

Chapter 4 Exercise Hints and Solutions

Agent-based and Individual-Based Modeling: A Practical Introduction, 2nd Edition

Exercise 1

Students should predict that when q is zero, the butterflies disperse in random directions instead of aggregating on a hilltop; and when q is one, they all follow the same paths directly to the nearest hilltop. These predictions should be correct.

Exercise 2

In the setup procedure, change this:

```
; Create butterflies
crt 500
[
  set size 2
  ; Set initial location to random patch
  setxy random-pxcor random-pycor
  pen-down
]
```

to something like this:

```
; Create butterflies
crt 500
[
  set size 2
  ; Set initial location to a patch near the center,
  ; which is at 74, 74
  setxy (70 + random 9) (70 + random 9)
  pen-down
]
```

Other potential solutions are:

```
; Create butterflies
crt 500
[
  set size 2
  ; Set initial location to a patch near the center,
  ; which is at 74, 74
  move-to one-of patches with [(distance patch 74 74) <= 10]
  pen-down
]
```

and:

```
; Create butterflies
crt 500
[
  set size 2
```

```

; Set initial location to a patch near the center,
; which is at 74, 74
move-to one-of patches with
[
  pxcor >= 64 and pxcor <= 83 and
  pycor >= 64 and pycor <= 83
]
pen-down
]

```

Exercise 3

It should be clear that butterflies tend to move in directions that are multiples of 45 degrees. To understand why, it helps to see the exact elevations of the patches.

You can see patch elevations by setting their label to their elevation, via this statement (which can be added to the `setup` procedure, or just entered in the Command Center):

```
ask patches [set plabel elevation]
```

But if you do this, the View becomes indecipherable because the patch labels occupy all the space. It helps to eliminate the decimal places in the elevation, and turn the labels black. Use this in `setup`:

```

; Assign an elevation to patches and color them by it
ask patches
[
  ; Elevation is a sine function of X, Y coordinates
  ; with maximum elevation of 400 when sin is 1.0
  set elevation 200 + (100 * (sin (pxcor * 3.8) + sin (pycor * 3.8)))

  set pcolor scale-color green elevation 0 400
  set plabel precision elevation 0
  set plabel-color black
] ; end of "ask patches"

