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Note

Grassland Birds and Rotational-Grazing in the Northeast: Breeding Ecology, Survival and Management Opportunities

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ABSTRACT We studied long-term (2002–2009) demographics of bobolinks (*Dolichonyx oryzivorus*) and savannah sparrows (*Passerculus sandwichensis*) breeding in rotationally grazed systems in the northeastern United States. Both nest success (6–44% bobolink; 7–48% savannah sparrow) and annual productivity (0.43–2.83 bobolink; 0.70–2.35 savannah sparrow) varied annually. Predation (48%) and trampling by cows (32%) accounted for most failed nests. Annual adult apparent survival ranged from 23% to 85% and showed substantial variation by species and sex. Although grazing resulted in substantial loss of vegetative cover, savannah sparrows responded similarly to predation and grazing-induced nest failure (time to renest, distance moved between nests) and generally remained in the same paddock to renest. Minimum paddock size to accommodate one female within this rotation was 70 m × 70 m (0.49 ha), allowing a female to stay within a paddock and move (approx. 50 m) between nesting attempts. To balance pasturing objectives and birds' needs in paddocks first grazed before 25 June, managers in the Northeast should rest that paddock 42–50 days before the second grazing. © 2011 The Wildlife Society.

KEY WORDS apparent survival, bobolink, *dolichonyx oryzivorus*, grassland birds, northeastern United States, *Passerculus sandwichensis*, pasture management, reproduction, rotational-grazing, savannah sparrow.

Grassland songbirds are dependent on prairies, hayfields, and pastures for breeding habitat. However, in managed grasslands, grazing can affect grassland birds both positively (Pykala 2000) and negatively. Grazing systems, through alteration of vegetation structure and composition, nest trampling, and even nest predation by cows (Nack and Ribic 2005), can affect songbird breeding success. Numerous studies in the midwestern United States have explored the effects of grazing on nest success. Regardless of stocking density, the potential for nest trampling increased exponentially with the length of time cows remained in a given paddock (Jensen et al. 1990, Paine et al. 1996). Grazing can also affect songbird density, which can increase with increasing pasture size (Renfew and Ribic 2008). Rahmig et al. (2009) found that burned pastures may have higher densities of grassland birds, although with significantly lower nest success, than in other unburned habitats. Although the intensity and timing of grazing strongly affects songbirds, those effects can be both positive and negative. For example, in Wisconsin, songbird density was higher but nest success was lower in rotationally grazed pastures compared to continuously grazed pastures (Temple et al. 1999). Although these midwestern studies provide insights as to how best to balance grazing and birds' needs, 2 important issues remain unresolved. First, in rotationally grazed systems, behavioral responses of birds to livestock are critical for developing sound management practices. When a nest fails as a result of grazing, birds may have an opportunity to renest, however the time it takes to renest and the distance birds move to a new nest site have important implications with respect to rotation length and paddock size, respectively. Second, it is unclear if these results apply to other regions.

With just over 1 million ha of pasture land in the Northeast (ME, NH, VT, MA, CT, RI, NY, and PA; National Agricultural Statistics Service [NASS] 2010), management practices on grazed lands could have significant impacts on grassland bird populations in the region. However, grassland songbird ecology has not been studied extensively in pastures in northeastern North America. The ecological factors that shape the relationship between grazing and grassland birds may vary regionally in 4 ways. First, grassland birds using midwestern prairies face the additional pressure of nest parasitism by brown-headed cowbirds (*Molothrus ater*; Johnson and Temple 1990), which does not appear to affect birds in the Northeast (>1,700 nests in VT have shown no evidence of parasitism; N. G. Perlut, Department of Environmental Studies, University of New England, unpublished data). Second, grazing landscapes are notably larger in the Midwest than the Northeast; single grazing paddocks in the Midwest can be larger than entire farms in the Northeast. Third, grassland bird species diversity is lower in the Northeast, although density may be equal or higher (Bollinger and Gavin 1992). Lastly, grazing systems in the Northeast do not incorporate burning, as is common in many parts of the Midwest. As a result of these differences,

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ecological relationships between grazing systems and grassland songbirds may differ between the Midwest and Northeast.

