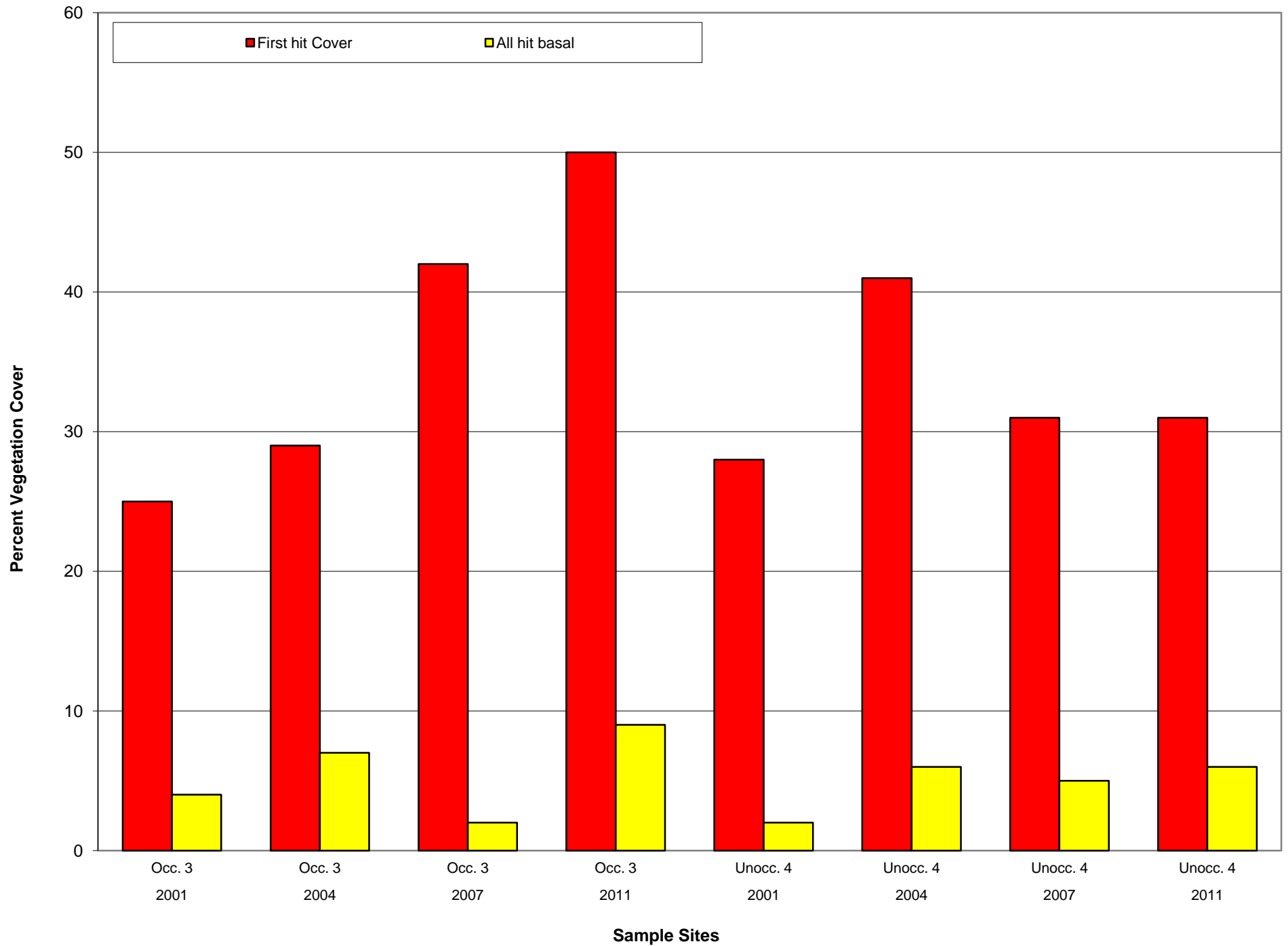


Figure 1b. Absolute Cover by Lifeform - Sherwood Parcel, Prairie Dog Study, Boulder County Open Space, CO - 2001, 2004, 2007 and 2011

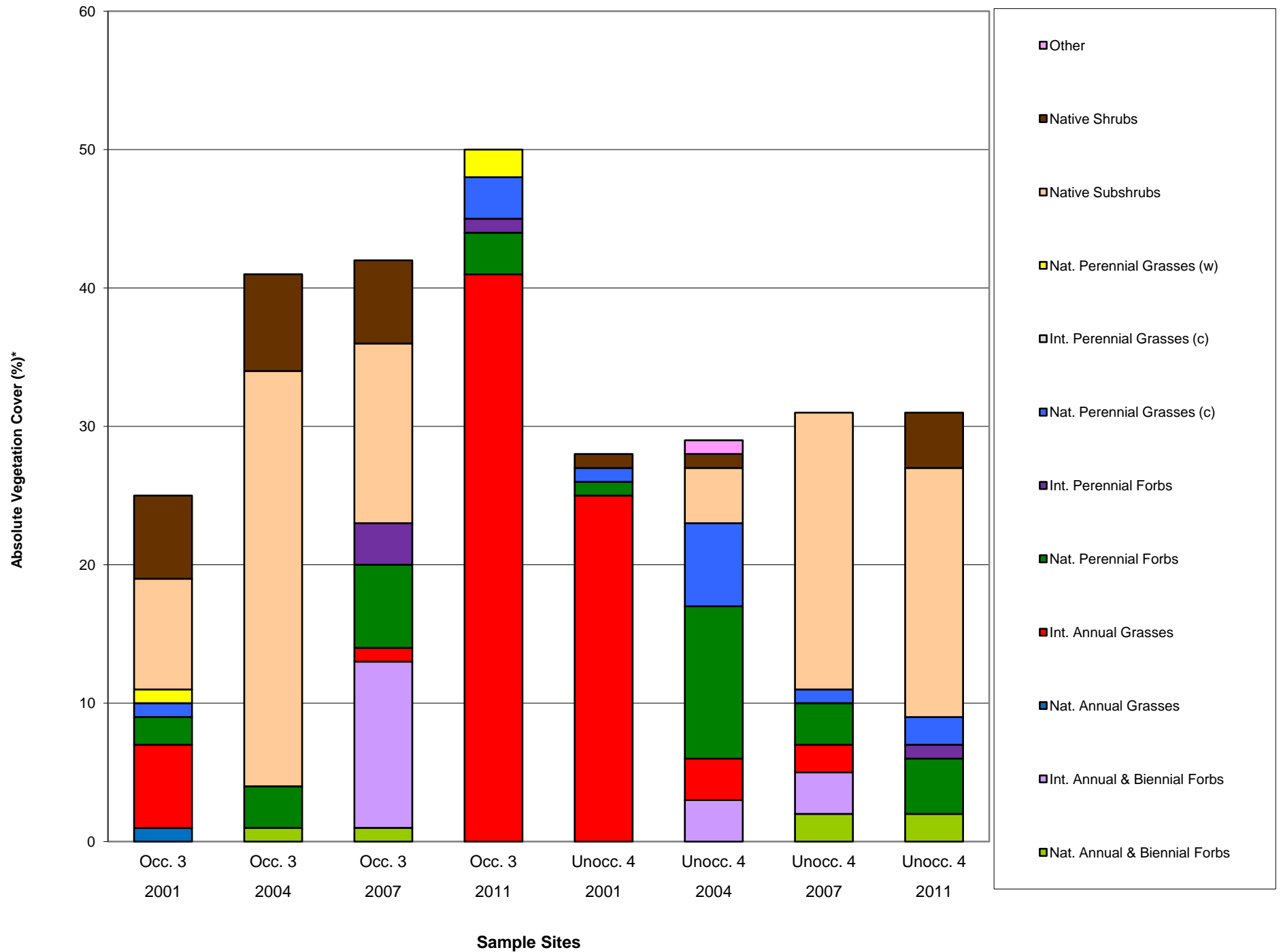
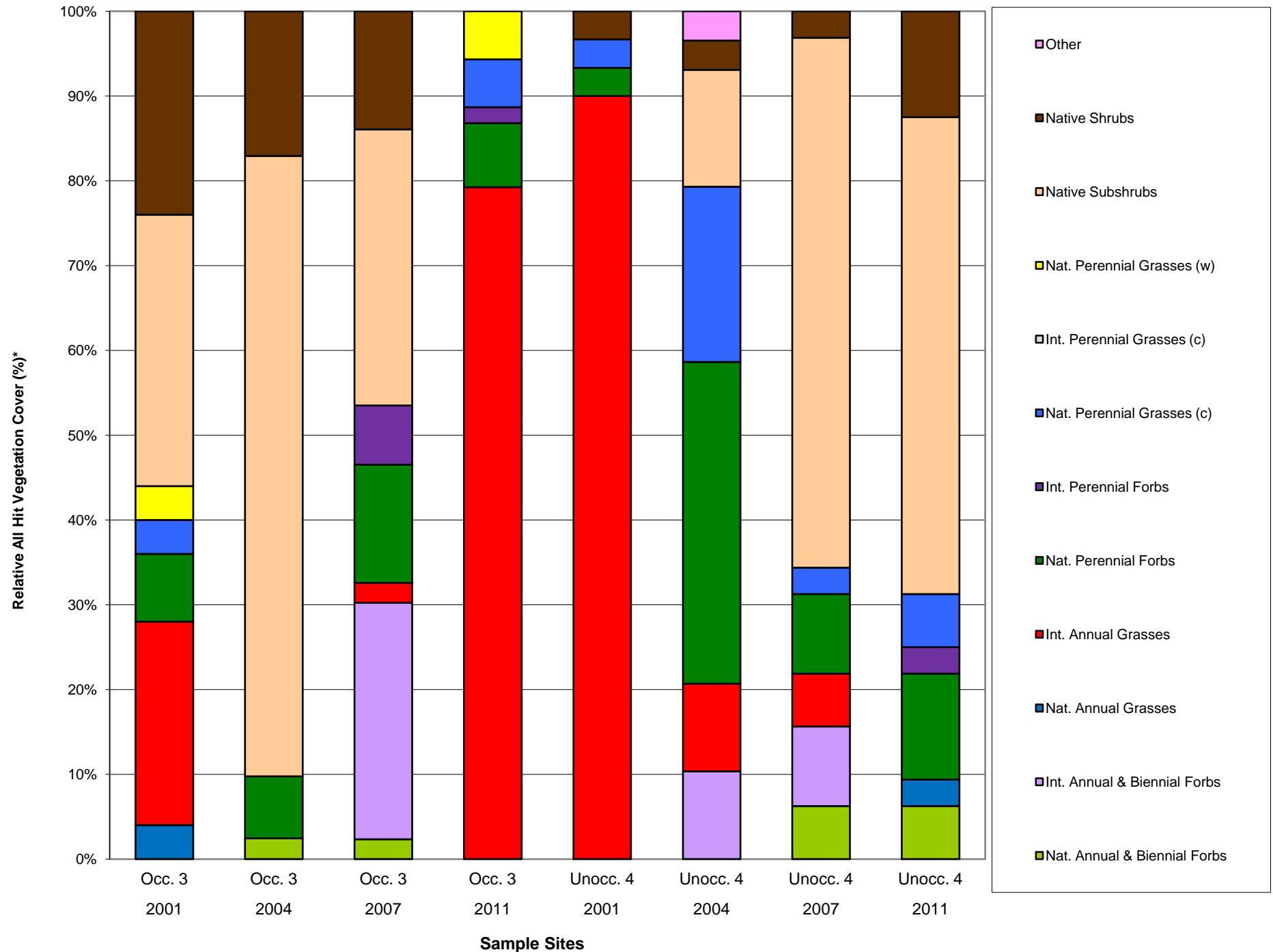