```

It also helps to make the world small so it includes only one (or part of one) hill. For example, set the world so that `max-pxcor` and `max-pycor` are 30 and the patch size is about 20. Now the View should look like this:

```

291 298 305 311 318 324 330 336 342 348 353 358 363 367 371 375 379 382 384 387 388 390 391 391 391 391 390 389 387 385 383
294 300 307 314 320 326 333 339 344 350 355 361 365 370 374 378 381 384 387 389 391 392 393 394 394 393 393 391 390 388 385
296 303 309 316 322 328 335 341 347 352 357 363 367 372 376 380 383 386 389 391 393 394 395 396 396 396 395 394 392 390 387
298 304 311 317 324 330 336 342 348 354 359 364 369 374 378 381 385 388 391 393 395 396 397 397 398 397 396 395 394 391 389
299 305 312 319 325 331 338 344 349 355 360 365 370 375 379 383 386 389 391 393 395 397 398 399 399 399 398 396 395 393 390
300 306 313 319 326 332 338 344 350 356 361 366 371 376 380 383 387 390 393 395 397 398 399 400 400 399 398 397 396 393 391
300 307 313 320 326 333 339 345 351 356 362 367 371 376 380 384 387 390 393 395 397 398 399 400 400 400 399 398 396 394 391
300 307 313 320 326 332 339 345 351 356 361 367 371 376 380 384 387 390 393 395 397 398 399 400 400 400 399 397 396 394 391
299 306 313 319 326 332 338 344 350 356 361 366 371 375 379 383 387 390 392 395 396 398 399 399 399 399 399 397 395 393 391
298 305 312 318 325 331 337 343 349 355 360 365 370 374 378 382 386 389 391 394 395 397 398 398 398 398 397 396 394 392 390
297 304 310 317 323 330 336 342 348 354 359 364 368 373 377 381 384 387 390 392 394 395 396 397 397 397 396 395 393 391 388
295 302 308 315 321 328 334 340 346 351 357 362 367 371 375 379 383 386 388 390 392 394 395 395 395 395 394 393 391 389 387
293 300 306 313 319 326 332 338 344 349 355 360 364 369 373 377 380 383 386 388 390 391 392 393 393 393 392 391 389 387 384
290 297 304 310 317 323 329 335 341 347 352 356 362 366 370 374 378 381 383 386 387 389 390 390 390 390 389 388 386 384 382
287 294 301 307 314 320 326 332 338 344 349 354 359 363 367 371 375 379 380 383 384 386 387 387 387 387 386 385 383 381 379
284 290 297 304 310 316 323 329 334 340 345 351 355 360 364 368 371 374 377 379 381 382 383 384 384 383 383 381 380 378 375
280 287 293 300 306 313 319 325 331 336 342 347 352 356 360 364 367 370 373 375 377 378 379 380 380 380 379 378 376 374 371
276 283 289 296 302 308 315 321 327 332 337 343 347 352 356 360 363 366 369 371 373 374 375 376 376 376 375 374 372 370 367
271 278 285 291 298 304 310 316 322 328 333 338 343 347 352 355 359 362 364 367 368 370 371 371 371 371 370 369 367 365 363
267 273 280 286 293 299 305 311 317 323 328 333 338 343 347 351 354 357 360 362 364 365 366 367 367 366 365 364 363 361 358
262 268 275 281 288 294 300 306 312 318 323 328 333 337 342 346 349 352 355 357 359 360 361 361 362 361 360 359 357 355 353
256 263 269 276 282 289 295 301 307 312 318 323 328 333 336 340 344 347 349 351 353 355 356 356 356 355 354 352 350 348
251 257 264 270 277 283 289 295 301 307 312 317 322 327 331 334 338 341 344 346 348 349 350 351 351 350 349 348 347 344 342
246 251 258 265 271 277 284 290 295 301 306 311 316 321 325 329 332 335 338 340 342 343 344 345 345 344 344 342 341 339 336
239 245 252 259 265 271 278 284 289 295 300 305 310 315 319 323 326 329 332 334 336 338 339 339 338 338 336 335 333 330
233 239 246 252 259 265 271 277 283 289 294 299 304 308 313 316 320 323 326 328 330 331 332 332 333 332 331 330 328 326 324
226 233 239 246 252 259 271 277 282 288 293 298 302 306 310 314 317 319 321 323 325 326 326 326 326 325 324 322 320 318
220 226 233 240 246 252 259 265 270 276 281 286 291 296 300 304 307 310 313 315 317 318 319 320 320 319 319 317 316 314 311
213 220 226 233 239 246 252 258 264 269 275 280 285 289 293 297 301 304 306 308 310 312 313 313 313 313 311 309 307 305
207 213 220 226 233 239 246 251 257 263 268 273 278 283 287 290 294 297 300 302 304 305 306 307 307 306 305 304 303 300 298
200 207 213 220 226 233 239 246 251 256 262 267 271 276 280 284 287 290 293 295 297 298 299 300 300 300 299 298 296 294 291

```

If you look at any patch, you see that the highest neighbor elevation is always either (a) at a 45-degree diagonal, or (b) directly left or right, or up or down. This regularity simply results from the geometry of the sinusoidal hill, which is symmetric.

Exercise 4

Adding random variation to the elevation breaks up the regularity identified in the solution to Exercise 3: now the highest neighbor is not always at a 45- or 90-degree heading. However, this effect is not clear unless the amount of randomness is relatively large compared to the differences in elevation among neighboring cells (as illustrated in the above figure), e.g., by adding a random number between zero and 50 to each patch's elevation.

A NetLogo code with this “noise” in the landscape is available with the instructor materials; it is called “ButterflyModel-NoiseInElevation-2ndEd.nlogo”.