Using 4 years and 5 years of field data, respectively, Perlut et al. (2006) compared reproductive ecology and Perlut et al. (2008*a*) compared adult apparent survival of 2 grassland songbird species breeding in rotationally grazed pastures to birds breeding in 3 hayfield types, in which management intensity varied from high to low. Both reproductive success and adult apparent survival in rotationally grazed pastures was higher than the most intensively managed hayfields but notably lower than the least intensively managed hayfields (Perlut et al. 2006, 2008*a*). We examined reproduction and adult apparent survival for 2 obligate grassland species breeding in rotationally grazed pastures. Using 8 years of demographic data (2002–2009), we explored annual variability and behavioral patterns, including timing of renesting and distance moved to renesting sites.

STUDY AREA

Chittenden County, Vermont, was located in the Champlain Valley, which included 146,000 ha of managed grasslands (NASS 2008). Of the agricultural land in this region, 18% was pasture, 62.2% was hayland, and 19.8% was corn or other row crops (Perlut et al. 2008*b*). Average pasture size in this region was 3.99 ± 3.97 (SD) ha (max. = 24.7, min. = 0.4; n = 116 pastures, 463 ha).

We studied reproductive success and annual adult apparent survival for grassland songbirds breeding in 2 rotationally grazed systems. The first system was 7.8 ha divided into 4 similar-sized paddocks separated by either standard metal fencing or electric fencing. Cows were moved from a given paddock every 7–10 days when vegetation was grazed to 10–15 cm. Therefore, individual paddocks rested for 21–30 days between grazing events. In some years paddocks were cut with a 25-cm brush hog in late-June; the grass was not picked up. The second system was 10.8 ha divided into 9 similar-sized paddocks separated by single-wire electric fencing. Cows were moved from the paddock approximately every 5–10 days when vegetation was grazed to 5–13 cm. Therefore, individual paddocks rested for 40–80 days between grazing events. Grass-based pastures had a 2.5–3.75 cow/ha stocking density. Grazing typically began in mid-May and continued into late-September at both sites.

METHODS

The bobolink (*Dolichonyx oryzivorus*) and savannah sparrow (*Passerculus sandwichensis*) account for 96.5% of all obligate grassland birds breeding in the Champlain Valley (A. M. Strong unpublished data). These species' life history strategies have both similarities and differences that are critical to consider when building management plans. Both species are grassland obligates that feed on seeds and insects, use dried grass to build nests on the ground, and have nesting cycles lasting approximately 23–26 days. However, differences in migration and wintering location influence breeding strategies. Savannah sparrows are short-distance migrants (Wheelwright and Rising 2008), arriving on the Champlain Valley breeding grounds in mid- to late-April. In hayfields and pastures in Vermont, the nesting season ranges from 6 May (incubation) to 23 August (nestlings); this long period allows enough time to attempt 2 broods. In contrast, bobolinks are long-distance migrants (Martin and Gavin 1995), arriving on their Champlain Valley breeding grounds in mid-May. Incubation can begin as early as 22 May and nestlings are present until as late as 30 July. This brief window generally provides enough time to raise only one brood, although bobolinks may renest after early failure and will occasionally attempt a second brood (Martin 1974, Gavin 1984, Perlut et al. 2006).

Beginning in early May each year, we captured birds with mist-nets and placed unique combinations of 3 color bands and one metal United States Geological Service band on the legs of all adults of both species. We re-sighted color-banded birds weekly throughout the breeding season. In mid-May we began efforts to find the nests of each female in both pasture systems for as long as birds remained in the fields (we also searched adjacent fields for banded birds). We located nests by behavioral observations and by flushing incubating birds off nests with bamboo sticks. After locating a nest, we immediately identified the associated female and male and recorded the nest location with a Global Positioning System (GPS). We captured and banded unbanded adults near the nest location. We visited a nest every 1–2 days until it either failed or the nestlings fledged.

We followed individually color-banded females for their entire breeding season(s), assessing the total number of nests, eggs laid, and offspring successfully produced per year on rotationally grazed pastures. We also used these nesting data to calculate logistic-exposure nest success, defined as successfully fledging ≥1 young from a given nest (Shaffer 2004). Additionally, nest data provided information on how long it took for a female to renest after fledging or failing. With the GPS data collected at each nest and using the Hawths Tools extension in ArcGIS, we identified the distance to paddock edge as well as the distance moved between nesting attempts. We assessed annual adult apparent survival (ϕ) using the Cormack–Jolly–Seber method (CJS; Lebreton et al. 1992) in Program MARK (White and Burnham 1999). Apparent survival is the joint probability that an individual survives, returns to a given location, and is detected. This modeling effort, using an information-theoretic approach, explored the main effects of species (bobolinks and savannah sparrow) and gender, including additive and interactive components.