Figure 2. Relative Cover by Lifeform - Sherwood Parcel, Prairie Dog Study, Boulder County Open Space, CO - 2001, 2004, 2007 and 2011



*All Hit data include both first and second hits - a first hit is the top-most layer of the vegetation canopy, below a first hit interception may exist other interceptions - these are referred to as second hits.

Figure 3. Species Density by Lifeform - Sherwood Parcel, Prairie Dog Study, Boulder County Open Space, CO - 2001, 2004, 2007 and 2011

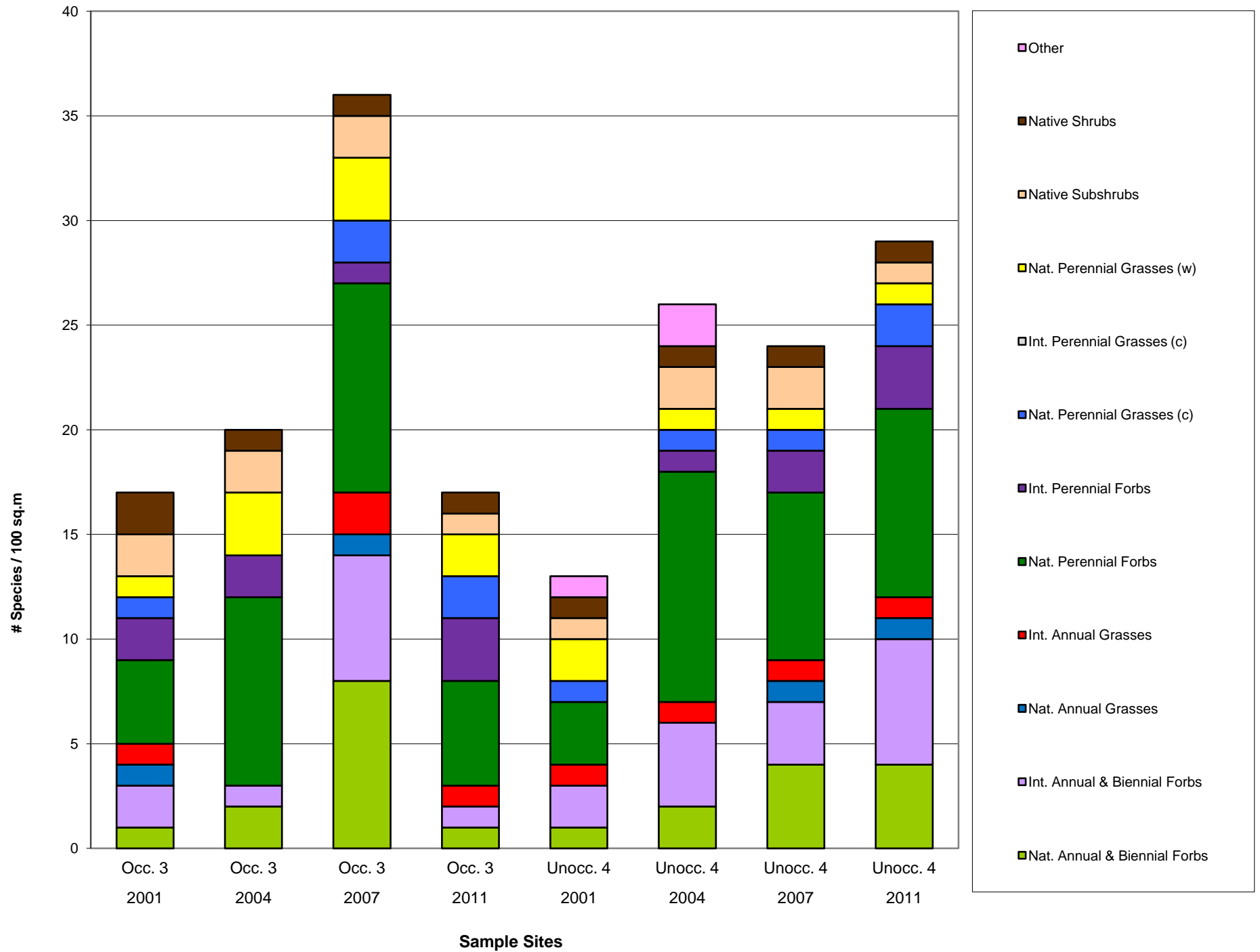
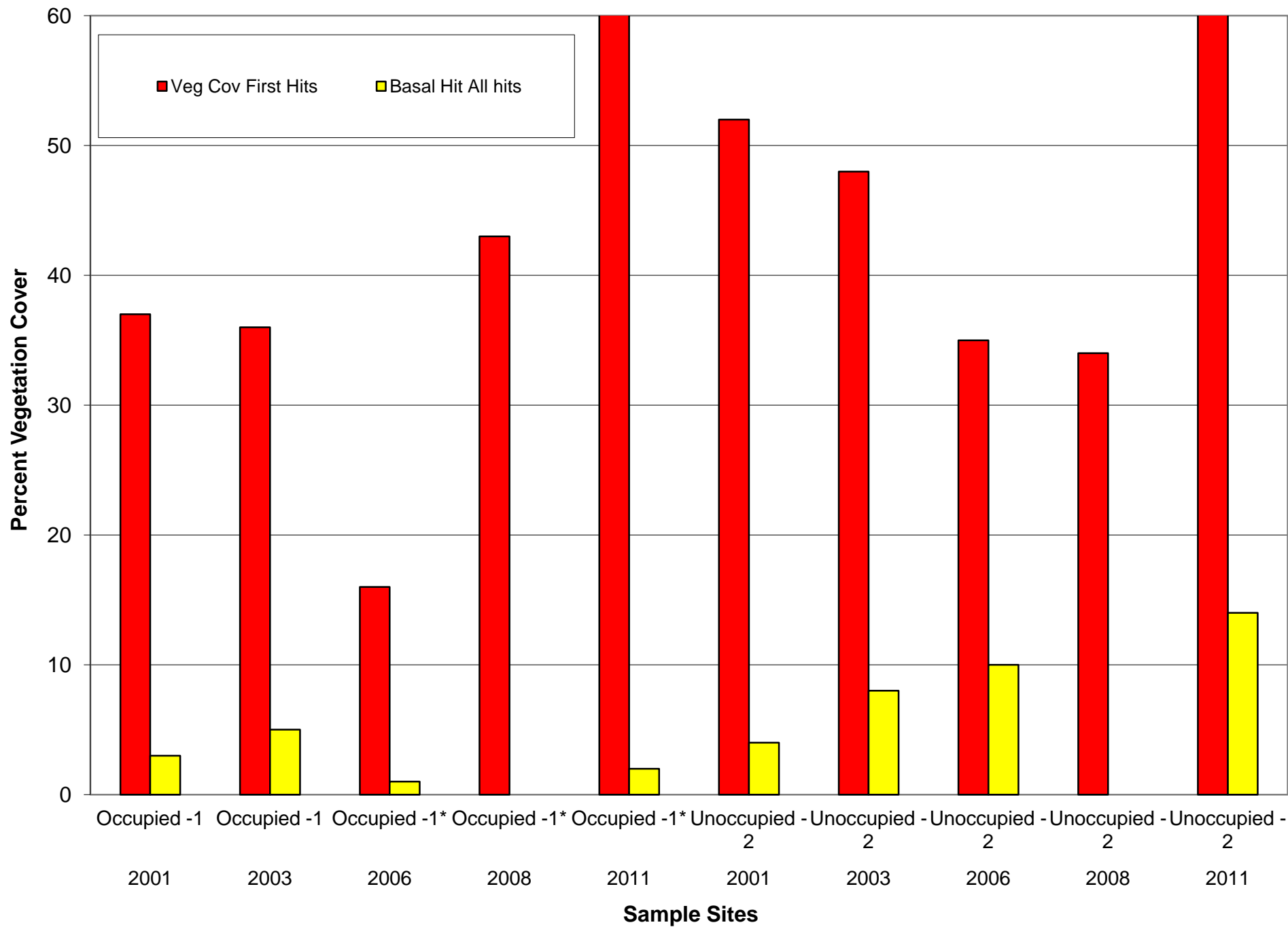


Figure 1a. Total Vegetation Cover - Heil Valley Ranch - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006, 2008 and 2011



*Prairie Dogs at Heil 1 dead (due to plague) as of 2006 sampling.

