Design Analysis

Summary:

We consider three microcontroller alternatives to the STM32L432KC (STM). The first is the MSP430F5359, which boasts efficient low-power modes and access to more memory and GPIO pins. The second is the ADuCM4050, which includes more memory and some security features. The third is the MAX32625, which has access to more memory, an extremely low power mode, and faster clock speed.

Alternative 1:
[MSP430F5359](http://www.ti.com/lit/ds/symlink/msp430f5359.pdf)
http://www.ti.com/lit/ds/symlink/msp430f5359.pdf

The MSP430F5359 (MSP) is a low-power MCU from Texas Instruments, with specifications that are comparable with the STM. The operating voltage for the MSP falls between 1.8V and 3.6V, which is similar to that of the STM. Both chips have dedicated 32 kHz oscillators for the RTC, a 12-bit ADC channel, access to general-purpose timers, and UART support. Both chips utilize a similar amount of SRAM, with the MSP using 66 kB while the STM uses 64 kB.

A benefit of using the MSP is that it has multiple efficient low-power modes, with most of its low-power modes consuming less than 4 uA of current per MHz. The only time the STM achieves this type of power efficiency is when it is in one of its stop modes. The MSP also has 74 GPIO pins compared to the STM's 26 pins, 64 priority levels for its interrupt handler compared to STM's 16 levels, and 512 kB of flash memory compared to the STM's 256 kB. Although the MSP seems to have higher specifications than the MSP, in practice we do not need the additional GPIO pins, priority levels, and flash, since we do not use all of the ones available on the STM.

A significant drawback is that the MSP uses a 16-bit RISC core instead of a 32-bit ARM core. As a result, it will be tough to implement floating-point operations, but it does have dedicated hardware for 32-bit integer operations. For 1000 units, the MSP is also more expensive, as it costs around $4.50 for the MSP on the Texas Instruments website. The STM only costs $2.43 from Digikey.

Alternative 2:
[ADuCM4050](https://www.analog.com/media/en/technical-documentation/data-sheets/ADuCM4050.pdf)
https://www.analog.com/media/en/technical-documentation/data-sheets/ADuCM4050.pdf

The ADuCM4050 is an ARM Cortex-M4F based microcontroller from Analog Devices. The specifications are similar to the STM, but there are a few differences that make it better in some regards, and worse in others. Both chips have similar power supply voltages, 1.74V-3.6V for the ADuCM and 1.71V-3.6V for the STM. They also both have hibernate/sleep modes, which is necessary for our long term use of the light sensor. The clock in both chips is controlled by a 32 kHz crystal oscillator clock. The temperature range for both microcontrollers is similar, -40C to 85C, however the data sheet for the STM says the upper range can be 85/105/125C.

The ADuCM chip only has three general purpose timers compared to the STM chip's 11 varied timers. It also lacks in communication interfaces, only having 7 serial communication ports compared to the STM's 14. Cost-wise, the ADuCM chip is much more expensive, currently priced at $10.29 per unit when buying 1000+, whereas the STM retails for $2.43.

Some advantages of the ADuCM chip are detailed below. The flash memory size is much larger, 512 kB versus 256 kB. This would allow for more storage of light sensor data and less time spent having to retrieve the data. The ADuCM chip also has 72 pins compared to the STM's 26. If necessary, the ADuCM chip also has a hardware cryptographic accelerator which supports 3 different types of cryptographic functions, which could be used to protect our data from anyone who may steal the chip while it is deployed.

Alternative 3:
MAX32625
https://datasheets.maximintegrated.com/en/ds/MAX32625-MAX32626.pdf

The MAX32625 is an ARM Cortex-M4 based microcontroller from Maxim Integrated that boasts some impressive specs, but for a slightly increased price. The power supply is a slightly tighter range than the STM's, running between 1.8V-3.3V compared to 1.71V-3.6V.

This chip is very powerful in some regards. It has 512 kB for flash storage compared to the STM's 256 kB, along with an 8 kB instruction cache to run operations more efficiently. The low power mode on this chip is extremely efficient, running at only 600 nA with the RTC enabled. There are also 40 pins available for GPIO purposes, which gives it a lot of versatility with different sensors; however, it is not as important of an advantage for this project. The chip also has built in support for various cryptographic functions, but again they are not as important.

While this chip has some advantages, it also has disadvantages. There are only six 32-bit timers in the MAX chip compared to 11 in the STM chip, but since we don't make use of all the timers in the STM chip, it is not that important of a downside. The biggest downside is the temperature range of the chip. The MAX chip only has a temperature range of -30C-85C compared to the STM's temperature range of -40C-85C. The 10 degree difference on the lower bound is extremely important because Indiana winters can get colder than -30C. For long-term survivability, this is a big flaw of this microcontroller.

Conclusion:

Overall, the three chips described here all serve as good microcontrollers, but for the light sensor project the STM chip is the best choice. This is due to its low cost for the specs it has. It may lack flash storage space, but this is mitigated by an idealized increase of people at the forest using an app to help collect the data more often.