RESULTS

Savannah sparrow incubation on rotationally grazed pastures began as early as 11 May and we found nestlings in nests as late as 3 August. For savannah sparrows, incubation began in 90% of nests between 18 May and 10 July. Bobolink incubation began as early as 23 May and nestlings were in the nest until as late as 30 July. For bobolinks, incubation began in 90% of nests between 28 May and 7 July.

In 2002–2009 we located and monitored 357 nests: including 242 savannah sparrow, 109 bobolink, 4 eastern meadowlark (*Sturnella magna*), 1 grasshopper sparrow (*Ammodramus*

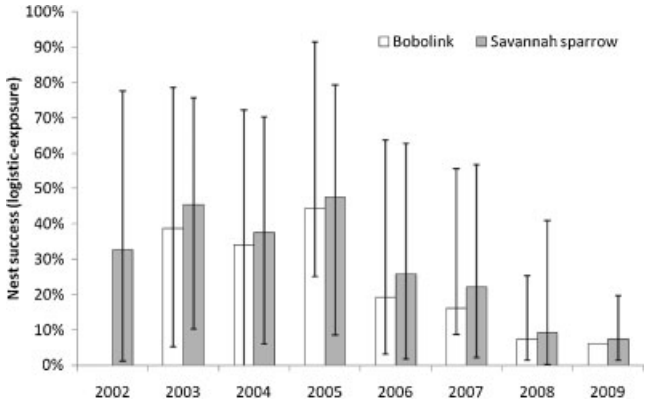

Figure 1. Nest success varied widely among years, ranging from 6% to 44% for bobolinks and 7–48% for savannah sparrows breeding in rotationally grazed pastures in Vermont, 2002–2009. We found no bobolink nests in 2002.

savannarum), and 1 song sparrow (*Melospiza melodia*) nest. Logistic-exposure nest success for bobolinks and savannah sparrows was 0.24 and 0.28, respectively (see Appendix A for model results). Daily nest survival was 0.920 ± 0.036 (SD) for bobolinks and 0.931 ± 0.032 (SD) for savannah sparrows. Nest success varied widely among years (0.06–0.44 for bobolinks, 0.07–0.48 for savannah sparrows; Fig. 1). Overall, savannah sparrow and bobolink females fledged 1.73 ± 0.16 and 1.42 ± 0.25 offspring per year, respectively, however, this too varied widely (range = 0.43–2.83; Fig. 2). Across all years and both species, females averaged 0.71–0.86 female offspring per year, slightly below the 1 female offspring per single year replacement value assuming a 1 male:1 female nestling sex ratio.

Renesting after either success or failure was rare for bobolinks (5% of F) but common for savannah sparrows (31% of F). Too few female bobolinks renested after failure to assess sources of variation for movement and timing. Savannah sparrows tended to renest in the same paddock after success or failure (of females that renested, 56% stayed in paddock; $n = 34$ F). For both species combined, nest failure was primarily a result of predation (48% of failed nests) and disturbance by cows (32% of failed nests; Table 1). However, savannah sparrow nests largely failed by predation (59%), whereas bobolink nests mainly failed as a result of disturbance by cows (57%). Savannah sparrows responded similarly to nest failure by cows and predation, renesting within approximately 9–10 days and moving approximately 40–44 m between nesting attempts (Table 2); savannah sparrows also responded similarly to nest failure by cows and weather (3 days longer to renest due to weather; Table 2). All cases of weather-related failures were caused by flooding from persistent rains. Females that renested after successful fledging moved a similar distance, but took twice as long to renest, as those that failed from cow disturbance (Table 2).