Figure 1b. Absolute Vegetation Cover by Lifeform - Heil Valley Ranch - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006, 2008 and 2011

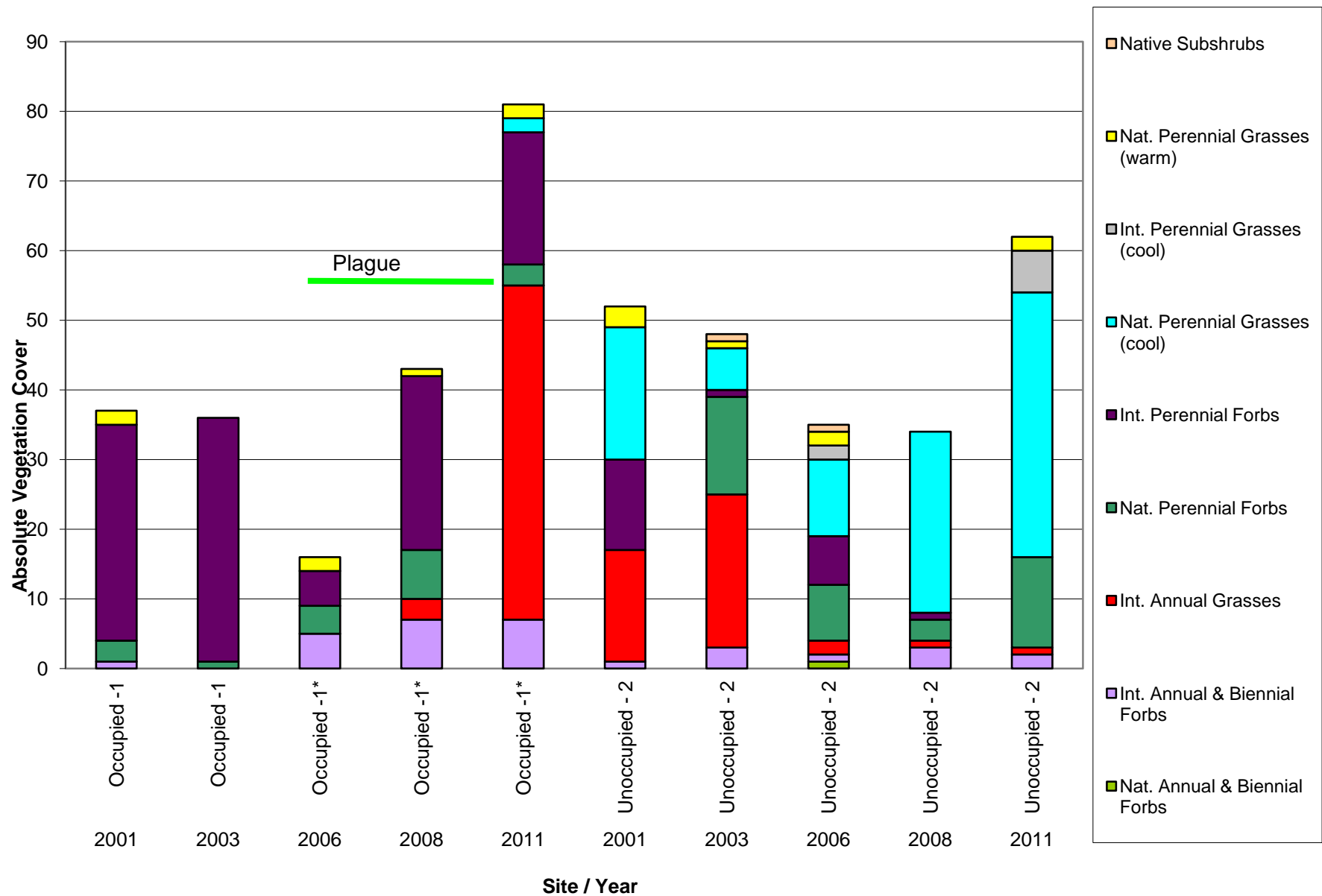
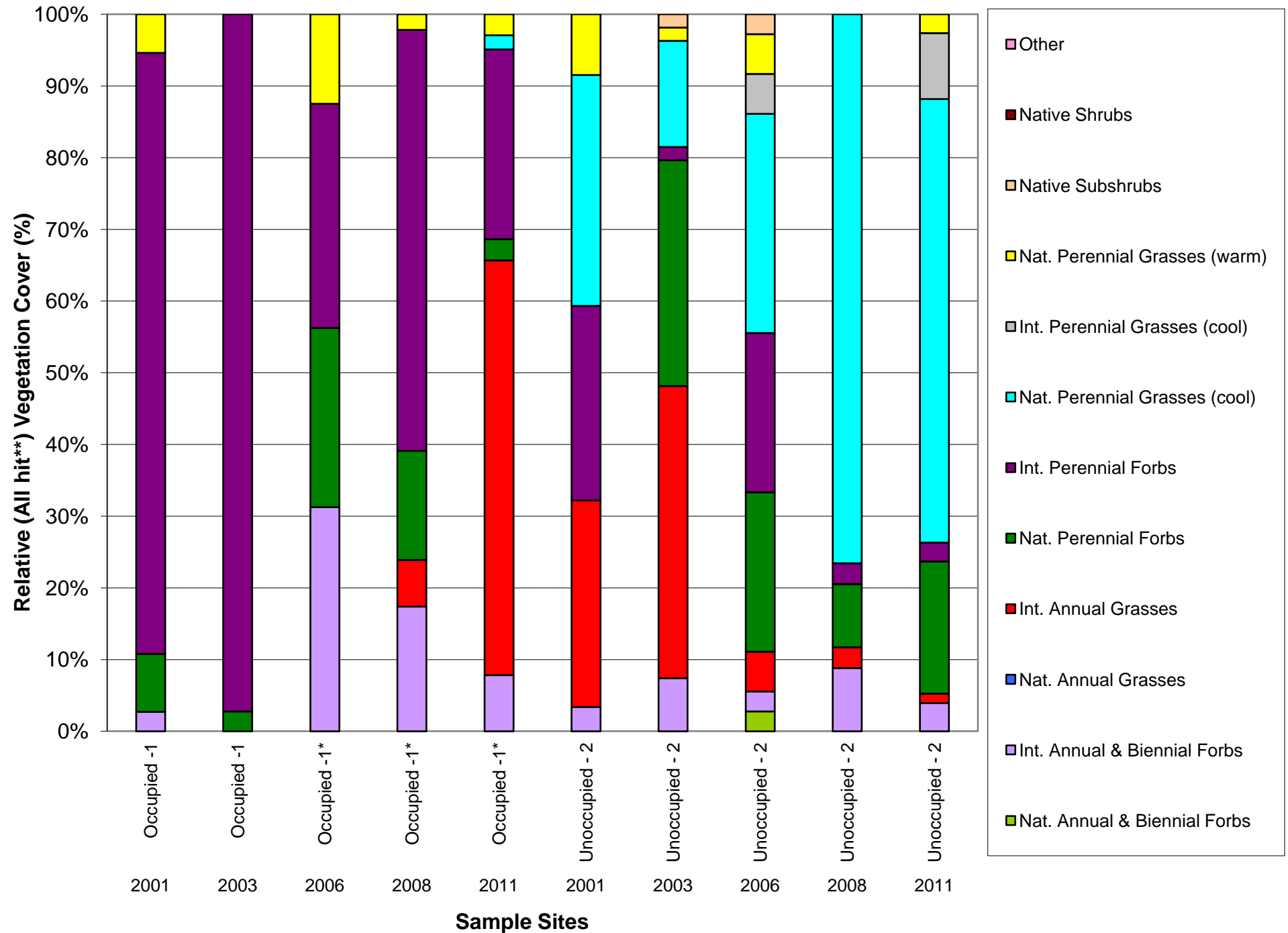


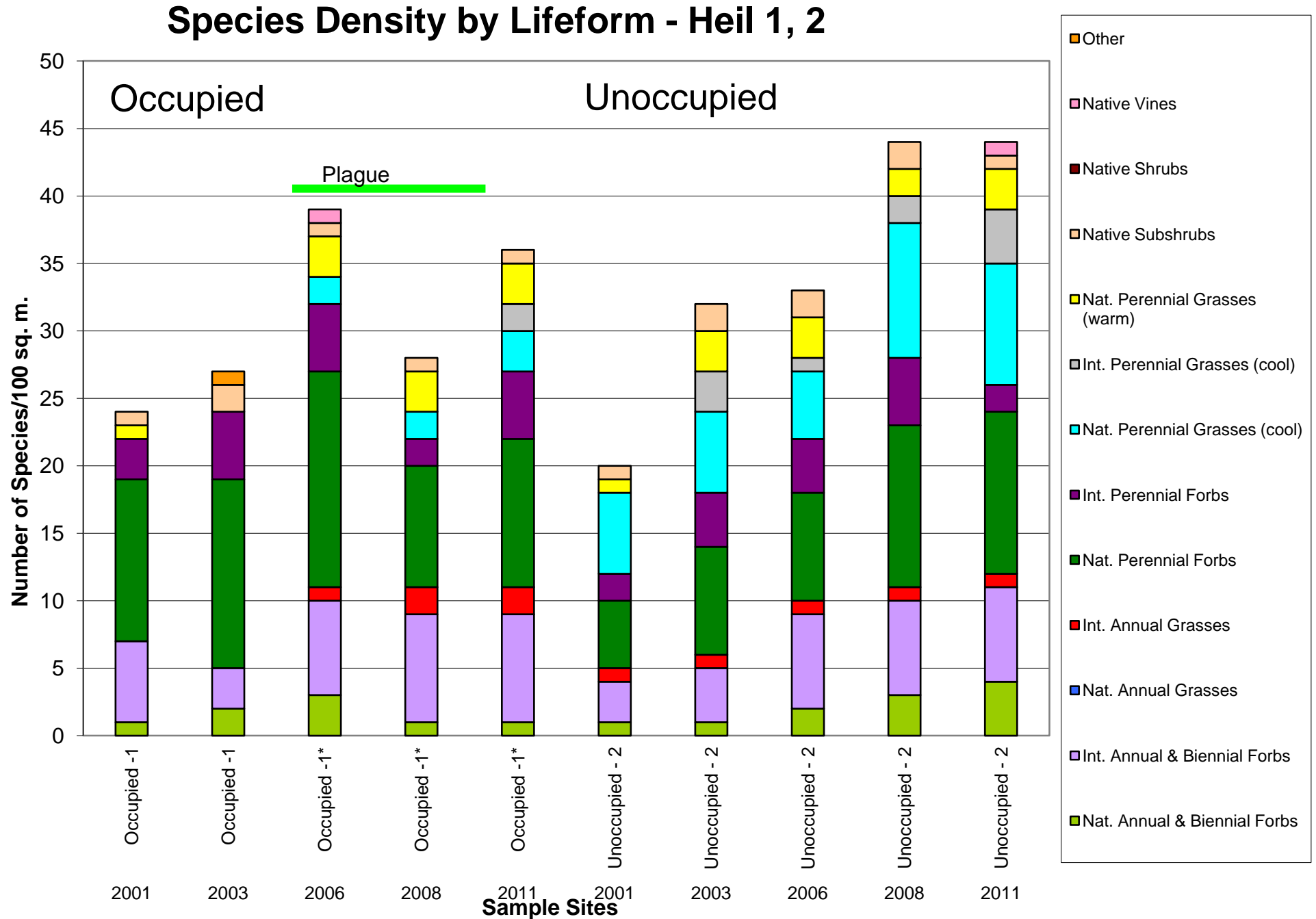
Figure 2. Relative Vegetation Cover by Lifeform - Heil Valley Ranch - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006, 2008 and 2011



*Prairie Dogs at Heil 1 dead (due to plague) as of 2006 sampling.

**All Hit data include 1st and 2nd hits-1st hit is top layer of veg. canopy, below 1st hit may exist other interceptions = 2nd hits.

Figure 3. Species Density by Lifeform - Heil Valley Ranch - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006, 2008 and 2011



*Prairie Dogs at Heil 1 dead (due to plague) as of 2006 sampling.

Figure 1a. Total Vegetation Cover - Heil Property, Prairie Dog Study, Boulder County Open Space, CO - 2002, 2005, 2007 and 2010

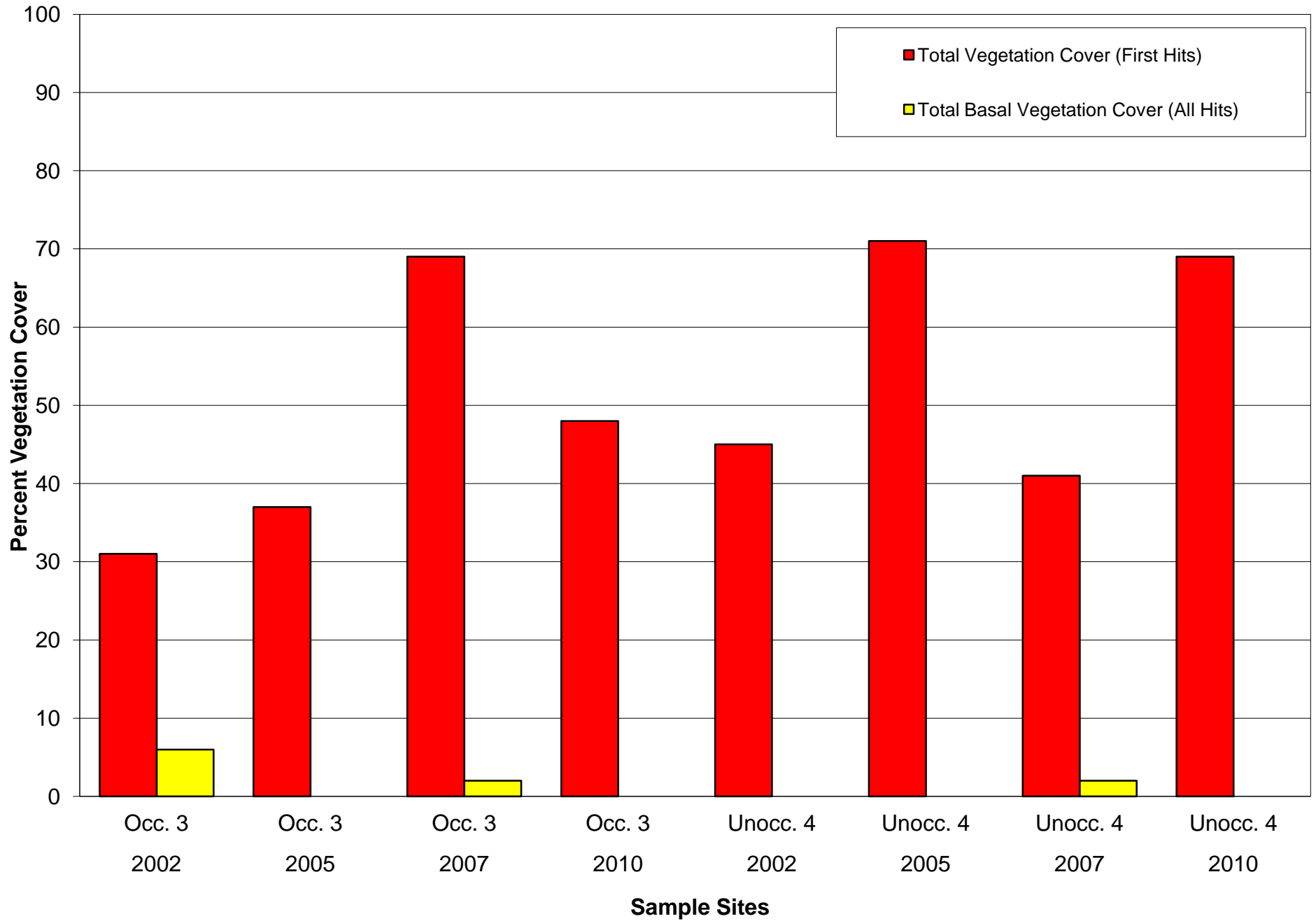


Figure 1b. Absolute Vegetation Cover by Lifeform - Heil Property, Prairie Dog Study, Boulder County Open Space, CO - 2002, 2005, 2007 and 2010