Females avoided nesting within 10 m of internal and external paddock edges; 90.2% and 89.3% of savannah sparrow and bobolink nests, respectively, were ≥10 m from the paddock edge (distance to paddock edge $\bar{x} = 55.8$, SD = 53.9 m for savannah sparrows; $\bar{x} = 40.8$, SD = 30.6 m for bobolinks). Across all years, we found an average of 28 ± 21.64 (SD) nests per paddock (min. = 6, max. = 74).

Survival analyses included 192 savannah sparrows (114 F, 78 M) and 95 bobolinks (64 F, 31 M) banded in 2002–2008 and resighted in 2003–2009. Apparent survival showed notable annual variation for both species and genders (Fig. 3). Bobolink apparent survival ranged from 0.23 to 0.74 and savannah sparrow apparent survival ranged from 0.28 to 0.85. Averaged across years, savannah sparrow apparent survival was 18% higher than that of bobolink, and male apparent survival was 22% higher than that of females (see Appendix B for model results).

Table 1. Causes of savannah sparrow and bobolink nest failure ($n = 227$) on rotationally grazed pastures in Vermont, 2002–2009.

Cause of nest failure	Bobolink (%)	No. nests	Savannah sparrow (%)	No. nests	Total (%)	No. nests
Depredated	29	22	59	88	48	110
Cows	57	44	19	29	32	73
Weather	4	3	15	22	11	25
Abandoned	6	5	5	7	5	12
Mowed	4	3	1	1	2	4
Unknown	0	0	1	2	1	2
Infertile	0	0	1	1	<1	1

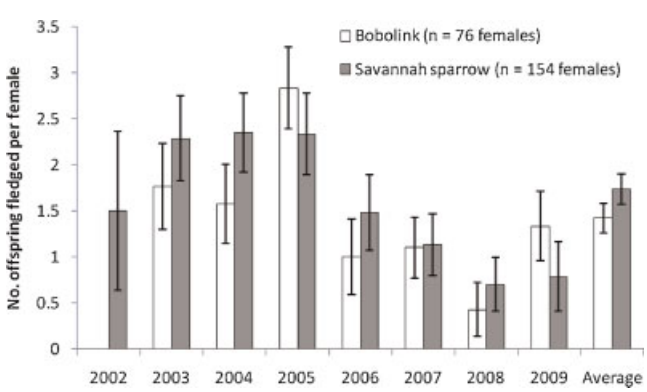

Figure 2. Reproductive parameters ($\bar{x} \pm$ SE) for savannah sparrows and bobolinks in 2 rotationally grazed systems in Vermont, 2002–2009, showed moderate rates of annual productivity as compared to hayfields in this region (Perlut et al. 2008*b*).

Table 2. Although nest destruction by cows resulted in both nest failure and a notable decrease in vegetative cover, savannah sparrows responded similarly to failure by cows and predation while nesting in rotationally grazed pastures in Vermont, 2002–2009. Due to the low number of females that renested, similar data were not available for bobolinks.

Cause of previous nests failure	No. days to renest	SE	No. nests	Distance moved between nests (m)	SE	No. nests
Cows	10.5 A	1.5	8	40.3 A	5.3	12
Depredated	8.7 B,C	0.7	9	44.3 B	5.3	17
Abandoned or weather	12 D	1.2	3	23.1 C	7.2	5
Fledge	17.4 A,C	1.6	16	37.2 D	5.7	19

Means in the same column with the same letter are significantly different (t-test, $P < 0.05$).

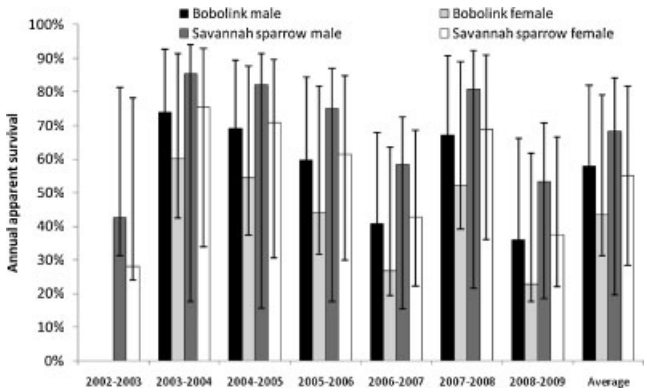

Figure 3. Annual apparent survival rates (ϕ) for savannah sparrows ($n = 192$) and bobolinks ($n = 95$) breeding in 2 rotationally grazed systems in Vermont's Champlain Valley, 2002–2009, showed high annual variation. There is no apparent survival estimate for bobolinks in 2002–2003 because we did not band any bobolinks in 2002.