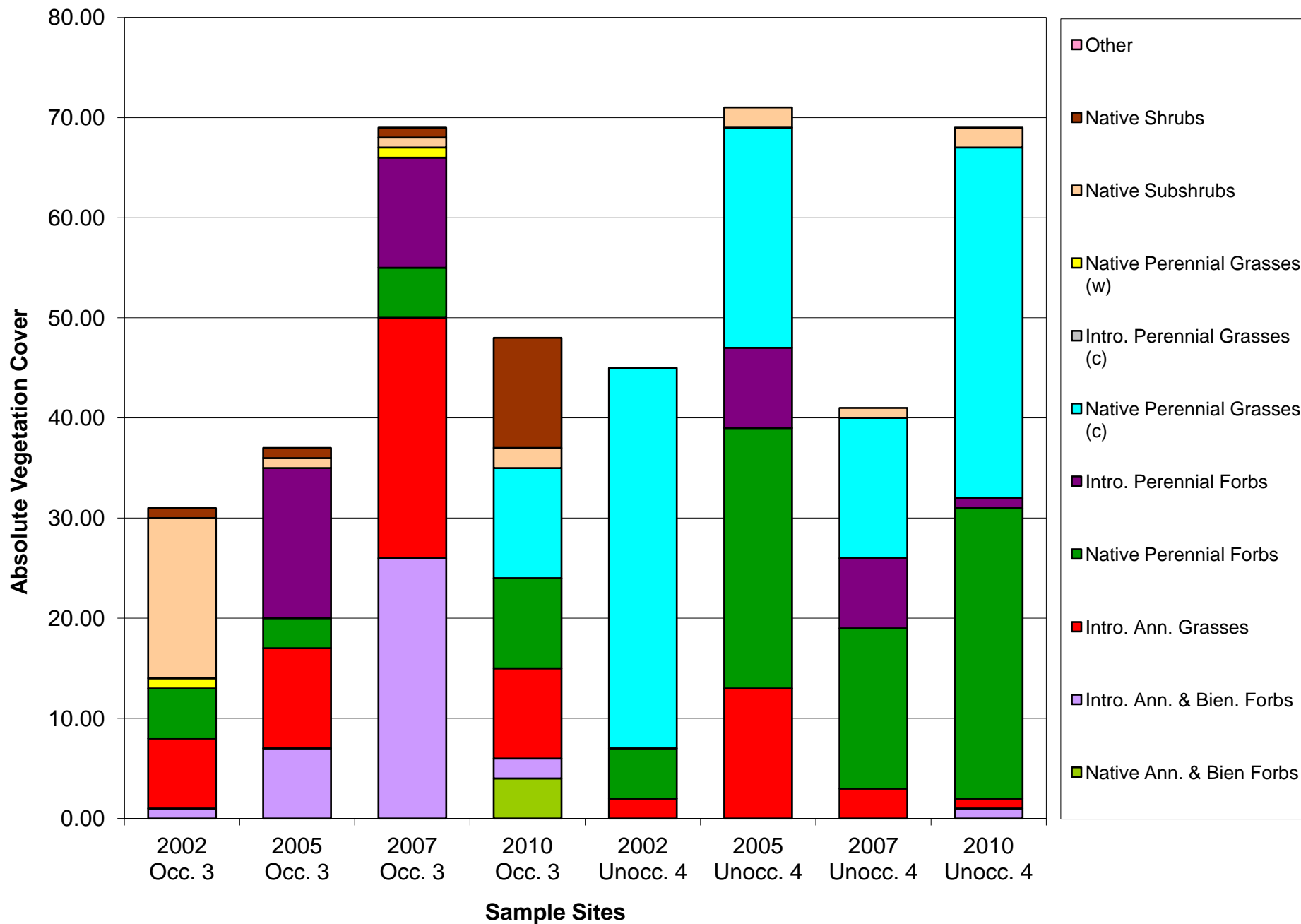
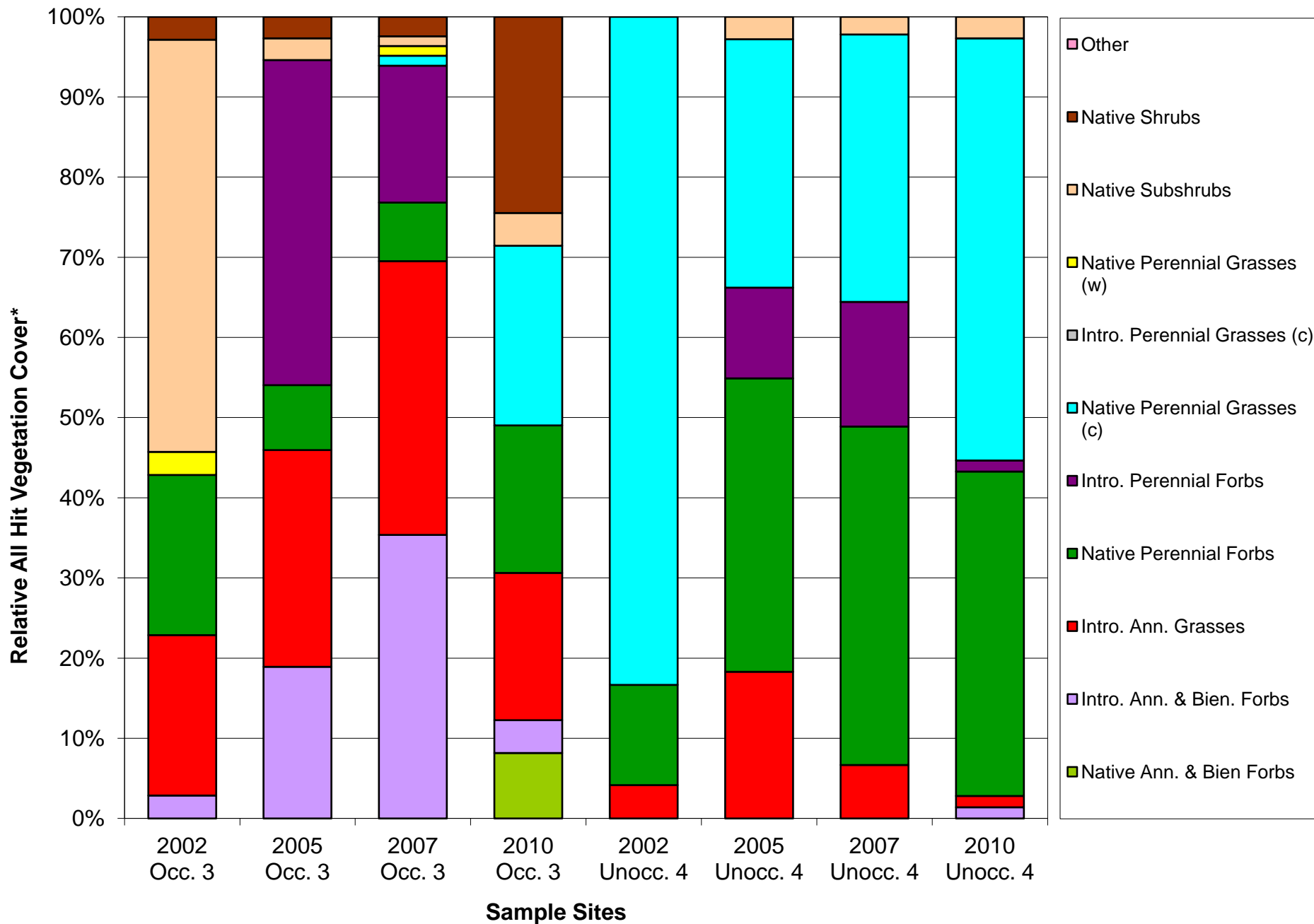
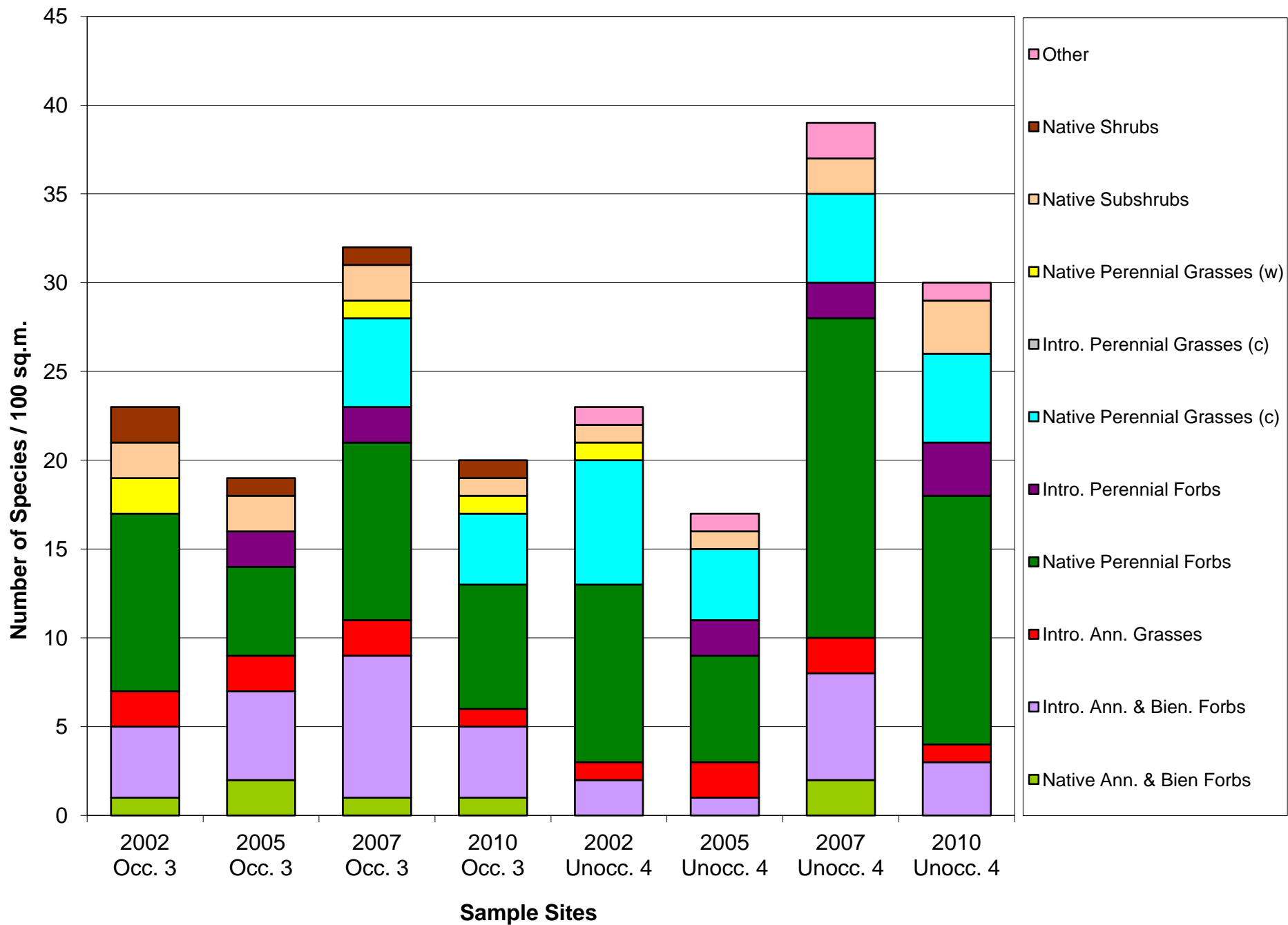


Figure 2. Relative Vegetation Cover by Lifeform - Heil Property, Prairie Dog Study, Boulder County Open Space, CO - 2002, 2005, 2007 and 2010



*All Hit data include both first and second hits - a first hit is the top-most layer of the vegetation canopy, below a first hit interception may exist other interceptions - these are referred to as second hits.

Figure 3. Species Density by Lifeform - Heil Property, Prairie Dog Study, Boulder County Open Space, CO - 2002, 2005, 2007 and 2010



Only Lifeforms quantitatively measured are included in this figure.

Figure 1a. Total Vegetation Cover - Hall Ranch Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2007 and 2010

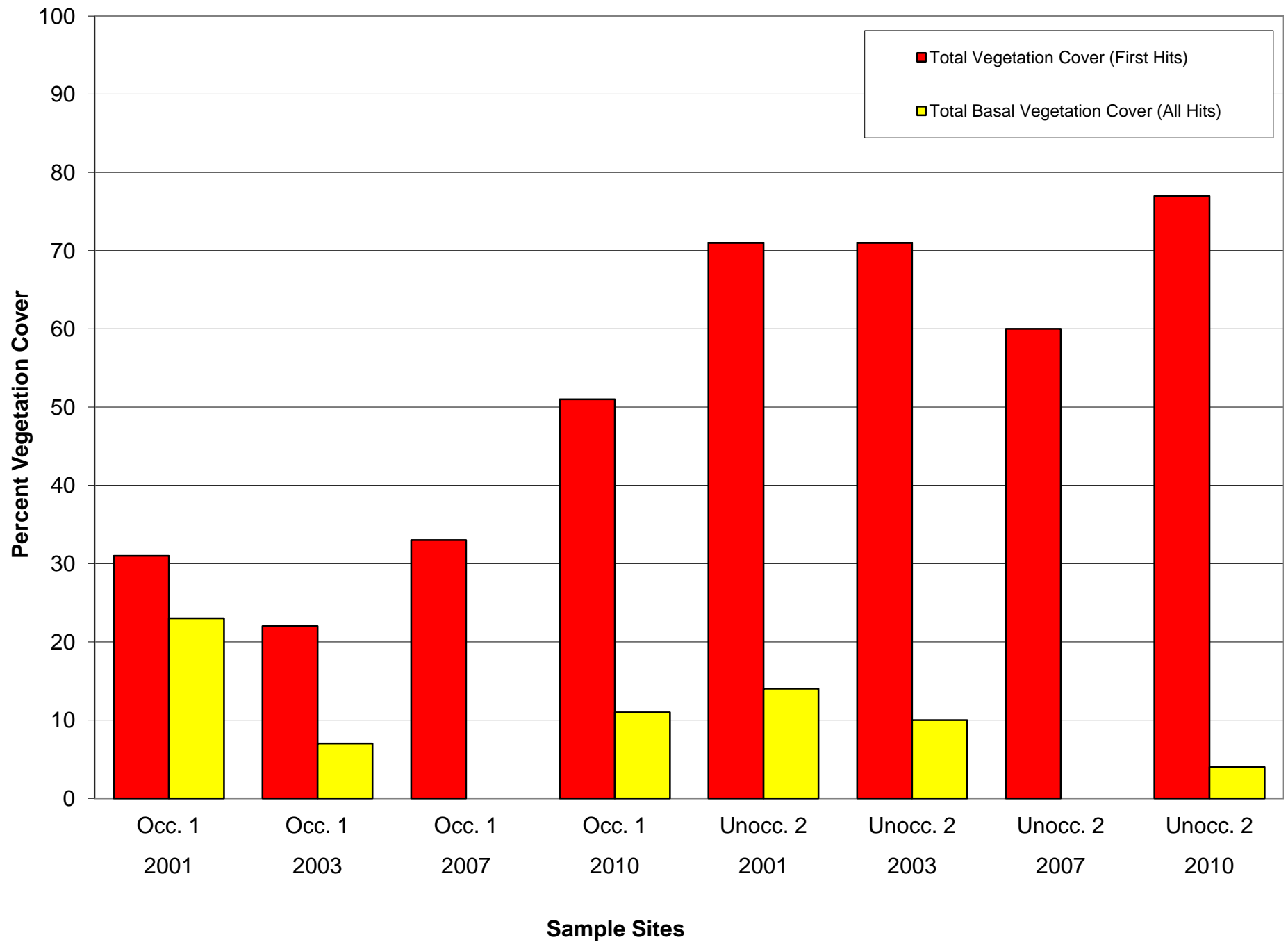


Figure 1b. Absolute Vegetation Cover by Lifeform - Hall Ranch Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2007 and 2010