DISCUSSION

Pastures comprised 18% of the agricultural landscape and pasture land in Vermont increased 64% from 83,780 acres to 137,165 acres between 1997 and 2007 (Perlut et al. 2008*b*, NASS 2010). At the same time, the use of rotationally grazed systems on Vermont dairy farms increased from 11.6% in 1997 to 20.2% in 2006 (Winsten et al. 2010; Pennsylvania also showed notable increases in rotational-grazing during this period, but similar data was not available for other northeastern states). Increasing trends of pasturing and use of rotational systems suggest that the role of these habitats in population viability should not be overlooked. However, in Vermont, grassland bird densities were generally lower in pastures than in hayfields. For example, Perlut et al. (2008*b*) found that savannah sparrow and bobolink densities were 14% and 44% lower, respectively, in pastures than in fields mowed after 1 August. Reproductive and survival rates we identified were generally higher in pastures than in hayfields cut before 11 June and lower than hayfields cut after 21 June (see Perlut et al. 2008*b* for hayfield values). Pastures' role in supporting regional population viability may be even more important in other northeastern states; while surveying six grassland habitat types in western New York, Norment et al. (1999) found that grassland bird abundance in pastures was comparable to hayfields and fallow fields.

Our report provides a more comprehensive view than that of Perlut et al. (2006, 2008*a*) of grassland songbird life-histories in northeastern rotationally grazed pastures largely due to a >50% greater sample size in our study. We found that reproduction and survival in northeastern pastures was highly variable among years. Nest success values in our study (0.24 bobolink, 0.28 savannah sparrow) were similar to those reported in Perlut et al. (2006), which only included data from 2002 to 2005 (41% of savannah sparrow and 47% of bobolink nests we used). In Perlut et al. (2006) bobolink and savannah sparrow nest success was 0.21 and 0.28, respectively. However, our larger dataset provides a rare look at long-term demographic variability. In fact, even in the Midwest, where there are many studies of grassland songbird density and occurrence in pastures, there are few studies of reproductive ecology and, to our knowledge, none of comparable length of time to our study.

Overall nest success values from our study, however, are similar to those published elsewhere. For example, Renfrew et al. (2005) found daily nest survival rates of 0.927 (incubation) and 0.924 (nestling) for bobolinks and 0.909 (incubation) and 0.935 (nestling) for savannah sparrows. For savannah sparrows, others have found nest success rates of 8–25% (Montana, Fondell and Bell 2004) and 22% (Saskatchewan, Davis 2003). Additionally, survival rates we report were higher for bobolinks than those reported in Perlut et al. (2008*a*), which only included 49% and 41% of the bobolinks and savannah sparrows, respectively, we sampled here. To our knowledge, there are no other studies on survival rates for these species breeding in pastures.

Although the high annual variation of both reproductive success and apparent survival are noteworthy, the factors causing variation may not be concordant. Specifically, the trends in variation for reproductive success and apparent survival do not parallel each other (Figs. 2 and 3), suggesting that ecological conditions that pressure these populations are not necessarily synchronous between the breeding and nonbreeding quarters (Stearns 1992). For example, reproductive success was low in 2007 and 2008, however, apparent survival was extremely high between those 2 years. Additionally, reproductive success increased from 2004 to 2005, however, apparent survival showed a modest decrease during that period.

Female savannah sparrows responded similarly to nest failure from predation and cows, which was surprising in that cows caused both nest failure and significant alteration of nest cover within the entire paddock, decreasing standing vegetation through foraging, trampling, and bedding. Understanding the response of grassland songbirds to grazing practices is critical in assessing the effects of paddock size and timing of rotation on avian demography. When cows caused savannah sparrow nests to fail, females renested in 10.5 ± 1.5 days and moved 40.3 ± 5.28 m between nesting attempts. Therefore, after cow-related nest failure, savannah sparrows needed approximately 42 days to successfully reproduce: 10 days until clutch completion, 10 days for incubation, 10 days to feed nestlings, and $\geq$12 days for fledglings to acquire basic foraging skills such that they were moderately independent (see Wheelwright and Templeton 2003). Because so few bobolinks renested after failure, similar estimates for renesting were not available. However, in hayfields, bobolinks return to mowed fields approximately 15 days postharvest (Perlut et al. 2006). Therefore, assuming that bobolinks will return to a paddock in a similar timing as after a field is hayed, a reasonable plan for bobolinks would provide approximately 50 days between grazing events within a given paddock.