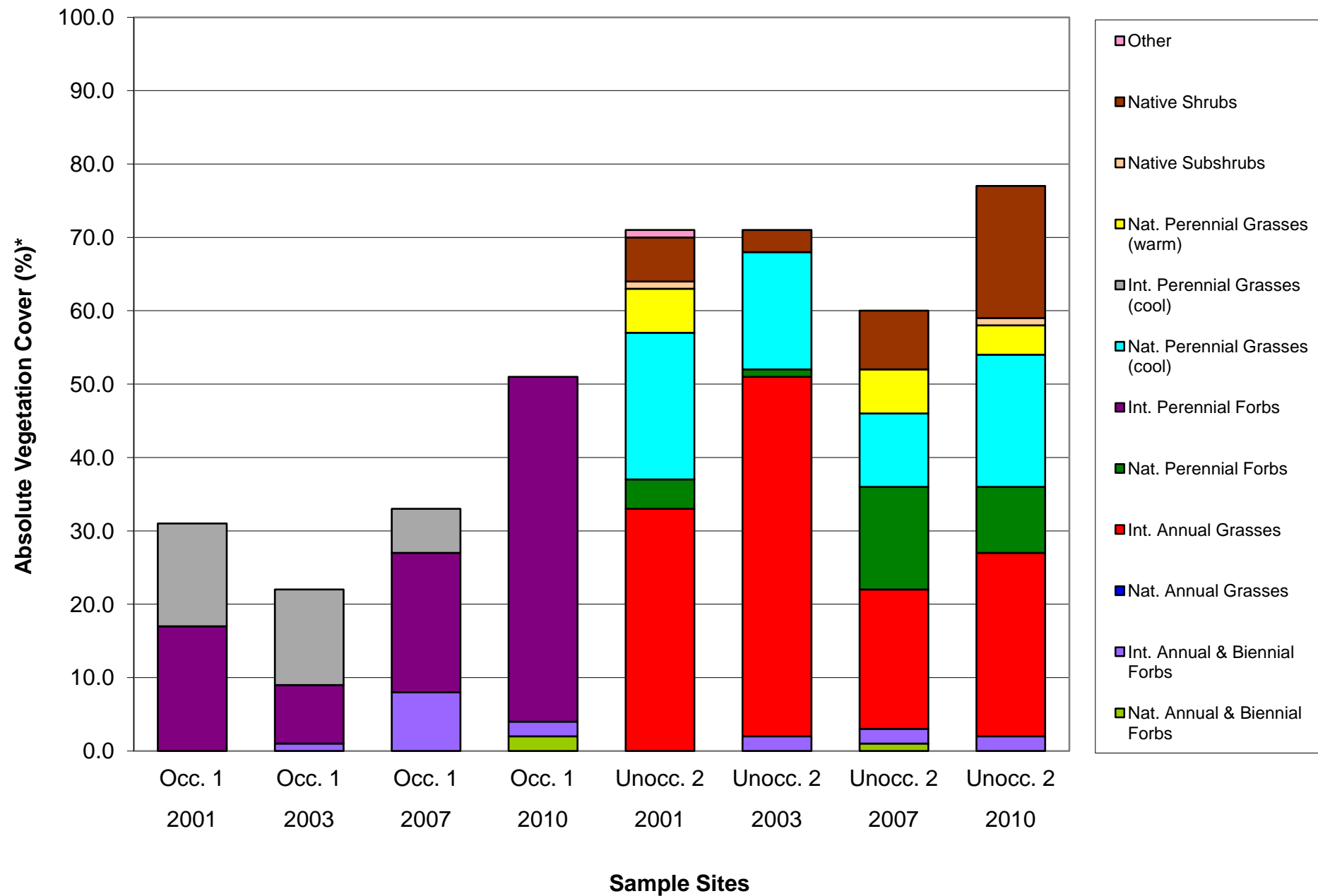
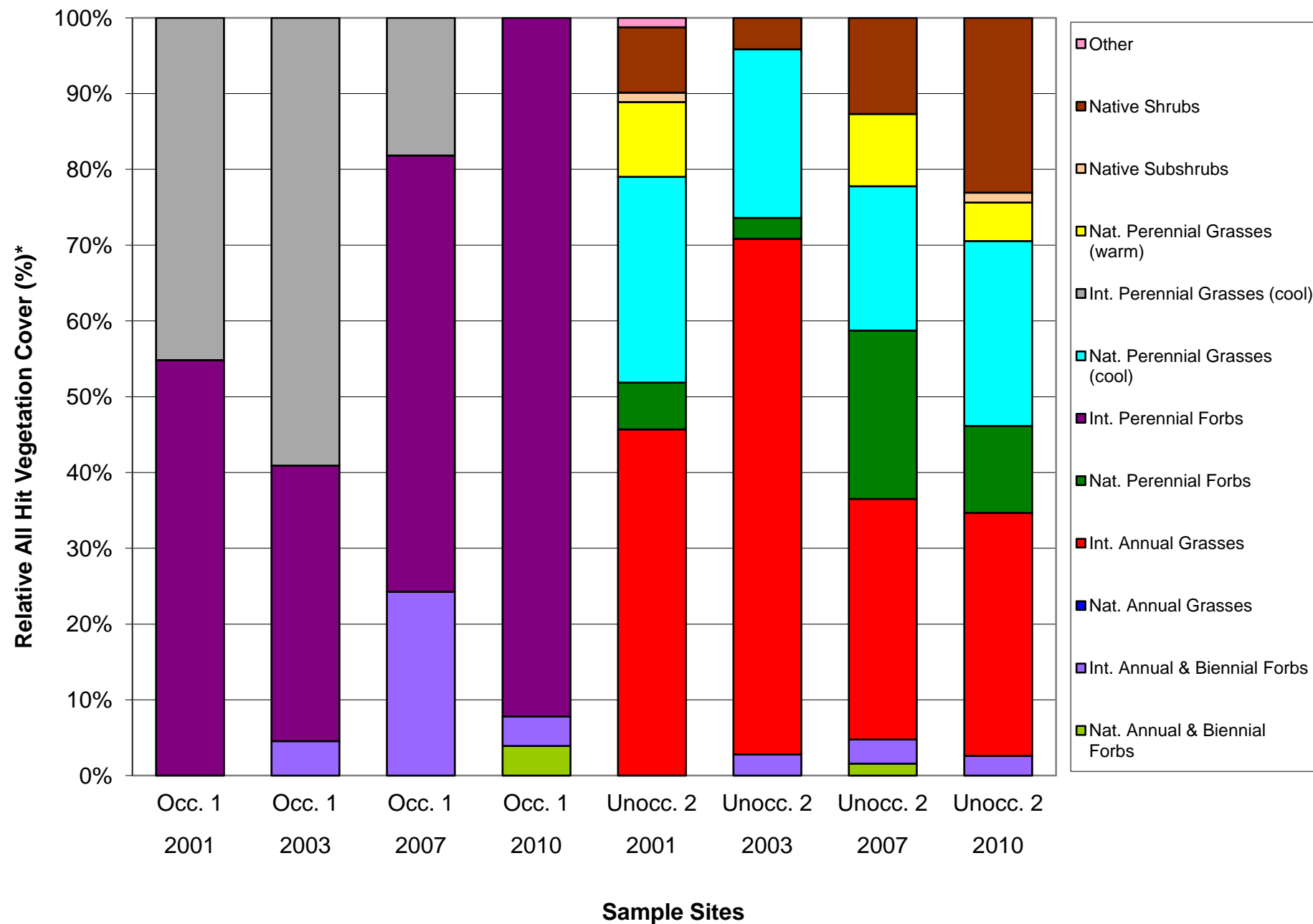
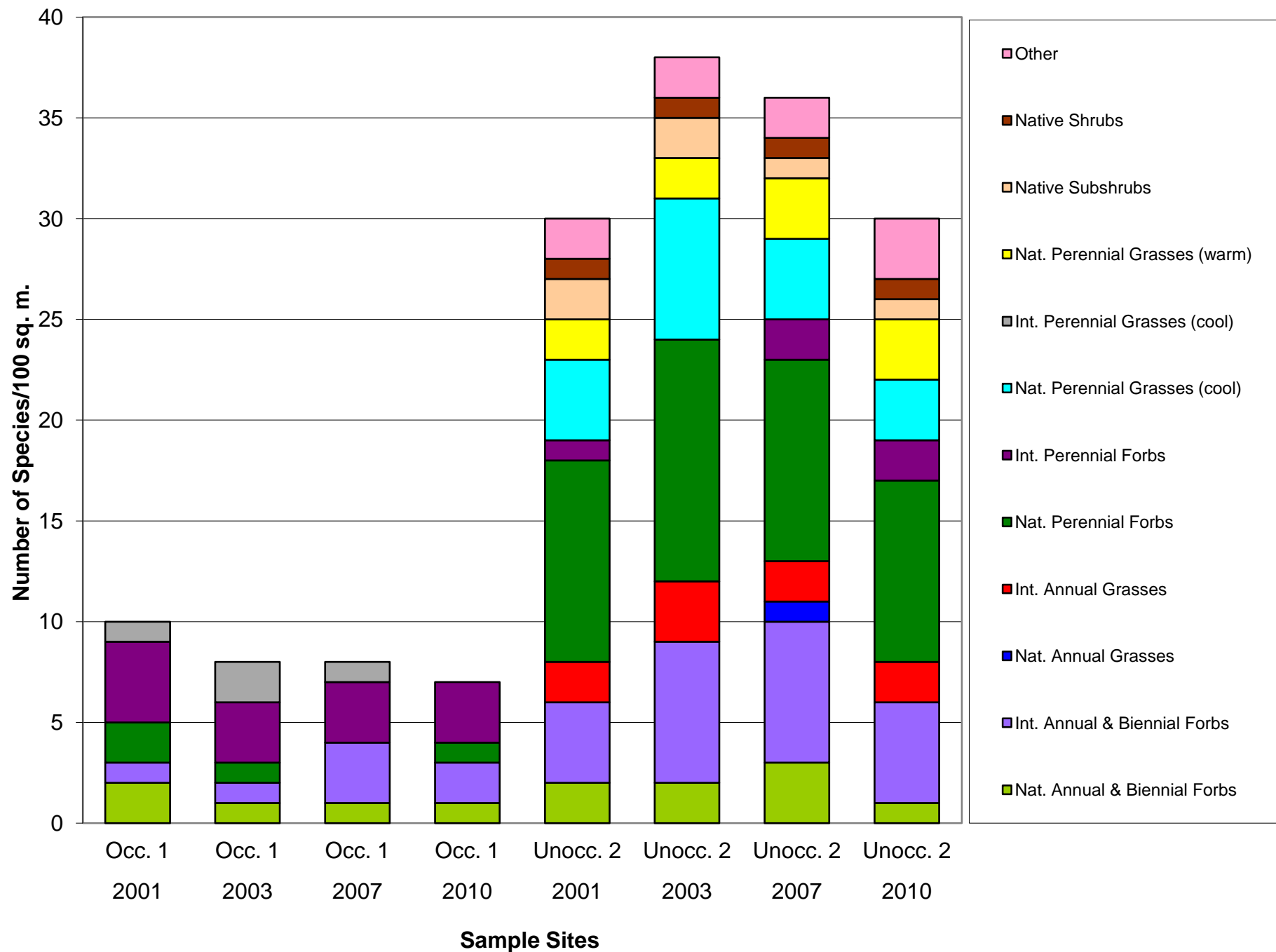


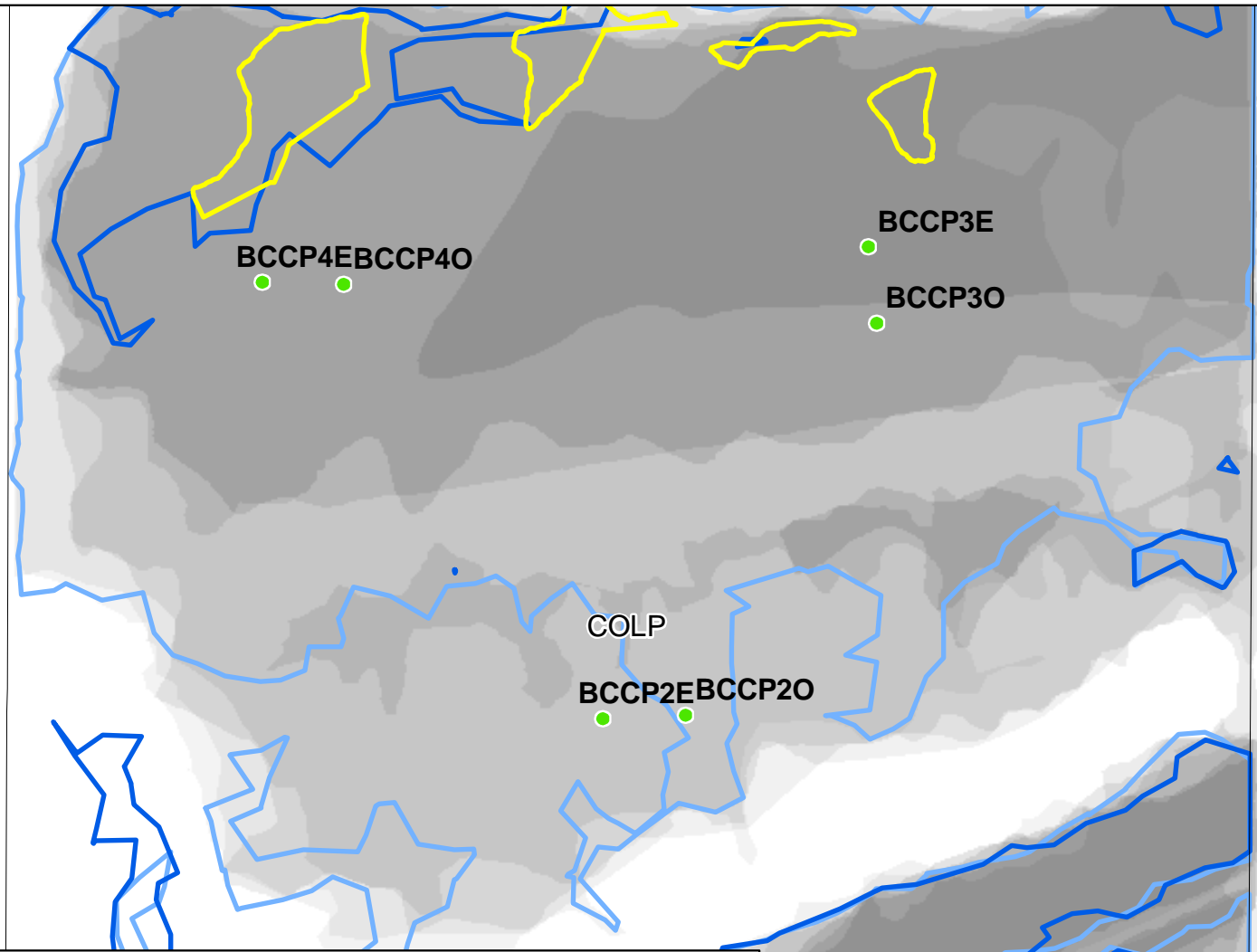
Figure 2. Relative All Hit Vegetation Cover by Lifeform - Hall Ranch Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2007 and 2010











*All Hit data include both first and second hits - a first hit is the top-most layer of the vegetation canopy, below a first hit interception may exist other interceptions - these are referred to as second hits.

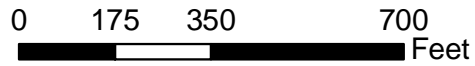
Figure 3. Species Density by Lifeform - Hall Ranch Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2007 and 2010





**Map 1. Boulder County
Prairie Dog Colony Mapping - COLP PARCEL**

- | | | | |
|--|------|---|-----------------------|
|  | 2010 |  | 2006 |
|  | 2009 |  | 2005 |
|  | 2008 |  | 2004 |
|  | 2007 |  | Boulder County Trails |



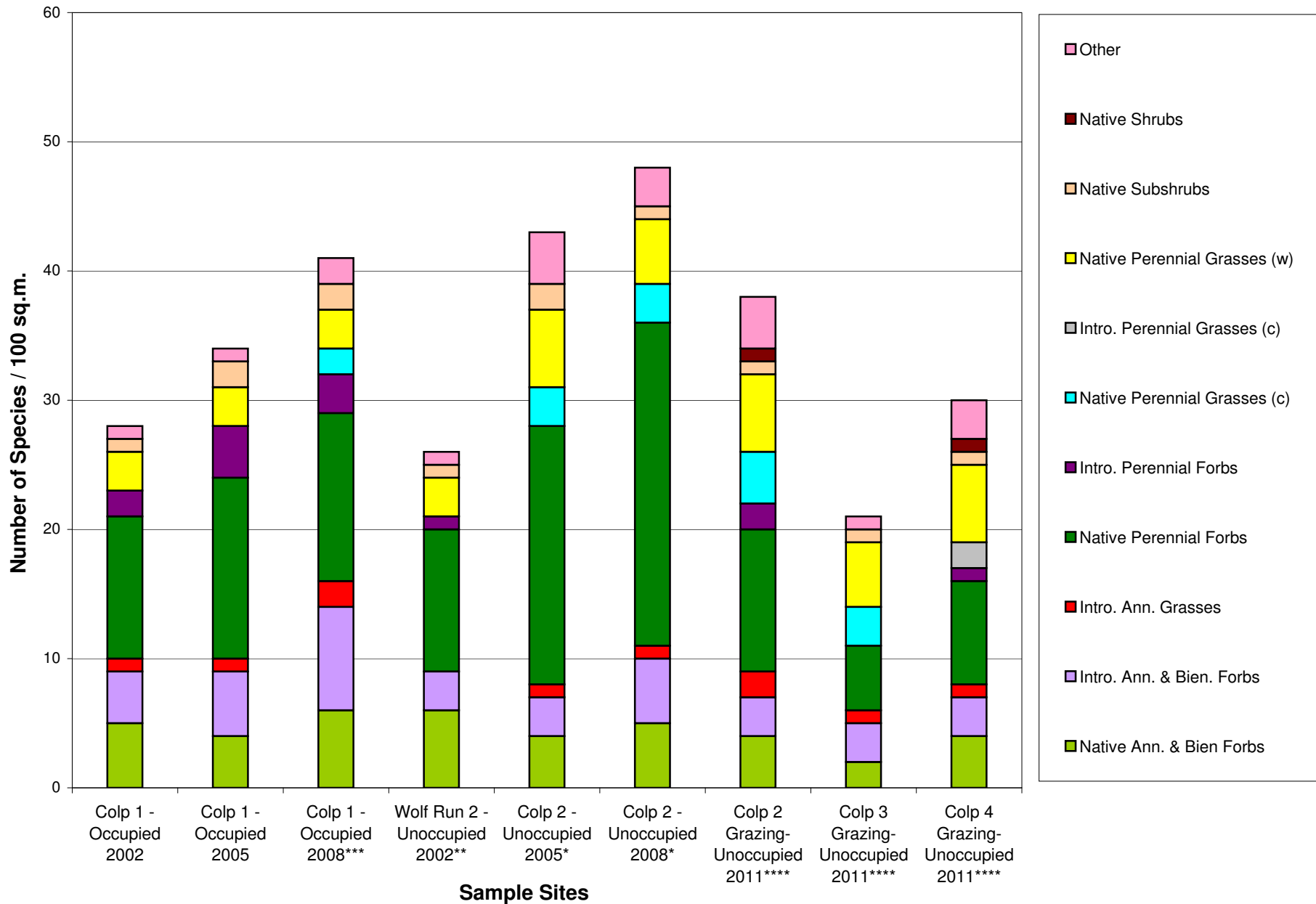
1 inch = 350 feet



~1997 darkest gray >> 2003 lightest gray



Figure 3. Species Density by Lifeform - Colp Property, Prairie Dog Study, Boulder County Open Space, CO - 2002, 2005 and 2008



**** 2011 Grazing Monitoring Colp Transects

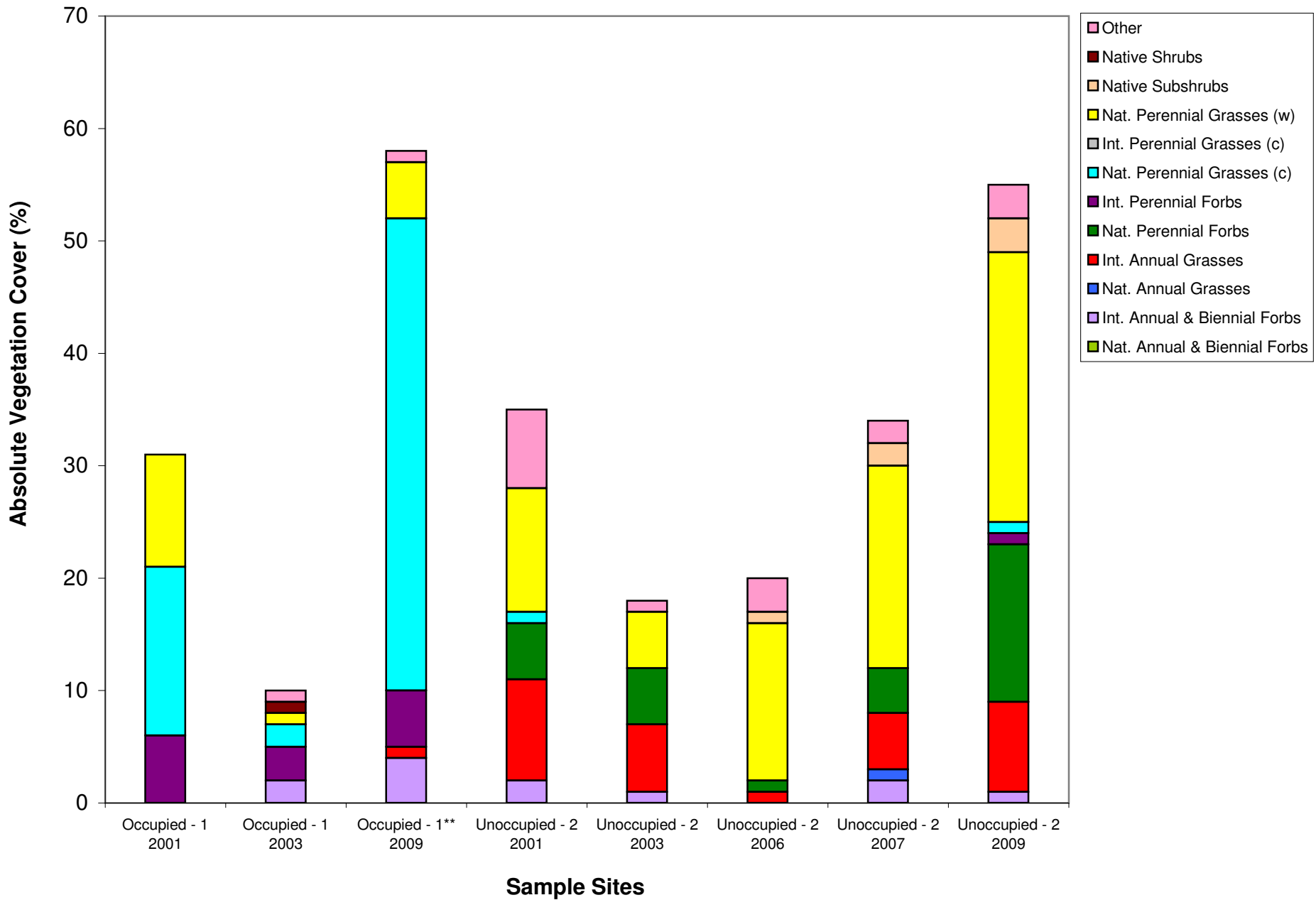
Only Lifeforms quantitatively measured included in figure.

*A new transect (Colp 2) set up on 8/9/2005.

**Colp Property occupied by Prairie Dogs in 2002. Wolf Run 2 chosen as a comparison site.

***Colp 1 (Occupied) now Dead due to plague

Figure 1b. Absolute Vegetation Cover by Lifeform - Wolf Run Parcel - Prairie Dog Study, Boulder County Open Space, CO - 2001, 2003, 2006, 2007 and 2009



*Wolf Run 1 (Occupied) now Dead