These breeding windows are only useful for management when paddocks are large enough to allow birds to remain within the same paddock after nest failure, as was the case for 56% of savannah sparrow renesting attempts in our

study. Minimum paddock size should allow a 10-m buffer from the fence edges, a biologically relevant width for our study region because 90% of all nests were ≥10 m from a paddock edge. Importantly, this buffer size is contingent of having additional adjacent paddocks that increase the total grass area, as these species are known to show area sensitivity (Ribic et al. 2009). Because these are social species that often nest near each other and because a male often has multiple females within his territory (Perlut et al. 2008*c*), paddocks should be large enough to support multiple females. Larger paddocks will offer habitat for additional females and smaller paddocks for fewer females. We encourage farmers and land managers in the Northeast to use this 70 m × 70 m (0.49 ha) guideline as a minimum paddock size and to consider the degree to which this could be increased in a given system such that managers can provide 42–50 days between grazing events for a given paddock (depending on the bird species present). Our study paddocks were all greater than this recommended size.

Other useful models have been proposed for midwestern grazing systems. To balance birds' and grazing needs, Temple et al. (1999) suggest a pro-bird rotational-grazing model where 33% of all grassland is left ungrazed and unmowed from 15 May through 1 July. Likewise, more recent work in native tallgrass prairies identified that increasing spatial and temporal heterogeneity of management can have strong, positive effects on grassland birds. This spatial and temporal heterogeneity was accomplished through varying cycles of both grazing and burning (Fuhlendorf et al. 2006). Our recommendations are complementary to these studies, which were done in a notably different region and scale (grazing system size).

Our study is the first to provide a comprehensive view of long-term demographics for grassland songbirds breeding in northeastern rotationally grazed pasture systems. Because females produce <1 female offspring per year, these pastures would not provide stable populations based on reproductive rates; however, guidelines for improving nest success with precise rotation lengths and paddock sizes may increase productivity.

Management Implications

To balance pasturing objectives and birds' needs, after a paddock is grazed, managers should provide 42–50 days rest before a paddocks' second grazing; this window of time can be adjusted based on the species present in a given year. Minimum paddock size should be 70 m × 70 m (0.49 ha), which would allow a 10-m buffer from the fence edge on each side and allow for 44.3 ± 5.33 m movements between nesting attempts. This plan applies to paddocks, for which management objectives require grazing before 25 June, as this is the latest date by which initiation of renesting could be expected following removal of cows.

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Appendix A. Akaike's Information Criterion values corrected for small sample sizes (AIC_C), differences in AIC values (Δ_i), and model weights (w_i) for logistic-exposure nest success models for savannah sparrows and bobolinks breeding in 2 rotationally grazed systems in Vermont's Champlain Valley (2002–2009) showed overwhelming support for the top 2 ranking models.

Rank	Model	No. parameters (k)	AIC_C	Δ_i	w_i
1	Year	8	1543.76	0	0.47
2	Year + species	9	1543.98	0.21	0.42
3	Year × species	14	1546.78	3.02	0.10
4	Species	2	1571.42	27.66	0.00

Appendix B. Akaike's Information Criterion values corrected for small sample sizes (AIC_C), differences in AIC values (Δ_i), and model weights (w_i) for Cormack–Jolly–Seber apparent survival models for savannah sparrows and bobolinks breeding in 2 rotationally grazed systems in Vermont's Champlain Valley (2002–2009) showed overwhelming support for the top ranked model.

Rank	Model	No. parameters (k)	AIC_C	Δ_i	w_i
1	ϕ (sex + species) P (time)	10	2141.49	0	0.91
2	ϕ (sex) P (time)	9	2147.40	5.92	0.05
3	ϕ (species) P (time)	9	2147.45	5.97	0.05
4	ϕ (.) P (time)	8	2156.04	14.56	0.00